

Allwinner A83T User Manual

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Revision History

Version	Date	Description
V1.0	2014/08/25	Initial release version
V1.1	2014/09/24	Correct Port Controller Description
V1.2	2014/10/23	Add SD/MMC,NAND,EMAC Register Description
V1.3	2014/12/30	Add R_timer,R_watchdog Description
V1.4	2015/03/16	Add R_PRCM Module Description
V1.5	2015/04/23	Add the programming guide of the Security System
V1.5.1	2015/05/11	Modify Security System Register

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Chapter 1 About This Documentation

1.1. Documentation Overview

This documentation provides an overall description of the Allwinner Octa-core A83T application processor, which will provide instructions to programmers from several sections, including system, memory, graphic, image, display and interface.

1.2. Acronyms and abbreviations

The table below contains acronyms and abbreviations used in this document.

A		
AES	Advanced Encryption Standard	A specification for the encryption of electronic data established by the U.S. National Institute of Standards and Technology (NIST) in 2001
AGC	Automatic Gain Control	An adaptive system found in electronic devices that automatically controls the gain of a signal: the average output signal level is fed back to adjust the gain to an appropriate level for a range of input signal levels
AHB	AMBA High-speed Bus	A bus protocol introduced in Advanced Microcontroller Bus Architecture version 2 published by ARM Ltd company
APB	Advanced Peripheral Bus	APB is designed for low bandwidth control accesses, which has an address and data phase similar to AHB, but a much reduced, low complexity signal list (for example no bursts)
AVS	Audio Video Standard	A compression standard for digital audio and video
C		
CIR	Consumer IR	The CIR (Consumer IR) interface is used for remote control through infra-red light

CRC	Cyclic Redundancy Check	A type of hash function used to produce a checksum in order to detect errors in data storage or transmission
CSI	CMOS Sensor Interface	The hardware block that interfaces with different image sensor interfaces and provides a standard output that can be used for subsequent image processing
D		
DES	Data Encryption Standard	A previously predominant algorithm for the encryption of electronic data
DLL	Delay-Locked Loop	A digital circuit similar to a phase-locked loop (PLL), with the main difference being the absence of an internal voltage-controlled oscillator, replaced by a delay line
DRC	Dynamic Range Compression	It reduces the volume of loud sounds or amplifies quiet sounds by narrowing or "compressing" an audio signal's dynamic range.
DVFS	Dynamic Voltage and Frequency Scaling	Dynamic voltage scaling is a power management technique where the voltage used in a component is increased or decreased, depending on circumstances. Dynamic frequency scaling is a technique whereby the frequency of a microprocessor can be automatically adjusted on the fly so that the power consumption or heat generated by the chip can be reduced. These two are often used together to save power in mobile devices.
E		
EHCI	Enhanced Host Controller Interface	The register-level interface for a Host Controller for the USB Revision 2.0.
eMMC	Embedded Multi-Media Card	An architecture consisting of an embedded storage solution with MMC interface, flash memory and controller, all in a small BGA package.
F		
FBGA	Fine Ball Grid Array	FBGA is based on BGA technology, but comes with thinner contacts and is mainly used in SoC design
G		

GIC	Generic Interrupt Controller	A centralized resource for supporting and managing interrupts in a system that includes at least one processor
H		
HDMI	High-Definition Multimedia Interface	A compact audio/video interface for transmitting uncompressed digital data
I		
I2S	Inter-IC Sound	An electrical serial bus interface standard used for connecting digital audio devices together
L		
LSB	Least Significant Bit	The bit position in a binary integer giving the units value, that is, determining whether the number is even or odd. It is sometimes referred to as the right-most bit, due to the convention in positional notation of writing less significant digits further to the right.
LRADC	Analog to Digital Converter	Used for KEY Application
M		
MAC	Media Access Control	A sublayer of the data link layer, which provides addressing and channel access control mechanisms that make it possible for several terminals or network nodes to communicate within a multiple access network that incorporates a shared medium, e.g. Ethernet.
MII	Media Independent Interface	An interface originally designed to connect a fast Ethernet MAC-block to a PHY chip, which now has been extended to support reduced signals and increased speeds.
MIPI	Mobile Industry Processor Interface	MIPI alliance is an open membership organization that includes leading companies in the mobile industry that share the objective of defining and promoting open specifications for interfaces inside mobile terminals.
MIPI DSI	MIPI Display Serial Interface	A specification by the Mobile Industry Processor Interface (MIPI) Alliance aimed at reducing the cost of display sub-systems in a mobile device

MSB	Most Significant Bit	The bit position in a binary number having the greatest value, which is sometimes referred to as the left-most bit due to the convention in positional notation of writing more significant digits further to the left
N		
NTSC	National Television System Committee	An analog television system that is used in most of North America, and many other countries
O		
OHCI	Open Host Controller Interface	A register-level interface that enables a host controller for USB to communicate with a host controller driver in software
P		
PCM	Pulse Code Modulation	A method used to digitally represent sampled analog signals
S		
SPI	Synchronous Peripheral Interface	A synchronous serial data link standard that operates in full duplex mode. Devices communicate in master/slave mode where the master device initiates the data frame.
U		
USB DRD	Universal Serial Bus Dual Role Device	A Dual Role Device controller, which supports both USB Host and USB Device functions .

Chapter 2 Overview

The Allwinner's A83T is a remarkably lower power, high performance octa-core mobile application processor based on ARM Cortex™-A7 CPU along with SGX544MP1 GPU architecture. It is also highly competitive in term of system cost thanks to its high system integration and is capable of delivering excellent user experience while maintaining low power consumption.

Main feature of A83T include:

- **CPU architecture:** Based on an octa-core Cortex™-A7 CPU architecture, the most power efficient CPU core ARM's ever developed.
- **Graphics:** A83T adopts the extensively implemented and technically mature PowerVR SGX544MP1 to provide mobile users with superior experience in web browsing, video playback and games; OpenGL ES1.1/2.0, OpenCL1.1 and DirectX 9.3 standards are supported.
- **Video:** Multi-format playback of up to 1080P high-definition video, and support MPEG1/2, MPEG4 SP/ASP GMC, H.263 including Sorenson Spark, H.264 BP/MP/HP, VP8, WMV9/VC1, JPEG/MJPEG standards with dedicated hardware, and HEVC/H.265 decoder 1080p@30fps with software.
- **Display:** Support RGB/LVDS/DSI/HDMI/CVBS interface to 1920x1200 resolution. Four-lane MIPI DSI is integrated as well.
- **Memory:** Support LPDDR2/LPDDR3/DDR3/DDR3L SDRAM, NAND Flash, SD/eMMC, Nor Flash.
- **HawKView™ ISP:** Support camera up to 8MPixels@30fps, better spatial de-noise and chrominance de-noise, Zone-based AE/AF/AWB statistics, Programmable color correction, Anti-flick detection statistics.

To reduce total system cost and enhance overall functionality, in addition to these major elements, A83T has a broad range of hardware peripherals such as MIPI CSI, LCD controller, Power management, DMA, Timers, High Speed Timer, Security System, GPIO, Digital Audio, UART, SPI, CIR, USB2.0, TWI etc.

A83T application usage is extremely diverse on tablets: users listen to music, watch movies, browse the web, share photos, play games, send emails, and more. When combined with Allwinner PMIC chip that supports CoolFlex technology, A83T enables devices to run different applications more efficiently on different CPU cores, which build a range of low-power devices and a better user experience.

2.1. Processor Features

2.1.1. CPU Architecture

The A83T platform is based on octa-core Cortex™-A7 CPU architecture.

- ARMv7 ISA standard instruction set plus Thumb-2 and Jazeller RCT
- NEON with SIMD and VFPv4 support
- Support LPAAE
- 32KB I-cache and 32KB D-cache per CPU
- 1MB L2-cache(512KB per Cluster)

2.1.2. GPU Architecture

- PowerVR SGX544MP1
- Support OpenGL ES 1.1/2.0
- Support OpenCL 1.1
- Support DirectX 9.3 standards
- Support RenderScript

2.1.3. Memory Subsystem

2.1.3.1. Boot ROM

- On-chip ROM boot loader
- Support secure and non-secure boot
- secure boot ROM : 64KB, non-secure boot ROM : 32KB
- Support system boot from NAND Flash, SD/TF card, eMMC, SPI NOR Flash.
- Support system code download through USB DRD(Dual Role Device)

2.1.3.2. SDRAM

- Compatible with the JEDEC standard LPDDR2/LPDDR3/DDR3/DDR3L SDRAM
- Up to 2GB address space

- 32-bit bus width
- Clock frequency up to 800MHz(DDR3)/667MHz(LPDDR3)/533MHz(LPDDR2)
- Support Memory Dynamic Frequency Scale
- 16 address signal lines and 3 bank signal lines
- Automatically generates initialization and refresh sequences
- Runtime-configurable parameters setting for application flexibility
- Random read or write operation is supported

2.1.3.3. NAND Flash

- 8-bit data BUS width
- Up to 64-bits ECC per 1024 bytes
- Up to 4 flash chips
- Support 1024, 2048, 4096, 8192, 16K bytes size per page
- Support SDR, ONFI DDR and Toggle DDR NAND

2.1.3.4. SD/MMC

- Up to three SD/MMC controllers
- Compatible with eMMC standard specification V4.41, SD physical layer specification V2.0, SDIO card specification V2.0
- 1-bit ,4-bit or 8-bit data bus transfer mode
- Up to 50MHz in both SDR and DDR modes
- Support SDIO suspend and resume operation
- Support hardware CRC generation and error detection
- Support SDIO interrupt detection
- Support block size of 1 to 65535 bytes

2.1.4. System Peripheral

2.1.4.1. Timer

- Up to two timers
- Two 33-bit AVS(audio and video synchronize) counters
- One watchdog to generate reset signal or interrupts

2.1.4.2. High Speed Timer

- Counters up to 56 bits
- Clock source is synchronized with AHB clock, much more accurate than other timers

2.1.4.3. OSC24M

- Support 1.8v oscillator
- Support internal RC oscillator

2.1.4.4. GIC

- 16 SGIs(Software Generated Interrupt)
- 16 PPIs(Private Peripheral Interrupt)
- 125 SPIs(Shared Peripheral Interrupts)

2.1.4.5. DMA

- 8-channel DMA
- Support data width of 8/16/32 bits
- Support linear and IO address modes
- Support data transfer types with memory-to-memory,memory-to-peripheral,peripheral-to-memory

2.1.4.6. CCU

- 11 PLLs
- Support a 24MHz oscillator and an on-chip RC oscillator
- Support clock configuration for corresponding modules
- Support software-controlled clock gating and software-controlled reset for corresponding modules

2.1.4.7. PWM

- Support outputting two kinds of waveform:continuous waveform and pulse waveform
- 0% to 100% adjustable duty cycle
- Up to 24MHz output frequency

2.1.4.8. Security System

- Support symmetrical algorithm: AES,DES,TDES
- Support hash algorithm: MD5,SHA1,SHA224,SHA256
- Support asymmetrical algorithm: RSA 512/1024/2048/3072-bits
- Support 160-bit hardware PRNG with 175-bit seed
- Support 256bits TRNG
- Support ECB,CBC,CTR,CTS modes for AES
- 128-bit, 192-bit and 256-bit key size for AES
- Support ECB,CBC,CTR modes for DES/TDES
- Support 2Kbit EFUSE for chip ID and security application

2.1.4.9. TrustZone

- Support TrustZone technology
- Support 96KB secure SRAM

2.1.4.10. CPU Configuration

- Support power clamp
- Support flexible CPU configuration

2.1.4.11. Power Management

- Support DVFS for CPU frequency and voltage adjustment
- Support flexible clock gate and module reset
- Support dynamic frequency adjustment for external DRAM
- Support multiple power domains

2.1.5. Display Subsystem

2.1.5.1. Display Engine2.0

- Support input layer size up to 2048x2048, and output size up to 2048x2048.
- Support four alpha blending channel for main display,two channel for aux display.
- Support four overlay layer in each channel, and has a independent scaler.
- Support potter-duff compatible blending operation.

- Support input format YUV422/YUV420/YUV411/ARGB8888/XRGB8888/RGB888/ARGB4444/ARGB1555 and RGB565
- Support Frame Packing/Top-and-Bottom/Side-by-Side Full/Side-by-Side Half 3D format data
- Support display enhancement 2.0 for excellent display experience
 - Adaptive edge sharpening
 - Adaptive color enhancement
 - Adaptive contrast enhancement and fresh tone rectify
- Support write back & rotation for high efficient dual display and miracast

2.1.5.2. Video Output

- Support two independent display channels
- Support RGB up to 1920x1200@60Hz resolution
- Support RGB666/656 dither function
- Support LVDS up to 1366x768@60Hz resolution
- Support 4-lane MIPI DSI (V1.0) up to 1920x1200@60Hz resolution
- Support HDMI V1.4 output with HDCP1.2

2.1.6. Video Engine

2.1.6.1. Video Decoding

- Support video playback up to 1080p@60fps
- Support multi-format video playback, including MPEG1/2, MPEG4 SP/ASP GMC, H.263 including Sorenson Spark, H.264 BP/ MP/HP ,VP8, WMV9/VC-1, JPEG/MJPEG, etc
- HEVC/H.265 decoder(software),Main Profile,1080p@30fps

2.1.6.2. Video Encoding

- Support H.264 video encoding up to 1080p@60fps, 720p@120fps
- JPEG baseline: picture size up to 8192x8192
- Support input picture size up to 4800x4800
- Support input format: tiled (128x32)/YU12/YV12/NU12/NV12/ARGB/YUYV
- Support Alpha blending
- Support thumb generation
- Support 4x2 scaling ratio: from 1/16 to 64 arbitrary non-integer ratio
- Support rotated input

2.1.7. Image Subsystem

2.1.7.1. CSI

- Up to 5M pixel camera sensor
- Video shot up to 720p@30fps
- Support 10-bit parallel camera sensor
- Support CCIR656 protocol for NTSC and PAL

2.1.7.2. MIPI CSI

- 4-lane MIPI CSI ,Compliant with MIPI-CSI2 V1.00 and MIPI DPHY V1.00.00
- Up to 1Gbps per Lane in HS Transmission
- Support video shot up to 1080p@60fps
- Maximum to 8M@30fps with 4 data lane
- Supports format: YUV422-8bit/10bit,YUV420-8bit/10bit,RAW-8,RAW-10,RAW-12,RGB888,RGB565

2.1.7.3. ISP

- Support input formats: 8/10-bit RAW RGB, 8-bit YCbCr
- Support output formats: YCbCr420 semi-planar,YCrCb420 semi-planar, YCbCr422 semi-planar,YCrCb422 semi-planar,YUV420 planar, YUV422 planar
- Support image mirror flip and rotation
- Support two output channels
- Support speed up to 8MPixels@30fps
- Defect pixel correction
- Super lens shading correction
- Anisotropic non-linear Bayer interpolation with false color suppression
- Programmable color correction
- Advanced contrast enhance and sharpening
- Advanced saturation adjust
- Advanced spatial (2D) de-noise filter
- Advanced chrominance noise reduction
- DRC(dynamic range compression)
- Zone-based AE/AF/AWB statistics
- Anti-flick detection statistics
- Histogram statistics

2.1.8. External Peripherals

2.1.8.1. USB

- USB 2.0 DRD
 - Complies with USB2.0 Specification
 - Support High-Speed(HS,480Mbps),Full-Speed(FS,12Mbps),and Low-Speed(LS,1.5Mbps) in host mode
 - Up to 10 User-Configurable Endpoints
 - Support point-to-point and point-to-multipoint transfer in both Host and Peripheral mode
- Two EHCI/OHCI compliant Host SIE multiplexed with one USB 2.0 analog PHY, one HSIC PHY
 - Support High-Speed(HS,480Mbps),Full-Speed(FS,12Mbps),and Low-Speed(LS,1.5Mbps) Device
 - An internal DMA Controller for data transfer with memory

2.1.8.2. EMAC

- Support 10/100/1000Mbps data transfer rate
- Support MII/RGMII PHY interface
- Support full-duplex and half-duplex operation
- Programmable frame length
- Flexible address filtering modes
- Automatic CRC and pad generation controllable on a per-frame basis
- Options for Automatic Pad/CRC Stripping on receive frames
- Programmable frame length to support Standard or Jumbo Ethernet frames with sizes up to 16 KB
- Programmable Inter Frame Gap (40-96 bit times in steps of 8)
- Supports a variety of flexible address filtering modes

2.1.8.3. ADC

- LRADC with 6-bit resolution
- Support hold key and continuous key
- Support single key, normal key and continuous key

2.1.8.4. Digital Audio

- I2S/PCM
 - I2S and PCM are configurable through software
 - Support I2S formats:normal,left-justified,right-justified
 - Audio data resolution:16bits, 20bits, 24bits
 - Audio sample rate up to 192KHz

- Master and slave work mode are configurable
- TDM(Time Division Multiplexing)
 - Master/Slave mode
 - Audio sample resolution from 8bits to 32bits
 - Sample rate from 8KHz to 192KHz
 - 4 data output pin
 - DMA-based or interrupt-based operation

2.1.8.5. CIR

- Support a flexible receiver for IR remote
- Programmable FIFO thresholds

2.1.8.6. UART

- Up to six UART controllers
- 64-Bytes Transmit and receive data FIFOs for all UART
- Compliant with industry-standard 16550 UARTs
- Support Infrared Data Association(IrDA) 1.0 SIR
- Interrupt support for FIFOs,Status Change

2.1.8.7. SPI

- Up to two SPI controllers
- Master/Slave configurable
- Polarity and phase of the chip select(SPI_SS) and SPI_Clock(SPI_CLK) are configurable
- Two 64-Bytes FIFO for SPI-TX and SPI-RX operation
- DMA-based or interrupt-based operation

2.1.8.8. TWI

- Up to four TWI(Two Wire Interface) controllers
- Support Standard mode(up to 100K bps) and Fast mode(up to 400K bps)
- Master/Slave configurable
- Allows 10-bit addressing transactions

2.1.8.9. RSB™ (Reduced Serial Bus)

- A simplified two wire protocol
- Support master mode

- Support multi-slaves
- Speed up to 20Mbps

2.1.9. Package

- FCBGA 345 balls, 0.65mm ball pitch, 14mm x 14mm

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2.2. System Block Diagram

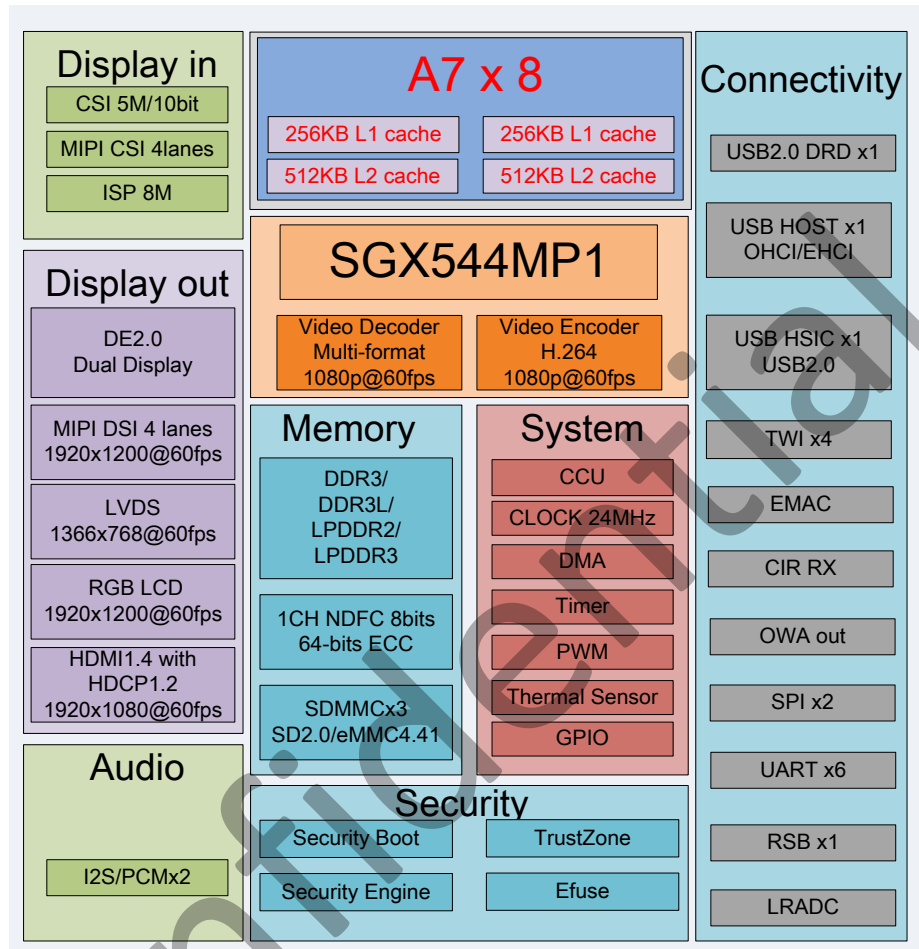


Figure 2-1. System Block Diagram

Chapter 3 System

The chapter describes the A83T system from following sections:

- [Memory Mapping](#)
- [Boot System](#)
- [CCU](#)
- [CPU Configuration](#)
- [TimeStamp](#)
- [System Control](#)
- [Timer](#)
- [Trusted Watchdog](#)
- [High-speed Timer](#)
- [PWM](#)
- [DMA](#)
- [GIC](#)
- [Message Box](#)
- [Spinlock](#)
- [Security System](#)
- [Security ID](#)
- [Secure Memory Controller](#)
- [Secure Memory Touch Arbiter](#)
- [Thermal Sensor Controller](#)
- [LRADC](#)
- [R_timer](#)
- [R_watchdog](#)
- [R_PRCM](#)
- [Port Controller](#)

3.1. Memory Mapping

Module	Address (It is for Cluster CPU)	Size (byte)
SRAM A1	0x0000 0000---0x0000 7FFF	32K
SRAM A2	0x0004 4000---0x0005 3FFF	64K
SRAM B(Secure)	0x0002 0000---0x0003 7FFF	96K
DE	0x0100 0000---0x013F FFFF	4M
CS Debug	0x0140 0000---0x0141 FFFF	128K
TSGEN RO	0x0150 6000---0x0150 6FFF	4K
TSGEN CTRL	0x0160 7000---0x0160 7FFF	4K
CPU_CFG	0x0170 0000---0x0170 03FF	1K
TIMESTAMP_STA	0x0171 0000---0x0171 0FFF	4K
TIMESTAMP_CTRL	0x0172 0000---0x0172 0FFF	4K
Cluster 0 MBIST	0x0150 2000---0x0150 2FFF	4K
Cluster 1 MBIST	0x0160 2000---0x0160 2FFF	4K
CCI-400	0x0179 0000---0x0179 FFFF	64K
SYS_CTRL	0x01C0 0000---0x01C0 0FFF	4K
DMA	0x01C0 2000---0x01C0 2FFF	4K
NDFC	0x01C0 3000---0x01C0 3FFF	4K
Key Memory Space	0x01C0 B000---0x01C0 BFFF	4K
LCD0	0x01C0 C000---0x01C0 CFFF	4K
LCD1	0x01C0 D000---0x01C0 DFFF	4K
VE	0x01C0 E000---0x01C0 EFFF	4K
SD/MMC 0	0x01C0 F000---0x01C0 FFFF	4K
SD/MMC 1	0x01C1 0000---0x01C1 0FFF	4K
SD/MMC 2	0x01C1 1000---0x01C1 1FFF	4K
SID	0x01C1 4000---0x01C1 43FF	1K
SS	0x01C1 5000---0x01C1 5FFF	4K
MSG_BOX	0x01C1 7000---0x01C1 7FFF	4K
SPINLOCK	0x01C1 8000---0x01C1 8FFF	4K
USB-DRD	0x01C1 9000---0x01C1 9FFF	4K
USB-EHCI0/OHCI0	0x01C1 A000---0x01C1 AFFF	4K
USB-EHCI1	0x01C1 B000---0x01C1 BFFF	4K
SMC	0x01C1 E000---0x01C1 EFFF	4K
CCU	0x01C2 0000---0x01C2 03FF	1K
PIO	0x01C2 0800---0x01C2 0BFF	1K
TIMER	0x01C2 0C00---0x01C2 0FFF	1K
OWA	0x01C2 1000---0x01C2 13FF	1K
PWM	0x01C2 1400---0x01C2 17FF	1K
DAUDIO-0	0x01C2 2000---0x01C2 23FF	1K
DAUDIO-1	0x01C2 2400---0x01C2 27FF	1K
DAUDIO-2	0x01C2 2800---0x01C2 2BFF	1K

TDM	0x01C2 3000---0x01C2 33FF	1K
SMTA	0x01C2 3400---0x01C2 37FF	1K
DSI	0x01C2 6000---0x01C2 6FFF	4K
UART 0	0x01C2 8000---0x01C2 83FF	1K
UART 1	0x01C2 8400---0x01C2 87FF	1K
UART 2	0x01C2 8800---0x01C2 8BFF	1K
UART 3	0x01C2 8C00---0x01C2 8FFF	1K
UART 4	0x01C2 9000---0x01C2 93FF	1K
TWI 0	0x01C2 AC00---0x01C2 AFFF	1K
TWI 1	0x01C2 B000---0x01C2 B3FF	1K
TWI 2	0x01C2 B400---0x01C2 B7FF	1K
EMAC	0x01C3 0000---0x01C3 FFFF	64K
GPU	0x01C4 0000---0x01C4 FFFF	64K
HSTMR	0x01C6 0000---0x01C6 0FFF	4K
DRAMCOM	0x01C6 2000---0x01C6 2FFF	4K
DRAMCTL0	0x01C6 3000---0x01C6 3FFF	4K
DRAMPHY0	0x01C6 5000---0x01C6 5FFF	4K
SPI0	0x01C6 8000---0x01C6 8FFF	4K
SPI1	0x01C6 9000---0x01C6 9FFF	4K
GIC	0x01C8 0000	
CSI	0x01CB 0000---0x01CE FFFF	256K
VE Memory Space	0x01D0 0000	
HDMI	0x01EE 0000---0x01EF FFFF	128K
R_TIMER	0x01F0 0800---0x01F0 0BFF	1K
R_INTC	0x01F0 0C00---0x01F0 0FFF	1K
R_WDOG	0x01F0 1000---0x01F0 13FF	1K
R_PRCM	0x01F0 1400---0x01F0 17FF	1K
R_TWD	0x01F0 1800---0x01F0 1BFF	1K
R_CPUS_CFG	0x01F0 1C00---0x01F0 1FFF	1K
R_CIR-RX	0x01F0 2000---0x01F0 23FF	1K
R_TWI	0x01F0 2400---0x01F0 27FF	1K
R_UART	0x01F0 2800---0x01F0 2BFF	1K
R_PIO	0x01F0 2C00---0x01F0 2FFF	1K
R_RSB	0x01F0 3400---0x01F0 37FF	1K
R_PWM	0x01F0 3800---0x01F0 3BFF	1K
R_LRADC	0x01F0 3C00---0x01F0 3FFF	1K
R_TH	0x01F0 4000---0x01F0 43FF	1K
DDR Space	0x4000 0000---0xBFFF FFFF	2G
S-BROM	0xFFFF 0000---0xFFFF FFFF	64K
NS-BROM	0xFFFF 0000---0xFFFF 7FFF	32K

3.2. Boot System

The Boot System includes the following features:

- The system will boot in different ways based on whether its security features are enabled
- Support CPU-0 boot process and CPU-0+ boot process
- Support CPU hot plug process
- Support super standby wakeup process
- Support mandatory upgrade process through SDC0 and USB DRD
- Support fast boot process from Raw NAND,eMMC,SD/TF card ,and SPI NOR Flash

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3.3. CCU

3.3.1. Overview

The CCU controls the PLLs configuration and most of the clock generation, division, distribution, synchronization and gating. CCU input signals include the external clock for the reference frequency (24MHz). The outputs from CCU are mostly clocks to other blocks in the system.

The CCU includes the following features:

- 11 PLLs, independent PLL for CPUX
- Bus Source and Divisions
- PLLs Bias Control
- PLLs Tuning Control
- PLLs Pattern Control
- Configuring Modules Clock
- Bus Clock Gating
- Bus Software Reset

3.3.2. Functionalities Description

3.3.2.1. System Bus

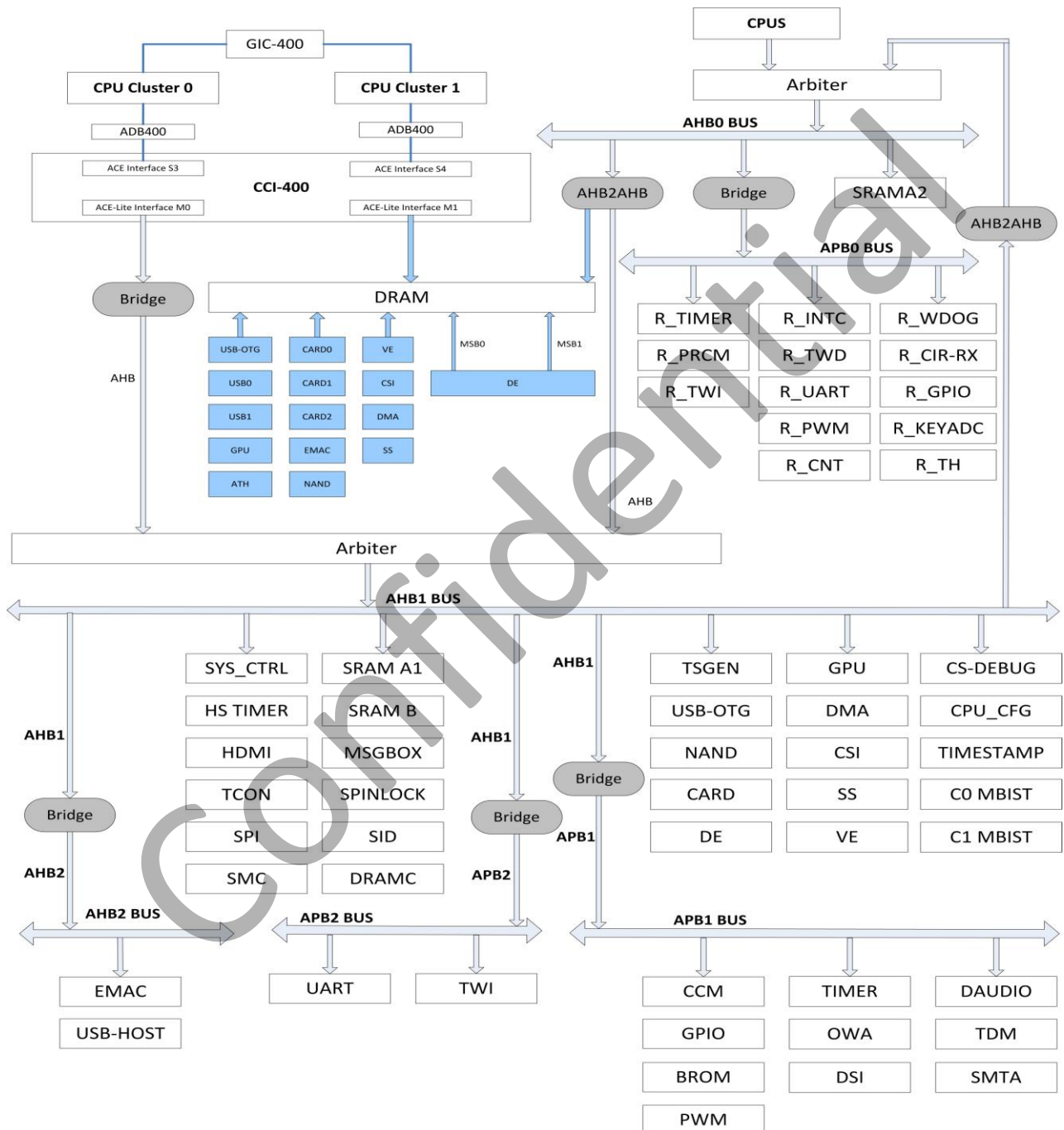


Figure 3-1. System Bus Tree

3.3.2.2. Bus clock tree

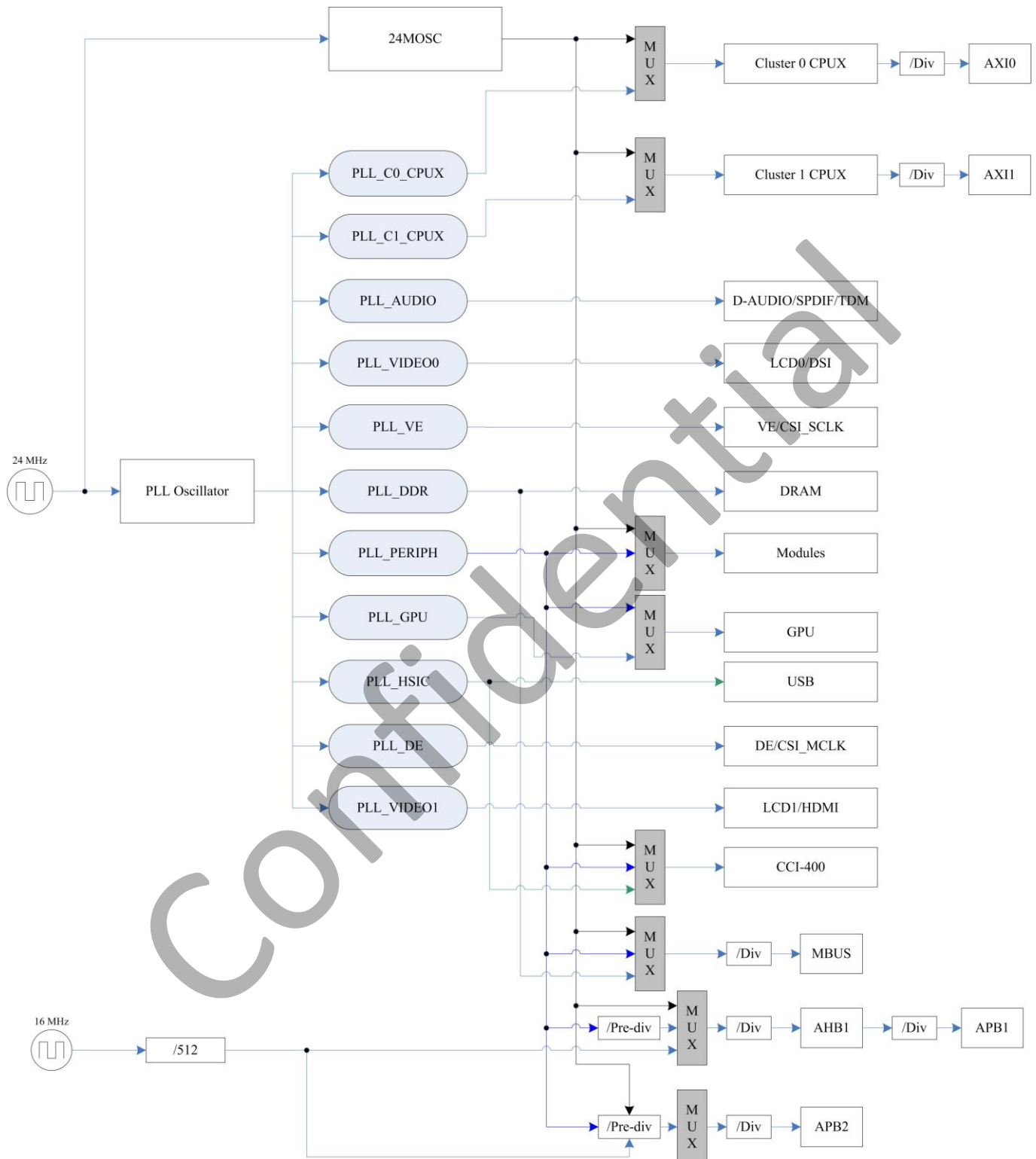


Figure 3-2. Bus Clock Tree

3.3.3. Typical Applications

Clock output of **PLL_COCPUX** is used only for Cluster 0 CPUX, and the frequency factor can be dynamically modified for DVFS;

Clock output of **PLL_C1CPUX** is used only for Cluster 1 CPUX, and the frequency factor can be dynamically modified for DVFS;

Clock output of **PLL_AUDIO** can be used for DAUDIO, TDM, OWA etc, and dynamic frequency scaling is not supported;

Clock output of **PLL_PERIPH** can be used for MBUS/AHB1/AHB2/APB1/APB2/CCI-400 and NAND/GPU_Memory/MMC/SS/SPI/CSI,etc, and dynamic frequency scaling is not supported;

Clock output of **PLL_VE** can be used for CSI and VE , and dynamic frequency scaling is not supported;

Clock output of **PLL_DDR** can be used for MBUS and DRAM, and dynamic frequency scaling is supported;

Clock output of **PLL_VIDEO0** can be used for TCON0 and MIPI_DSI, and dynamic frequency scaling is not supported;

Clock output of **PLL_VIDEO1** can be used for TCON1 and HDMI, and dynamic frequency scaling is not supported;

Clock output of **PLL_DE** can be used for CSI, and dynamic frequency scaling is not supported;

Clock output of **PLL_HSIC** can be used for CCI-400 and USBPHY, and dynamic frequency scaling is not supported;

Clock output of **PLL_GPU** can be used for GPU_Core/GPU_Memory, and dynamic frequency scaling is not supported;

3.3.4. Register List

Module Name	Base Address
CCU	0x01C20000

Register Name	Offset	Description
PLL_COCPUX_CTRL_REG	0x0000	PLL_COCPUX Control Register
PLL_C1CPUX_CTRL_REG	0x0004	PLL_C1CPUX Control Register
PLL_AUDIO_CTRL_REG	0x0008	PLL_AUDIO Control Register
PLL_VIDEO0_CTRL_REG	0x0010	PLL_VIDEO0 Control Register
PLL_VE_CTRL_REG	0x0018	PLL_VE Control Register
PLL_DDR_CTRL_REG	0x0020	PLL_DDR Control Register
PLL_PERIPH_CTRL_REG	0x0028	PLL_PERIPH Control Register
PLL_GPU_CTRL_REG	0x0038	PLL_GPU Control Register
PLL_HSIC_CTRL_REG	0x0044	PLL_HSIC Control Register
PLL_DE_CTRL_REG	0x0048	PLL_DE Control Register
PLL_VIDEO1_CTRL_REG	0x004C	PLL_VIDEO1 Control Register
CPUX_AXI_CFG_REG	0x0050	CPUX/AXI Configuration Register
AHB1_APB1_CFG_REG	0x0054	AHB1/APB1 Configuration Register
APB2_CFG_REG	0x0058	APB2 Configuration Register
AHB2_CFG_REG	0x005C	AHB2 Configuration Register
BUS_CLK_GATING_REG0	0x0060	Bus Clock Gating Register 0
BUS_CLK_GATING_REG1	0x0064	Bus Clock Gating Register 1

BUS_CLK_GATING_REG2	0x0068	Bus Clock Gating Register 2
BUS_CLK_GATING_REG3	0x006C	Bus Clock Gating Register 3
CCI400_CFG_REG	0x0078	CCI-400 Configuration Register
NAND_CLK_REG	0x0080	NAND Clock Register
SDMMC0_CLK_REG	0x0088	SDMMC0 Clock Register
SDMMC1_CLK_REG	0x008C	SDMMC1 Clock Register
SDMMC2_CLK_REG	0x0090	SDMMC2 Clock Register
SS_CLK_REG	0x009C	SS Clock Register
SPI0_CLK_REG	0x00A0	SPI0 Clock Register
SPI1_CLK_REG	0x00A4	SPI1 Clock Register
DAUDIO0_CLK_REG	0x00B0	DAUDIO0 Clock Register
DAUDIO1_CLK_REG	0x00B4	DAUDIO1 Clock Register
DAUDIO2_CLK_REG	0x00B8	DAUDIO2 Clock Register
TDM_CLK_REG	0x00BC	TDM Clock Register
OWA_CLK_REG	0x00C0	OWA Clock Register
USBPHY_CFG_REG	0x00CC	USBPHY Configuration Register
DRAM_CFG_REG	0x00F4	DRAM Configuration Register
PLL_DDR_CFG_REG	0x00F8	PLL_DDR Configuration Register
MBUS_RST_REG	0x00FC	MBUS Reset Register
DRAM_CLK_GATING_REG	0x0100	DRAM Clock Gating Register
TCON0_CLK_REG	0x0118	TCON0 Clock Register
TCON1_CLK_REG	0x011C	TCON1 Clock Register
MIPI_CSI_CLK_REG	0x0130	MIPI_CSI Clock Register
CSI_CLK_REG	0x0134	CSI Clock Register
VE_CLK_REG	0x013C	VE Clock Register
AVS_CLK_REG	0x0144	AVS Clock Register
HDMI_CLK_REG	0x0150	HDMI Clock Register
HDMI_SLOW_CLK_REG	0x0154	HDMI Slow Clock Register
MBUS_CLK_REG	0x015C	MBUS Clock Register
MIPI_DSI_CLK_REG	0x0168	MIPI_DSI Clock Register
GPU_CORE_CLK_REG	0x01A0	GPU Core Clock Register
GPU_MEM_CLK_REG	0x01A4	GPU Memory Clock Register
GPU_HYD_CLK_REG	0x01A8	GPU HYD Clock Register
PLL_STABLE_TIME_REG0	0x0200	PLL Stable Time Register 0
PLL_STABLE_TIME_REG1	0x0204	PLL Stable Time Register 1
PLL_STB_STATUS_REG	0x020C	PLL Stable Status Register
PLL_COCPUX_BIAS_REG	0x0220	PLL_COCPUX Bias Register
PLL_AUDIO_BIAS_REG	0x0224	PLL_AUDIO Bias Register
PLL_VIDEO0_BIAS_REG	0x0228	PLL_VIDEO0 Bias Register
PLL_VE_BIAS_REG	0x022C	PLL_VE Bias Register
PLL_DDR_BIAS_REG	0x0230	PLL_DDR Bias Register
PLL_PERIPH_BIAS_REG	0x0234	PLL_PERIPH Bias Register
PLL_COCPUX_BIAS_REG	0x0238	PLL_C1CPUX Bias Register
PLL_GPU_BIAS_REG	0x023C	PLL_GPU Bias Register

PLL_HSIC_BIAS_REG	0x0244	PLL_HSIC Bias Register
PLL_DE_BIAS_REG	0x0248	PLL_DE Bias Register
PLL_VIDEO1_BIAS_REG	0x024C	PLL_VIDEO1 Bias Register
PLL_COCPUX_TUN_REG	0x0250	PLL_COCPUX Tuning Register
PLL_C1CPUX_TUN_REG	0x0254	PLL_C1CPUX Tuning Register
PLL_AUDIO_PAT_CTRL_REG0	0x0284	PLL_AUDIO Pattern Control Register 0
PLL_VIDEO0_PAT_CTRL_REG0	0x0288	PLL_VIDEO0 Pattern Control Register 0
PLL_DDR_PAT_CTRL_REG0	0x0290	PLL_DDR Pattern Control Register 0
PLL_AUDIO_PAT_CTRL_REG1	0x02A4	PLL_AUDIO Pattern Control Register 1
PLL_VIDEO0_PAT_CTRL_REG1	0x02A8	PLL_VIDEO0 Pattern Control Register 1
PLL_DDR_PAT_CTRL_REG1	0x02B0	PLL_DDR Pattern Control Register 1
BUS_SOFT_RST_REG0	0x02C0	Bus Software Reset Register 0
BUS_SOFT_RST_REG1	0x02C4	Bus Software Reset Register 1
BUS_SOFT_RST_REG2	0x02C8	Bus Software Reset Register 2
BUS_SOFT_RST_REG3	0x02D0	Bus Software Reset Register 3
BUS_SOFT_RST_REG4	0x02D8	Bus Software Reset Register 4

3.3.5. Register Description

3.3.5.1. PLL_COCPUX Control Register (Default Value: 0x02001100)

Offset: 0x0000			Register Name: PLL_COCPUX_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE 0: Disable 1: Enable. The PLL Output= 24MHz*N/P. The PLL output is for the Cluster 0 CPU0/1/2/3 Clock. Note: the PLL output clock must be in the range of 200MHz~3GHz. Its default is 408MHz.
30:27	/	/	/
26:24	R/W	0x2	PLL_LOCK_TIME PLL Lock Time.
23:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19:17	/	/	/
16	R/W	0x0	PLL_OUT_EXT_DIVP

			PLL Output External Divider P. 0: /1 1: /4. Note:The P factor only use in the condition that PLL output less than 288 MHz.
15:8	R/W	0x11	PLL_FACTOR_N PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12)
7:2	/	/	/
1:0	R/W	0x0	PLL_POSTDIV_M Post Divider Factor M. The range is from 0 to 3. This factor is only for test.

3.3.5.2. PLL_C1CPUX Control Register (Default Value: 0x02001100)

Offset: 0x0004			Register Name: PLL_C1CPUX_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE 0: Disable. 1: Enable. The PLL Output= 24MHz*N/P. The PLL output is for the Cluster 1 CPU0/1/2/3 Clock. Note: the PLL output clock must be in the range of 200MHz~3GHz. Its default is 408MHz.
30:27	/	/	/
26:24	R/W	0x2	PLL_LOCK_TIME PLL Lock Time.
23:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19:17	/	/	/
16	R/W	0x0	PLL_OUT_EXT_DIVP PLL Output External Divider P. 0: /1 1: /4. Note:The P factor only use in the condition that PLL output less than 288 MHz.
15:8	R/W	0x11	PLL_FACTOR_N. PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12)
7:2	/	/	/

1:0	R/W	0x0	PLL_POSTDIV_M Post Divider Factor M. The range is from 0 to 3. This factor is only for test.
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3.3.5.3. PLL_Audio Control Register (Default Value: 0x00042B14)

Offset: 0x0008			Register Name: PLL_AUDIO_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE 0: Disable. 1: Enable. This PLL is for Audio. The PLL Output = $24\text{MHz} * N / (\text{Div1} + 1) / (\text{Div2} + 1) / (P + 1)$. Its default is 24.5714 MHz.
30:25	/	/	/
24	R/W	0x0	PLL_SDM_EN 0: Disable. 1: Enable.
23:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19	/	/	/
18	R/W	0x1	PLL_DIV2 PLL Div2 Factor = 0 or 1 (Output Div).
17	/	/	/
16	R/W	0x0	PLL_DIV1 PLL Div1 Factor = 0 or 1 (Input Div).
15:8	R/W	0x2B	PLL_FACTOR_N PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12)
7:6	/	/	/
5:0	R/W	0x14	PLL_POSTDIV_P Post Divider Factor P. The range is from 0 to 63

3.3.5.4. PLL_VIDEO0 Control Register (Default Value: 0x00016300)

Offset: 0x0010			Register Name: PLL_VIDEO0_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE.

			0: Disable 1: Enable. This PLL is for the Video . The PLL Output = $24\text{MHz} * N / (\text{Div} + 1) / P$. Its default is 1188 MHz.
30:25	/	/	/
24	R/W	0x0	PLL_SDM_EN. 0: Disable 1: Enable.
23:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19	/	/	/
18	R/W	0x0	PLL_DIV2. PLL Div2 Factor = 0 or 1 (Output Div).This factor is only for test.
17	/	/	/
16	R/W	0x1	PLL_DIV. PLL Div Factor = 0 or 1 (Input Div).
15:8	R/W	0x63	PLL_FACTOR_N. PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12).
7:2	/	/	/
1:0	R/W	0x0	PLL_OUT_EXT_DIVP. PLL Output External Divider P. 00: /1 01: /2 10: /4 11: /8.

3.3.5.5. PLL_VE Control Register (Default Value: 0x00042400)

Offset: 0x0018			Register Name: PLL_VE_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE. 0: Disable 1: Enable. This PLL is for the VE. The PLL Output = $24\text{MHz} * N / (\text{Div}1 + 1) / (\text{Div}2 + 1)$. Its default is 432 MHz.
30:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable

			1: Disable.
19	/	/	/
18	R/W	0x1	PLL_DIV2. PLL Div2 Factor = 0 or 1(Output Div).
17	/	/	/
16	R/W	0x0	PLL_DIV1. PLL Div1 Factor = 0 or 1.(Input Div).
15:8	R/W	0x24	PLL_FACTOR_N. PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12).
7:0	/	/	/

3.3.5.6. PLL_DDR Control Register (Default Value: 0x00042400)

Offset: 0x0020			Register Name: PLL_DDR_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE. 0: Disable 1: Enable. This PLL is for the DRAM. The PLL Output = $24\text{MHz} \times (N+1) / (\text{Div1}+1) / (\text{Div2}+1)$. Its default is 432 MHz.
30	R/W	0x0	SDRPLL_UPD. SDRPLL Configuration Update. Note: When PLL_DDR has changed, this bit should be set to 1 to validate the PLL, otherwise the change is invalid. It will be auto cleared after the PLL is valid. 0: No effect. 1: To validate the PLL_DDR.
29:23	/	/	/
24	R/W	0x0	PLL_SDM_EN. 0: Disable 1: Enable.
23:22	/	/	/
21	R/W	0x0	DDR_CLOCK_Select 0:PLL_DDR 1:PLL_PERIPH
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19	/	/	/
18	R/W	0x1	PLL_DIV2.

			PLL Div2 Factor = 0 or 1 (Output Div).
17	/	/	/
16	R/W	0x0	PLL_DIV1. PLL Div1 Factor = 0 or 1 (Input Div).
15:14	/	/	/
13:8	R/W	0x24	PLL_FACTOR_N. PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12).
7:0	/	/	/

3.3.5.7. PLL_PERIPH Control Register (Default Value: 0x00001900)

Offset: 0x0028			Register Name: PLL_PERIPH_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE. 0: Disable 1: Enable. This PLL is for the peripheral. The PLL Output = $24\text{MHz} * N / (\text{Div1} + 1) / (\text{Div2} + 1)$. Note: The PLL_PERIPH Output should be fixed to 600MHz, it is not recommended to vary this value arbitrarily. Its default value is 600 MHz.
30:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19	/	/	/
18	R/W	0x0	PLL_DIV2. PLL Div2 Factor = 0 or 1.(Output Div)
17	/	/	/
16	R/W	0x0	PLL_DIV1. PLL Div1 Factor = 0 or 1.(Input Div)
15:8	R/W	0x19	PLL_FACTOR_N. PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12).
7:0	/	/	/

3.3.5.8. PLL_GPU Control Register (Default Value: 0x00042400)

Offset: 0x0038			Register Name: PLL_GPU_CTRL_REG
Bit	R/W	Default/Hex	Description

31	R/W	0x0	PLL_ENABLE. 0: Disable 1: Enable. This PLL is for the GPU. The PLL Output = $24\text{MHz} \times N / (\text{Div1} + 1) / (\text{Div2} + 1)$. Its default is 432 MHz.
30:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19	/	/	/
18	R/W	0x1	PLL_DIV2. PLL Div2 Factor = 0 or 1(Output Div).
17	/	/	/
16	R/W	0x0	PLL_DIV1. PLL Div1 Factor = 0 or 1 (Input Div).
15:8	R/W	0x24	PLL_FACTOR_N. PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12)
7:0	/	/	/

3.3.5.9. PLL_HSIC Control Register (Default Value: 0x00042800)

Offset: 0x0044			Register Name: PLL_HSIC_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE. 0: Disable 1: Enable. This PLL is for the HSIC. The PLL Output = $24\text{MHz} \times N / (\text{Div1} + 1) / (\text{Div2} + 1)$. Its default is 480 MHz.
30:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19	/	/	/
18	R/W	0x1	PLL_DIV2. PLL Div2 Factor = 0 or 1(Output Div).
17	/	/	/
16	R/W	0x0	PLL_DIV1. PLL Div1 Factor = 0 or 1(Input Div).
15:8	R/W	0x28	PLL_FACTOR_N.

			PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12).
7:0	/	/	/

3.3.5.10. PLL_DE Control Register (Default Value: 0x00042400)

Offset: 0x0048			Register Name: PLL_DE_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE. 0: Disable 1: Enable. This PLL is for the DE. The PLL Output = $24\text{MHz} * N / (\text{Div1} + 1) / (\text{Div2} + 1)$. Its default is 432 MHz.
30:25	/	/	/
24	R/W	0x0	PLL_SDM_EN. 0: Disable 1: Enable.
23:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19	/	/	/
18	R/W	0x1	PLL_DIV2. PLL Div2 factor = 0 or 1(Output Div).
17	/	/	/
16	R/W	0x0	PLL_DIV1. PLL Div1 factor = 0 or 1(Input Div).
15:8	R/W	0x24	PLL_FACTOR_N. PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12)
7:0	/	/	/

3.3.5.11. PLL_VIDEO1 Control Register (Default Value: 0x00016300)

Offset: 0x004C			Register Name: PLL_VIDEO1_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	PLL_ENABLE. 0: Disable 1: Enable.

			This PLL is for the Video . The PLL Output = 24MHz*N/(Div+1)/P. Its default is 1188 MHz.
30:25	/	/	/
24	R/W	0x0	PLL_SDM_EN. 0: Disable 1: Enable.
23:21	/	/	/
20	R/W	0x0	CLOCK_OUTPUT 0: Enable 1: Disable.
19	/	/	/
18	R/W	0x0	PLL_DIV2. PLL Div2 Factor = 0 or 1 (Output Div).This factor is only for test.
17	/	/	/
16	R/W	0x1	PLL_DIV. PLL Div Factor = 0 or 1 (Input Div).
15:8	R/W	0x63	PLL_FACTOR_N. PLL Factor N. The range is from 0 to 255 (In application, Factor N should be no less than 12)
7:2	/	/	/
1:0	R/W	0x0	PLL_OUT_EXT_DIVP. PLL Output External Divider P. 00: /1 01: /2 10: /4 11: /8.

3.3.5.12. CPUX/AXI Configuration Register (Default Value: 0x00000000)

Offset: 0x0050			Register Name: CPUX_AXI_CFG_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28	R/W	0x0	C1_CPUX_CLK_SRC_SEL. 0: OSC24M 1: PLL_C1CPUX.
27:18	/	/	/
17:16	R/W	0x0	AXI1_CLK_DIV_RATIO. AXI1 Clock Divide Ratio. AXI1 Clock source is C1_CPUX clock. 00: /1 01: /2

			10: /3 11: /4.
15:13	/	/	/
12	R/W	0x0	CO_CPUX_CLK_SRC_SEL. 0: OSC24M 1: PLL_COCPUX.
11:2	/	/	/
1:0	R/W	0x0	AXIO_CLK_DIV_RATIO. AXIO Clock Divide Ratio. AXIO Clock source is CO_CPUX clock. 00: /1 01: /2 10: /3 11: /4.

3.3.5.13. AHB1/APB1 Configuration Register (Default Value: 0x00000000)

Offset: 0x0054			Register Name: AHB1_APB1_CFG_REG
Bit	R/W	Default/Hex	Description
31:14	/	/	/
13:12	R/W	0x1	AHB1_CLK_SRC_SEL. 00: Internal OSC / 512 01: OSC24M 1X: PLL_PERIPH/ AHB1_PRE_DIV.
11:10	/	/	/
9:8	R/W	0x0	APB1_CLK_RATIO. APB1 Clock Divide Ratio. APB1 clock source is AHB1 clock. 00: /1 01: /2 10: /3 11: /4.
7:6	R/W	0x0	AHB1_PRE_DIV AHB1 Clock Pre Divide Ratio 00: /1 01: /2 10: /3 11: /4.
5:4	R/W	0x1	AHB1_CLK_DIV_RATIO. AHB1 Clock Divide Ratio. 00: /1 01: /2 10: /4 11: /8.
3:0	/	/	/

3.3.5.14. APB2 Configuration Register (Default Value: 0x01000000)

Offset: 0x0058			Register Name: APB2_CFG_REG
Bit	R/W	Default/Hex	Description
31:26	/	/	/
25:24	R/W	0x1	APB2_CLK_SRC_SEL. APB2 Clock Source Select 00: Internal OSC / 512 01: OSC24M 1X: PLL_PERIPH. This clock is used for some special module apbclk(UART、TWI). Because these modules need special clock rate even if the apb1clk changed.
23:18	/	/	/
17:16	R/W	0x0	CLK_RAT_N Clock Pre Divide Ratio (n) The select clock source is pre-divided by 2^n. The divider is 1/2/4/8.
15:5	/	/	/
4:0	R/W	0x0	CLK_RAT_M. Clock Divide Ratio (m) The Pre Divide clock is divided by (m+1). The divider M is from 1 to 32.

3.3.5.15. AHB2 Configuration Register (Default Value: 0x00000000)

Offset: 0x005C			Register Name: AHB2_CFG_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1:0	R/W	0x0	AHB2_CLK_CFG. 00: AHB1 Clock 01: PLL_PERIPH / 2 1X: /. EMAC and USBHOST clock source is AHB2 Clock.

3.3.5.16. Bus Clock Gating Register0 (Default Value: 0x00000000)

Offset: 0x0060			Register Name: BUS_CLK_GATING_REG0
Bit	R/W	Default/Hex	Description
31:30	/	/	/
29	R/W	0x0	USB_OHCI0_GATING. 0: Mask 1: Pass.

28	/	/	/
27	R/W	0x0	USB_EHCI1_GATING. 0: Mask 1: Pass.
26	R/W	0x0	USB_EHCI0_GATING. 0: Mask 1: Pass.
25	/	/	/
24	R/W	0x0	USB_DRD_GATING. 0: Mask 1: Pass.
23:22	/	/	/
21	R/W	0x0	SPI1_GATING. 0: Mask 1: Pass.
20	R/W	0x0	SPI0_GATING. 0: Mask 1: Pass.
19	R/W	0x0	HSTIMER_GATING. 0: Mask 1: Pass.
18:15	/	/	/
17	R/W	0x0	EMAC_GATING. 0: Mask 1: Pass.
16:15	/	/	/
14	R/W	0x0	DRAM_GATING. 0: Mask 1: Pass.
13	R/W	0x0	NAND_GATING. 0: Mask 1: Pass.
12:11	/	/	/
10	R/W	0x0	MMC2_GATING. 0: Mask 1: Pass.
9	R/W	0x0	MMC1_GATING. 0: Mask 1: Pass.
8	R/W	0x0	MMC0_GATING. 0: Mask 1: Pass.
7	/	/	/
6	R/W	0x0	DMA_GATING. 0: Mask

			1: Pass.
5	R/W	0x0	SS_GATING. 0: Mask 1: Pass.
4:2	/	/	/
1	R/W	0x0	MIPIDSI_GATING. 0: Mask 1: Pass.
0	/	/	/

3.3.5.17. Bus Clock Gating Register1 (Default Value: 0x00000000)

Offset: 0x0064			Register Name: BUS_CLK_GATING_REG1
Bit	R/W	Default/Hex	Description
31:23	/	/	/
22	R/W	0x0	SPINLOCK_GATING. 0: Mask 1: Pass.
21	R/W	0x0	MSGBOX_GATING. 0: Mask 1: Pass.
20	R/W	0x0	GPU_GATING. 0: Mask 1: Pass.
19:13	/	/	/
12	R/W	0x0	DE_GATING. 0: Mask 1: Pass.
11	R/W	0x0	HDMI_GATING. 0: Mask 1: Pass.
10:9	/	/	/
8	R/W	0x0	CSI_GATING. 0: Mask 1: Pass.
7:6	/	/	/
5	R/W	0x0	TCON1_GATING. 0: Mask 1: Pass.
4	R/W	0x0	TCON0_GATING. 0: Mask 1: Pass.
3:1	/	/	/

0	R/W	0x0	VE_GATING. 0: Mask 1: Pass.
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3.3.5.18. Bus Clock Gating Register2 (Default Value: 0x00000000)

Offset: 0x0068			Register Name: BUS_CLK_GATING_REG2
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15	R/W	0x0	TDM_GATING. 0: Mask 1: Pass.
14	R/W	0x0	DAUDIO2_GATING. 0: Mask 1: Pass.
13	R/W	0x0	DAUDIO1_GATING. 0: Mask 1: Pass.
12	R/W	0x0	DAUDIO0_GATING. 0: Mask 1: Pass.
11:6	/	/	/
5	R/W	0x0	PIO_GATING. 0: Mask 1: Pass.
4:2	/	/	/
1	R/W	0x0	OWA_GATING. 0: Mask 1: Pass.
0	/	/	/

3.3.5.19. Bus Clock Gating Register3 (Default Value: 0x00000000)

Offset: 0x006C			Register Name: BUS_CLK_GATING_REG3
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20	R/W	0x0	UART4_GATING. 0: Mask 1: Pass.
19	R/W	0x0	UART3_GATING. 0: Mask 1: Pass.

18	R/W	0x0	UART2_GATING. 0: Mask 1: Pass.
17	R/W	0x0	UART1_GATING. 0: Mask 1: Pass.
16	R/W	0x0	UART0_GATING. 0: Mask 1: Pass.
15:3	/	/	/
2	R/W	0x0	TWI2_GATING. 0: Mask 1: Pass.
1	R/W	0x0	TWI1_GATING. 0: Mask 1: Pass.
0	R/W	0x0	TWI0_GATING. 0: Mask 1: Pass.

3.3.5.20. CCI-400 Configuration Register (Default Value: 0x00000000)

Offset: 0x0078			Register Name: CCI400_CLK_CFG_REG
Bit	R/W	Default/Hex	Description
31:26	/	/	/
25:24	R/W	0x0	CCI400_CLK_SRC_SEL. Clock Source Select 00: OSC24M 01: PLL_PERIPH 10: PLL_HSIC 11: /.
23:2	/	/	/
1:0	R/W	0x0	CCI400_CLK_DIV_RATIO. CCI-400 Clock Divide Ratio. 00: /1 01: /2 10: /3 11: /4. Note: When the clock source changed from OSC24M to PLL_PERIPH or PLL_HSIC, it must follow these procedure: 1. The CCI-400 clock divide ratio should be changed at first. 2. It must wait for at least 10 CCI-400 clock cycles before changing clock source.

3.3.5.21. NAND Clock Register (Default Value: 0x00000000)

Offset: 0x0080			Register Name: NAND_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK = Clock Source/Divider N/Divider M.
30:26	/	/	/
25:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 00: OSC24M 01: PLL_PERIPH 1X: /.
23:18	/	/	/
17:16	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (n) 00: /1 01: /2 10: /4 11: /8.
15:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.22. SDMMC0 Clock Register (Default Value: 0x00000000)

Offset: 0x0088			Register Name: SDMMC0_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK = Clock Source/Divider N/Divider M.
30:26	/	/	/
25:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 00: OSC24M 01: PLL_PERIPH 1X: /.
23	/	/	/

22:20	R/W	0x0	SAMPLE_CLK_PHASE_CTR. Sample Clock Phase Control. The sample clock phase delay is based on the number of source clock that is from 0 to 7.
19:18	/	/	/
17:16	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (n) 00: /1 01: /2 10: /4 11: /8.
15:11	/	/	/
10:8	R/W	0x0	OUTPUT_CLK_PHASE_CTR. Output Clock Phase Control. The output clock phase delay is based on the number of source clock that is from 0 to 7.
7:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.23. SDMMC1 Clock Register (Default Value: 0x00000000)

Offset: 0x008C			Register Name: SDMMC1_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK= Clock Source/Divider N/Divider M.
30:26	/	/	/
25:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 00: OSC24M 01: PLL_PERIPH 1X: /.
23	/	/	/
22:20	R/W	0x0	SAMPLE_CLK_PHASE_CTR. Sample Clock Phase Control. The sample clock phase delay is based on the number of source clock that is from 0 to 7.
19:18	/	/	/
17:16	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre-Divide Ratio (n)

			00: /1 01: /2 10: /4 11: /8.
15:11	/	/	/
10:8	R/W	0x0	OUTPUT_CLK_PHASE_CTR. Output Clock Phase Control. The output clock phase delay is based on the number of source clock that is from 0 to 7.
7:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.24. SDMMC2 Clock Register (Default Value: 0x00000000)

Offset: 0x0090			Register Name: SDMMC2_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. If SDMMC2 is in old mode, SCLK = Clock Source/Divider N/Divider M. If SDMMC2 is in new mode, SCLK= Clock Source/Divider N/Divider M/2.
30	R/W	0x0	MMC2_MODE_SELECT. 0: Old Mode 1: New Mode.
29:26	/	/	/
25:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 00: OSC24M 01: PLL_PERIPH 1X: /.
23	/	/	/
22:20	R/W	0x0	CLK_PHASE_CTR. Sample Clock Phase Control. The sample clock phase delay is based on the number of source clock that is from 0 to 7.
19:18	/	/	/
17:16	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (n) 00: /1 01: /2 10: /4

			11: /8.
15:11	/	/	/
10:8	R/W	0x0	OUTPUT_CLK_PHASE_CTR. Output Clock Phase Control. The output clock phase delay is based on the number of source clock that is from 0 to 7.
7:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.25. SS Clock Register (Default Value: 0x00000000)

Offset: 0x009C			Register Name: SS_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 400MHz) 0: Clock is OFF 1: Clock is ON. SCLK = Clock Source/Divider N/Divider M.
30:26	/	/	/
25:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 00: OSC24M 01: PLL_PERIPH 1X: /.
23:18	/	/	/
17:16	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (n) 00: /1 01: /2 10: /4 11: /8.
15:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock divide ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.26. SPI0 Clock Register (Default Value: 0x00000000)

Offset: 0x00A0			Register Name: SPI0_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING.

			Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK = Clock Source/Divider N/Divider M.
30:26	/	/	/
25:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 00: OSC24M 01: PLL_PERIPH 1X: /.
23:18	/	/	/
17:16	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (n) 00: /1 01: /2 10: /4 11: /8.
15:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.27. SPI1 Clock Register (Default Value: 0x00000000)

Offset: 0x00A4			Register Name: SPI1_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK= Clock Source/Divider N/Divider M.
30:26	/	/	/
25:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 00: OSC24M 01: PLL_PERIPH 1X: /.
23:18	/	/	/
17:16	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (n) 00: /1 01: /2 10: /4 11: /8.

15:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.28. DAUDIO0 Clock Register (Default Value: 0x00000000)

Offset: 0x00B0			Register Name: DAUDIO0_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK= Clock Source PLL_AUDIO/Divider M.
30:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.29. DAUDIO1 Clock Register (Default Value: 0x00000000)

Offset: 0x00B4			Register Name: DAUDIO1_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK= Clock Source PLL_AUDIO/Divider M.
30:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.30. DAUDIO2 Clock Register (Default Value: 0x00000000)

Offset: 0x00B8			Register Name: DAUDIO2_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON.

			SCLK= Clock Source PLL_AUDIO/Divider M.
30:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.31. TDM Clock Register (Default Value: 0x00000000)

Offset: 0x00BC			Register Name: TDM_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK= PLL_AUDIO/Divider M.
30:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.32. OWA Clock Register (Default Value: 0x00000000)

Offset: 0x00C0			Register Name: OWA_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock(Max Clock = 200MHz) 0: Clock is OFF 1: Clock is ON. SCLK= PLL_AUDIO/Divider M.
30:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.33. USBPHY Clock Register (Default Value: 0x00000000)

Offset: 0x00CC			Register Name: USBPHY_CLK_REG
Bit	R/W	Default/Hex	Description
31:17	/	/	/
16	R/W	0x0	SCLK_GATING_OHCI0. Gating Special Clock for OHCI0

			0: Clock is OFF 1: Clock is ON.
15:12	/	/	/
11	R/W	0	SCLK_GATING_12M Gating Special 12M Clock for HSIC 0: Clock is OFF 1: Clock is ON. The special 12M clock = OSC24M/2.
10	R/W	0	SCLK_GATING_HSIC Gating Special Clock for HSIC 0: Clock is OFF 1: Clock is ON. The special clock is from PLL_HSIC.
9	R/W	0x0	SCLK_GATING_USBPHY1. Gating Special Clock for USB PHY1 0: Clock is OFF 1: Clock is ON.
8	R/W	0x0	SCLK_GATING_USBPHY0. Gating Special Clock for USB PHY0(USB DRD) 0: Clock is OFF 1: Clock is ON.
7:3	/	/	/
2	R/W	0	USBHSIC_RST USB HSIC Reset Control 0: Assert 1: De-assert.
1	R/W	0x0	USBPHY1_RST. USB PHY1 Reset Control 0: Assert 1: De-assert.
0	R/W	0x0	USBPHY0_RST. USB PHY0 Reset Control 0: Assert 1: De-assert.

3.3.5.34. DRAM Clock Register (Default Value: 0x00000001)

Offset: 0x00F4			Register Name: DRAM_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	DRAM_CTR_RST. DRAM Controller Reset For AHB Clock Domain. 0: Assert 1: De-assert.
30:15			

16	R/W	0x0	SDRCLK_UPD. SDRCLK Configuration Update. 0:Invalid 1:Valid. Note: Set this bit will validate Configuration . It will be auto cleared after the Configuration is valid. The DRAMCLK Source is from PLL_DDR.
15:4	/	/	/
3:0	R/W	0x1	DRAM_DIV_M. DRAMCLK Divider of Configuration. The clock is divided by (m+1). The divider M should be from 2 to 16.

3.3.5.35. PLL_DDR Configuration Register (Default Value: 0x00000030)

Offset: 0x00F8			Register Name: PLL_DDR_CFG_REG
Bit	R/W	Default/Hex	Description
31:13	/	/	/
12	R/W	0x0	PLL_DDR_MODE. 0: Normal Mode 1: Continuously Frequency Scale.
11:7	/	/	/
6:4	R/W	0x3	PLL_DDR_PHASE_COMPENSATE. The value of bit[6:4] is based on 24M clock, then the default PLL_DDR phase compensate is (3/24000000) s.
3:0	R/W	0x0	PLL_DDR_STEP. 0000: 0.004MHz/us ($576/2^{17}$) 0001: 0.008MHz/us ($576/2^{16}$) 0010: 0.016MHz/us ($576/2^{15}$) 0011: 0.032MHz/us ($576/2^{14}$) 0100: 0.064MHz/us ($576/2^{13}$) 0101: 0.128MHz/us ($576/2^{12}$) 0110: 0.256MHz/us ($576/2^{11}$) 0111: 0.512MHz/us ($576/2^{10}$) 1000: 1.024MHz/us ($576/2^9$) 1001: 2.048MHz/us ($576/2^8$) Others: 0.004MHz/us ($576/2^{17}$).

3.3.5.36. MBUS Reset Register (Default Value: 0x80000000)

Offset: 0x00FC			Register Name: MBUS_RST_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x1	MBUS_RESET.

			0: Reset Mbus Domain 1: Assert Mbus Domain.
30:0	/	/	/

3.3.5.37. DRAM Clock Gating Register (Default Value: 0x00000000)

Offset: 0x0100			Register Name: DRAM_CLK_GATING_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R/W	0x0	CSI_DCLK_GATING. Gating DRAM Clock For CSI 0: Mask 1: Pass.
0	R/W	0x0	VE_DCLK_GATING. Gating DRAM Clock For VE 0: Mask 1: Pass.

3.3.5.38. TCON0 Clock Register (Default Value: 0x00000000)

Offset: 0x0118			Register Name: TCON0_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock 0: Clock is OFF 1: Clock is ON.
30:27	/	/	/
26:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 000: PLL_VIDEO Others: /.
23:0	/	/	/

3.3.5.39. TCON1 Clock Register (Default Value: 0x00000000)

Offset: 0x011C			Register Name: TCON1_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock 0: Clock is OFF 1: Clock is ON.

			SCLK = Clock Source/ Divider M.
30:26	/	/	/
25:24	R/W	0x0	SCLK_SEL. Special Clock Source Select 00: PLL_VIDEO1 Others: /.
23:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.40. MIPI_CSI Clock Register (Default Value: 0x00000000)

Offset: 0x0130			Register Name: MIPI_CSI_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	MIPI_CSI_CFG. 0: Clock is OFF 1: Clock is ON. This clock = OSC24M.
30:17	/	/	/
16	R/W	0x0	CSI_MISC_CLK_GATING. Gating clock for CSI MISC, this clock is 24OSC. 0: Clock is OFF 1: Clock is ON.
15:0	/	/	/

3.3.5.41. CSI Clock Register (Default Value: 0x00000000)

Offset: 0x0134			Register Name: CSI_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	CSI_SCLK_GATING. Gating Special Clock 0: Clock is OFF 1: Clock is ON. SCLK= Special Clock Source/CSI_SCLK_DIV_M.
30:27	/	/	/
26:24	R/W	0x0	SCLK_SRC_SEL. Special Clock Source Select 000: PLL_PERIPH 101: PLL_VE Others:/.
23:20	/	/	/

19:16	R/W	0x0	CSI_SCLK_DIV_M. CSI Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.
15	R/W	0x0	CSI_MCLK_GATING. Gating Master Clock 0: Clock is OFF 1: Clock is ON This clock =Master Clock Source/ CSI_MCLK_DIV_M.
14:11	/	/	/
10:8	R/W	0x0	MCLK_SRC_SEL. Master Clock Source Select 011: PLL_DE 101: OSC24M Others: /.
7:5	/	/	/
4:0	R/W	0x0	CSI_MCLK_DIV_M. CSI Master Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 32.

3.3.5.42. VE Clock Register (Default Value: 0x00000000)

Offset: 0x013C			Register Name: VE_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	VE_SCLK_GATING. Gating Special Clock 0: Clock is OFF 1: Clock is ON. SCLK = PLL_VE /Divider N.
30:19	/	/	/.
18:16	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (N) The select clock source is pre-divided by n+1. The divider N is from 1 to 8.
15:0	/	/	/

3.3.5.43. AVS Clock Register (Default Value: 0x00000000)

Offset: 0x0144			Register Name: AVS_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock 0: Clock is OFF 1: Clock is ON.

			SCLK= OSC24M.
30:0	/	/	/

3.3.5.44. HDMI Clock Register (Default Value: 0x00000000)

Offset: 0x0150			Register Name: HDMI_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock 0: Clock is OFF 1: Clock is ON. SCLK= Clock Source/ Divider M.
30:26	/	/	/
25:24	R/W	0x0	SCLK_SEL. Special Clock Source Select 00: PLL_VIDEO1 Others: /
23:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.45. HDMI Slow Clock Register (Default Value: 0x00000000)

Offset: 0x0154			Register Name: HDMI_SLOW_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	HDMI_DDC_CLK_GATING. 0: Clock is OFF 1: Clock is ON. SCLK = OSC24M.
30:0	/	/	/

3.3.5.46. MBUS Clock Register (Default Value: 0x00000000)

Offset: 0x015C			Register Name: MBUS_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	MBUS_SCLK_GATING. Gating Clock for MBUS 0: Clock is OFF 1: Clock is ON. MBUS_CLOCK = Clock Source/Divider M

30:26	/	/	/
25:24	R/W	0x0	MBUS_SCLK_SRC Clock Source Select 00: OSC24M 01: PLL_PERIPH 10: PLL_DDR 11: /.
23:3	/	/	/
2:0	R/W	0x0	MBUS_SCLK_RATIO_M Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 8. Note: If the clock has been changed ,it must wait for at least 16 cycles.

3.3.5.47. MIPI_DSI Clock Register0 (Default Value: 0x00000000)

Offset: 0x0168			Register Name: MIPI_DSI_CLK_REG0
Bit	R/W	Default/Hex	Description
31	R/W	0x0	DSI_SCLK_GATING. Gating DSI Special Clock 0 0: Clock is OFF 1: Clock is ON DSI Special Clock 0 = Clock Source/ CLK_DIV_RATIO_M.
30:28	/	/	/
27:24	R/W	0x8	DSI_SCLK0_SRC_SEL. DSI Special Clock Source Select 1000: PLL_VIDEO0 1001: /
23:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.48. MIPI_DSI Clock Register1 (Default Value: 0x00000000)

Offset: 0x016C			Register Name: MIPI_DSI_CLK_REG1
Bit	R/W	Default/Hex	Description
31	R/W	0x0	DSI_SCLK_GATING. Gating DSI Special Clock 1 0: Clock is OFF 1: Clock is ON. DSI Special Clock = Clock Source/DSI_SCLK_DIV_M.
30:28	/	/	/

27:24	R/W	0x0	DSI_SCLK1_SRC_SEL. DSI Special Clock Source Select 0000: OSC24M 1001: PLL_VIDEO0.
23:4	/	/	/.
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider M is from 1 to 16.

3.3.5.49. GPU Core Clock Register (Default Value: 0x00000000)

Offset: 0x01A0			Register Name: GPU_CORE_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. 0: Clock is OFF 1: Clock is ON. SCLK= PLL-GPU/Divider N.
30:3	/	/	/.
2:0	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (N) The select clock source is pre-divided by(n+1). The divider N is from 1 to 8.

3.3.5.50. GPU Memory Register (Default Value: 0x00000000)

Offset: 0x01A4			Register Name: GPU_MEM_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. 0: Clock is OFF 1: Clock is ON. SCLK= Clock Source/Divider N.
30:25	/	/	/.
24	R/W	0x0	CLK_SRC_SEL 0: PLL_GPU 1: PLL_PERIPH.
23:3	/	/	/
2:0	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (N) The select clock source is pre-divided by(n+1). The divider N is from 1 to 8.

3.3.5.51. GPU HYD Clock Register (Default Value: 0x00000000)

Offset: 0x01A8			Register Name: GPU_HYD_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. 0: Clock is OFF 1: Clock is ON. SCLK= PLL_GPU/Divider N.
30:3	/	/	/.
2:0	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (N) The select clock source is pre-divided by(n+1). The divider N is from 1 to 8.

3.3.5.52. PLL Stable Time Register0 (Default Value: 0x000000FF)

Offset: 0x0200			Register Name: PLL_STABLE_TIME_REG0
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15:0	R/W	0x00FF	PLL_LOCK_TIME PLL Lock Time (Unit: us). Note: When any PLL (except PLL_CPUX) is enabled or changed, the corresponding PLL lock bit will be set after the PLL STABLE Time.

3.3.5.53. PLL Stable Time Register1 (Default Value: 0x000000FF)

Offset: 0x0204			Register Name: PLL_STABLE_TIME_REG1
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15:0	R/W	0x00FF	PLL_CPUX_LOCK_TIME PLL_CPUX Lock Time (Unit: us). Note: When PLL_CPUX is enabled or changed, the PLL_CPUX lock bit will be set after the PLL_CPUX STABLE Time.

3.3.5.54. PLL Stable Status Register (Default Value: 0x00000000)

Offset: 0x020C			Register Name: PLL_STABLE_STATUS_REG
Bit	R/W	Default/Hex	Description
31:11	/	/	/
10	R	0x0	PLL_VIDEO1_STB 0: Unstable

			1: Stable (It indicates that the PLL_VIDEO1 has been stable.)
9	R	0x0	PLL_DE_STB 0: Unstable 1: Stable (It indicates that the PLL_DE has been stable.)
8	R	0x0	PLL_HSIC_STB 0: Unstable 1: Stable (It indicates that the PLL_HSIC has been stable.)
7	R	0x0	PLL_GPU_STB 0: Unstable 1: Stable (It indicates that the PLL_GPU has been stable.)
6	R	0x0	PLL_PERIPH_STB 0: Unstable 1: Stable (It indicates that the PLL_PERIPH0 has been stable.)
5	R	0x0	PLL_DDR_STB 0: Unstable 1: Stable (It indicates that the PLL_DDR has been stable.)
4	R	0x0	PLL_VE_STB 0: Unstable 1: Stable (It indicates that the PLL_VE has been stable.)
3	R	0x0	PLL_VIDEO0_STB 0: Unstable 1: Stable (It indicates that the PLL_VIDEO0 has been stable.)
2	R	0x0	PLL_ADUIO_STB 0: Unstable 1: Stable (It indicates that the PLL_AUDIO has been stable.)
1	R	0x0	PLL_C1CPUX_STB 0: Unstable 1: Stable (It indicates that the PLL_C1CPUX has been stable.)
0	R	0x0	PLL_COCPUX_STB 0: Unstable 1: Stable (It indicates that the PLL_COCPUX has been stable.)

3.3.5.55. PLL_COCPUX Bias Register (Default Value: 0x08040000)

Offset: 0x0220			Register Name: PLL_COCPUX_BIAS_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x1	VCO_RST. VCO Reset In.
30:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CUR. PLL Current Bias Control [4:0] ,cpu_cp
15:0	/	/	/

3.3.5.56. PLL_AUDIO Bias Register (Default Value: 0x00040000)

Offset: 0x0224			Register Name: PLL_AUDIO_BIAS_REG
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.57. PLL_VIDEO0 Bias Register (Default Value: 0x00040000)

Offset: 0x0228			Register Name: PLL_VIDEO0_BIAS_REG
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.58. PLL_VE Bias Register (Default Value: 0x00040000)

Offset: 0x022C			Register Name: PLL_VE_BIAS_REG
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.59. PLL_DDR Bias Register (Default Value: 0x00040000)

Offset: 0x0230			Register Name: PLL_DDR_BIAS_REG
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.60. PLL_PERIPH Bias Register (Default Value: 0x00040000)

Offset: 0x0234			Register Name: PLL_PERIPH_BIAS_REG
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Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.61. PLL_C1CPUX Bias Register (Default Value: 0x80040000)

Offset: 0x0238			Register Name: PLL_C1CPUX_BIAS_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x1	VCO_RST. VCO Reset In.
30:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CUR. PLL Current Bias Control [4:0] ,cpu_cp
15:0	/	/	/

3.3.5.62. PLL_GPU Bias Register (Default Value: 0x00040000)

Offset: 0x023C			Register Name: PLL_GPU_BIAS_REG
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.63. PLL_HSIC Bias Register (Default Value: 0x00040000)

Offset: 0x0244			Register Name: PLL_HSIC_BIAS_REG
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.64. PLL_DE Bias Register (Default Value: 0x00040000)

Offset: 0x0248			Register Name: PLL_DE_BIAS_REG
Bit	R/W	Default/Hex	Description

31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.65. PLL_VIDEO1 Bias Register (Default Value: 0x00040000)

Offset: 0x024C			Register Name: PLL_VIDEO1_BIAS_REG
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R/W	0x04	PLL_BIAS_CTRL. PLL Current Bias Control[4:0]._cp
15:0	/	/	/

3.3.5.66. PLL_COCPUX Tuning Register (Default Value: 0x44404000)

Offset: 0x0250			Register Name: PLL_COCPUX_TUN_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x4	VCO_RNG_CTRL. VCO Range Control [2:0].
27	/	/	/
26:24	R/W	0x4	VCO_GAIN_CTRL. KVCO Gain Control Bits[2:0].
23	/	/	/
22:16	R/W	0x40	CNT_INT_CTRL. Counter Initial Control[6:0].
15	R/W	0x0	C_OD. C-Reg-Od for verify
14:8	R/W	0x40	C_B_IN. C-B-In[6:0] for verify.
7	R/W	0x0	C_OD1. C-Reg-Od1 for verify
6:0	RO	0x0	C_B_OUT. For verify

3.3.5.67. PLL_C1CPUX Tuning Register (Default Value: 0x44404000)

Offset: 0x0254			Register Name: PLL_C1CPUX_TUN_REG
Bit	R/W	Default/Hex	Description
31	/	/	/

30:28	R/W	0x4	VCO_RNG_CTRL. VCO Range Control [2:0].
27	/	/	/
26:24	R/W	0x4	VCO_GAIN_CTRL. KVCO Gain Control Bits[2:0].
23	/	/	/
22:16	R/W	0x40	CNT_INT_CTRL. Counter Initial Control[6:0].
15	R/W	0x0	C_OD. C-Reg-Od for verify
14:8	R/W	0x40	C_B_IN. C-B-In[6:0] for verify.
7	R/W	0x0	C_OD1. C-Reg-Od1 for verify
6:0	RO	0x0	C_B_OUT. For verify

3.3.5.68. PLL_AUDIO Pattern Control Register0 (Default Value: 0x00000000)

Offset: 0x0284			Register Name: PLL_AUDIO_PAT_CTRL_REG0
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SIG_DELT_PAT_EN. Sigma-delta Pattern Enable.
30:29	R/W	0x0	SPR_FREQ_MODE. Spread Frequency Mode. 00: DC=0 01: DC=1 10: Triangular(1 bit pattern) 11: /
28:20	R/W	0x0	WAVE_STEP. Wave Step.
19	R/W	0x0	CLK_SRC_SEL 0: 24MHz 1: 12MHz
18:17	R/W	0x0	FREQ. Frequency. 00: 31.5KHz 01: 32KHz 10: 32.5KHz 11: 33KHz
16:0	R/W	0x0	WAVE_BOT. Wave Bottom.

3.3.5.69. PLL_VIDEO0 Pattern Control Register 0 (Default Value: 0x00000000)

Offset: 0x0288			Register Name: PLL_VIDEO0_PAT_CTRL_REG0
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SIG_DELT_PAT_EN. Sigma-delta Pattern Enable.
30:29	R/W	0x0	SPR_FREQ_MODE. Spread Frequency Mode. 00: DC=0 01: DC=1 10: Triangular(1 bit pattern) 11: /
28:20	R/W	0x0	WAVE_STEP. Wave Step.
19	R/W	0x0	CLK_SRC_SEL 0: 24MHz 1: 12MHz
18:17	R/W	0x0	FREQ. Frequency. 00: 31.5KHz 01: 32KHz 10: 32.5KHz 11: 33KHz
16:0	R/W	0x0	WAVE_BOT. Wave Bottom.

3.3.5.70. PLL_DDR Pattern Control Register 0 (Default Value: 0x00000000)

Offset: 0x0290			Register Name: PLL_DDR_PAT_CTRL_REG0
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SIG_DELT_PAT_EN. Sigma-delta Pattern Enable.
30:29	R/W	0x0	SPR_FREQ_MODE. Spread Frequency Mode. 00: DC=0 01: DC=1 10: / 11: Triangular(3 bit pattern)
28:20	R/W	0x0	WAVE_STEP. Wave step.
19	R/W	0x0	CLK_SRC_SEL 0: 24MHz 1: 12MHz

18:17	R/W	0x0	FREQ. Frequency. 00: 31.5KHz 01: 32KHz 10: 32.5KHz 11: 33KHz
16:0	R/W	0x0	WAVE_BOT. Wave Bottom.

3.3.5.71. PLL_AUDIO Pattern Control Register 1 (Default Value: 0x00000000)

Offset: 0x02A4			Register Name: PLL_AUDIO_PAT_CTRL_REG1
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24	R/W	0x0	DITHER_EN.
23:21	/	/	/
20	R/W	0x0	FRAC_EN.
19:17	/	/	/
16:0	R/W	0x0	FRAC_IN.

3.3.5.72. PLL_VIDEO0 Pattern Control Register 1 (Default Value: 0x00000000)

Offset: 0x02A8			Register Name: PLL_VIDEO0_PAT_CTRL_REG1
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24	R/W	0x0	DITHER_EN.
23:21	/	/	/
20	R/W	0x0	FRAC_EN.
19:17	/	/	/
16:0	R/W	0x0	FRAC_IN.

3.3.5.73. PLL_DDR Pattern Control Register 1 (Default Value: 0x00000000)

Offset: 0x02B0			Register Name: PLL_DDR_PAT_CTRL_REG1
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24	R/W	0x0	DITHER_EN.
23:21	/	/	/
20	R/W	0x0	FRAC_EN.
19:17	/	/	/

16:0	R/W	0x0	FRAC_IN.
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3.3.5.74. Bus Software Reset Register 0 (Default Value: 0x00000000)

Offset: 0x02C0			Register Name: BUS_SOFT_RST_REG0
Bit	R/W	Default/Hex	Description
31:30	/	/	/
29	R/W	0x0	USB_OHCI0_RST. USB OHCI0 Reset 0: Assert 1: De-assert.
28	/	/	/
27	R/W	0x0	USB_EHCI1_RST. USB EHCI1 Reset 0: Assert 1: De-assert.
26	R/W	0x0	USB_EHCI0_RST. USB EHCI0 Reset 0: Assert 1: De-assert.
25	/	/	/
24	R/W	0x0	USB_DRD_RST. USB DRD Reset 0: Assert 1: De-assert.
23:22	/	/	/
21	R/W	0x0	SPI1_RST. SPI1 Reset. 0: Assert 1: De-assert.
20	R/W	0x0	SPI0_RST. SPI0 Reset. 0: Assert 1: De-assert.
19	R/W	0x0	HSTIMR_RST. HSTIMR Reset. 0: Assert 1: De-assert.
18	/	/	/
17	R/W	0x0	EMAC_RST. EMAC Reset. 0: Assert 1: De-assert.
16:15	/	/	/

14	R/W	0x0	DRAM_RST. DRAM AHB Reset. 0: Assert 1: De-assert.
13	R/W	0x0	NAND_RST. NAND Reset. 0: Assert 1: De-assert.
12:11	/	/	/
10	R/W	0x0	MMC2_RST. MMC2 Reset. 0: Assert 1: De-assert.
9	R/W	0x0	MMC1_RST. MMC1 Reset. 0: Assert 1: De-assert.
8	R/W	0x0	MMC0_RST. MMC0 Reset. 0: Assert 1: De-assert.
7	/	/	/
6	R/W	0x0	DMA_RST. DMA Reset. 0: Assert 1: De-assert.
5	R/W	0x0	SS_RST. SS Reset. 0: Assert 1: De-assert.
4:2	/	/	/
1	R/W	0x0	MIPI_DSI_RST. MIPI DSI Reset. 0: Assert 1: De-assert.
0	/	/	/

3.3.5.75. Bus Software Reset Register 1 (Default Value: 0x00000000)

Offset: 0x02C4			Register Name: BUS_SOFT_RST_REG1
Bit	R/W	Default/Hex	Description
31:23	/	/	/
22	R/W	0x0	SPINLOCK_RST. SPINLOCK Reset.

			0: Assert 1: De-assert.
21	R/W	0x0	MSGBOX_RST. MSGBOX Reset. 0: Assert 1: De-assert.
20	R/W	0x0	GPU_RST. GPU Reset. 0: Assert 1: De-assert.
19:13	/	/	/
12	R/W	0x0	DE_RST. DE Reset. 0: Assert 1: De-assert.
11	R/W	0x0	HDMI1_RST. HDMI1 Reset. 0: Assert 1: De-assert.
10	R/W	0x0	HDMI0_RST. HDMI0 Reset. 0: Assert 1: De-assert.
9	/	/	/
8	R/W	0x0	CSI_RST. CSI Reset. 0: Assert 1: De-assert.
7:6	/	/	/
5	R/W	0x0	TCON1_RST. TCON1 Reset. 0: Assert 1: De-assert.
4	R/W	0x0	TCON0_RST. TCON0 Reset. 0: Assert 1: De-assert.
3:1	/	/	/
0	R/W	0x0	VE_RST. VE Reset. 0: Assert 1: De-assert.

3.3.5.76. Bus Software Reset Register 2 (Default Value: 0x00000000)

Offset: 0x02C8			Register Name: BUS_SOFT_RST_REG2
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	LVDS_RST. LVDS Reset. 0: Assert 1: De-assert.

3.3.5.77. Bus Software Reset Register 3 (Default Value: 0x00000000)

Offset: 0x02D0			Register Name: BUS_SOFT_RST_REG3
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15	R/W	0x0	TDM_RST. TDM Reset. 0: Assert 1: De-assert.
14	R/W	0x0	DAUDIO2_RST. DAUDIO 2 Reset. 0: Assert 1: De-assert.
13	R/W	0x0	DAUDIO1_RST. DAUDIO 1 Reset. 0: Assert 1: De-assert.
12	R/W	0x0	DAUDIO0_RST. DAUDIO 0 Reset. 0: Assert 1: De-assert.
11:2	/	/	/
1	R/W	0x0	OWA_RST. OWA Reset. 0: Assert 1: De-assert.
0	/	/	/

3.3.5.78. Bus Software Reset Register 4 (Default Value: 0x00000000)

Offset: 0x02D8			Register Name: BUS_SOFT_RST_REG4
Bit	R/W	Default/Hex	Description

31:21	/	/	/
20	R/W	0x0	UART4_RST. UART4 Reset. 0: Assert 1: De-assert.
19	R/W	0x0	UART3_RST. UART3 Reset. 0: Assert 1: De-assert.
18	R/W	0x0	UART2_RST. UART2 Reset. 0: Assert 1: De-assert.
17	R/W	0x0	UART1_RST. UART1 Reset. 0: Assert 1: De-assert.
16	R/W	0x0	UART0_RST. UART0 Reset. 0: Assert 1: De-assert.
15:3	/	/	/
2	R/W	0x0	TWI2_RST. TWI2 Reset. 0: Assert 1: De-assert.
1	R/W	0x0	TWI1_RST. TWI1 Reset. 0: Assert 1: De-assert.
0	R/W	0x0	TWI0_RST. TWI0 Reset. 0: Assert 1: De-assert.

3.3.6. Programming Guidelines

3.3.6.1. PLL

- 1) In practical application, other PLLs doesn't support dynamic frequency scaling except for PLL_CPUX and PLL_DDR;
- 2) After the PLL_DDR frequency changes, the 30-bit of PLL_DDR Control Register should be written 1 to make it valid;

3.3.6.2. BUS

- 1) When setting the BUS clock , you should set the division factor first, and after the division factor becomes valid, switch the clock source. The clock source will be switched after at least three clock cycles;
- 2) The BUS clock should not be dynamically changed in most applications.

3.3.6.3. Clock Switch

Make sure that the clock source output is valid before the clock source switch, and then set a proper divide ratio; after the division factor becomes valid, switch the clock source.

3.3.6.4. Gating and reset

Make sure that the reset signal has been released before the release of module clock gating;

Confidential

3.4. CPU Configuration

3.4.1. Overview

CPUCFG module is used to configure related CPU control of the two clusters, including power, reset, cache, debug, CPU status, etc; It will be used when you want to disable/enable the CPU, cluster switch, CPU status check, and debug, etc.

It features:

- Capable of CPU reset, including core reset, debug circuit rest, etc
- Capable of Cache control, including cache reset, idle control, etc
- Capable of other CPU-related control, including interface control, CP15 control, and power control, etc
- Capable of checking CPU status, including idle status, SMP status, and interrupt status, etc

3.4.2. Functionalities Description

3.4.2.1. L2 Idle Mode

When the L2 of Cluster needs to enter WFI mode, firstly make sure the CPU0/1/2/3 of Cluster all enter WFI mode, which can be checked in Cluster CPU status Register, and then pull the ACINACTM of Cluster high by writing related register bit to 1, and then check whether L2 enters idle status by checking whether the STANDBYWFI_L2 is high. Remember to set the ACINACTM to low when exiting the L2 idle mode;

3.4.2.2. CPU Reset System

The CPU reset includes core reset, power on reset and H_reset. And their scopes rank: Core Reset < Power-On Reset < H_Reset.

3.4.3. Block Diagram

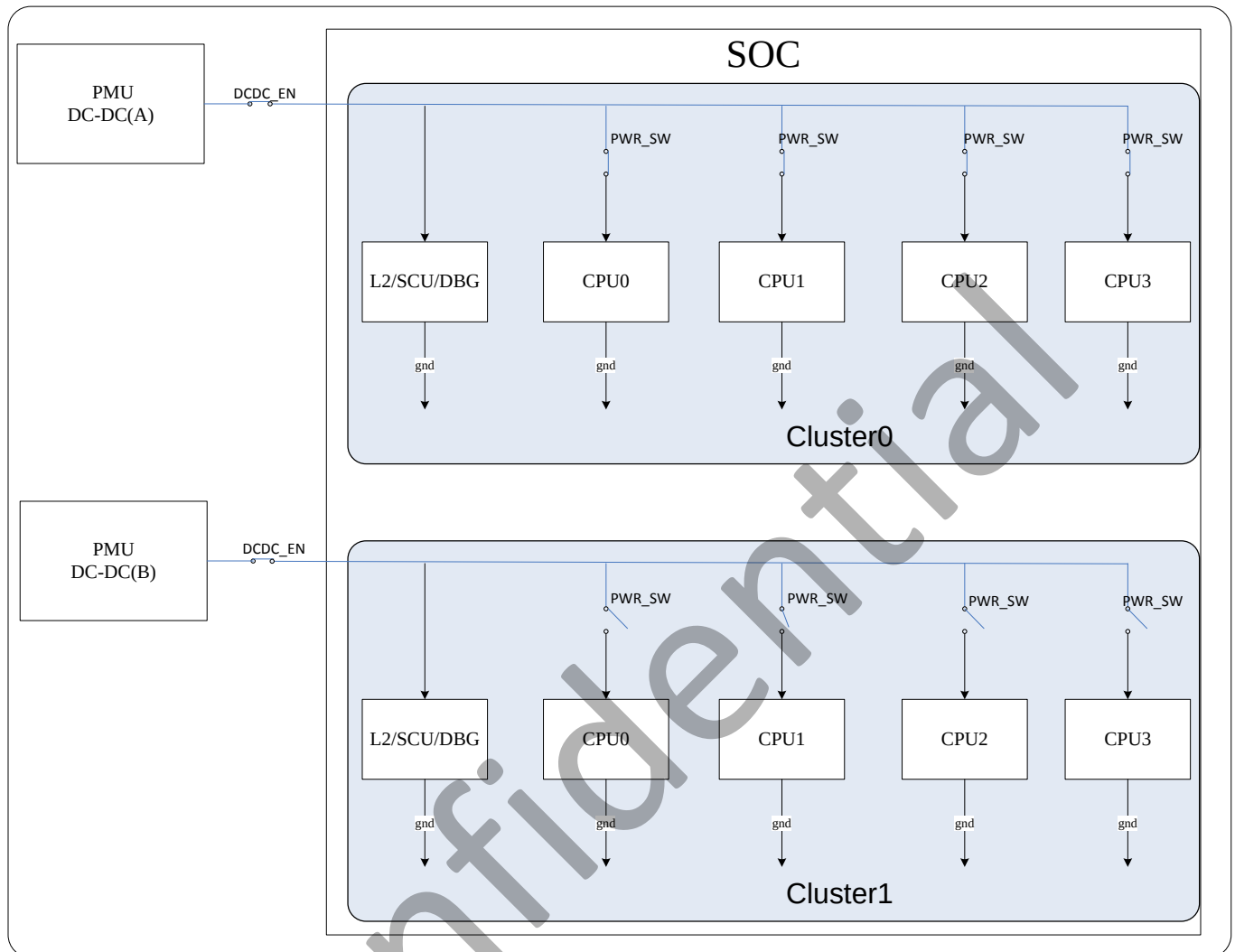


Figure 3-3. CPU Power Domain Diagram(Default State)

The figure above lists the CPU reset power domain. Since each CPU and its appended circuits have the same power domain, the processor and related L1 cache, neon, and vfp should be taken as a whole when it comes to the CPU core enable/disable.

3.4.4. Operation Principle

CPU-related operation needs proper configuration of CPUCFG related register, as well as related system control resource including BUS, clock ,reset and power control;

3.4.5. Register List

Module Name	Base Address
CPUCFG	0x01700000

Register Name	Offset	Description
C0_CTRL_REG0	0x0000	Cluster 0 Control Register0
C0_CTRL_REG1	0x0004	Cluster 0 Control Register1
C0_ADB400_PWRDNREQN_REG	0x0008	Cluster 0 adb400 pwrdsnreqn Register
C1_CTRL_REG0	0x0010	Cluster 1 Control Register0
C1_CTRL_REG1	0x0014	Cluster 1 Control Register1
C1_ADB400_PWRDNREQN_REG	0x0018	Cluster 1 adb400 pwrdsnreqn Register
GENER_CTRL_REG0	0x0028	General Control Register0
GENER_CTRL_REG1	0x002C	General Control Register1
C0_CPU_STATUS	0x0030	Cluster0 CPU Status Register
C1_CPU_STATUS	0x0034	Cluster1 CPU Status Register
IRQ_FIQ_STATUS	0x003C	Cluster CPU Irq and FiQ Status Register
IRQ_FIQ_MASK	0x0040	Cluster CPU Irq and FiQ Mask Register to CPUS
C0_RST_CTRL	0x0080	Cluster 0 Reset Control Register
C1_RST_CTRL	0x0084	Cluster 1 Reset Control Register
GIC_JTAG_RST_CTRL	0x0088	GIC and Jtag reset control Register

3.4.6. Register Description

3.4.6.1. Cluster 0 Control Register0(Default Value:0x60000000)

Offset: 0x00			Register Name: C0_CTRL_REG0
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SYSBAR_DISABLE. Disable broadcasting of barriers onto system bus: 0:Barriers are broadcast onto system bus,this requires an AMBA4 interconnect. 1: Barriers are not broadcast onto the system bus.This is compatible with an AXI3 interconnect.
30	R/W	0x1	BROADCAST_INNER. Enable broadcasting of Inner Shareable transactions: 0: Inner shareable transactions are not broadcasted externally. 1: Inner shareable transactions are broadcasted externally.

29	R/W	0x1	BROADCAST_OUTER. Enable broadcasting of outer shareable transactions: 0: Outer Shareable transactions are not broadcasted externally. 1: Outer Shareable transactions are broadcasted externally.
28	R/W	0x0	BROADCAST_CACHE_MAINT Enable broadcasting of cache maintenance operations to downstream caches: 0: Cache maintenance operations are not broadcasted to downstream caches. 1: Cache maintenance operations are broadcasted to downstream caches.
27:12	/	/	/
11:8	R/W	0x0	CP15S_DISABLE. Disable write access to some secure CP15 register.
7:6	/	/	/
5	R/W	0x0	CFGS_DISABLE. Disable write access to some secure GIC register.
4	R/W	0x0	L2_RST_DISABLE. Disable automatic L2 cache invalidate at reset: 0: L2 cache is reset by hardware. 1: L2 cache is not reset by hardware.
3:0	R/W	0x0	L1_RST_DISABLE. Disable automatic Cluster0 CPU0/1/2/3 L1 cache invalidate at reset: 0: L1 cache is reset by hardware. 1: L1 cache is not reset by hardware.

3.4.6.2. Cluster 0 Control Register1(Default Value:0x00000000)

Offset: 0x04			Register Name: CO_CTRL_REG1
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:20	R/W	0x0	SLEEP. Cluster 0 CPU L1 cache Sleep Mode Control 0: Normal 1: Sleeping.
19:17	/	/	/
16	R/W	0x0	SLEEP_L2. Cluster 0 L2 Sleep Mode Control 0: Normal 1: Sleeping.
15:12	R/W	0x0	SHUT_DOWN. Cluster 0 CPU L1 cache Shut Down Control (The data in cache will be lost) 0:Normal 1:Shut Down.
11:9	/	/	/

8	R/W	0x0	SHUT_DOWN_L2. Cluster 0 L2 cache Shut Down Control (The data in cache will be lost) 0:Normal 1:Shut Down.
7:1	/	/	/
0	R/W	0x0	ACINACTM. Snoop interface is inactive and no longer accepting requests.

3.4.6.3. Cluster 0 adb400 pwrdrnreqn Register(Default Value:0x00000001)

Offset: 0x08			Register Name: C0_ADB400_PWRDRNREQN_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x1	ADB400_PWRDRNREQN.

3.4.6.4. Cluster 1 Control Register0(Default Value:0x60000000)

Offset: 0x10			Register Name: C1_CTRL_REG0
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SYSBAR_DISABLE. Disable broadcasting of barriers onto system bus: 0: Barriers are broadcast onto system bus,this requires an AMBA4 interconnect. 1: Barriers are not broadcast onto the system bus.This is compatible with an AXI3 interconnect.
30	R/W	0x1	BROADCAST_INNER. Enable broadcasting of Inner Shareable transactions: 0: Inner shareable transactions are not broadcasted externally. 1: Inner shareable transactions are broadcasted externally.
29	R/W	0x1	BROADCAST_OUTER. Enable broadcasting of outer shareable transactions: 0: Outer Shareable transactions are not broadcasted externally. 0: Outer Shareable transactions are broadcasted externally.
28	R/W	0x0	BROADCAST_CACHE_MAINT Enable broadcasting of cache maintenance operations to downstream caches: 0: Cache maintenance operations are not broadcasted to downstream caches. 1: Cache maintenance operations are broadcasted to downstream caches.
27:12	/	/	/
11:8	R/W	0x0	CP15S_DISABLE. Disable write access to some secure CP15 register.

7:6	/	/	/
5	R/W	0x0	CFGs_DISABLE. Disable write access to some secure GIC register.
4	R/W	0x0	L2_RST_DISABLE. Disable automatic L2 cache invalidate at reset: 0: L2 cache is reset by hardware. 1: L2 cache is not reset by hardware.
3:0	R/W	0x0	L1_RST_DISABLE. Disable automatic Cluster1 CPU0/1/2/3 L1 cache invalidate at reset: 0: L1 cache is reset by hardware. 1: L1 cache is not reset by hardware.

3.4.6.5. Cluster 1 Control Register1(Default Value:0x00000000)

Offset: 0x14			Register Name: C1_CTRL_REG1
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:20	R/W	0x0	SLEEP. Cluster 1 CPU L1 cache Sleep Mode Control 0: Normal 1: Sleeping.
19:17	/	/	/
16	R/W	0x0	SLEEP_L2. Cluster 1 L2 Sleep Mode Control 0: Normal 1: Sleeping.
15:12	R/W	0x0	SHUT_DOWN. Cluster 1 CPU L1 cache Shut Down Control (The data in cache will be lost) 0:Normal 1:Shut Down.
11:9	/	/	/
8	R/W	0x0	SHUT_DOWN_L2. Cluster 1 L2 cache Shut Down Control (The data in cache will be lost) 0:Normal 1:Shut Down.
7:1	/	/	/
0	R/W	0x0	ACINACTM. Snoop interface is inactive and no longer accepting requests.

3.4.6.6. Cluster 1 adb400 pwrdrnreqn Register(Default Value:0x00000001)

Offset: 0x18	Register Name: C1_ADB400_PWRDNREQN_REG
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Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x1	ADB400_PWRDNREQN.

3.4.6.7. Debug Control Register0(Default Value:0x00000F0F)

Offset: 0x20			Register Name: DBG_REG0
Bit	R/W	Default/Hex	Description
31:20	/	/	/
19:12	/	/	/
11:8	R/W	0xF	C1_DBG_PWRDUP. Cluster Powered-up
7:4	/	/	/
3:0	R/W	0xF	C0_DBG_PWRDUP. Cluster Powered-up

3.4.6.8. General Control Register0(Default Value:0x00000000)

Offset: 0x28			Register Name: GENER_CTRL_REG0
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	GIC_CFGSDISABLE. Disables write access to some secure GIC registers.

3.4.6.9. General Control Register1(Default Value:0x0000000E)

Offset: 0x2C			Register Name: GENER_CTRL_REG1
Bit	R/W	Default/Hex	Description
31:6	/	/	/
5:4	R/W	0x0	QOSOVERRIDE. If HIGH, internally generated values override the ARQOS and AWQOS inputs. One bit exists for each slave interface.
3:2	R/W	0x3	ACCHANNELEN. If LOW, then AC requests are never issued on the corresponding slave interface. One bit exists for each slave interface.
1	R/W	0x1	CCI_CLK_ON. Set 1 means CCI Clock always on.
0	R/W	0x0	CCI_CLK_OFF. Set 1 means CCI Clock always off. Note: When CCI_CLK_OFF and CCI_CLK_ON are active simultaneously, the

		priority of CCI_CLK_OFF is higher than CCI_CLK_ON.
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3.4.6.10. Cluster0 CPU Status Register(Default Value: 0x00000000)

Offset: 0x30			Register Name: C0_CPU_STATUS
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:24	R	0x0	SMP_AMP A CPU is in Symmetric Multiprocessing mode or Asymmetric Multiprocessing mode. 0: AMP mode 1: SMP mode
23:20	/	/	/
19:16	R	0x0	STANDBYWFI. Indicates if Cluster0 CPU0/1/2/3 is in WFI standby mode: 0: Processor not in WFI standby mode. 1: Processor in WFI standby mode
15:12	/	/	/
11:8	R	0x0	STANDBYWFE. Indicates if Cluster0 CPU0/1/2/3 is in the WFE standby mode: 0: Processor not in WFE standby mode 1: Processor in WFE standby mode
7:1	/	/	/
0	R	0x0	STANDBYWFIL2. Indicates if the Cluster0 L2 memory system is in WFI standby mode. 0:active 1:idle

3.4.6.11. Cluster1 CPU Status Register(Default Value: 0x00000000)

Offset: 0x34			Register Name: C1_CPU_STATUS
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:24	R	0x0	SMP_AMP A CPU is in Symmetric Multiprocessing mode or Asymmetric Multiprocessing mode. 0: AMP mode 1: SMP mode
23:20	/	/	/
19:16	R	0x0	STANDBYWFI. Indicates if Cluster1 CPU0/1/2/3 is in WFI standby mode: 0: Processor not in WFI standby mode.

			1: Processor in WFI standby mode
15:12	/	/	/
11:8	R	0x0	STANDBYWFE. Indicates if Cluster1 CPU0/1/2/3 is in the WFE standby mode: 0: Processor not in WFE standby mode 1: Processor in WFE standby mode
7:1	/	/	/
0	R	0x0	STANDBYWFI2. Indicates if the Cluster1 L2 memory system is in WFI standby mode. 0:active 1:idle

3.4.6.12. Cluster CPU IRQ and FIQ Status Register(Default Value: 0x001F0000)

Offset: 0x3C			Register Name: IRQ_FIQ_STATUS
Bit	R/W	Default/Hex	Description
31:21	/	/	/
20:16	R	0x1F	EVENT_CNT_OF Event counter over flag[4:0].The CCI-400 counters: The CCNT overflow is bit 4,event counters on bits[3:0]. 0: Counter has overflowed 1: Counter has not overflowed
15:12	R	0x0	C1_FIQ_OUT[3:0]. Cluster1 CPU FIQ wakeup output 0: Normal 1: FIQ happen
11:8	R	0x0	C0_FIQ_OUT[3:0]. Cluster0 CPU FIQ wakeup output 0: Normal 1: FIQ happen
7:4	R	0x0	C1_IRQ_OUT[3:0]. Cluster1 CPU IRQ wakeup output 0: Normal 1: IRQ happen
3:0	R	0x0	C0_IRQ_OUT[3:0]. Cluster0 CPU IRQ wakeup output 0: Normal 1: IRQ happen

3.4.6.13. Cluster CPU IRQ and FIQ Mask Register (Default Value: 0x00000000)

Offset: 0x40	Register Name: IRQ_FIQ_MASK
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Bit	R/W	Default/Hex	Description
31:16	/	/	/
15:12	R/W	0x0	C1_FIQ_MASK[3:0]. Cluster1 CPU FIQ signals Mask to GIC_OUT 0: masks 1: unmask.
11:8	R/W	0x0	C0_FIQ_MASK[3:0]. Cluster0 CPU FIQ signals Mask to GIC_OUT 0: masks 1: unmask.
7:4	R/W	0x0	C1_IRQ_MASK[3:0]. Cluster1 CPU IRQ signals Mask to GIC_OUT 0: masks 1: unmask.
3:0	R/W	0x0	C0_IRQ_MASK[3:0]. Cluster0 CPU IRQ signals Mask to GIC_OUT 0: masks 1: unmask.

3.4.6.14. Cluster 0 Reset Control Register(Default Value: 0x01FF1101)

Offset: 0x80			Register Name: C0_RST_CTRL
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24	R/W	0x1	SOC_DBG_RST. Cluster0 SOC Debug Reset 0: assert 1: de-assert.
23:20	R/W	0xF	ETM_RST. Cluster0 ETM Reset Assert. 0: assert 1: de-assert.
19:16	R/W	0xF	DBG_RST. Cluster0 Debug Reset Assert. 0: assert 1: de-assert.
15:13	/	/	/
12	R/W	0x1	HRESET. Cluster0 H_Reset. Reset all the Cluster0 Logic and Cluster0 Interface Logic. 0: assert 1: de-assert.
11:9	/	/	/
8	R/W	0x1	L2_RST. Cluster0 L2 Cache Reset

			0: assert 1: de-assert.
7:4	/	/	/
3:0	R/W	0x1	CORE_RESET. Cluster0 CPU0/1/2/3 Reset Assert. 0: assert 1: de-assert.

3.4.6.15. Cluster 1 Reset Control Register(Default Value: 0x01FF1100)

Offset: 0x84			Register Name: C1_RST_CTRL
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24	R/W	0x1	SOC_DBG_RST. Cluster1 SOC Debug Reset 0: assert 1: de-assert.
23:20	R/W	0xF	ETM_RST. Cluster1 ETM Reset Assert. 0: assert 1: de-assert.
19:16	R/W	0xF	DBG_RST. Cluster1 Debug Reset Assert. 0: assert 1: de-assert.
15:13	/	/	/
12	R/W	0x1	HRESET. Cluster1 H_Reset. Reset all the Cluster1 Logic and Cluster1 Interface Logic. 0: assert 1: de-assert.
11:9	/	/	/
8	R/W	0x1	L2_RST. Cluster1 L2 Cache Reset 0: assert 1: de-assert.
7:4	/	/	/
3:0	R/W	0x0	CORE_RESET. Cluster1 CPU0/1/2/3 Reset Assert. 0: assert 1: de-assert.

3.4.6.16. GIC and Jtag Reset Control Register(Default Value: 0x00000F01)

Offset: 0x88			Register Name: GIC_JTAG_RST_CTRL
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11	R/W	0x1	CS_RST CoreSight Reset. 0: assert 1: de-assert.
10	R/W	0x1	DAP_RST DAP Reset. 0: assert 1: de-assert.
9	R/W	0x1	PORTRST Jtag portrst. 0: assert 1: de-assert.
8	R/W	0x1	TRST. Jtag trst. 0: assert 1: de-assert.
7:1	/	/	/
0	R/W	0x1	GIC_RESET. Gic_reset_cpu_reg 0: assert 1: de-assert.

3.5. TimeStamp

3.5.1. Overview

The timestamp module generates and distributes a consistent timestamp value for multiple processors and other SOC IP .

It features:

- The Timestamp uses a timing reference with a fixed frequency clock OSC24M.
- The Timestamp functions as the clock source of the CPU local timer only.

3.5.2. Register List

Module Name	Base Address
TIMESTAMP_STA	0x01710000

Note: Timestamp status Register

Register Name	Offset	Description
CNT_LOW_REG	0x0000	Counter low register[31:0] value
CNT_HI_REG	0x0004	Counter high register[63:32] value

Module Name	Base Address
TIMESTAMP_CTRL	0x01720000

Register Name	Offset	Description
TSTAMP_CTRL_REG	0x0000	Timestamp control register
CNT_LOW_REG	0x0008	Counter low register[31:0] value
CNT_HI_REG	0x000C	Counter high register[63:32] value
CNT_FREQID_REG	0x0020	The Counter Base Frequency ID Register

3.5.3. Timestamp Status Register Description

3.5.3.1. Counter Low Register (Default Value: 0x00000000)

Offset: 0x0000			Register Name: CNT_LOW_REG
Bit	R/W	Default/Hex	Description
31:0	R	0x0	CNT_LOW_REG. Current value of counter[31:0]

3.5.3.2. Counter High Register (Default Value: 0x00000000)

Offset: 0x0004			Register Name: CNT_HI_REG
Bit	R/W	Default/Hex	Description
31:0	R	0x0	CNT_HI_REG. Current value of counter[64:32]

3.5.4. Timestamp Counter Control Register Description

3.5.4.1. Timestamp Control Register (Default Value: 0x00000000)

Offset: 0x0000			Register Name: TSTAMP_CTRL_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/.
0	R/W	0x0	EN. Timestamp Counter Enable. 0: Disable 1: Enable

3.5.4.2. Counter Low Register (Default Value: 0x00000000)

Offset: 0x0008			Register Name: CNT_LOW_REG
Bit	R/W	Default/Hex	Description
31:0	R	0x0	CNT_LOW_REG. Current value of counter[31:0]

3.5.4.3. Counter High Register (Default Value: 0x00000000)

Offset: 0x000C			Register Name: CNT_HI_REG
Bit	R/W	Default/Hex	Description
31:0	R	0x0	CNT_HI_REG. Current value of counter[64:32]

3.5.4.4. Counter Base Frequency ID Register (Default : 0x00000000)

Offset: 0x0020			Register Name: CNT_BASE_FREQID_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	FREQ. This register must be programmed to match the clock frequency of the timestamp generator, in ticks per second. For example, in our SOC for a 24 MHz clock, it must program 0x16E3600.

3.5.5. Programming Guidelines

- 1) Timestamp Counter is used to provide time baseline for the local timer of processor, so the counter should be enabled before the OS runs.
- 2) Timestamp Counter Status Registers(TIMESTAMP STA) are readable only, indicating the current 64-bit counter value;
- 3) TSTAMP_CTRL_REG of Timestamp Counter Control Registers(TIMESTAMP CTRL) is used to enable or disable the counter; Base Frequency ID Register should define the timestamp generator frequency so that other software interface can access the timestamp clock source information through this register.
- 4) CNT_LOW/HI_REG of Timestamp Counter Control Registers(TIMESTAMP CTRL) is writeable and readable, indicating the current 64-bit counter value. It is not recommended to write this register, however, if writing is required, you must follow steps below:
 - Disable the counter;
 - The first write access must be to the lower 32bits;(Counter Low Register)
 - The second write access can be the high 32bits;(Counter High Register)
 - The counter initial value then will be updated.

3.6. System Control

3.6.1. Overview

Area	Address	Size(Bytes)
A1	0x00000000--0x00007FFF	32K
A2	0x00044000--0x00053FFF	64K
B(Secure RAM)	0x00020000--0x00037FFF	96K
C0_CPUX I-Cache		32K (X=0,1,2,3)
C0_CPUX D-Cache		32K (X=0,1,2,3)
Cluster 0 L2 Cache		512K
C1_CPUX I-Cache		32K (X=0,1,2,3)
C1_CPUX D-Cache		32K (X=0,1,2,3)
Cluster 1 L2 Cache		512K
Total		1728K

3.6.2. System Control Register List

Module Name	Base Address
System Control	0x01C00000

Register Name	Offset	Description
VER_REG	0x24	Version Register
EMAC_CLK_REG	0x30	EMAC Clock Register

3.6.3. System Control Register Description

3.6.3.1. Version Register

Offset:0x24			Register Name: VER_REG
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15	/	/	/
14:9	/	/	/
8	R	x	UBOOT_SEL_PAD_STA. U_boot Select Pin Status. 0: U_Boot; 1: Normal Boot.
7:0	R	0x0	VER_BITS. This read-only bit field always reads back the mask revision level of the chip.

Note:

The UBOOT_SEL_PAD_STA pin is indicated whether system should jump to USB boot, and the pin is pull up by internal 50K resistor in R_state.

3.6.3.2. EMAC Clock Register (Default Value: 0x00000000)

Offset:0x30			Register Name: EMAC_CLK_REG
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15	R/W	0x0	TXC_DIV_CFG. Clock pre-divide ratio. External transmit clock (125MHz) is pre-divided by as follows for RGMII. 0: /1, generate 125MHz 1: /5, generate 25MHz
14:13	/	/	/
12:10	R/W	0x0	ETXDC. Configure EMAC Transmit Clock Delay Chain.
9:5	R/W	0x0	ERXDC. Configure EMAC Receive Clock Delay Chain.
4	R/W	0x0	ERXIE Enable EMAC Receive Clock Invertor. 0: Disable; 1: Enable;
3	R/W	0x0	ETXIE Enable EMAC Transmit Clock Invertor.

			0: Disable; 1: Enable;
2	R/W	0x0	EPIT EMAC PHY Interface Type 0: GMII/MII; 1: RGMII;
1:0	R/W	0x0	ETCS. EMAC Transmit Clock Source 00: Transmit clock source for MII; 01: External transmit clock source for GMII and RGMII; 10: Internal transmit clock source for GMII and RGMII; 11: Reserved;

Confidential

3.7. Timer

3.7.1. Overview

Timer 0/1 can take their inputs from Internal OSC or OSC24M. They provide the operating system's scheduler interrupt. It is designed to offer maximum accuracy and efficient management, even for systems with long or short response time. They provide 24-bit programmable overflow counter and work in auto-reload mode or no-reload mode. When the current value in *Current Value Register* is counting down to zero, the timer will generate interrupt if set interrupt enable bit.

The watchdog is used to resume the controller operation when it had been disturbed by malfunctions such as noise and system errors. It features a down counter that allows a watchdog period of up to 16 seconds (512000 cycles). It can generate a general reset or interrupt request.

3.7.2. Block Diagram

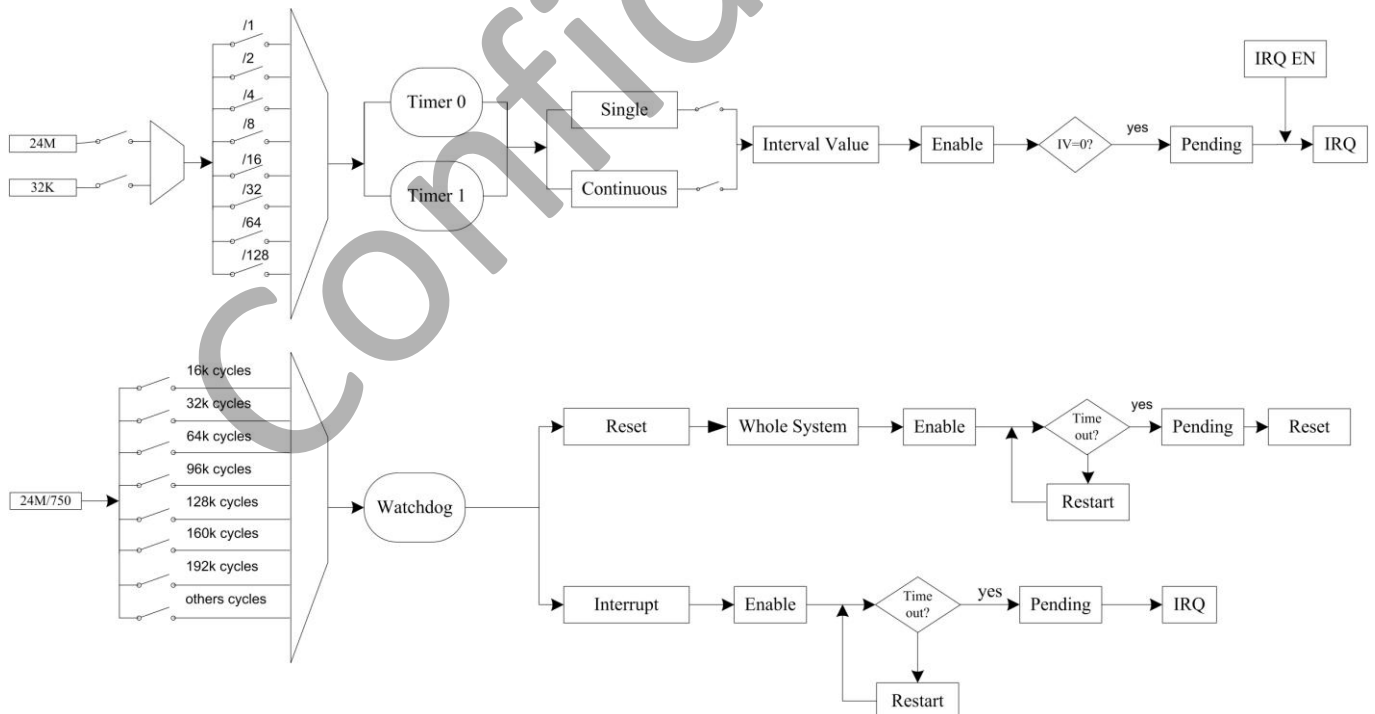


Figure 3-4. Timer Block Diagram

3.7.3. Timer Register List

Module Name	Base Address
TIMER	0x01C20C00

Register Name	Offset	Description
TMR_IRQ_EN_REG	0x0	Timer IRQ Enable Register
TMR_IRQ_STA_REG	0x4	Timer Status Register
TMRO_CTRL_REG	0x10	Timer 0 Control Register
TMRO_INTV_VALUE_REG	0x14	Timer 0 Interval Value Register
TMRO_CUR_VALUE_REG	0x18	Timer 0 Current Value Register
TMR1_CTRL_REG	0x20	Timer 1 Control Register
TMR1_INTV_VALUE_REG	0x24	Timer 1 Interval Value Register
TMR1_CUR_VALUE_REG	0x28	Timer 1 Current Value Register
AVS_CNT_CTL_REG	0x80	AVS Control Register
AVS_CNT0_REG	0x84	AVS Counter 0 Register
AVS_CNT1_REG	0x88	AVS Counter 1 Register
AVS_CNT_DIV_REG	0x8C	AVS Divisor Register
WDOG0_IRQ_EN_REG	0xA0	Watchdog 0 IRQ Enable Register
WDOG0_IRQ_STA_REG	0xA4	Watchdog 0 Status Register
WDOG0_CTRL_REG	0xB0	Watchdog 0 Control Register
WDOG0_CFG_REG	0xB4	Watchdog 0 Configuration Register
WDOG0_MODE_REG	0xB8	Watchdog 0 Mode Register

3.7.4. Timer Register Description

3.7.4.1. Timer IRQ Enable Register (Default Value: 0x00000000)

Offset:0x0			Register Name: TMR_IRQ_EN_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R/W	0x0	TMR1_IRQ_EN. Timer 1 Interrupt Enable. 0: No effect; 1: Timer 1 Interval Value reached interrupt enable.
0	R/W	0x0	TMRO_IRQ_EN. Timer 0 Interrupt Enable. 0: No effect;

			1: Timer 0 Interval Value reached interrupt enable.
--	--	--	---

3.7.4.2. Timer IRQ Status Register (Default Value: 0x00000000)

Offset:0x04			Register Name: TMR_IRQ_STA_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R/W	0x0	TMR1_IRQ_PEND. Timer 1 IRQ Pending. Set 1 to the bit will clear it. 0: No effect; 1: Pending, timer 1 interval value is reached.
0	R/W	0x0	TMRO_IRQ_PEND. Timer 0 IRQ Pending. Set 1 to the bit will clear it. 0: No effect; 1: Pending, timer 0 interval value is reached.

3.7.4.3. Timer 0 Control Register (Default Value: 0x00000004)

Offset:0x10			Register Name: TMRO_CTRL_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0x0	TMRO_MODE. Timer 0 mode. 0: Continuous mode. When interval value reached, the timer will not disable automatically. 1: Single mode. When interval value reached, the timer will disable automatically.
6:4	R/W	0x0	TMRO_CLK_PRES. Select the pre-scale of timer 0 clock source. 000: /1 001: /2 010: /4 011: /8 100: /16 101: /32 110: /64 111: /128
3:2	R/W	0x1	TMRO_CLK_SRC. Timer 0 Clock Source. 00: 32K 01: OSC24M. 10: /

			11: /
1	R/W	0x0	TMRO_RELOAD. Timer 0 Reload. 0: No effect, 1: Reload timer 0 Interval value. After the bit is set, it can not be written again before it's cleared automatically.
0	R/W	0x0	TMRO_EN. Timer 0 Enable. 0: Stop/Pause, 1: Start. When the timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0. If the current counter does not reach the zero, the timer enable bit is set to "0", the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1. In timer pause state; the interval value register can be modified. If the timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time.

3.7.4.4. Timer 0 Interval Value Register(Default Value: 0x00000000)

Offset:0x14			Register Name: TMRO_INTV_VALUE_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	TMRO_INTV_VALUE. Timer 0 Interval Value. The value setting should consider the system clock and the timer clock source.

3.7.4.5. Timer 0 Current Value Register(Default Value: 0x00000000)

Offset:0x18			Register Name: TMRO_CUR_VALUE_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	TMRO_CUR_VALUE. Timer 0 Current Value. It is a 32-bit down-counter (from interval value to 0).

3.7.4.6. Timer 1 Control Register (Default Value: 0x00000004)

Offset:0x20			Register Name: TMR1_CTRL_REG
Bit	R/W	Default/Hex	Description

31:8	/	/	/
7	R/W	0x0	TMR1_MODE. Timer 1 mode. 0: Continuous mode. When interval value reached, the timer will not disable automatically. 1: Single mode. When interval value reached, the timer will disable automatically.
6:4	R/W	0x0	TMR1_CLK_PRES. Select the pre-scale of timer 1 clock source. 000: /1 001: /2 010: /4 011: /8 100: /16 101: /32 110: /64 111: /128
3:2	R/W	0x1	TMR1_CLK_SRC. 00: 32K 01: OSC24M. 10: / 11: /.
1	R/W	0x0	TMR1_RELOAD. Timer 1 Reload. 0: No effect, 1: Reload timer 1 Interval value. After the bit is set, it can not be written again before it's cleared automatically.
0	R/W	0x0	TMR1_EN. Timer 1 Enable. 0: Stop/Pause, 1: Start. If the timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0. If the current counter does not reach the zero, the timer enable bit is set to "0", the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1. In timer pause state, the interval value register can be modified. If the timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time.

3.7.4.7. Timer 1 Interval Value Register(Default Value: 0x00000000)

Offset:0x24			Register Name: TMR1_INTV_VALUE_REG
Bit	R/W	Default/Hex	Description

31:0	R/W	0x0	TMR1_INTV_VALUE. Timer 1 Interval Value. The value setting should consider the system clock and the timer clock source.
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3.7.4.8. Timer 1 Current Value Register(Default Value: 0x00000000)

Offset:0x28			Register Name: TMR1_CUR_VALUE_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	TMR1_CUR_VALUE. Timer 1 Current Value. It is a 32-bit down-counter (from interval value to 0).

3.7.4.9. AVS Counter Control Register (Default Value: 0x00000000)

Offset:0x80			Register Name: AVS_CNT_CTL_REG
Bit	R/W	Default/Hex	Description
31:10	/	/	/
9	R/W	0x0	AVS_CNT1_PS. Audio/Video Sync Counter 1 Pause Control 0: Not pause, 1: Pause Counter 1.
8	R/W	0x0	AVS_CNT0_PS. Audio/Video Sync Counter 0 Pause Control 0: Not pause, 1: Pause Counter 0.
7:2	/	/	/
1	R/W	0x0	AVS_CNT1_EN. Audio/Video Sync Counter 1 Enable/ Disable. The counter source is OSC24M. 0: Disable, 1: Enable.
0	R/W	0x0	AVS_CNT0_EN. Audio/Video Sync Counter 1 Enable/ Disable. The counter source is OSC24M. 0: Disable, 1: Enable.

3.7.4.10. AVS Counter 0 Register (Default Value: 0x00000000)

Offset:0x84			Register Name: AVS_CNT0_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	AVS_CNT0.

		Counter 0 for Audio/ Video Sync Application The high 32 bits of the internal 33-bits counter register. The initial value of the internal 33-bits counter register can be set by software. The LSB bit of the 33-bits counter register should be zero when the initial value is updated. It will count from the initial value. The initial value can be updated at any time. It can also be paused by setting AVS_CNT0_PS to '1'. When it is paused, the counter won't increase.
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3.7.4.11. AVS Counter 1 Register (Default Value: 0x00000000)

Offset:0x88			Register Name: AVS_CNT1_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	AVS_CNT1. Counter 1 for Audio/ Video Sync Application The high 32 bits of the internal 33-bits counter register. The initial value of the internal 33-bits counter register can be set by software. The LSB bit of the 33-bits counter register should be zero when the initial value is updated. It will count from the initial value. The initial value can be updated at any time. It can also be paused by setting AVS_CNT1_PS to '1'. When it is paused, the counter won't increase.

3.7.4.12. AVS Counter Divisor Register (Default Value: 0x05DB05DB)

Offset:0x8C			Register Name: AVS_CNT_DIV_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0x5DB	AVS_CNT1_D. Divisor N for AVS Counter 1 AVS CN1 CLK=24MHz/Divisor_N1. Divisor N1 = Bit [27:16] + 1. The number N is from 1 to 0x7ff. The zero value is reserved. The internal 33-bits counter engine will maintain another 12-bits counter. The 12-bits counter is used for counting the cycle number of one 24Mhz clock. When the 12-bits counter reaches ($\geq$ N) the divisor value, the internal 33-bits counter register will increase 1 and the 12-bits counter will reset to zero and restart again.
15:12	/	/	/
11:0	R/W	0x5DB	AVS_CNT0_D. Divisor N for AVS Counter 0 AVS CN0 CLK=24MHz/Divisor_N0. Divisor N0 = Bit [11:0] + 1 The number N is from 1 to 0x7ff. The zero value is reserved.

			The internal 33-bits counter engine will maintain another 12-bits counter. The 12-bits counter is used for counting the cycle number of one 24Mhz clock. When the 12-bits counter reaches ($\geq N$) the divisor value, the internal 33-bits counter register will increase 1 and the 12-bits counter will reset to zero and restart again.
--	--	--	---

3.7.4.13. Watchdog0 IRQ Enable Register (Default Value: 0x00000000)

Offset:0xA0			Register Name: WDOG0_IRQ_EN_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	WDOG0_IRQ_EN. Watchdog0 Interrupt Enable. 0: No effect, 1: Watchdog0 interrupt enable.

3.7.4.14. Watchdog0 Status Register (Default Value: 0x00000000)

Offset:0xA4			Register Name: WDOG0_IRQ_STA_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	WDOG0_IRQ_PEND. Watchdog0 n IRQ Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending, watchdog0 interval value is reached.

3.7.4.15. Watchdog0 Control Register (Default Value: 0x00000000)

Offset:0xB0			Register Name: WDOG0_CTRL_REG
Bit	R/W	Default/Hex	Description
31:13	/	/	/
12:1	R/W	0x0	WDOG0_KEY_FIELD. Watchdog0 Key Field. Should be written at value 0xA57. Writing any other value in this field aborts the write operation.
0	R/W	0x0	WDOG0_RSTART. Watchdog0 Restart. 0: No effect, 1: Restart watchdog0.

3.7.4.16. Watchdog0 Configuration Register (Default Value: 0x00000001)

Offset:0xB4			Register Name: WDOG0_CFG_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1:0	R/W	0x1	WDOG0_CONFIG. Watchdog0 generates a reset signal 00: / 01: To whole system 10: Only interrupt 11: /

3.7.4.17. Watchdog0 Mode Register (Default Value: 0x00000000)

Offset:0xB8			Register Name: WDOG0_MODE_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:4	R/W	0x0	WDOG0_INTV_VALUE. Watchdog0 Interval Value Watchdog0 clock source is <i>OSC24M / 750</i> . If the clock source is turned off, Watchdog 0 will not work. 0000: 16000 cycles (0.5s) 0001: 32000 cycles (1s) 0010: 64000 cycles (2s) 0011: 96000 cycles (3s) 0100: 128000 cycles (4s) 0101: 160000 cycles (5s) 0110: 192000 cycles (6s) 0111: 256000 cycles (8s) 1000: 320000 cycles (10s) 1001: 384000 cycles (12s) 1010: 448000 cycles (14s) 1011: 512000 cycles (16s) others: /
3:1	/	/	/
0	R/W	0x0	WDOG0_EN. Watchdog0 Enable. 0: No effect; 1: Enable watchdog0.

3.7.5. Programming Guidelines

3.7.5.1. Timer

Take making a Timer0 1ms delay for an example, 24M clock source, single mode and 2 pre-scale will be selected in the instance.

```
writel(0x2EE0,TMR_0_INTV);           //Set interval value
writel(0x94, TMR_0_CTRL);             //Select Single mode,24MHz clock source,2 pre-scale
writel(readl(TMR_0_CTRL)|(1<<1), TMR_0_CTRL); //Set Reload bit
while((readl(TMR_0_CTRL)>>1)&1);       //Waiting Reload bit turns to 0
writel(readl(TMR_0_CTRL)|(1<<0), TMR_0_CTRL); //Enable Timer0
```

3.7.5.2. Watchdog Reset

In the following instance making configurations for Watchdog: configure clock source as 24M/750, configure Interval Value as 1s and configure Watchdog Configuration as To whole system. This instance indicates that reset system after 1s.

```
writel(0x1, WDOG_CONFIG);             //To whole system
writel(0x10, WDOG_MODE);               //Interval Value set 1s
writel(readl(WDOG_MODE)|(1<<0), WDOG_MODE); //Enable Watchdog
```

3.7.5.3. Watchdog Restart

In the following instance making configurations for Watchdog: configure clock source as 24M/750, configure Interval Value as 1s and configure Watchdog Configuration as To whole system. In the following instance, if the time of other codes is larger than 1s, watchdog will reset the whole system. If the sentence of restart watchdog is implemented inside 1s, watchdog will be restarted.

```
writel(0x1, WDOG_CONFIG);             //To whole system
writel(0x10, WDOG_MODE);               //Interval Value set 1s
writel(readl(WDOG_MODE)|(1<<0), WDOG_MODE); //Enable Watchdog
---other codes---
writel(readl(WDOG_CTRL)|(0xA57<<1)|(1<<0), WDOG_CTRL); //Writel 0xA57 at Key Field and Restart Watchdog
```

3.8. Trusted Watchdog

3.8.1. Overview

The trusted watchdog is primarily used to protect the trusted world operations from denial of service when secure services are dependent to the RichOS scheduler. For example, if the trusted world is not entered after a defined time limit the SoC is re-started to perform an authentication of the system.

The trusted watchdog can also be used to mask the real cause of a security error thanks to the delayed warm reset it generates.

3.8.2. Block Diagram

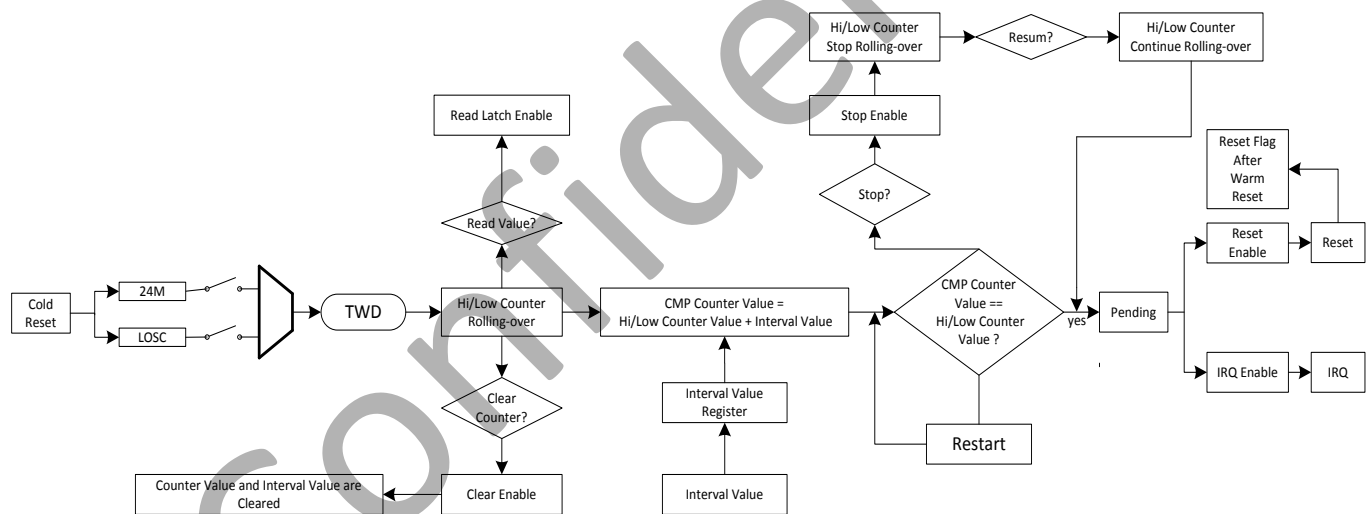


Figure 3-5. TWD Block Diagram

The trusted watchdog must always be running when the SoC wakes up from cold reset and can be refreshed, suspended, or reset only by secure accesses. And a clock of at least 32 kHz is used when the device is not a power saving cycles.

The trusted watchdog timer is able to generate a SoC warm reset after a duration programmed into the timer or set by default in hardware. And the flag indicating the occurrence of a watchdog triggered warm reset has occurred since the last cold reset.

Clock sources driving the watchdog timer must be controlled or managed by a trusted entity. This means that non-trusted world accesses are not permitted to turn on, turn off or modify the characteristics of clock source. The **Clear Enable** will reset relevant bits in the watchdog registers, except the reset flag.

3.8.3. TWD Register List

Module Name	Base Address
TWD	0x01F01800

Register Name	Offset	Description
TWD_STATUS_REG	0x0000	TWD Status Register
TWD_CTRL_REG	0x0010	TWD Control Register
TWD_RESTART_REG	0x0014	TWD Restart Register
TWD_LOW_CNT_REG	0x0020	TWD Low Counter Register
TWD_HIGH_CNT_REG	0x0024	TWD High Counter Register
TWD_INTV_VAL_REG	0x0030	TWD Interval Value Register
TWD_LOW_CNT_CMP_REG	0x0040	TWD Low Counter Compare Register
TWD_HIGH_CNT_CMP_REG	0x0044	TWD High Counter Compare Register
SST_NV_CNT_REG	0x0100	Secure Storage NV-Counter Register
SYN_DATA_CNT_REG0	0x0110	Synchronize Data Counter Register 0
SYN_DATA_CNT_REG1	0x0114	Synchronize Data Counter Register 1
SYN_DATA_CNT_REG2	0x0118	Synchronize Data Counter Register 2
SYN_DATA_CNT_REG3	0x011C	Synchronize Data Counter Register 3

3.8.4. TWD Register Description

3.8.4.1. TWD Status Register (Default Value: 0x00000000)

Offset: 0x0000			Register Name: TWD_STATUS_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	TWD_PEND_FLAG. Interrupt pending. Set 1 to the bit will clear it. 0: No effect. 1: Pending.

3.8.4.2. TWD Control Register (Default Value: 0x00000000)

Offset: 0x0010			Register Name: TWD_CTRL_REG
Bit	R/W	Default/Hex	Description

31	R/W	0x0	CNT64_CLK_SRC_SEL. 64-bit counter clock source select. 0: LOSC. 1: OSC24M.
30:10	/	/	/
9	R/W	0x0	TWD_RESET_EN. TWD reset enable. 0: Reset disable. 1: Reset enable.
8	R/W	0x0	TWD_INT_EN. TWD Interrupt Enable. 0: Interrupt disable. 1: Interrupt enable.
7:2	/	/	/
1	R/W	0x0	TWD_STOP_EN. TWD stop enable. 0: Resume rolling-over. 1: Stop rolling-over.
0	R/W	0x0	TWD_CLR_EN. TWD clear enable. 0: No effect. 1: To clear relevant registers and it will change to zero after the registers are cleared.

3.8.4.3. TWD Restart Register (Default Value: 0x00000000)

Offset: 0x0014			Register Name: TWD_RESTART_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	WO	0x0	TWD_RESTART_KEYFILED. Should be written at value 0xD14. Writing any other value in this field aborts the write operation.
15:1	/	/	/
0	WO	0x0	TWD_RESTART_EN. If writing '1' in this bit, the value of <i>Counter Compare Registers</i> would change. 0: No effect. 1: Restart enable.

3.8.4.4. TWD Low Counter Register (Default Value: 0x00000000)

Offset: 0x0020	Register Name: TWD_LOW_CNT_REG
----------------	---------------------------------------

Bit	R/W	Default/Hex	Description
31:0	RO	0x0	TWD_LOW_CNT. The TWD low 32-bit counter.

3.8.4.5. TWD High Counter Register (Default Value: 0x00000000)

Offset: 0x0024			Register Name: TWD_HIGH_CNT_REG
Bit	R/W	Default/Hex	Description
31:0	RO	0x0	TWD_HIGH_CNT. The TWD high 32-bit counter.

3.8.4.6. TWD Interval Value Register (Default Value: 0x00000000)

Offset: 0x0030			Register Name: TWD_INTV_VAL_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	TWD_INTV_VAL. The TWD interval value.

3.8.4.7. TWD Low Counter Compare Register (Default Value: 0x00000000)

Offset: 0x0040			Register Name: TWD_LOW_CNT_CMP_REG
Bit	R/W	Default/Hex	Description
31:0	RO	0x0	TWD_LOW_CMP. The TWD low 32-bit compare counter.

3.8.4.8. TWD High Counter Compare Register (Default Value: 0x00000000)

Offset: 0x0044			Register Name: TWD_HIGH_CNT_CMP_REG
Bit	R/W	Default/Hex	Description
31:0	RO	0x0	TWD_HIGH_CMP. The TWD high 32-bit compare counter.

3.8.4.9. Secure Storage NV-Counter Register (Default Value: 0x00000000)

Offset: 0x0100			Register Name: SST_NV_CNT_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	SST_NV_CNT. This counter protects the trusted world Secure Storage file from replay

			attacks.
--	--	--	----------

3.8.4.10. Synchronize Data Counter Register 0 (Default Value: 0x00000000)

Offset: 0x0110			Register Name: SYN_DATA_CNT_REG0
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	SYN_DATA_CNT0. This counter is used for synchronizing data stores against replay attacks.

3.8.4.11. Synchronize Data Counter Register 1 (Default Value: 0x00000000)

Offset: 0x0114			Register Name: SYN_DATA_CNT_REG1
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	SYN_DATA_CNT1. This counter is used for synchronizing data stores against replay attacks.

3.8.4.12. Synchronize Data Counter Register 2 (Default Value: 0x00000000)

Offset: 0x0118			Register Name: SYN_DATA_CNT_REG2
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	SYN_DATA_CNT2. This counter is used for synchronizing data stores against replay attacks.

3.8.4.13. Synchronize Data Counter Register 3 (Default Value: 0x00000000)

Offset: 0x011C			Register Name: SYN_DATA_CNT_REG3
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	SYN_DATA_CNT3. This counter is used for synchronizing data stores against replay attacks.

3.9. High-speed Timer

3.9.1. Overview

High Speed Timer Clock Source are fixed to AHBCLK, which is much higher than OSC24M. Compared with other timers, High Speed Timer clock source is synchronized with AHB clock. When the current value in both LO and HI Current Value Register are counting down to zero, the timer will generate interrupt if set interrupt enable bit.

The HSTimer includes the following features:

- 56-bit counter
- Clock source is synchronized with AHB clock, which means calculating much more accurate than other timers

3.9.2. Operation Principle

3.9.2.1. HSTimer clock gating and software reset

By default the HSTimer clock gating is mask. When it is necessary to use HSTimer, it's clock gating should be open in **BUS Clock Gating Register0** and then de-assert the software reset in **BUS Software Reset Register0** on CCU module. If it is no need to use HSTimer, both the gating bit and software reset bit should be set 0.

3.9.2.2. HSTimer reload bit

Differing from the reload of Timer, when interval value is reloaded into current value register, the reload bit would not turn to 0 automatically until you clear it. If software hopes the current value register to down-count from the new interval value in pause status, the reload bit and the enable bit should be written 1 at the same time.

3.9.3. HSTimer Register List

Module Name	Base Address
-------------	--------------

High Speed Timer	0x01C60000
------------------	------------

Register Name	Offset	Description
HS_TMR_IRQ_EN_REG	0x00	HS Timer IRQ Enable Register
HS_TMR_IRQ_STAS_REG	0x04	HS Timer Status Register
HS_TMR_CTRL_REG	0x10	HS Timer Control Register
HS_TMR_INTV_LO_REG	0x14	HS Timer Interval Value Low Register
HS_TMR_INTV_HI_REG	0x18	HS Timer Interval Value High Register
HS_TMR_CURNT_LO_REG	0x1C	HS Timer Current Value Low Register
HS_TMR_CURNT_HI_REG	0x20	HS Timer Current Value High Register

3.9.4. HSTimer Register Description

3.9.4.1. HS Timer IRQ Enable Register (Default Value: 0x00000000)

Offset:0x0			Register Name: HS_TMR_IRQ_EN_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	HS_TMR_INT_EN. High Speed Timer Interrupt Enable. 0: No effect; 1: High Speed Timer Interval Value reached interrupt enable.

3.9.4.2. HS Timer IRQ Status Register (Default Value: 0x00000000)

Offset:0x4			Register Name: HS_TMR_IRQ_STAS_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	HS_TMR_IRQ_PEND. High Speed Timer IRQ Pending. Set 1 to the bit will clear it. 0: No effect; 1: Pending, High speed timer interval value is reached.

3.9.4.3. HS Timer Control Register (Default Value: 0x00000000)

Offset:0x10	Register Name: HS_TMR_CTRL_REG
-------------	---------------------------------------

Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0x0	HS_TMR_MODE. High Speed Timer mode. 0: Continuous mode. When interval value reached, the timer will not disable automatically. 1: Single mode. When interval value reached, the timer will disable automatically.
6:4	R/W	0x0	HS_TMR_CLK Select the pre-scale of the high speed timer clock sources. 000: /1 001: /2 010: /4 011: /8 100: /16 101: / 110: / 111: /
3:2	/	/	/
1	R/W	0x0	HS_TMR_RELOAD. High Speed Timer Reload. 0: No effect, 1: Reload High Speed Timer Interval Value.
0	R/W	0x0	HS_TMR_EN. High Speed Timer Enable. 0: Stop/Pause, 1: Start. If the timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0. If the current counter does not reach the zero, the timer enable bit is set to "0", the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1. In timer pause state, the interval value register can be modified. If the timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time.

3.9.4.4. HS Timer Interval Value Lo Register

Offset:0x14			Register Name: HS_TMR_INTV_LO_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	x	HS_TMR_INTV_VALUE_LO. High Speed Timer Interval Value [31:0].

3.9.4.5. HS Timer Interval Value Hi Register

Offset:0x18			Register Name: HS_TMR_INTV_HI_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R/W	x	HS_TMR_INTV_VALUE_HI. High Speed Timer Interval Value [55:32].

Note:

The interval value register is a 56-bit register. When read or write the interval value, the Lo register should be read or write first. And the Hi register should be written after the Lo register.

3.9.4.6. HS Timer Current Value Lo Register

Offset:0x1C			Register Name: HS_TMR_CURNT_LO_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	x	HS_TMR_CUR_VALUE_LO. High Speed Timer Current Value [31:0].

3.9.4.7. HS Timer Current Value Hi Register

Offset:0x20			Register Name: HS_TMR_CURNT_HI_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R/W	x	HS_TMR_CUR_VALUE_HI. High Speed Timer Current Value [55:32].

Note:

- HSTimer current value is a 56-bit down-counter (from interval value to 0).
- The current value register is a 56-bit register. When read or write the current value, the Lo register should be read or write first.

3.9.5. Programming Guidelines

Take making a 1us delay using HSTimer for an instance as follow, AHB1CLK will be configured as 100MHz and n_mode, Single mode and 2 pre-scale will be selected in this instance.

```
writel(0x0, HS_TMR_INTV_HI);           //Set interval value Hi 0x0
writel(0x32, HS_TMR_INTV_LO);          //Set interval value Lo 0x32
writel(0x90, HS_TMR_CTRL);             //Select n_mode,2 pre-scale,single mode
```

```
writel(readl(HS_TMR_CTRL)|(1<<1), HS_TMR_CTRL); //Set Reload bit
writel(readl(HS_TMR_CTRL)|(1<<0), HS_TMR_CTRL); //Enable HSTimer
While(!(readl(HS_TMR_IRQ_STAT)&1)); //Wait for HSTimer to generate pending
Writel(1,HS_TMR_IRQ_STAT); //Clear HSTimer pending
```

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3.10. PWM

3.10.1. Overview

PWM is suitable for display device such as LVDS. The output of the PWM is a toggling signal whose frequency and duty cycle can be modulated by its programmable registers. Each channel has a dedicated internal 16-bit up counter. If the counter reaches the value stored in the channel period register, it resets. At the beginning of a count period cycle, the PWMOUT is set to active state and count from 0x0000.

The PWM divider divides the clock(24MHz) by 1~4096 according to the pre-scalar bits in the PWM control register.

In PWM cycle mode, the output will be a square waveform, the frequency is set to the period register. In PWM pulse mode, the output will be a positive pulse or a negative pulse.

3.10.2. Block Diagram

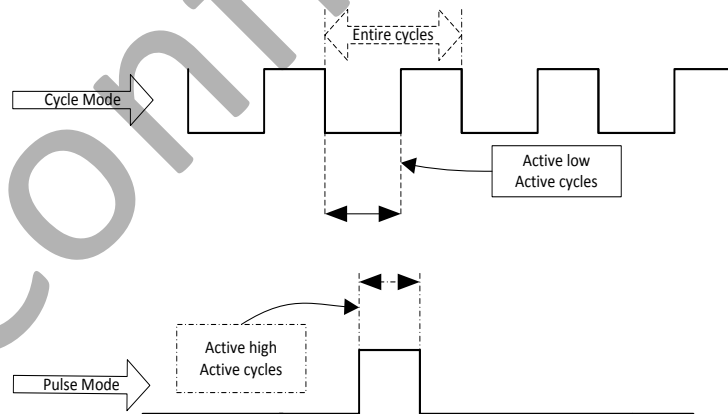


Figure 3-6. PWM Block Diagram

The PWM divider divides the clock (24MHz) by 1-64 according to the pre-scalar bits in the PWM control register. The PWM output Frequency can be divided by 65536 at most. In PWM cycle mode, the output will be a square waveform; the frequency is set to the period register. In PWM pulse mode, the output will be a positive pulse or a negative pulse.

PWM Outputs continuous waveform in Continuous Mode and a pulse waveform in Pulse Mode. Each PWM channel has two 16bit counters existing in corresponding Period Register, whose bit[31:16] indicate one 16bits counter for counting Entire Cycle and bit[15:0] indicate the other 16bits counter for counting Active Cycle.

3.10.3. PWM Register List

Module Name	Base Address
PWM	0x01C21400

Register Name	Offset	Description
PWM_CH_CTRL	0x00	PWM Control Register
PWM_CH0_PERIOD	0x04	PWM Channel 0 Period Register

3.10.4. PWM Register Description

3.10.4.1. PWM Control Register(Default Value: 0x00000000)

Offset:0x0			Register Name: PWM_CTRL_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28	RO	0x0	PWM0_RDY. PWM0 period register ready. 0: PWM0 period register is ready to write, 1: PWM0 period register is busy.
27:10	/	/	/
9	R/W	0x0	PWM0_BYPASS. PWM CH0 bypass enable. If the bit is set to 1, PWM0's output is OSC24MHz. 0: disable, 1: enable.
8	R/W	0x0	PWM_CH0_PUL_START. PWM Channel 0 pulse output start. 0: no effect, 1: output 1 pulse. The pulse width should be according to the period 0 register[15:0],and the pulse state should be according to the active state. After the pulse is finished,the bit will be cleared automatically.
7	R/W	0x0	PWM_CHANNELO_MODE. 0: cycle mode, 1: pulse mode.

6	R/W	0x0	SCLK_CH0_GATING. Gating the Special Clock for PWM0(0: mask, 1: pass).
5	R/W	0x0	PWM_CH0_ACT_STA. PWM Channel 0 Active State. 0: Low Level, 1: High Level.
4	R/W	0x0	PWM_CH0_EN. PWM Channel 0 Enable. 0: Disable, 1: Enable.
3:0	R/W	0x0	PWM_CH0_PRESCAL. PWM Channel 0 Prescaler. These bits should be setting before the PWM Channel 0 clock gate on. 0000: /120 0001: /180 0010: /240 0011: /360 0100: /480 0101: / 0110: / 0111: / 1000: /12k 1001: /24k 1010: /36k 1011: /48k 1100: /72k 1101: / 1110: / 1111: /1

3.10.4.2. PWM Channel 0 Period Register(Default Value: 0x00000000)

Offset:0x4			Register Name: PWM_CH0_PERIOD
Bit	R/W	Default/Hex	Description
31:16	R/W	x	PWM_CH0_ENTIRE_CYS Number of the entire cycles in the PWM clock. 0 = 1 cycle 1 = 2 cycles N = N+1 cycles If the register need to be modified dynamically, the PCLK should be faster than the PWM CLK (PWM CLK = 24MHz/pre-scale).
15:0	R/W	x	PWM_CH0_ENTIRE_ACT_CYS Number of the active cycles in the PWM clock. 0 = 0 cycle 1 = 1 cycles

			 N = N cycles
--	--	--	-----------------------

Note:

The active cycles should be no larger than the period cycles.

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3.11. DMA

3.11.1. Overview

There are 8 DMA channels in the chip. Each DMA channel can generate interrupts. According to different pending status, the referenced DMA channel generates corresponding interrupt. And, the configuration information of every DMA channel are storing in the DDR or SRAM. When start a DMA transferring, the **DMA Channel Descriptor Address Register** contains the address information in the DDR or SRAM, where has the relevance configuration information of the DMA transferring.

3.11.2. Functionalities Description

3.11.2.1. Block Diagram

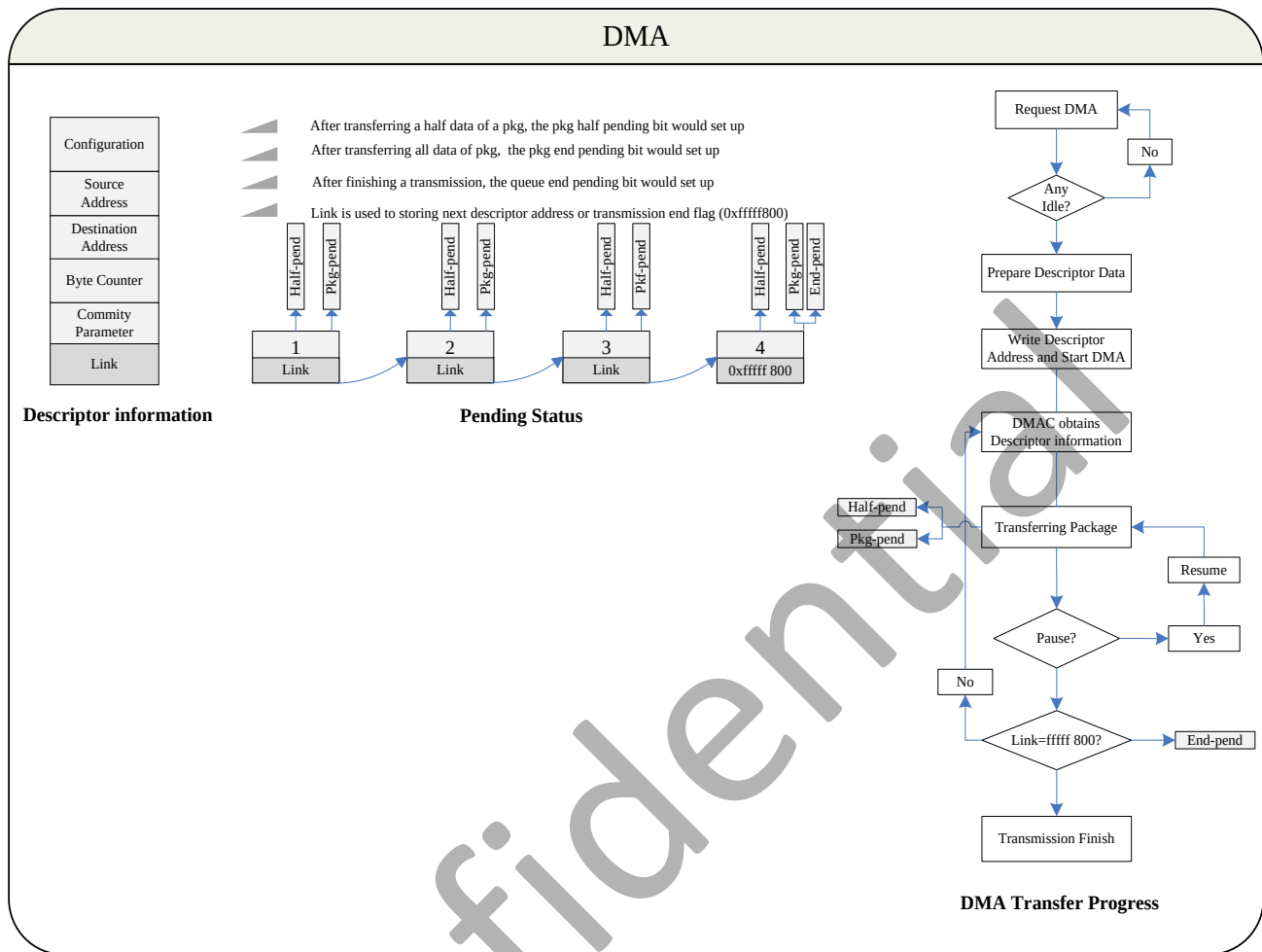


Figure 3-7. DMA Block Diagram

3.11.2.2. DRQ Type and Corresponding Relation

Table 3-1. DMA DRQ Table

Source DRQ Type		Destination DRQ Type	
Port NO.	Module Name	Port NO.	Module Name
Port 0	SRAM	Port 0	SRAM
Port 1	SDRAM	Port 1	SDRAM
Port 2	OWA_RX	Port 2	OWA_TX
Port 3	DAUDIO0_RX	Port 3	DAUDIO0_TX
Port 4	DAUDIO1_RX	Port 4	DAUDIO1_TX
Port 5	NAND	Port 5	NAND
Port 6	UART0_RX	Port 6	UART0_TX
Port 7	UART1_RX	Port 7	UART1_TX
Port 8	UART2_RX	Port 8	UART2_TX

Port 9	UART3_RX	Port 9	UART3_TX
Port 10	UART4_RX	Port 10	UART4_TX
Port 11	/	Port 11	/
Port 12	/	Port 12	/
Port 13	/	Port 13	/
Port 14	/	Port 14	/
Port 15	/	Port 15	/
Port 16	/	Port 16	/
Port 17	USB DRD_EP1	Port 17	USB DRD_EP1
Port 18	USB DRD_EP2	Port 18	USB DRD_EP2
Port 19	USB DRD_EP3	Port 19	USB DRD_EP3
Port20	USB DRD_EP4	Port 20	USB DRD_EP4
Port 21	USB DRD_EP5	Port 21	USB DRD_EP5
Port 22	/	Port 22	/
Port 23	SPI0_RX	Port 23	SPI0_TX
Port 24	SPI1_RX	Port 24	SPI1_TX
Port 25		Port 25	
Port 26		Port 26	
Port 27		Port 27	DAUDIO2_TX
Port 28	TDM-RX	Port 28	TDM-TX
Port 29		Port 29	
Port 30		Port 30	

Note:

SRAM or DRAM DRQ signal is always high.

3.11.2.3. DMA Descriptor

In this section, the DMA descriptor registers will be introduced in detail.

When starting a DMA transmission, the module data are transferred as packages, which have the link data information. And, by reading the DMA Status Register, the status of a DMA channel could be known. Reading back the descriptor address register, the value is the link data in the transferring package. If only the value is equal to 0xfffff800, then it can be regarded as NULL, which means the package is the last package in this DMA transmission. Otherwise, the value means the start address of the next package. And, the Descriptor Address Register can be changed during a package transferring.

When transferring the half of a package, the relevant pending bit will be set up automatically, and if the corresponding interrupt is enabled, DMA generates an interrupt to the system. The similar thing would occur when transferring a package completely. Meanwhile, if DMA have transferred the last package in the data, the relevant pending bit would be set up, and generates an interrupt if the corresponding interrupt is enabled. The flow-process diagram is showed in Block Diagram section.

During a DMA transmission, the configuration could be obtained via the Configuration Register. And, behind the address of the config register in DDR or SRAM, there are some registers including other information of a DMA transmission. The

structure chart is showed in Block Diagram section. Also, other information of a transferring data can be obtained by reading the Current Source Address Register, Current Destination Address Register and Byte Counter Left Register. The configuration must be word-aligning.

The transferring data would be paused when setting up the relevant Pause Register, if coming up emergency. And the pausing data could be presumable when set 0 to the same bit in Pause Register.

3.11.3. DMA Register List

Module Name	Base Address
DMA	0x01C02000

Register Name	Offset	Description
DMA_IRQ_EN_REG	0x0	DMA IRQ Enable Register
DMA_IRQ_PEND_REG	0x10	DMA IRQ Pending Register
DMA_AUTO_GATE_REG	0x20	DMA Auto Gating Register
DMA_SECURE_REG	0x28	DMA Security Register
DMA_STA_REG	0x30	DMA Status Register
DMA_EN_REG	$0x100+N*0x40$	DMA Channel Enable Register (N=0~7)
DMA_PAU_REG	$0x100+N*0x40+0x4$	DMA Channel Pause Register (N=0~7)
DMA_DESC_ADDR_REG	$0x100+N*0x40+0x8$	DMA Channel Start Address Register (N=0~7)
DMA_CFG_REG	$0x100+N*0x40+0xC$	DMA Channel Configuration Register (N=0~7)
DMA_CUR_SRC_REG	$0x100+N*0x40+0x10$	DMA Channel Current Source Register (N=0~7)
DMA_CUR_DEST_REG	$0x100+N*0x40+0x14$	DMA Channel Current Destination Register (N=0~7)
DMA_BCNT_LEFT_REG	$0x100+N*0x40+0x18$	DMA Channel Byte Counter Left Register (N=0~7)
DMA_PARA_REG	$0x100+N*0x40+0x1C$	DMA Channel Parameter Register (N=0~7)

3.11.4. DMA Register Description

3.11.4.1. DMA IRQ Enable Register (Default Value: 0x00000000)

Offset: 0x0000			Register Name: DMA_IRQ_EN_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30	R/W	0x0	DMA7_QUEUE_IRQ_EN DMA 7 Queue End Transfer Interrupt Enable. 0: Disable, 1: Enable.
29	R/W	0x0	DMA7_PKG_IRQ_EN DMA 7 Package End Transfer Interrupt Enable. 0: Disable, 1: Enable.
28	R/W	0x0	DMA7_HLAF_IRQ_EN DMA 7 Half Package Transfer Interrupt Enable. 0: Disable, 1: Enable.
27	/	/	/
26	R/W	0x0	DMA6_QUEUE_IRQ_EN DMA 6 Queue End Transfer Interrupt Enable. 0: Disable, 1: Enable.
25	R/W	0x0	DMA6_PKG_IRQ_EN DMA 6 Package End Transfer Interrupt Enable. 0: Disable, 1: Enable.
24	R/W	0x0	DMA6_HLAF_IRQ_EN DMA 6 Half Package Transfer Interrupt Enable. 0: Disable, 1: Enable.
23	/	/	/
22	R/W	0x0	DMA5_QUEUE_IRQ_EN DMA 5 Queue End Transfer Interrupt Enable. 0: Disable, 1: Enable.
21	R/W	0x0	DMA5_PKG_IRQ_EN DMA 5 Package End Transfer Interrupt Enable. 0: Disable, 1: Enable.
20	R/W	0x0	DMA5_HLAF_IRQ_EN DMA 5 Half package Transfer Interrupt Enable. 0: Disable, 1: Enable.
19	/	/	/
18	R/W	0x0	DMA4_QUEUE_IRQ_EN DMA 4 Queue End Transfer Interrupt Enable. 0: Disable, 1: Enable.
17	R/W	0x0	DMA4_PKG_IRQ_EN DMA 4 Package End Transfer Interrupt Enable.

			0: Disable, 1: Enable.
16	R/W	0x0	DMA4_HLAF_IRQ_EN DMA 4 Half Package Transfer Interrupt Enable. 0: Disable, 1: Enable.
15	/	/	/
14	R/W	0x0	DMA3_QUEUE_IRQ_EN DMA 3 Queue End Transfer Interrupt Enable. 0: Disable, 1: Enable.
13	R/W	0x0	DMA3_PKG_IRQ_EN DMA 3 Package End Transfer Interrupt Enable. 0: Disable, 1: Enable.
12	R/W	0x0	DMA3_HLAF_IRQ_EN DMA 3 Half Package Transfer Interrupt Enable. 0: Disable, 1: Enable.
11	/	/	/
10	R/W	0x0	DMA2_QUEUE_IRQ_EN DMA 2 Queue End Transfer Interrupt Enable. 0: Disable, 1: Enable.
9	R/W	0x0	DMA2_PKG_IRQ_EN DMA 2 Package End Transfer Interrupt Enable. 0: Disable, 1: Enable.
8	R/W	0x0	DMA2_HLAF_IRQ_EN DMA 2 Half Package Transfer Interrupt Enable. 0: Disable, 1: Enable.
7	/	/	/
6	R/W	0x0	DMA1_QUEUE_IRQ_EN DMA 1 Queue End Transfer Interrupt Enable. 0: Disable, 1: Enable.
5	R/W	0x0	DMA1_PKG_IRQ_EN DMA 1 Package End Transfer Interrupt Enable. 0: Disable, 1: Enable.
4	R/W	0x0	DMA1_HLAF_IRQ_EN DMA 1 Half Package Transfer Interrupt Enable. 0: Disable, 1: Enable.
3	/	/	/
2	R/W	0x0	DMA0_QUEUE_IRQ_EN DMA 0 Queue End Transfer Interrupt Enable. 0: Disable, 1: Enable.
1	R/W	0x0	DMA0_PKG_IRQ_EN DMA 0 Package End Transfer Interrupt Enable. 0: Disable, 1: Enable.
0	R/W	0x0	DMA0_HLAF_IRQ_EN DMA 0 Half Package Transfer Interrupt Enable. 0: Disable, 1: Enable

3.11.4.2. DMA IRQ Pending Status Register (Default Value: 0x00000000)

Offset:0x10			Register Name: DMA_IRQ_PEND_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30	R/W	0x0	DMA7_QUEUE_IRQ_PEND. DMA 7 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
29	R/W	0x0	DMA7_PKG_IRQ_PEND DMA 7 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
28	R/W	0x0	DMA7_HLAF_IRQ_PEND. DMA 7 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
27	/	/	/
26	R/W	0x0	DMA6_QUEUE_IRQ_PEND. DMA 6 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
25	R/W	0x0	DMA6_PKG_IRQ_PEND DMA 6 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
24	R/W	0x0	DMA6_HLAF_IRQ_PEND. DMA 6 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
23	/	/	/
22	R/W	0x0	DMA5_QUEUE_IRQ_PEND. DMA 5 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
21	R/W	0x0	DMA5_PKG_IRQ_PEND DMA 5 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
20	R/W	0x0	DMA5_HLAF_IRQ_PEND. DMA 5 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
19	/	/	/
18	R/W	0x0	DMA4_QUEUE_IRQ_PEND. DMA 4 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
17	R/W	0x0	DMA4_PKG_IRQ_PEND DMA 4 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
16	R/W	0x0	DMA4_HLAF_IRQ_PEND. DMA 4 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.

15	/	/	/
14	R/W	0x0	DMA3_QUEUE_IRQ_PEND. DMA 3 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
13	R/W	0x0	DMA3_PKG_IRQ_PEND DMA 3 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
12	R/W	0x0	DMA3_HLAF_IRQ_PEND. DMA 3 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
11	/	/	/
10	R/W	0x0	DMA2_QUEUE_IRQ_PEND. DMA 2 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
9	R/W	0x0	DMA2_PKG_IRQ_PEND DMA 2 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
8	R/W	0x0	DMA2_HLAF_IRQ_PEND. DMA 2 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
7	/	/	/
6	R/W	0x0	DMA1_QUEUE_IRQ_PEND. DMA 1 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
5	R/W	0x0	DMA1_PKG_IRQ_PEND DMA 1 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
4	R/W	0x0	DMA1_HLAF_IRQ_PEND. DMA 1 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
3	/	/	/
2	R/W	0x0	DMA0_QUEUE_IRQ_PEND. DMA 0 Queue End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
1	R/W	0x0	DMA0_PKG_IRQ_PEND DMA 0 Package End Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.
0	R/W	0x0	DMA0_HLAF_IRQ_PEND. DMA 0 Half Package Transfer Interrupt Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending.

3.11.4.3. DMA Auto Gating Register (Default Value: 0x00000000)

Offset:0x20	Register Name: DMA_AUTO_GATE_REG
-------------	---

Bit	R/W	Default/Hex	Description
31:3	/	/	/
2	R/W	0x0	DMA_MCLK_CIRCUIT. DMA MCLK interface circuit auto gating bit. 0: Auto gating enable 1: Auto gating disable.
1	R/W	0x0	DMA_COMMON_CIRCUIT. DMA common circuit auto gating bit. 0: Auto gating enable 1: Auto gating disable.
0	R/W	0x0	DMA_CHAN_CIRCUIT. DMA channel circuit auto gating bit. 0: Auto gating enable 1: Auto gating disable.

Note:

When initializing DMA Controller, bit-2 should be set up.

3.11.4.4. DMA Security Register (Default Value: 0x00000000)

Offset: 0x28			Register Name: DMA_SECURE_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0x0	DMA7_SECURE. Indicating DMA 7 security. 0: Secure, 1: Non-secure.
6	R/W	0x0	DMA6_SECURE. Indicating DMA 6 security. 0: Secure, 1: Non-secure.
5	R/W	0x0	DMA5_SECURE. Indicating DMA 5 security. 0: Secure, 1: Non-secure.
4	R/W	0x0	DMA4_SECURE. Indicating DMA 4 security. 0: Secure, 1: Non-secure.
3	R/W	0x0	DMA3_SECURE. Indicating DMA 3 security. 0: Secure, 1: Non-secure.
2	R/W	0x0	DMA2_SECURE. Indicating DMA 2 security. 0: Secure,

			1: Non-secure.
1	R/W	0x0	DMA1_SECURE. Indicating DMA 1 security. 0: Secure, 1: Non-secure.
0	R/W	0x0	DMA0_SECURE. Indicating DMA 0 security. 0: Secure, 1: Non-secure.

3.11.4.5. DMA Status Register (Default Value: 0x00000000)

Offset:0x30			Register Name: DMA_STA_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	RO	0x0	DMA7_STATUS DMA Channel 7 Status. 0: Idle, 1: Busy.
6	RO	0x0	DMA6_STATUS DMA Channel 6 Status. 0: Idle, 1: Busy.
5	RO	0x0	DMA5_STATUS DMA Channel 5 Status. 0: Idle, 1: Busy.
4	RO	0x0	DMA4_STATUS DMA Channel 4 Status. 0: Idle, 1: Busy.
3	RO	0x0	DMA3_STATUS DMA Channel 3 Status. 0: Idle, 1: Busy.
2	RO	0x0	DMA2_STATUS DMA Channel 2 Status. 0: Idle, 1: Busy.
1	RO	0x0	DMA1_STATUS DMA Channel 1 Status. 0: Idle, 1: Busy.
0	RO	0x0	DMA0_STATUS DMA Channel 0 Status. 0: Idle, 1: Busy.

3.11.4.6. DMA Channel Enable Register (Default Value: 0x00000000)

Offset: 0x100+N*0x40+0x0(N=0~7)			Register Name: DMA_EN_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	DMA_EN. DMA Channel Enable 0: Disable, 1: Enable.

3.11.4.7. DMA Channel Pause Register (Default Value: 0x00000000)

Offset: 0x100+N*0x40+0x4(N=0~7)			Register Name: DMA_PAU_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	DMA_PAUSE. Pausing DMA Channel Transfer Data. 0: Resume Transferring, 1: Pause Transferring.

3.11.4.8. DMA Channel Descriptor Address Register

Offset: :0x100+N*0x40+0x8(N=0~7)			Register Name: DMA_DESC_ADDR_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	x	DMA_DESC_ADDR DMA Channel Descriptor Address.

3.11.4.9. DMA Channel Configuration Register (Default Value: 0x00000000)

Offset: 0x100+N*0x40+0xC(N=0~7)			Register Name: DMA_CFG_REG
Bit	R/W	Default/Hex	Description
31:27	/	/	/
26:25	RO	0x0	DMA_DEST_DATA_WIDTH. DMA Destination Data Width. 00: 8-bit 01: 16-bit 10: 32-bit 11: /
24:23	RO	0x0	DMA_DEST_BST_LEN. DMA Destination Burst Length. 00: 1 01: /

			10: 8 11: /
22:21	RO	0x0	DMA_ADDR_MODE. DMA Destination Address Mode 0x0: Linear Mode 0x1: IO Mode 0x2: / 0x3: /
20:16	RO	0x0	DMA_DEST_DRQ_TYPE. DMA Destination DRQ Type The details in DRQ Type and Port Corresponding Relation.
15:11	/	/	/
10:9	RO	0x0	DMA_SRC_DATA_WIDTH. DMA Source Data Width. 00: 8-bit 01: 16-bit 10: 32-bit 11: /
8:7	RO	0x0	DMA_SRC_BST_LEN. DMA Source Burst Length. 00: 1 01: / 10: 8 11: /
6:5	RO	0x0	DMA_SRC_ADDR_MODE. DMA Source Address Mode 0x0: Linear Mode 0x1: IO Mode 0x2: / 0x3: /
4:0	RO	0x0	DMA_SRC_DRQ_TYPE. DMA Source DRQ Type The details in DRQ Type and Port Corresponding Relation.

Note1:

If the DRQ type is dram, then, the corresponding burst length will be fixed, and the options will be invalid.

Note2:

The address of the *DMA Channel Configuration Register* must be word-aligned.

Note3:

If the DRQ type is SRAM, then source address of destination address must be word-aligned.

3.11.4.10. DMA Channel Current Source Address Register (Default Value: 0x00000000)

Offset: 0x100+N*0x40+0x10 (N=0~7)	Register Name: DMA_CUR_SRC_REG
--------------------------------------	---------------------------------------

Bit	R/W	Default/Hex	Description
31:0	RO	0x0	DMA_CUR_SRC. DMA Channel Current Source Address, read only.

Note:

The address of the *DMA Channel Current Source Address Register* must be word-aligned.

3.11.4.11. DMA Channel Current Destination Address Register (Default Value: 0x00000000)

Offset: 0x100+N*0x40+0x14(N=0~7)			Register Name: DMA_CUR_DEST_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	DMA_CUR_DEST. DMA Channel Current Destination Address, read only.

Note:

The address of the *DMA Channel Current Destination Address Register* must be word-aligned.

3.11.4.12. DMA Channel Byte Counter Left Register (Default Value: 0x00000000)

Offset: 0x100+N*0x40+0x18(N=0~7)			Register Name: DMA_BCNT_LEFT_REG
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24:0	RO	0x0	DMA_BCNT_LEFT. DMA Channel Byte Counter Left, read only.

Note:

The address of the *DMA Channel Byte Counter Left Register* must be word-aligned.

3.11.4.13. DMA Channel Parameter Register (Default Value: 0x00000000)

Offset: 0x100+N*0x40+0x1C(N=0~7)			Register Name: DMA_PARA_REG
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15:8	RO	0x0	DATA_BLK_SIZE. Data Block Size N.
7:0	RO	0x0	WAIT_CYC. Wait Clock Cycles n.

Note1:

The number of data block size usually depends on the capacity of the device's FIFO in the practical application.

Note2:

The data block size must be multiple of burst*width (byte). For example: if burst is 4 and the width is 32-bit, so the data block size must be m*16(byte), i.e. N = m * 16.

Note3:

When DMA controller has completed transferring N bytes data, and waiting n clock cycles to check the DRQ signal.

Note4:

This register is only effective to devices, and the Data Block Size N should be 0 if it is less than 32.

Confidential

3.12. GIC

3.12.1. Interrupt Source

Interruptnumber	Interrupt Source	Description
0	Sgi 0	Sgi 0 interrupt
1	Sgi 1	Sgi 1 interrupt
2	Sgi 2	Sgi 2 interrupt
3	Sgi 3	Sgi 3 interrupt
4	Sgi 4	Sgi 4 interrupt
5	Sgi 5	Sgi 5 interrupt
6	Sgi 6	Sgi 6 interrupt
7	Sgi 7	Sgi 7 interrupt
8	Sgi 8	Sgi 8 interrupt
9	Sgi 9	Sgi 9 interrupt
10	Sgi 10	Sgi 10 interrupt
11	Sgi 11	Sgi 11 interrupt
12	Sgi 12	Sgi 12 interrupt
13	Sgi 13	Sgi 13 interrupt
14	Sgi 14	Sgi 14 interrupt
15	Sgi 15	Sgi 15 interrupt
16	Ppi 0	Ppi 0 interrupt
17	Ppi 1	Ppi 1 interrupt
18	Ppi 2	Ppi 2 interrupt
19	Ppi 3	Ppi 3 interrupt
20	Ppi 4	Ppi 4 interrupt
21	Ppi 5	Ppi 5 interrupt
22	Ppi 6	Ppi 6 interrupt
23	Ppi 7	Ppi 7 interrupt
24	Ppi 8	Ppi 8 interrupt
25	Ppi 9	Ppi 9 interrupt
26	Ppi 10	Ppi 10 interrupt
27	Ppi 11	Ppi 11 interrupt
28	Ppi 12	Ppi 12 interrupt
29	Ppi 13	Ppi 13 interrupt
30	Ppi 14	Ppi 14 interrupt
31	Ppi 15	Ppi 15 interrupt
32	UART 0	UART 0 interrupt
33	UART 1	UART 1 interrupt

34	UART 2	UART 2 interrupt
35	UART 3	UART 3 interrupt
36	UART 4	UART 4 interrupt
37		
38	TWI 0	TWI 0 interrupt
39	TWI 1	TWI 1 interrupt
40	TWI 2	TWI 2 interrupt
41		
42		
43		
44	OWA	OWA interrupt
45	DAUDIO-0	DAUDIO-0 interrupt
46	DAUDIO-1	DAUDIO-1 interrupt
47	PB_EINT	PB_EINT interrupt
48		
49	PG_EINT	PG_EINT interrupt
50	Timer 0	Timer 0 interrupt
51	Timer 1	Timer 1 interrupt
52		
53		
54		
55		
56		
57	Watchdog	Watchdog interrupt
58		
59		
60		
61		
62		
63		
64	External NMI	External Non-Mask Interrupt
65	R_timer 0	R_timer 0 interrupt
66	R_timer 1	R_timer 1 interrupt
67		
68	R_watchdog	R_watchdog interrupt
69	R_CIR-RX	R_CIR-RX interrupt
70	R_UART	R_UART interrupt
71	R_RSB	R_RSB interrupt
72		
73	R_TH	R_TH interrupt
74	R_LRADC	R_LRADC interrupt
75		
76	R_TWI	R_TWI interrupt
77	R_PL_EINT	R_PL_EINT interrupt

78	R_TWD	R_TWD interrupt
79		
80		
81	M-box	M-box interrupt
82	DMA	DMA channel interrupt
83	HS Timer	HS Timer interrupt
84		
85		
86		
87		
88	SMC	SMC interrupt
89		
90	VE	VE interrupt
91		
92	SD/MMC 0	SD/MMC Host Controller 0 interrupt
93	SD/MMC 1	SD/MMC Host Controller 1 interrupt
94	SD/MMC 2	SD/MMC Host Controller 2 interrupt
95		
96		
97	SPI 0	SPI 0 interrupt
98	SPI 1	SPI 1 interrupt
99		
100		
101		
102	NAND	NAND Flash Controller interrupt
103	USB-DRD	USB-DRD interrupt
104	USB-EHCI0	USB-EHCI0 interrupt
105	USB-OHCI0	USB-OHCI0 interrupt
106	USB-EHCI1	USB-EHCI1 interrupt
107		
108		
109		
110		
111		
112	SS	SS interrupt
113		
114	EMAC	EMAC interrupt
115	MIPI_CSI	MIPI_CSI interrupt
116	CSI	CSI interrupt
117	CSI_CCI	CSI_CCI interrupt
118	LCD0	LCD0 Controller interrupt
119	LCD1	LCD1 Controller interrupt
120	HDMI	HDMI interrupt
121	MIPI DSI	MIPI DSI interrupt

122		
123	DE_IRQ0	RT-mixer and RTWB interrupt
124	DE_IRQ1	Rotation interrupt
125		
126		
127		
128		
129	GPU	GPU interrupt
130	TDM	TDM interrupt
131	DAUDIO-2	DAUDIO-2 interrupt
132	PH_EINT	PH_EINT interrupt
133		
134		
135		
136		
137		
138		
139		
140		
141		
142		
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145		
146		
147		
148		
159		
150		
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152		
153		
154		
155		
156		
157		
158		
159		
160	Cluster0_CTIO	Cluster0_CTIO interrupt
161	Cluster0_CT11	Cluster0_CT11 interrupt
162	Cluster0_CT12	Cluster0_CT12 interrupt
163	Cluster0_CT13	Cluster0_CT13 interrupt
164	Cluster0_PMU0	Cluster0_PMU0 interrupt
165	Cluster0_PMU1	Cluster0_PMU1 interrupt

166	Cluster0_PMU2	Cluster0_PMU2 interrupt
167	Cluster0_PMU3	Cluster0_PMU3 interrupt
168	Cluster0_AXIERR	Cluster0_AXIERR interrupt
169	Cluster0_COMMTX0	Cluster0_COMMTX0 interrupt
170	Cluster0_COMMTX1	Cluster0_COMMTX1 interrupt
171	Cluster0_COMMTX2	Cluster0_COMMTX2 interrupt
172	Cluster0_COMMTX3	Cluster0_COMMTX3 interrupt
173	Cluster0_COMMRX0	Cluster0_COMMRX0 interrupt
174	Cluster0_COMMRX1	Cluster0_COMMRX1 interrupt
175	Cluster0_COMMRX2	Cluster0_COMMRX2 interrupt
176	Cluster0_COMMRX3	Cluster0_COMMRX3 interrupt
177	Cluster0_AXI_WR	Cluster0_AXI_WR interrupt
178	Cluster0_AXI_RD	Cluster0_AXI_RD interrupt
179	Cluster1_CTI0	Cluster1_CTI0 interrupt
180	Cluster1_CTI1	Cluster1_CTI1 interrupt
181	Cluster1_CTI2	Cluster1_CTI2 interrupt
182	Cluster1_CTI3	Cluster1_CTI3 interrupt
183	Cluster1_PMU0	Cluster1_PMU0 interrupt
184	Cluster1_PMU1	Cluster1_PMU1 interrupt
185	Cluster1_PMU2	Cluster1_PMU2 interrupt
186	Cluster1_PMU3	Cluster1_PMU3 interrupt
187	Cluster1_AXIERR	Cluster1_AXIERR interrupt
188	Cluster1_COMMTX0	Cluster1_COMMTX0 interrupt
189	Cluster1_COMMTX1	Cluster1_COMMTX1 interrupt
190	Cluster1_COMMTX2	Cluster1_COMMTX2 interrupt
191	Cluster1_COMMTX3	Cluster1_COMMTX3 interrupt
192	Cluster1_COMMRX0	Cluster1_COMMRX0 interrupt
193	Cluster1_COMMRX1	Cluster1_COMMRX1 interrupt
194	Cluster1_COMMRX2	Cluster1_COMMRX2 interrupt
195	Cluster1_COMMRX3	Cluster1_COMMRX3 interrupt
196	Cluster1_AXI_WR	Cluster1_AXI_WR interrupt
197	Cluster1_AXI_RD	Cluster1_AXI_RD interrupt
198	CCI400_ERR	CCI400_ERR interrupt
199	CCI400_EVENTOF	CCI400_EVENTOF interrupt

3.13. Message Box

3.13.1. Overview

Message Box provides an MSGBox-interrupt mechanism for on-chip processors intercommunication.

The MSGBox-interrupt mechanism allows the software to establish a communication channel between the two users through a set of registers and associated interrupt signals by sending or receiving messages.

The Message Box includes the following features:

- Two users for Message Box instance(User0 for CPUS and User1 for C0-CPUX/C1-CPUX)
- Eight Message Queues for the MSGBox instance
- Each of Queues could be configured as transmitter or receiver for user
- Two interrupts (one per user) for the MSGBox instance
- Register polling for the MSGBox instance
- 32-bit message width
- Each message queue has four-message FIFO depth

3.13.2. Functionalities Description

3.13.2.1. Typical Applications

Message Box is typically designed for making the on-chip processors interconnection be true. It could establish an interconnection channel between processors by configuring a set of Message Box registers. Each of Message Queues is bidirectional for users, that means, while a message queue is configured as a receiver for a user, it is a transmitter for the interconnectible user beside. If a processor would like to interconnect with the other processor, it should configure one or more Message Queues firstly. Although Message Box provides two interrupt mechanism to notice user to transmit or receive messages, the way check out queue FIFO full status is usually adopted before transmitting a message and receiving a message is still depended on the reception notification. The Message Box is usually applied as the below flow chart:

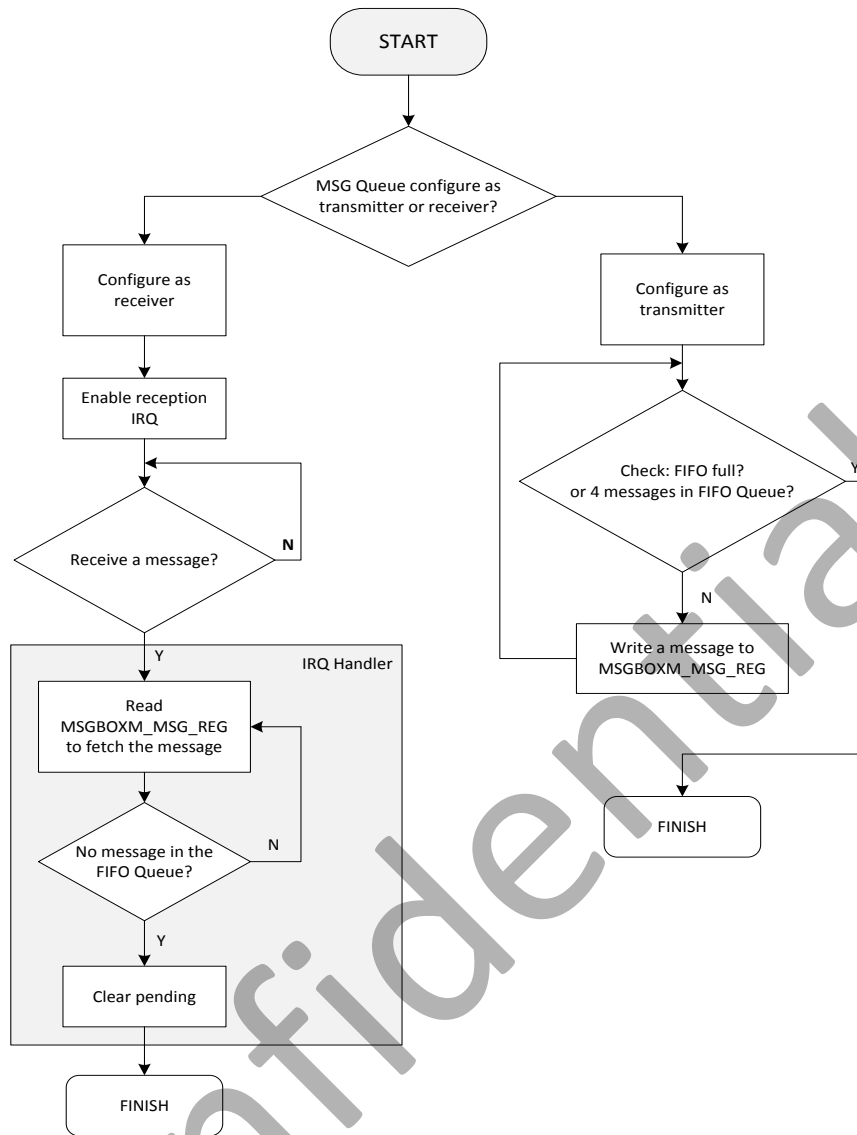


Figure 3-8. Message Box Typical Application Chart

3.13.2.2. Functional Block Diagram

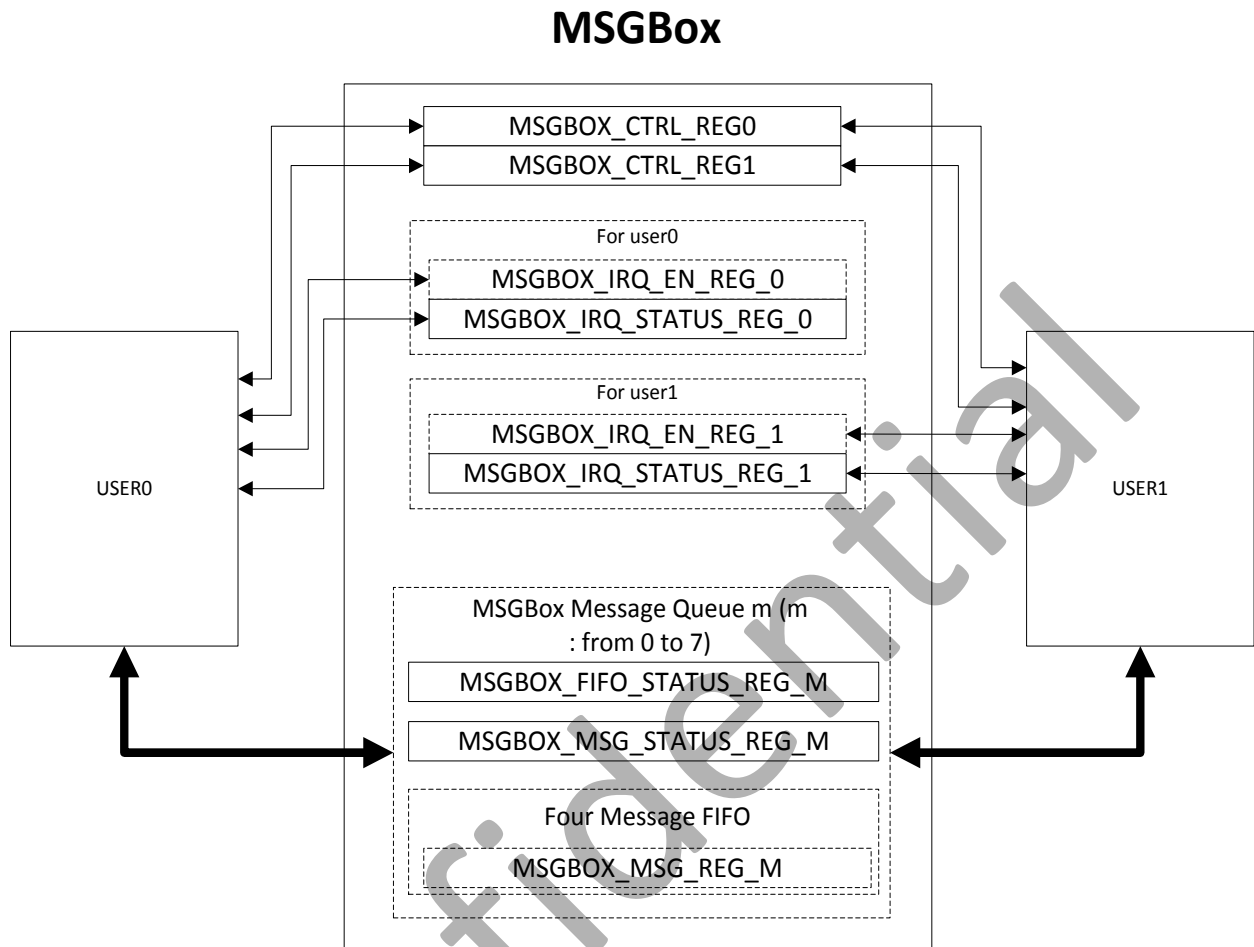


Figure 3-9. Message Box Functional Block Diagram

Message Box supports a set of registers for a processor to establish an interconnection channel with the others. The processor determines message queue numbers for interconnection and the used queues to be transmitter or receiver for itself and the interconnectable one. Every queue has a *MSGBox FIFO Status Register* for processor to check out queue FIFO full status and a *MSGBox Message Status Register* for processor to check out message numbers in queue FIFO. Otherwise, every queue has a corresponding IRQ status bit and a corresponding IRQ enable bit, which used for requesting an interrupt.

3.13.3. Operation Principle

3.13.3.1. Message Box clock gating and software reset

By default the Message Box clock gating is mask. When it is necessary to use Message Box, it's clock gating should be open in *Bus Clock Gating Register1* and then de-assert the software reset in *Bus Software Reset Register1* on CCU module. If it is no need to use Message Box, both the gating bit and software reset bit should set 0.

3.13.3.2. Message Queue Assignment

When a processor needs to transmit or receive a message from the other one, it should configure the Message Queue assignment for the other one and itself. *MSGBOX_CTRL_REG0* and *MSGBOX_CTRL_REG1* hold the eight Message Queues assignment. For an instance, *RECEPTION_MQ0* bit is set to 0 and *TRANSMIT_MQ0* bit is set to 1, which means, user1 transmits messages and user0 receives them. Or *RECEPTION_MQ0* bit and *TRANSMIT_MQ0* bit are both set to 0, which means user0 transmits messages to itself.

3.13.3.3. Interrupt request

Message Box provides Message reception and queue-not-full notification interrupt mechanism. For a Message Queue configured as transmitter for a user, this queue transmit pending bit will always be set to 1 of this user if it is not full. For a Message Queue configured as receiver for a user, this queue reception pending bit will be set to 1 for this user only if it receives a new message. For example, Message Queue0 is configured as a transmitter for user0 and a receiver for user1. The thing Message Queue0 is not full always makes *TRANSMIT_MQ0_IRQ_PEND* bit set to 1. If *TRANSMIT_MQ0_IRQ_EN* bit is set to 1, user0 will request a queue-not-full interrupt. When Message Queue0 has received a new message, *RECEPTION_MQ0_IRQ_PEND* bit would be set to 1 and user1 will request a new message reception interrupt if *RECEPTION_MQ0_IRQ_EN* bit is set to 1. *MSGBox IRQ Status Register u* ($u=0, 1$) hold the IRQ status for user0 and user1. *MSGBox IRQ Enable Register u* ($u=0, 1$) determine whether the user could request the interrupt or not.

3.13.3.4. Transmit and receive messages

Every Message Queue has a couple of private registers for query: *MSGBox Message Status Register* and *MSGBox FIFO Status Register* and a store register bridged to Message Queue FIFO: *MSGBox Message Queue Register*. *MSGBox Message Status Register* records present message number in the Message Queue. *MSGBox FIFO Status Register* indicates whether the Message Queue is full obviously. *MSGBox Message Queue Register* stores the next to be read message of the message FIFO queue or the message to be written into the queue FIFO. The thing that queue is not full

usually indicates that you could write messages into the queue FIFO and that there is one or more message in the queue FIFO indicates that you could read messages from the queue FIFO.

Writing a message into the queue FIFO realizes a transmission and reading a message makes a reception. You could transmit messages by writing messages to MSGBOX Message Queue Register continuously or receive messages by reading MSGBOX Message Queue Register continuously. The writing or reading operation could be continuous means it's no need to make a delay between operations.

3.13.4. Message Box Register List

Module Name	Base Address
MSGBOX	0x01C17000

Register Name	Offset	Description
MSGBOX_CTRL_REG0	0x0000	Message Queue Attribute Control Register 0
MSGBOX_CTRL_REG1	0x0004	Message Queue Attribute Control Register 1
MSGBOXU_IRQ_EN_REG	0x0040+n*0x20	IRQ Enable For User N(N=0,1)
MSGBOXU_IRQ_STATUS_REG	0x0050+n*0x20	IRQ Status For User N(N=0,1)
MSGBOXM_FIFO_STATUS_REG	0x0100+N*0x4	FIFO Status For Message Queue N(N = 0~7)
MSGBOXM_MSG_STATUS_REG	0x0140+N*0x4	Message Status For Message Queue N(N=0~7)
MSGBOXM_MSG_REG	0x0180+N*0x4	Message Register For Message Queue N(N=0~7)

3.13.5. Message Box Register Description

3.13.5.1. MSGBox Control Register 0(Default Value: 0x10101010)

Offset: 0x00			Register Name: MSGBOX_CTRL_REG0
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28	R/W	0x1	TRANSMIT_MQ3. Message Queue 3 is a Transmitter of user u. 0: user0 1: user1
27:25	/	/	/

24	R/W	0x0	RECEPTION_MQ3. Message Queue 3 is a Receiver of user u. 0: user0 1: user1
23:21	/	/	/
20	R/W	0x1	TRANSMIT_MQ2. Message Queue 2 is a Transmitter of user u. 0: user0 1: user1
19:17	/	/	/
16	R/W	0x0	RECEPTION_MQ2. Message Queue 2 is a Receiver of user u. 0: user0 1: user1
15:13	/	/	/
12	R/W	0x1	TRANSMIT_MQ1 Message Queue 1 is a Transmitter of user u. 0: user0 1: user1
11:9	/	/	/
8	R/W	0x0	RECEPTION_MQ1. Message Queue 1 is a Receiver of user u. 0: user0 1: user1
7:5	/	/	/
4	R/W	0x1	TRANSMIT_MQ0. Message Queue 0 is a Transmitter of user u. 0: user0 1: user1
3:1	/	/	/
0	R/W	0x0	RECEPTION_MQ0. Message Queue 0 is a Receiver of user u. 0: user0 1: user1

3.13.5.2. MSGBox Control Register 1(Default Value: 0x10101010)

Offset: 0x04			Register Name: MSGBOX_CTRL_REG1
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28	R/W	0x1	TRANSMIT_MQ7. Message Queue 7 is a Transmitter of user u. 0: user0 1: user1

27:25	/	/	/
24	R/W	0x0	RECEPTION_MQ7. Message Queue 7 is a Receiver of user u. 0: user0 1: user1
23:21	/	/	/
20	R/W	0x1	TRANSMIT_MQ6. Message Queue 6 is a Transmitter of user u. 0: user0 1: user1
19:17	/	/	/
16	R/W	0x0	RECEPTION_MQ6. Message Queue 6 is a Receiver of user u. 0: user0 1: user1
15:13	/	/	/
12	R/W	0x1	TRANSMIT_MQ5 Message Queue 5 is a Transmitter of user u. 0: user0 1: user1
11:9	/	/	/
8	R/W	0x0	RECEPTION_MQ5. Message Queue 5 is a Receiver of user u. 0: user0 1: user1
7:5	/	/	/
4	R/W	0x1	TRANSMIT_MQ4. Message Queue 4 is a Transmitter of user u. 0: user0 1: user1
3:1	/	/	/
0	R/W	0x0	RECEPTION_MQ4. Message Queue 4 is a Receiver of user u. 0: user0 1: user1

3.13.5.3. MSGBox IRQ Enable Register u(u=0,1)(Default Value: 0x00000000)

Offset:0x40+N*0x20 (N=0,1)			Register Name: MSGBOXU_IRQ_EN_REG
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15	R/W	0x0	TRANSMIT_MQ7_IRQ_EN. 0: Disable

			1: Enable (It will Notify user u by interrupt when Message Queue 7 is not full.)
14	R/W	0x0	RECEPTION_MQ7_IRQ_EN. 0: Disable 1: Enable (It will notify user u by interrupt when Message Queue 7 has received a new message.)
13	R/W	0x0	TRANSMIT_MQ6_IRQ_EN. 0: Disable 1: Enable (It will Notify user u by interrupt when Message Queue 6 is not full.)
12	R/W	0x0	RECEPTION_MQ6_IRQ_EN. 0: Disable 1: Enable (It will notify user u by interrupt when Message Queue 6 has received a new message.)
11	R/W	0x0	TRANSMIT_MQ5_IRQ_EN. 0: Disable 1: Enable (It will Notify user u by interrupt when Message Queue 5 is not full.)
10	R/W	0x0	RECEPTION_MQ5_IRQ_EN. 0: Disable 1: Enable (It will notify user u by interrupt when Message Queue 5 has received a new message.)
9	R/W	0x0	TRANSMIT_MQ4_IRQ_EN. 0: Disable 1: Enable (It will Notify user u by interrupt when Message Queue 4 is not full.)
8	R/W	0x0	RECEPTION_MQ4_IRQ_EN. 0: Disable 1: Enable (It will notify user u by interrupt when Message Queue 4 has received a new message.)
7	R/W	0x0	TRANSMIT_MQ3_IRQ_EN. 0: Disable 1: Enable (It will Notify user u by interrupt when Message Queue 3 is not full.)
6	R/W	0x0	RECEPTION_MQ3_IRQ_EN. 0: Disable 1: Enable (It will notify user u by interrupt when Message Queue 3 has received a new message.)
5	R/W	0x0	TRANSMIT_MQ2_IRQ_EN. 0: Disable 1: Enable (It will Notify user u by interrupt when Message Queue 2 is not full.)
4	R/W	0x0	RECEPTION_MQ2_IRQ_EN. 0: Disable 1: Enable (It will notify user u by interrupt when Message Queue 2 has

			received a new message.)
3	R/W	0x0	TRANSMIT_MQ1_IRQ_EN. 0: Disable 1: Enable (It will Notify user u by interrupt when Message Queue 1 is not full.)
2	R/W	0x0	RECEPTION_MQ1_IRQ_EN. 0: Disable 1: Enable (It will notify user u by interrupt when Message Queue 1 has received a new message.)
1	R/W	0x0	TRANSMIT_MQ0_IRQ_EN. 0: Disable 1: Enable (It will Notify user u by interrupt when Message Queue 0 is not full.)
0	R/W	0x0	RECEPTION_MQ0_IRQ_EN. 0: Disable 1: Enable (It will notify user u by interrupt when Message Queue 0 has received a new message.)

3.13.5.4. MSGBox IRQ Status Register u(Default Value: 0x0000AAAA)

Offset:0x50+N*0x20 (N=0,1)			Register Name: MSGBOXU_IRQ_STATUS_REG
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15	R/W	0x1	TRANSMIT_MQ7_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 7 is not full. Set one to this bit will clear it.
14	R/W	0x0	RECEPTION_MQ7_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 7 has received a new message. Set one to this bit will clear it.
13	R/W	0x1	TRANSMIT_MQ6_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 6 is not full. Set one to this bit will clear it.
12	R/W	0x0	RECEPTION_MQ6_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 6 has received a new message. Set one to this bit will clear it.
11	R/W	0x1	TRANSMIT_MQ5_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 5 is not full. Set one to this bit will clear it.
10	R/W	0x0	RECEPTION_MQ5_IRQ_PEND.

			0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 5 has received a new message. Set one to this bit will clear it.
9	R/W	0x1	TRANSMIT_MQ4_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 4 is not full. Set one to this bit will clear it.
8	R/W	0x0	RECEPTION_MQ4_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 4 has received a new message. Set one to this bit will clear it.
7	R/W	0x1	TRANSMIT_MQ3_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 3 is not full. Set one to this bit will clear it.
6	R/W	0x0	RECEPTION_MQ3_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 3 has received a new message. Set one to this bit will clear it.
5	R/W	0x1	TRANSMIT_MQ2_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 2 is not full. Set one to this bit will clear it.
4	R/W	0x0	RECEPTION_MQ2_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 2 has received a new message. Set one to this bit will clear it.
3	R/W	0x1	TRANSMIT_MQ1_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 1 is not full. Set one to this bit will clear it.
2	R/W	0x0	RECEPTION_MQ1_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 1 has received a new message. Set one to this bit will clear it.
1	R/W	01	TRANSMIT_MQ0_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 0 is not full. Set one to this bit will clear it.
0	R/W	0x0	RECEPTION_MQ0_IRQ_PEND. 0: No effect, 1: Pending. This bit will be pending for user u when Message Queue 0 has received a new message. Set one to this bit will clear it.

3.13.5.5. MSGBox FIFO Status Register m(Default Value: 0x00000000)

Offset:0x100+N*0x4 (N=0~7)			Register Name: MSGBOXM_FIFO_STATUS_REG
Bit	R/W	Default/Hex	Description
31: 1	/	/	/
0	RO	0x0	FIFO_FULL_FLAG. 0: The Message FIFO queue is not full (space is available), 1: The Message FIFO queue is full. This FIFO status register has the status related to the message queue.

3.13.5.6. MSGBox Message Status Register m(Default Value: 0x00000000)

Offset:0x140+N*0x4 (N=0~7)			Register Name: MSGBOXM_MSG_STATUS_REG
Bit	R/W	Default/Hex	Description
31:3	/	/	/
2:0	RO	0x0	MSG_NUM. Number of unread messages in the message queue. Here, limited to four messages per message queue. 000: There is no message in the message FIFO queue. 001: There is 1 message in the message FIFO queue. 010: There are 2 messages in the message FIFO queue. 011: There are 3 messages in the message FIFO queue. 100: There are 4 messages in the message FIFO queue. 101~111:/

3.13.5.7. MSGBox Message Queue Register m(Default Value: 0x00000000)

Offset:0x180+N*0x4 (N=0~7)			Register Name: MSGBOXM_MSG_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	The message register stores the next to be read message of the message FIFO queue. Reads remove the message from the FIFO queue.

3.13.6. Programming Guidelines

Assuming that C0-CPU0 establishes an interconnected channel with CPUS using message queue0 and message queue1. The example is as follow:

CPU0 of Cluster 0

Step 1: CPU0 establishes an interconnection channel with CPUS

```
writel(readl(BUS_GATING_REG1)|(1<<21),BUS_GATING_REG1); //open Message Box clock gating
```

```
writel(readl(BUS_RST_REG1)|(1<<21), BUS_RST_REG1);           //software reset Message Box
writel(0x00000110, MSGBOX_CTRL_REG0);                       //set CPU0 transmits messages to CPUS through Queue0 and
                                                            // set CPUS transmits messages to CPU0 through Queue1
Writel(0x4, MSGBOXU_IRQ_EN_REG1);                           //enable queue1 reception irq of user1
Writel(0x1, MSGBOXU_IRQ_EN_REG0);                           //enable queue0 reception irq of user0
```

Step 2: CPU0 transmits 4 messages to CPUS

//before transmitting messages, check out queue FIFO full status or message numbers in queue FIFO.

```
for(i=0;i<4;i++)
```

```
writel(queue0_transmit_buf[i], MSGBOXM_MSG_REG0); //write 4 messages stored in
```

```
// queue0_transmit_buf[i](i=0~4) to queue0
```

step 3: CPU0 waits for CPUS to read all messages in queue0

```
while(readl(MSGBOXM_MSG_STATUS_REG 0)); //CPU0 waits for CPUS to read all messages in queue0
```

Step 4: CPU0 waits for CPUS transmits messages for itself and receive them in queue1 irq handler

```
while(!readl(MSGBOXM_FIFO_STATUS_REG1)); //wait for queue1 turns to full status
```

queue1 irq handler:

```
while(readl(MSGBOXM_MSG_STATUS_REG1) != 0) //read all messages from queue1 and store them in
```

```
{ // queue1_receive_buf[i](i=0~4)
```

```
    rdata=readl(MSGBOXM_MSG_REG 1);
```

```
    writel(rdata,queue0_receive_buf[i]);
```

```
}
```

CPUS

Step 1: CPUS waits for CPU0 transmits messages for itself and receive them in queue0 irq handler

```
while(!readl(MSGBOXM_FIFO_STATUS_REG0)); //wait for queue0 turns to full status
```

queue0 irq handler:

```
while(readl(MSGBOXM_MSG_STATUS_REG0) != 0) //read all messages from queue0 and store them in
```

```
{ // queue0_receive_buf[i](i=0~4)
```

```
    rdata=readl(MSGBOXM_MSG_REG 0);
```

```
    writel(rdata,queue0_receive_buf[i]);
```

```
}
```

Step 2: CPUS transmits 4 messages to CPU0

```
for(i=0;i<4;i++)
```

```
writel(queue1_transmit_buf[i], MSGBOXM_MSG_REG1); //write 4 messages stored in
```

```
// queue1_transmit_buf[i](i=0~4) to queue1
```

The result of the upper instance is: the messages in the queue0_transmit_buf[i](i=0~4) are transmitted to queue0_receive_buf[i](i=0~4) and the messages in the queue1_transmit_buf[i](i=0~4) are transmitted to queue1_receive_buf[i](i=0~4).

3.14. Spinlock

3.14.1. Overview

Spinlock provides hardware assistance for synchronizing the processes running on multiple processors in the device. The SpinLock module implements thirty-two 32-bit spinlocks (or hardware semaphores), which provide an efficient way to perform a lock operation of a device resource using a single read access, thus avoiding the need for a 'read-modify-write' bus transfer that not all the programmable cores are capable of.

Spinlocks are present to solve the need for synchronization and mutual exclusion between heterogeneous processors and those not operating under a single, shared operating system. There is no alternative mechanism to accomplish these operations between processors in separate subsystems. However, Spinlocks do not solve all system synchronization issues. They have limited applicability and should be used with care to implement higher level synchronization protocols.

A spinlock is appropriate for mutual exclusion for access to a shared data structure. It should be used only when:

- 1) The time to hold the lock is predictable and small (for example, a maximum hold time of less than 200 CPU cycles may be acceptable).
- 2) The locking task cannot be preempted, suspended, or interrupted while holding the lock (this would make the hold time large and unpredictable).
- 3) The lock is lightly contended, that is the chance of any other process (or processor) trying to acquire the lock while it is held is small.

If the conditions are not met, then a spinlock is not a good candidate. One alternative is to use a spinlock for critical section control (engineered to meet the conditions) to implement a higher level semaphore that can support preemption, notification, timeout or other higher level properties.

The Spinlock includes the following features:

- Spinlock module includes 32 spinlocks
- Two kinds of status of lock register: TAKEN and NOT TAKEN

3.14.2. Functionalities Description

3.14.2.1. Typical Applications

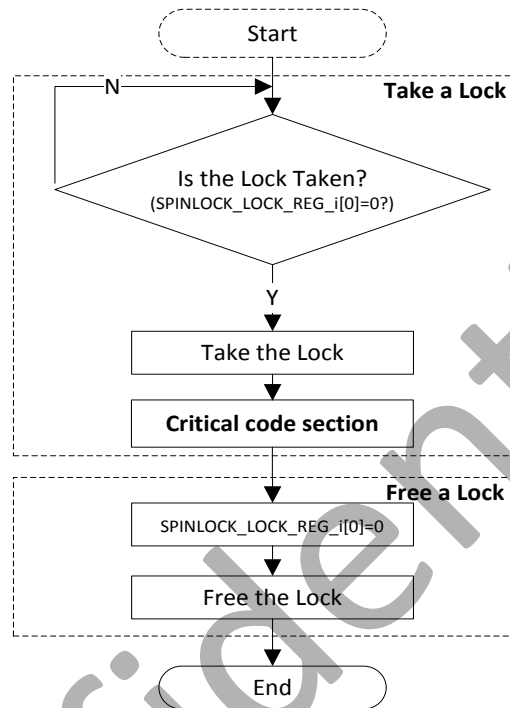


Figure3-10. Spinlock Typical Application Flow Chart

3.14.2.2. Functional Block Diagram

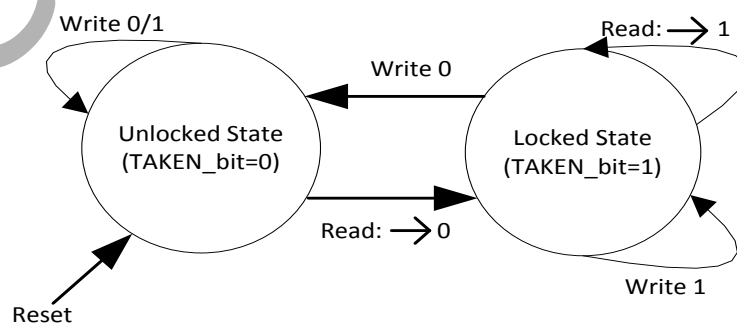


Figure 3-11. Spinlock Lock Register State Diagram

Every lock register has two kinds of states: TAKEN(locked) or NOT TAKEN(Unlocked). Only read-0-access and write-0-access could change lock register' state and the other accesses has no effect. Just 32-bit reads and writes are

supported to access all lock registers.

3.14.3. Operation Principle

3.14.3.1. Spinlock clock gating and software reset

Spinlock clock gating should be open before using it. Setting *Bus Clock Gating Register1* bit[22] to 1 could activate Spinlock and then de-asserting it's software reset. Setting *Bus Software Reset Register1* bit[22] to 1 could de-assert the software reset of Spinlock. If it is no need to use spinlock, both the gating bit and software reset bit should be set 0.

3.14.3.2. Take and free a spinlock

Checking out *SpinLock Register Status* is necessary when a processor would like to take a spinlock. This register stores all 32 lock registers' status: TAKEN or NOT TAKEN(free).

In order to request to take a spinlock, a processor has to do a read-access to the corresponding lock register. If lock register returns 0, the processor takes this spinlock. And if lock register returns 1, the processor must retry.

Writing 0 to a lock register frees the corresponding spinlock. If the lock register is not taken, write-access has no effect. For a taken spinlock, every processor has the privilege to free this spinlock. But it is suggested that the processor which has taken the spinlock free it for strictness.

3.14.4. Spinlock Register List

Module Name	Base Address
Spinlock	0x01C18000

Register Name	Offset	Description
SPINLOCK_SYSTATUS_REG	0x0000	Spinlock System Status Register
SPINLOCK_STATUS_REG	0x0010	Spinlock Status Register
SPINLOCK_LOCK_REGN	0x100+N*0x4	Spinlock Register N (N=0~31)

3.14.5. Spinlock Register Description

3.14.5.1. Spinlock System Status Register (Default Value: 0x10000000)

Offset: 0x0			Register Name: SPINLOCK_SYSTATUS_REG
Bit	R/W	Default/Hex	Description
31:30	/	/	/
29:28	RO	0x1	LOCKS_NUM. Number of lock registers implemented. 0x1: This instance has 32 lock registers. 0x2: This instance has 64 lock registers. 0x3: This instance has 128 lock registers. 0x4: This instance has 256 lock registers.
27:16	/	/	/
15:9	/	/	/
8	RO	0x0	IU0. In-Use flag0, covering lock register0-31. 0: All lock register 0-31 are in the Not Taken state. 1: At least one of the lock register 0-31 is in the Taken state.
7:0	/	/	/

3.14.5.2. Spinlock Register Status (Default Value: 0x00000000)

Offset: 0x10			Register Name: SPINLOCK_STATUS_REG
Bit	R/W	Default/Hex	Description
[i] (i=0~31)	RO	0x0	LOCK_REG_STATUS. SpinLock[i] status (i=0~31) 0: The Spinlock is free, 1: The Spinlock is taken.

3.14.5.3. Spinlock Register N (N=0 to 31)(Default Value:0x00000000)

Offset:0x100+N*0x4 (N=0~31)			Register Name: SPINLOCKN_LOCK_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	TAKEN. Lock State. Read 0x0: The lock was previously Not Taken (free).The requester is granted the lock.

			Write 0x0: Set the lock to Not Taken (free). Read 0x1: The lock was previously Taken. The requester is not granted the lock and must retry. Write 0x1: No update to the lock value.
--	--	--	---

3.14.6. Programming Guidelines

Take C0-CPU0's synchronization with CPUS with Spinlock0 for an example, CPU0 takes the spinlock0 firstly in the instance:

CPU0 of Cluster 0

Step 1: CPU0 initializes Spinlock

```
writel(readl(BUS_GATING_REG1)|(1<<22),BUS_GATING_REG1); //open Spinlock clock gating
writel(readl(BUS_RST_REG1)|(1<<22),BUS_RST_REG1); //software reset Spinlock
```

Step 2: CPU0 requests to take spinlock0

```
rdata=readl(SPINLOCK_STATUS_REG0); //check lock register0 status, if it is taken, check till
if(rdata != 0) rdata=readl(SPINLOCK_STATUS_REG0); // lock register0 is free
      ⋮
rdata=readl(SPINLOCKCN_LOCK_REG0); //request to take spinlock0, if fail, retry till
if(rdata != 0) rdata=readl(SPINLOCKCN_LOCK_REG0); // lock register0 is taken
      ⋮
----- CPU0 critical code section -----
```

Step 3: CPU0 free spinlock0

```
writel(0, SPINLOCKCN_LOCK_REG0); //CPU0 frees spinlock0
```

Step 4: CPU0 waits for CPUS' freeing spinlock0

```
writel(readl(SPINLOCK_STATUS_REG0) == 1); // CPU0 waits for CPUS' freeing spinlock0
```

CPUS

Step 1: CPU0 has taken spinlock0, CPUS waits for CPU0' freeing spinlock0

```
while(readl(SPINLOCK_STATUS_REG0) == 1); // CPUS waits for CPU0' freeing spinlock0
```

Step 2: CPUS takes spinlock0 and go on

----- CPUS critical code section -----

Step 3: CPUS frees spinlock0

```
writel(0, SPINLOCKCN_LOCK_REG0); //CPUS frees spinlock0
```


3.15. Security System

3.15.1. Overview

The Security System (SS) is one encrypt/ decrypt function accelerator. It is suitable for a variety of applications. It can support both encryption/decryption and signature/verification, calculate the hash value. Several modes are supported by the security system. SS has an internal DMA(IDMA) controller to transfer data between SS and memory.

It includes the following features:

- Support symmetrical algorithm :AES, DES, TDES
- Support Secure Hash algorithm: MD5, SHA-1,SHA-224,SHA-256
- Support asymmetrical algorithm :RSA512/1024/2048/3072-bits
- Support signature and verification based on the RSA algorithm
- Support 160-bits hardware PRNG with 175-bits seed
- Support 256-bits hardware TRNG
- Support ECB, CBC, CTR modes for DES/TDES
- Support ECB, CBC, CTR, CTS modes for AES
- Support 128-bits, 192-bits and 256-bits key size for AES
- Support IDMA mode
- Support serial and parallel mode

3.15.2. Block Diagram

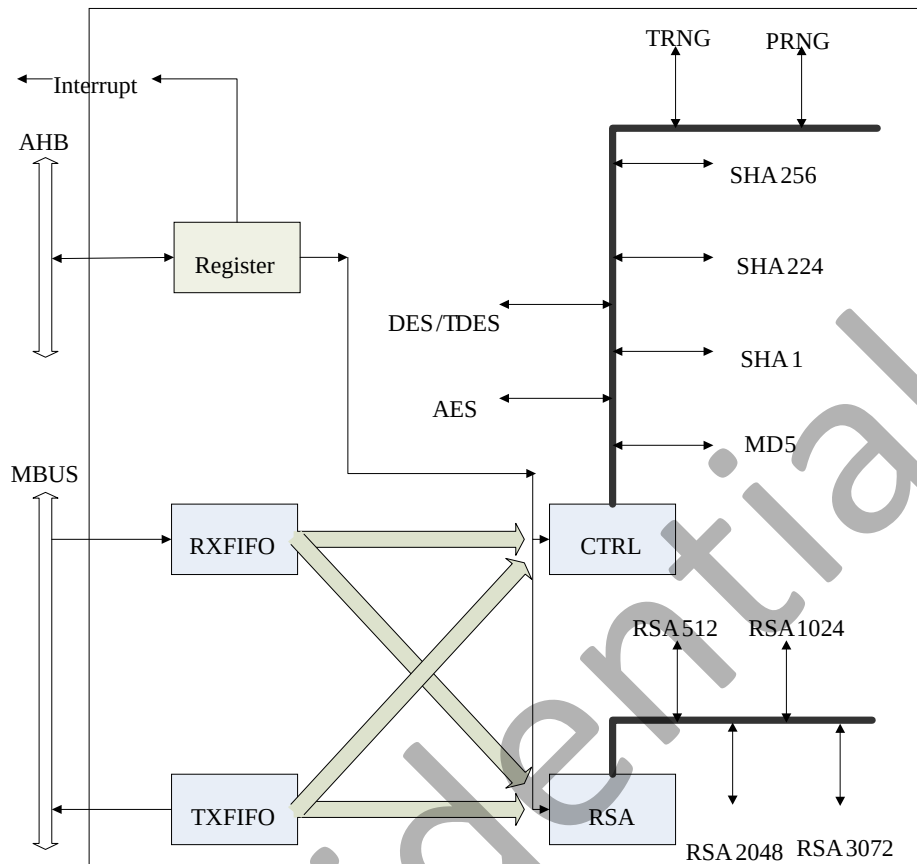


Figure 3-12. SS Block Diagram

3.15.3. Security System Register List

Module Name	Base Address
SS	0x01C15000

Register Name	Offset	Description
SS_CTL	0x00	Security Control Register
SS_ICR	0x04	Security Interrupt Control Register
SS_ISR	0x08	Security Interrupt Status Register
SS_Key_Address	0x10	Security Input Key Address Register
SS_IV_Address	0x18	Security Initialization Vector/Preload Counter/Public Modulus Address Register
SS_DataSrc_Address	0x20	Security Source Address Register

SS_DataDst_Address	0x28	Security Destination Address Register
SS_Data_Length	0x30	Security Data Length Register
SS_CTR0	0x34	Security Counter0 Register for Stream0
SS_CTR1	0x38	Security Counter1 Register for Stream0
SS_CTR2	0x3C	Security Counter2 Register for Stream0
SS_CTR3	0x40	Security Counter3 Register for Stream0
SS_CTR4	0x48	Security Counter4 Register for Stream1
SS_CTR5	0x4C	Security Counter5 Register for Stream1
SS_CTR6	0x50	Security Counter6 Register for Stream1
SS_CTR7	0x54	Security Counter7 Register for Stream1

3.15.4. Security System Register Description

3.15.4.1. Security System Control Register(Default Value: 0x20000000)

Offset: 0x0			Register Name: SS_CTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	Stream1_SELECT This bit is set by software and cleared by hardware. Software write "1" select stream1, when write "0" invalid.
30	R/W	0	Stream0_SELECT This bit is set by software and cleared by hardware. Write "1" select stream0,,when write "0" invalid. Note:When execute a stream,be sure to write bit31 or bit30 to 1; When both bit31 and bit30 wrote at the same time, the priority of bit30 is higher than bit31; When both bit31 and bit30 are 0, on behalf of no stream in the execution.
29	R	1	SS_IDLE 0: the status of SS is busy 1: the status of SS is idle
28	R/W	0	FLOW_MODE Mode with the last flow 0:non-continue mode 1:continue mode
27	R/W	0	DMA Read/Write Consistent 0:Send end flag after data write-instruction finished 1:Read data when receive response of write-instruction ,if write-operation is non-finished, waiting until write-operation finished.
26:23	R/W	0	SKEY_SELECT

			AES key select 0: Select input SS_KEYx (Normal Mode) 1:Select {SSK} 2:Select {HUK} 3:Select {RSSK} 4-7:Reserved 8-15: Select internal Key n (n from 0 to 7)
22:20	R	x	DIE_ID Die Bonding ID
19	/	/	/
18	R/W	0	TRNG/PRNG_MODE TRNG/PRNG generator mode 0: One-shot mode 1: Continue mode
17	R/W	0	IV_MODE IV Steady of SHA-1/SHA-224/SHA-256/MD5 constants 0: Constants 1: Arbitrary IV Notes: It is only used for SHA-1/SHA-224/SHA-256/MD5 engine.
16	R/W	0	AES_CTS_LAST_PACKAGE_FLAG When writing "1", it means this is the last package for AES-CTS mode. (the size of the last package >128bit)
15	/	/	/
14:13	R/W	0	SS_OP_MODE SS Operation Mode 00: Electronic Code Book (ECB) mode 01: Cipher Block Chaining (CBC) mode 10: Counter (CTR) mode 11: AES Ciphertext Stealing (CTS) mode
12:11	R/W	0	CTR_WIDTH Counter Width for CTR Mode 00: 16-bits Counter 01: 32-bits Counter 10: 64-bits Counter 11: 128-bits Counter
10:9	R/W	0	RSA Pubic Modulus_Width 00:512 bit 01:1024 bit 10:2048 bit 11:3072 bit
8:7	R/W	0	AES_KEY_SIZE Key Size for AES 00: 128-bits 01: 192-bits 10: 256-bits

			11: Reserved
6	R/W	0	SS_OP_DIR SS Operation Direction 0: Encryption 1: Decryption
5:2	R/W	0	SS_METHOD SS Method 0000: AES 0001: DES 0010: Triple DES (3DES) 0011: MD5 0100: PRNG 0101: TRNG 0110: SHA-1 0111: SHA-224 1000: SHA-256 1001: RSA Others: Reserved
1	R/W	0	PRNG/TRNG_START PRNG/TRNG start bit In PRNG/TRNG one-shot mode, write '1' to start PRNG/TRNG. After generating one group random data , this bit is clear to '0' by hardware.
0	R/W	0	SS_Start Write '1' to start SS .

3.15.4.2. Security System Interrupt Control Register(Default Value: 0x00000000)

Offset: 0x4			Register Name: SS_INT_CTL_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R/W	0	FLOW1_ENCRY/DECRY_END_Enable Flow1 Encry/Decry End Available Interrupt Enable 0: Disable 1: Enable
0	R/W	0	FLOW0_ENCRY/DECRY_END_Enable Flow0 Encry/Decry End Available Interrupt Enable 0: Disable 1: Enable

3.15.4.3. Security System Interrupt Status Register(Default Value: 0x00000000)

Offset: 0x8	Register Name: SS_INT_STATUS_REG
-------------	---

Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R/W	0	FLOW1_ENCRY/DECY_END_PENDING_BIT Flow1 Encry/Decry End Available Pending bit 0: No end pending 1: end pending Notes: Write '1' to clear it
0	R/W	0	FLOW0_ENCRY/DECY_END_PENDING_BIT Flow0 Encry/Decry End Available Pending bit 0: No end pending 1: end pending Notes: Write '1' to clear it.

3.15.4.4. Security System Key Address Register(Default Value: 0x00000000)

Offset: 0x10			Register Name: SS_KEY_ADR_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	SS Key Input Address(2 words alignment)write in the register

3.15.4.5. Security System Pubic Modulus/IV/ Counter Address Register(Default Value: 0x00000000)

Offset: 0x18			Register Name: SS_PM/IV/CNT_ADR_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	SS Initialization Vector/Preload Counter/Pubic Modulus Address(2words alignment)write in the register

3.15.4.6. Security System Data Source Address Register(Default Value: 0x00000000)

Offset: 0x20			Register Name: SS_DataSrc_ADR_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	SS Data Source Address Source address (2words alignment)write in the register

3.15.4.7. Security System Data Destination Address Register(Default Value: 0x00000000)

Offset: 0x28			Register Name: SS_DataDst_ADR_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	SS Data Destination Address Destination address (2words alignment)write in the register

			Note:Read out data from destination address in bytes only for SHA1/SHA224/SHA256 .
--	--	--	--

3.15.4.8. Security System Data Length Register(Default Value: 0x00000000)

Offset: 0x30			Register Name: SS_Data_LEN_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	SS Data Length Record the length of plaint/cipher and random data access in Word. 4 words alignment for AES; 2 words alignment for DES/3DES; 16 words alignment for SHA1/MD5/SHA224/SHA256; 5 words alignment for PRNG random data; 8 words alignment for TRNG random data; Note:When it uses in AES-CTS mode , Data Length access in Byte.

3.15.4.9. Security System Counter[n] Register0(Default Value: 0x00000000)

Offset: 0x34+4*n			Register Name: SS_CTR[n]_REG0
Bit	R/W	Default/Hex	Description
31:0	R	0	SS_CTR_VALUE Record counter's middle value every block in AES/DES/3DES CTR mode (n=0~3) Note:SS_CTR[0] ~SS_CTR[3] for stream0 only.

3.15.4.10. Security System Counter[n] Register1(Default Value: 0x00000000)

Offset: 0x48+4*(n-4)			Register Name: SS_CTR[n]_REG1
Bit	R/W	Default/Hex	Description
31:0	R	0	SS_CTR_VALUE Record counter's middle value every block in AES/DES/3DES CTR mode (n=4~7) Note:SS_CTR[4] ~SS_CTR[7] for stream1 only.

3.15.5. Security System Clock Requirement

Clock Name	Description	Requirement
ahb_clk	AHB bus clock	>=24MHz
ss_clk	SS serial clock	<= 300MHz && >=24MHz

3.15.6. Programming Guidelines

- (1) Datasrc_address needs align by 2 words.
- (2) Datadst_address needs align by 2 words.
- (3) After the selected signal of channel-0 or channel-1 is recognized as low level(the bit31 or bit30 of SS_CTL register is 0),channel-0 or channel-1 could be requested to calculate.
- (4) The input data sequence of RSA is that the low word store in the low address.
- (5) Before the Hash algorithm is operated, the SS controller need reset, which avoid the influence of other algorithms to the Hash algorithm.
- (6) For SHA1/SHA224/SHA256,It should be noted the sequence of the initial hash value.

SHA1/SHA224/SHA256 is the big-endian algorithm, within each word,the most significant bit is stored in the left-most bit position.For example,the initial hash value of SHA1 in Fips180-2, $H^{(0)}$ shall consist of the following five 32-bit words,in hex:

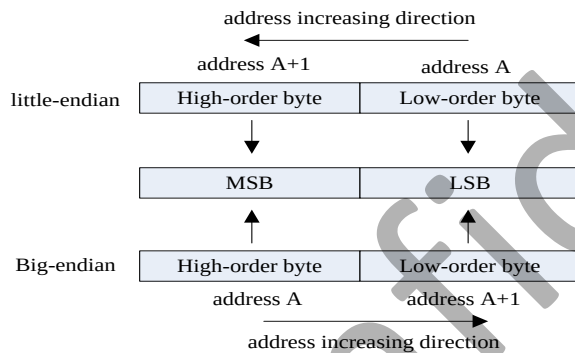
$H_0^{(0)} = 67452301$

$H_1^{(0)} = \text{efcdab89}$

$H_2^{(0)} = 98badcfe$

$H_3^{(0)} = 10325476$

$H_4^{(0)} = \text{c3d2e1f0}$



The default access mode of ARM is little-endian. So When we write the initial value in the IV descriptor address, according to the following array input sequence:

For SHA1:

```
unsigned char iv_sha1[20]={
0x67,0x45,0x23,0x01,0xef,0xcd,0xab,0x89,0x98,0xba,0xdc,0xfe,0x10,0x32,0x54,0x76,
0xc3,0xd2,0xe1,0xf0};
```

Then:

```
IV descriptor address :      0x01234567
IV descriptor address +0x4:  0x89abcdef
IV descriptor address +0x8:  0xfedcba98
IV descriptor address +0xC:  0x76543210
IV descriptor address +0x10: 0xf0e1d2c3
```

For SHA224:

```
unsigned char iv_sha224[32]={
0xc1,0x05,0x9e,0xd8,0x36,0x7c,0xd5,0x07,0x30,0x70,0xdd,0x17,0xf7,0x0e,0x59,0x39,
0xff,0xc0,0x0b,0x31,0x68,0x58,0x15,0x11,0x64,0xf9,0x8f,0xa7,0xbe,0xfa,0x4f,0xa4};
```

For SHA256:

```
unsigned char iv_sha256[32]={
```



```
0x6a,0x09,0xe6,0x67,0xbb,0x67,0xae,0x85,0x3c,0x6e,0xf3,0x72,0xa5,0x4f,0xf5,0x3a,  
0x51,0x0e,0x52,0x7f,0x9b,0x05,0x68,0x8c,0x1f,0x83,0xd9,0xab,0x5b,0xe0,0xcd,0x19};
```

- (7) The generation of the true random numbers uses one 16MHz Oscillator source. So when using TRNG algorithm, the 16MHz oscillator need enable, that the bit[0] of **OSC24M_CTRL_REG** in R_PRCM is wrote to 1. After completed, the 16MHz oscillator need disable.

Confidential

3.16. Security ID

3.16.1. Overview

There is one on chip EFUSE, which provides 128-bit, 64-bit and one 32-bit electrical fuses for security application. The users can use them as root key, security JTAG key and other applications.

It includes the following features:

- 128-bit electrical fuses for chip ID
- 64-bit electrical fuses for thermal sensor

Confidential

3.17. Secure Memory Controller

3.17.1. Overview

The SMC is an Advanced Microcontroller Bus Architecture compliant System-on-Chip peripheral. It is a high-performance, area-optimized address space controller with on-chip AMBA bus interfaces that conform to the AMBA Advanced extensible Interface protocol and the AMBA Advanced Peripheral Bus protocol. You can configure the SMC to provide the optimum security address region control functions required for your intended application.

The SMC includes the following features:

- Enables you to program security access permissions each address region.
- Permits the transfer of data between master and slave only if the security status of the AXI transaction matches the security settings of the memory region it addresses.

3.17.2. Functionalities Description

By default, the SMC performs read or write speculative that means it forwards an AXI transaction address to a slave, before it verifies that the AXI transaction is permitted to read address or write address respectively.

The SMC only permits the transfer of data between its AXI bus interfaces, after verifying the access that the read or write access is permitted respectively. If the verification fails, then it prevents the transfer of data between the master and slave as Denied AXI transactions.

When the speculative accesses are disabled, the SMC verifies the permissions of the access before it forwards the access to the slave. If the SMC:

- Permits the access, it commences an AXI transaction to the slave, and it adds one clock latency.
- Denies the access, it prevents the transfer of data between the master and slave. In this situation, the slave is unaware when the SMC prevents the master from accessing the slave.

3.17.3. Diagram and Table

3.17.3.1. DRM Block Diagram

G. NS.M stands for General Non-secure Master

D. NS.M stands for Non-secure Master appointed by DRM

S.M. stands for Secure Mater

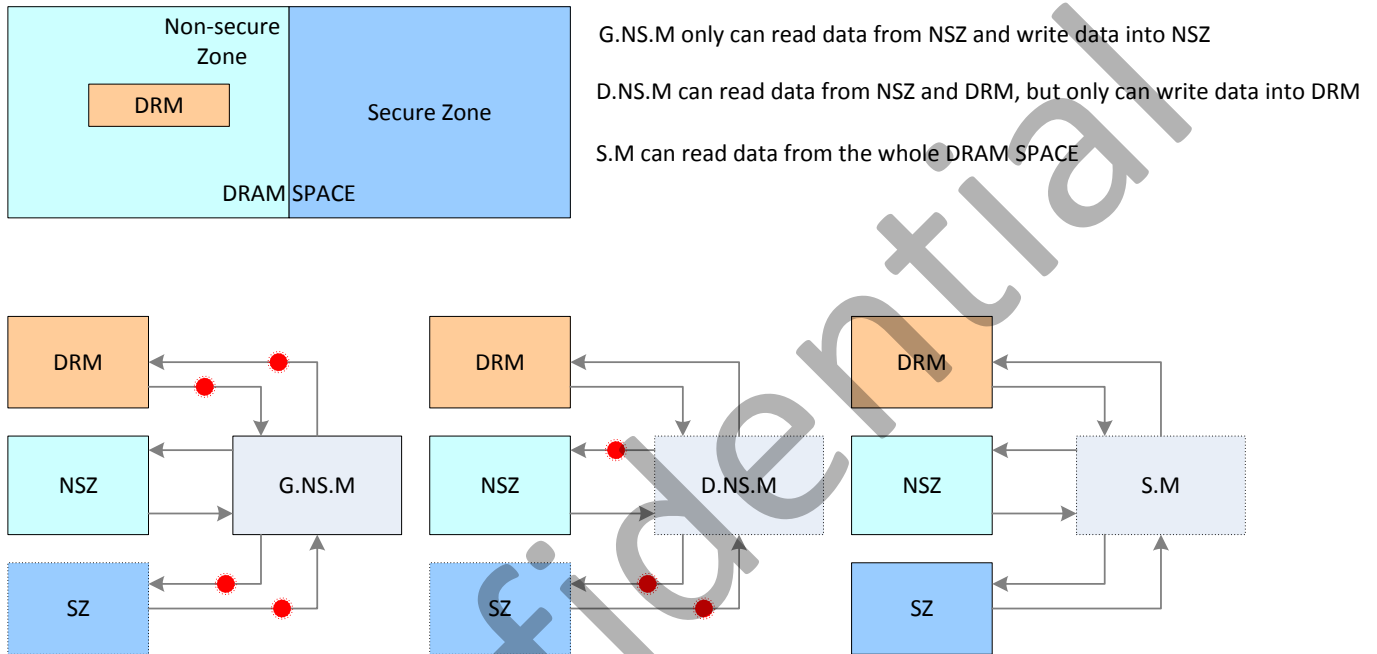


Figure 3-13. DRM Block Diagram

3.17.3.2. Master ID Table

ID	Master	ID	Master
0	CPU	11	DMA
1	GPU	12	VE
2	CPUS	13	CSI
3	ATH (test interface for AHB)	14	NAND
4	USB-DRD	15	SS
5	MSTG0 (MMC0)	16	DE_RT-MIXER0
6	MSTG1 (MMC1)	17	DE_RT-MIXER1
7	MSTG2 (MMC2)	18	DE_RT-WB
8	USB0	19	DE_ROT
9	USB1	20	
10	EMAC	21	

3.17.3.3. Region Size Table

Size<n>	Size of region<n>	Base address constraints
b000000-b001101	Reserved	-
b001110	32KB	-
b001111	64KB	Bit [15] must be zero
b010000	128KB	Bits [16:15] must be zero
b010001	256KB	Bits [17:15] must be zero
b010010	512KB	Bits [18:15] must be zero
b010011	1MB	Bits [19:15] must be zero
b010100	2MB	Bits [20:15] must be zero
b010101	4MB	Bits [21:15] must be zero
b010110	8MB	Bits [22:15] must be zero
b010111	16MB	Bits [23:15] must be zero
b011000	32MB	Bits [24:15] must be zero
b011001	64MB	Bits [25:15] must be zero
b011010	128MB	Bits [26:15] must be zero
b011011	256MB	Bits [27:15] must be zero
b011100	512MB	Bits [28:15] must be zero
b011101	1GB	Bits [29:15] must be zero
b011110	2GB	Bits [30:15] must be zero
b011111	4GB	Bits [31:15] must be zero
B100000	8GB	Bits [32:15] must be zero

3.17.4. Operation Modes

3.17.4.1. Security inversion

There are two modes of operation for the region security permissions, with or without security inversion. By default, if you program a region to support non-secure accesses, the SMC ensures that region must also support secure accesses. For example, if you program the region permissions for region 3 to be non-secure read only, the SMC permits access to region 3 for secure reads and non-secure reads. If you require that some regions are not accessible to masters in Secure state, but are accessible in Non-secure state, then you must enable security inversion. See **Region security permissions** section and **Security Inversion Enable Register** for more information.

3.17.4.2. Inversion is disabled

Table 3-2 shows the possible security permissions when security inversion is disabled.

Table 3-2

SPN field	Secure Read	Secure Write	Non-secure Read	Non-secure Write
4b0000	No	No	No	No
4b0100	No	Yes	No	No
4b0001, 4b0101	No	Yes	No	Yes
4b1000	Yes	No	No	No
4b0010, 4b1010	Yes	No	Yes	No
4b1100	Yes	Yes	No	No
4b1001, 4b1101	Yes	Yes	No	Yes
4b0110, 4b1110	Yes	Yes	Yes	No
4b0011-4b1111	Yes	Yes	Yes	Yes

3.17.4.3. Inversion is disabled

If you enable security inversion, the SMC permits you to program any combination of security permissions as Table 3-3 shows.

Table 3-3

SPN field	Secure Read	Secure Write	Non-secure Read	Non-secure Write
4b0000	No	No	No	No
4b0001	No	No	No	Yes
4b0010	No	No	Yes	No
4b0011	No	No	Yes	Yes
4b0100	No	Yes	No	No
4b0101	No	Yes	No	Yes
4b0110	No	Yes	Yes	No
4b0111	No	Yes	Yes	Yes
4b1000	Yes	No	No	No
4b1001	Yes	No	No	Yes
4b1010	Yes	No	Yes	No
4b1011	Yes	No	Yes	Yes
4b1100	Yes	Yes	No	No
4b1101	Yes	Yes	No	Yes
4b1110	Yes	Yes	Yes	No
4b1111	Yes	Yes	Yes	Yes

3.17.5. SMC Register List

Module Name	Base Address
SMC	0x01C1E000

Register Name	Offset	Description
SMC_CONFIG_REG	0x0	SMC Configuration Register
SMC_ACTION_REG	0x4	SMC Action Register
SMC_LD_RANGE_REG	0x8	SMC Lock Down Range Register
SMC_LD_SELECT_REG	0xC	SMC Lock Down Select Register
SMC_INT_STATUS_REG	0x10	SMC Interrupt Status Register
SMC_INT_CLEAR_REG	0x14	SMC Interrupt Clear Register
SMC_MST_BYP_REG	0x18	SMC Master Bypass Register
SMC_MST_SEC_REG	0x1C	SMC Master Secure Register
SMC_FAIL_ADDR_REG	0x20	SMC Fail Address Register
SMC_FAIL_CTRL_REG	0x28	SMC Fail Control Register
SMC_FAIL_ID_REG	0x2C	SMC Fail ID Register
SMC_SPECU_CTRL_REG	0x30	SMC Speculation Control Register
SMC_SEC_INV_EN_REG	0x34	SMC Security Inversion Enable Register
SMC_MST_ATTRI_REG	0x48	SMC Master Attribute Register
DRM_MASTER_EN_REG	0x50	DRM Master Enable Register
DRM_ILLACCE_REG	0x58	DRM Illegal Access Register
DRM_STATADDR_REG	0x60	DRM Start Address Register
DRM_ENDADDR_REG	0x68	DRM End Address Register
SMC_REGION_SETUP_LO_REG	0x100+N*0x10	Region Setup Low Register N (N=0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)
SMC_REGION_SETUP_HI_REG	0x104+N*0x10	Region Setup High Register N (N=0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)
SMC_REGION_ATTR_REG	0x108+N*0x10	Region Attribute Register N (N=0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15)

3.17.6. SMC Register Description

3.17.6.1. SMC Configuration Register(Default Value: 0x00001F0F)

Offset: 0x0			Register Name: SMC_CONFIG_REG
Bit	R/W	Default/Hex	Description
31:14	/	/	/
13:8	R	0x1F	ADDR_WIDTH_RTN. Address width. Return the width of the AXI address bus. 6'b 000000-6'b011110 reserved. 6'b 011111 = 32-bit 6'b 111111 = 64-bit
7:4	/	/	/
3:0	R	0xF	REGIONS_RTN. Returns the number of the regions that the SMC provides. 4'b0000 = reserved 4'b0001 = 2 regions 4'b1111 = 16 regions.

3.17.6.2. SMC Action Register(Default Value: 0x00000001)

Offset: 0x4			Register Name: SMC_ACTION_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1:0	R/W	0x1	SMC_INT_RESP. Control how the SMC uses the bresps[1:0], rresps[1:0], and smc_int signals when a region permission failure occurs: 2'b00 = sets smc_int LOW and issues an OKEY response 2'b01 = sets smc_int LOW and issues a DECERR response 2'b10 = sets smc_int HIGH and issues an OKEY response 2'b11 = sets smc_int HIGH and issues a DECERR response

Note:

This action is only valid for CPU access, not for MBUS and DMA access.

3.17.6.3. SMC Lockdown Range Register(Default Value: 0x00000000)

Offset: 0x8			Register Name: SMC_LD_RANGE_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	LOCKDOWN_EN. When set to 1, it enables the lockdown_regions field to control the regions that are to be locked.
30:4	/	/	/

3:0	R/W	0x0	NO_REGIONS_LOCKDOWN. Control the number of regions to lockdown when the enable bit is set to 1. 4'b0000 = region no_of_regions-1 is locked 4'b0001 = region no_of_regions-1 to region no_of_regions-2 are locked 4'b1111 = region no_of_regions-1 to region no_of_regions-16 are locked
-----	-----	-----	---

Note1:

No_of_regions is the value of the no_of_regions field in the configuration register.

Note2:

the value programmed in lockdown_range register must not be greater than no_of_regions-1 ,else all regions are locked.

3.17.6.4. SMC Lockdown Select Register(Default Value: 0x00000000)

Offset: 0xC			Register Name: SMC_LD_SELECT_REG
Bit	R/W	Default/Hex	Description
31:3	/	/	/
2	R/W	0x0	ACCESS_TYPE_SPECU. Modify the access type of the speculation_control register: 0: no effect. The speculation register remains RW. 1: speculation_control register is RO
1	R/W	0x0	ACCESS_TYPE_SEC_INV_EN. Modify the access type of the security_inversion_en register. 0: no effect. Security_inversion_en register remains RW. 1: security_inversion_en register is RO
0	R/W	0x0	ACCESS_TYPE_LOCKDOWN_RANGE. Modify the access type of the lockdown_range register. 0: no effect. Lockdown_range register remains RW 1: lockdown_range register is RO.

3.17.6.5. SMC Interrupt Status Register(Default Value: 0x00000000)

Offset: 0x10			Register Name: SMC_INT_STATUS_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R	0x0	INT_OVERRUN. When set to 1, it indicates the occurrence of two or more region permission failure since the interrupt was last cleared.
0	R	0x0	INT_STATUS. Return the status of the interrupt. 0: interrupt is inactive. 1: interrupt is active.

3.17.6.6. SMC Interrupt Clear Register(Default Value: 0x00000000)

Offset: 0x14			Register Name: SMC_INT_CLEAR_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	SMC_CLR_REG. Write any value to the int_clear register sets the : Status bit to 0 in the int_status register Overrun bit to 0 in the int_status register. Note: It will be auto clear after the write operation.

3.17.6.7. SMC Master Bypass Register(Default Value: 0xFFFFFFFF)

Offset: 0x18			Register Name: SMC_MST_BYP_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0xFFFFFFFF	SMC_MASTER_BYPASS_EN. SMC Master n Bypass Enable. (n = 0~31, see the Table 1. MASTER and MASTER ID for detail.) Note: Bit[31:0] stand for Master ID [31:0] If the master n bypass enable is set to 0, the master n access must be through the SMC. 0: Bypass Disable 1: Bypass Enable.

3.17.6.8. SMC Master Secure Register(Default Value: 0x00000000)

Offset: 0x1C			Register Name: SMC_MST_SEC_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	SMC_MASTER_SEC. SMC Master n Secure Configuration. (n = 0~31, see the Table 1 for detail.) 0: secure 1: non-secure.

3.17.6.9. SMC Fail Address Register(Default Value: 0x00000000)

Offset: 0x20			Register Name: SMC_FAIL_ADDR_REG
Bit	R/W	Default/Hex	Description
31:0	R	0x0	FIRST_ACCESS_FAIL. Return the address bits [31:0] of the first access to fail a region permission check after the interrupt was cleared.

			For external 16-bit DDR2, the address [2:0] is fixed to zero. For external 32-bit DDR2 and 16-bit DDR3, the address [3:0] is fixed to zero. For external 32-bit DDR3, the address [4:0] is fixed to zero.
--	--	--	---

Note:

if the master ID="SRAM" and the register value is between 0x80000 to 0xBFFFF,
the real address should be divide by 4.

3.17.6.10. SMC Fail Control Register(Default Value: 0x00000000)

Offset: 0x28			Register Name: SMC_FAIL_CTRL_REG
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24	R	0x0	READ_WRITE. This bit indicates whether the first access to fail a region permission check was a write or read as: 0 = read access 1 = write access.
23:22	/	/	/
21	R	0x0	NON_SECURE. After clearing the interrupt status, this bit indicates whether the first access to fail a region permission check was non-secure. Read as: 0 = secure access 1 = non-secure access
20	R	0x0	PRIVILEGED. After clearing the interrupt status, this bit indicates whether the first access to fail a region permission check was privileged. Read as: 0 = unprivileged access. 1 = privileged access
19:0	/	/	/

3.17.6.11. SMC Fail ID Register(Default Value: 0x00001F00)

Offset: 0x2C			Register Name: SMC_FAIL_ID_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:16	R	0x0	FAIL_BST_LEN. Fail burst length. 0 = 1 word length 0xf =16 words length
15:8	/	/	/
7:0	R	0x0	FAIL_MASTER_ID.

			Fail Master ID. The value stands for master id, see the Table 1 MASTER and MASTER ID for detail.
--	--	--	---

3.17.6.12. SMC Speculation Control Register(Default Value: 0x00000000)

Offset: 0x30			Register Name: SMC_SPECU_CTRL_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R/W	0x0	WRITE_SPECU. Write_speculation. Control the write access speculation: 0 = write access speculation is enabled 1 = write access speculation is disabled.
0	R/W	0x0	READ_SPECU. Read_speculation. Control the read access speculation: 0 = read access speculation is enabled 1 = read access speculation is disabled.

3.17.6.13. SMC Security Inversion Enable Register(Default Value: 0x00000000)

Offset: 0x34			Register Name: SMC_SEC_INV_EN_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	SEC_INV_EN. Security_inversion_en. Controls whether the SMC permits security inversion to occur. 0 = security inversion is not permitted. 1 = security inversion is permitted. This enables a region to be accessible to masters in Non-secure state but not accessible to masters in Secure state. See Table 2 and Table 3.

3.17.6.14. SMC Master Attribute Register(Default Value: 0x00000000)

Offset: 0x48			Register Name: SMC_MST_ATTRI_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	MST_ATTRI. 0: The secure attribute of master is up to master security extensions; 1: The secure attribute of master is up to <i>Master Secure Register</i> .

3.17.6.15. SMC Master Enable Register(Default Value: 0x00000000)

Offset: 0x50			Register Name: DRM_MASTER_EN_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	DRM_EN. DRM enable.
30:12	/	/	/
13	R/W	0x0	GPU_WRITE_EN GPU write enable.
12	R/W	0x0	GPU_READ_EN GPU read enable.
11:8	/	/	/
7	R/W	0x0	DE_ROT DE_ROT enable.
6	R/W	0x0	DE_RT-WB DE_RT-WB enable.
5	R/W	0x0	DE_RT-MIXER1 DE_RT-MIXER1 enable.
4	R/W	0x0	DE_RT-MIXER0 DE_RT-MIXER0 enable.
3:1	/	/	/
0	R/W	0x0	VE_ENCODE_EN VE encode enable.

3.17.6.16. SMC Illegal Access Register(Default Value: 0x00000000)

Offset: 0x58			Register Name: DRM_ILLACCE_REGO
Bit	R/W	Default/Hex	Description
31:0	RO	0x0	DRM_ILLACCE_REG. When a master, which is non-secure, accesses the DRM space, then the relevant bit will be set up. See Table 1 for detail.

3.17.6.17. SMC Start Address Register(Default Value: 0x00000000)

Offset: 0x60			Register Name: DRM_STATADDR_REG
Bit	R/W	Default/Hex	Description
31:15	R/W	0x0	DRM_STATADDR_REG.
14:0	/	/	/

3.17.6.18. SMC End Address Register(Default Value: 0x00000000)

Offset: 0x68			Register Name: DRM_ENDADDR_REG
Bit	R/W	Default/Hex	Description
31:15	R/W	0x0	DRM_ENDADDR_REG.
14:0	/	/	/

3.17.6.19. SMC Region Setup Low Register(Default Value: 0x00000000)

Offset: 0x100+N*0x10(N=0~15)			Register Name: SMC_REGION_SETUP_LO_REG
Bit	R/W	Default/Hex	Description
31:15	R/W	0x0	BASE_ADDRESS_LOW. Controls the base address [31:15] of region<n>. The SMC only permits a region to start at address 0x0, or at a multiple of its region size. For example, if the size of a region is 512MB, and it is not at address 0x0, the only valid settings for this field are: 17'b001000000000000000 17'b010000000000000000 17'b011000000000000000 17'b100000000000000000 17'b101000000000000000 17'b110000000000000000 17'b111000000000000000
14:0	/	/	/

Note1:

For region 0, this field is Read Only (RO). The SMC sets the base address of region 0 to 0x0.
The base address should be equal to the DRAM absolutely address.

3.17.6.20. SMC Region Setup High Register(Default Value: 0x00000000)

Offset: 0x104+N*0x10(N=0~15)			Register Name: SMC_REGION_SETUP_HI_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	BASE_ADDRESS_HIGH The SMC only permits a region to start at address 0x0, or at a multiple of its region size. If you program a region size to be 8GB or more, then the SMC might ignore certain bits depending on the region size.

3.17.6.21. SMC Region Attributes Register(Default Value: 0x00000000)

Offset: 0x108+N*0x10(N=0~15)			Register Name: SMC_REGION_ATTR_REG
------------------------------	--	--	---

Bit	R/W	Default/Hex	Description
31:28	R/W	0x0	REGION_ATTR_SPN. SP<n>. Permission setting for region <n>. if an AXI transaction occurs to region n, the value in the sp<n> field controls whether the SMC permits the transaction to proceed. . See Table 2 and Table 3.
27:16	/	/	/.
15:8	R/W	0x0	SUB_REGION_DISABLE. Subregion_disable. Regions are split into eight equal-sized sub-regions, and each bit enables the corresponding subregion to be disabled. Bit [15] = 1 subregion 7 is disabled. Bit [14] = 1 subregion 6 is disabled. Bit [13] = 1 subregion 5 is disabled. Bit [12] = 1 subregion 4 is disabled. Bit [11] = 1 subregion 3 is disabled. Bit [10] = 1 subregion 2 is disabled. Bit [9] = 1 subregion 1 is disabled. Bit [8] = 1 subregion 0 is disabled.
7	/	/	/
6:1	R/W	0x0	REGION_ATTR_SIZE. Size<n>. Size of region<n>, see Table 4 for detail.
0	R/W	0x0	REGION_ATTR_EN. EN<n>. Enable for region<n>. 0 = region <n> is disabled. 1 = region <n> is enabled.

3.18. Secure Memory Touch Arbiter

3.18.1. Overview

Secure Memory Touch Arbiter provides a software interface to the protection bits in a secure system in a TrustZone design. It provides system flexibility that enables to configure different areas of memory as secure or non-secure.

The SMTA includes the following features:

- It has protection bits to enable you to program some areas of memory as secure or non-secure.

3.18.2. Functionalities Description

3.18.2.1. Typical Applications

The SMTA provides a software interface to set up memory areas as secure or non-secure. It does this in two ways:

- Programmable protection bits that can be allocated to areas of memory as determined by an external decoder
- Programmable region size value for use by an AXI TrustZone Memory Adapter.

3.18.2.2. SMTA Configuration Table

Register	Bit	SMTA0	SMTA1	SMTA2
		Module Name	Module Name	Module Name
SMTA DECPOR _{Tx} (x=0,1,2)	[0]	/	NAND	/
	[1]	I2C0	DMA	/
	[2]	I2C1	SS	/
	[3]	SPI0	SRAM A1	/
	[4]	SPI1	USB_DRD	DE
	[5]	GPIO	USB0	/
	[6]	/	DRAMC	/
	[7]	SD/eMMC0	/	/

3.18.3. SMTA Register List

Module Name	Base Address
SMTA	0x01C23400

Register Name	Offset	Description
SMTA_R0SIZE_REG	0x0	SMTA R0SIZE Register
SMTA_DECPORT0_STA_REG	0x4	SMTA Decode Port0 Status Register
SMTA_DECPORT0_SET_REG	0x8	SMTA Decode Port0 Set Register
SMTA_DECPORT0_CLR_REG	0xC	SMTA Decode Port0 Clear Register
SMTA_DECPORT1_STA_REG	0x10	SMTA Decode Port1 Status Register
SMTA_DECPORT1_SET_REG	0x14	SMTA Decode Port1 Set Register
SMTA_DECPORT1_CLR_REG	0x18	SMTA Decode Port1 Clear Register
SMTA_DECPORT2_STA_REG	0x1C	SMTA Decode Port2 Status Register
SMTA_DECPORT2_SET_REG	0x20	SMTA Decode Port2 Set Register
SMTA_DECPORT2_CLR_REG	0x24	SMTA Decode Port2 Clear Register

3.18.4. SMTA Register Description

3.18.4.1. SMTA R0SIZE Register(Default Value: 0x00000018)

Offset: 0x0			Register Name: SMTA_R0SIZE_REG
Bit	R/W	Default/Hex	Description
31:10	/	/	/.
9:0	RO	0x18	SEC_RAM_SIZE. Secure RAM region size in 4KB step. 0x000: = no secure region 0x001: = 4KB secure region 0x002: = 8KB secure region 0x003: = 12KB secure region 0x004: = 16KB secure region 0x010: = 64KB secure region 0x1FF: = 2044KB secure region 0x200 or above sets the entire RAM to secure regardless of size.

3.18.4.2. SMTA DECPORT0 Status Register(Default Value: 0x00000000)

Offset: 0x4			Register Name: SMTA_DECPORT0_STA_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	RO	0x0	STA_DEC_PROTO_OUT. Show the status of the decode protection output: 0: = Decode region corresponding to the bit is secure 1: = Decode region corresponding to the bit is non-secure. There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).

3.18.4.3. SMTA DECPORT0 Set Register(Default Value: 0x00000000)

Offset: 0x8			Register Name: SMTA_DECPORT0_SET_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/.
7:0	WO	0x0	SET_DEC_PORT0_OUT. Sets the corresponding decode protection output: 0: = No effect 1: = Set decode region to non-secure. There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).

3.18.4.4. SMTA DECPORT0 Clear Register(Default Value: 0x00000000)

Offset: 0xC			Register Name: SMTA_DECPORT0_CLR_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	WO	0x0	CLR_DEC_PROTO_OUT. Clears the corresponding decode protection output: 0: = No effect 1: = Set decode region to secure. There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).

3.18.4.5. SMTA DECPORT1 Status Register(Default Value: 0x00000000)

Offset: 0x10			Register Name: SMTA_DECPORT1_STA_REG
Bit	R/W	Default/Hex	Description

31:8	/	/	/
7:0	RO	0x0	STA_DEC_PROT1_OUT. Show the status of the decode protection output: 0: = Decode region corresponding to the bit is secure 1: = Decode region corresponding to the bit is non-secure. There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).

3.18.4.6. SMTA DECPORT1 Set Register(Default Value: 0x00000000)

Offset: 0x14			Register Name: SMTA_DECPORT1_SET_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	WO	0x0	SET_DEC_PORT1_OUT. Sets the corresponding decode protection output: 0: = No effect 1: = Set decode region to non-secure. There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).

3.18.4.7. SMTA DECPORT1 Clear Register(Default Value: 0x00000000)

Offset: 0x18			Register Name: SMTA_DECPORT1_CLR_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	WO	0x0	CLR_DEC_PROT1_OUT. Clears the corresponding decode protection output: 0: = No effect 1: = Set decode region to secure. There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).

3.18.4.8. SMTA DECPORT2 Status Register(Default Value: 0x00000000)

Offset: 0x1C			Register Name: SMTA_DECPORT2_STA_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	RO	0x0	STA_DEC_PROT2_OUT. Show the status of the decode protection output: 0: = Decode region corresponding to the bit is secure 1: = Decode region corresponding to the bit is non-secure.

			There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).
--	--	--	---

3.18.4.9. SMTA DECPORT2 Set Register(Default Value: 0x00000000)

Offset: 0x20			Register Name: SMTA_DECPORT2_SET_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	WO	0x0	SET_DEC_PORT2_OUT. Sets the corresponding decode protection output: 0: = No effect 1: = Set decode region to non-secure. There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).

3.18.4.10. SMTA DECPORT2 Clear Register(Default Value: 0x00000000)

Offset: 0x24			Register Name: SMTA_DECPORT2_CLR_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	WO	0x0	CLR_DEC_PROT2_OUT. Clears the corresponding decode protection output: 0: = No effect 1: = Set decode region to secure. There is one bit of the register for each protection output (See the SMTA Configuration Table in detail).

3.19. Thermal Sensor Controller

3.19.1. Overview

The thermal sensors have become common elements in wide range of modern system on chip (SOC) platform. Thermal sensors are used to constantly monitor the temperature on the chip.

A83T embeds three thermal sensors in possible hot spots on the die, sensor0 located in the CPU Class0, sensor1 located in the CPU Class1 and the sensor2 located in the GPU. The thermal sensor Generates interrupt to SW to lower temperature via DVFS, on reaching a certain thermal threshold.

The Thermal Sensor Controller includes the following features:

- Supports APB 32-bits bus width
- Power supply voltage:1.8V
- Low power dissipation
- Periodic temperature measurement
- Averaging filter for thermal sensor reading
- Support over-temperature protection interrupt and over-temperature alarm interrupt

3.19.2. Clock and Timing Requirements

CLK_IN = 24MHz

Conversion Time = $1/(24\text{MHz}/14\text{Cycles}) = 0.583\mu\text{s}$

THERMAL_PER (configured by the value of THERMAL_PER) is must be greater than (ACQ1 + ACQ0+Conversion Time)

THERMAL_PER > ACQ1 + ACQ0+Conversion Time:

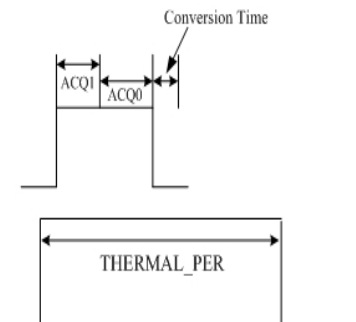


Figure 3-14. Thermal Conversion phase

3.19.3. Thermal Sensor Register List

Module Name	Base Address
Thermal Sensor	0x01F04000

Register Name	Offset	Description
THS_CTRL0	0x00	THS Control Register0
THS_CTRL1	0x04	THS Control Register1
ADC_CDAT	0x14	ADC calibration data Register
THS_CTRL2	0x40	THS Control Register2
THS_INT_CTRL	0x44	THS Interrupt Control Register
THS_STAT	0x48	THS Status Register
THS0_ALARM_CTRL	0x50	Alarm threshold Control Register0
THS1_ALARM_CTRL	0x54	Alarm threshold Control Register1
THS2_ALARM_CTRL	0x58	Alarm threshold Control Register2
THS0_SHUTDOWN_CTRL	0x60	Shutdown threshold Control Register0
THS1_SHUTDOWN_CTRL	0x64	Shutdown threshold Control Register1
THS2_SHUTDOWN_CTRL	0x68	Shutdown threshold Control Register2
THS_FILTER	0x70	Median filter Control Register
THS0_1_CDATA	0x74	Thermal Sensor 0 1 Calibration Data
THS2_CDATA	0x78	Thermal Sensor2 Calibration Data
THS0_DATA	0x80	THS0 Data Register
THS1_DATA	0x84	THS1 Data Register
THS2_DATA	0x88	THS2 Data Register

3.19.4. Thermal Sensor Register Description

3.19.4.1. THS Control Register0 (Default Value: 0x00000000)

Offset: 0x00			Register Name: THS0_CTRL_REG
Bit	R/W	Default/Hex	Description
31:16	/	/	/
15:0	R/W	0x0	SENSOR_ACQ0 ADC acquire time CLK_IN/(N+1)

3.19.4.2. THS Control Register1 (Default Value: 0x00000000)

Offset: 0x04			Register Name: THS1_CTRL_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23	R/W	0x0	Debug control 0:Disable the debug mode 1: Enable the debug mode
22	/	/	/
21:20	R/W	0x0	THS_OP_BIAS. THS OP Bias
19:18	/	/	/
17	R/W	0x0	ADC_CALI_EN. ADC Calibration 1: start Calibration, it is clear to 0 after calibration
16:0	/	/	/

3.19.4.3. ADC calibration Data Register (Default Value: 0x00000000)

Offset: 0x14			Register Name: ADC_CDAT_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11:0	R/W	0x0	ADC_CDAT. ADC calibration data

3.19.4.4. THS Control Register2 (Default Value: 0x00040000)

Offset: 0x40			Register Name: THS2_CTRL_REG
Bit	R/W	Default/Hex	Description
31:16	R/W	0x4	SENSOR_ACQ1. Sensor acquire time CLK_IN/(N+1)
15:3	/	/	/
2	R/W	0x0	SENSE2_EN. Enable temperature measurement sensor2 0:Disable 1:Enable
1	R/W	0x0	SENSE1_EN. Enable temperature measurement sensor1 0:Disable 1:Enable
0	R/W	0x0	SENSE0_EN.

			Enable temperature measurement sensor0 0:Disable 1:Enable
--	--	--	---

3.19.4.5. THS Interrupt Control Register (Default Value: 0x00000000)

Offset: 0x44			Register Name: THS_INT_CTRL_REG
Bit	R/W	Default/Hex	Description
31:12	R/W	0x0	THERMAL_PER. $4096 * (n+1) / \text{CLK_IN}$
11	/	/	/
10	R/W	0x0	THS2_DATA_IRQ_EN. Selects Temperature measurement data of sensor2 0: No select 1: Select
9	R/W	0x0	THS1_DATA_IRQ_EN. Selects Temperature measurement data of sensor1 0: No select 1: Select
8	R/W	0x0	THS0_DATA_IRQ_EN. Selects Temperature measurement data of sensor0 0: No select 1: Select
7	/	/	/
6	R/W	0x0	SHUT_INT2_EN. Selects shutdown interrupt for sensor2 0: No select 1: Select
5	R/W	0x0	SHUT_INT1_EN. Selects shutdown interrupt for sensor1 0: No select 1: Select
4	R/W	0x0	SHUT_INT0_EN. Selects shutdown interrupt for sensor0 0: No select 1: Select
3	/	/	/
2	R/W	0x0	ALARM_INT2_EN. Selects Alert interrupt for sensor2 0: No select 1: Select
1	R/W	0x0	ALARM_INT1_EN. Selects Alert interrupt for sensor1 0: No select

			1: Select
0	R/W	0x0	ALARM_INT0_EN. Selects Alert interrupt for sensor0 0: No select 1: Select

3.19.4.6. THS status Register (Default Value: 0x00000000)

Offset: 0x48			Register Name: THS_STAT_REG
Bit	R/W	Default/Hex	Description
31:11	/	/	/
10	R/W	0x0	THS2_DATA_IRQ_STS. Data interrupt status for sensor2 Write '1' to clear this interrupt or automatic clear if interrupt condition fails
9	R/W	0x0	THS1_DATA_IRQ_STS. Data interrupt status for sensor1 Write '1' to clear this interrupt or automatic clear if interrupt condition fails
8	R/W	0x0	THS0_DATA_IRQ_STS. Data interrupt status for sensor0 Write '1' to clear this interrupt or automatic clear if interrupt condition fails
7	/	/	/
6	R/W	0x0	SHUT_INT2_STS. Shutdown interrupt status for sensor2 Write '1' to clear this interrupt or automatic clear if interrupt condition fails
5	R/W	0x0	SHUT_INT1_STS. Shutdown interrupt status for sensor1 Write '1' to clear this interrupt or automatic clear if interrupt condition fails
4	R/W	0x0	SHUT_INT0_STS. Shutdown interrupt status for sensor0 Write '1' to clear this interrupt or automatic clear if interrupt condition fails
3	/	/	/
2	R/W	0x0	ALARM_INT2_STS. Alarm interrupt pending for sensor2 Write '1' to clear this interrupt or automatic clear if interrupt condition fails
1	R/W	0x0	ALARM_INT1_STS. Alarm interrupt pending for sensor1 Write '1' to clear this interrupt or automatic clear if interrupt condition fails

			fails
0	R/W	0x0	ALARM_INT0_STS. Alarm interrupt pending for sensor0 Write '1' to clear this interrupt or automatic clear if interrupt condition fails

3.19.4.7. Alarm threshold Control Register0 (Default Value: 0x051a0644)

Offset: 0x50			Register Name: THS0_ALARM_CTRL_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0x51A	ALARM0_T_HOT. Thermal sensor0 Alarm Threshold for hot temperature
15:12	/	/	/
11:0	R/W	0x644	ALARM0_T_HYST Thermal sensor0 Alarm threshold for hysteresis temperature

3.19.4.8. Alarm threshold Control Register1 (Default Value: 0x051a0644)

Offset: 0x54			Register Name: THS1_ALARM_CTRL_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0x51A	ALARM1_T_HOT. Thermal sensor1 Alarm Threshold for hot temperature
15:12	/	/	/
11:0	R/W	0x644	ALARM1_T_HYST Thermal sensor1 Alarm threshold for hysteresis temperature

3.19.4.9. Alarm threshold Control Register2 (Default Value: 0x051a0644)

Offset: 0x58			Register Name: THS2_ALARM_CTRL_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0x51A	ALARM2_T_HOT. Thermal sensor2 Alarm Threshold for hot temperature
15:12	/	/	/
11:0	R/W	0x644	ALARM2_T_HYST Thermal sensor2 Alarm threshold for hysteresis temperature

3.19.4.10. Shutdown threshold Control Register0 (Default Value: 0x03f00000)

Offset: 0x60			Register Name: THS0_SHUTDOWN_CTRL_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0x3F0	SHUT0_T_HOT. Thermal sensor0 Shutdown Threshold for hot temperature
15:0	/	/	/

3.19.4.11. Shutdown threshold Control Register1 (Default Value: 0x03f00000)

Offset: 0x64			Register Name: THS1_SHUTDOWN_CTRL_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0x3F0	SHUT1_T_HOT. Thermal sensor1 Shutdown Threshold for hot temperature
15:0	/	/	/

3.19.4.12. Shutdown threshold Control Register2(Default Value: 0x03f00000)

Offset: 0x68			Register Name: THS2_SHUTDOWN_CTRL_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0x3F0	SHUT2_T_HOT. Thermal sensor2 Shutdown Threshold for hot temperature
15:0	/	/	/

3.19.4.13. Average filter Control Register (Default Value: 0x00000001)

Offset: 0x70			Register Name: THS_FILTER_REG
Bit	R/W	Default/Hex	Description
31:3	/	/	/
2	R/W	0x0	FILTER_EN. Filter Enable 0: Disable 1: Enable
1:0	R/W	0x1	FILTER_TYPE. Average Filter Type 00: 2 01: 4

			10: 8 11: 16
--	--	--	-----------------

3.19.4.14. Thermal Sensor 0&1 calibration Data Register (Default Value: 0x08000800)

Offset: 0x74			Register Name: THS0_1_CDATA_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0x800	THES1_CDATA. Thermal Sensor1 calibration data
15:12	/	/	/
11:0	R/W	0x800	THES0_CDATA. Thermal Sensor0 calibration data

3.19.4.15. Thermal Sensor 2 calibration Data Register (Default Value: 0x00000800)

Offset: 0x78			Register Name: THS2_CDATA_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11:0	R/W	0x800	THES2_CDATA. Thermal Sensor2 calibration data

3.19.4.16. THS0 Data Register (Default Value: 0x00000000)

Offset: 0x80			Register Name: THS0_DATA_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11:0	R	0x0	THS0_DATA. Temperature measurement data of sensor0

3.19.4.17. THS1 Data Register (Default Value: 0x00000000)

Offset: 0x84			Register Name: THS1_DATA_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11:0	R	0x0	THS1_DATA. Temperature measurement data of sensor1

3.19.4.18. THS2 Data Register (Default Value: 0x00000000)

Offset: 0x88			Register Name: THS2_DATA_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11:0	R	0x0	THS2_DATA. Temperature measurement data of sensor2

3.19.5. Programming Guidelines

- 1) Timing must be like this: THERMAL_PER > ACQ1 + ACQ0 + Conversion Time
- 2) Configure THS Interrupt Control Register to set the THERMAL_PER and IRQ
- 3) Configure the Alarm threshold Control Register and Shutdown threshold Control Register to set the ALARM_T_HOT and SHUT_T_HOT
- 4) Configure THS Control Register to set the SENSOR_ACQ and enable the sensor
- 5) The real temperature value of each sensor is Tem, then

$$T = (2719 - \text{Tem}) / 14.186$$

Reading back the temperature from the temperature value register requires a 2-byte read. Use 12-bit temperature data format.

3.20. LRADC

3.20.1. Overview

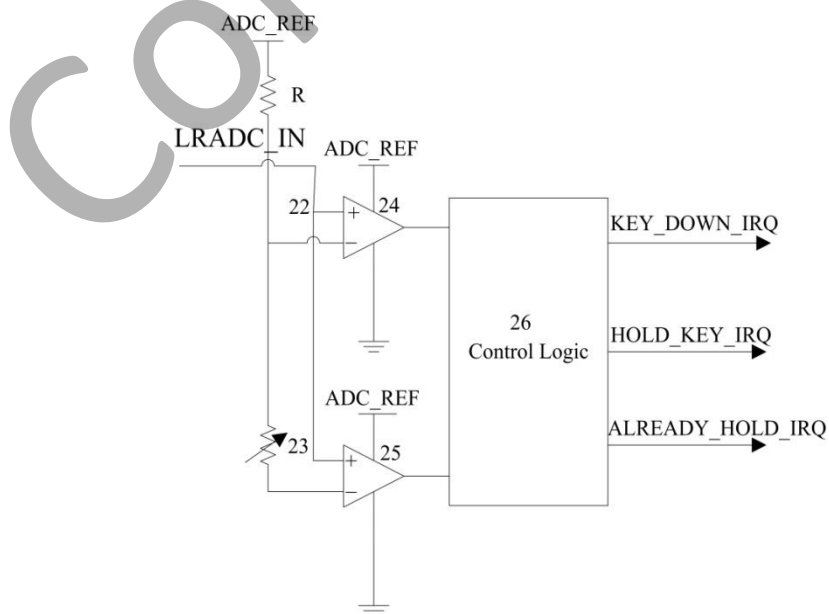
LRADC is 6-bit resolution ADC for key application. The LRADC can work up to 250Hz conversion rate.

The LRADC includes the following features:

- Supports APB 32-bits bus width
- Support interrupt
- Support Hold Key and General Key
- Support Single Key and Continue Key mode
- Support 6-bits resolution
- Voltage input range between 0V to 1.35V
- Sample rate up to 250Hz

3.20.2. Operation Principle

The LRADC converted data can accessed by interrupt and polling method. If software can't access the last converted data instantly, the new converted data would update the old one at new sampling data.



When ADC_IN Signal change from 1.8V to less than 1.35V (Level A), the comparator24 send first interrupt to control

logic; When ADC_IN Signal change from 1.35V to less than certain level (Program can set), the comparator25 give second interrupt. If the control Logic get the first interrupt, In a certain time range (program can set), doesn't get second interrupt, it will send hold key interrupt to the host; If the control Logic get the first interrupt, In a certain time range (program can set), get second interrupt, it will send key down interrupt to the host; If the control logic only get the second interrupt, doesn't get the first interrupt, it will send already hold interrupt to the host.

The LRADC have three mode, Normal Mode、Single Mode and Continue Mode. Normal mode is that the LRADC will report the result data of each convert all the time when the key is down. Single Mode is that the LRADC will only report the first convert result data when the key is down. Continue Mode is that the LRADC will report one of $8*(N+1)$ (N is program can set) sample convert result data when key is down.

The LRADC is support four sample rate such as 250Hz、125Hz、62.5Hz and 32.25Hz, you can configure the value of ADC_SAMPLE_RATE to select the fit sample rate.

3.20.3. LRADC Register List

Module Name	Base Address
LRADC	0x01F03C00

Register Name	Offset	Description
LRADC_CTRL	0x00	LRADC Control Register
LRADC_INTC	0x04	LRADC Interrupt Control Register
LRADC_INTS	0x08	LRADC Interrupt Status Register
LRADC_DATA	0x0C	LRADC Data Register

3.20.4. LRADC Register Description

3.20.4.1. LRADC Control Register (Default Value: 0x01000168)

Offset: 0x00			Register Name: LRADC_CTRL_REG
Bit	R/W	Default/Hex	Description
31: 24	R/W	0x1	FIRST_CONVERT_DLY. ADC First Convert Delay setting, ADC conversion is delayed by n samples
23:22	R/W	0x0	Reserved to 0
21:20	/	/	/

19:16	R/W	0x0	CONTINUE_TIME_SELECT. Continue Mode time select, one of 8*(N+1) sample as a valuable sample data
15:14	/	/	/
13:12	R/W	0x0	KEY_MODE_SELECT. Key Mode Select: 00: Normal Mode 01: Single Mode 10: Continue Mode
11:8	R/W	0x1	LEVELA_B_CNT. Level A to Level B time threshold select, judge ADC convert value in level A to level B in n+1 samples
7	R/W	0x0	ADC_HOLD_KEY_EN ADC Hold Key Enable 0: Disable 1: Enable
6	R/W	0x1	ADC_HOLD_EN. ADC Sample hold Enable 0: Disable 1: Enable
5: 4	R/W	0x2	LEVELB_VOL. Level B Corresponding Data Value setting (the real voltage value) 00: 0x3C (~1.285v) 01: 0x39 (~1.221v) 10: 0x36 (~1.157v) 11: 0x33 (~1.092v)
3: 2	R/W	0x2	ADC_SAMPLE_RATE. ADC Sample Rate 00: 250 Hz 01: 125 Hz 10: 62.5 Hz 11: 32.25 Hz
1	/	/	/
0	R/W	0x0	ADC_EN. ADC enable 0: Disable 1: Enable

3.20.4.2. LRADC Interrupt Control Register (Default Value: 0x00000000)

Offset: 0x04			Register Name: LRADC_INTC_REG
Bit	R/W	Default/Hex	Description
31:5	/	/	/
4	R/W	0x0	ADC_KEYUP_IRQ_EN.

			ADC Key Up IRQ Enable 0: Disable 1: Enable
3	R/W	0x0	ADC_ALRDY_HOLD_IRQ_EN. ADC Already Hold IRQ Enable 0: Disable 1: Enable
2	R/W	0x0	ADC_HOLD_IRQ_EN. ADC Hold Key IRQ Enable 0: Disable 1: Enable
1	R/W	0x0	ADC_KEYDOWN_EN ADC Key Down Enable 0: Disable 1: Enable
0	R/W	0x0	ADC_DATA_IRQ_EN. ADC Data IRQ Enable 0: Disable 1: Enable

3.20.4.3. LRADC Interrupt Status Register (Default Value: 0x00000000)

Offset: 0x08			Register Name: LRADC_INTS_REG
Bit	R/W	Default/Hex	Description
31:5	/	/	/
4	R/W	0x0	ADC_KEYUP_PENDING. ADC Key up pending Bit When general key pull up, it the corresponding interrupt is enabled. 0: No IRQ 1: IRQ Pending Notes: Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable
3	R/W	0x0	ADC_ALRDY_HOLD_PENDING. ADC Already Hold Pending Bit When hold key pull down and pull the general key down, if the corresponding interrupt is enabled. 0: No IRQ 1: IRQ Pending Notes: Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable
2	R/W	0x0	ADC_HOLDKEY_PENDING. ADC Hold Key pending Bit When Hold key pull down, the status bit is set and the interrupt line is set if the corresponding interrupt is enabled.

			0: NO IRQ 1: IRQ Pending Notes: Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable.
1	R/W	0x0	ADC_KEYDOWN_PENDING. ADC Key Down IRQ Pending Bit When General key pull down, the status bit is set and the interrupt line is set if the corresponding interrupt is enabled. 0: No IRQ 1: IRQ Pending Notes: Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable.
0	R/W	0x0	ADC_DATA_PENDING. ADC Data IRQ Pending Bit 0: No IRQ 1: IRQ Pending Notes: Writing 1 to the bit will clear it and its corresponding interrupt if the interrupt is enable.

3.20.4.4. LRADC Data Register Register (Default Value: 0x00000000)

Offset: 0x0C			Register Name: LRADC_DATA_REG
Bit	R/W	Default/Hex	Description
31:6	/	/	/
5:0	R	0x0	LRADC_DATA. LRADC Data

3.21. R_timer

3.21.1. Overview

R_timer 0 and R_timer 1 are general timers, and use the Internal OSC / 512 or OSC24M as source clock. R_timer 0 and R_timer 1 share a programmable 3-bit pre-scale that provides the division of the clock source. They can work in auto-reload mode or no-reload mode. When the current value in *Current Value Register* is counting down to zero, the timer will generate interrupt if set interrupt enable bit.

3.21.2. R_timer Register List

Module Name	Base Address
R_timer	0x01F00800

Register Name	Offset	Description
RTMR_IRQ_EN_REG	0x0	R_timer IRQ Enable Register
RTMR_IRQ_STA_REG	0x4	R_timer IRQ Status Register
RTMR0_CTRL_REG	0x20	R_timer 0 Control Register
RTMR0_INTV_VALUE_REG	0x24	R_timer 0 Interval Value Register
RTMR0_CUR_VALUE_REG	0x28	R_timer 0 Current Value Register
RTMR1_CTRL_REG	0x40	R_timer 1 Control Register
RTMR1_INTV_VALUE_REG	0x44	R_timer 1 Interval Value Register
RTMR1_CUR_VALUE_REG	0x48	R_timer 1 Current Value Register

3.21.3. R_timer Register Description

3.21.3.1. R_timer IRQ Enable Register (Default Value: 0x00000000)

Offset: 0x00			Register Name: RTMR_IRQ_EN_REG
Bit	R/W	Default/Hex	Description

31:2	/	/	/
1	R/W	0x0	RTMR1_IRQ_EN. R_timer 1 Interrupt Enable. 0: No effect; 1: R_timer 1 Interval Value reached interrupt enable.
0	R/W	0x0	RTMR0_IRQ_EN. R_timer 0 Interrupt Enable. 0: No effect; 1: R_timer 0 Interval Value reached interrupt enable.

3.21.3.2. R_timer IRQ Status Register (Default Value: 0x00000000)

Offset: 0x04			Register Name: RTMR_IRQ_STA_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R/W	0x0	RTMR1_IRQ_PEND. R_timer 1 IRQ Pending. Set 1 to the bit will clear it. 0: No effect; 1: Pending, R_timer 1 interval value is reached.
0	R/W	0x0	RTMR0_IRQ_PEND. R_timer 0 IRQ Pending. Set 1 to the bit will clear it. 0: No effect; 1: Pending, R_timer 0 interval value is reached.

3.21.3.3. R_timer 0 Control Register (Default Value: 0x00000004)

Offset: 0x20			Register Name: RTMR0_CTRL_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0x0	RTMR0_MODE. R_timer 0 mode. 0: Continuous mode. When interval value reached, the R_timer will not disable automatically. 1: Single mode. When interval value reached, the R_timer will disable automatically.
6:4	R/W	0x0	RTMR0_CLK_PRES. Select the pre-scale of R_timer 0 clock source. 000: /1 001: /2 010: /4 011: /8 100: /16

			101: /32 110: /64 111: /128
3:2	R/W	0x1	RTMRO_CLK_SRC. 00: Internal OSC / 512 01: OSC24M. Others: /
1	R/W	0x0	RTMRO_RELOAD. R_timer 0 Reload. 0: No effect, 1: Reload R_timer 0 Interval value. After the bit is set, it can not be written again before it's cleared automatically.
0	R/W	0x0	RTMRO_EN. R_timer 0 Enable. 0: Stop/Pause, 1: Start. If the R_timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0. If the current counter does not reach the zero, the R_timer enable bit is set to '0'; the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1. In R_timer pause state, the interval value register can be modified. If the R_timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time.

3.21.3.4. R_timer 0 Interval Value Register

Offset: 0x24			Register Name: RTMRO_INTV_VALUE_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	x	RTMRO_INTV_VALUE. R_timer 0 Interval Value.

Note: The value setting should consider the system clock and the R_timer clock source.

3.21.3.5. R_timer 0 Current Value Register (Default Value: 0x00000000)

Offset: 0x28			Register Name: RTMRO_CUR_VALUE_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	RTMRO_CUR_VALUE. R_timer 0 Current Value.

Note: R_timer 0 current value is a 32-bit down-counter (from interval value to 0).

3.21.3.6. R_timer 1 Control Register (Default Value: 0x00000004)

Offset: 0x40			Register Name: RTMR1_CTRL_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0x0	RTMR1_MODE. R_timer 1 mode. 0: Continuous mode. When interval value reached, the R_timer will not disable automatically. 1: Single mode. When interval value reached, the R_timer will disable automatically.
6:4	R/W	0x0	RTMR1_CLK_PRE. Select the pre-scale of R_timer 1 clock source. 000: /1 001: /2 010: /4 011: /8 100: /16 101: /32 110: /64 111: /128
3:2	R/W	0x1	RTMR1_CLK_SRC. 00: Internal OSC / 512 01: OSC24M. 10: / 11: /
1	R/W	0x0	RTMR1_RELOAD. R_timer 1 Reload. 0: No effect, 1: Reload R_timer 1 Interval value. After the bit is set, it can not be written again before it's cleared automatically.
0	R/W	0x0	RTMR1_EN. R_timer 1 Enable. 0: Stop/Pause, 1: Start. If the R_timer is started, it will reload the interval value to internal register, and the current counter will count from interval value to 0. If the current counter does not reach the zero, the R_timer enable bit is set to '0'; the current value counter will pause. At least wait for 2 cycles, the start bit can be set to 1. In R_timer pause state, the interval value register can be modified. If the R_timer is started again, and the Software hope the current value register to down-count from the new interval value, the reload bit and the enable bit should be set to 1 at the same time.

3.21.3.7. R_timer 1 Interval Value Register

Offset: 0x44			Register Name: RTMR1_INTV_VALUE_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	x	RTMR1_INTV_VALUE. R_timer 1 Interval Value.

Note: The value setting should consider the system clock and the R_timer clock source.

3.21.3.8. R_timer 1 Current Value Register (Default Value: 0x00000000)

Offset: 0x48			Register Name: RTMR1_CUR_VALUE_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	RTMR1_CUR_VALUE. R_timer 1 Current Value.

Note: R_timer 1 current value is a 32-bit down-counter (from interval value to 0).

3.22. R_watchdog

3.22.1. Overview

The R_watchdog is used to resume the controller operation when it had been disturbed by malfunctions such as noise and system errors. It features a down counter that allows a watchdog period of up to 16 seconds. It can generate a general reset or interrupt request. The watchdog generates the reset signal to reset CPUS or the whole system.

3.22.2. R_watchdog Register List

Module Name	Base Address
R_watchdog	0x01F01000

Register Name	Offset	Description
RWDOG_IRQ_EN_REG	0x0	R_watchdog IRQ Enable Register
RWDOG_IRQ_STA_REG	0x4	R_watchdog Status Register
RWDOG_CTRL_REG	0x10	R_watchdog Control Register
RWDOG_CFG_REG	0x14	R_watchdog Configuration Register
RWDOG_MODE_REG	0x18	R_watchdog Mode Register

3.22.3. R_watchdog Register Description

3.22.3.1. R_watchdog IRQ Enable Register (Default Value: 0x00000000)

Offset: 0x00			Register Name: RWDOG_IRQ_EN_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	RWDOG_IRQ_EN. R_watchdog Interrupt Enable. 0: No effect, 1: R_watchdog interrupt enable.

3.22.3.2. R_watchdog Status Register (Default Value: 0x00000000)

Offset: 0x04			Register Name: RWDog_IRQ_STA_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	RWDog_IRQ_PEND. R_watchdog IRQ Pending. Set 1 to the bit will clear it. 0: No effect, 1: Pending, r_watchdog interval value is reached.

3.22.3.3. R_watchdog Control Register (Default Value: 0x00000000)

Offset: 0x10			Register Name: RWDog_CTRL_REG
Bit	R/W	Default/Hex	Description
31:13	/	/	/
12:1	R/W	0x0	RWDog_KEY_FIELD. R_watchdog Key Field. Should be written at value 0xA57. Writing any other value in this field aborts the write operation.
0	R/W	0x0	RWDog_RESTART. R_watchdog Restart. 0: No effect, 1: Restart the r_watchdog.

3.22.3.4. R_watchdog Configuration Register (Default Value: 0x00000000)

Offset: 0x14			Register Name: RWDog_CFG_REG
Bit	R/W	Default/Hex	Description
31:9	/	/	/
8	R/W	0x0	RWDog_CLK_SRC. Select r_watchdog clock sources. 0: 24M / 750 1: Internal OSC / 512
7:2	/	/	/
1:0	R/W	0x1	RWDog_CONFIG. R_watchdog generates a reset signal 00: / 01: to whole system 10: only interrupt 11: /

3.22.3.5. R_watchdog Mode Register (Default Value: 0x00000000)

Offset: 0x18			Register Name: RWDOG_MODE_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:4	R/W	0x0	RWDOG_INTV_VALUE. R_watchdog Interval Value. When the clock source is 24M/750 , the time of 16000 cycles is equal to 0.5 sec, and when the clock source is Internal OSC / 512 , the time of 16000 cycles is based on the number of Internal OSC / 512 . 0000: 16000 cycles 0001: 32000 cycles 0010: 64000 cycles 0011: 96000 cycles 0100: 128000 cycles 0101: 160000 cycles 0110: 192000 cycles 0111: 256000 cycles 1000: 320000 cycles 1001: 384000 cycles 1010: 448000 cycles 1011: 512000 cycles others: /
3:1	/	/	/
0	R/W	0x0	RWDOG_EN. R_watchdog Enable. 0: No effect; 1: Enable the r_watchdog.

3.23. R_PRCM

3.23.1. Overview

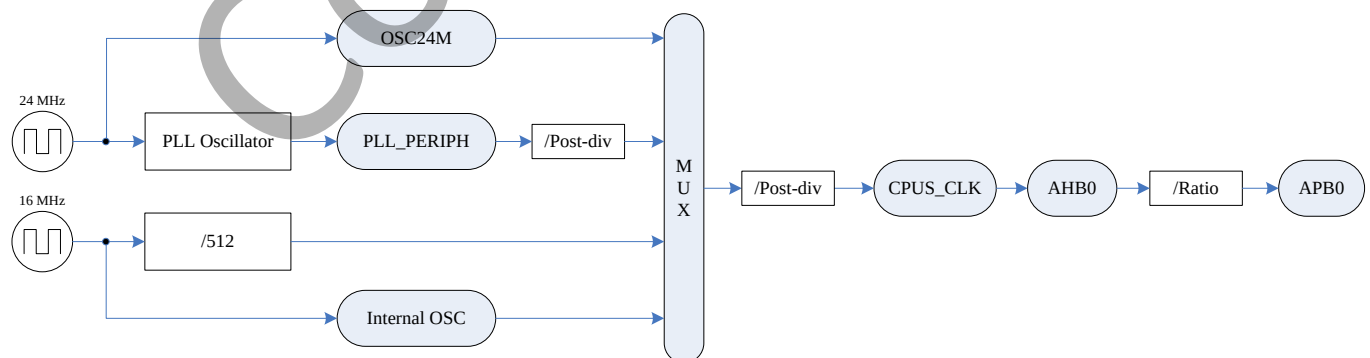
The R_PRCM module is one of the most important design aspects in this system. It provides a versatile supporting multiple power-management techniques. And it also manages the gating and enabling of the clocks to the device modules.

The system-level reset management provides correct reset routing and sequencing when one or more devices are stacked together in the same package. The device-level reset management provides reset routing to relevant devices, such as r_timer, r_uart, r_dma and so on.

The R_PRCM includes the following features:

- Support VDD_SYS power domain modules reset control
- Support CPUS clock configuration
- Support devices clock gating, division and software reset in the CPUS domain
- Support CPUX、GPU、VDD_SYS power off gating control
- Support CPUX power switch control
- Support RAM Configuration and Test Function
- BROM Output

3.23.2. Block Diagram



CPUS Clock Tree

3.23.3. Operation Mode

3.23.3.1. HOSC

24MHz clock has two clock sources, one is from an external 24MHz crystal oscillator input, the other one is about 16MHz internal RC oscillator. In the super standby mode, CPUS uses 16MHz clock source to save the power consumption of 24MHz crystal, also make CPUS operate at a high frequency, fewer super standby wake-up time, improve the response speed. There is a simple operation process:

- (1) Enable 16MHz RC oscillator: The bit[0] of **OSC24M Control Register** is set to 1;
- (2) Switch HOSC clock source: The bit[1] of **OSC24M Control Register** is set to 1;
- (3) Close the external 24MHz oscillator: The bit[2] of **PLL Control Register 1** is cleared;

The next step can be operated before the previous step has been taken effect.

3.23.3.2. Pad Hold

In the super standby mode,GPIO B/C/D/E/F/G/H of VDD_SYS domain can hold a particular output state through GPIO pad hold function,but VCC power of GPIO can not be closed at this time;after exiting the super standby,if you need to use these GPIOs,need to be reconfigured.In power down,GPIO L can hold status through power off hold function;after system powered up at each time,Using GPIO L need to reset **R_PIO Hold Control Register**,so that avoid the previous power down residual configuration. Simple operation is as the following:

- (1) GPIO B/C/D/E/F/G/H pad hold: the bit[12] of **VDD_SYS Power Off Gating Register** can set to 1.
- (2) GPIO L pad hold: Please refer to **R_PIO Hold Control Register**.

3.23.3.3. Power Switch

Each CPU power switch is composed by eight chains, there are chain0~chain7, which respectively correspond bit[0]~bit[7] of **Cluster CPU Power Switch Control Register**.Chain0~chain6 is belong to daisy chain, mainly for CPU charge to reduce the impact of the PMU power load.Chain7 is belong to fishbone chain, mainly for CPU core circuitry power supply.When CPU starts to power up,the corresponding value of **Cluster CPU Power Switch Control Register** should be 0xFF,namely power off;then successively write 0xFE、0xFC、0xF8、0xF0、0x00 to the register, there is a 10us delay after each write operation completed, then it starts to the next write operation. When the CPU power down, you can be directly written 0xFF to the register.

3.23.3.4. OSC24 Control

RTC module of CPUS domain contains a RC oscillator about 16MHz. The frequency is divided to SS module for generating a true random number. At the same time, 24MHz clock source can be switched to 16MHz, which need to effectively configure OSC24M control Register.

3.23.4. R_PRCM Register List

Module Name	Base Address
R_PRCM	0x01F01400

Register Name	Offset	Description
CPUS_CLK_REG	0x0000	CPUS Clock Register
APB0_CFG_REG	0x000C	APB0 Configuration Register
APB0_CLK_GATING_REG	0x0028	APB0 Clock Gating Register
PLL_CTRL_REG1	0x0044	PLL Control Register 1
R_CIR_RX_CLK_REG	0x0054	R_CIR_RX Clock Register
APB0_SOFT_RST_REG	0x00B0	APB0 Software Reset Register
COCPUX_PWROFF_GATING_REG	0x0100	Cluster0 CPUX Power Off Gating Register
C1CPUX_PWROFF_GATING_REG	0x0104	Cluster1 CPUX Power Off Gating Register
VDD_SYS_PWROFF_GATING_REG	0x0110	VDD_SYS Power Off Gating Register
GPU_PWROFF_GATING_REG	0x0118	GPU Power Off Gating Register
VDD_SYS_PWROFF_RST_REG	0x0120	VDD_SYS Power Domain Reset Register
C0_CPU0_PWR_SWITCH_CTRL	0x0140	C0_CPU0 Power Switch Control Register
C0_CPU1_PWR_SWITCH_CTRL	0x0144	C0_CPU1 Power Switch Control Register
C0_CPU2_PWR_SWITCH_CTRL	0x0148	C0_CPU2 Power Switch Control Register
C0_CPU3_PWR_SWITCH_CTRL	0x014C	C0_CPU3 Power Switch Control Register
C1_CPU0_PWR_SWITCH_CTRL	0x0150	C1_CPU0 Power Switch Control Register
C1_CPU1_PWR_SWITCH_CTRL	0x0154	C1_CPU1 Power Switch Control Register
C1_CPU2_PWR_SWITCH_CTRL	0x0158	C1_CPU2 Power Switch Control Register
C1_CPU3_PWR_SWITCH_CTRL	0x015C	C1_CPU3 Power Switch Control Register
RPIO_HOLD_CTRL_REG	0x01F0	R_PIO Hold Control Register
OSC24M_CTRL_REG	0x01F4	OSC24M Control Register

3.23.5. R_PRCM Register Description

3.23.5.1. CPUS Clock Register (Default Value: 0x00010000)

Offset: 0x00			Register Name: CPUS_CLK_REG
Bit	R/W	Default/Hex	Description
31:18	/	/	/
17:16	R/W	0x1	CPUS_CLK_SRC_SEL. CPUS Clock Source Select. Internal OSC is about 16M. 00: Internal OSC / 512 01: OSC24M 10: PLL_PERIPH/ CPUS_POST_DIV 11: Internal OSC . Note: CPUS_CLK = CPUS Clock Source / CPUS_CLK_RATIO
15:13	/	/	/
12:8	R/W	0x0	CPUS_POST_DIV 00000: /1 00001: /2 00010: /3 11111: /32.
7:6	/	/	/
5:4	R/W	0x0	CPUS_CLK_RATIO 00:/1 01:/2 10:/4 11:/8.
3:0	/	/	/

3.23.5.2. APB0 Configuration Register (Default Value: 0x00000000)

Offset: 0x0C			Register Name: APB0_CFG_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1:0	R/W	0x0	APB0_CLK_RATIO. APB0 Clock Divide Ratio. APB0 clock source is AHB0 clock. 00: /1 01: /2 10: /3 11: /4.

			Note: This clock is used for some special module apbclk (R_UART/R_TWI/R_RSB)
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3.23.5.3. APB0 Clock Gating Register (Default Value: 0x00000080)

Offset: 0x0028			Register Name: APB0_CLK_GATING_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0x1	R_TWD_GATING Gating APB Clock for R_TWD 0: Mask 1: Pass.
6	R/W	0x0	R_TWI_GATING Gating APB Clock for R_TWI 0: Mask 1: Pass.
5	/	/	/
4	R/W	0x0	R_UART_GATING. Gating APB Clock for R_UART 0: Mask 1: Pass.
3	R/W	0x0	R_RSB_GATING. Gating APB Clock for R_RSB 0: Mask 1: Pass.
2	R/W	0x0	R_TIMER_GATING. Gating APB Clock for R_TIMER 0: Mask 1: Pass.
1	R/W	0x0	R_CIR_GATING. Gating APB Clock for R_CIR-RX 0: Mask 1: Pass.
0	R/W	0x0	R_PIO_GATING Gating APB Clock for R_PIO 0: Mask 1: Pass.

3.23.5.4. PLL Control Register 1 (Default Value: 0x00040015)

Offset: 0x0044			Register Name: PLL_CTRL_REG1
Bit	R/W	Default/Hex	Description

31:24	R/W	0x0	KEY_FIELD. Key Field for LDO Enable bit. If the key field value is 0xA7, the bit[23:0] can be modified.
23:3	/	/	/
2	R/W	1	OSC24M_EN. External Crystal OSC24M Enable
1	/	/	/
0	R/W	1	LDO_EN. 0: Disable 1: Enable. Note: PLL Power enable (power source from VCC_PLL).

3.23.5.5. R_CIR_RX Clock Register (Default Value: 0x00000000)

Offset: 0x0054			Register Name: R_CIR_RX_CLK_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	SCLK_GATING. Gating Special Clock (Max Clock = 100MHz) 0: Clock is OFF 1: Clock is ON. SCLK= Clock Source/Pre-Divider N/Divider M.
30:26	/	/	/
25:24	R/W	0x0	CLK_SRC_SEL. Clock Source Select 00: Internal OSC / 16 01: OSC24M 1X: /. The Internal OSC is about 16M.
23:18	/	/	/
16:17	R/W	0x0	CLK_DIV_RATIO_N. Clock Pre Divide Ratio (n) 00: /1 01: /2 10: /4 11: /8.
15:4	/	/	/
3:0	R/W	0x0	CLK_DIV_RATIO_M. Clock Divide Ratio (m) The pre-divided clock is divided by (m+1). The divider is from 1 to 16.

3.23.5.6. APB0 Software Reset Register(Default Value: 0x00000000)

Offset: 0x00B0			Register Name: APB0_SOFT_RST_REG
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6	R/W	0x0	R_TWI_RST. R_TWI Reset Control 0: Assert 1: De-assert.
5	/	/	/
4	R/W	0x0	R_UART_RST. R_UART Reset Control 0: Assert 1: De-assert.
3	R/W	0x0	R_RSB_RST. R_P2WI Reset Control 0: Assert 1: De-assert.
2	R/W	0x0	R_TIMER_RST. R_TIMER Reset Control 0: Assert 1: De-assert.
1	R/W	0x0	R_CIR_RX_RST. R_CIR_RX Reset Control 0: Assert 1: De-assert.
0	/	/	/

3.23.5.7. Cluster0 CPUX Power Off Gating Register (Default Value: 0x00000000)

Offset: 0x0100			Register Name: COCPUX_PWROFF_GATING_REG
Bit	R/W	Default/Hex	Description
31:5	/	/	/
4	R/W	0x0	PWROFF_GATING Gating the corresponding modules when CO_CPU0 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before CO_CPU0 power off while it should be set to 0 after the CO_CPU0 power on.
3	R/W	0x0	PWROFF_GATING Gating the corresponding modules when CO_CPU3 power off. 0: Invalid 1: Valid.

			Note: This bit should be set to 1 before C0_CPU3 power off while it should be set to 0 after the C0_CPU3 power on.
2	R/W	0x0	PWROFF_GATING Gating the corresponding modules when C0_CPU2 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before C0_CPU2 power off while it should be set to 0 after the C0_CPU2 power on.
1	R/W	0x0	PWROFF_GATING Gating the corresponding modules when C0_CPU1 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before C0_CPU1 power off while it should be set to 0 after the C0_CPU1 power on.
0	R/W	0x0	PWROFF_GATING Gating the corresponding modules when Cluster 0 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before Cluster 0 power off while it should be set to 0 after the Cluster 0 power on.

3.23.5.8. Cluster1 CPUX Power Off Gating Register (Default Value: 0x0000001F)

Offset: 0x0104			Register Name: C1CPUX_PWROFF_GATING_REG
Bit	R/W	Default/Hex	Description
31:5	/	/	/
4	R/W	0x0	PWROFF_GATING Gating the corresponding modules when C1_CPU0 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before C1_CPU0 power off while it should be set to 0 after the C1_CPU0 power on.
3	R/W	0x0	PWROFF_GATING Gating the corresponding modules when C1_CPU3 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before C1_CPU3 power off while it should be set to 0 after the C1_CPU3 power on.
2	R/W	0x0	PWROFF_GATING Gating the corresponding modules when C1_CPU2 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before C1_CPU2 power off while it should be set to 0 after the C1_CPU2 power on.

1	R/W	0x0	PWROFF_GATING Gating the corresponding modules when C1_CPU1 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before C1_CPU1 power off while it should be set to 0 after the C1_CPU1 power on.
0	R/W	0x0	PWROFF_GATING Gating the corresponding modules when Cluster 1 power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before Cluster1 power off while it should be set to 0 after the Cluster1 power on.

3.23.5.9. VDD_SYS Power Off Gating Register (Default Value: 0x00000000)

Offset: 0x0110			Register Name: VDD_SYS_PWROFF_GATING_REG
Bit	R/W	Default/Hex	Description
31:13	/	/	/
12	R/W	0x0	VCC_GPIO_GATING Gating the VCC_GPIO (GPIO BCDEFGH) when VDD_SYS power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before VDD_SYS power off while it should be set to 0 after the VDD_SYS power on.
11:9	/	/	/
8	R/W	0x0	VCC_PLL_GATING Gating the VCC_PLL when VDD_SYS power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before VDD_SYS power off while it should be set to 0 after the VDD_SYS power on.
7:3	/	/	/
4	R/W	0x0	VCC_PLL_LOW_VOLTAGE_GATING Gating the VCC_PLL Low Voltage when VDD_SYS power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before VDD_SYS power off while it should be set to 0 after the VDD_SYS power on.
3	R/W	0x0	VDD_CPUS_GATING Gating the corresponding modules to the CPUS Power Domain when VDD_SYS power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before VDD_SYS power off while it should

			be set to 0 after the VDD_SYS power on. CPUS CLK Source should switch to Internal OSC before CPUs Power Off Gating.
2	/	/	/
1	R/W	0x0	DRAM_ZQ_PAD_HOLD. 0:Not Hold 1:Hold DRAM ZQ Pad. Note: This bit should be set to 1 before VDD_SYS power off while it should be set to 0 after the VDD_SYS power on.
0	R/W	0x0	DRAM_CH_PAD_HOLD. Hold the pad of DRAM channel 0:Not Hold 1:Hold DRAM Pad. Note: This bit should be set to 1 before VDD_SYS power off while it should be set to 0 after the VDD_SYS power on.

3.23.5.10. GPU Power Off Gating Register(Default Value: 0x00000000)

Offset: 0x0118			Register Name: GPU_PWROFF_GATING_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x0	PWROFF_GATING Gating the corresponding modules when GPU power off. 0: Invalid 1: Valid. Note: This bit should be set to 1 before GPU power off while it should be set to 0 after the GPU power on.

3.23.5.11. VDD_SYS Power Domain Reset Register (Default Value: 0x00000001)

Offset: 0x0120			Register Name: VDD_SYS_PWROFF_RST_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0x1	MODULE_RST VDD_SYS Power Domain Modules should be reset before VDD_SYS power on. 0: Assert 1: De-assert.

3.23.5.12. C0_CPU0 Power Switch Control Register (Default Value: 0x00000000)

Offset: 0x0140			Register Name: C0_CPU0_PWR_SWITCH_CTRL
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Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0x0	C0_CPU0_PWR_SWITCH_CTRL. 0x00: Power On 0xFF: Power Down.

3.23.5.13. C0_CPU1 Power Switch Control Register (Default Value: 0x00000000)

Offset: 0x0144			Register Name: C0_CPU1_PWR_SWITCH_CTRL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0x0	C0_CPU1_PWR_SWITCH_CTRL. 0x00: Power On 0xFF: Power Down.

3.23.5.14. C0_CPU2 Power Switch Control Register (Default Value: 0x00000000)

Offset: 0x0148			Register Name: C0_CPU2_PWR_SWITCH_CTRL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0x0	C0_CPU2_PWR_SWITCH_CTRL. 0x00: Power On 0xFF: Power Down.

3.23.5.15. C0_CPU3 Power Switch Control Register (Default Value: 0x00000000)

Offset: 0x014C			Register Name: C0_CPU3_PWR_SWITCH_CTRL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0x0	C0_CPU3_PWR_SWITCH_CTRL. 0x00: Power On 0xFF: Power Down.

3.23.5.16. C1_CPU0 Power Switch Control Register (Default Value: 0x00000000)

Offset: 0x0150			Register Name: C1_CPU0_PWR_SWITCH_CTRL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0x0	C1_CPU0_PWR_SWITCH_CTRL. 0x00: Power On 0xFF: Power Down.

3.23.5.17. C1_CPU1 Power Switch Control Register (Default Value: 0x00000000)

Offset: 0x0154			Register Name: C1_CPU1_PWR_SWITCH_CTRL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0x0	C1_CPU1_PWR_SWITCH_CTRL. 0x00: Power On 0xFF: Power Down.

3.23.5.18. C1_CPU2 Power Switch Control Register (Default Value: 0x00000000)

Offset: 0x0158			Register Name: C1_CPU2_PWR_SWITCH_CTRL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0x0	C1_CPU2_PWR_SWITCH_CTRL. 0x00: Power On 0xFF: Power Down.

3.23.5.19. C1_CPU3 Power Switch Control Register (Default Value: 0x00000000)

Offset: 0x015C			Register Name: C1_CPU3_PWR_SWITCH_CTRL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0x0	C1_CPU0_PWR_SWITCH_CTRL. 0x00: Power On 0xFF: Power Down.

3.23.5.20. R_PIO Hold Control Register (Default Value: 0x00000000)

Offset: 0x01F0			Register Name: RPIO_HOLD_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0x0	WRITE_PULSE Set 1 then immediately set 0 to write the value of DATA_WRITE into the corresponding PIO Register that its address is allocated by PIO_REG_ADDR. It's no need to consider the delay time between the set 1 and set 0 operation on software.
30:18	/	/	/
17:16	R/W	0x0	PIO_REG_ADDR The Corresponding PIO Register Address. Address0 bit0: R_PIO Pad Hold control(the Power Off Hold Pad : PL)
15:8	R/W	0x0	DATA_WRITE. The data that should be written to the corresponding PIO Register.
7:0	R	0x0	DATA_READ. The value of the corresponding PIO Register.

Note: This register is in the RTC domain.

3.23.5.21. OSC24M Control Register (Default Value: 0x00000000)

Offset: 0x01F4			Register Name: OSC24M_CTRL_REG
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1	R/W	0x0	OSC24M_SRC_SELECT. 0: 24MHz, it is from external oscillator. 1: 16MHz, it is from RC oscillator in the SOC. Before selecting 16MHz OSC, the 16MHz OSC must be enabled.
0	RO	0x0	OSC16M_ENABLE. 0: Disable. 1: Enable.

3.23.6. Programming Guidelines

- (1) Release the device's clock gating after software reset has been de-assert.
- (2) To switch device clock source need set reasonable and effective division factor.
- (3) After wrote VDD_SYS Power gating Register, gating can be valid after 1us delay; After wrote VDD_SYS reset Register, reset can be valid after 1us delay.
- (4) Two CPU can not operate simultaneously **R_PIO Hold Control Register**.

3.24. Port Controller

The chip has 8 ports for multi-functional input/output pins. They are shown below:

- Port B(PB): 11 input/output port
- Port C(PC): 19 input/output port
- Port D(PD): 30 input/output port
- Port E(PE): 20 input/output port
- Port F(PF): 7 input/output port
- Port G(PG): 14 input/output port
- Port H(PH): 12 input/output port
- Port L(PL): 13 input/output port

For various system configurations, these ports can be easily configured by software. All these ports can be configured as GPIO if multiplexed functions are not used. The total 4 group external PIO interrupt sources are supported and interrupt mode can be configured by software.

3.24.1. Port Controller Register List

Module Name	Base Address
PIO	0x01C20800

Register Name	Offset	Description
Pn_CFG0	n*0x24+0x00	Port n Configure Register 0 (n from 1 to 7)
Pn_CFG1	n*0x24+0x04	Port n Configure Register 1 (n from 1 to 7)
Pn_CFG2	n*0x24+0x08	Port n Configure Register 2 (n from 1 to 7)
Pn_CFG3	n*0x24+0x0C	Port n Configure Register 3 (n from 1 to 7)
Pn_DAT	n*0x24+0x10	Port n Data Register (n from 1 to 7)
Pn_DRV0	n*0x24+0x14	Port n Multi-Driving Register 0 (n from 1 to 7)
Pn_DRV1	n*0x24+0x18	Port n Multi-Driving Register 1 (n from 1 to 7)
Pn_PUL0	n*0x24+0x1C	Port n Pull Register 0 (n from 1 to 7)
Pn_PUL1	n*0x24+0x20	Port n Pull Register 1 (n from 1 to 7)
PB_INT_CFG0	0x200+0*0x20+0x00	PIO Interrupt Configure Register 0
PB_INT_CFG1	0x200+0*0x20+0x04	PIO Interrupt Configure Register 1
PB_INT_CFG2	0x200+0*0x20+0x08	PIO Interrupt Configure Register 2
PB_INT_CFG3	0x200+0*0x20+0x0C	PIO Interrupt Configure Register 3
PB_INT_CTL	0x200+0*0x20+0x10	PIO Interrupt Control Register

PB_INT_STA	0x200+0*0x20+0x14	PIO Interrupt Status Register
PB_INT_DEB	0x200+0*0x20+0x18	PIO Interrupt Debounce Register
PG_INT_CFG0	0x200+1*0x20+0x00	PIO Interrupt Configure Register 0
PG_INT_CFG1	0x200+1*0x20+0x04	PIO Interrupt Configure Register 1
PG_INT_CFG2	0x200+1*0x20+0x08	PIO Interrupt Configure Register 2
PG_INT_CFG3	0x200+1*0x20+0x0C	PIO Interrupt Configure Register 3
PG_INT_CTL	0x200+1*0x20+0x10	PIO Interrupt Control Register
PG_INT_STA	0x200+1*0x20+0x14	PIO Interrupt Status Register
PG_INT_DEB	0x200+1*0x20+0x18	PIO Interrupt Debounce Register
PH_INT_CFG0	0x200+2*0x20+0x00	PIO Interrupt Configure Register 0
PH_INT_CFG1	0x200+2*0x20+0x04	PIO Interrupt Configure Register 1
PH_INT_CFG2	0x200+2*0x20+0x08	PIO Interrupt Configure Register 2
PH_INT_CFG3	0x200+2*0x20+0x0C	PIO Interrupt Configure Register 3
PH_INT_CTL	0x200+2*0x20+0x10	PIO Interrupt Control Register
PH_INT_STA	0x200+2*0x20+0x14	PIO Interrupt Status Register
PH_INT_DEB	0x200+2*0x20+0x18	PIO Interrupt Debounce Register

Module Name	Base Address
PL_PIO	0x01F02C00

Register Name	Offset	Description
PL_CFG0	0*0x24+0x00	Port L Configure Register 0
PL_CFG1	0*0x24+0x04	Port L Configure Register 1
PL_CFG2	0*0x24+0x08	Port L Configure Register 2
PL_CFG3	0*0x24+0x0C	Port L Configure Register 3
PL_DAT	0*0x24+0x10	Port L Data Register
PL_DRV0	0*0x24+0x14	Port L Multi-Driving Register 0
PL_DRV1	0*0x24+0x18	Port L Multi-Driving Register 1
PL_PUL0	0*0x24+0x1C	Port L Pull Register 0
PL_PUL1	0*0x24+0x20	Port L Pull Register 1
PL_INT_CFG0	0x200+0*0x20+0x00	PIO Interrupt Configure Register 0
PL_INT_CFG1	0x200+0*0x20+0x04	PIO Interrupt Configure Register 1
PL_INT_CFG2	0x200+0*0x20+0x08	PIO Interrupt Configure Register 2
PL_INT_CFG3	0x200+0*0x20+0x0C	PIO Interrupt Configure Register 3
PL_INT_CTL	0x200+0*0x20+0x10	PIO Interrupt Control Register
PL_INT_STA	0x200+0*0x20+0x14	PIO Interrupt Status Register
PL_INT_DEB	0x200+0*0x20+0x18	PIO Interrupt Debounce Register

3.24.2. Port Controller Register Description

3.24.2.1. PB Configure Register 0 (Default Value: 0x77777777)

Offset: 0x24			Register Name: PB_CFG0_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PB7_SELECT
			000:Input 001:Output
			010:I2S0_DIN 011:TDM_DIN
			100:Reserved 101:Reserved
			110:PB_EINT7 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PB6_SELECT
			000:Input 001:Output
			010:I2S0_DOUT 011:TDM_DOUT
			100:Reserved 101:Reserved
			110:PB_EINT6 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PB5_SELECT
			000:Input 001:Output
			010:I2S0_BCLK 011:TDM_BCLK
			100:Reserved 101:Reserved
			110:PB_EINT5 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PB4_SELECT
			000:Input 001:Output
			010:I2S0_LRCK 011:TDM_LRCK
			100:Reserved 101:Reserved
			110:PB_EINT4 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PB3_SELECT
			000:Input 001:Output
			010:UART2_CTS 011:JTAG_DIO
			100:Reserved 101:Reserved
			110:PB_EINT3 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PB2_SELECT
			000:Input 001:Output
			010:UART2_RTS 011:JTAG_DO0
			100:Reserved 101:Reserved
			110:PB_EINT2 111:IO Disable

7	/	/	/
6:4	R/W	0x7	PB1_SELECT 000:Input 001:Output 010:UART2_RX 011:JTAG_CK0 100:Reserved 101:Reserved 110:PB_EINT1 111:IO Disable
3	/	/	/
2:0	R/W	0x7	PB0_SELECT 000:Input 001:Output 010:UART2_TX 011:JTAG_MS0 100:Reserved 101:Reserved 110:PB_EINT0 111:IO Disable

3.24.2.2. PB Configure Register 1 (Default Value: 0x00000777)

Offset: 0x28			Register Name: PB_CFG1_REG
Bit	R/W	Default/Hex	Description
31:11	/	/	/
10:8	R/W	0x7	PB10_SELECT 000:Input 001:Output 010:UART0_RX 011:Reserved 100:Reserved 101:Reserved 110:PB_EINT10 111:IO Disable
7	/	/	/
6:4	R/W	0x7	PB9_SELECT 000:Input 001:Output 010:UART0_TX 011:Reserved 100:Reserved 101:Reserved 110:PB_EINT9 111:IO Disable
3	/	/	/
2:0	R/W	0x7	PB8_SELECT 000:Input 001:Output 010:I2S0_MCLK 011:TDM_MCLK 100:Reserved 101:Reserved 110:PB_EINT8 111:IO Disable

3.24.2.3. PB Configure Register 2 (Default Value: 0x00000000)

Offset: 0x2C			Register Name: PB_CFG2_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.4. PB Configure Register 3 (Default Value: 0x00000000)

Offset: 0x30			Register Name: PB_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.5. PB Data Register (Default Value: 0x00000000)

Offset: 0x34			Register Name: PB_DATA_REG
Bit	R/W	Default/Hex	Description
31:11	/	/	/
10:0	R/W	0x0	PB_DAT If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read.

3.24.2.6. PB Multi-Driving Register 0 (Default Value: 0x00155555)

Offset: 0x38			Register Name: PB_DRV0_REG
Bit	R/W	Default/Hex	Description
31:22	/	/	Reserved
$[2i+1:2i]$ $(i=0\sim10)$	R/W	0x1	PB_DRV PB[n] Multi-Driving Select (n = 0~10) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.7. PB Multi-Driving Register 1 (Default Value: 0x00000000)

Offset: 0x3C			Register Name: PB_DRV1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.8. PB PULL Register 0 (Default Value: 0x00000000)

Offset: 0x40			Register Name: PB_PULL0_REG
Bit	R/W	Default/Hex	Description
31:22	/	/	Reserved
$[2i+1:2i]$	R/W	0x0	PB_PULL

(i=0~10)			PB[n] Pull-up/down Select (n = 0~10) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved
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3.24.2.9. PB PULL Register 1 (Default Value: 0x00000000)

Offset: 0x44			Register Name: PB_PULL1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.10. PC Configure Register 0 (Default Value: 0x77777777)

Offset: 0x48			Register Name: PC_CFG0_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PC7_SELECT 000:Input 001:Output 010:NAND_RB1 011:Reserved 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PC6_SELECT 000:Input 001:Output 010:NAND_RB0 011:SDC2_CMD 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PC5_SELECT 000:Input 001:Output 010:NAND_RE 011:SDC2_CLK 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PC4_SELECT 000:Input 001:Output 010:NAND_CE0 011:Reserved 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PC3_SELECT 000:Input 001:Output 010:NAND_CE1 011:SPIO_CS

			100:Reserved 110:Reserved	101:Reserved 111:IO Disable
11	/	/	/	
10:8	R/W	0x7	PC2_SELECT 000:Input 010:NAND_CLE 100:Reserved 110:Reserved	001:Output 011:SPIO_CLK 101:Reserved 111:IO Disable
7	/	/	/	
6:4	R/W	0x7	PC1_SELECT 000:Input 010:NAND_ALE 100:Reserved 110:Reserved	001:Output 011:SPIO_MISO 101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PC0_SELECT 000:Input 010:NAND_WE 100:Reserved 110:Reserved	001:Output 011:SPIO_MOSI 101:Reserved 111:IO Disable

3.24.2.11. PC Configure Register 1 (Default Value: 0x77777777)

Offset: 0x4C			Register Name: PC_CFG1_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PC15_SELECT
			000:Input 001:Output
			010:NAND_DQ7 011:SDC2_D7
			100:Reserved 101:Reserved
			110:Reserved 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PC14_SELECT
			000:Input 001:Output
			010:NAND_DQ6 011:SDC2_D6
			100:Reserved 101:Reserved
			110:Reserved 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PC13_SELECT
			000:Input 001:Output
			010:NAND_DQ5 011:SDC2_D5
			100:Reserved 101:Reserved
			110:Reserved 111:IO Disable
19	/	/	/

18:16	R/W	0x7	PC12_SELECT 000:Input 001:Output 010:NAND_DQ4 011:SDC2_D4 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PC11_SELECT 000:Input 001:Output 010:NAND_DQ3 011:SDC2_D3 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PC10_SELECT 000:Input 001:Output 010:NAND_DQ2 011:SDC2_D2 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
7	/	/	/
6:4	R/W	0x7	PC9_SELECT 000:Input 001:Output 010:NAND_DQ1 011:SDC2_D1 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
3	/	/	/
2:0	R/W	0x7	PC8_SELECT 000:Input 001:Output 010:NAND_DQ0 011:SDC2_D0 100:Reserved 101:Reserved 110:Reserved 111:IO Disable

3.24.2.12. PC Configure Register 2 (Default Value: 0x00000777)

Offset: 0x50			Register Name: PC_CFG2_REG
Bit	R/W	Default/Hex	Description
31:11	/	/	/
10:8	R/W	0x7	PC18_SELECT 000:Input 001:Output 010:NAND_CE3 011:Reserved 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
7	/	/	/
6:4	R/W	0x7	PC17_SELECT 000:Input 001:Output 010:NAND_CE2 011:Reserved

			100:Reserved 110:Reserved	101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PC16_SELECT 000:Input 010:NAND_DQS 100:Reserved 110:Reserved	001:Output 011:SDC2_RST 101:Reserved 111:IO Disable

3.24.2.13. PC Configure Register 3 (Default Value: 0x00000000)

Offset: 0x54			Register Name: PC_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.14. PC Data Register (Default Value: 0x00000000)

Offset: 0x58			Register Name: PC_DATA_REG
Bit	R/W	Default/Hex	Description
31:19	/	/	/
18:0	R/W	0x0	PC_DAT If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read.

3.24.2.15. PC Multi-Driving Register 0 (Default Value: 0x55555555)

Offset: 0x5C			Register Name: PC_DRV0_REG
Bit	R/W	Default/Hex	Description
[2i+1:2i] (i=0~15)	R/W	0x1	PC_DRV PC[n] Multi-Driving SELECT (n = 0~15) 00: Level 0 10: Level 2 01: Level 1 11: Level 3

3.24.2.16. PC Multi-Driving Register 1 (Default Value: 0x00000015)

Offset: 0x60			Register Name: PC_DRV1_REG
Bit	R/W	Default/Hex	Description

31:6	/	/	/
[2i+1:2i] (i=0~2)	R/W	0x1	PC_DRV PC[n] Multi-Driving Select (n = 16~18) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.17. PC PULL Register 0 (Default Value: 0x00005140)

Offset: 0x64			Register Name: PC_PULL0_REG
Bit	R/W	Default/Hex	Description
[2i+1:2i] (i=0~15)	R/W	0x5140	PC_PULL PC[n] Pull-up/down Select (n = 0~15) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.18. PC PULL Register 1 (Default Value: 0x00000014)

Offset: 0x68			Register Name: PC_PULL1_REG
Bit	R/W	Default/Hex	Description
31:6	/	/	Reserved
[2i+1:2i] (i=0~2)	R/W	0x14	PC_PULL PC[n] Pull-up/down Select (n = 16~18) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.19. PD Configure Register 0 (Default Value: 0x77777777)

Offset: 0x6C			Register Name: PD_CFG0_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PD7_SELECT 000:Input 001:Output 010:LCD_D7 011:Reserved 100: RGMII-RXCTL/MII-RXDV 101:Reserved 110:Reserved 111:IO Disable
27	/	/	Reserved
26:24	R/W	0x7	PD6_SELECT 000:Input 001:Output 010:LCD_D6 011:Reserved 100: RGMII-RXCK/MII-RXCK 101:Reserved 110:Reserved 111:IO Disable

23	/	/	/
22:20	R/W	0x7	PD5_SELECT 000:Input 001:Output 010:LCD_D5 011:Reserved 100: RGMII-RXD0/MII-RXD0 101:Reserved 110:Reserved 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PD4_SELECT 000:Input 001:Output 010:LCD_D4 011:Reserved 100: RGMII-RXD1/MII-RXD1 101:Reserved 110:Reserved 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PD3_SELECT 000:Input 001:Output 010:LCD_D3 011:Reserved 100: RGMII-RXD2/MII-RXD2 101:Reserved 110:Reserved 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PD2_SELECT 000:Input 001:Output 010:LCD_D2 011:Reserved 100: RGMII-RXD3/MII-RXD3 101:Reserved 110:Reserved 111:IO Disable
7:0	R/W	0x77	/

3.24.2.20. PD Configure Register 1 (Default Value: 0x77777777)

Offset: 0x70			Register Name: PD_CFG1_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PD15_SELECT 000:Input 001:Output 010:LCD_D15 011:Reserved 100:RGMII-NULL/MII-CRS 101:Reserved 110:Reserved 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PD14_SELECT 000:Input 001:Output 010:LCD_D14 011:Reserved 100:RGMII-TXD0/MII-TXD0 101:Reserved 110:Reserved 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PD13_SELECT

			000:Input 001:Output 010:LCD_D13 011:Reserved 100:RGMII-TXD1/MII-TXD1 101:Reserved 110:Reserved 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PD12_SELECT 000:Input 001:Output 010:LCD_D12 011:Reserved 100:RGMII-TXD2/MII-TXD2 101:Reserved 110:Reserved 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PD11_SELECT 000:Input 001:Output 010:LCD_D11 011:Reserved 100:RGMII-TXD3/MII-TXD3 101:Reserved 110:Reserved 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PD10_SELECT 000:Input 001:Output 010:LCD_D10 011:Reserved 100:RGMII-NULL/MII-RXERR 101:Reserved 110:Reserved 111:IO Disable
7:0	R/W	0x77	/

3.24.2.21. PD Configure Register 2 (Default Value: 0x77777777)

Offset: 0x74			Register Name: PD_CFG2_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PD23_SELECT 000:Input 001:Output 010:LCD_D23 011:LVDS_VN2 100:GMDIO 101:Reserved 110:Reserved 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PD22_SELECT 000:Input 001:Output 010:LCD_D22 011:LVDS_VP2 100:GMDC 101:Reserved 110:Reserved 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PD21_SELECT 000:Input 001:Output 010:LCD_D21 011:LVDS_VN1

			100:GCLKIN/ECOL 110:Reserved	101:Reserved 111:IO Disable
19	/	/	/	
18:16	R/W	0x7	PD20_SELECT 000:Input 010:LCD_D20 100:GNULL/ETXERR 110:Reserved	001:Output 011:LVDS_VP1 101:Reserved 111:IO Disable
15	/	/	/	
14:12	R/W	0x7	PD19_SELECT 000:Input 010:LCD_D19 100:GTXCTL/ETXEN 110:Reserved	001:Output 011:LVDS_VN0 101:Reserved 111:IO Disable
11	/	/	/	
10:8	R/W	0x7	PD18_SELECT 000:Input 010:LCD_D18 100:GTXCK/ETXCK 110:Reserved	001:Output 011:LVDS_VP0 101:Reserved 111:IO Disable
7:0	R/W	0x77	/	

3.24.2.22. PD Configure Register 3 (Default Value: 0x00777777)

Offset: 0x78			Register Name: PD_CFG3_REG	
Bit	R/W	Default/Hex	Description	
31:24	/	/	/	
23	/	/	/	
22:20	R/W	0x7	PD29_SELECT 000:Input 010:Reserved 100:Reserved 110:Reserved	001:Output 011:Reserved 101:Reserved 111:IO Disable
19	/	/	/	
18:16	R/W	0x7	PD28_SELECT 000:Input 010:PWM 100:Reserved 110:Reserved	001:Output 011:Reserved 101:Reserved 111:IO Disable
15	/	/	/	
14:12	R/W	0x7	PD27_SELECT 000:Input 010:LCD_VSYNC 100:Reserved	001:Output 011:LVDS_VN3 101:Reserved

			110:Reserved	111:IO Disable
11	/	/	Reserved	
10:8	R/W	0x7	PD26_SELECT 000:Input 010:LCD_HSYNC 100:Reserved 110:Reserved	001:Output 011:LVDS_VP3 101:Reserved 111:IO Disable
7	/	/	/	
6:4	R/W	0x7	PD25_SELECT 000:Input 010:LCD_DE 100:Reserved 110:Reserved	001:Output 011:LVDS_VNC 101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PD24_SELECT 000:Input 010:LCD_CLK 100:Reserved 110:Reserved	001:Output 011:LVDS_VPC 101:Reserved 111:IO Disable

3.24.2.23. PD Data Register (Default Value: 0x00000000)

Offset: 0x7C			Register Name: PD_DATA_REG
Bit	R/W	Default/Hex	Description
31:30	/	/	/
29:0	R/W	0x0	PD_DAT If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read.

3.24.2.24. PD Multi-Driving Register 0 (Default Value: 0x55555555)

Offset: 0x80			Register Name: PD_DRV0_REG
Bit	R/W	Default/Hex	Description
[2i+1:2i] (i=0~15)	R/W	0x1	PD_DRV PD[n] Multi-Driving SELECT (n = 0~15) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.25. PD Multi-Driving Register 1 (Default Value: 0x05555555)

Offset: 0x84			Register Name: PD_DRV1_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
[2i+1:2i] (i=0~13)	R/W	0x1	PD_DRV PD[n] Multi-Driving Select (n = 16~29) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.26. PD PULL Register 0 (Default Value: 0x00000000)

Offset: 0x88			Register Name: PD_PULL0_REG
Bit	R/W	Default/Hex	Description
[2i+1:2i] (i=0~15)	R/W	0x0	PD_PULL PD[n] Pull-up/down Select (n = 0~15) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.27. PD PULL Register 1 (Default Value: 0x00000000)

Offset: 0x8C			Register Name: PD_PULL1_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	Reserved
[2i+1:2i] (i=0~13)	R/W	0x0	PD_PULL PD[n] Pull-up/down Select (n = 16~29) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.28. PE Configure Register 0 (Default Value: 0x77777777)

Offset: 0x90			Register Name: PE_CFG0_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PE7_SELECT 000:Input 001:Output 010:CSI_D3 011:Reserved 100: CCIR-D1 101:Reserved 110:Reserved 111:IO Disable
27	/	/	/

26:24	R/W	0x7	PE6_SELECT 000:Input 001:Output 010:CSI_D2 011:Reserved 100: CCIR-D0 101:Reserved 110:Reserved 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PE5_SELECT 000:Input 001:Output 010: CSI_D1 011:Reserved 100: Reserved 101:Reserved 110:Reserved 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PE4_SELECT 000:Input 001:Output 010: CSI_D0 011:Reserved 100: Reserved 101:Reserved 110:Reserved 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PE3_SELECT 000:Input 001:Output 010:CSI_VSYNC 011:Reserved 100: CCIR-VSYNC 101:Reserved 110:Reserved 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PE2_SELECT 000:Input 001:Output 010:CSI_HSYNC 011:Reserved 100:CCIR-HSYNC 101:Reserved 110:Reserved 111:IO Disable
7	/	/	/
6:4	R/W	0x7	PE1_SELECT 000:Input 001:Output 010:CSI_MCLK 011:Reserved 100:CCIR-DE 101:Reserved 110:Reserved 111:IO Disable
3	/	/	/
2:0	R/W	0x7	PE0_SELECT 000:Input 001:Output 010:CSI_PCLK 011:Reserved 100:CCIR-CLK 101:Reserved 110:Reserved 111:IO Disable

3.24.2.29. PE Configure Register 1 (Default Value: 0x77777777)

Offset: 0x94			Register Name: PE_CFG1_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PE15_SELECT 000:Input 001:Output 010: CSI_SDA 011: TWI2_SDA 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PE14_SELECT 000:Input 001:Output 010: CSI_SCK 011: TWI2_SCK 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PE13_SELECT 000:Input 001:Output 010: CSI_D9 011: UART4_CTS 100: CCIR-D7 101:Reserved 110:Reserved 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PE12_SELECT 000:Input 001:Output 010: CSI_D8 011: UART4_RTS 100: CCIR-D6 101:Reserved 110:Reserved 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PE11_SELECT 000:Input 001:Output 010:CSI_D7 011: UART4_RX 100: CCIR-D5 101:Reserved 110:Reserved 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PE10_SELECT 000:Input 001:Output 010:CSI_D6 011: UART4_TX 100: CCIR-D4 101:Reserved 110:Reserved 111:IO Disable
7	/	/	/
6:4	R/W	0x7	PE9_SELECT 000:Input 001:Output 010:CSI_D5 011: Reserved

			100: CCIR-D3 110:Reserved	101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PE8_SELECT 000:Input 010:CSI_D4 100: CCIR-D2 110:Reserved	001:Output 011: Reserved 101:Reserved 111:IO Disable

3.24.2.30. PE Configure Register 2 (Default Value: 0x00007777)

Offset: 0x98			Register Name: PE_CFG2_REG	
Bit	R/W	Default/Hex	Description	
31:15	/	/	/	
14:12	R/W	0x7	PE19_SELECT 000:Input 010:Reserved 100:Reserved 110:Reserved	001:Output 011:Reserved 101:Reserved 111:IO Disable
11	/	/	/	
10:8	R/W	0x7	PE18_SELECT 000:Input 010:Reserved 100:Reserved 110:Reserved	001:Output 011:OWA_DOUT 101:Reserved 111:IO Disable
7	/	/	/	
6:4	R/W	0x7	PE17_SELECT 000:Input 010:Reserved 100:Reserved 110:Reserved	001:Output 011:Reserved 101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PE16_SELECT 000:Input 010:Reserved 100:Reserved 110:Reserved	001:Output 011: Reserved 101:Reserved 111:IO Disable

3.24.2.31. PE Configure Register 3 (Default Value: 0x00000000)

Offset: 0x9C			Register Name: PE_CFG3_REG	
Bit	R/W	Default/Hex	Description	

31:0	/	/	/
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3.24.2.32. PE Data Register (Default Value: 0x00000000)

Offset: 0xA0			Register Name: PE_DATA_REG
Bit	R/W	Default/Hex	Description
31:20	/	/	/
19:0	R/W	0x0	PE_DAT If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read.

3.24.2.33. PE Multi-Driving Register 0 (Default Value: 0x55555555)

Offset: 0xA4			Register Name: PE_DRV0_REG
Bit	R/W	Default/Hex	Description
[2i+1:2i] (i=0~15)	R/W	0x1	PE_DRV PE[n] Multi-Driving SELECT (n = 0~15) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.34. PE Multi-Driving Register 1 (Default Value: 0x00000055)

Offset: 0xA8			Register Name: PE_DRV1_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	/
[2i+1:2i] (i=0~3)	R/W	0x1	PE_DRV PE[n] Multi-Driving Select (n = 16~19) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.35. PE PULL Register 0 (Default Value: 0x00000000)

Offset: 0xAC			Register Name: PE_PULL0_REG
Bit	R/W	Default/Hex	Description
[2i+1:2i] (i=0~15)	R/W	0x0	PE_PULL PE[n] Pull-up/down Select (n = 0~15) 00: Pull-up/down disable 01: Pull-up

			10: Pull-down	11: Reserved
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3.24.2.36. PE PULL Register 1 (Default Value: 0x00000000)

Offset: 0xB0			Register Name: PE_PULL1_REG
Bit	R/W	Default/Hex	Description
31:8	/	/	Reserved
[2i+1:2i] (i=0~3)	R/W	0x0	PE_PULL PE[n] Pull-up/down Select (n = 16~19) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.37. PF Configure Register 0 (Default Value: 0x07373733)

Offset: 0xB4			Register Name: PF_CFG0_REG
Bit	R/W	Default/Hex	Description
31:27	/	/	/
26:24	R/W	0x7	PF6_SELECT 000:Input 001:Output 010:Reserved 011:Reserved 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
23			
22:20	R/W	0x3	PF5_SELECT 000:Input 001:Output 010:SDC0_D2 011:JTAG_CK1 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PF4_SELECT 000:Input 001:Output 010:SDC0_D3 011:UART0_RX 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
15	/	/	/
14:12	R/W	0x3	PF3_SELECT 000:Input 001:Output 010:SDC0_CMD 011:JTAG_DO1 100:Reserved 101:Reserved 110:Reserved 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PF2_SELECT

			000:Input 010:SDC0_CLK 100:Reserved 110:Reserved	001:Output 011:UART0_TX 101:Reserved 111:IO Disable
7	/	/	/	/
6:4	R/W	0x3	PF1_SELECT 000:Input 010:SDC0_D0 100:Reserved 110:Reserved	001:Output 011:JTAG_DI1 101:Reserved 111:IO Disable
3	/	/	/	/
2:0	R/W	0x3	PF0_SELECT 000:Input 010:SDC0_D1 100:Reserved 110:Reserved	001:Output 011:JTAG_MS1 101:Reserved 111:IO Disable

3.24.2.38. PF Configure Register 1 (Default Value: 0x00000000)

Offset: 0xB8			Register Name: PF_CFG1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.39. PF Configure Register 2(Default Value: 0x00000000)

Offset: 0xBC			Register Name: PF_CFG2_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.40. PF Configure Register 3(Default Value: 0x00000000)

Offset: 0xC0			Register Name: PF_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.41. PF Data Register (Default Value: 0x00000000)

Offset: 0xC4			Register Name: PF_DATA_REG
Bit	R/W	Default/Hex	Description

31:7	/	/	/
6:0	R/W	0x0	PF_DAT If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read.

3.24.2.42. PF Multi-Driving Register 0 (Default Value: 0x00001555)

Offset: 0xC8			Register Name: PF_DRV0_REG
Bit	R/W	Default/Hex	Description
31:14	/	/	/
[2i+1:2i] (i=0~6)	R/W	0x1	PF_DRV PF[n] Multi-Driving SELECT (n = 0~6) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.43. PF Multi-Driving Register 1 (Default Value: 0x00000000)

Offset: 0xCC			Register Name: PF_DRV1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.44. PF PULL Register 0 (Default Value: 0x00000000)

Offset: 0xD0			Register Name: PF_PULL0_REG
Bit	R/W	Default/Hex	Description
31:14	/	/	/
[2i+1:2i] (i=0~6)	R/W	0x0	PF_PULL PF[n] Pull-up/down Select (n = 0~6) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.45. PF PULL Register 1 (Default Value: 0x00000000)

Offset: 0xD4			Register Name: PF_PULL1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	Reserved

3.24.2.46. PG Configure Register 0 (Default Value: 0x77777777)

Offset: 0xD8			Register Name: PG_CFG0_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PG7_SELECT 000:Input 001:Output 010:UART1_RX 011:SPI1_CLK 100:Reserved 101:Reserved 110:PG_EINT7 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PG6_SELECT 000:Input 001:Output 010:UART1_TX 011:SPI1_CS 100:Reserved 101:Reserved 110:PG_EINT6 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PG5_SELECT 000:Input 001:Output 010:SDC1_D3 011:Reserved 100:Reserved 101:Reserved 110:PG_EINT5 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PG4_SELECT 000:Input 001:Output 010:SDC1_D2 011:Reserved 100:Reserved 101:Reserved 110:PG_EINT4 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PG3_SELECT 000:Input 001:Output 010:SDC1_D1 011:Reserved 100:Reserved 101:Reserved 110:PG_EINT3 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PG2_SELECT 000:Input 001:Output 010:SDC1_D0 011:Reserved 100:Reserved 101:Reserved 110:PG_EINT2 111:IO Disable
7	/	/	/
6:4	R/W	0x7	PG1_SELECT 000:Input 001:Output 010:SDC1_CMD 011:Reserved

			100:Reserved 110:PG_EINT1	101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PG0_SELECT 000:Input 010:SDC1_CLK 100:Reserved 110:PG_EINT0	001:Output 011:Reserved 101:Reserved 111:IO Disable

3.24.2.47. PG Configure Register 1 (Default Value: 0x00777777)

Offset: 0xDC			Register Name: PG_CFG1_REG	
Bit	R/W	Default/Hex	Description	
31:23	/	/	/	
22:20	R/W	0x7	PG13_SELECT 000:Input 010:I2S1_DIN 100:Reserved 110:PG_EINT13	001:Output 011:UART3_CTS 101:Reserved 111:IO Disable
19	/	/	/	
18:16	R/W	0x7	PG12_SELECT 000:Input 010:I2S1_DOUT 100:Reserved 110:PG_EINT12	001:Output 011:UART3_RTS 101:Reserved 111:IO Disable
15	/	/	/	
14:12	R/W	0x7	PG11_SELECT 000:Input 010:I2S1_LRCK 100:Reserved 110:PG_EINT11	001:Output 011:UART3_RX 101:Reserved 111:IO Disable
11	/	/	/	
10:8	R/W	0x7	PG10_SELECT 000:Input 010:I2S1_BCLK 100:Reserved 110:PG_EINT10	001:Output 011:UART3_TX 101:Reserved 111:IO Disable
7	/	/	/	
6:4	R/W	0x7	PG9_SELECT 000:Input 010:UART1_CTS 100:Reserved 110:PG_EINT9	001:Output 011:SPI1_MISO 101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PG8_SELECT	

			000:Input	001:Output
			010:UART1_RTS	011:SPI1_MOSI
			100:Reserved	101:Reserved
			110:PG_EINT8	111:IO Disable

3.24.2.48. PG Configure Register 2 (Default Value: 0x00000000)

Offset: 0xE0			Register Name: PG_CFG2_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.49. PG Configure Register 3 (Default Value: 0x00000000)

Offset: 0xE4			Register Name: PG_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.50. PG Data Register (Default Value: 0x00000000)

Offset: 0xE8			Register Name: PG_DATA_REG
Bit	R/W	Default/Hex	Description
31:14	/	/	/
13:0	R/W	0x0	PG_DAT If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read.

3.24.2.51. PG Multi-Driving Register 0 (Default Value: 0x05555555)

Offset: 0xEC			Register Name: PG_DRV0_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
[2i+1:2i] (i=0~13)	R/W	0x1	PF_DRV PF[n] Multi-Driving SELECT (n = 0~13) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.52. PG Multi-Driving Register 1 (Default Value: 0x00000000)

Offset: 0xF0			Register Name: PG_DRV1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.53. PG PULL Register 0 (Default Value: 0x00000000)

Offset: 0xF4			Register Name: PG_PULL0_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
[2i+1:2i] (i=0~13)	R/W	0x5140	PF_PULL PF[n] Pull-up/down Select (n = 0~13) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.54. PG PULL Register 1 (Default Value: 0x00000000)

Offset: 0xF8			Register Name: PG_PULL1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.55. PH Configure Register 0 (Default Value: 0x77777777)

Offset: 0xFC			Register Name: PH_CFG0_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PH7_SELECT 000:Input 001:Output 010:HSDA 011:Reserved 100:Reserved 101:Reserved 110:PH_EINT7 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PH6_SELECT 000:Input 001:Output 010:HSCL 011:Reserved 100:Reserved 101:Reserved 110: PH_EINT6 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PH5_SELECT

			000:Input 010:TWI2_SDA 100:Reserved 110: PH_EINT5	001:Output 011:Reserved 101:Reserved 111:IO Disable
19	/	/	/	
18:16	R/W	0x7	PH4_SELECT 000:Input 010:TWI2_SCK 100:Reserved 110: PH_EINT4	001:Output 011:Reserved 101:Reserved 111:IO Disable
15	/	/	/	
14:12	R/W	0x7	PH3_SELECT 000:Input 010:TWI1_SDA 100:Reserved 110: PH_EINT3	001:Output 011:Reserved 101:Reserved 111:IO Disable
11	/	/	/	
10:8	R/W	0x7	PH2_SELECT 000:Input 010:TWI1_SCK 100:Reserved 110: PH_EINT2	001:Output 011:Reserved 101:Reserved 111:IO Disable
7	/	/	/	
6:4	R/W	0x7	PH1_SELECT 000:Input 010:TWI0_SDA 100:Reserved 110: PH_EINT1	001:Output 011:Reserved 101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PH0_SELECT 000:Input 010:TWI0_SCK 100:Reserved 110: PH_EINT0	001:Output 011:Reserved 101:Reserved 111:IO Disable

3.24.2.56. PH Configure Register 1 (Default Value: 0x00007777)

Offset: 0x100			Register Name: PH_CFG1_REG	
Bit	R/W	Default/Hex	Description	
31:7	/	/	/	
14:12	R/W	0x7	PH11_SELECT	
			000:Input	001:Output
			010:Reserved	011:Reserved
			100:Reserved	101:Reserved

			110: PH_EINT11	111:IO Disable
11	/	/	/	
10:8	R/W	0x7	PH10_SELECT 000:Input 010:Reserved 100:Reserved 110: PH_EINT10	001:Output 011:Reserved 101:Reserved 111:IO Disable
7	/	/	/	
6:4	R/W	0x7	PH9_SELECT 000:Input 010:Reserved 100:Reserved 110: PH_EINT9	001:Output 011:Reserved 101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PH8_SELECT 000:Input 010:HCEC 100:Reserved 110: PH_EINT8	001:Output 011:Reserved 101:Reserved 111:IO Disable

3.24.2.57. PH Configure Register 2 (Default Value: 0x00000000)

Offset: 0x104			Register Name: PH_CFG2_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.58. PH Configure Register 3 (Default Value: 0x00000000)

Offset: 0x108			Register Name: PH_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.59. PH Data Register (Default Value: 0x00000000)

Offset: 0x10C			Register Name: PH_DATA_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11:0	R/W	0x0	PH_DAT If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the

		port is configured as functional pin, the undefined value will be read.
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3.24.2.60. PH Multi-Driving Register 0 (Default Value: 0x00555555)

Offset: 0x110			Register Name: PH_DRV0_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
[2i+1:2i] (i=0~11)	R/W	0x1	PH_DRV PH[n] Multi-Driving SELECT (n = 0~11) 00: Level 0 01: Level 1 10: Level 2 11: Level 3

3.24.2.61. PH Multi-Driving Register 1 (Default Value: 0x00000000)

Offset: 0x114			Register Name: PH_DRV1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.62. PH PULL Register 0 (Default Value: 0x00000000)

Offset: 0x118			Register Name: PH_PULL0_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
[2i+1:2i] (i=0~11)	R/W	0x0	PH_PULL PH[n] Pull-up/down Select (n = 0~11) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.63. PH PULL Register 1 (Default Value: 0x00000000)

Offset: 0x11C			Register Name: PH_PULL1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.64. PB External Interrupt Configure Register 0 (Default Value: 0x00000000)

Offset: 0x200			Register Name: PB_EINT_CFG0_REG
Bit	R/W	Default/Hex	Description

[4i+3:4i] (i=0~7)	R/W	0	EINT_CFG External INTn Mode (n = 0~7) 0x0: Positive Edge 0x1: Negative Edge 0x2: High Level 0x3: Low Level 0x4: Double Edge (Positive/ Negative) Others: Reserved
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3.24.2.65. PB External Interrupt Configure Register 1 (Default Value: 0x00000000)

Offset: 0x204			Register Name: PB_EINT_CFG1_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
[4i+3:4i] (i=0~2)	R/W	0	EINT_CFG External INTn Mode (n = 8~10) 0x0: Positive Edge 0x1: Negative Edge 0x2: High Level 0x3: Low Level 0x4: Double Edge (Positive/ Negative) Others: Reserved

3.24.2.66. PB External Interrupt Configure Register 2 (Default Value: 0x00000000)

Offset: 0x208			Register Name: PB_EINT_CFG2_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.67. PB External Interrupt Configure Register 3 (Default Value: 0x00000000)

Offset: 0x20C			Register Name: PB_EINT_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.68. PB External Interrupt Control Register (Default Value: 0x00000000)

Offset: 0x210			Register Name: PB_EINT_CTL_REG
Bit	R/W	Default/Hex	Description

31:11	/	/	/
[n] (n=0~10)	R/W	0	EINT_CTL External INTn Enable (n = 0~10) 0: Disable 1: Enable

3.24.2.69. PB External Interrupt Status Register (Default Value: 0x00000000)

Offset: 0x214			Register Name: PB_EINT_STATUS_REG
Bit	R/W	Default/Hex	Description
31:11	/	/	/
[n] (n=0~10)	R/W	0	EINT_STATUS External INTn Pending Bit (n = 0~10) 0: No IRQ pending 1: IRQ pending Write '1' to clear

3.24.2.70. PB External Interrupt Debounce Register (Default Value: 0x00000000)

Offset: 0x218			Register Name: PB_EINT_DEB_REG
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6:4	R/W	0	DEB_CLK_PRE_SCALE Debounce Clock Pre-scale n The selected clock source is prescaled by 2^n.
3:1	/	/	/
0	R/W	0	PIO_INT_CLK_SELECT PIO Interrupt Clock Select 0: LOSC 32Khz 1: HOSC 24Mhz

3.24.2.71. PG External Interrupt Configure Register 0 (Default Value: 0x00000000)

Offset: 0x220			Register Name: PG_EINT_CFG0_REG
Bit	R/W	Default/Hex	Description
[4i+3:4i] (i=0~7)	R/W	0	EINT_CFG External INTn Mode (n = 0~7) 0x0: Positive Edge 0x1: Negative Edge 0x2: High Level 0x3: Low Level

			0x4: Double Edge (Positive/ Negative) Others: Reserved
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3.24.2.72. PG External Interrupt Configure Register 1 (Default Value: 0x00000000)

Offset: 0x224			Register Name: PG_EINT_CFG1_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
[4i+3:4i] (i=0~5)	R/W	0	EINT_CFG External INTn Mode (n = 8~13) 0x0: Positive Edge 0x1: Negative Edge 0x2: High Level 0x3: Low Level 0x4: Double Edge (Positive/ Negative) Others: Reserved

3.24.2.73. PG External Interrupt Configure Register 2 (Default Value: 0x00000000)

Offset: 0x228			Register Name: PG_EINT_CFG2_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.74. PG External Interrupt Configure Register 3 (Default Value: 0x00000000)

Offset: 0x22C			Register Name: PG_EINT_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.75. PG External Interrupt Control Register (Default Value: 0x00000000)

Offset: 0x230			Register Name: PG_EINT_CTL_REG
Bit	R/W	Default/Hex	Description
31:14	/	/	/
[n] (n=0~13)	R/W	0	EINT_CTL External INTn Enable (n = 0~13) 0: Disable 1: Enable

3.24.2.76. PG External Interrupt Status Register (Default Value: 0x00000000)

Offset: 0x234			Register Name: PG_EINT_STATUS_REG
Bit	R/W	Default/Hex	Description
31:14	/	/	/
[n] (n=0~13)	R/W	0	EINT_STATUS External INTn Pending Bit (n = 0~13) 0: No IRQ pending 1: IRQ pending Write '1' to clear

3.24.2.77. PG External Interrupt Debounce Register (Default Value: 0x00000000)

Offset: 0x238			Register Name: PG_EINT_DEB_REG
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6:4	R/W	0	DEB_CLK_PRE_SCALE Debounce Clock Pre-scale n The selected clock source is prescaled by 2^n.
3:1	/	/	/
0	R/W	0	PIO_INT_CLK_SELECT PIO Interrupt Clock Select 0: LOSC 32Khz 1: HOSC 24Mhz

3.24.2.78. PH External Interrupt Configure Register 0 (Default Value: 0x00000000)

Offset: 0x240			Register Name: PH_EINT_CFG0_REG
Bit	R/W	Default/Hex	Description
[4i+3:4i] (i=0~7)	R/W	0	EINT_CFG External INTn Mode (n = 0~7) 0x0: Positive Edge 0x1: Negative Edge 0x2: High Level 0x3: Low Level 0x4: Double Edge (Positive/ Negative) Others: Reserved

3.24.2.79. PH External Interrupt Configure Register 1 (Default Value: 0x00000000)

Offset: 0x244			Register Name: PH_EINT_CFG1_REG
Bit	R/W	Default/Hex	Description
31:16	/	/	/
[4i+3:4i] (i=0~3)	R/W	0	EINT_CFG External INTn Mode (n = 8~11) 0x0: Positive Edge 0x1: Negative Edge 0x2: High Level 0x3: Low Level 0x4: Double Edge (Positive/ Negative) Others: Reserved

3.24.2.80. PH External Interrupt Configure Register 2 (Default Value: 0x00000000)

Offset: 0x248			Register Name: PH_EINT_CFG2_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.81. PH External Interrupt Configure Register 3 (Default Value: 0x00000000)

Offset: 0x24C			Register Name: PH_EINT_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.82. PH External Interrupt Control Register (Default Value: 0x00000000)

Offset: 0x250			Register Name: PH_EINT_CTL_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
[n] (n=0~11)	R/W	0	EINT_CTL External INTn Enable (n = 0~11) 0: Disable 1: Enable

3.24.2.83. PH External Interrupt Status Register (Default Value: 0x00000000)

Offset: 0x254			Register Name: PH_EINT_STATUS_REG
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Bit	R/W	Default/Hex	Description
31:12	/	/	/
[n] (n=0~11)	R/W	0	EINT_STATUS External INTn Pending Bit (n = 0~11) 0: No IRQ pending 1: IRQ pending Write '1' to clear

3.24.2.84. PH External Interrupt Debounce Register (Default Value: 0x00000000)

Offset: 0x258			Register Name: PH_EINT_DEB_REG
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6:4	R/W	0	DEB_CLK_PRE_SCALE Debounce Clock Pre-scale n The selected clock source is prescaled by 2^n.
3:1	/	/	/
0	R/W	0	PIO_INT_CLK_SELECT PIO Interrupt Clock Select 0: LOSC 32Khz 1: HOSC 24Mhz

3.24.2.85. PB Group Configuration Register (Default Value: 0x0000000D)

Offset: 0x304			Register Name: PB_GRP_CONFIG_REG
Bit	R/W	Default/Hex	Description
31:4	/	/	/
3:0	R/W	0xD	IO_BIAS_CONFIG IO Pad Bias Configuration Value 0x0: for 1.8V Power Supply; 0x6: for 2.5V Power Supply; 0x9: for 2.8V Power Supply; 0xA: for 3.0V Power Supply; 0xD: for 3.3V Power Supply; Others: Reserved. Note: The configuration value must greater than or equal to the corresponding value of the voltage supplied to the IO Group.

3.24.2.86. PC Group Configuration Register (Default Value: 0x00000006)

Offset: 0x308			Register Name: PC_GRP_CONFIG_REG
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Bit	R/W	Default/Hex	Description
31:4	/	/	/
3:0	R/W	0x6	IO_BIAS_CONFIG IO Pad Bias Configuration Value 0x0: for 1.8V Power Supply; 0x6: for 2.5V Power Supply; 0x9: for 2.8V Power Supply; 0xA: for 3.0V Power Supply; 0xD: for 3.3V Power Supply; Others: Reserved. Note: The configuration value must greater than or equal to the corresponding value of the voltage supplied to the IO Group.

3.24.2.87. PD Group Configuration Register (Default Value: 0x0000000D)

Offset: 0x30C			Register Name: PD_GRP_CONFIG_REG
Bit	R/W	Default/Hex	Description
31:4	/	/	/
3:0	R/W	0xD	IO_BIAS_CONFIG IO Pad Bias Configuration Value 0x0: for 1.8V Power Supply; 0x6: for 2.5V Power Supply; 0x9: for 2.8V Power Supply; 0xA: for 3.0V Power Supply; 0xD: for 3.3V Power Supply; Others: Reserved. Note: The configuration value must greater than or equal to the corresponding value of the voltage supplied to the IO Group.

3.24.2.88. PE Group Configuration Register (Default Value: 0x0000000D)

Offset: 0x310			Register Name: PE_GRP_CONFIG_REG
Bit	R/W	Default/Hex	Description
31:4	/	/	/
3:0	R/W	0xD	IO_BIAS_CONFIG IO Pad Bias Configuration Value 0x0: for 1.8V Power Supply; 0x6: for 2.5V Power Supply; 0x9: for 2.8V Power Supply; 0xA: for 3.0V Power Supply; 0xD: for 3.3V Power Supply; Others: Reserved.

			Note: The configuration value must greater than or equal to the corresponding value of the voltage supplied to the IO Group.
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3.24.2.89. PF Group Configuration Register (Default Value: 0x0000000D)

Offset: 0x314			Register Name: PF_GRP_CONFIG_REG
Bit	R/W	Default/Hex	Description
31:4	/	/	/
3:0	R/W	0xD	IO_BIAS_CONFIG IO Pad Bias Configuration Value 0x0: for 1.8V Power Supply; 0x6: for 2.5V Power Supply; 0x9: for 2.8V Power Supply; 0xA: for 3.0V Power Supply; 0xD: for 3.3V Power Supply; Others: Reserved. Note: The configuration value must greater than or equal to the corresponding value of the voltage supplied to the IO Group.

3.24.2.90. PG Group Configuration Register (Default Value: 0x0000000D)

Offset: 0x318			Register Name: PG_GRP_CONFIG_REG
Bit	R/W	Default/Hex	Description
31:4	/	/	/
3:0	R/W	0xD	IO_BIAS_CONFIG IO Pad Bias Configuration Value 0x0: for 1.8V Power Supply; 0x6: for 2.5V Power Supply; 0x9: for 2.8V Power Supply; 0xA: for 3.0V Power Supply; 0xD: for 3.3V Power Supply; Others: Reserved. Note: The configuration value must greater than or equal to the corresponding value of the voltage supplied to the IO Group.

3.24.2.91. PH Group Configuration Register (Default Value: 0x0000000D)

Offset: 0x31C			Register Name: PH_GRP_CONFIG_REG
Bit	R/W	Default/Hex	Description
31:4	/	/	/
3:0	R/W	0xD	IO_BIAS_CONFIG

			IO Pad Bias Configuration Value 0x0: for 1.8V Power Supply; 0x6: for 2.5V Power Supply; 0x9: for 2.8V Power Supply; 0xA: for 3.0V Power Supply; 0xD: for 3.3V Power Supply; Others: Reserved. Note: The configuration value must greater than or equal to the corresponding value of the voltage supplied to the IO Group.
--	--	--	--

3.24.2.92. PL Configure Register 0 (Default Value: 0x77777777)

Offset: 0x00			Register Name: PL_CFG0_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0x7	PL7_SELECT 000:Input 001:Output 010:S_JTAG_DI 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT7 111:IO Disable
27	/	/	/
26:24	R/W	0x7	PL6_SELECT 000:Input 001:Output 010:S_JTAG_DO 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT6 111:IO Disable
23	/	/	/
22:20	R/W	0x7	PL5_SELECT 000:Input 001:Output 010:S_JTAG_CK 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT5 111:IO Disable
19	/	/	/
18:16	R/W	0x7	PL4_SELECT 000:Input 001:Output 010:S_JTAG_MS 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT4 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PL3_SELECT 000:Input 001:Output 010:S_UART_RX 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT3 111:IO Disable

11	/	/	/
10:8	R/W	0x7	PL2_SELECT 000:Input 001:Output 010:S_UART_TX 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT2 111:IO Disable
7	/	/	/
6:4	R/W	0x7	PL1_SELECT 000:Input 001:Output 010:S_RSB_SDA 011:S_TWI_SDA 100:Reserved 101:Reserved 110:S_PL_EINT1 111:IO Disable
3	/	/	/
2:0	R/W	0x7	PL0_SELECT 000:Input 001:Output 010:S_RSB_SCK 011:S_TWI_SCK 100:Reserved 101:Reserved 110:S_PL_EINT0 111:IO Disable

3.24.2.93. PL Configure Register 1 (Default Value: 0x00077777)

Offset: 0x04			Register Name: PL_CFG1_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
18:16	R/W	0x7	PL12_SELECT 000:Input 001:Output 010:S_CIR_RX 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT12 111:IO Disable
15	/	/	/
14:12	R/W	0x7	PL11_SELECT 000:Input 001:Output 010: Reserved 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT11 111:IO Disable
11	/	/	/
10:8	R/W	0x7	PL10_SELECT 000:Input 001:Output 010:S_PWM 011:Reserved 100:Reserved 101:Reserved 110:S_PL_EINT10 111:IO Disable
7	/	/	/
6:4	R/W	0x7	PL9_SELECT 000:Input 001:Output

			010:S_TWI_SDA 100:Reserved 110:S_PL_EINT9	011:Reserved 101:Reserved 111:IO Disable
3	/	/	/	
2:0	R/W	0x7	PL8_SELECT 000:Input 010:S_TWI_SCK 100:Reserved 110:S_PL_EINT8	001:Output 011:Reserved 101:Reserved 111:IO Disable

3.24.2.94. PL Configure Register 2 (Default Value: 0x00000000)

Offset: 0x08			Register Name: PL_CFG2_REG
Bit	R/W	Default/Hex	Description
31	/	/	/

3.24.2.95. PL Configure Register 3 (Default Value: 0x00000000)

Offset: 0x0C			Register Name: PL_CFG3_REG
Bit	R/W	Default/Hex	Description
31	/	/	/

3.24.2.96. PL Data Register (Default Value: 0x00000000)

Offset: 0x10			Register Name: PL_DATA_REG
Bit	R/W	Default/Hex	Description
31:19	/	/	/
12:0	R/W	0x0	PL_DAT If the port is configured as input, the corresponding bit is the pin state. If the port is configured as output, the pin state is the same as the corresponding bit. The read bit value is the value setup by software. If the port is configured as functional pin, the undefined value will be read.

3.24.2.97. PL Multi-Driving Register 0 (Default Value: 0x01555555)

Offset: 0x14			Register Name: PL_DRV0_REG
Bit	R/W	Default/Hex	Description
31:26	/	/	/
[2i+1:2i]	R/W	0x1	PL_DRV

(i=0~12)			PL[n] Multi-Driving SELECT (n = 0~12) 00: Level 0 01: Level 1 10: Level 2 11: Level 3
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3.24.2.98. PL Multi-Driving Register 1 (Default Value: 0x00000000)

Offset: 0x18			Register Name: PL_DRV1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.99. PL PULL Register 0 (Default Value: 0x00000005)

Offset: 0x1C			Register Name: PL_PULL0_REG
Bit	R/W	Default/Hex	Description
31:26	/	/	/
[2i+1:2i] (i=0~12)	R/W	0x5	PF_PULL PF[n] Pull-up/down Select (n = 0~12) 00: Pull-up/down disable 01: Pull-up 10: Pull-down 11: Reserved

3.24.2.100. PL PULL Register 1 (Default Value: 0x00000000)

Offset: 0x20			Register Name: PL_PULL1_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.101. PL External Interrupt Configure Register 0 (Default Value: 0x00000000)

Offset: 0x200			Register Name: PL_EINT_CFG0_REG
Bit	R/W	Default/Hex	Description
[4i+3:4i] (i=0~7)	R/W	0	EINT_CFG External INTn Mode (n = 0~7) 0x0: Positive Edge 0x1: Negative Edge 0x2: High Level 0x3: Low Level 0x4: Double Edge (Positive/ Negative) Others: Reserved

3.24.2.102. PL External Interrupt Configure Register 1 (Default Value: 0x00000000)

Offset: 0x204			Register Name: PL_EINT_CFG1_REG
Bit	R/W	Default/Hex	Description
31:20	/	/	/
[4i+3:4i] (i=0~4)	R/W	0	EINT_CFG External INTn Mode (n = 8~12) 0x0: Positive Edge 0x1: Negative Edge 0x2: High Level 0x3: Low Level 0x4: Double Edge (Positive/ Negative) Others: Reserved

3.24.2.103. PL External Interrupt Configure Register 2 (Default Value: 0x00000000)

Offset: 0x208			Register Name: PL_EINT_CFG2_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.104. PL External Interrupt Configure Register 3 (Default Value: 0x00000000)

Offset: 0x20C			Register Name: PL_EINT_CFG3_REG
Bit	R/W	Default/Hex	Description
31:0	/	/	/

3.24.2.105. PL External Interrupt Control Register (Default Value: 0x00000000)

Offset: 0x210			Register Name: PL_EINT_CTL_REG
Bit	R/W	Default/Hex	Description
31:13	/	/	/
[n] (n=0~12)	R/W	0	EINT_CTL External INTn Enable (n = 0~12) 0: Disable 1: Enable

3.24.2.106. PL External Interrupt Status Register (Default Value: 0x00000000)

Offset: 0x214			Register Name: PL_EINT_STATUS_REG
Bit	R/W	Default/Hex	Description

31:13	/	/	/
[n] (n=0~12)	R/W	0	EINT_STATUS External INTn Pending Bit (n = 0~12) 0: No IRQ pending 1: IRQ pending Write '1' to clear it.

3.24.2.107. PL External Interrupt Debounce Register (Default Value: 0x00000000)

Offset: 0x218			Register Name: PL_EINT_DEB_REG
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6:4	R/W	0	DEB_CLK_PRE_SCALE Debounce Clock Pre-scale n The selected clock source is prescaled by 2^n.
3:1	/	/	/
0	R/W	0	PIO_INT_CLK_SELECT PIO Interrupt Clock Select 0: LOSC 32Khz 1: HOSC 24Mhz

3.24.2.108. PL Group Configuration Register (Default Value: 0x0000000D)

Offset: 0x300			Register Name: PL_GRP_CONFIG_REG
Bit	R/W	Default/Hex	Description
31:4	/	/	/
3:0	R/W	0xD	IO_BIAS_CONFIG IO Pad Bias Configuration Value 0x0: for 1.8V Power Supply; 0x6: for 2.5V Power Supply; 0x9: for 2.8V Power Supply; 0xA: for 3.0V Power Supply; 0xD: for 3.3V Power Supply; Others: Reserved. Note: The configuration value must greater than or equal to the corresponding value of the voltage supplied to the IO Group.

Chapter 4 Memory

This section describes the A83T memory from three aspects:

- [SDRAM](#)
- [NAND Flash](#)
- [SD/MMC](#)

4.1. SDRAM

4.1.1. Overview

The SDRAM Controller (DRAMC) provides a simple, flexible, burst-optimized interface to all industry-standard SDRAM. It supports up to a 16G bits memory address space.

The DRAMC automatically handles memory management, initialization, and refresh operations. It gives the host CPU a simple command interface, hiding details of the required address, page, and burst handling procedures. All memory parameters are runtime-configurable, including timing, memory setting, SDRAM type, and Extended-Mode-Register settings. To simplify chip system integration, DDR controller works in half rate mode.

The DRAMC includes the following features:

- 32-bits data width
- Support 2 Chip Select
- Support DDR3/DDR3L/LPDDR2/LPDDR3 SDRAM
- Support Different Memory Device's Power Voltage of 1.2V 1.35V 1.5V and 1.8V
- Support clock frequency up to 800MHz(DDR3)/667MHz(LPDDR3)/533MHz(LPDDR2)
- Support Memory Capacity up to 16G bits (2G Bytes)
- Support 16 address lines and three bank address lines per channel
- Automatically generates initialization and refresh sequences
- Runtime-configurable parameters setting for application flexibility
- Support Memory Dynamic Frequency Scale
- Priority of transferring through multiple ports is programmable
- Random read or write operation is supported

4.2. NAND Flash

4.2.1. Overview

The NDFC is the NAND Flash Controller which supports all NAND flash memory available in the market. New type flash can be supported by software re-configuration.

The On-the-fly error correction code (ECC) is built-in NDFC for enhancing reliability. BCH is implemented and it can detect and correct up to 64 bits error per 512 or 1024 bytes data. The on chip ECC and parity checking circuitry of NDFC frees CPU for other tasks. The ECC function can be disabled by software.

The data can be transferred by DMA or by CPU memory-mapped IO method. The NDFC provides automatic timing control for reading or writing external Flash. The NDFC maintains the proper relativity for CLE, CE# and ALE control signal lines. Three kind of modes are supported for serial read access. The conventional serial access is mode 0 and mode 1 is for EDO type and mode 2 for extension EDO type. NDFC can monitor the status of R/B# signal line.

Block management and wear leveling management are implemented in software.

The NAND Flash Controller (NDFC) includes the following features:

- Supports all SLC/MLC/TLC flash and EF-NAND memory available in the market
- Software configure seed for randomize engine
- Software configure method for adaptability to a variety of system and memory types
- Supports 8-bit Data Bus Width
- Supports 1024, 2048, 4096, 8192, 16384 bytes size per page
- Supports Conventional and EDO serial access method for serial reading Flash
- On-the-fly BCH error correction code which correcting up to 64 bits per 512 or 1024 bytes
- Corrected Error bits number information report
- ECC automatic disable function for all 0xff data
- NDFC status information is reported by its' registers and interrupt is supported
- One Command FIFO
- External DMA is supported for transferring data
- Two 256x32-bit RAM for Pipeline Procession
- Support SDR, ONFI DDR and Toggle DDR NAND
- Support self –debug for NDFC debug

4.2.2. Block Diagram

The NAND Flash Controller (NDFC) system block diagram is shown below:

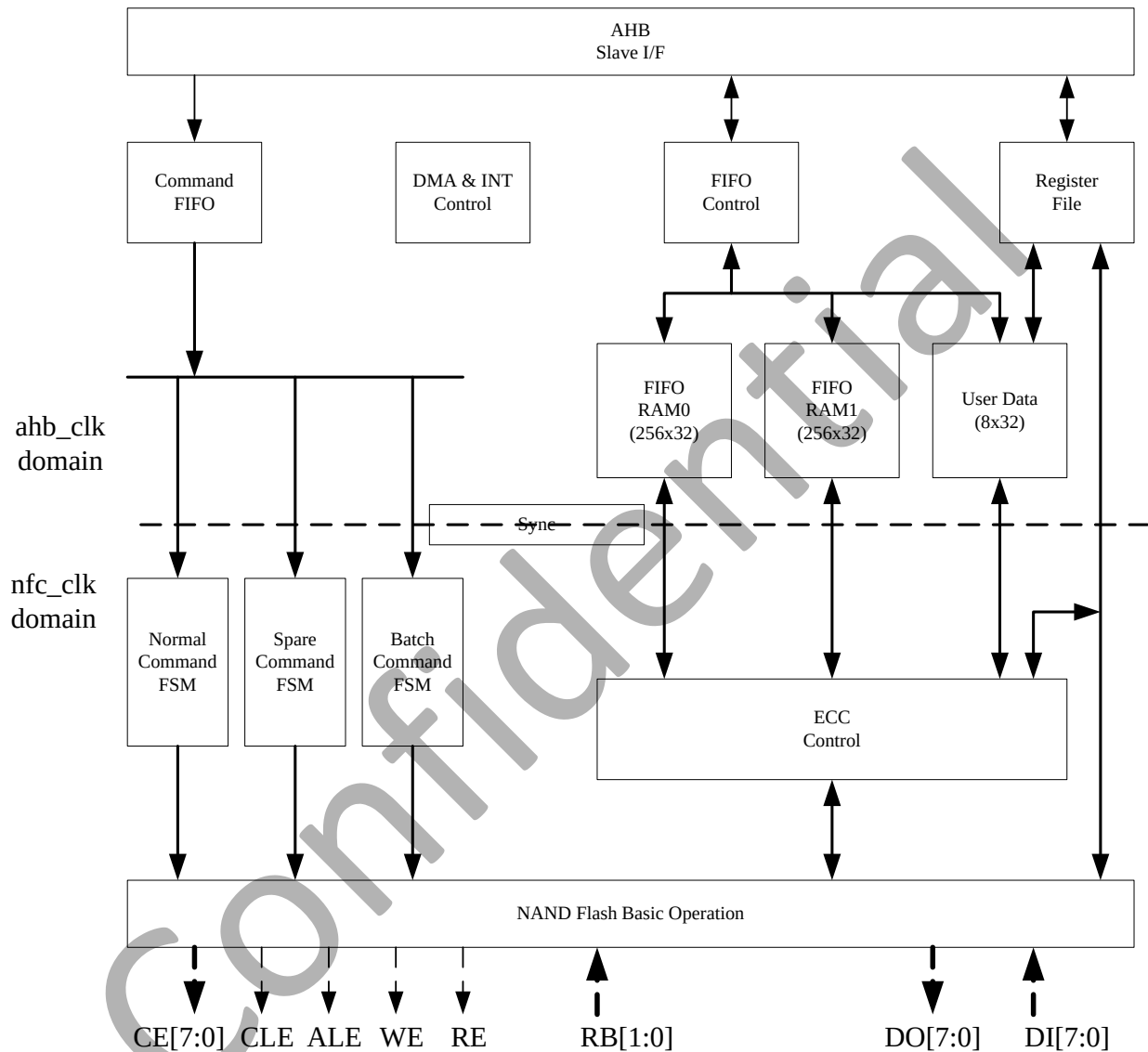


Figure 4-1. NDFC Block Diagram

4.2.3. NDFC Timing Diagram

Typically, there are two kinds of serial access method. One method is conventional method which fetching data at the rise edge of NDFC_RE# signal line. Another one is EDO type which fetching data at the next fall edge of NDFC_RE# signal line.

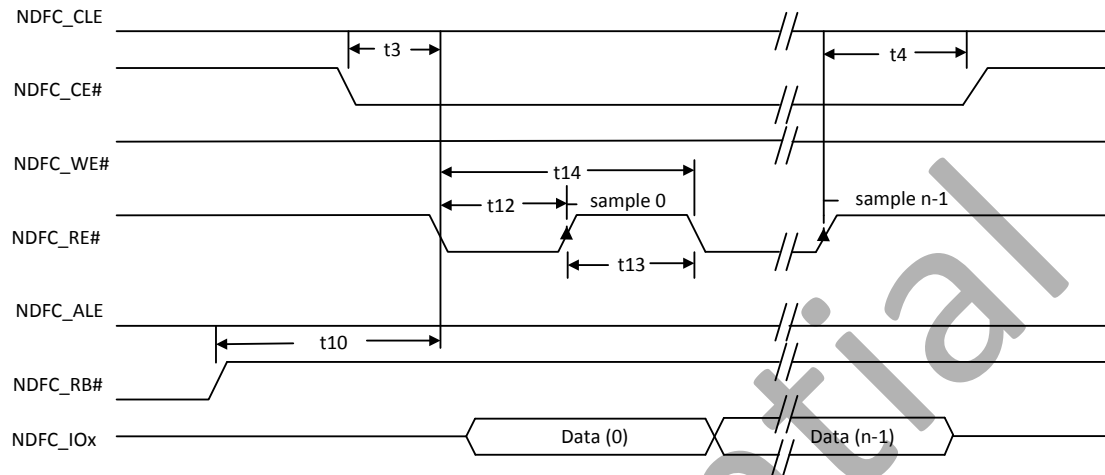


Figure 4-2. Conventional Serial Access Cycle Diagram (SAM0)

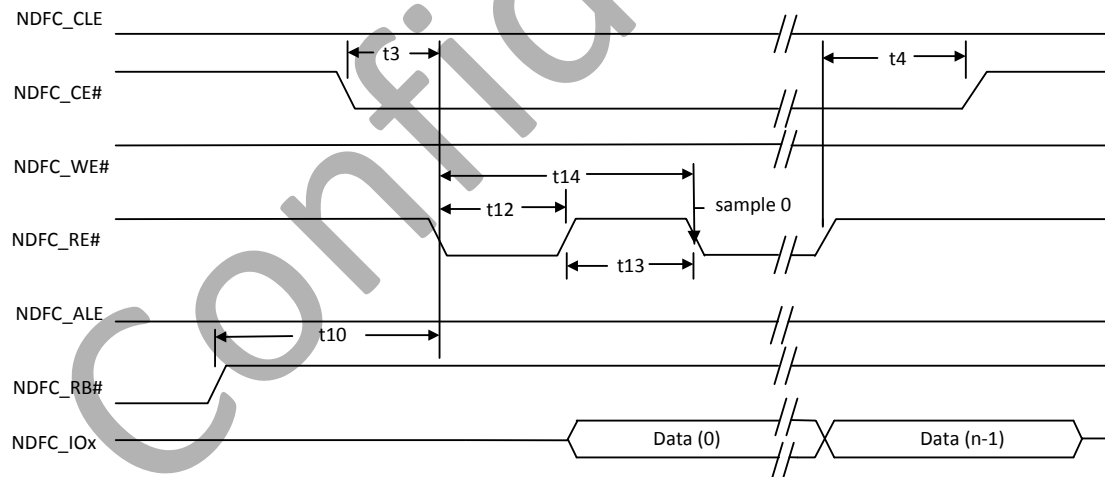


Figure 4-3. EDO type Serial Access after Read Cycle (SAM1)

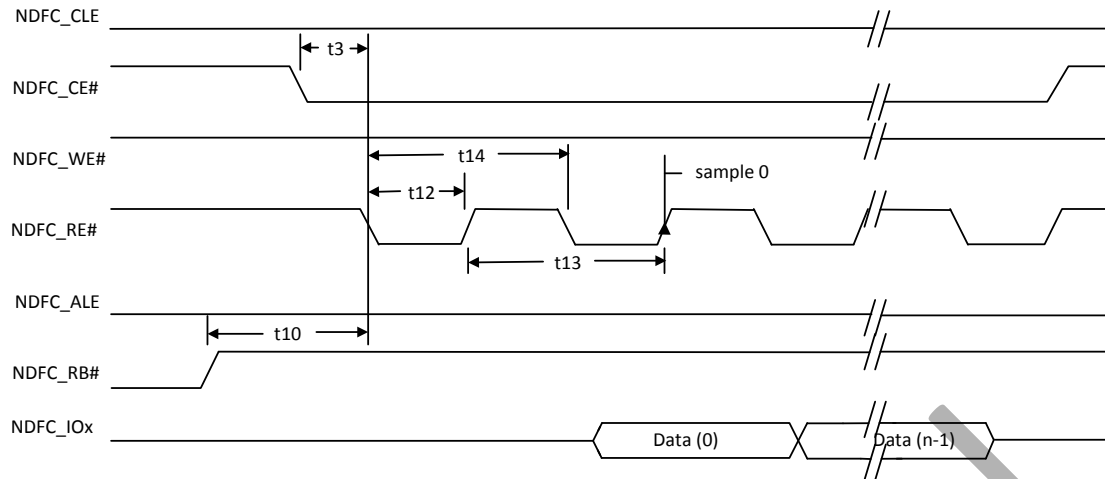


Figure 4-4. Extending EDO type Serial Access Mode (SAM2)

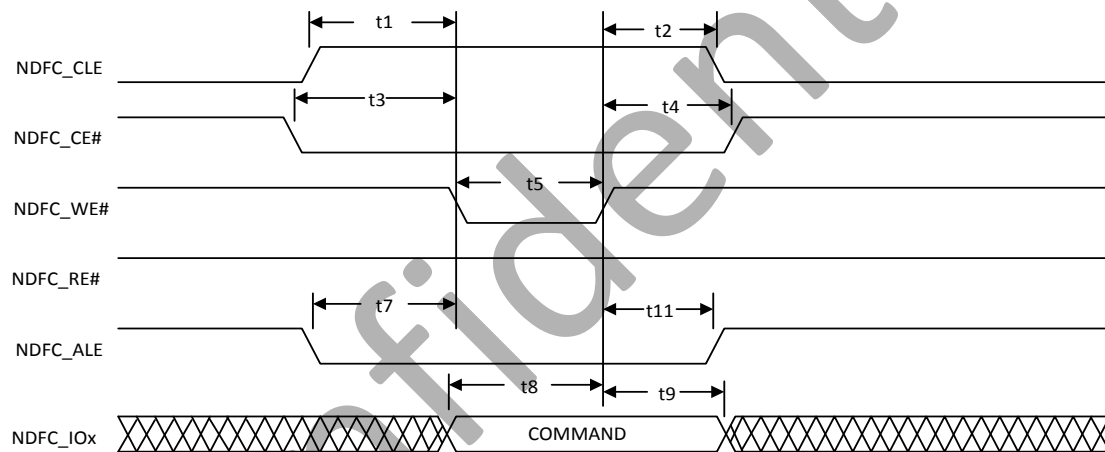


Figure 4-5. Command Latch Cycle

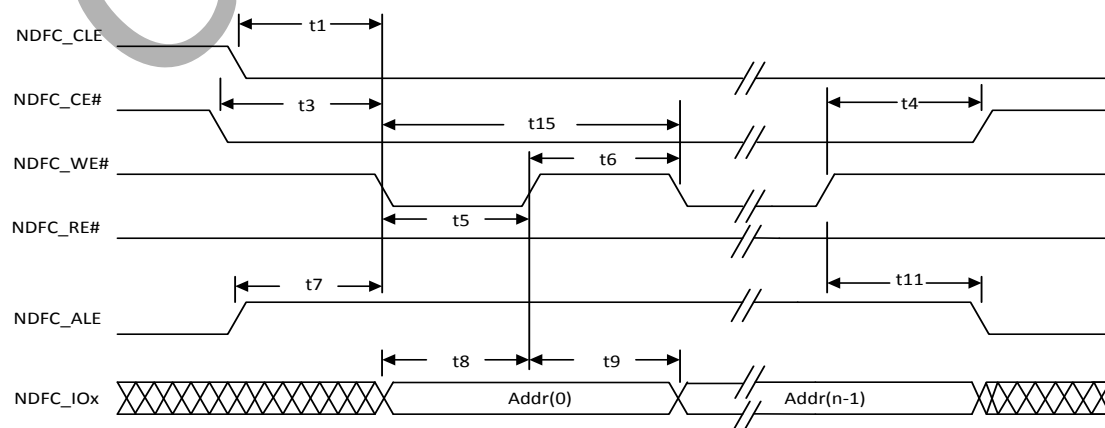


Figure 4-6. Address Latch Cycle

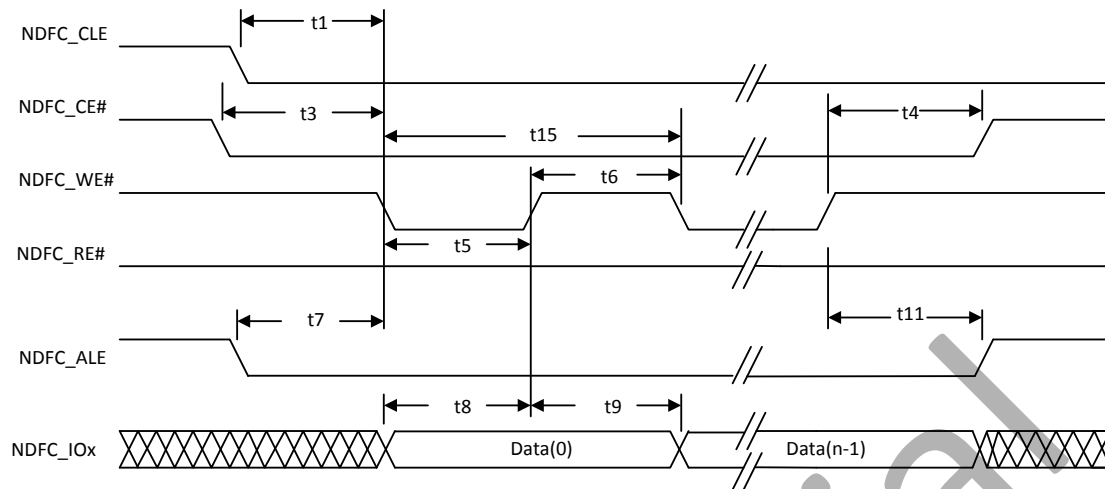


Figure 4-7. Write Data to Flash Cycle

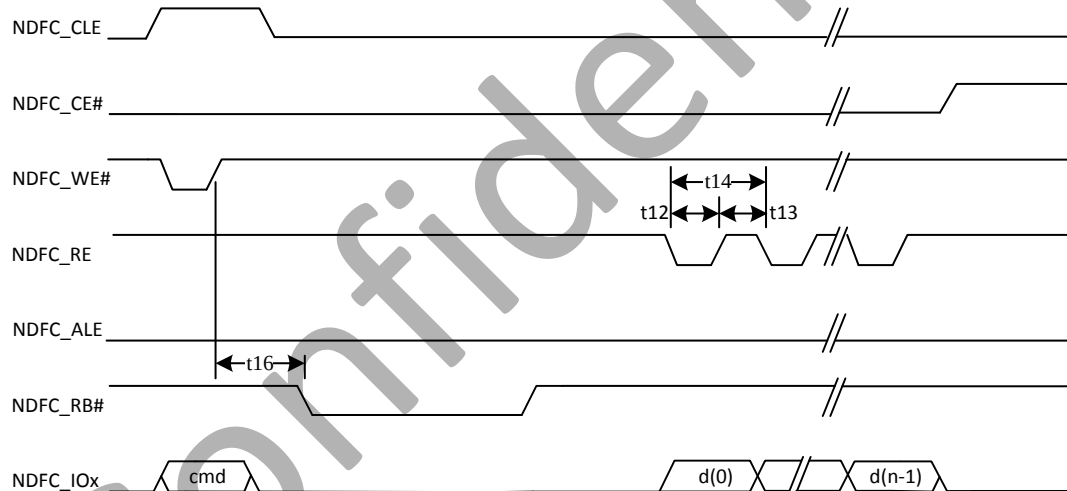


Figure 4-8. Waiting R/B# ready Diagram

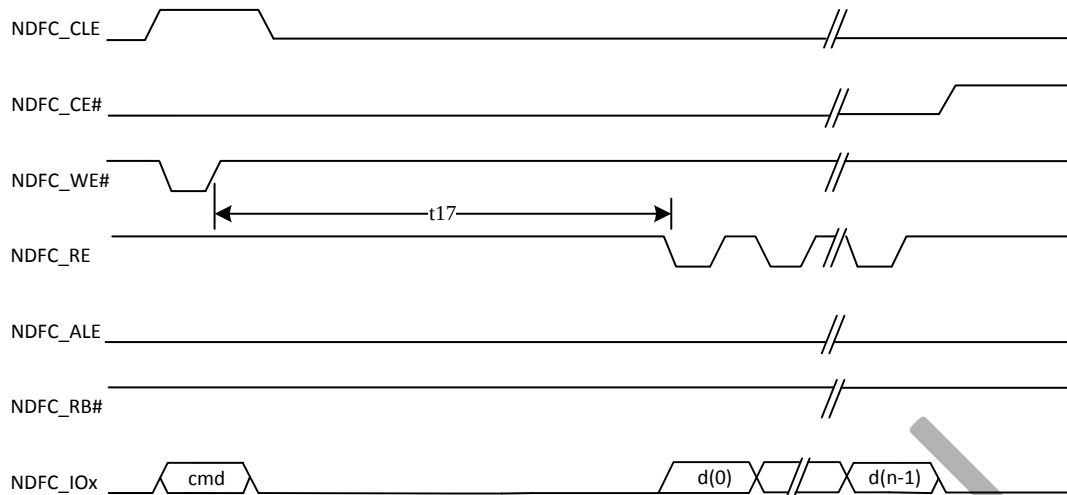


Figure 4-9. WE# high to RE# low Timing Diagram

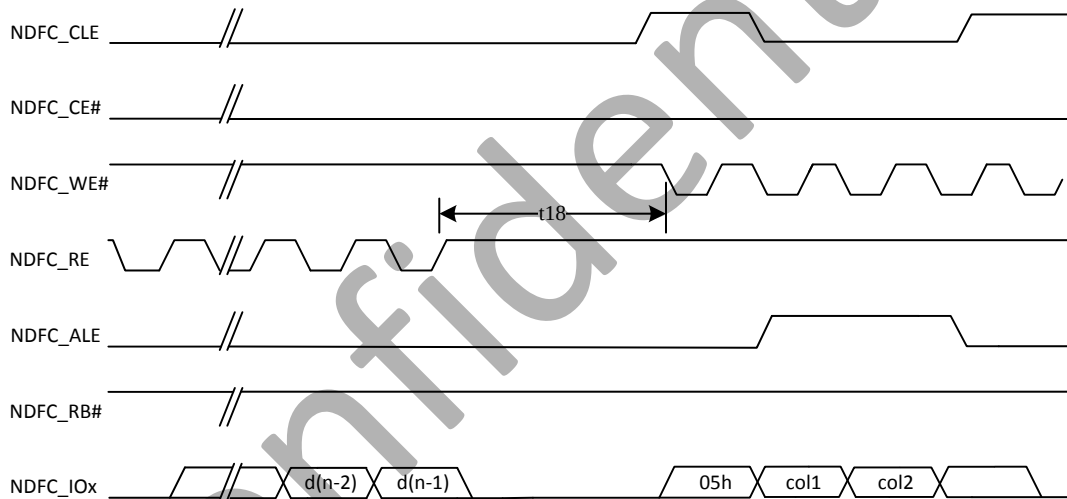


Figure 4-10. RE# high to WE# low Timing Diagram

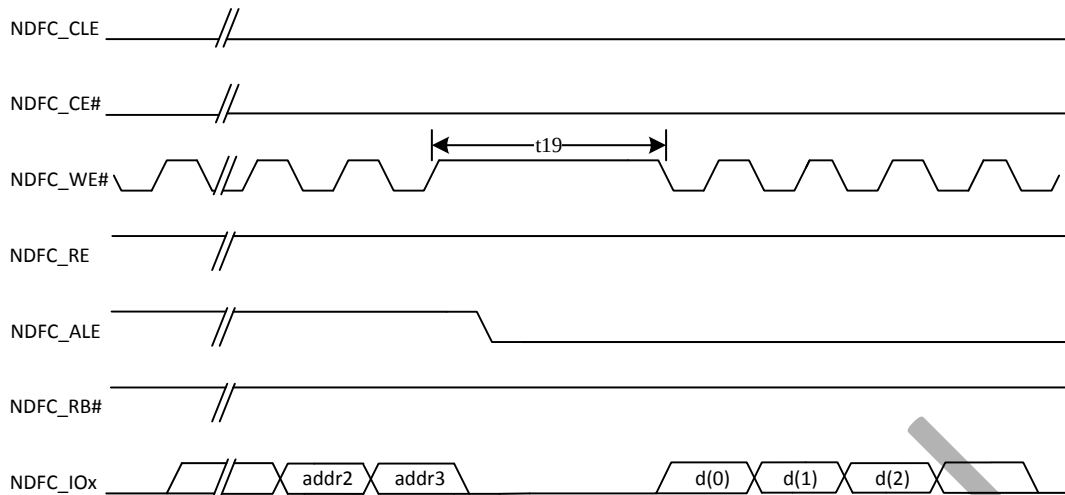


Figure 4-11. Address to Data Loading Timing Diagram

Timing cycle list:

ID	Parameter	Timing	Notes
t1	NDFC_CLE setup time	T	
t2	NDFC_CLE hold time	T	
t3	NDFC_CE setup time	T	
t4	NDFC_CE hold time	T	
t5	NDFC_WE# pulse width	T	
t6	NDFC_WE# hold time	T	
t7	NDFC_ALE setup time	T	
t8	Data setup time	T	
t9	Data hold time	T	
t10	Ready to NDFC_RE# low	3T	
t11	NDFC_ALE hold time	T	
t12	NDFC_RE# pulse width	T	
t13	NDFC_RE# hold time	T	
t14	Read cycle time	2T	
t15	Write cycle time	2T	
t16	NDFC_WE# high to R/B# busy	tWB	Specified by timing configure register (NDFC_TIMING_CFG)
t17	NDFC_WE# high to NDFC_RE# low	tWHR	Specified by timing configure register (NDFC_TIMING_CFG)
t18	NDFC_RE# high to NDFC_WE# low	tRHW	Specified by timing configure register (NDFC_TIMING_CFG)
t19	Address to Data Loading time	tADL	Specified by timing configure register (NDFC_TIMING_CFG)

Notes:

T is the clock period duration of NDFC_CLK (x2).

4.2.4. NDFC Operation Guide

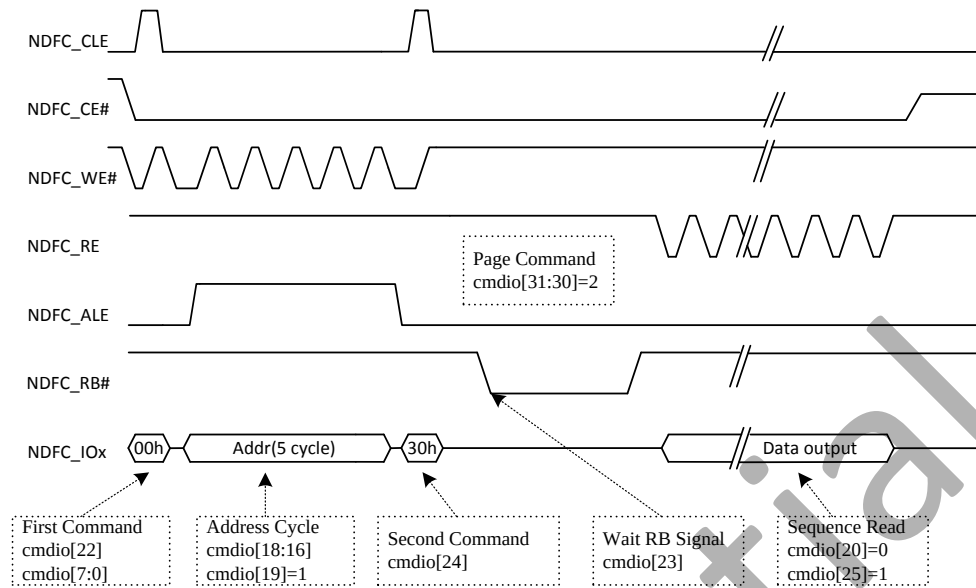


Figure 4-12. Page Read Command Diagram

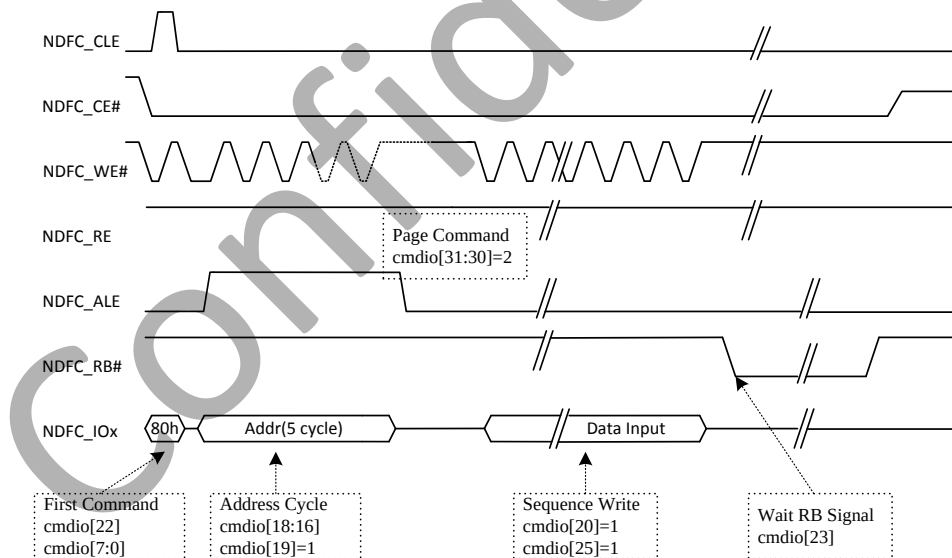


Figure 4-13. Page Program Diagram



Module Name	Base Address
NDFC	0x01C03000

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NDFC_CTL	0x00	NDFC Configure and Control Register
NDFC_ST	0x04	NDFC Status Information Register
NDFC_INT	0x08	NDFC Interrupt Control Register
NDFC_TIMING_CTL	0x0C	NDFC Timing Control Register
NDFC_TIMING_CFG	0x10	NDFC Timing Configure Register
NDFC_ADDR_LOW	0x14	NDFC Low Word Address Register
NDFC_ADDR_HIGH	0x18	NDFC High Word Address Register
NDFC_BLOCK_NUM	0x1C	NDFC Data Block Number Register
NDFC_CNT	0x20	NDFC Data Counter for data transfer Register
NDFC_CMD	0x24	Set up NDFC commands Register
NDFC_RCMD_SET	0x28	Read Command Set Register for vendor's NAND memory
NDFC_WCMD_SET	0x2C	Write Command Set Register for vendor's NAND memory
NDFC_ECC_CTL	0x34	ECC Configure and Control Register
NDFC_ECC_ST	0x38	ECC Status and Operation information Register
NDFC_EFR	0x3C	Enhanced Feature Register
NDFC_ERR_CNT0	0x40	Corrected Error Bit Counter Register 0
NDFC_ERR_CNT1	0x44	Corrected Error Bit Counter Register 1
NDFC_USER_DATA _n	0x50+4*n	User Data Field Register n (n from 0 to 15)
NDFC_EFNAND_STA	0x90	EFNAND Status Register
NDFC_SPARE_AREA	0xA0	Spare Area Configure Register
NDFC_PAT_ID	0xA4	Pattern ID Register
NDFC_RDATA_STA_CTL	0xA8	Read Data Status Control Register
NDFC_RDATA_STA_0	0xAC	Read Data Status Register 0
NDFC_RDATA_STA_1	0xB0	Read Data Status Register 1
NDFC_MDMA_ADDR	0xC0	MBUS DMA Address Register
NDFC_MDMA_CNT	0xC4	MBUS DMA Data Counter Register
NDFC_IO_DATA	0x300	Data Input/ Output Port Address Register
RAM0_BASE	0x400	1024 Bytes RAM0 base
RAM1_BASE	0x800	1024 Bytes RAM1 base

4.2.6. NDFC Register Description

4.2.6.1. NDFC Control Register(Default Value: 0x00000000)

Offset: 0x00			Register Name: NDFC_CTL
Bit	Read/Write	Default	Description
31:28	/	/	/
27:24	R/W	0	NDFC_CE_SEL

			Chip Select for 8 NAND Flash Chips 0 -7: NDFC Chip Select Signal 0-7 is selected 8-15: NDFC CS[7:0] not selected. GPIO pins can be used for CS. NDFC can support up to 16 CS.
23:22	/	/	/
21	R/W	0	NDFC_DDR_RM DDR Repeat data mode 0: Lower byte 1: Higher byte
20	R/W	0	NDFC_DDR_REN DDR Repeat Enable 0: Disable 1: Enable
19:18	R/W	0	NF_TYPE NAND Flash Type 0x0: Normal SDR NAND 0x1: Reserved 0x2: ONFI DDR NAND 0x3: Toggle DDR NAND
17	R/W	0	NDFC_CLE_POL NDFC Command Latch Enable (CLE) Signal Polarity Select 0: High active 1: Low active
16	R/W	0	NDFC_ALE_POL NDFC Address Latch Enable (ALE) Signal Polarity Select 0: High active 1: Low active
15	R/W	0	NDFC_DMA_TYPE 0: Dedicated DMA 1: Normal DMA
14	R/W	0	NDFC_RAM_METHOD Access internal RAM method 0: Access internal RAM by AHB bus 1: Access internal RAM by DMA bus
13:12	/	/	/
11:8	R/W	0x0	NDFC_PAGE_SIZE 0x0: 1024 bytes 0x1: 2048 bytes 0x2: 4096 bytes 0x3: 8192 bytes 0x4: 16384 bytes Notes: The page size is for main field data.
7	/	/	/
6	R/W	0	NDFC_CE_ACT Chip Select Signal CE# Control During NAND operation

			0: De-active Chip Select Signal NDFC_CE# during data loading, serial access and other no operation stage for power consumption. NDFC automatic control Chip Select Signals. 1: Chip select signal NDFC_CE# is always active after NDFC is enabled
5	/	/	/
4:3	R/W	0	NDFC_RB_SEL NDFC external R/B Signal select The value 0-3 selects the external R/B signal. The same R/B signal can be used for multiple chip select flash.
2	R/W	0	NDFC_BUS_WIDTH 0: 8-bit bus 1: 16-bit bus
1	R/W	0	NDFC_RESET NDFC Reset Write 1 to reset NDFC and clear to 0 after reset
0	R/W	0	NDFC_EN NDFC Enable Control 0: Disable NDFC 1: Enable NDFC

4.2.6.2. NDFC Status Register(Default Value: 0x00000000)

Offset: 0x04			Register Name: NDFC_ST
Bit	Read/Write	Default	Description
31:14	/	/	/
13	R	/	NDFC_RDATA_STA_0 0: The number of bit 1 during current read operation is greater threshold value. 1: The number of bit 1 during current read operation is less than or equal to threshold value. This field only is valid when NDFC_RDATA_STA_EN is 1. The threshold value is configured in NDFC_RDATA_STA_TH.
12	R	/	NDFC_RDATA_STA_1 0: The number of bit 0 during current read operation is greater threshold value. 1: The number of bit 0 during current read operation is less than or equal to than threshold value. This field only is valid when NDFC_RDATA_STA_EN is 1. The threshold value is configured in NDFC_RDATA_STA_TH.
11	R	/	NDFC_RB_STATE3 NAND Flash R/B 3 Line State 0: NAND Flash in BUSY State 1: NAND Flash in READY State
10	R	/	NDFC_RB_STATE2

			NAND Flash R/B 2 Line State 0: NAND Flash in BUSY State 1: NAND Flash in READY State
9	R	/	NDFC_RB_STATE1 NAND Flash R/B 1 Line State 0: NAND Flash in BUSY State 1: NAND Flash in READY State
8	R	/	NDFC_RB_STATE0 NAND Flash R/B 0 Line State 0: NAND Flash in BUSY State 1: NAND Flash in READY State
7:5	/	/	/
4	R	0	NDFC_STA 0: NDFC FSM in IDLE state 1: NDFC FSM in BUSY state When NDFC_STA is 0, NDFC can accept new command and process command.
3	R	0	NDFC_CMD_FIFO_STATUS 0: Command FIFO not full and can receive new command 1: Full and waiting NDFC to process commands in FIFO Since there is only one 32-bit FIFO for command. When NDFC latches one command, command FIFO is free and can accept another new command.
2	R/W	0	NDFC_DMA_INT_FLAG When it is 1, it means that a pending DMA is completed. It will be clear after writing 1 to this bit or it will be automatically clear before FSM processing an new command.
1	R/W	0	NDFC_CMD_INT_FLAG When it is 1, it means that NDFC has finished one Normal Command Mode or one Batch Command Work Mode. It will be clear after writing 1 to this bit or it will be automatically clear before FSM processing an new command.
0	R/W	0	NDFC_RB_B2R When it is 1, it means that NDFC_R/B# signal is transferred from BUSY state to READY state. It will be clear after writing 1 to this bit.

4.2.6.3. NDFC Interrupt and DMA Enable Register(Default Value: 0x00000000)

Offset: 0x08			Register Name: NDFC_INT
Bit	Read/Write	Default	Description
31:3	/	/	/
2	R/W	0	NDFC_DMA_INT_ENABLE Enable or disable interrupt when a pending DMA is completed.
1	R/W	0	NDFC_CMD_INT_ENABLE Enable or disable interrupt when NDFC has finished the procession of a single command in Normal Command Work Mode or one Batch Command Work

			Mode. 0: Disable 1: Enable
0	R/W	0	NDFC_B2R_INT_ENABLE Enable or disable interrupt when NDFC_RB# signal is transferring from BUSY state to READY state 0: Disable 1: Enable

4.2.6.4. NDFC Timing Control Register(Default Value: 0x00000000)

Offset: 0x0C			Register Name: NDFC_TIMING_CTL
Bit	Read/Write	Default	Description
31:12	/	/	/
11:8	R/W	0x0	NDFC_READ_PIPE In SDR mode: 0: Normal 1: EDO 2: E-EDO Other : Reserved In DDR mode: 1~15 is valid.(These bits configure the number of clock when data is valid after RE#'s falling edge)
7:6	/	/	/
5:0	R/W	0x0	NDFC_DC_CTL NDFC Delay Chain Control. (These bits are only valid in DDR data interface, and configure the relative phase between DQS and DQ[0...7])

4.2.6.5. NDFC Timing Configure Register(Default Value: 0x00000095)

Offset: 0x10			Register Name: NDFC_TIMING_CFG
Bit	Read/Write	Default	Description
31:20	/	/	/
19:18	R/W	0	T_WC Write Cycle Time 0: 1*T 1: 2*T 2: 3*T 3: 4*T
17:16	R/W	0	T_CCS

			Change Column Setup Time 0: 16*2T 1: 24*2T 2: 32*2T 3: 64*2T
15:14	R/W	0	T_CLHZ CLE High to Output Hi-z 0: 2*2T 1: 8*2T 2: 16*2T 3: 31*2T
13:12	R/W	0	T_CS CE Setup Time 0: 2*T 1: 8*T 2: 16*T 3: 31*T
11			T_CDQSS DQS Setup Time for data input start 0: 8*T 1: 24*T
10:8	R/W	0	T_CAD Command, Address, Data Delay 000: 4*2T 001: 8*2T 010: 12*2T 011: 16*2T 100: 24*2T 101: 32*2T 110/111: 64*2T
7:6	R/W	0x2	T_RHW RE# high to WE# low cycle number 00: 4T 01: 8T 10: 12T 11: 20T
5:4	R/W	0x1	T_WHR WE# high to RE# low cycle number 00: 8T 01: 16T 10: 24T 11: 32T
3:2	R/W	0x1	T_ADL Address to Data Loading cycle number 00: 8T

			01: 16T 10: 24T 11: 32T
1:0	R/W	0x1	T_WB WE# high to busy cycle number 00:6T 01: 12T 10: 16T 11: 20T

4.2.6.6. NDFC Address Low Word Register(Default Value: 0x00000000)

Offset: 0x14			Register Name: NDFC_ADDR_LOW
Bit	Read/Write	Default	Description
31:24	R/W	0	ADDR_DATA4 NAND Flash 4th Cycle Address Data
23:16	R/W	0	ADDR_DATA3 NAND Flash 3rd Cycle Address Data
15:8	R/W	0	ADDR_DATA2 NAND Flash 2nd Cycle Address Data
7:0	R/W	0	ADDR_DATA1 NAND Flash 1st Cycle Address Data

4.2.6.7. NDFC Address High Word Register(Default Value: 0x00000000)

Offset: 0x18			Register Name: NDFC_ADDR_HIGH
Bit	Read/Write	Default	Description
31:24	R/W	0	ADDR_DATA8 NAND Flash 8th Cycle Address Data
23:16	R/W	0	ADDR_DATA7 NAND Flash 7th Cycle Address Data
15:8	R/W	0	ADDR_DATA6 NAND Flash 6th Cycle Address Data
7:0	R/W	0	ADDR_DATA5 NAND Flash 5th Cycle Address Data

4.2.6.8. NDFC Data Block Number Register(Default Value: 0x00000000)

Offset: 0x1C			Register Name: NDFC_DATA_BLOCK_NUM
Bit	Read/Write	Default	Description
31:6	/	/	/

4:0	R/W	0	NDFC_DATA_BLOCK_NUM DATA BLOCK Number It is used for batch command procession. 0: no data 1: 1 data blocks 2: 2 data blocks ... 16: 16 data blocks Others: Reserved Notes: 1 data block = 512 or 1024 bytes main field data
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4.2.6.9. NDFC Data Counter Register(Default Value: 0x00000000)

Offset: 0x20			Register Name: NDFC_CNT
Bit	Read/Write	Default	Description
31:10	/	/	/
9:0	R/W	0	NDFC_DATA_CNT Transfer Data Byte Counter The length can be set from 1 byte to 1024 bytes. However, 1024 bytes is set when it is zero.

4.2.6.10. NDFC Command IO Register(Default Value: 0x00000000)

Offset: 0x24			Register Name: NDFC_CMD
Bit	Read/Write	Default	Description
31:30	R/W	0	NDFC_CMD_TYPE 00: Common Command for normal operation 01: Special Command for Flash Spare Field Operation 10: Page Command for batch process operation 11: Reserved
29	R/W	0	NDFC_SEND_FOURTH_CMD 0: Don't send third set command 1: Send it on the external memory's bus Notes: It is used for EF-NAND page read.
28	R/W	0	NDFC_SEND_THIRD_CMD 0: Don't send third set command 1: Send it on the external memory's bus Notes: It is used for EF-NAND page read.
27	R/W	0	NDFC_ROW_ADDR_AUTO Row Address Auto Increase for Page Command 0: Normal operation 1: Row address increasing automatically

26	R/W	0	NDFC_DATA_METHOD Data swap method when the internal RAM and system memory It is only active for Common Command and Special Command. 0: No action 1: DMA transfer automatically It only is active when NDFC_RAM_METHOD is 1. If this bit is set to 1, NDFC should setup DRQ to fetching data before output to Flash or NDFC should setup DRQ to sending out to system memory after fetching data from Flash. If this bit is set to 0, NDFC output the data in internal RAM or do nothing after fetching data from Flash.
25	R/W	0	NDFC_SEQ User data & BCH check word position. It only is active for Page Command, don't care about this bit for other two commands 0: Interleave Method (on page spare area) 1: Sequence Method (following data block)
24	R/W	0	NDFC_SEND_SECOND_CMD 0: Don't send second set command 1: Send it on the external memory's bus
23	R/W	0	NDFC_WAIT_FLAG 0: NDFC can transfer data regardless of the internal NDFC_RB wire 1: NDFC can transfer data when the internal NDFC_RB wire is READY; otherwise it can't when the internal NDFC_RB wire is BUSY.
22	R/W	0	NDFC_SEND_FIRST_CMD 0: Don't send first set command 1: Send it on the external memory's bus
21	R/W	0	NDFC_DATA_TRANS 0: No data transfer on external memory bus 1: Data transfer and direction is decided by the field NDFC_ACCESS_DIR
20	R/W	0	NDFC_ACCESS_DIR 0: Read NAND Flash 1: Write NAND Flash
19	R/W	0	NDFC_SEND_ADR 0: Don't send ADDRESS 1: Send N cycles ADDRESS, the number N is specified by NDFC_ADR_NUM field
18:16	R/W	0	NDFC_ADR_NUM Address Cycles' Number 000: 1 cycle address field 001: 2 cycles address field 010: 3 cycles address field 011: 4 cycles address field 100: 5 cycles address field 101: 6 cycles address field 110: 7 cycles address field

			111: 8 cycles address field
15:8	R/W	0	NDFC_CMD_HIGH_BYTE NDFC Command high byte data If 8-bit command is supported, the high byte should be zero for 16-bit bus width NAND Flash. For 8-bit bus width NAND Flash, high byte command is discarded.
7:0	R/W	0	NDFC_CMD_LOW_BYTE NDFC Command low byte data This command will be sent to external Flash by NDFC.

4.2.6.11. NDFC Command Set Register 0(Default Value: 0x00E00530)

Offset: 0x28			Register Name: NDFC_CMD_SET0
Bit	Read/Write	Default	Description
31:24	/	/	/
23:16	R/W	0xE0	NDFC_RANDOM_READ_CMD1 Used for Batch Read Operation
15:8	R/W	0x05	NDFC_RANDOM_READ_CMD0 Used for Batch Read Operation
7:0	R/W	0x30	NDFC_READ_CMD Used for Batch Read Operation

4.2.6.12. NDFC Command Set Register 1(Default Value: 0x70008510)

Offset: 0x2C			Register Name: NDFC_CMD_SET1
Bit	Read/Write	Default	Description
31:16	R/W	0x70	NDFC_READ_CMD0 Used for EF-NAND Page Read operation
23:16	R/W	0x00	NDFC_READ_CMD1 Used for EF-NAND Page Read operation
15:8	R/W	0x85	NDFC_RANDOM_WRITE_CMD Used for Batch Write Operation
7:0	R/W	0x10	NDFC_PROGRAM_CMD Used for Batch Write Operation

4.2.6.13. NDFC IO Data Register(Default Value: 0x00000000)

Offset: 0x30			Register Name: NDFC_IO_DATA
Bit	Read/Write	Default	Description
31:0	R/W	0	NDFC_IO_DATA Read/ Write data into internal RAM

Access unit is 32-bit.

4.2.6.14. NDFC ECC Control Register(Default Value: 0x4a800008)

Offset: 0x34			Register Name: NDFC_ECC_CTL
Bit	Read/Write	Default	Description
31	/	/	/
30:16	R/W	0x4a80	NDFC_RANDOM_SEED The seed value for randomize engine. It is only active when NDFC_RANDOM_EN is set to '1'.
15:12	R/W	0	NDFC_ECC_MODE 0x0: BCH-16 for one ECC Data Block 0x1: BCH-24 for one ECC Data Block 0x2 : BCH-28 for one ECC Data Block 0x3 : BCH-32 for one ECC Data Block 0x4 : BCH-40 for one ECC Data Block 0x5 : BCH-48 for one ECC Data Block 0x6 : BCH-56 for one ECC Data Block 0x7 : BCH-60 for one ECC Data Block 0x8 : BCH-64 for one ECC Data Block Others: Reserved
11	R/W	0	NDFC_RANDOM_SIZE 0: ECC block size 1: Page size
10	R/W	0	NDFC_RANDOM_DIRECTION 0: LSB first 1: MSB first
9	R/W	0	NDFC_RANDOM_EN 0: Disable Data Randomize 1: Enable Data Randomize
8:6	/	/	/
5	R/W	0	NDFC_ECC_BLOCK_SIZE 0: 1024 bytes of one ECC data block 1: 512 bytes of one ECC data block
4	R/W	0	NDFC_ECC_EXCEPTION 0: Normal ECC 1: For ECC, there is an exception. If all data is 0xff or 0x00 for the block. When reading this page, ECC assumes that it is right. For this case, no error information is reported. Notes: It only is active when ECC is ON
3	R/W	1	NDFC_ECC_PIPELINE Pipeline function enable or disable for batch command 0: Error Correction function no pipeline with next block operation 1: Error Correction pipeline

2:1	/	/	/
0	R/W	0	NDFC_ECC_EN 0: ECC is OFF 1: ECC is ON

4.2.6.15. NDFC ECC Status Register(Default Value: 0x00000000)

Offset: 0x38			Register Name: NDFC_ECC_ST
Bit	Read/Write	Default	Description
31:16	R	0	NDFC_PAT_FOUND Special pattern (all 0x00 or all x0ff) Found Flag for 16 Data Blocks 0: No Found 1: Special pattern is found When this field is '1', this means that the special data is found for reading external NAND flash. The register of NDFC_PAT_ID would indicates which pattern is found.
15:0	R	0	NDFC_ECC_ERR Error information bit of 16 Data Blocks 0: ECC can correct these error bits or there is no error bit 1: Error bits number beyond of ECC correction capability and can't correct them Notes: The LSB of this register is corresponding the 1st ECC data block. 1 ECC Data Block = 512 or 1024 bytes.

4.2.6.16. NDFC Enhanced Feature Register(Default Value: 0x00000000)

Offset: 0x3C			Register Name: NDFC_EFR
Bit	Read/Write	Default	Description
31:9	R/W	0	/
8	R/W	0	NDFC_WP_CTRL NAND Flash Write Protect Control Bit 0: Write Protect is active 1: Write Protect is not active Notes: When this bit is '0', WP signal line is low level and external NAND flash is on protected state.
7	/	/	/
6:0	R/W	0	NDFC_ECC_DEBUG For the purpose of debugging ECC engine, special bits error are inserted before writing external Flash Memory. 0: No error is inserted (ECC Normal Operation) n: N bits error are inserted

4.2.6.17. NDFC Error Counter Register 0(Default Value: 0x00000000)

Offset: 0x40			Register Name: NDFC_ERR_CNT0
Bit	Read/Write	Default	Description
[8i+7:8i] (i=0~3)	R	0	ECC_COR_NUM ECC Corrected Bits Number for ECC Data Block[n] (n from 0 to 3) 0: No corrected bits 1: 1 corrected bit 2: 2 corrected bits ... 64: 64 corrected bits Others: Reserved Notes: 1 ECC Data Block = 512 or 1024 bytes

4.2.6.18. NDFC Error Counter Register 1(Default Value: 0x00000000)

Offset: 0x44			Register Name: NDFC_ERR_CNT1
Bit	Read/Write	Default	Description
[8i+7:8i] (i=0~3)	R	0	ECC_COR_NUM ECC Corrected Bits Number for ECC Data Block[n] (n from 4 to 7) 0: No corrected bits 1: 1 corrected bit 2: 2 corrected bits ... 64: 64 corrected bits Others: Reserved Notes: 1 ECC Data Block = 512 or 1024 bytes

4.2.6.19. NDFC Error Counter Register 2(Default Value: 0x00000000)

Offset: 0x48			Register Name: NDFC_ERR_CNT2
Bit	Read/Write	Default	Description
[8i+7:8i] (i=0~3)	R	0	ECC_COR_NUM ECC Corrected Bits Number for ECC Data Block[n] (n from 8 to 11) 0: No corrected bits 1: 1 corrected bit 2: 2 corrected bits ... 64: 64 corrected bits Others: Reserved Notes: 1 ECC Data Block = 512 or 1024 bytes

4.2.6.20. NDFC Error Counter Register 3(Default Value: 0x00000000)

Offset: 0x4C			Register Name: NDFC_ERR_CNT3
Bit	Read/Write	Default	Description
[8i+7:8i] (i=0~3)	R	0	ECC_COR_NUM ECC Corrected Bits Number for ECC Data Block[n] (n from 12 to 15) 0: No corrected bits 1: 1 corrected bit 2: 2 corrected bits ... 64: 64 corrected bits Others: Reserved Notes: 1 ECC Data Block = 512 or 1024 bytes

4.2.6.21. NDFC User Data Register [n](Default Value: 0xffffffff)

Offset: 0x50 + 0x4*n			Register Name: NDFC_USER_DATAn
Bit	Read/Write	Default	Description
31:0	R/W	0xffffffff	USER_DATA User Data for ECC Data Block[n] (n from 0 to 15) Notes: 1 ECC Data Block = 512 or 1024 bytes

Notes: n from 0 to 15

4.2.6.22. NDFC EFNAND STATUS Register(Default Value: 0x00000000)

Offset: 0x90			Register Name: NDFC_EFNAND_STATUS
Bit	Read/Write	Default	Description
31:8	/	/	/
7:0	R	0x0	EF_NAND_STATUS The Status Value for EF-NAND Page Read operation

4.2.6.23. NDFC Spare Area Register(Default Value: 0x00000400)

Offset: 0xA0			Register Name: NDFC_SPARE_AREA
Bit	Read/Write	Default	Description
31:16	/	/	/
15:0	R/W	0x400	NDFC_SPARE_ADR This value indicates the spare area first byte address for NDFC interleave page operation.

4.2.6.24. NDFC Pattern ID Register(Default Value: 0x00000000)

Offset: 0xA4			Register Name: NDFC_PAT_ID
Bit	Read/Write	Default	Description
[2i+1:2i] (i=0~15)	R	0	PAT_ID Special Pattern ID for 16 ECC data block 0: All 0x00 is found 1: All 0xFF is found Others: Reserved

4.2.6.25. NDFC Read Data Status Control Register(Default Value: 0x01000000)

Offset: 0xA8			Register Name: NDFC_RDATA_STA_CTL
Bit	Read/Write	Default	Description
31:25	/	/	/
24	R/W	1	NDFC_RDATA_STA_EN 0: Disable to count the number of bit 1 and bit 0 during current read operation; 1: Enable to count the number of bit 1 and bit 0 during current read operation; The number of bit 1 and bit 0 during current read operation can be used to check whether a page is blank or bad.
23:18	/	/	/
17:0	R/W	0	NDFC_RDATA_STA_TH The threshold value to generate data status. If the number of bit 1 during current read operation is less than or equal to threshold value, the bit 13 of NDFC_ST register will be set. If the number of bit 0 during current read operation is less than or equal to threshold value, the bit 12 of NDFC_ST register will be set.

4.2.6.26. NDFC Read Data Status Register 0(Default Value: 0x00000000)

Offset: 0xAC			Register Name: NDFC_RDATA_STA_0
Bit	Read/Write	Default	Description
31:0	R	0	BIT_CNT_1 The number of input bit 1 during current command. It will be cleared automatically when next command is executed.

4.2.6.27. NDFC Read Data Status Register 1(Default Value: 0x00000000)

Offset: 0xB0			Register Name: NDFC_RDATA_STA_1
Bit	Read/Write	Default	Description
31:0	R	0	BIT_CNT_0 The number of input bit 0 during current command. It will be cleared automatically when next command is executed.

4.2.6.28. NDFC MBUS DMA Address Register(Default Value: 0x00000000)

Offset: 0xC0			Register Name: NDFC_MDMA_ADDR
Bit	Read/Write	Default	Description
31:0	R/W	0	MDMA_ADDR MBUS DMA address

4.2.6.29. NDFC MBUS DMA Byte Counter Register(Default Value: 0x00000000)

Offset: 0xC4			Register Name: NDFC_MDMA_CNT
Bit	Read/Write	Default	Description
14:0	R/W	0	MDMA_CNT MBUS DMA data counter

4.3. SD/MMC

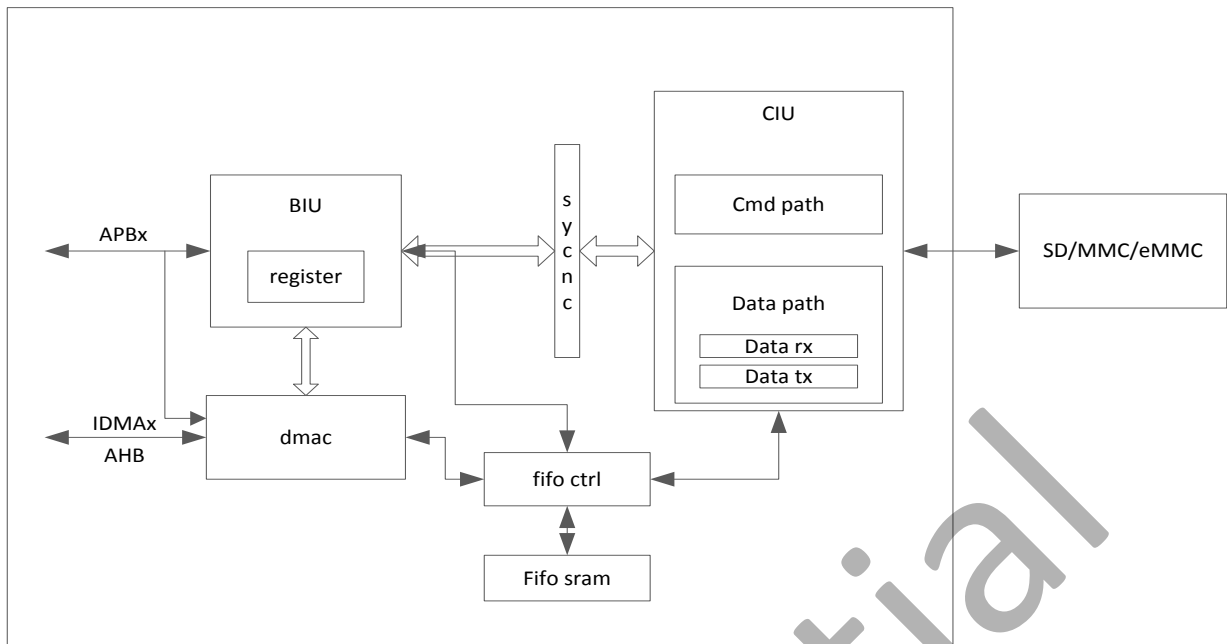
4.3.1. Overview

The SD/MMC controller can be configured either as a Secure Digital Multimedia Card controller, which simultaneously supports Secure Digital I/O (SDIO), Multimedia Cards (MMC), and eMMC Card.

The SD/MMC controller includes the following features:

- Supports Secure Digital memory protocol commands (up to SD2.0)
- Supports Secure Digital I/O protocol commands
- Supports Multimedia Card protocol commands (up to eMMC4.41)
- Supports eMMC boot operation
- Supports one SD (Version 1.0 to 2.0) or MMC (Version 3.3 to eMMC4.41)
- Supports hardware CRC generation and error detection
- Supports host pull-up control
- Supports SDIO interrupts in 1-bit and 4-bit modes
- Supports SDIO suspend and resume operation
- Supports SDIO read wait
- Supports block size of 1 to 65535 bytes
- Supports descriptor-based internal DMA controller

4.3.2. Block Diagram



(BIU: Bus Interface Unit; CIU: Card Interface Unit)

Figure 4-16. SD/MMC Controller Block Diagram

4.3.3. SD/MMC Controller Timing Diagram

Please refer to relative specifications:

- Physical Layer Specification Ver2.00
- SDIO Specification Ver2.00
- Multimedia Cards (MMC – version 4.2)
- JEDEC Standard – JESD84-44, EMBEDDED MULTI-MEDIA CARD (eMMC)

4.3.4. SD/MMC Controller Special Requirement

4.3.4.1. SD/MMC Pin List

Port Name	Width	Direction	Description
SD_CCLK	1	OUT	Clock output for SD/SDIO/MMC card

SD_CCMD	1	IN/OUT	CMD line
SD_CDATA	1/4/8	IN/OUT	Data line

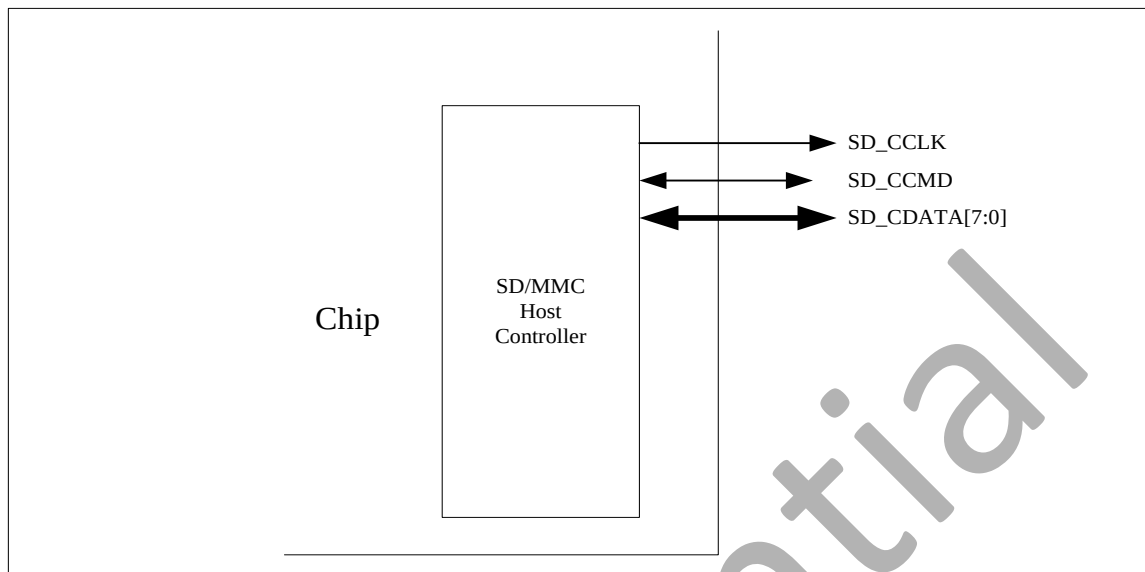


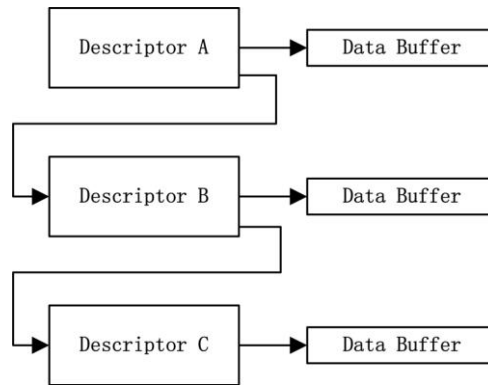
Figure 4-17. SD/MMC Pin Diagram

4.3.5. Internal DMA Controller Description

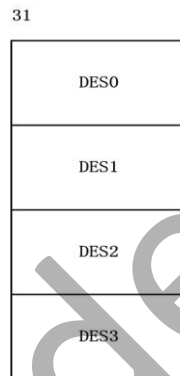
SD/MMC controller has an internal DMA controller (IDMAC) to transfer data between host memory and SDMMC port. With a descriptor, IDMAC can efficiently move data from source to destination by automatically loading next DMA transfer arguments, which need less CPU intervention. Before transfer data in IDMAC, host driver should construct a descriptor list, configure arguments of every DMA transfer, then launch the descriptor and start the DMA. IDMAC has an interrupt controller, when enabled, it can interrupt the HOST CPU in situations such as data transmission completed or some errors happened.

4.3.5.1. IDMAC Descriptor Structure

The IDMAC uses a descriptor with a chain structure, and each descriptor points to a unique buffer and the next descriptor.



This figure illustrates the internal formats of a descriptor. The descriptor addresses must be aligned to the bus width used for 32-bit buses. Each descriptor contains 16 bytes of control and status information.



DES0 is a notation used to denote the [31:0] bits, DES1 to denote [63:32] bits, DES2 to denote [95:64]bits, and DES3 to denote [127:96]bits in a descriptor.

4.3.5.2. DES0 definition

Bits	Name	Descriptor
31	HOLD	DES_OWN_FLAG When set, this bit indicates that the descriptor is owned by the IDMAC. When this bit is reset, it indicates that the descriptor is owned by the host. This bit is cleared when transfer is over.
30	ERROR	ERR_FLAG When some error happened in transfer, this bit will be set.
29:5	/	/
4	Chain Flag	CHAIM_MOD When set, this bit indicates that the second address in descriptor is the next descriptor address. Must be set 1.
3	First DES Flag	FIRST_FLAG When set, this bit indicates that this descriptor contains the first buffer

		of data. Must be set to 1 in first DES.
2	Last DES Flag	LAST_FLAG When set, this bit indicates that the buffers pointed to by this descriptor are the last data buffer
1	Disable Interrupt on completion	CUR_TXRX_OVER_INT_DIS When set, this bit will prevent the setting of the TX/RX interrupt bit of the IDMAC status register for data that ends in the buffer pointed to by this descriptor
0	/	/

4.3.5.3. DES1 definition

Bits	Name	Descriptor
31:13	/	/
15:0	Buffer size	BUFF_SIZE These bits indicate the data buffer byte size, which must be a multiple of 4 bytes. If this field is 0, the DMA ignores this buffer and proceeds to the next descriptor.

4.3.5.4. DES2 definition

Bits	Name	Descriptor
31:0	Buffer address pointer	BUFF_ADDR These bits indicate the physical address of data buffer. The IDMAC ignores DES2[1:0], corresponding to the bus width of 32.

4.3.5.5. DES3 definition

Bits	Name	Descriptor
31:0	Next descriptor address	NEXT_DESP_ADDR These bits indicate the pointer to the physical memory where the next descriptor is present.

4.3.6. SD/MMC Register List

Module Name	Base Address
SDC0	0x01C0F000

SDC1	0x01C10000
SDC2	0x01C11000

Register Name	Offset	Description
SD_GCTL	0x00	Control register
SD_CKCR	0x04	Clock Control register
SD_TMOR	0x08	Time out register
SD_BWDR	0x0C	Bus Width register
SD_BKSR	0x10	Block size register
SD_BYCR	0x14	Byte count register
SD_CMDR	0x18	Command register
SD_CAGR	0x1c	Command argument register
SD_RESP0	0x20	Response 0 register
SD_RESP1	0x24	Response 1 register
SD_RESP2	0x28	Response 2 register
SD_RESP3	0x2C	Response 3 register
SD_IMKR	0x30	Interrupt mask register
SD_MISR	0x34	Masked interrupt status register
SD_RISR	0x38	Raw interrupt status register
SD_STAR	0x3C	Status register
SD_FWLR	0x40	FIFO Water Level register
SD_FUNS	0x44	FIFO Function Select register
SD_A12A	0x58	Auto command 12 argument
SD_NTSR	0x5c	SD NewTiming Set Register
SD_SDBG	0x60	SD NewTiming Set Debug Register
SD_HWRST	0x78	Hardware Reset Register
SD_DMAR	0x80	BUS Mode Control
SD_DLBA	0x84	Descriptor List Base Address
SD_IDST	0x88	DMAC Status
SD_IDIE	0x8c	DMAC Interrupt Enable
SD_THLDC	0x100	Card Threshold Control register
SD_DSBD	0x10c	eMMC4.5 DDR Start Bit Detection Control
SD_FIFO	0x200	Read/ Write FIFO

4.3.7. SD/MMC Register Description

4.3.7.1. SD Global Control Register(Default Value: 0x00000100)

Offset: 0x0000	Register Name: SD_CTRL
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Bit	R/W	Default/Hex	Description
31	R/W	0	FIFO_AC_MOD FIFO Access Mode 1-AHB bus 0-DMA bus
30:11	-	-	/
10	R/W	0	DDR_MOD_SEL DDR Mode Select 0 – SDR mode 1 – DDR mode
9	-	-	reserved
8	R/W	1	CD_DBC_ENB Card Detect (Data[3] status) De-bounce Enable 0 - disable de-bounce 1 – enable de-bounce
7:6	-	-	/
5	R/W	0	DMA_ENB DMA Global Enable 0 – Disable DMA to transfer data, using AHB bus 1 – Enable DMA to transfer data
4	R/W	0	INT_ENB Global Interrupt Enable 0 – Disable interrupts 1 – Enable interrupts
3	-	-	/
2	R/W	0	DMA_RST DMA Reset
1	R/W	0	FIFO_RST FIFO Reset 0 – No change 1 – Reset FIFO <i>This bit is auto-cleared after completion of reset operation.</i>
0	R/W	0	SOFT_RST Software Reset 0 – No change 1 – Reset SD/MMC controller <i>This bit is auto-cleared after completion of reset operation.</i>

4.3.7.2. SD Clock Control Register(Default Value: 0x00000000)

Offset: 0x0004			Register Name: SD_CLKDIV
Bit	R/W	Default/Hex	Description
31	R/W	0	MASK_DATA0 0 - Do not mask data0 when updata clock ;

			1 - Mask data0 when updata clock; Default value : 0;
30:18	/	/	/
17	R/W	0	CCLK_CTRL Card Clock Output Control 0 – Card clock always on 1 – Turn off card clock when FSM in IDLE state
16	R/W	0	CCLK_ENB Card Clock Enable 0 – Card Clock off 1 – Card Clock on
15:8	/	/	/
7:0	R/W	0	CCLK_DIV Card clock divider n – Source clock is divided by 2*n.(n=0~255)

4.3.7.3. SD Timeout Register (Default Value: 0xFFFFF40)

Offset: 0x0008			Register Name: SD_TMOUT
Bit	R/W	Default/Hex	Description
31:8	R/W	0xffffffff	DTO_LMT Data Timeout Limit
7:0	R/W	0x40	RTO_LMT Response Timeout Limit

4.3.7.4. SD Bus Width Register (Default Value: 0x00000000)

Offset: 0x000c			Register Name: SD_CTYPE
Bit	R/W	Default/Hex	Description
31:2	/	/	/
1:0	R/W	0	CARD_WID Card width 2'b00 – 1-bit width 2'b01 – 4-bit width 2'b1x – 8-bit width

4.3.7.5. SD Block Size Register (Default Value: 0x00000200)

Offset: 0x0010			Register Name: SD_BLKSIZE
Bit	R/W	Default/Hex	Description
31:16	/	/	/

15:0	R/W	0x200	BLK_SZ Block size
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4.3.7.6. SD Block Count Register (Default Value: 0x0000200)

Offset: 0x0014			Register Name: SD_BYTCNT
Bit	R/W	Default/Hex	Description
31:0	R/W	0x200	BYTE_CNT Byte counter Number of bytes to be transferred; should be integer multiple of Block Size for block transfers.

4.3.7.7. SD Command Register (Default Value: 0x00000000)

Offset: 0x0018			Register Name: SD_CMD
Bit	R/W	Default/Hex	Description
31	R/W	0	CMD_LOAD Start Command. This bit is auto cleared when current command is sent. If there is no any response error happened, a command complete interrupt bit (CMD_OVER) will be set in interrupt register. You should not write any other command before this bit is cleared, or a command busy interrupt bit (CMD_BUSY) will be set in interrupt register.
30	/	/	/
29	R/W	0	Use Hold Register 0 - CMD and DATA sent to card bypassing HOLD Register 1 - CMD and DATA sent to card through the HOLD Register
28	R/W	0	VOL_SW Voltage Switch 0 – normal command 1 – Voltage switch command, set for CMD11 only
27	R/W	0	BOOT_ABT Boot Abort Setting this bit will terminate the boot operation.
26	R/W	0	EXP_BOOT_ACK Expect Boot Acknowledge. When Software sets this bit along in mandatory boot operation, controller expects a boot acknowledge start pattern of 0-1-0 from the selected card.
25:24	R/W	0	BOOT_MOD Boot Mode 2'b00 – normal command 2'b01 - Mandatory Boot operation

			2'b10 - Alternate Boot operation 2'b11 - reserved
23	/	/	/
22	/	/	/
21	R/W	0	PRG_CLK Change Clock 0 – Normal command 1 – Change Card Clock; when this bit is set, controller will change clock domain and clock output. No command will be sent.
20:16	/	/	/
15	R/W	0	SEND_INIT_SEQ Send Initialization 0 – normal command sending 1 – Send initialization sequence before sending this command.
14	R/W	0	STOP_ABT_CMD Stop Abort Command 0 – normal command sending 1 – send Stop or abort command to stop current data transfer in progress.(CMD12, CMD52 for writing “I/O Abort” in SDIO CCCR)
13	R/W	0	WAIT_PRE_OVER Wait Data Transfer Over 0 – Send command at once, do not care of data transferring 1 – Wait for data transfer completion before sending current command
12	R/W	0	STOP_CMD_FLAG Send Stop CMD Automatically (CMD12) 0 – Do not send stop command at end of data transfer 1 – Send stop command automatically at end of data transfer
11	R/W	0	TRANS_MODE Transfer Mode 0 – Block data transfer command 1 – Stream data transfer command
10	R/W	0	TRANS_DIR Transfer Direction 0 – Read operation 1 – Write operation
9	R/W	0	DATA_TRANS Data Transfer 0 – without data transfer 1 – with data transfer
8	R/W	0	CHK_RESP_CRC Check Response CRC 0 – Do not check response CRC 1 – Check response CRC
7	R/W	0	LONG_RESP Response Type

			0 –Short Response (48 bits) 1 –Long Response (136 bits)
6	R/W	0	RESP_RCV Response Receive 0 – Command without Response 1 – Command with Response
5:0	R/W	0	CMD_IDX CMD Index Command index value

4.3.7.8. SD Command Argument Register (Default Value: 0x00000000)

Offset: 0x001c			Register Name: SD_CMDARG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	CMD_ARG Command argument

4.3.7.9. SD Response 0 Register (Default Value: 0x00000000)

Offset: 0x0020			Register Name: SD_RESP0
Bit	R/W	Default/Hex	Description
31:0	R	0	CMD_RESP0 response 0 Bit[31:0] of response

4.3.7.10. SD Response 1 Register (Default Value: 0x00000000)

Offset: 0x0024			Register Name: SD_RESP1
Bit	R/W	Default/Hex	Description
31:0	R	0	CMD_RESP1 response 1 Bit[63:31] of response

4.3.7.11. SD Response 2 Register (Default Value: 0x00000000)

Offset: 0x0028			Register Name: SD_RESP2
Bit	R/W	Default/Hex	Description
31:0	R	0	CMD_RESP2 response 2

			Bit[95:64] of response
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4.3.7.12. SD Response 3 Register (Default Value: 0x00000000)

Offset: 0x002C			Register Name: SD_RESP3
Bit	R/W	Default/Hex	Description
31:0	R	0	CMD_RESP3 response 3 Bit[127:96] of response

4.3.7.13. SD Interrupt Mask Register (Default Value: 0x00000000)

Offset: 0x0030			Register Name: SD_INTMASK
Bit	R/W	Default/Hex	Description
31:0	R/W	0	INT_MASK 0 – interrupt masked 1 – interrupt enabled Bit field defined as following: bit 31– card removed bit 30 – card inserted bit 17~29 - reserved bit 16 – SDIO interrupt bit 15 – Data End-bit error bit 14 – Auto Stop Command done bit 13 – Data Start Error bit 12 – Command Busy and illegal write bit 11 – FIFO under run/overflow bit 10 – Data starvation timeout /V1.8 Switch Done bit 9 – Data timeout/Boot data start bit 8 – Response timeout/Boot ACK received bit 7 – Data CRC error bit 6 – Response CRC error bit 5 – Data Receive Request bit 4 –Data Transmit Request bit 3 – Data Transfer Complete bit 2 – Command Complete bit 1 – Response Error (no response or response CRC error) bit 0 – Reserved

4.3.7.14. SD Masked Interrupt Status Register (Default Value: 0x00000000)

Offset: 0x0034			Register Name: SD_MINTSTS
Bit	R/W	Default/Hex	Description
31:0	R	0	MSKD_ISTA Interrupt status. Enabled only if corresponding bit in mask register is set. Bit field defined as following: bit 31 – card removed bit 30 – card inserted bit 17~29 - reserved bit 16 – SDIO interrupt bit 15 – Data End-bit error bit 14 – Auto command done bit 13 – Data Start Error bit 12 – Command Busy and illegal write bit 11 – FIFO under run/overflow bit 10 – Data starvation timeout (HTO)/V1.8 Switch Done bit 9 – Data timeout/Boot data start bit 8 – Response timeout/Boot ACK received bit 7 – Data CRC error bit 6 – Response CRC error bit 5 – Data Receive Request bit 4 – Data Transmit Request bit 3 – Data Transfer Complete bit 2 – Command Complete bit 1 – Response Error (no response or response CRC error) bit 0 – Reserved

4.3.7.15. SD Raw Interrupt Status Register (Default Value: 0x00000000)

Offset: 0x0038			Register Name: SD_RINTSTS
Bit	R/W	Default/Hex	Description
31:0	R/W	0	RAW_ISTA Raw Interrupt Status. <i>This is write-1-to-clear bits.</i> Bit field defined as following: bit 31 – card removed bit 30 – card inserted bit 17~29 - reserved bit 16 – SDIO interrupt bit 15 – Data End-bit error

		bit 14 – Auto command done bit 13 – Data Start Error bit 12 – Command Busy and illegal write bit 11 – FIFO under run/overflow bit 10 – Data starvation timeout (HTO)/V1.8 Switch Done bit 9 – Data timeout/Boot data start bit 8 – Response timeout/Boot ACK received bit 7 – Data CRC error bit 6 – Response CRC error bit 5 – Data Receive Request bit 4 – Data Transmit Request bit 3 – Data Transfer Complete bit 2 – Command Complete bit 1 – Response Error (no response or response CRC error) bit 0 – Reserved
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4.3.7.16. SD Status Register (Default Value: 0x00000006)

Offset: 0x003C			Register Name: SD_STATUS
Bit	R/W	Default/Hex	Description
31	R	0	DMA_REQ dma_req DMA request signal state
30:22	/	/	/
21:17	R	0	FIFO_LEVEL FIFO Level Number of filled locations in FIFO
16:11	R	0	RESP_IDX Response Index Index of previous response, including any auto-stop sent by controller
10	R	0	FSM_BUSY Data FSM Busy Data transmit or receive state-machine is busy
9	R	0	CARD_BUSY Card data busy Inverted version of DATA[0] 0 – card data not busy 1 – card data busy
8	R	0	CARD_PRESENT Data[3] status level of DATA[3]; checks whether card is present 0 – card not present 1 – card present
7:4	R	0	FSM_STA

			Command FSM states: 0 – Idle 1 – Send init sequence 2 – Tx cmd start bit 3 – Tx cmd tx bit 4 – Tx cmd index + arg 5 – Tx cmd crc7 6 – Tx cmd end bit 7 – Rx resp start bit 8 – Rx resp IRQ response 9 – Rx resp tx bit 10 – Rx resp cmd idx 11 – Rx resp data 12 – Rx resp crc7 13 – Rx resp end bit 14 – Cmd path wait NCC 15 – Wait; CMD-to-response turnaround
3	R	0	FIFO_FULL FIFO full 1 – FIFO full 0 – FIFO not full
2	R	1	FIFO_EMPTY FIFO Empty 1 – FIFO Empty 0 – FIFO not Empty
1	R	1	FIFO_TX_LEVEL FIFO TX Water Level flag 0 – FIFO didn't reach transmit trigger level 1 – FIFO reached transmit trigger level
0	R	0	FIFO_RX_LEVEL FIFO RX Water Level flag 0 – FIFO didn't reach receive trigger level 1 – FIFO reached receive trigger level

4.3.7.17. SD FIFO Water Level Register (Default Value: 0x000F0000)

Offset: 0x0040			Register Name: SD_FIFOTH
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0	BSIZE_OF_TRANS Burst size of multiple transaction 000 – 1 transfers 001 – 4 010 – 8

			011 – 16 100 – 32 101 – 64 110 – 128 111 – 256 Should be programmed same as DMA controller multiple transaction size. The units for transfers are the DWORD. A single transfer would be signaled based on this value. Value should be sub-multiple of (RX_TL + 1) and (FIFO_DEPTH - TX_TL) Recommended: MSize = 8, TX_TL = 16, RX_TL = 15
27:21	R	0	/
20:16	R/W	0xF	RX_TL Rx Trigger Level 0x0~0x1e – RX Trigger Level is 0~30 0x1f – reserved FIFO threshold when FIFO request host to receive data from FIFO. When FIFO data level is greater than this value, DMA is request is raised if DMA enabled, or RX interrupt bit is set if interrupt enabled. At the end of packet, if the last transfer is less than this level, the value is ignored and relative request will be raised as usual. Recommended: 15 (means greater than 15)
15:5	R	0	/
4:0	R/W	0	TX_TL TX Trigger Level 0x1~0xf – TX Trigger Level is 1~31 0x0 – no trigger FIFO threshold when FIFO requests host to transmit data to FIFO. When FIFO data level is less than or equal to this value, DMA TX request is raised if DMA enabled, or TX request interrupt bit is set if interrupt enabled. At the end of packet, if the last transfer is less than this level, the value is ignored and relative request will be raised as usual. Recommended: 16 (means less than or equal to 16)

4.3.7.18. SD Function Select Register (Default Value: 0x00000000)

Offset: 0x0044			Register Name: SD_CTRL
Bit	R/W	Default/Hex	Description
31:3	/	/	/
2	R/W	0	ABT_RDATA Abort Read Data 0 – Ignored 1 –After suspend command is issued during read-transfer, software polls card to find when suspend happened. Once suspend occurs, software sets

			bit to reset data state-machine, which is waiting for next block of data. Used in SDIO card suspends sequence. This bit is auto-cleared once controller reset to idle state.
1	R/W	0	READ_WAIT Read Wait 0 – Clear SDIO read wait 1 – Assert SDIO read wait
0	R/W	0	HOST_SEND_MMC_IRQRESQ Host Send MMC IRQ Response 0 – Ignored 1 – Send auto IRQ response When host is waiting MMC card interrupt response, setting this bit will make controller cancel wait state and return to idle state, at which time, controller will receive IRQ response sent by itself. This bit is auto-cleared after response is sent.

4.3.7.19. SD Auto Command 12 Register (Default Value: 0x0000FFFF)

Offset: 0x0058			Register Name: SD_A12A
Bit	R/W	Default/Hex	Description
31:16	/	/	/
0:15	R/W	0xffff	SD_A12A. SD_A12A set the argument of command 12 automatically send by controller

4.3.7.20. SD NewTiming Set Register (Default Value: 0x00000001,only used in SDC2)

Offset: 0x005C			Register Name: SD_NTSR_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	MODE_SELEC 0 - Old mode of Sample/Output Timing ; 1 - New mode of Sample/Output Timing; Default value : 0;
30:6	R/W	0x00	SAMPLE_TIMING_PHASE(RX) 00 - Sample timing phase offset 90° ; 01 - Sample timing phase offset 180° ; 10 - Sample timing phase offset 270° ; 11 - Ignore; Default value : 00;
3:2	/	/	/
1:0	R/W	0x01	OUTPUT_TIMING_PHASE(TX) 00 - Output timing phase offset 90° ; 01 - Output timing phase offset 180° ;

			10 - Output timing phase offset 270° ; 11 - Ignore; Default value : 01;
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4.3.7.21. SD Hardware Reset Register (Default Value: 0x00000001)

Offset: 0x0078			Register Name: SD_HWRST
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	1	HW_RESET. 1 – Active mode 0 – Reset These bits cause the cards to enter pre-idle state, which requires them to be re-initialized.

4.3.7.22. SD DMAC Control Register (Default Value: 0x0000_0000)

Offset: 0x0080			Register Name: SD_BUS_MODE
Bit	R/W	Default/Hex	Description
31	W	0	DES_LOAD_CTRL When DMAC fetches a descriptor, if the valid bit of a descriptor is not set, DMAC FSM will go to the suspend state. Setting this bit will make DMAC re-fetch descriptor again and do the transfer normally.
30:11	/	/	/
10:8	R	0	PRG_BURST_LEN Programmable Burst Length. These bits indicate the maximum number of beats to be performed in one IDMAC transaction. The IDMAC will always attempt to burst as specified in PBL each time it starts a Burst transfer on the host bus. The permissible values are 1, 4, 8, 16, 32, 64, 128 and 256. This value is the mirror of MSIZE of FIFOTH register. In order to change this value, write the required value to FIFOTH register. This is an encode value as follows. 000 – 1 transfers 001 – 4 transfers 010 – 8 transfers 011 – 16 transfers 100 – 32 transfers 101 – 64 transfers 110 – 128 transfers 111 – 256 transfers Transfer unit is either 16, 32, or 64 bits, based on HDATA_WIDTH. PBL is a read-only value.

7	R/W	0	IDMAC_ENB IDMAC Enable. When set, the IDMAC is enabled. DE is read/write.
6:2	R/W	0	DES_SKIP_LEN Descriptor Skip Length. Specifies the number of Word to skip between two unchained descriptors. This is applicable only for dual buffer structure. Default value is set to 4 DWORD.
1	R/W	0	FIX_BUST_CTRL Fixed Burst. Controls whether the AHB Master interface performs fixed burst transfers or not. When set, the AHB will use only SINGLE, INCR4, INCR8 during start of normal burst transfers. When reset, the AHB will use SINGLE and INCR burst transfer operations.
0	R/W	0	IDMAC_RST DMA Reset. When set, the DMA Controller resets all its internal registers. SWR is read/write. It is automatically cleared after 1 clock cycle.

4.3.7.23. SD Descriptor List Base Address Register (Default Value: 0x00000000)

Offset: 0x0084			Register Name: SD_DLBA
Bit	R/W	Default/Hex	Description
31:0	R/W	0	DES_BASE_ADDR Start of Descriptor List. Contains the base address of the First Descriptor. The LSB bits [1:0] are ignored and taken as all-zero by the IDMAC internally. Hence these LSB bits are read-only.

4.3.7.24. SD DMAC Status Register (Default Value: 0x00000000)

Offset: 0x0088			Register Name: SD_DSR
Bit	R/W	Default/Hex	Description
31:17	/	/	/
16:13	R	0	DMAC_FSM_STA DMAC FSM present state. 0 – DMA_IDLE 1 – DMA_SUSPEND 2 – DESC_RD 3 – DESC_CHK 4 – DMA_RD_REQ_WAIT 5 – DMA_WR_REQ_WAIT

			6 – DMA_RD 7 – DMA_WR 8 – DESC_CLOSE This bit is read-only.
12:10	R	0	DMAC_ERR_STA Error Bits. Indicates the type of error that caused a Bus Error. Valid only with Fatal Bus Error bit (IDSTS[2]) set. This field does not generate an interrupt. 3'b001 – Host Abort received during transmission 3'b010 – Host Abort received during reception Others: Reserved EB is read-only.
9	R/W	0	ABN_INT_SUM Abnormal Interrupt Summary. Logical OR of the following: IDSTS[2] – Fatal Bus Interrupt IDSTS[4] – DU bit Interrupt IDSTS[5] – Card Error Summary Interrupt Only unmasked bits affect this bit. This is a sticky bit and must be cleared each time a corresponding bit that causes AIS to be set is cleared. Writing a 1 clears this bit.
8	R/W	0	NOR_INT_SUM Normal Interrupt Summary. Logical OR of the following: IDSTS[0] – Transmit Interrupt IDSTS[1] – Receive Interrupt Only unmasked bits affect this bit. This is a sticky bit and must be cleared each time a corresponding bit that causes NIS to be set is cleared. Writing a 1 clears this bit.
7:6	/	/	/
5	R/W	0	ERR_FLAG_SUM Card Error Summary. Indicates the status of the transaction to/from the card; also present in RINTSTS. Indicates the logical OR of the following bits: EBE – End Bit Error RTO – Response Timeout/Boot Ack Timeout RCRC – Response CRC SBE – Start Bit Error DRTO – Data Read Timeout/BDS timeout DCRC – Data CRC for Receive RE – Response Error Writing a 1 clears this bit.
4	R/W	0	DES_UNAVL_INT Descriptor Unavailable Interrupt. This bit is set when the descriptor is unavailable due to OWN bit = 0 (DES0[31] = 0). Writing a 1 clears this bit.

3	/	/	/
2	R/W	0	FATAL_BERR_INT Fatal Bus Error Interrupt. Indicates that a Bus Error occurred (IDSTS[12:10]). When this bit is set, the DMA disables all its bus accesses. Writing a 1 clears this bit.
1	R/W	0	RX_INT Receive Interrupt. Indicates the completion of data reception for a descriptor. Writing a 1 clears this bit.
0	R/W	0	TX_INT Transmit Interrupt. Indicates that data transmission is finished for a descriptor. Writing a '1' clears this bit.

4.3.7.25. SD DMAC Interrupt Enable Register (Default Value: 0x00000000)

Offset: 0x008C			Register Name: SD_IDIE_REG
Bit	R/W	Default/Hex	Description
31:10	/	/	/
9	R/W	0	ABN_INT_ENB Abnormal Interrupt Summary Enable. When set, an abnormal interrupt is enabled. This bit enables the following bits: IDINTEN[2] – Fatal Bus Error Interrupt IDINTEN[4] – DU Interrupt IDINTEN[5] – Card Error Summary Interrupt
8	R/W	0	NOR_INT_ENB Normal Interrupt Summary Enable. When set, a normal interrupt is enabled. When reset, a normal interrupt is disabled. This bit enables the following bits: IDINTEN[0] – Transmit Interrupt IDINTEN[1] – Receive Interrupt
7:6	/	/	/
5	R/W	0	ERR_SUM_INT_ENB Card Error summary Interrupt Enable. When set, it enables the Card Interrupt summary.
4	R/W	0	DES_UNAVL_INT_ENB Descriptor Unavailable Interrupt. When set along with Abnormal Interrupt Summary Enable, the DU interrupt is enabled.
3	/	/	/
2	R/W	0	FERR_INT_ENB Fatal Bus Error Enable. When set with Abnormal Interrupt Summary Enable, the Fatal Bus Error

			Interrupt is enabled. When reset, Fatal Bus Error Enable Interrupt is disabled.
1	R/W	0	RX_INT_ENB Receive Interrupt Enable. When set with Normal Interrupt Summary Enable, Receive Interrupt is enabled. When reset, Receive Interrupt is disabled.
0	R/W	0	TX_INT_ENB Transmit Interrupt Enable. When set with Normal Interrupt Summary Enable, Transmit Interrupt is enabled. When reset, Transmit Interrupt is disabled.

4.3.7.26. Card Threshold Control Register (Default Value: 0x00000000)

Offset: 0x0100			Register Name: SD_THLD_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0	CARD_RD_THLD Card Read Threshold Size
15:1	/	/	/
0	R/W	0	CARD_RD_THLD_ENB Card Read Threshold Enable 0 – Card Read Threshold Disable 1 - Card Read Threshold Enable Host controller initiates Read Transfer only if CARD_RD_THLD amount of space is available in receive FIFO

4.3.7.27. eMMC4.41 DDR Start Bit Detection Control Register (Default Value: 0x00000000)

Offset: 0x010C			Register Name: EMMC_DDR_SBIT_DET_REG
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0	HALF_START_BIT Control for start bit detection mechanism inside mstorage based on duration of start bit. For eMMC 4.41, start bit can be: 0 - Full cycle 1 - Less than one full cycle Set HALF_START_BIT=1 for eMMC 4.41 and above; set to 0 for SD applications.

4.3.7.28. SD FIFO Register (Default Value: 0x00000000)

Offset: 0x0200			Register Name: SD_FIFO_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	TX/RX_FIFO Data FIFO

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Chapter 5 Image

This section describes the image of A83T:

- [MIPI CSI](#)
- [CSI](#)

5.1. MIPI CSI

5.1.1. Overview

The MIPI CSI includes the following feature:

- Compliant with MIPI-CSI2 V1.00 and MIPI DPHY V1.00
- 1/2/3/4 Data Lanes Configuration and up to 1Gbps per Lane in HS Transmission
- Maximum to 8M@30fps with 4 data lane
- Supports format: YUV422-8bit/10bit, YUV420-8bit/10bit, RAW-8, RAW-10, RAW-12, RGB888, RGB565

5.2. CSI

5.2.1. Overview

The CSI includes the following feature:

- Support 10bit yuv422 /raw CMOS sensor interface
- Support CCIR656 protocol for NTSC and PAL
- Support parallel interface still capture resolution up to 5M, video capture resolution up to 720p@30fps
- Support MIPI interface still capture resolution up to 8M, video capture resolution up to 1080p@60fps

5.2.2. Functionalities Description

5.2.2.1. Block Diagram

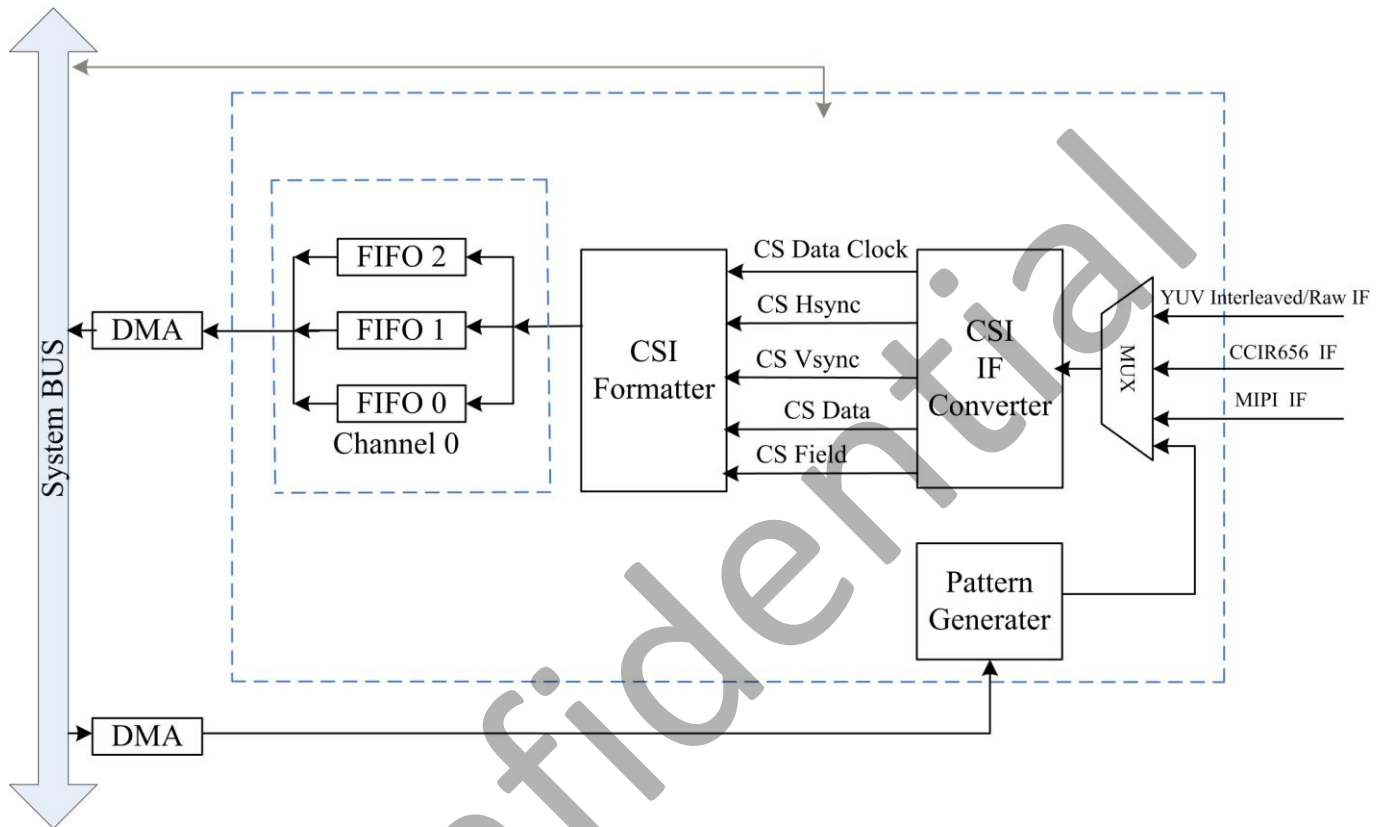


Figure 5-1. CSI Block Diagram

5.2.2.2. Timing

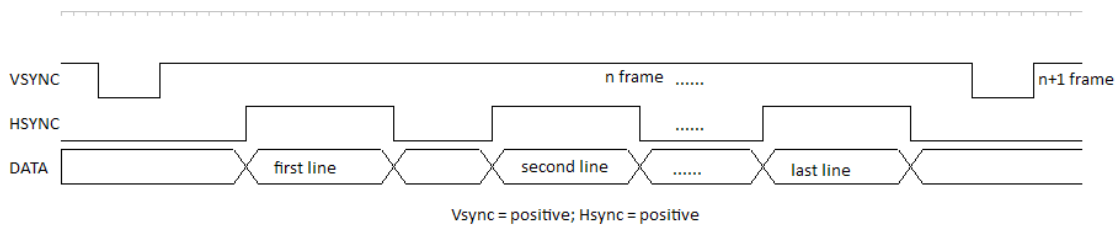


Figure 5-2. Vref= positive; Href= positive

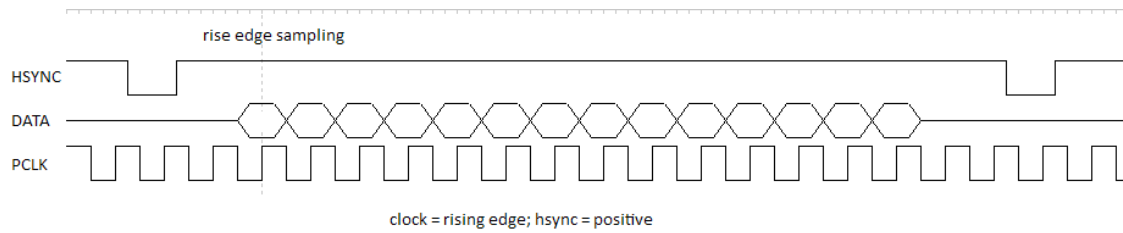


Figure 5-3. horizontal size setting and pixel clock timing(Href= positive)

5.2.2.3. Bit Definition

Data Bit	First Word(0xFF)	Second Word(0x00)	Third Word(0x00)	Fourth Word
CS D[9] (MSB)	1	0	0	1
CS D[8]	1	0	0	F
CS D[7]	1	0	0	V
CS D[6]	1	0	0	H
CS D[5]	1	0	0	P3
CS D[4]	1	0	0	P2
CS D[3]	1	0	0	P1
CS D[2]	1	0	0	P0
CS D[1]	x	x	x	x
CS D[0]	x	x	x	x

Note:

For compatibility with 8-bit interface, CS D[1] and CS D[0] are not defined.

Decode	F	V	H	P3	P2	P1	P0
Field 1 start of active video (SAV)	0	0	0	0	0	0	0
Field 1 end of active video (EAV)	0	0	1	1	1	0	1
Field 1 SAV (digital blanking)	0	1	0	1	0	1	1
Field 1 EAV (digital blanking)	0	1	1	0	1	1	0
Field 2 SAV	1	0	0	0	1	1	1
Field 2 EAV	1	0	1	1	0	1	0
Field 2 SAV (digital blanking)	1	1	0	1	1	0	0
Field 2 EAV (digital blanking)	1	1	1	0	0	0	1

5.2.3. Register list

Module Name	Base Address
CSI0	0x01CB0000

Register Name	Offset	Register name
CSI0_EN_REG	0X0000	CSI Enable register
CSI0_IF_CFG_REG	0X0004	CSI Interface Configuration Register
CSI0_CAP_REG	0X0008	CSI Capture Register
CSI0_SYNC_CNT_REG	0X000C	CSI Synchronization Counter Register
CSI0_FIFO_THRS_REG	0X0010	CSI FIFO Threshold Register
CSI0_PTN_LEN_REG	0X0030	CSI Pattern Generation Length register
CSI0_PTN_ADDR_REG	0X0034	CSI Pattern Generation Address register
CSI0_VER_REG	0X003C	CSI Version Register
CSI0_CO_CFG_REG	0X0044	CSI Channel_0 configuration register
CSI0_CO_SCALE_REG	0X004C	CSI Channel_0 scale register
CSI0_CO_F0_BUFA_REG	0X0050	CSI Channel_0 FIFO 0 output buffer-A address register
CSI0_CO_F1_BUFA_REG	0X0058	CSI Channel_0 FIFO 1 output buffer-A address register
CSI0_CO_F2_BUFA_REG	0X0060	CSI Channel_0 FIFO 2 output buffer-A address register
CSI0_CO_CAP_STA_REG	0X006C	CSI Channel_0 status register
CSI0_CO_INT_EN_REG	0X0070	CSI Channel_0 interrupt enable register
CSI0_CO_INT_STA_REG	0X0074	CSI Channel_0 interrupt status register
CSI0_CO_HSIZE_REG	0X0080	CSI Channel_0 horizontal size register
CSI0_CO_VSIZE_REG	0X0084	CSI Channel_0 vertical size register
CSI0_CO_BUF_LEN_REG	0X0088	CSI Channel_0 line buffer length register
CSI0_CO_FLIP_SIZE_REG	0X008C	CSI Channel_0 flip size register
CSI0_CO_FRM_CLK_CNT_REG	0X0090	CSI Channel_0 frame clock counter register
CSI0_CO_ACC_ITNL_CLK_CNT_REG	0X0094	CSI Channel_0 accumulated and internal clock counter register
CSI0_CO_FIFO_STAT_REG	0X0098	CSI Channel_0 FIFO Statistic Register
CSI0_CO_PCLK_STAT_REG	0X009C	CSI Channel_0 PCLK Statistic Register
CCI_CTRL	0x3000	CCI control register
CCI_CFG	0x3004	CCI transmission config register
CCI_FMT	0x3008	CCI packet format register
CCI_BUS_CTRL	0x300C	CCI bus control register
CCI_INT_CTRL	0x3014	CCI interrupt control register
CCI_LC_TRIG	0x3018	CCI line counter trigger register
CCI_FIFO_ACC	0x3100	CCI FIFO access register
CCI_RSV_REG	0x3200	CCI reserved register

5.2.4. Register Description

5.2.4.1. CSI Enable Register (Default Value: 0x00000000)

Offset: 0x0000			Register Name: CSIO_EN_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30	R/W	0x0	VER_EN CSI Version Register Read Enable: 0: Disable 1: Enable
29:24	/	/	/
23:16	R/W	0x00	PTN_CYCLE Pattern generating cycle counter. The pattern in dram will be generated in cycles of PTN_CYCLE+1.
15:9	/	/	/
8	R/W	0x0	SRAM_PWDN 0: SRAM in normal 1: SRAM in power down
7:5	/	/	/
4	R/W	0x0	PTN_START CSI Pattern Generating Start 0: Finish other: Start Software write this bit to“1” to start pattern generating from DRAM. When finished, the hardware will clear this bit to “0” automatically. Generating cycles depends on PTN_CYCLE.
3	R/W	0	CLK_CNT_SPL Sampling time for clk counter per frame 0: Sampling clock counter every frame done 1: Sampling clock counter every vsync
2	R/W	0	CLK_CNT_EN clk count per frame enable
1	R/W	0	PTN_GEN_EN Pattern Generation Enable
0	R/W	0	CSI_EN Enable 0: Reset and disable the CSI module 1: Enable the CSI module

5.2.4.2. CSI Interface Configuration Register (Default Value: 0x00000000)

Offset: 0x0004			Register Name: CSIO_IF_CFG_REG
Bit	R/W	Default/Hex	Description
31:22	/	/	/
21	R/W	0	SRC_TYPE Source type 0: Progressed 1: Interlaced
20	R/W	0	FPS_DS Fps down sample 0: no down sample 1: 1/2 fps, only receives the first frame every 2 frames
19	R/W	0	FIELD For YUV HV timing, Field polarity 0: negative(field=0 indicate odd, field=1 indicate even) 1: positive(field=1 indicate odd, field=0 indicate even) For BT656 timing, Field sequence 0: Normal sequence (field 0 first) 1: Inverse sequence (field 1 first)
18	R/W	1	VREF_POL Vref polarity 0: negative 1: positive This register is not apply to CCIR656 interface.
17	R/W	0	HERF_POL Href polarity 0: negative 1: positive This register is not apply to CCIR656 interface.
16	R/W	1	CLK_POL Data clock type 0: active in rising edge 1: active in falling edge
15:12	/	/	/
11:10	R/W	0	SEQ_8PLUS2 When select IF_DATA_WIDTH to be 8+2bit, odd/even pixel byte at CSI-D[11:4] will be rearranged to D[11:2]+2'b0 at the actual csi data bus according to these sequences: 00: 6'bx+D[9:8], D[7:0] 01: D[9:2], 6'bx+D[1:0] 10: D[7:0], D[9:8]+6'bx 11: D[7:0], 6'bx+D[9:8]
9:8	R/W	0	IF_DATA_WIDTH 00: 8 bit data bus

			01: 10 bit data bus 10: 12 bit data bus 11: 8+2bit data bus
7	R/W	0	MIPI_IF MIPI Interface Enable: 0: CSI 1: MIPI
6:5	/	/	/
4:0	R/W	0	CSI_IF YUV: 00000: YUYV422 Interleaved or RAW (All data in one data bus) CCIR656: 00100: YUYV422 Interleaved or RAW (All data in one data bus) Others: Reserved

5.2.4.3. CSI Capture Register (Default Value: 0x00000000)

Offset: 0x0008			Register Name: CSIO_CAP_REG
Bit	R/W	Default/Hex	Description
31:6	/	/	/
5:2	R/W	0x0	CH0_CAP_MASK Vsync number masked before capture.
1	R/W	0x0	CH0_VCAP_ON Video capture control: Capture the video image data stream on channel 0. 0: Disable video capture If video capture is in progress, the CSI stops capturing image data at the end of the current frame, and all of the current frame data is wrote to output FIFO. 1: Enable video capture The CSI starts capturing image data at the start of the next frame.
0	R/W	0x0	CH0_SCAP_ON Still capture control: Capture a single still image frame on channel 0. 0: Disable still capture. 1: Enable still capture The CSI module starts capturing image data at the start of the next frame. The CSI module captures only one frame of image data. This bit is self clearing and always reads as a 0.

5.2.4.4. CSI Synchronization Counter Register (Default Value: 0x00000000)

Offset: 0x000C			Register Name: CSIO_SYNC_CNT_REG
Bit	R/W	Default/Hex	Description

31:24	/	/	/
23:0	R	0	SYNC_CNT The counter value between vsync of CSI0 channel 0 and vsync of CSI1 channel 0 , using 24MHz.

5.2.4.5. CSI FIFO Threshold Register (Default Value: 0x040f0400)

Offset: 0x0010			Register Name: CSI0_FIFO_THRS_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:26	R/W	0x1	FIFO_NEARLY_FULL_TH The threshold of FIFO being nearly full. Indicates that the ISP should stop writing. Only valid when ISP is enabled. 0~7: The smaller the value, the flag of FIFO being nearly full is easier to reach.
25:24	R/W	0x0	PTN_GEN_CLK_DIV Packet generator clock divider
23:16	R/W	0x0f	PTN_GEN_DLY Clocks delayed before pattern generating start.
15:12	/	/	/
11:00	R/W	0x400	FIFO_THRS When CSI0 FIFO occupied memory exceed the threshold, dram frequency can not change.

5.2.4.6. CSI Pattern Generation Length Register (Default Value: 0x00000000)

Offset: 0x0030			Register Name: CSI0_PTN_LEN_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	PTN_LEN The pattern length in byte when generating pattern.

5.2.4.7. CSI Pattern Generation Address Register (Default Value: 0x00000000)

Offset: 0x0034			Register Name: CSI0_PTN_ADDR_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0x0	PTN_ADDR The pattern DRAM address when generating pattern.

5.2.4.8. CSI Version Register (Default Value: 0x00000000)

Offset: 0x003C			Register Name: CSIO_VER_REG
Bit	R/W	Default/Hex	Description
31:0	R	0x0	VER Version of hardware circuit. Only can be read when version register read enable is on.

5.2.4.9. CSI Channel_0 configuration Register (Default Value: 0x00300200)

Offset: 0x0044			Register Name: CSIO_CO_CFG_REG
Bit	R/W	Default/Hex	Description
31:24	R/W	0	PAD_VAL Padding value when OUTPUT_FMT is prgb888 0x00~0xff
23:20	R/W	3	INPUT_FMT Input data format 0000: RAW stream 0001: reserved 0010: reserved 0011: YUV422 0100: YUV420 Others: reserved
19:16	R/W	0	OUTPUT_FMT Output data format When the input format is set RAW stream 0000: field-raw-8 0001: field-raw-10 0010: field-raw-12 0011: reserved 0100: field-rgb565 0101: field-rgb888 0110: field-prgb888 0111: field-uv-combined 1000: frame-raw-8 1001: frame-raw-10 1010: frame-raw-12 1011: reserved 1100: frame-rgb565 1101: frame-rgb888 1110: frame-prgb888 1111: frame-uv-combined

			When the input format is set YUV422 0000: field planar YCbCr 422 0001: field planar YCbCr 420 0010: frame planar YCbCr 420 0011: frame planar YCbCr 422 0100: field planar YCbCr 422 UV combined 0101: field planar YCbCr 420 UV combined 0110: frame planar YCbCr 420 UV combined 0111: frame planar YCbCr 422 UV combined 1000: field MB YCbCr 422 1001: field MB YCbCr 420 1010: frame MB YCbCr 420 1011: frame MB YCbCr 422 1100: field planar YCbCr 422 10bit UV combined 1101: field planar YCbCr 420 10bit UV combined 1110: Reserved 1111: Reserved When the input format is set YUV420 0000: Reserved 0001: field planar YCbCr 420 0010: frame planar YCbCr 420 0011: Reserved 0100: Reserved 0101: field planar YCbCr 420 UV combined 0110: frame planar YCbCr 420 UV combined 0111: Reserved 1000: Reserved 1001: field MB YCbCr 420 1010: frame MB YCbCr 420 1011: Reserved 1100: Reserved 1101: field planar YCbCr 420 10bit UV combined 1110: Reserved 1111: Reserved Others: reserved
15:14	/	/	/
13	R/W	0	VFLIP_EN Vertical flip enable When enabled, the received data will be arranged in vertical flip. 0:Disable 1:Enable
12	R/W	0	HFLIP_EN Horizontal flip enable

			When enabled, the received data will be arranged in horizontal flip. 0:Disable 1:Enable
11:10	R/W	0	FIELD_SEL Field selection. 00: capturing with field 1. 01: capturing with field 2. 10: capturing with either field. 11: reserved
09:08	R/W	2	INPUT_SEQ Input data sequence, only valid for YUV422 and YUV420 input format. All data interleaved in one channel: 00: YUYV 01: YVYU 10: UYVY 11: VYUY Y and UV in separated channel: x0: UV x1: VU
07:02	/	/	/
01:00	R/W	0	MIN_SDR_WR_SIZE Minimum size of SDRAM block write 0: 256 bytes (if hflip is enable, always select 256 bytes) 1: 512 bytes 2: 1k bytes 3: 2k bytes

5.2.4.10. CSI Channel_0 scale Register (Default Value: 0x00000000)

Offset: 0x004C			Register Name: CSIO_CO_SCALE_REG
Bit	R/W	Default/Hex	Description
31:01	/	/	/
00	R/W	0	QUART_EN When this bit is set to 1, input image will be decimated to quarter size. All input format are supported.

5.2.4.11. CSI Channel_0 FIFO 0 output buffer-A address Register (Default Value: 0x00000000)

Offset: 0x0050			Register Name: CSIO_CO_F0_BUFA_REG
Bit	R/W	Default/Hex	Description
31:00	R/W	0	COF0_BUFA FIFO 0 output buffer-A address

5.2.4.12. CSI Channel_0 FIFO 1 output buffer-A address Register (Default Value: 0x00000000)

Offset: 0x0058			Register Name: CSI0_CO_F1_BUFA_REG
Bit	R/W	Default/Hex	Description
31:00	R/W	0	COF1_BUFA FIFO 1 output buffer-A address

5.2.4.13. CSI Channel_0 FIFO 2 output buffer-A address Register (Default Value: 0x00000000)

Offset: 0x0060			Register Name: CSI0_CO_F2_BUFA_REG
Bit	R/W	Default/Hex	Description
31:00	R/W	0	COF2_BUFA FIFO 2 output buffer-A address

5.2.4.14. CSI Channel_0 status Register (Default Value: 0x00000000)

Offset: 0x006C			Register Name: CSI0_CO_CAP_STA_REG
Bit	R/W	Default/Hex	Description
31:03	/	/	/
02	R	0	FIELD_STA The status of the received field 0: Field 0 1: Field 1
01	R	0	VCAP_STA Video capture in progress Indicates the CSI is capturing video image data (multiple frames). The bit is set at the start of the first frame after enabling video capture. When software disables video capture, it clears itself after the last pixel of the current frame is captured.
00	R	0	SCAP_STA Still capture in progress Indicates the CSI is capturing still image data (single frame). The bit is set at the start of the first frame after enabling still frame capture. It clears itself after the last pixel of the first frame is captured. For CCIR656 interface, if the output format is frame planar YCbCr 420 mode, the frame end means the field2 end, the other frame end means filed end.

5.2.4.15. CSI Channel_0 interrupt enable Register (Default Value: 0x00000000)

Offset: 0x0070			Register Name: CSIO_CO_INT_EN_REG
Bit	R/W	Default/Hex	Description
31:08	/	/	/
07	R/W	0	VS_INT_EN vsync flag The bit is set when vsync come. And at this time load the buffer address for the coming frame. So after this irq come, change the buffer address could only effect next frame
06	R/W	0	HB_OF_INT_EN Hblank FIFO overflow The bit is set when 3 FIFOs still overflow after the hblank.
05	R/W	0	MUL_ERR_INT_EN Multi-channel writing error Indicates error has been detected for writing data to a wrong channel.
04	R/W	0	FIFO2_OF_INT_EN FIFO 2 overflow The bit is set when the FIFO 2 become overflow.
03	R/W	0	FIFO1_OF_INT_EN FIFO 1 overflow The bit is set when the FIFO 1 become overflow.
02	R/W	0	FIFO0_OF_INT_EN FIFO 0 overflow The bit is set when the FIFO 0 become overflow.
01	R/W	0	FD_INT_EN Frame done Indicates the CSI has finished capturing an image frame. Applies to video capture mode. The bit is set after each completed frame capturing data is wrote to buffer as long as video capture remains enabled.
00	R/W	0	CD_INT_EN Capture done Indicates the CSI has completed capturing the image data. For still capture, the bit is set when one frame data has been wrote to buffer. For video capture, the bit is set when the last frame has been wrote to buffer after video capture has been disabled. For CCIR656 interface, if the output format is frame planar YCbCr 420 mode, the frame end means the field2 end, the other frame end means field end.

5.2.4.16. CSI Channel_0 interrupt status Register (Default Value: 0x00000000)

Offset: 0x0074	Register Name: CSIO_CO_INT_STA_REG
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Bit	R/W	Default/Hex	Description
31:08	/	/	/
07	R/W	0	VS_PD vsync flag
06	R/W	0	HB_OF_PD Hblank FIFO overflow
05	R/W	0	MUL_ERR_PD Multi-channel writing error
04	R/W	0	FIFO2_OF_PD FIFO 2 overflow
03	R/W	0	FIFO1_OF_PD FIFO 1 overflow
02	R/W	0	FIFO0_OF_PD FIFO 0 overflow
01	R/W	0	FD_PD Frame done
00	R/W	0	CD_PD Capture done

5.2.4.17. CSI Channel_0 horizontal size Register (Default Value: 0x05000000)

Offset: 0x0080			Register Name: CSIO_CO_HSIZE_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:16	R/W	500	HOR_LEN Horizontal pixel unit length. Valid pixel of a line.
15:13	/	/	/
12:00	R/W	0	HOR_START Horizontal pixel unit start. Pixel is valid from this pixel.

5.2.4.18. CSI Channel_0 vertical size Register (Default Value: 0x01E00000)

Offset: 0x0084			Register Name: CSIO_CO_VSIZE_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:16	R/W	1E0	VER_LEN Vertical line length. Valid line number of a frame.
15:13	/	/	/
12:00	R/W	0	VER_START Vertical line start. data is valid from this line.

5.2.4.19. CSI Channel_0 buffer length Register (Default Value: 0x01400280)

Offset: 0x0088			Register Name: CSIO_CO_BUF_LEN_REG
Bit	R/W	Default/Hex	Description
31:30	/	/	/
29:16	R/W	140	BUF_LEN_C Buffer length of chroma C in a line. Unit is byte.
15:14	/	/	/
13:00	R/W	280	BUF_LEN Buffer length of luminance Y in a line. Unit is byte.

5.2.4.20. CSI Channel_0 flip size Register (Default Value: 0x01E00280)

Offset: 0x008C			Register Name: CSIO_CO_FLIP_SIZE_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:16	R/W	1E0	VER_LEN Vertical line number when in vflip mode.
15:13	/	/	/
12:00	R/W	280	VALID_LEN Valid components of a line when in flip mode.

5.2.4.21. CSI Channel_0 frame clock counter Register (Default Value: 0x00000000)

Offset: 0x0090			Register Name: CSIO_CO_FRM_CLK_CNT_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:00	R	0	FRM_CLK_CNT Counter value between every frame. For instant hardware frame rate statics. The internal counter is added by one every 24MHz clock cycle. When frame done or vsync comes, the internal counter value is sampled to FRM_CLK_CNT, and cleared to 0.

5.2.4.22. CSI Channel_0 accumulated and internal clock counter Register (Default Value: 0x00000000)

Offset: 0x0094			Register Name: CSIO_CO_ACC_ITNL_CLK_CNT_REG
Bit	R/W	Default/Hex	Description
31:24	R	0	ACC_CLK_CNT The accumulated value of FRM_CLK_CNT for software frame rate statics.

			Every interrupt of frame done, the software check this accumulated value and clear it to 0. If the ACC_CLK_CNT is larger than 1, the software has lost frame. When frame done or vsync comes, ACC_CLK_CNT = ACC_CLK_CNT + 1, and cleared to 0 when writing 0 to this register.
23:00	R	0	ITNL_CLK_CNT The instant value of internal frame clock counter. When frame done interrupt comes, the software can query this counter for judging whether it is the time for updating the double buffer address registers.

5.2.4.23. CSI Channel_0 FIFO Statistic Register (Default Value: 0x00000000)

Offset: 0x0098			Register Name: CSIO_CO_FIFO_STAT_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11:00	R	0	FIFO_FRM_MAX Indicates the maximum depth of FIFO being occupied for whole frame. Update at every vsync or framedone.

5.2.4.24. CSI Channel_0 PCLK Statistic Register (Default Value: 0x00007FFF)

Offset: 0x009C			Register Name: CSIO_CO_PCLK_STAT_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30:16	R	0	PCLK_CNT_LINE_MAX Indicates maximum pixel clock counter value for each line. Update at every vsync or framedone.
15	/	/	/
14:00	R	0x7fff	PCLK_CNT_LINE_MIN Indicates minimum pixel clock counter value for each line. Update at every vsync or framedone.

5.2.4.25. CCI Control Register (Default Value: 0x00000000)

Offset: 0x3000			Register Name: CCI_CTRL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	SINGLE_TRAN 0: Transmission idle 1: Start single transmission Automatically cleared to '0' when finished. Abort current transmission

			immediately if changing from '1' to '0'. If slave not respond for the expected status over the time defined by TIMEOUT, current transmission will stop. PACKET_CNT will return the sequence number when transmission fail. All format setting and data will be loaded from registers and FIFO when transmission start.
30	R/W	0	REPEAT_TRAN 0: transmission idle 1: repeated transmission When this bit is set to 1, transmission repeats when trigger signal (such as VSYNC/ VCAP done) repeats. If changing this bit from '1' to '0' during transmission, the current transmission will be guaranteed then stop.
29	R/W	0	RESTART_MODE 0: RESTART 1: STOP+START Define the CCI action after sending register address.
28	R/W	0	READ_TRAN_MODE 0: send slave_id+W 1: do not send slave_id+W Setting this bit to 1 if reading from a slave which register width is equal to 0.
27:24	R	0	TRAN_RESULT 000: OK 001: FAIL Other: Reserved
23:16	R	/	CCI_STA 0x00: bus error 0x08: START condition transmitted 0x10: Repeated START condition transmitted 0x18: Address + Write bit transmitted, ACK received 0x20: Address + Write bit transmitted, ACK not received 0x28: Data byte transmitted in master mode, ACK received 0x30: Data byte transmitted in master mode, ACK not received 0x38: Arbitration lost in address or data byte 0x40: Address + Read bit transmitted, ACK received 0x48: Address + Read bit transmitted, ACK not received 0x50: Data byte received in master mode, ACK received 0x58: Data byte received in master mode, ACK not received 0x01: Timeout when sending 9th SCL clk Other: Reserved
15:2	/	/	/
1	R/W	0	SOFT_RESET 0: normal 1: reset
0	R/W	0	CCI_EN

			0: Module disable 1: Module enable
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5.2.4.26. CCI Transmission Configuration Register (Default Value: 0x10000000)

Offset: 0x3004			Register Name: CCI_CFG_REG
Bit	R/W	Default/Hex	Description
31:24	R/W	0x10	TIMEOUT_N When sending the 9th clock, assert fail signal when slave device did not response after N*FSCL cycles. And software must do a reset to CCI module and send a stop condition to slave.
23:16	R/W	0x00	INTERVAL Define the interval between each packet in 40*FSCL cycles. 0~255
15	R/W	0	PACKET_MODE Select where to load slave id / data width 0: Compact mode 1: Complete mode In compact mode, slave id/register width / data width will be loaded from CCI_FMT register, only address and data read from memory. In complete mode, they will be loaded from packet memory.
14:7	/	/	/
6:4	R/W	0	TRIG_MODE Transmit mode: 000: Immediately, no trigger 001: Reserved 010: CSI0 int trigger 011: CSI1 int trigger
3:0	R/W	0	CSI_TRIG CSI Int trig signal select: 0000: First HREF start 0001: Last HREF done 0010: Line counter trigger other: Reserved

5.2.4.27. CCI Packet Format Register (Default Value: 0x00110001)

Offset: 0x3008			Register Name: CCI_FMT_REG
Bit	R/W	Default/Hex	Description
31:25	R/W	0	SLV_ID 7bit address
24	R/W	0	CMD 0: write

			1: read
23:20	R/W	1	ADDR_BYTE How many bytes be sent as address 0~15
19:16	R/W	1	DATA_BYTE How many bytes be sent/received as data 1~15 Normally use ADDR_DATA with 0_2, 1_1, 1_2, 2_1, 2_2 access mode. If DATA bytes is 0, transmission will not start. In complete mode, the ADDR_BYTE and DATA_BYTE is defined in a byte's high/low 4bit.
15:0	R/W	1	PACKET_CNT FIFO data be transmitted as PACKET_CNT packets in current format. Total bytes not exceed 32bytes.

5.2.4.28. CCI Bus Control Register (Default Value: 0x00002500)

Offset: 0x300C			Register Name: CCI_BUS_REG
Bit	R/W	Default/Hex	Description
31:16	R/W	0	DLY_CYC 0~65535 FSCL cycles between each transmission
15	R/W	0	DLY_TRIG 0: disable 1: execute transmission after internal counter delay when triggered
14:12	R/W	0x2	CLK_N CCI bus sampling clock $F_0 = 24\text{MHz} / 2^{\text{CLK_N}}$
11:8	R/W	0x5	CLK_M CCI output SCL frequency is $\text{FSCL} = F_1 / 10 = (F_0 / (\text{CLK_M} + 1)) / 10$
7	R	/	SCL_STA SCL current status
6	R	/	SDA_STA SDA current status
5	R/W	0	SCL_PEN SCL PAD enable
4	R/W	0	SDA_PEN SDA PAD enable
3	R/W	0	SCL_MOV SCL manual output value
2	R/W	0	SDA_MOV SDA manual output value
1	R/W	0	SCL_MOE SCL manual output en
0	R/W	0	SDA_MOE SDA manual output en

5.2.4.29. CCI Interrupt Control Register (Default Value: 0x00000000)

Offset: 0x3014			Register Name: CCI_INT_CTRL_REG
Bit	R/W	Default/Hex	Description
31:18	/	/	/
17	R/W	0	S_TRAN_ERR_INT_EN
16	R/W	0	S_TRAN_COM_INT_EN
15:2	/	/	/
1	R/W	0	S_TRAN_ERR_PD
0	R/W	0	S_TRAN_COM_PD

5.2.4.30. CCI Line Counter Trigger Control Register (Default Value: 0x00000000)

Offset: 0x3018			Register Name: CCI_LC_REG
Bit	R/W	Default/Hex	Description
31:13	/	/	/
12:0	R/W	0	LN_CNT 0~8191: line counter send trigger when 1st~8192th line is received.

5.2.4.31. CCI FIFO Access Register (Default Value: 0x00000000)

Offset: 0x3100~0x313f			Register Name: CCI_FIFO_ACC_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	DATA_FIFO From 0x100 to 0x13f, CCI data fifo is 64bytes, used in fifo input mode. CCI transmission read/write data from/to fifo in byte.

Chapter 6 Display

This chapter describes the A83T display system from following perspectives:

- [Display Engine2.0](#)
- [TCON](#)

6.1. Display System

Figure 6-1 shows the block diagram of display system.

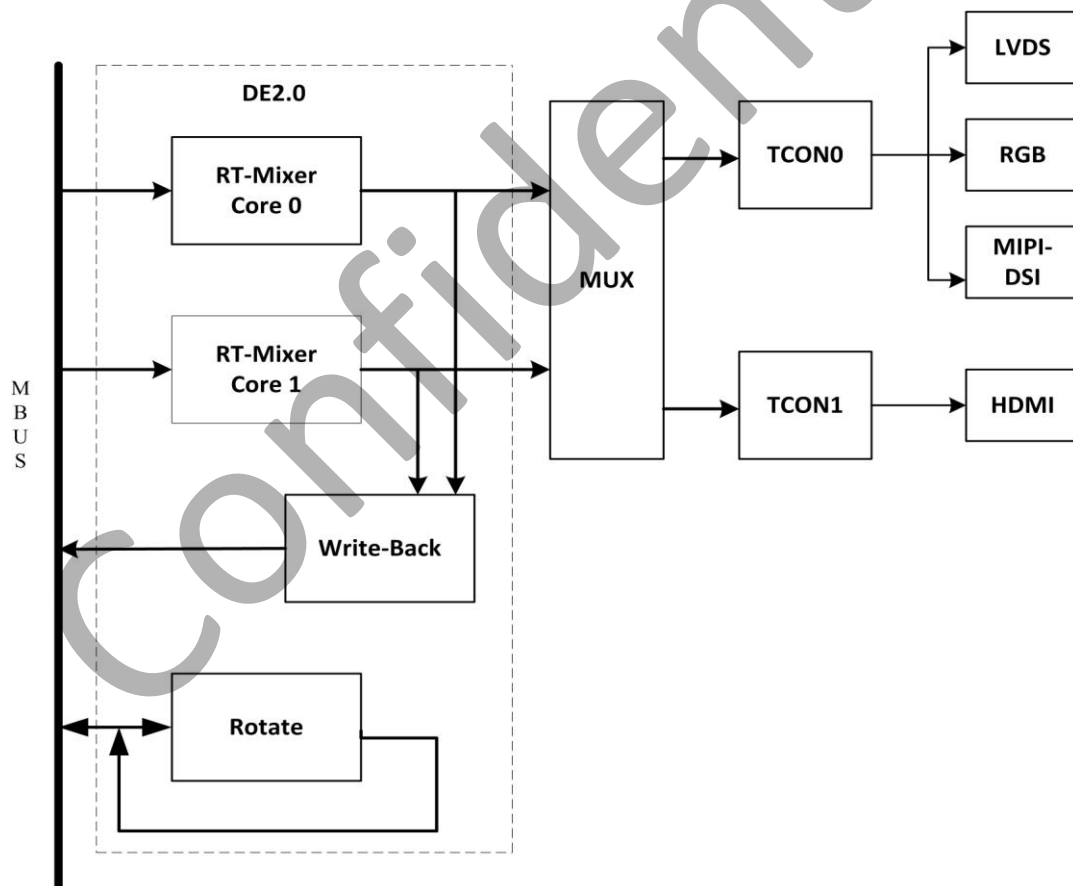


Figure 6-1. Display System Block Diagram

6.2. Display Engine2.0

6.2.1. Overview

- Support input layer size up to 2048x2048, and output size up to 2048x2048.
- Support four alpha blending channel for main display,two channel for aux display.
- Support four overlay layer in each channel, and has a independent scaler.
- Support potter-duff compatible blending operation.
- Support input format YUV422/YUV420/YUV411/ARGB8888/XRGB8888/RGB888/ARGB4444/ARGB1555 and RGB565
- Support Frame Packing/Top-and-Bottom/Side-by-Side Full/Side-by-Side Half 3D format data
- Support display enhancement 2.0 for excellent display experience
 - Adaptive edge sharpening
 - Adaptive color enhancement
 - Adaptive contrast enhancement and fresh tone rectify
- Support write back & rotation for high efficient dual display and miracast.

6.3. TCON

6.3.1. Overview

The TCON0 module is used for LCD panel, and TCON1 module is used for HDTV.

- Support LVDS interface with single link, up to 1280x800@60fps
- Support RGB interface with DE/SYNC mode, up to 1920x1200@60fps
- Support serial RGB/dummy RGB/CCIR656 interface, up to 1280x800@60fps
- Support i80 interface with 18/16/9/8 bit, TE supported, up to 1280x800@60fps
- Support pixel format: RGB888, RGB666 and RGB565
- Dither function from RGB666/RGB565 to RGB888
- Gamma correction with R/G/B channel independence
- 4 interrupts for programmer single LCD output
- Support 3D function

6.3.2. Block Diagram

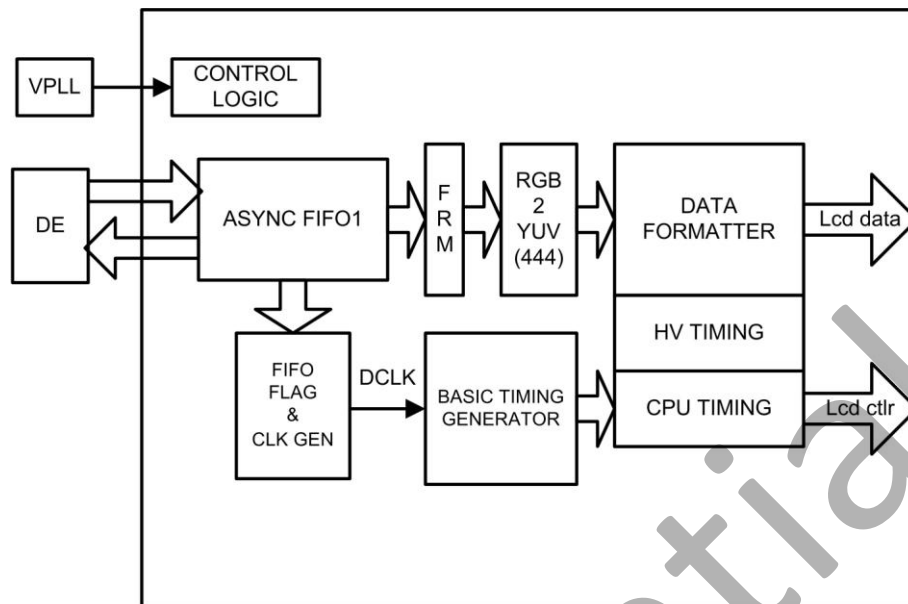


Figure 6-2. TCON0 Block Diagram

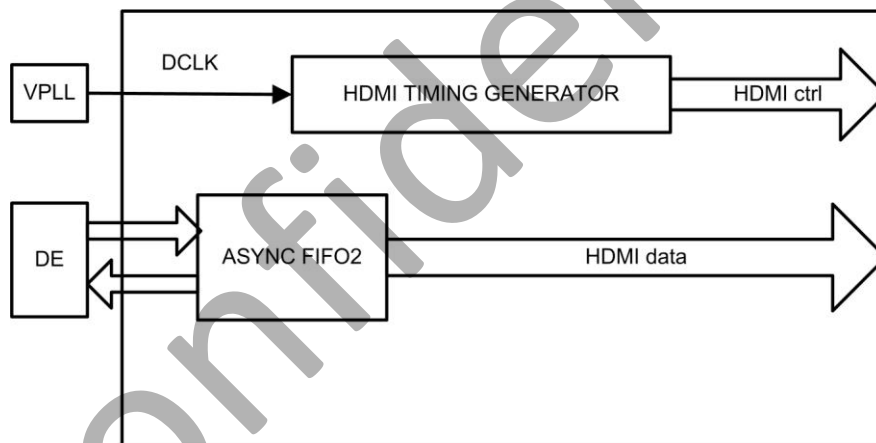


Figure 6-3. TCON1 Block Diagram

6.3.3. Functionalities Description

6.3.3.1. Panel Interface

HV_I/F(Sync+DE mode)

HV I/F is also known as Sync + DE mode, which is widely used in TFT LCD module for PMP/MP4 applications. Its signals are define as:

Main Signal	I/O type	Definition And Description
Vsync	O	Vertical sync, indicates one new frame
Hsync	O	Horizontal sync, indicate one new scan line
DCLK	O	Dot clock, pixel data are sync by this clock
LDE	O	LCD data enable
LD[23..0]	O	24Bit RGB/YUV output from input FIFO for panel

HV control signals are active low.

Vertical Timing

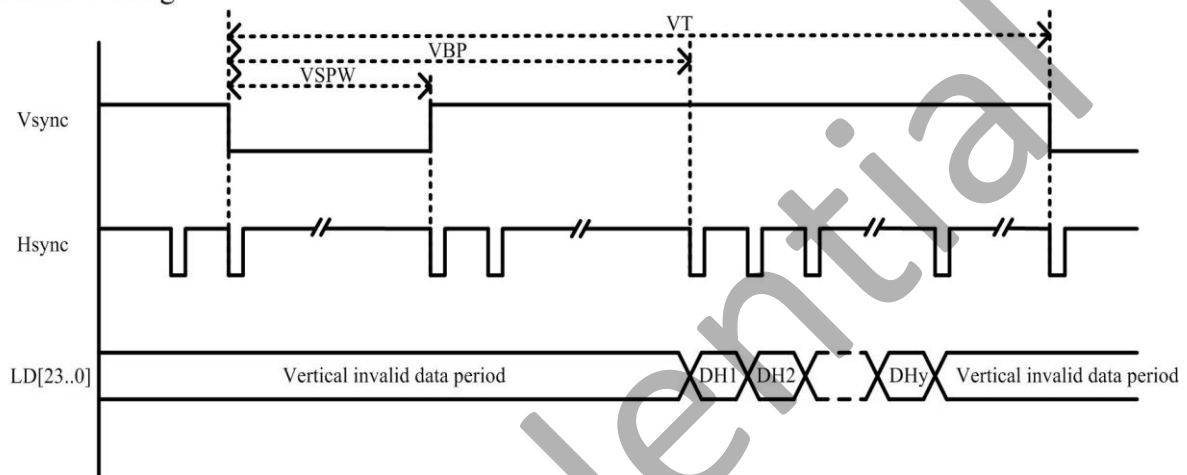


Figure 6-4. Panel Interface Odd/Even Field Timing

Vertical Timing

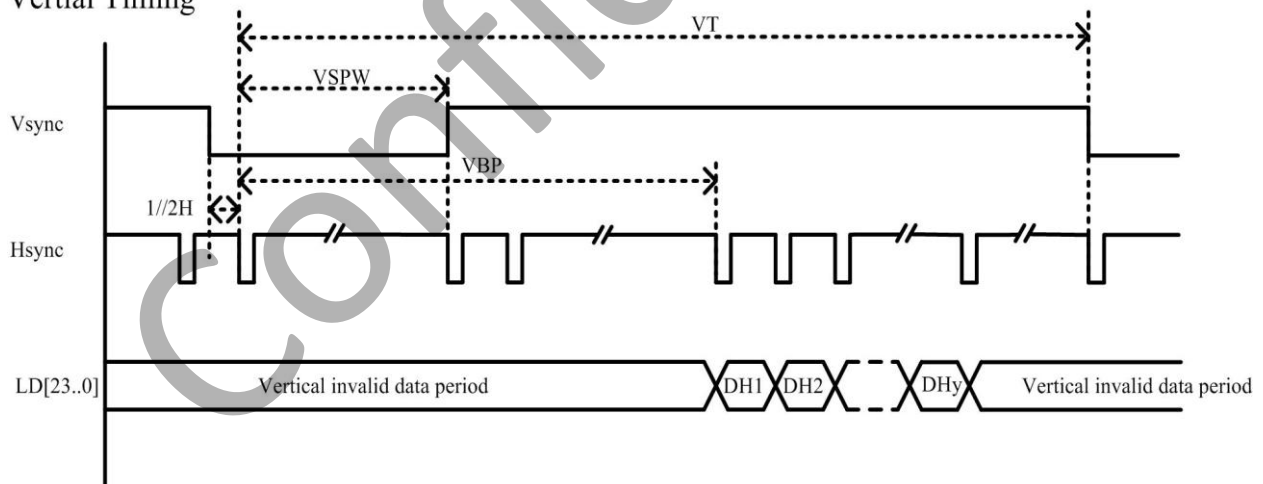


Figure 6-5. Panel Interface Even Filed Timing

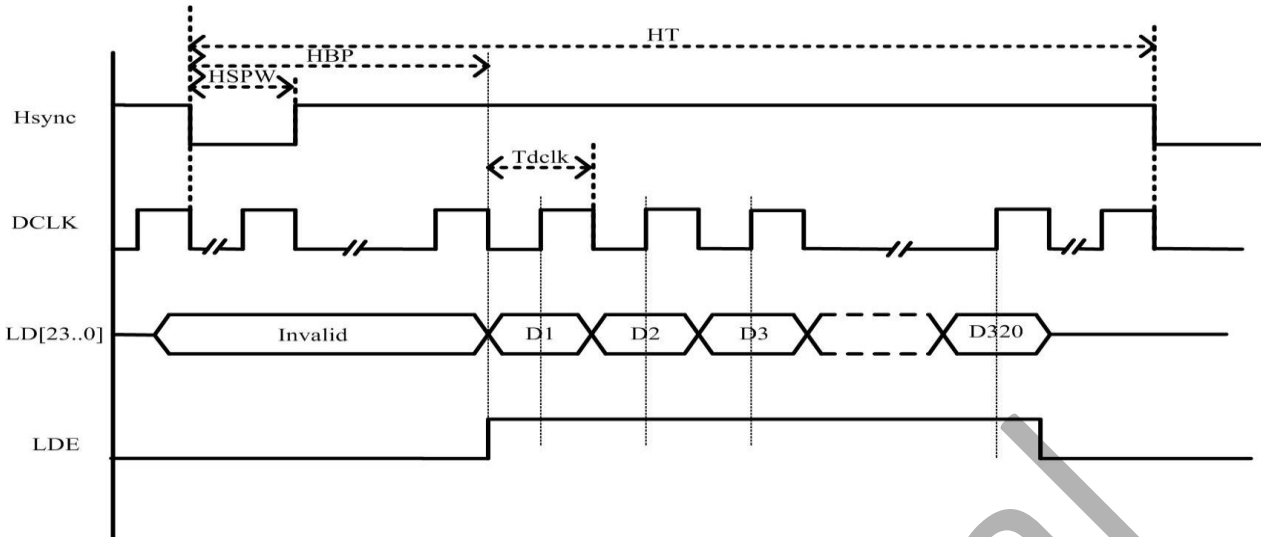


Figure 6-6. Parallel Mode Horizontal Timing

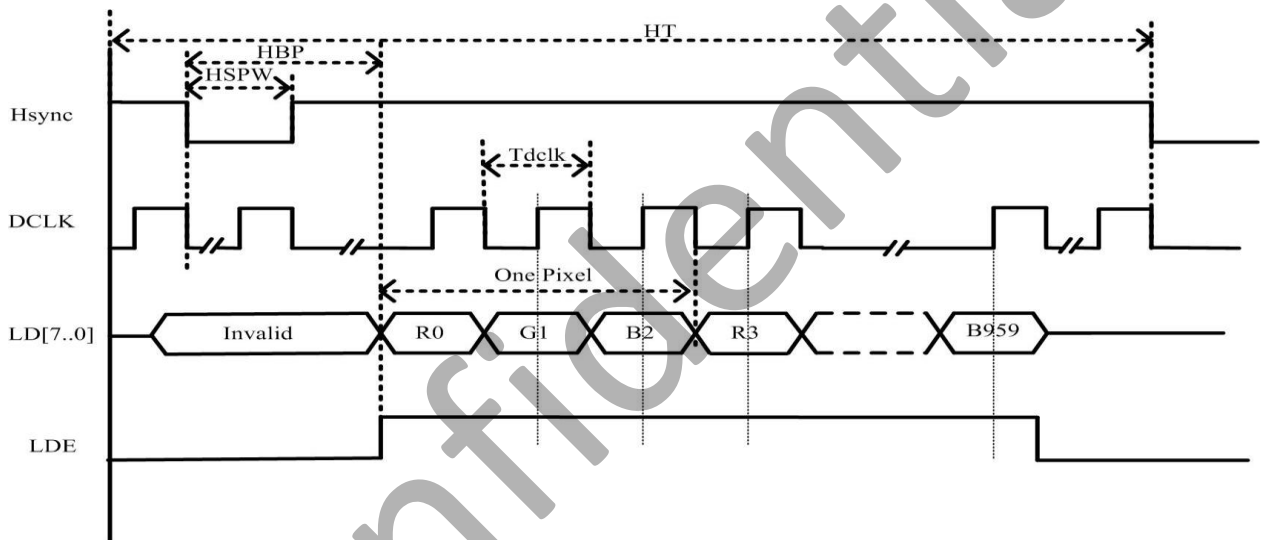


Figure 6-7. Serial Mode Horizontal Timing

CCIR output SAV/EAV sync signal

When in HV serial YUV output mode, it's timing is CCIR656/601 compatible. SAV add right before active area every line; EAV add right after active area every line.

It logic are:

F = "0" for Field 1 F = "1" for Field 2

V = "1" during vertical blanking

H = "0" at SAV H = "1" at EAV

P3-P0 = protection bits

$P3 = V \oplus H$

$P2 = F \oplus H$

$P1 = F \oplus V$

$P0 = F \oplus V \oplus H$

Where $\oplus$ represents the exclusive-OR function

The 4 byte SAV/EAV sequences are:

	8-bit Data								10-bit Data	
	D9 (MSB)	D8	D7	D6	D5	D4	D3	D2	D1	D0
preamble	1	1	1	1	1	1	1	1	1	1
	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0
Status word	1	F	V	H	P3	P2	P1	P0	0	0

CPU_I/F

CPU I/F LCD panel is most common interface for small size, low resolution LCD panels.

CPU control signals are active low.

Main Signal	I/O type	Definition And Description
CS	O	Chip select, active low
WR	O	Write strobe, active low
RD	O	Read strobe, active low
A1	O	Address bit, controlled by "LCD_CPUI/F" BIT26/25
D[23..0]	I/O	Digital RGB output signal

The following figure relationship between basic timing and CPU timing.

WR is 180 degree delay of DCLK; CS is active when pixel data are valid;

RD is always set to 1; A1 are set by "Lcd_CPUI/F".

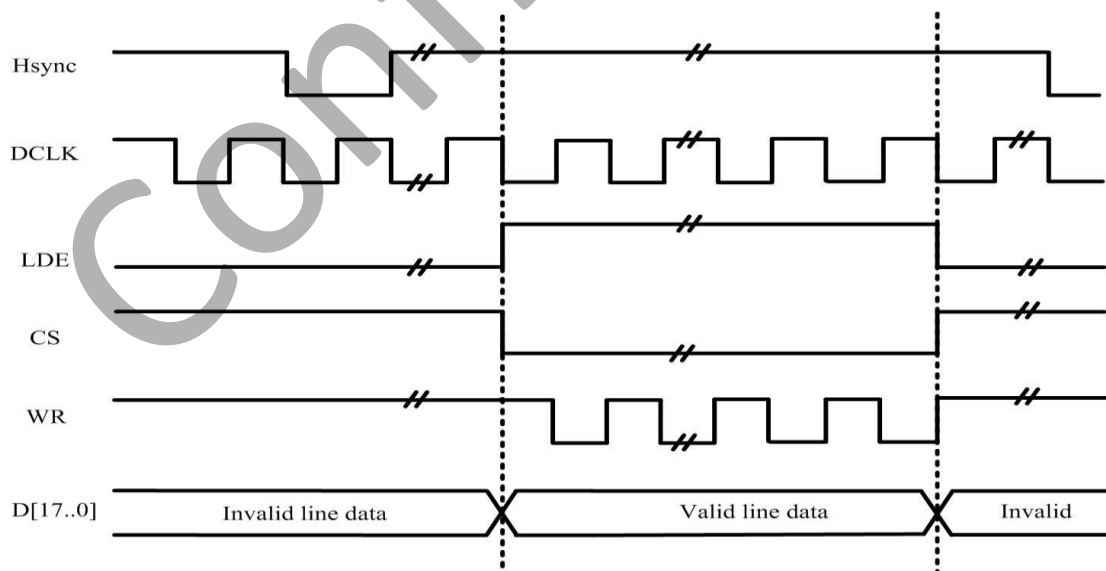


Figure 6-8. Lcd_CPUI/F Timing

When CPU I/F is in IDLE state, it can generate WR/RD timing by setting "Lcd_CPUI/F". CS strobe is one DCLK width, WR/RD strobe is half DCLK width.

LVDS_IF

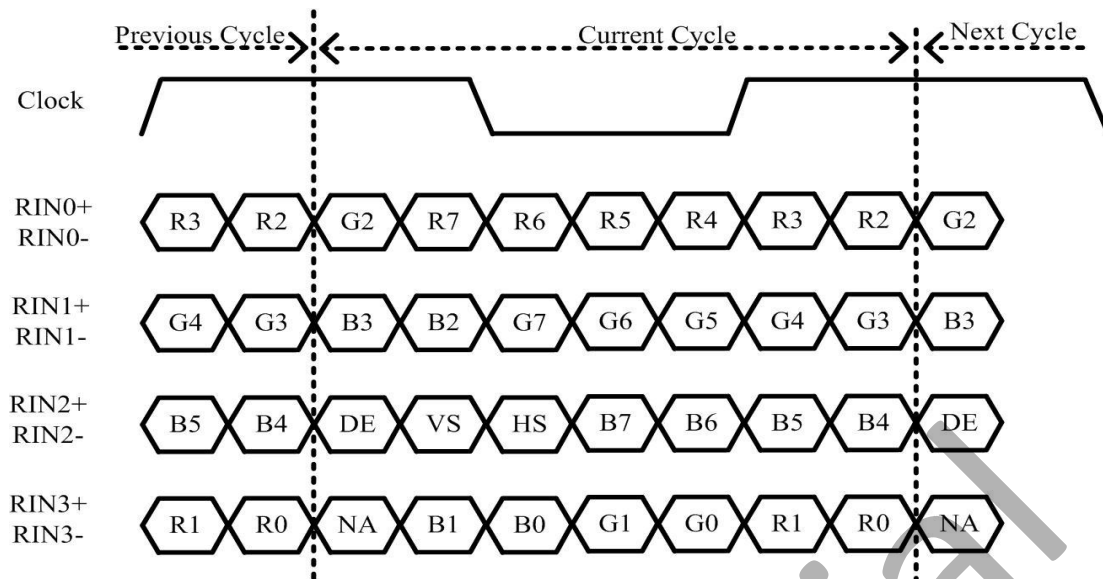


Figure 6-9. JEDIA Mode Timing

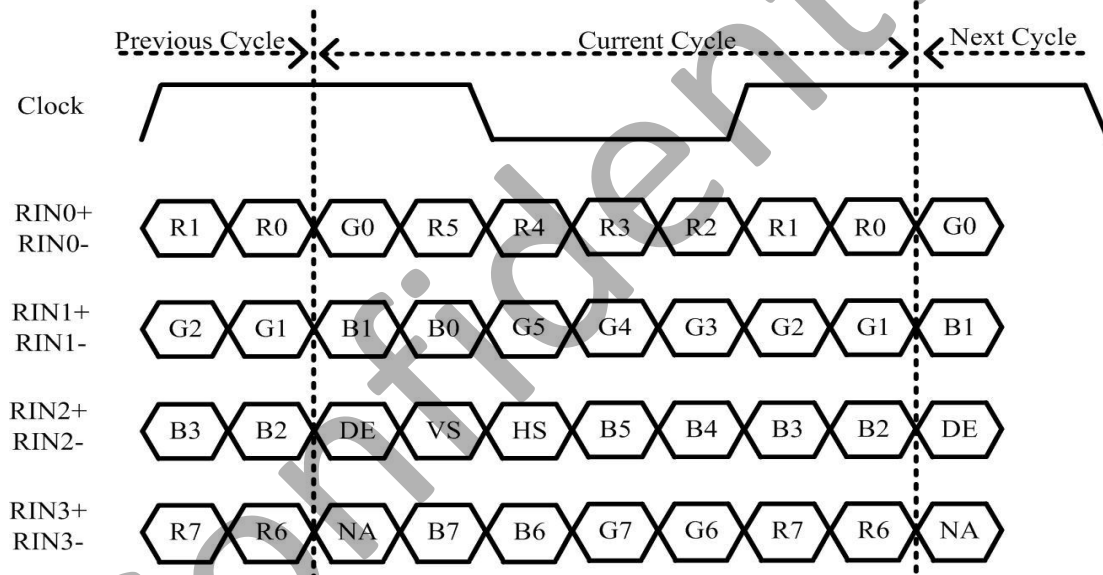


Figure 6-10. NS Mode Timing

6.3.3.2. RGB gamma correction

Function: This module correct the RGB input data of DE0 .

A 256*8*3 Byte register file is used to store the gamma table. The following is the layout:

Offset	Value
0x400, 0x401, 0x402	{ B0[7:0], G0[7:0], R0[7:0] }
0x404,	{ B1[7:0], G1[7:0], R1[7:0] }
.....	
0x4FC	{ B255[7:0], G255[7:0], R255[7:0] }

6.3.3.3. CEU module

Function: This module enhance color data from DE0 .

$$R' = Rr \cdot R + Rg \cdot G + Rb \cdot B + Rc$$

$$G' = Gr \cdot R + Gg \cdot G + Gb \cdot B + Gc$$

$$B' = Br \cdot R + Bg \cdot G + Bb \cdot B + Bc$$

Note:

Rr, Rg, Rb, ,Gr, Gg, Gb, Br, Bg, Bb s13 (-16,16)

Rc, Gc, Bc s19 (-16384, 16384)

R, G, B u8 [0-255]

R' have the range of [Rmin ,Rmax]

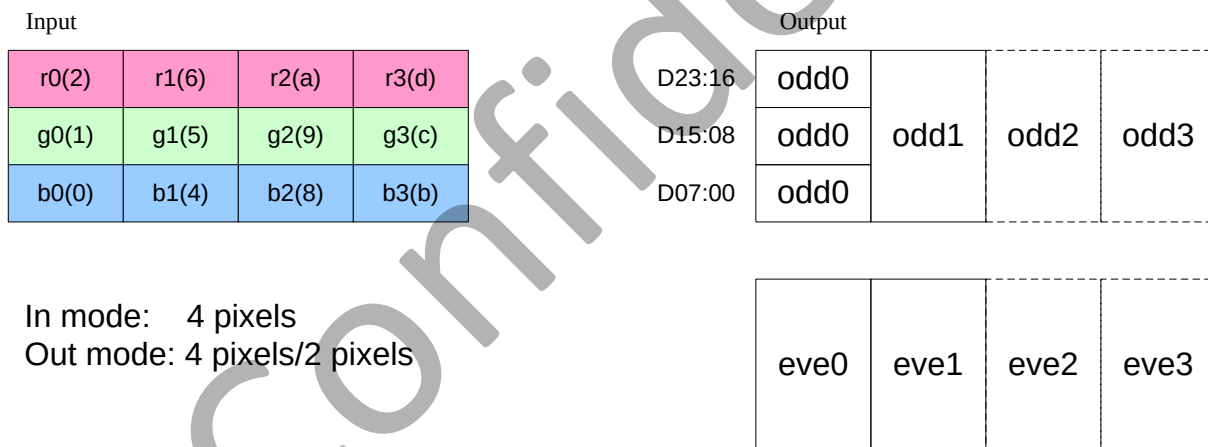
G' have the range of [Rmin ,Rmax]

B' have the range of [Rmin ,Rmax]

6.3.3.4. CMAP module

Function: This module map color data from DE0

Every 4 input pixels as an unit. an unit is divided into 12 bytes. Output byte can select one of those 12 bytes. Note that even line and odd line can be different, and output can be 12 bytes(4 pixels) or reduce to 6 bytes(2 pixels).



6.3.4. TCON0 Module Register List

Module Name	Base Address
TCON0	0x01C0C000

Register Name	Offset	Description
TCON_GCTL_REG	0x000	TCON global control register
TCON_GINTO_REG	0x004	TCON global interrupt register0

TCON_GINT1_REG	0x008	TCON global interrupt register1
TCON0_FRM_CTL_REG	0x010	TCON FRM control register
TCON0_FRM_SEED_REG	0x014+N*0x04	TCON FRM seed register (N=0,1,2,3,4,5)
TCON0_FRM_TAB_REG	0x02C+N*0x04	TCON FRM table register (N=0,1,2,3)
TCON0_3D_FIFO_REG	0x03C	TCON0 3D fifo register
TCON0_CTL_REG	0x040	TCON0 control register
TCON0_DCLK_REG	0x044	TCON0 data clock register
TCON0_BASIC0_REG	0x048	TCON0 basic timing register0
TCON0_BASIC1_REG	0x04C	TCON0 basic timing register1
TCON0_BASIC2_REG	0x050	TCON0 basic timing register2
TCON0_BASIC3_REG	0x054	TCON0 basic timing register3
TCON0_HV_IF_REG	0x058	TCON0 hv panel interface register
TCON0_CPU_IF_REG	0x060	TCON0 cpu panel interface register
TCON0_CPU_WR_REG	0x064	TCON0 cpu panel write data register
TCON0_CPU_RD0_REG	0x068	TCON0 cpu panel read data register0
TCON0_CPU_RD1_REG	0x06C	TCON0 cpu panel read data register1
TCON0_LVDS_IF_REG	0x084	TCON0 lvds panel interface register
TCON0_IO_POL_REG	0x088	TCON0 IO polarity register
TCON0_IO_TRI_REG	0x08C	TCON0 IO control register
TCON_DEBUG_REG	0x0FC	TCON debug register
TCON_CEU_CTL_REG	0x100	TCON CEU control register
TCON_CEU_COEF_MUL_REG	0x110+N*0x04	TCON CEU coefficient register0 (N=0,1,2,4,5,6,8,9,10)
TCON_CEU_COEF_ADD_REG	0x11C+N*0x10	TCON CEU coefficient register1 (N=0,1,2)
TCON_CEU_COEF_RANG_REG	0x140+N*0x04	TCON CEU coefficient register2 (N=0,1,2)
TCON0_CPU_TRI0_REG	0x160	TCON0 cpu panel trigger register0
TCON0_CPU_TRI1_REG	0x164	TCON0 cpu panel trigger register1
TCON0_CPU_TRI2_REG	0x168	TCON0 cpu panel trigger register2
TCON0_CPU_TRI3_REG	0x16C	TCON0 cpu panel trigger register3
TCON0_CPU_TRI4_REG	0x170	TCON0 cpu panel trigger register4
TCON0_CPU_TRI5_REG	0x174	TCON0 cpu panel trigger register5
TCON_CMAP_CTL_REG	0x180	TCON color map control register
TCON_CMAP_ODD0_REG	0x190	TCON color map odd line register0
TCON_CMAP_ODD1_REG	0x194	TCON color map odd line register1
TCON_CMAP_EVEN0_REG	0x198	TCON color map even line register0
TCON_CMAP_EVEN1_REG	0x19C	TCON color map even line register1

TCON_SAFE_PERIOD_REG	0x1F0	TCON safe period register
TCON0_LVDS_ANAO_REG	0x220	TCON LVDS analog register0
TCON_GAMMA_TABLE_REG	0x400-0x7FF	
TCON0_3D_FIFO_BIST_REG	0xFF4	
TCON_TRI_FIFO_BIST_REG	0xFF8	
TCON_ECC_FIFO_BIST_REG	0xFFC	

6.3.5. TCON0 Module Register Description

6.3.5.1. TCON_GCTL_REG

Offset: 0x0000			Register Name: TCON_GCTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	TCON_En 0: disable 1: enable When it's disabled, the module will be reset to idle state.
30	R/W	0	TCON_Gamma_En 0: disable 1: enable
29:0	/	/	/

6.3.5.2. TCON_GINT0_REG

Offset: 0x0004			Register Name: TCON_GINT0_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	TCON0_Vb_Int_En 0: disable 1: enable
30	/	/	/
29	R/W	0	TCON0_Line_Int_En 0: disable 1: enable
28	/	/	/
27	R/W	0	TCON0_Tri_Finish_Int_En 0: disable 1: enable
26:	R/W	0	TCON0_Tri_Counter_Int_En

			0: disable 1: enable
25:16	/	/	/
15	R/W	0	TCON0_Vb_Int_Flag Asserted during vertical no-display period every frame. Write 0 to clear it.
14	/	/	/
13	R/W	0	TCON0_Line_Int_Flag trigger when SY0 match the current TCON0 scan line Write 0 to clear it.
12	/	/	/
11	R/W	0	TCON0_Tri_Finish_Int_Flag trigger when cpu trigger mode finish Write 0 to clear it.
10	R/W	0	TCON0_Tri_Counter_Int_Flag trigger when tri counter reache this value Write 0 to clear it.
9	R/W	0	TCON0_Tri_Underflow_Flag only used in dsi video mode, tri when sync by dsi but not finish Write 0 to clear it.
8:0	/	/	/

6.3.5.3. TCON_GINT1_REG

Offset: 0x0008			Register Name: TCON_GINT1_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0	TCON0_Line_Int_Num scan line for TCON0 line trigger(including inactive lines) Setting it for the specified line for trigger0. Note: SY0 is writable only when LINE_TRG0 disable.
15:12	/	/	/
11:0	/	/	/

6.3.5.4. TCON_FRM_CTL_REG

Offset: 0x0010			Register Name: TCON_FRM_CTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	TCON0_Frm_En 0:disable 1:enable
30:7	/	/	/

6	R/W	0	TCON0_Frm_Mode_R 0: 6bit frm output 1: 5bit frm output
5	R/W	0	TCON0_Frm_Mode_G 0: 6bit frm output 1: 5bit frm output
4	R/W	0	TCON0_Frm_Mode_B 0: 6bit frm output 1: 5bit frm output
3:2	/	/	/
1:0	R/W	0	TCON0_Frm_Test 00: FRM 01: half 5/6bit, half FRM 10: half 8bit, half FRM 11: half 8bit, half 5/6bit

6.3.5.5. TCON0_FRM_SEED_REG

Offset: 0x014+N*0x04(N=0,1,2,3,4,5)			Register Name: TCON0_FRM_SEED_REG
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24:0	R/W	0	Seed_Value N=0: Pixel_Seed_R N=1: Pixel_Seed_G N=2: Pixel_Seed_B N=3: Line_Seed_R N=4: Line_Seed_G N=5: Line_Seed_B Note: avoid set it to 0

6.3.5.6. TCON0_FRM_TAB_REG

Offset: 0x02C+N*0x04(N=0,1,2,3)			Register Name: TCON0_FRM_TAB_REG
Bit	R/W	Default/Hex	Description
31:0	R/W	0	Frm_Table_Value

6.3.5.7. TCON0_3D_FIFO_REG

Offset: 0x03C			Register Name: TCON0_3D_FIFO_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	3D_FIFO_BIST_EN

			0: disable 1: enable
30:14	/	/	/
13:4	R/W	0	3D_FIFO_HALF_LINE_SIZE Note: The number of data in half line=3D_FIFO_HALF_LINE_SIZE+1 only valid when 3D_FIFO_SETTING set as 2
3:2	/	/	/
1:0	R/W	0	3D_FIFO_SETTING 0: by pass 1: used as normal FIFO 2: used as 3D interlace FIFO 3: reserved

6.3.5.8. TCON0_CTL_REG

Offset: 0x040			Register Name: TCON0_CTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	TCON0_En 0: disable 1: enable Note: It executes at the beginning of the first blank line of TCON0 timing.
30:29	/	/	/
28	R/W	0	TCON0_Work_Mode 0: normal 1: dynamic freq
27:26	/	/	/
25:24	R/W	0	TCON0_IF 00: HV(Sync+DE) 01: 8080 I/F 1x:reserved
23	R/W	0	TCON0_RB_Swap 0: default 1: swap RED and BLUE data at FIFO1
22	/	/	/
21	R/W	0	TCON0_FIFO1_Rst Write 1 and then 0 at this bit will reset FIFO 1 Note: 1 holding time must more than 1 DCLK
20:9	/	/	/
8:4	R/W	0	TCON0_Start_Delay STA delay NOTE: valid only when TCON0_EN == 1
3	/	/	/

2:0	R/W	0	TCON0_SRC_SEL: 000: DE0 001: reservd 010: reservd 011: reservd 100: Test Data all 0 101: Test Data all 1 11x: reservd
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6.3.5.9. TCON0_DCLK_REG

Offset: 0x044			Register Name: TCON0_DCLK_REG
Bit	R/W	Default/Hex	Description
31:28	R/W	0	TCON0_Dclk_En LCLK_EN[3:0] :TCON0 clock enable 4'h0, 'h4,4'h6,4'ha7:dclk_en=0;dclk1_en=0;dclk2_en=0;dclkm2_en=0; 4'h1: dclk_en = 1; dclk1_en = 0; dclk2_en = 0; dclkm2_en = 0; 4'h2: dclk_en = 1; dclk1_en = 0; dclk2_en = 0; dclkm2_en = 1; 4'h3: dclk_en = 1; dclk1_en = 1; dclk2_en = 0; dclkm2_en = 0; 4'h5: dclk_en = 1; dclk1_en = 0; dclk2_en = 1; dclkm2_en = 0; 4'h8,4'h9,4'ha,4'hb,4'hc,4'hd,4'he,4'hf: dclk_en = 1; dclk1_en = 1; dclk2_en = 1; dclkm2_en = 1;
27:7	/	/	/
6:0	R/W	0	TCON0_Dclk_Div Tdclk = Tscclk * DCLKDIV Note: 1.if dclk1&dclk2 used, DCLKDIV >=6 2.if dclk only, DCLKDIV >=1

6.3.5.10. TCON0_BASIC0_REG

Offset: 0x048			Register Name: TCON0_BASIC0_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0	TCON0_X Panel width is X+1
15:12	/	/	/
11:0	R/W	0	TCON0_Y Panel height is Y+1

6.3.5.11. TCON0_BASIC1_REG

Offset: 0x04C			Register Name: TCON0_BASIC1_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	Reservd
30:29	/	/	/
28:16	R/W	0	HT $T_{hcycle} = (HT+1) * T_{dclk}$ Computation 1) parallel: $HT = X + BLANK$ Limitation: 1) parallel: $HT \geq (HBP + 1) + (X+1) + 2$ 2) serial 1: $HT \geq (HBP + 1) + (X+1) * 3 + 2$ 3) serial 2: $HT \geq (HBP + 1) + (X+1) * 3 / 2 + 2$
15:12	/	/	/
11:0	R/W	0	HBP horizontal back porch (in dclk) $T_{hbp} = (HBP + 1) * T_{dclk}$

6.3.5.12. TCON0_BASIC2_REG

Offset: 0x050			Register Name: TCON0_BASIC2_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:16	R/W	0	VT $T_{VT} = (VT)/2 * T_{hsync}$ Note: $VT/2 \geq (VBP+1) + (Y+1) + 2$
15:12	/	/	/
11:0	R/W	0	VBP $T_{vbp} = (VBP + 1) * T_{hsync}$

6.3.5.13. TCON0_BASIC3_REG

Offset: 0x054			Register Name: TCON0_BASIC3_REG
Bit	R/W	Default/Hex	Description
31:26	/	/	/
25:16	R/W	0	HSPW $T_{hspw} = (HSPW+1) * T_{dclk}$ Note: $HT > (HSPW+1)$
15:10	/	/	/
9:0	R/W	0	VSPW

			$Tv_{spw} = (VSPW+1) * Th_{sync}$ Note: $VT/2 > (VSPW+1)$
--	--	--	--

6.3.5.14. TCON0_HV_IF_REG

Offset: 0x058			Register Name: TCON0_HV_IF_REG
Bit	R/W	Default/Hex	Description
31:28	R/W	0	HV_Mode 0000: 24bit/1cycle parallel mode 1000: 8bit/3cycle RGB serial mode(RGB888) 1010: 8bit/4cycle Dummy RGB(DRGB) 1011: 8bit/4cycle RGB Dummy(RGBD) 1100: 8bit/2cycle YUV serial mode(CCIR656)
27:26	R/W	0	RGB888_SM0 serial RGB888 mode Output sequence at odd lines of the panel (line 1, 3, 5, 7...) 00: R→G→B 01: B→R→G 10: G→B→R 11: R→G→B
25:24	R/W	0	RGB888_SM1 serial RGB888 mode Output sequence at even lines of the panel (line 2, 4, 6, 8...) 00: R→G→B 01: B→R→G 10: G→B→R 11: R→G→B
23:22	R/W	0	YUV_SM serial YUV mode Output sequence 2-pixel-pair of every scan line 00: YUYV 01: YVYU 10: UYVY 11: VYUY
21:20	R/W	0	YUV EAV/SAV F line delay 0:F toggle right after active video line 1:delay 2 line(CCIR NTSC) 2:delay 3 line(CCIR PAL) 3:reserved
19	R/W	0	CCIR_CSC_Dis 0: enable 1: disable Only valid when HV mode is "1100", select '0' TCON convert source from RGB to YUV
18:0	/	/	/

6.3.5.15. TCON0_CPU_IF_REG

Offset: 0x060			Register Name: TCON0_CPU_IF_REG
Bit	R/W	Default/Hex	Description
31:28	R/W	0	CPU_Mode 0000: 18bit/256K mode 0010: 16bit mode0 0100: 16bit mode1 0110: 16bit mode2 1000: 16bit mode3 1010: 9bit mode 1100: 8bit 256K mode 1110: 8bit 65K mode xxx1: 24bit for DSI
27	/	/	/
26	R/W	0	DA pin A1 value in 8080 mode auto/flash states
25	R/W	0	CA pin A1 value in 8080 mode WR/RD execute
24	/	/	/
23	R	0	Wr_Flag 0:write operation is finishing 1:write operation is pending
22	R	0	Rd_Flag 0:read operation is finishing 1:read operation is pending
21:18	/	/	/
17	R/W	0	AUTO auto Transfer Mode: If it's 1, all the valid data during this frame are write to panel. Note: This bit is sampled by Vsync
16	R/W	0	FLUSH direct transfer mode: If it's enabled, FIFO1 is regardless of the HV timing, pixels data keep being transferred unless the input FIFO was empty. Data output rate control by DCLK.
15:6	/	/	/
5:4	R/W	0	Trigger_Sync_Mode 0: start frame flush immediately by bit1. 1: start frame flush sync to TE PIN. rising by bit1. 2. start frame flush sync to TE PIN. falling by bit1. when set as 1 or 2, io0 is map as TE input.
3	R/W	0	Trigger_FIFO_Bist_En

			0: disable 1: enable Entry addr is 0xFF8
2	R/W	0	Trigger_FIFO_En 0:enable 1:disable
1	R/W	0	Trigger_Start write '1' to start a frame flush, write'0' has no effect. this flag indicated frame flush is running software must make sure write '1' only when this flag is '0'.
0	R/W	0	Trigger_En 0: trigger mode disable 1: trigger mode enable

6.3.5.16. TCON0_CPU_WR_REG

Offset: 0x064			Register Name: TCON0_CPU_WR_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	W	0	Data_Wr data write on 8080 bus, launch a write operation on 8080 bus

6.3.5.17. TCON0_CPU_RD0_REG

Offset: 0x068			Register Name: TCON0_CPU_RD0_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R	/	Data_Rd0 data read on 8080 bus, launch a new read operation on 8080 bus

6.3.5.18. TCON0_CPU_RD1_REG

Offset: 0x06C			Register Name: TCON0_CPU_RD1_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R	/	Data_Rd1 data read on 8080 bus, without a new read operation on 8080 bus

6.3.5.19. TCON0_LVDS_IF_REG

Offset: 0x084			Register Name: TCON0_LVDS_IF_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	TCON0_LVDS_En 0: disable 1: enable
30	/	/	/
29	R/W	0	TCON0_LVDS_Even_Odd_Dir 0: normal 1: reverse
28	R/W	0	TCON0_LVDS_Dir 0: normal 1: reverse NOTE: LVDS direction
27	R/W	0	TCON0_LVDS_Mode 0: NS mode 1: JEIDA mode
26	R/W	0	TCON0_LVDS_BitWidth 0: 24bit 1: 18bit
25	R/W	0	TCON0_LVDS_DeBug_En 0: disable 1: enable
24	R/W	0	TCON0_LVDS_DeBug_Mode 0: mode0 RANDOM DATA 1: mode1 output CLK period=7/2 LVDS CLK period
23	R/W	0	TCON0_LVDS_Correct_Mode 0: mode0 1: mode1
22:21	/	/	/
20	R/W	0	TCON0_LVDS_Clk_Sel 0: MIPI PLL 1: TCON0 CLK
19:5	/	/	/
4	R/W	0	TCON0_LVDS_CLK_Polarity 0: reverse 1: normal
3:0	R/W	0	TCON0_LVDS_Data_Polarity 0: reverse 1: normal

6.3.5.20. TCON0_IO_POL_REG

Offset: 0x088			Register Name: TCON0_IO_POL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	IO_Output_Sel 0: normal output 1: register output when set as '1', d[23:0], io0, io1,io3 sync to dclk
30:28	R/W	0	DCLK_Sel 000: used DCLK0(normal phase offset) 001: used DCLK1(1/3 phase offset) 010: used DCLK2(2/3 phase offset) 100: DCLK0/2 phase 0 101: DCLK0/2 phase 90 reserved
27	R/W	0	IO3_Inv 0: not invert 1: invert
26	R/W	0	IO2_Inv 0: not invert 1: invert
25	R/W	0	IO1_Inv 0: not invert 1: invert
24	R/W	0	IO0_Inv 0: not invert 1: invert
23:0	R/W	0	Data_Inv TCON0 output port D[23:0] polarity control, with independent bit control: 0s: normal polarity 1s: invert the specify output

6.3.5.21. TCON0_IO_TRI_REG

Offset: 0x088			Register Name: TCON0_IO_TRI_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28	/	/	RGB_Endian 0: normal 1: bits_invert
27	R/W	1	IO3_Output_Tri_En 1: disable 0: enable

26	R/W	1	IO2_Output_Tri_En 1: disable 0: enable
25	R/W	1	IO1_Output_Tri_En 1: disable 0: enable
24	R/W	1	IO0_Output_Tri_En 1: disable 0: enable
23:0	R/W	0xFFFFFFFF	Data_Output_Tri_En TCON0 output port D[23:0] output enable, with independent bit control: 1s: disable 0s: enable

6.3.5.22. TCON_DEBUG_REG

Offset: 0x0FC			Register Name: TCON_DEBUG_REG
Bit	R/W	Default/Hex	Description
31	R/W	/	TCON0_FIFO_Under_Flow
30	/	/	/
29	R	/	TCON0_Field_Polarity 0: second field 1: first field
28	/	/	/
27:16	R	/	TCON0_Current_Line
15:14	/	/	/
13	R/W	0	ECC_FIFO_Bypass 0: used 1: bypass
12	/	/	/
11:0	/	/	/

6.3.5.23. TCON_CEU_CTL_REG

Offset: 0x100			Register Name: TCON_CEU_CTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	CEU_en 0: bypass 1: enable
30:0	/	/	/

6.3.5.24. TCON_CEU_COEF_MUL_REG

Offset: 0x110+N*0x04 (N=0,1,2,4,5,6,8,9,10)			Register Name: TCON_CEU_COEF_MUL_REG
Bit	R/W	Default/Hex	Description
31:13	/	/	/
12:0	R/W	0	CEU_Coef_Mul_Value signed 13bit value, range of (-16,16) N=0: Rr N=1: Rg N=2: Rb N=4: Gr N=5: Gg N=6: Gb N=8: Br N=9: Bg N=10: Bb

6.3.5.25. TCON_CEU_COEF_RANG_REG

Offset: 0x140+N*0x04 (N=0,1,2)			Register Name: TCON_CEU_COEF_RANG_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:16	R/W	0	CEU_Coef_Range_Min unsigned 8bit value, range of [0,255]
15:8	/	/	/
7:0	R/W	0	CEU Coef_Range_Max unsigned 8bit value, range of [0,255]

6.3.5.26. TCON0_CPU_TRIO_REG

Offset: 0x160			Register Name: TCON0_CPU_TRIO_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0	Block_Space should be set >20*pixel_cycle
15:12	/	/	/
11:0	R/W	0	Block_Size

6.3.5.27. TCON0_CPU_TRI1_REG

Offset: 0x164			Register Name: TCON0_CPU_TRI1_REG
Bit	R/W	Default/Hex	Description
31:16	R	0	Block_Current_Num
15:0	R/W	0	Block_Num

6.3.5.28. TCON0_CPU_TRI2_REG

Offset: 0x168			Register Name: TCON0_CPU_TRI2_REG
Bit	R/W	Default/Hex	Description
31:16	R/W	0x20	Start_Delay Tdly = (Start_Delay +1) * be_clk*8
15	R/W	0	Trans_Start_Mode 0: ecc_fifo+tri_fifo 1: tri_fifo
14:13	R/W	0	Sync_Mode 0x: auto 10: 0 11: 1
12:0	R/W	0	Trans_Start_Set

6.3.5.29. TCON0_CPU_TRI3_REG

Offset: 0x16C			Register Name: TCON0_CPU_TRI3_REG
Bit	R/W	Default/Hex	Description
31:30	/	/	/
29:28	R/W	0	
27:24	/	/	Tri_Int_Mode 00: disable 01: counter mode 10: te rising mode 11: te falling mode when set as 01, Tri_Counter_Int occur in cycle of (Count_N+1) × (Count_M+1) × 4 dclk. when set as 10 or 11, io0 is map as TE input.
23:8	R/W	0	/
7:0	R/W	0	Counter_N
			Counter_M

6.3.5.30. TCON0_CPU_TRI4_REG

Offset: 0x170			Register Name: TCON0_CPU_TRI4_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	
28	R/W	0	Plug_Mode_En 0: disable 1:enable
27:25	/	/	/
24	R/W	0	A1 Valid in first Block
23:0	R/W	0	D23-D0 Valid in first Block

6.3.5.31. TCON0_CPU_TRI5_REG

Offset: 0x174			Register Name: TCON0_CPU_TRI5_REG
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24	R/W	0	A1 Valid in Block except first
23:0	R/W	0	D23-D0 Valid in Block except first

6.3.5.32. TCON_CMAP_CTL_REG

Offset: 0x180			Register Name: TCON_CMAP_CTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	Color_Map_En 0: bypass 1: enable This module only work when X is divided by 4
30:1	/	/	/
0	R/W	0	Out_Format 0: 4 pixel output mode: Out0 -> Out1 -> Out2 -> Out3 1: 2 pixel output mode: Out0 -> Out1

6.3.5.33. TCON_CMAP_ODD0_REG

Offset: 0x190			Register Name: TCON_CMAP_ODD0_REG
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Bit	R/W	Default/Hex	Description
31:16	R/W	0	Out_Odd1
15:0	R/W	0	Out_Odd0 bit15-12: Reservd bit11-08: Out_Odd0[23:16] bit07-04: Out_Odd0[15:8] bit03-00: Out_Odd0[7:0] 0x0: in_b0 0x1: in_g0 0x2: in_r0 0x3: reservd 0x4: in_b1 0x5: in_g1 0x6: in_r1 0x7: reservd 0x8: in_b2 0x9: in_g2 0xa: in_r2 0xb: reservd 0xc: in_b3 0xd: in_g3 0xe: in_r3 0xf: reservd

6.3.5.34. TCON_CMAP_ODD1_REG

Offset: 0x194			Register Name: TCON_CMAP_ODD1_REG
Bit	R/W	Default/Hex	Description
31:16	R/W	0	Out_Odd3
15:0	R/W	0	Out_Odd2

6.3.5.35. TCON_CMAP_EVEN0_REG

Offset: 0x198			Register Name: TCON_CMAP_EVEN0_REG
Bit	R/W	Default/Hex	Description
31:16	R/W	0	Out_Even1
15:0	R/W	0	Out_Even0

6.3.5.36. TCON_CMAP_EVEN1_REG

Offset: 0x19C			Register Name: TCON_CMAP_EVEN1_REG
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Bit	R/W	Default/Hex	Description
31:16	R/W	0	Out_Even3
15:0	R/W	0	Out_Even2

6.3.5.37. TCON_SAFE_PERIOD_REG

Offset: 0x1F0			Register Name: TCON_SAFE_PERIOD_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:16	R/W	0	Safe_Period_FIFO_Num
15:2	/	/	/
1:0	R/W	0	Safe_Period_Mode 0: unsafe 1: safe 2: safe at ecc_fifo_curr_num > safe_period_fifo_num 3: safe at 2 and safe at sync active

6.3.5.38. TCON_LVDS_ANA0_REG

Offset: 0x220			Register Name: TCON_LVDS_ANA0_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	lvds0_en_mb enable the bias circuit of the LVDS_Ana module 0: Disable 1: Enable
30:25	/	/	/
24	R/W	0	lvds0_hpren_drvc Enable clock channel drive 0: Disable 1: Enable
23:20	R/W	0	lvds0_hpren_drv Enable data channel[3:0] drive 0: Disable 1: Enable
19:17	R/W	0	lvds0_reg_c adjust current flowing through Rload of Rx to change the differential signals amplitude 0: 216mv 1: 252mv 2: 276mv 3: 312mv 4: 336mv 5: 372mv 6: 395mv 7: 432mv
16	R/W	0	lvds0_reg_denc choose data output or PLL test clock output in LVDS_tx
15:12	R/W	0	lvds0_reg_den choose data output or PLL test clock output in LVDS_tx
11	/	/	/
10:8	R/W	0	lvds0_reg_r

			adjust current flowing through Rload of Rx to change the common signals amplitude 0: 0.925v 1: 0.950v 2: 0.975v 3: 1.000v 4: 1.025v 5: 1.050v 6: 1.075v 7: 1.100v
7:5	/	/	/
4	R/W	0	lvds0_reg_plrc Lvds clock channel direction 0: normal 1: reverse
3:0	R/W	0	lvds0_reg_plr Lvds data channel [3:0] direction 0: normal 1: reverse

6.3.6. TCON1 Module Register List

Module Name	Base Address
TCON1	0x01C0D000

Register Name	Offset	Description
TCON_GCTL_REG	0x000	TCON global control register
TCON_GINT0_REG	0x004	TCON global interrupt register0
TCON_GINT1_REG	0x008	TCON global interrupt register1
TCON1_CTL_REG	0x090	TCON1 control register
TCON1_BASIC0_REG	0x094	TCON1 basic timing register0
TCON1_BASIC1_REG	0x098	TCON1 basic timing register1
TCON1_BASIC2_REG	0x09C	TCON1 basic timing register2
TCON1_BASIC3_REG	0x0A0	TCON1 basic timing register3
TCON1_BASIC4_REG	0x0A4	TCON1 basic timing register4
TCON1_BASIC5_REG	0x0A8	TCON1 basic timing register5
TCON1_PS_SYNC_REG	0x0B0	TCON1 sync register
TCON1_IO_POL_REG	0x0F0	TCON1 IO polarity register
TCON1_IO_TRI_REG	0x0F4	TCON1 IO control register
TCON_ECC_FIFO_REG	0x0F8	TCON ECC FIFO register
TCON_DEBUG_REG	0x0FC	TCON debug register
TCON_CEU_CTL_REG	0x100	TCON CEU control register
TCON_CEU_COEF_MUL_REG	0x110+N*0x04	TCON CEU coefficient register0 (N=0,1,2,4,5,6,8,9,10)
TCON_CEU_COEF_ADD_REG	0x11C+N*0x10	TCON CEU coefficient register1 (N=0,1,2)

TCON_CEU_COEF_RANG_REG	0x140+N*0x04 (N=0,1,2)	TCON CEU coefficient register2
TCON_SAFE_PERIOD_REG	0x1F0	TCON safe period register
TCON1_FILL_CTL_REG	0x300	TCON1 fill data control register
TCON1_FILL_BEGIN_REG	0x304+N*0x0C (N=0,1,2)	TCON1 fill data begin register
TCON1_FILL_END_REG	0x308+N*0x0C (N=0,1,2)	TCON1 fill data end register
TCON1_FILL_DATA0_REG	0x30C+N*0x0C (N=0,1,2)	TCON1 fill data value register
TCON1_GAMMA_TABLE_REG	0x400-0x7FF	
TCON_ECC_FIFO_BIST_REG	0xFFC	

6.3.7. TCON1 Module Register Description

6.3.7.1. TCON_GCTL_REG

Offset: 0x0000			Register Name: TCON_GCTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	TCON_En 0: disable 1: enable When it's disabled, the module will be reset to idle state.
30	R/W	0	TCON_Gamma_En 0: disable 1: enable
29:0	/	/	/

6.3.7.2. TCON_GINT0_REG

Offset: 0x0004			Register Name: TCON_GINT0_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30	R/W	0	TCON1_Vb_Int_En 0: disable

			1: enable
29	/	/	/
28	R/W	0	TCON1_Line_Int_En 0: disable 1: enable
27:15	/	/	/
14	R/W	0	TCON1_Vb_Int_Flag Asserted during vertical no-display period every frame. Write 0 to clear it.
13	/	/	/
12	R/W	0	TCON1_Line_Int_Flag trigger when SY1 match the current TCON1 scan line Write 0 to clear it.
11:0	/	0	/

6.3.7.3. TCON_GINT1_REG

Offset: 0x0008			Register Name: TCON_GINT1_REG
Bit	R/W	Default/Hex	Description
31:12	/	/	/
11:0	R/W	0	TCON1_Line_Int_Num scan line for TCON1 line trigger(including inactive lines) Setting it for the specified line for trigger 1. Note: SY1 is writable only when LINE_TRG1 disable.

6.3.7.4. TCON1_CTL_REG

Offset: 0x0090			Register Name: TCON1_CTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	TCON1_En 0: disable 1: enable
30:9	/	/	/
8:4	R/W	0	Start_Delay This is for DE1 and DE2
3:2	/	/	/
1:0	R/W	0	TCON1_Src_Sel 00: DE 0 01: reserved 1x: BLUE data(FIFO2 disable, RGB=0000FF)

6.3.7.5. TCON1_BASIC0_REG

Offset: 0x0094			Register Name: TCON1_BASIC0_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0	TCON1_XI source width is X+1
15:12	/	/	/
11:0	R/W	0	TCON1_YI source height is Y+1

6.3.7.6. TCON1_BASIC1_REG

Offset: 0x0098			Register Name: TCON1_BASIC1_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0	LS_XO width is LS_XO+1
15:12	/	/	/
11:0	R/W	0	LS_YO width is LS_YO+1 NOTE: this version LS_YO = TCON1_YI

6.3.7.7. TCON1_BASIC2_REG

Offset: 0x009C			Register Name: TCON1_BASIC2_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27:16	R/W	0	TCON1_XO width is TCON1_XO+1
15:12	/	/	/
11:0	R/W	0	TCON1_YO height is TCON1_YO+1

6.3.7.8. TCON1_BASIC3_REG

Offset: 0x00A0			Register Name: TCON1_BASIC3_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:16	R/W	0	HT

			horizontal total time $Th_{cycle} = (HT+1) * Th_{dclk}$
15:12	/	/	/
11:0	R/W	0	HBP horizontal back porch $Th_{bp} = (HBP +1) * Th_{dclk}$

6.3.7.9. TCON1_BASIC4_REG

Offset: 0x00A4			Register Name: TCON1_BASIC4_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:16	R/W	0	VT horizontal total time (in HD line) $T_{vt} = VT/2 * Th$
15:12	/	/	/
11:0	R/W	0	VBP horizontal back porch (in HD line) $T_{vbp} = (VBP +1) * Th$

6.3.7.10. TCON1_BASIC5_REG

Offset: 0x00A8			Register Name: TCON1_BASIC5_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
25:16	R/W	0	HSPW horizontal Sync Pulse Width (in dclk) $Th_{spw} = (HSPW+1) * T_{dclk}$ Note: $HT > (HSPW+1)$
15:10	/	/	/
9:0	R/W	0	VSPW vertical Sync Pulse Width (in lines) $T_{vspw} = (VSPW+1) * Th$ Note: $VT/2 > (VSPW+1)$

6.3.7.11. TCON1_PS_SYNC_REG

Offset: 0x00B0			Register Name: TCON1_PS_SYNC_REG
Bit	R/W	Default/Hex	Description
31:16	R/W	0	SYNC_X
15:0	R/W	0	SYNC_Y

6.3.7.12. TCON1_IO_POL_REG

Offset: 0x00F0			Register Name: TCON1_IO_POL_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27	R/W	0	IO3_Inv 0: not invert 1: invert
26	R/W	0	IO2_Inv 0: not invert 1: invert
25	R/W	0	IO1_Inv 0: not invert 1: invert
24	R/W	0	IO0_Inv 0: not invert 1: invert
23:0	R/W	0	Data_Inv TCON1 output port D[23:0] polarity control, with independent bit control: 0s: normal polarity 1s: invert the specify output

6.3.7.13. TCON1_IO_TRI_REG

Offset: 0x00F4			Register Name: TCON1_IO_TRI_REG
Bit	R/W	Default/Hex	Description
31:28	/	/	/
27	R/W	1	IO3_Output_Tri_En 1: disable 0: enable
26	R/W	1	IO2_Output_Tri_En 1: disable 0: enable
25	R/W	1	IO1_Output_Tri_En 1: disable 0: enable
24	R/W	1	IO0_Output_Tri_En 1: disable 0: enable
23:0	R/W	0xFFFFFFFF	Data_Output_Tri_En TCON1 output port D[23:0] output enable, with independent bit control:

			1s: disable 0s: enable
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6.3.7.14. TCON1_ECC_FIFO_REG

Offset: 0x00F8			Register Name: TCON1_ECC_FIFO_REG
Bit	R/W	Default/Hex	Description
31	R/W	/	ECC_FIFO_BIST_EN 0: disable 1: enable
30	R/W	/	ECC_FIFO_ERR_FLAG
29:24	/	/	/
23:16	R/W	/	ECC_FIFO_ERR_BITS
15:9	/	/	/
8	R/W	/	ECC_FIFO_BLANK_EN 0: disable ecc function in blanking 1: enable ecc function in blanking ECC function is tent to trigged in blanking area at hv mode, set '0' when in hv mode
7:0	R/W	/	ECC_FIFO_SETTING Note: bit3 0 enable, 1 disable

6.3.7.15. TCON_DEBUG_REG

Offset: 0x00FC			Register Name: TCON_DEBUG_REG
Bit	R/W	Default/Hex	Description
31	/	/	/
30	R/W	/	TCON1_FIFO_Under_Flow
29	/	/	/
28	R	/	TCON1_Field_Polarity 0: second field 1: first field
27:14	/	/	/
13	R/W	0	ECC_FIFO_Bypass 0: used 1: bypass
12	/	/	/
11:0	R	/	TCON1_Current_Line

6.3.7.16. TCON_CEU_CTL_REG

Offset: 0x0100			Register Name: TCON1_CEU_CTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	CEU_en 0: bypass 1: enable
30:0	/	/	/

6.3.7.17. TCON_CEU_COEF_MUL_REG

Offset: 0x0110+N*0x04 (N=0,1,2,4,5,6,8,9,10)			Register Name: TCON_CEU_COEF_MUL_REG
Bit	R/W	Default/Hex	Description
31:13	/	/	/
12:0	R/W	0	CEU_Coef_Mul_Value signed 13bit value, range of (-16,16) N=0: Rr N=1: Rg N=2: Rb N=4: Gr N=5: Gg N=6: Gb N=8: Br N=9: Bg N=10: Bb

6.3.7.18. TCON_CEU_COEF_ADD_REG

Offset: 0x011C+N*0x10 (N=0,1,2)			Register Name: TCON_CEU_COEF_ADD_REG
Bit	R/W	Default/Hex	Description
31:19	/	/	/
18:0	R/W	0	CEU_Coef_Add_Value signed 19bit value, range of (-16384, 16384) N=0: Rc N=1: Gc N=2: Bc

6.3.7.19. TCON_CEU_COEF_RANG_REG

Offset: 0x0140+N*0x4 (N=0,1,2)			Register Name: TCON_CEU_COEF_RANG_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:16	R/W	0	CEU_Coef_Range_Min unsigned 8bit value, range of [0,255]
15:8	/	/	/
7:0	R/W	0	CEU Coef_Range_Max unsigned 8bit value, range of [0,255]

6.3.7.20. TCON_SAFE_PERIOD_REG

Offset: 0x01F0			Register Name: TCON_SAFE_PERIOD_REG
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28:16	R/W	0	Safe_Period_FIFO_Num
15:2	/	/	/
1:0	R/W	0	Safe_Period_Mode 0: unsafe 1: safe 2: safe at ecc_fifo_curr_num > safe_period_fifo_num 3: safe at 2 and safe at sync active

6.3.7.21. TCON1_FILL_CTL_REG

Offset: 0x0300			Register Name: TCON1_FILL_CTL_REG
Bit	R/W	Default/Hex	Description
31	R/W	0	TCON1_Fill_En 0: bypass 1: enable
30:0	/	/	/

6.3.7.22. TCON1_FILL_BEGIN_REG

Offset: 0x0304+N*0x0C(N=0,1,2)			Register Name: TCON1_FILL_BEGIN_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R/W	0	Fill_Begin

6.3.7.23. TCON1_FILL_END_REG

Offset: 0x0308+N*0x0C(N=0,1,2)			Register Name: TCON1_FILL_END_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R/W	0	Fill_End

6.3.7.24. TCON1_FILL_DATA_REG

Offset: 0x030C+N*0x0C(N=0,1,2)			Register Name: TCON1_FILL_DATA_REG
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R/W	0	Fill_Value

Chapter 7 Interfaces

This chapter describes the A83T interfaces, including:

- TWI
- SPI
- UART
- RSB
- CIR Receiver
- USB
- TDM
- EMAC

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7.1. TWI

7.1.1. Overview

This TWI Controller is designed to be used as an interface between CPU host and the serial TWI bus. It can support all the standard TWI transfer, including Slave and Master. The communication to the TWI bus is carried out on a byte-wise basis using interrupt or polled handshaking. This TWI Controller can be operated in standard mode (100K bps) or fast-mode, supporting data rate up to 400K bps. Multiple Masters and 10-bit addressing Mode are supported for this specified application. General Call Addressing is also supported in Slave mode.

The TWI Controller includes the following features:

- Software-programmable for Slave or Master
- Support Repeated START signal
- Multi-master systems supported
- Allow 10-bit addressing with TWI bus
- Performs arbitration and clock synchronization
- Own address and General Call address detection
- Interrupt on address detection
- Support speeds up to 400Kbits/s ("fast mode")
- Allow operation from a wide range of input clock frequencies

7.1.2. Timing Description

Data transferred are always in a unit of 8-bit (byte), followed by an acknowledge bit. The number of bytes that can be transmitted per transfer is unrestricted. Data is transferred in serial with the MSB first. Between each byte of data transfer, a receiver device will hold the clock line SCL low to force the transmitter into a wait state while waiting the response from microprocessor.

Data transfer with acknowledge is obligatory. The clock line is driven by the master all the time, including the acknowledge-related clock cycle, except for the SCL holding between each bytes. After sending each byte, the transmitter releases the SDA line to allow the receiver to pull down the SDA line and send an acknowledge signal (or leave it high to send a "not acknowledge") to the transmitter.

When a slave receiver doesn't acknowledge the slave address (unable to receive because of no resource available), the data line must be left high by the slave so that the master can then generate a STOP condition to abort the transfer. Slave receiver can also indicate not to want to send more data during a transfer by leave the acknowledge signal high. And the master should generate the STOP condition to abort the transfer.

7.1.3. TWI Controller Register List

Module Name	Base Address
R_TWI	0x01F02400
TWI0	0x01C2AC00
TWI1	0x01C2B000
TWI2	0x01C2B400

Register Name	Offset	Description
TWI_ADDR	0x0000	TWI Slave address
TWI_XADDR	0x0004	TWI Extended slave address
TWI_DATA	0x0008	TWI Data byte
TWI_CNTR	0x000C	TWI Control register
TWI_STAT	0x0010	TWI Status register
TWI_CCR	0x0014	TWI Clock control register
TWI_SRST	0x0018	TWI Software reset
TWI_EFR	0x001C	TWI Enhance Feature register
TWI_LCR	0x0020	TWI Line Control register

7.1.4. TWI Controller Register Description

7.1.4.1. TWI Slave Address Register(Default Value: 0x0000_0000)

Offset: 0x00			Register Name: TWI_ADDR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:1	R/W	0	SLA Slave address 7-bit addressing SLA6, SLA5, SLA4, SLA3, SLA2, SLA1, SLA0 10-bit addressing 1, 1, 1, 1, 0, SLAX[9:8]
0	R/W	0	GCE General call address enable 0: Disable 1: Enable

Notes:

For 7-bit addressing:

SLA6 – SLA0 is the 7-bit address of the TWI when in slave mode. When the TWI receives this address after a START condition, it will generate an interrupt and enter slave mode. (SLA6 corresponds to the first bit received from the TWI bus.) If **GCE** is set to '1', the TWI will also recognize the general call address (00h).

For 10-bit addressing:

When the address received starts with 11110b, the TWI recognizes this as the first part of a 10-bit address and if the next two bits match ADDR[2:1] (i.e. SLAX9 and SLAX8 of the device's extended address), it sends an ACK. (The device does not generate an interrupt at this point.) If the next byte of the address matches the **XADDR** register (SLAX7 – SLAX0), the TWI generates an interrupt and goes into slave mode.

7.1.4.2. TWI Extend Address Register(Default Value: 0x0000_0000)

Offset: 0x04			Register Name: TWI_XADDR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0	SLAX Extend Slave Address SLAX[7:0]

7.1.4.3. TWI Data Register(Default Value: 0x0000_0000)

Offset: 0x08			Register Name: TWI_DATA
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0	TWI_DATA Data byte for transmitting or received

7.1.4.4. TWI Control Register(Default Value: 0x0000_0000)

Offset: 0x0C			Register Name: TWI_CNTR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0	INT_EN Interrupt Enable 1'b0: The interrupt line always low 1'b1: The interrupt line will go high when INT_FLAG is set.
6	R/W	0	BUS_EN

			TWI Bus Enable 1'b0: The TWI bus inputs ISDA/ISCL are ignored and the TWI Controller will not respond to any address on the bus 1'b1: The TWI will respond to calls to its slave address – and to the general call address if the GCE bit in the ADDR register is set. Notes: In master operation mode, this bit should be set to '1'
5	R/W	0	M_STA Master Mode Start When M_STA is set to '1', TWI Controller enters master mode and will transmit a START condition on the bus when the bus is free. If the M_STA bit is set to '1' when the TWI Controller is already in master mode and one or more bytes have been transmitted, then a repeated START condition will be sent. If the M_STA bit is set to '1' when the TWI is being accessed in slave mode, the TWI will complete the data transfer in slave mode then enter master mode when the bus has been released. The M_STA bit is cleared automatically after a START condition has been sent: writing a '0' to this bit has no effect.
4	R/W	0	M_STP Master Mode Stop If M_STP is set to '1' in master mode, a STOP condition is transmitted on the TWI bus. If the M_STP bit is set to '1' in slave mode, the TWI will behave as if a STOP condition has been received, but no STOP condition will be transmitted on the TWI bus. If both M_STA and M_STP bits are set, the TWI will first transmit the STOP condition (if in master mode) then transmit the START condition. The M_STP bit is cleared automatically: writing a '0' to this bit has no effect.
3	R/W	0	INT_FLAG Interrupt Flag INT_FLAG is automatically set to '1' when any of 28 (out of the possible 29) states is entered (see 'STAT Register' below). The only state that does not set INT_FLAG is state F8h. If the INT_EN bit is set, the interrupt line goes high when IFLG is set to '1'. If the TWI is operating in slave mode, data transfer is suspended when INT_FLAG is set and the low period of the TWI bus clock line (SCL) is stretched until '1' is written to INT_FLAG. The TWI clock line is then released and the interrupt line goes low.
2	R/W	0	A_ACK Assert Acknowledge When A_ACK is set to '1', an Acknowledge (low level on SDA) will be sent during the acknowledge clock pulse on the TWI bus if: 1. Either the whole of a matching 7-bit slave address or the first or the second byte of a matching 10-bit slave address has been received. 2. The general call address has been received and the GCE bit in the ADDR register is set to '1'. 3. A data byte has been received in master or slave mode. When A_ACK is '0', a Not Acknowledge (high level on SDA) will be sent when

			a data byte is received in master or slave mode. If A_ACK is cleared to '0' in slave transmitter mode, the byte in the DATA register is assumed to be the 'last byte'. After this byte has been transmitted, the TWI will enter state C8h then return to the idle state (status code F8h) when INT_FLAG is cleared. The TWI will not respond as a slave unless A_ACK is set.
1:0	R/W	0	/

7.1.4.5. TWI Status Register(Default Value: 0x0000_00F8)

Offset: 0x10			Register Name: TWI_STAT
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R	0xF8	STA Status Information Byte Code Status 0x00: Bus error 0x08: START condition transmitted 0x10: Repeated START condition transmitted 0x18: Address + Write bit transmitted, ACK received 0x20: Address + Write bit transmitted, ACK not received 0x28: Data byte transmitted in master mode, ACK received 0x30: Data byte transmitted in master mode, ACK not received 0x38: Arbitration lost in address or data byte 0x40: Address + Read bit transmitted, ACK received 0x48: Address + Read bit transmitted, ACK not received 0x50: Data byte received in master mode, ACK transmitted 0x58: Data byte received in master mode, not ACK transmitted 0x60: Slave address + Write bit received, ACK transmitted 0x68: Arbitration lost in address as master, slave address + Write bit received, ACK transmitted 0x70: General Call address received, ACK transmitted 0x78: Arbitration lost in address as master, General Call address received, ACK transmitted 0x80: Data byte received after slave address received, ACK transmitted 0x88: Data byte received after slave address received, not ACK transmitted 0x90: Data byte received after General Call received, ACK transmitted 0x98: Data byte received after General Call received, not ACK transmitted 0xA0: STOP or repeated START condition received in slave mode 0xA8: Slave address + Read bit received, ACK transmitted 0xB0: Arbitration lost in address as master, slave address + Read bit received, ACK transmitted 0xB8: Data byte transmitted in slave mode, ACK received 0xC0: Data byte transmitted in slave mode, ACK not received

			0xC8: Last byte transmitted in slave mode, ACK received 0xD0: Second Address byte + Write bit transmitted, ACK received 0xD8: Second Address byte + Write bit transmitted, ACK not received 0xF8: No relevant status information, INT_FLAG=0 Others: Reserved
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7.1.4.6. TWI Clock Register(Default Value: 0x0000_0000)

Offset: 0x14			Register Name: TWI_CCR
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6:3	R/W	0	CLK_M
2:0	R/W	0	CLK_N The TWI bus is sampled by the TWI at the frequency defined by F0: $F_{\text{samp}} = F_0 = F_{\text{in}} / 2^{\text{CLK_N}}$ The TWI OSCL output frequency, in master mode, is F1/10: $F_1 = F_0 / (\text{CLK_M} + 1)$ $F_{\text{oscl}} = F_1 / 10 = F_{\text{in}} / (2^{\text{CLK_N}} * (\text{CLK_M} + 1) * 10)$ For Example: Fin = 48Mhz (APB clock input) For 400kHz full speed 2Wire, CLK_N = 2, CLK_M=2 $F_0 = 48\text{M} / 2^2 = 12\text{Mhz}$, $F_1 = F_0 / (10 * (2+1)) = 0.4\text{Mhz}$ For 100Khz standard speed 2Wire, CLK_N=2, CLK_M=11 $F_0 = 48\text{M} / 2^2 = 12\text{Mhz}$, $F_1 = F_0 / (10 * (11+1)) = 0.1\text{Mhz}$

7.1.4.7. TWI Soft Reset Register(Default Value: 0x0000_0000)

Offset: 0x18			Register Name: TWI_SRST
Bit	R/W	Default/Hex	Description
31:1	/	/	/
0	R/W	0	SOFT_RST Soft Reset Write '1' to this bit to reset the TWI and clear to '0' when completing Soft Reset operation.

7.1.4.8. TWI Enhance Feature Register(Default Value: 0x0000_0000)

Offset: 0x1C			Register Name: TWI_EFR
Bit	R/W	Default/Hex	Description

31:2	/	/	/
0:1	R/W	0	DBN Data Byte number follow Read Command Control 0— No Data Byte to be written after read command 1— Only 1 byte data to be written after read command 2— 2 bytes data can be written after read command 3— 3 bytes data can be written after read command

7.1.4.9. TWI Line Control Register(Default Value: 0x0000_003A)

Offset: 0x20			Register Name: TWI_LCR
Bit	R/W	Default/Hex	Description
31:6	/	/	/
5	R	1	SCL_STATE Current state of TWI_SCL 0 – low 1 - high
4	R	1	SDA_STATE Current state of TWI_SDA 0 – low 1 - high
3	R/W	1	SCL_CTL TWI_SCL line state control bit When line control mode is enabled (bit[2] set), value of this bit decide the output level of TWI_SCL 0 – output low level 1 – output high level
2	R/W	0	SCL_CTL_EN TWI_SCL line state control enable When this bit is set, the state of TWI_SCL is control by the value of bit[3]. 0-disable TWI_SCL line control mode 1-enable TWI_SCL line control mode
1	R/W	1	SDA_CTL TWI_SDA line state control bit When line control mode is enabled (bit[0] set), value of this bit decide the output level of TWI_SDA 0 – output low level 1 – output high level
0	R/W	0	SDA_CTL_EN TWI_SDA line state control enable When this bit is set, the state of TWI_SDA is control by the value of bit[1]. 0-disable TWI_SDA line control mode 1-enable TWI_SDA line control mode

7.1.4.10. TWI DVFS Register(Default Value: 0x0000_0000)

Offset: 0x24			Register Name: TWI_DVFSR
Bit	R/W	Default/Hex	Description
31:3	/	/	/
2	R/W	0	MS_PRIORITY CPU and DVFS BUSY set priority select 0: CPU has higher priority 1: DVFS has higher priority
1	R/W	0	CPU_BUSY_SET CPU Busy set
0	R/W	0	DVFS_BUSY_SET DVFS Busy set

Notes:

This register is only implemented in TWI0.

7.1.5. TWI Controller Special Requirement

7.1.5.1. TWI Pin List

Port Name	Width	Direction	Description
TWI_SCL	1	IN/OUT	TWI Clock line
TWI_SDA	1	IN/OUT	TWI Serial Data line

7.1.5.2. TWI Controller Operation

There are four operation modes on the TWI bus which dictates the communications method. They are Master Transmit, Master Receive, Slave Transmit and Slave Receive. In general, CPU host controls TWI by writing commands and data to its registers. The TWI interrupts the CPU host for the attention each time a byte transfer is done or a START/STOP conditions is detected. The CPU host can also poll the status register for current status if the interrupt mechanism is not disabled by the CPU host.

When the CPU host wants to start a bus transfer, it initiates a bus START to enter the master mode by setting IM_STA bit in the 2WIRE_CNTR register to high (before it must be low). The TWI will assert INT line and INT_FLAG to indicate a completion for the START condition and each consequent byte transfer. At each interrupt, the micro-processor needs to check the 2WIRE_STAT register for current status. A transfer has to be concluded with STOP condition by setting M_STP bit high.

In Slave Mode, the TWI also constantly samples the bus and look for its own slave address during addressing cycles. Once a match is found, it is addressed and interrupt the CPU host with the corresponding status. Upon request, the CPU host should read the status, read/write 2WIRE_DATA data register, and set the 2WIRE_CNTR control register. After each byte transfer, a slave device always halt the operation of remote master by holding the next low pulse on SCL line until the microprocessor responds to the status of previous byte transfer or START condition.

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7.2. SPI

7.2.1. Overview

The SPI is the Serial Peripheral Interface which allows rapid data communication with fewer software interrupts. The SPI module contains one 64x8 receiver buffer (RXFIFO) and one 64x8 transmit buffer (TXFIFO). It can work at two modes: Master mode and Slave mode.

The SPI includes the following features:

- Full-duplex synchronous serial interface
- Master/Slave configurable
- Four chip selects to support multiple peripherals for SPI0, SPI1 has one chip select
- 8-bit wide by 64-entry FIFO for both transmit and receive data
- Polarity and phase of the Chip Select (SPI_SS) and SPI Clock (SPI_SCLK) are configurable

7.2.2. SPI Timing Diagram

The serial peripheral interface master uses the SPI_SCLK signal to transfer data in and out of the shift register. Data is clocked using any one of four programmable clock phase and polarity combinations.

During Phase 0, Polarity 0 and Phase 1, Polarity 1 operations, output data changes on the falling clock edge and input data is shifted in on the rising edge.

During Phase 1, Polarity 0 and Phase 0, Polarity 1 operations, output data changes on the rising edges of the clock and is shifted in on falling edges.

The POL defines the signal polarity when SPI_SCLK is in idle state. The SPI_SCLK is high level when POL is '1' and it is low level when POL is '0'. The PHA decides whether the leading edge of SPI_SCLK is used for setup or sample data. The leading edge is used for setup data when PHA is '1' and for sample data when PHA is '0'. The four kind of modes are listed below:

SPI Mode	POL	PHA	Leading Edge	Trailing Edge
0	0	0	Rising, Sample	Falling, Setup
1	0	1	Rising, Setup	Falling, Sample
2	1	0	Falling, Sample	Rising, Setup
3	1	1	Falling, Setup	Rising, Sample

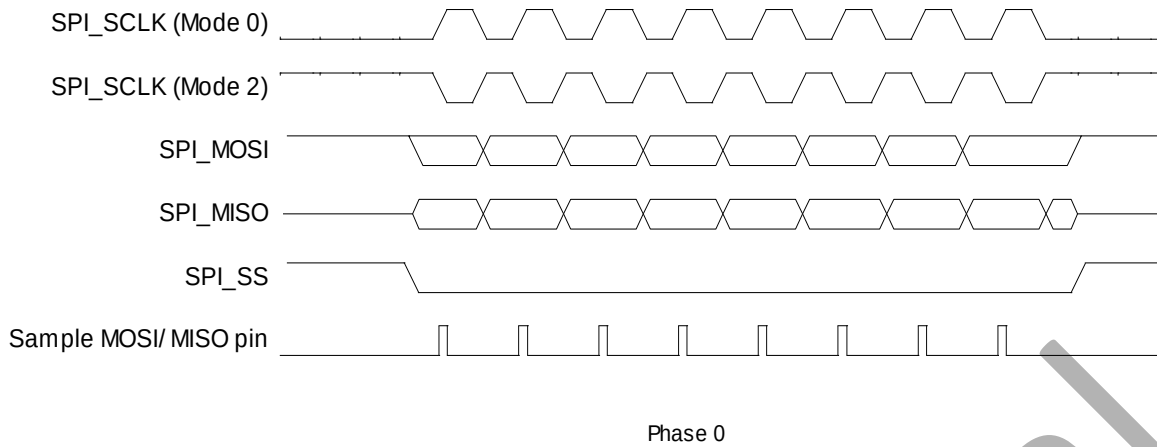


Figure 7-1. SPI Phase 0 Timing Diagram

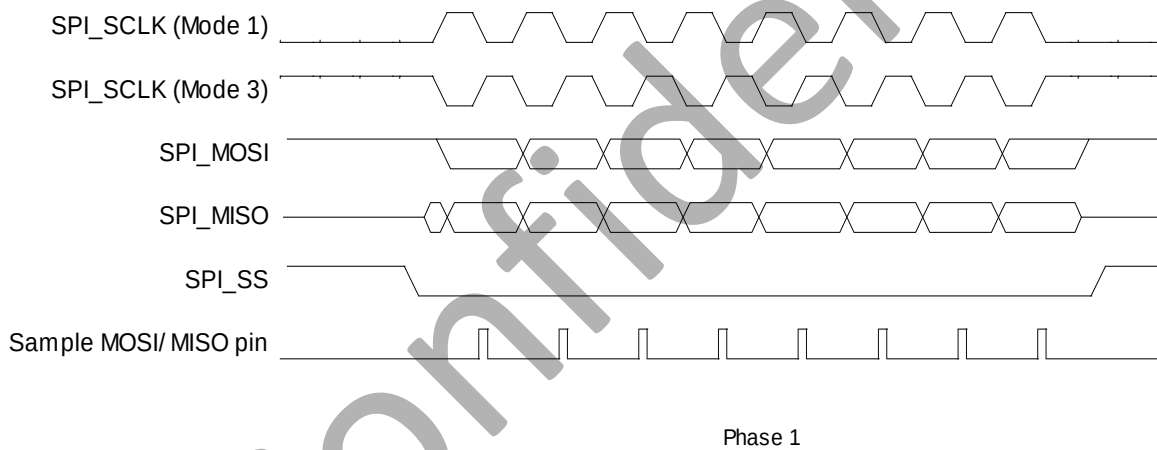


Figure 7-2. SPI Phase 1 Timing Diagram

7.2.3. SPI Register List

Module Name	Base Address
SPI0	0x01C68000
SPI1	0x01C69000

Register Name	Offset	Description
SPI_GCR	0x04	SPI Global Control Register
SPI_TCR	0x08	SPI Transfer Control register
/	0x0c	reserved
SPI_IER	0x10	SPI Interrupt Control register
SPI_ISR	0x14	SPI Interrupt Status register
SPI_FCR	0x18	SPI FIFO Control register
SPI_FSR	0x1C	SPI FIFO Status register
SPI_WCR	0x20	SPI Wait Clock Counter register
SPI_CCR	0x24	SPI Clock Rate Control register
/	0x28	reserved
/	0x2c	reserved
SPI_MBC	0x30	SPI Burst Counter register
SPI_MTC	0x34	SPI Transmit Counter Register
SPI_BCC	0x38	SPI Burst Control register
SPI_TXD	0x200	SPI TX Data register
SPI_RXD	0x300	SPI RX Data register

7.2.4. SPI Register Description

7.2.4.1. SPI Global Control Register(Default Value: 0x0000_0080)

Offset: 0x04			Register Name: SPI_CTL
Bit	R/W	Default/Hex	Description
31	R/W	0	SRST Soft reset Write '1' to this bit will clear the SPI controller, and auto clear to '0' when reset operation completes Write '0' has no effect.
30:8	/	/	/
7	R/W	1	TP_EN Transmit Pause Enable

			In master mode, it is used to control transmit state machine to stop smart burst sending when RX FIFO is full. 1 – stop transmit data when RXFIFO full 0 – normal operation, ignore RXFIFO status Note: Can't be written when XCH=1
6:2	/	/	/
1	R/W	0	MODE SPI Function Mode Select 0: Slave Mode 1: Master Mode Note: Can't be written when XCH=1
0	R/W	0	EN SPI Module Enable Control 0: Disable 1: Enable

7.2.4.2. SPI Transfer Control Register(Default Value: 0x0000_0087)

Offset: 0x08			Register Name: SPI_INTCTL
Bit	R/W	Default/Hex	Description
31	R/W	0x0	XCH Exchange Burst In master mode it is used to start SPI burst 0: Idle 1: Initiates exchange. Write "1" to this bit will start the SPI burst, and will auto clear after finishing the bursts transfer specified by BC. Write "1" to SRST will also clear this bit. Write '0' to this bit has no effect. Note: Can't be written when XCH=1.
30:14	/	/	/
13	R/W	0x0	SDM Master Sample Data Mode 0 - Delay Sample Mode 1 - Normal Sample Mode In Normal Sample Mode, SPI master samples the data at the correct edge for each SPI mode; In Delay Sample Mode, SPI master samples data at the edge that is half cycle delayed by the correct edge defined in respective SPI mode.
12	R/W	0x0	FBS First Transmit Bit Select 0: MSB first 1: LSB first Note: Can't be written when XCH=1.
11	R/W	0x0	SDC

			Master Sample Data Control Set this bit to '1' to make the internal read sample point with a delay of half cycle of SPI_CLK. It is used in high speed read operation to reduce the error caused by the time delay of SPI_CLK propagating between master and slave. 0 – normal operation, do not delay internal read sample point 1 – delay internal read sample point Note: Can't be written when XCH=1.
10	R/W	0x0	RPSM Rapids mode select Select Rapids mode for high speed write. 0: normal write mode 1: rapids write mode Note: Can't be written when XCH=1.
9	R/W	0x0	DDB Dummy Burst Type 0: The bit value of dummy SPI burst is zero 1: The bit value of dummy SPI burst is one Note: Can't be written when XCH=1.
8	R/W	0x0	DHB Discard Hash Burst In master mode it controls whether discarding unused SPI bursts 0: Receiving all SPI bursts in BC period 1: Discard unused SPI bursts, only fetching the SPI bursts during dummy burst period. The bursts number is specified by TC. Note: Can't be written when XCH=1.
7	R/W	0x1	SS_LEVEL When control SS signal manually (SPI_CTRL_REG.SS_CTRL==1), set this bit to '1' or '0' to control the level of SS signal. 0: set SS to low 1: set SS to high Note: Can't be written when XCH=1.
6	R/W	0x0	SS_OWNER SS Output Owner Select Usually, controller sends SS signal automatically with data together. When this bit is set to 1, software must manually write SPI_CTL_REG.SS_LEVEL to 1 or 0 to control the level of SS signal. 0: SPI controller 1: Software Note: Can't be written when XCH=1.
5:4	R/W	0x0	SS_SEL SPI Chip Select Select one of four external SPI Master/Slave Devices 00: SPI_SS0 will be asserted 01: SPI_SS1 will be asserted 10: SPI_SS2 will be asserted

			11: SPI_SS3 will be asserted Note: Can't be written when XCH=1.
3	R/W	0x0	SSCTL In master mode, this bit selects the output wave form for the SPI_SSx signal. Only valid when SS_OWNER = 0. 0: SPI_SSx remains asserted between SPI bursts 1: Negate SPI_SSx between SPI bursts Note: Can't be written when XCH=1.
2	R/W	0x1	SPOL SPI Chip Select Signal Polarity Control 0: Active high polarity (0 = Idle) 1: Active low polarity (1 = Idle) Note: Can't be written when XCH=1.
1	R/W	0x1	CPOL SPI Clock Polarity Control 0: Active high polarity (0 = Idle) 1: Active low polarity (1 = Idle) Note: Can't be written when XCH=1.
0	R/W	0x1	CPHA SPI Clock/Data Phase Control 0: Phase 0 (Leading edge for sample data) 1: Phase 1 (Leading edge for setup data) Note: Can't be written when XCH=1.

7.2.4.3. SPI Interrupt Control Register(Default Value: 0x0000_0000)

Offset: 0x10			Register Name: SPI_IER
Bit	R/W	Default/Hex	Description
31:14	R	0x0	Reserved.
13	R/W	0x0	SS_INT_EN SSI Interrupt Enable Chip Select Signal (SSx) from valid state to invalid state 0: Disable 1: Enable
12	R/W	0x0	TC_INT_EN Transfer Completed Interrupt Enable 0: Disable 1: Enable
11	R/W	0x0	TF_UDR_INT_EN TXFIFO under run Interrupt Enable 0: Disable 1: Enable
10	R/W	0x0	TF_OVF_INT_EN TX FIFO Overflow Interrupt Enable

			0: Disable 1: Enable
9	R/W	0x0	RF_UDR_INT_EN RXFIFO under run Interrupt Enable 0: Disable 1: Enable
8	R/W	0x0	RF_OVF_INT_EN RX FIFO Overflow Interrupt Enable 0: Disable 1: Enable
7	R	0x0	Reserved.
6	R/W	0x0	TF_FUL_INT_EN TX FIFO Full Interrupt Enable 0: Disable 1: Enable
5	R/W	0x0	TX_EMP_INT_EN TX FIFO Empty Interrupt Enable 0: Disable 1: Enable
4	R/W	0x0	TX_ERQ_INT_EN TX FIFO Empty Request Interrupt Enable 0: Disable 1: Enable
3	R	0x0	Reserved
2	R/W	0x0	RF_FUL_INT_EN RX FIFO Full Interrupt Enable 0: Disable 1: Enable
1	R/W	0x0	RX_EMP_INT_EN RX FIFO Empty Interrupt Enable 0: Disable 1: Enable
0	R/W	0x0	RF_RDY_INT_EN RX FIFO Ready Request Interrupt Enable 0: Disable 1: Enable

7.2.4.4. SPI Interrupt Status Register(Default Value: 0x0000_0022)

Offset: 0x14			Register Name: SPI_INT_STA
Bit	R/W	Default/Hex	Description
31:14	/	0x0	/
13	R/W	0	SSI SS Invalid Interrupt

			When SSI is 1, it indicates that SS has changed from valid state to invalid state. Writing 1 to this bit clears it.
12	R/W	0	TC Transfer Completed In master mode, it indicates that all bursts specified by BC has been exchanged. In other condition, When set, this bit indicates that all the data in TXFIFO has been loaded in the Shift register, and the Shift register has shifted out all the bits. Writing 1 to this bit clears it. 0: Busy 1: Transfer Completed
11	R/W	0	TF_UDF TXFIFO Underrun This bit is set when if the TXFIFO is underrun. Writing 1 to this bit clears it. 0: TXFIFO is not underrun 1: TXFIFO is underrun
10	R/W	0	TF_OVF TXFIFO Overflow This bit is set when if the TXFIFO is overflow. Writing 1 to this bit clears it. 0: TXFIFO is not overflow 1: TXFIFO is overflowed
9	R/W	0	RX_UDF RXFIFO Underrun When set, this bit indicates that RXFIFO has underrun. Writing 1 to this bit clears it.
8	R/W	0	RX_OVF RXFIFO Overflow When set, this bit indicates that RXFIFO has overflowed. Writing 1 to this bit clears it. 0: RXFIFO is available. 1: RXFIFO has overflowed.
7	/	/	/
6	R/W	0	TX_FULL TXFIFO Full This bit is set when if the TXFIFO is full . Writing 1 to this bit clears it. 0: TXFIFO is not Full 1: TXFIFO is Full
5	R/W	1	TX_EMP TXFIFO Empty This bit is set if the TXFIFO is empty. Writing 1 to this bit clears it. 0: TXFIFO contains one or more words. 1: TXFIFO is empty
4	R/W	0	TX_READY TXFIFO Ready 0: TX_WL > TX_TRIG_LEVEL 1: TX_WL <= TX_TRIG_LEVEL

			This bit is set any time if TX_WL <= TX_TRIG_LEVEL. Writing "1" to this bit clears it. Where TX_WL is the water level of RXFIFO
3	/	/	reserved
2	R/W	0	RX_FULL RXFIFO Full This bit is set when the RXFIFO is full . Writing 1 to this bit clears it. 0: Not Full 1: Full
1	R/W	1	RX_EMP RXFIFO Empty This bit is set when the RXFIFO is empty . Writing 1 to this bit clears it. 0: Not empty 1: empty
0	R/W	0	RX_RDY RXFIFO Ready 0: RX_WL < RX_TRIG_LEVEL 1: RX_WL >= RX_TRIG_LEVEL This bit is set any time if RX_WL >= RX_TRIG_LEVEL. Writing "1" to this bit clears it. Where RX_WL is the water level of RXFIFO.

7.2.4.5. SPI FIFO Control Register(Default Value: 0x0040_0001)

Offset: 0x18			Register Name: SPI_FCR
Bit	R/W	Default/Hex	Description
31	R/W	0	TX_FIFO_RST TX FIFO Reset Write '1' to this bit will reset the control portion of the TX FIFO and auto clear to '0' when completing reset operation, write to '0' has no effect.
30	R/W	0	TF_TEST_ENB TX Test Mode Enable 0: disable 1: enable Note: In normal mode, TX FIFO can only be read by SPI controller, write '1' to this bit will switch TX FIFO read and write function to AHB bus. This bit is used to test the TX FIFO, don't set in normal operation and don't set RF_TEST and TF_TEST at the same time.
29:26	/	/	/
25	/	/	/
24	R/W	0x0	TF_DRQ_EN TX FIFO DMA Request Enable 0: Disable 1: Enable
23:16	R/W	0x40	TX_TRIG_LEVEL

			TX FIFO Empty Request Trigger Level
15	R/W	0x0	RF_RST RXFIFO Reset Write '1' to this bit will reset the control portion of the receiver FIFO, and auto clear to '0' when completing reset operation, write '0' to this bit has no effect.
14	R/W	0x0	RF_TEST RX Test Mode Enable 0: Disable 1: Enable Note: In normal mode, RX FIFO can only be written by SPI controller, write '1' to this bit will switch RX FIFO read and write function to AHB bus. This bit is used to test the RX FIFO, don't set in normal operation and don't set RF_TEST and TF_TEST at the same time.
13:10	R	0x0	Reserved
9	R/W	0x0	RX_DMA_MODE SPI RX DMA Mode Control 0: Normal DMA mode 1: Dedicate DMA mode
8	R/W	0x0	RF_DRQ_EN RX FIFO DMA Request Enable 0: Disable 1: Enable
7:0	R/W	0x1	RX_TRIG_LEVEL RX FIFO Ready Request Trigger Level

7.2.4.6. SPI FIFO Status Register(Default Value: 0x0000_0000)

Offset: 0x1C			Register Name: SPI_FSR
Bit	R/W	Default/Hex	Description
31	R	0x0	TB_WR TX FIFO Write Buffer Write Enable
30:28	R	0x0	TB_CNT TX FIFO Write Buffer Counter These bits indicate the number of words in TX FIFO Write Buffer
27:24	R	0x0	Reserved
23:16	R	0x0	TF_CNT TX FIFO Counter These bits indicate the number of words in TX FIFO 0: 0 byte in TX FIFO 1: 1 byte in TX FIFO ... 64: 64 bytes in TX FIFO
15	R	0x0	RB_WR

			RX FIFO Read Buffer Write Enable
14:12	R	0x0	RB_CNT RX FIFO Read Buffer Counter These bits indicate the number of words in RX FIFO Read Buffer
11:8	R	0x0	Reserved
7:0	R	0x0	RF_CNT RX FIFO Counter These bits indicate the number of words in RX FIFO 0: 0 byte in RX FIFO 1: 1 byte in RX FIFO ... 64:64 bytes in RX FIFO

7.2.4.7. SPI Wait Clock Register(Default Value: 0x0000_0000)

Offset: 0x20			Register Name: SPI_WAIT
Bit	R/W	Default/Hex	Description
31:20	/	/	/
19:16	R/W	0x0	SWC Dual mode direction switch wait clock counter (for master mode only). 0: No wait states inserted n: n SPI_SCLK wait states inserted Note: These bits control the number of wait states to be inserted before start dual data transfer in dual SPI mode. The SPI module counts SPI_SCLK by SWC for delaying next word data transfer. Note: Can't be written when XCH=1.
15:0	R/W	0	WCC Wait Clock Counter (In Master mode) These bits control the number of wait states to be inserted in data transfers. The SPI module counts SPI_SCLK by WCC for delaying next word data transfer. 0: No wait states inserted N: N SPI_SCLK wait states inserted

7.2.4.8. SPI Clock Control Register(Default Value: 0x0000_0002)

Offset: 0x24			Register Name: SPI_CCTL
Bit	R/W	Default/Hex	Description
31:13	/	/	/
12	R/W	0	DRS Divide Rate Select (Master Mode Only) 0: Select Clock Divide Rate 1

			1: Select Clock Divide Rate 2
11:8	R/W	0	CDR1 Clock Divide Rate 1 (Master Mode Only) The SPI_SCLK is determined according to the following equation: $SPI_CLK = Source_CLK / 2^n$.
7:0	R/W	0x2	CDR2 Clock Divide Rate 2 (Master Mode Only) The SPI_SCLK is determined according to the following equation: $SPI_CLK = Source_CLK / (2^{*(n + 1)})$.

7.2.4.9. SPI Master Burst Counter Register(Default Value: 0x0000_0000)

Offset: 0x30			Register Name: SPI_BC
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R/W	0	MBC Master Burst Counter In master mode, this field specifies the total burst number. 0: 0 burst 1: 1 burst ... N: N bursts

7.2.4.10. SPI Master Transmit Counter Register(Default Value: 0x0000_0000)

Offset: 0x34			Register Name: SPI_TC
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:0	R/W	0	MWTC Master Write Transmit Counter In master mode, this field specifies the burst number that should be sent to TXFIFO before automatically sending dummy burst. For saving bus bandwidth, the dummy burst (all zero bits or all one bits) is sent by SPI Controller automatically. 0: 0 burst 1: 1 burst ... N: N bursts

7.2.4.11. SPI Master Burst Control Counter Register(Default Value: 0x0000_0000)

Offset: 0x38			Register Name: SPI_BCC
Bit	R/W	Default/Hex	Description
31:29	R	0x0	Reserved
28	R/W	0x0	DRM Master Dual Mode RX Enable 0: RX use single-bit mode 1: RX use dual mode Note: Can't be written when XCH=1.
27:24	R/W	0x0	DBC Master Dummy Burst Counter In master mode, this field specifies the burst number that should be sent before receive in dual SPI mode. The data is don't care by the device. 0: 0 burst 1: 1 burst ... N: N bursts Note: Can't be written when XCH=1.
23:0	R/W	0x0	STC Master Single Mode Transmit Counter In master mode, this field specifies the burst number that should be sent in single mode before automatically sending dummy burst. This is the first transmit counter in all bursts. 0: 0 burst 1: 1 burst ... N: N bursts Note: Can't be written when XCH=1.

7.2.4.12. SPI TX Data Register(Default Value: 0x0000_0000)

Offset: 0x200			Register Name: SPI_TXD
Bit	R/W	Default/Hex	Description
31:0	W/R	0x0	TDATA Transmit Data This register can be accessed in byte, half-word or word unit by AHB. In byte accessing method, if there are rooms in RXFIFO, one burst data is written to RXFIFO and the depth is increased by 1. In half-word accessing method, two SPI burst data are written and the TXFIFO depth is increase by 2. In word accessing method, four SPI burst data are written and the TXFIFO depth is increased by 4. Note: This address is writing-only if TF_TEST is '0', and if TF_TEST is set to '1', this address is readable and writable to test the TX FIFO through the AHB

			bus.
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7.2.4.13. SPI RX Data Register(Default Value: 0x0000_0000)

Offset: 0x300			Register Name: SPI_RXD
Bit	R/W	Default/Hex	Description
31:0	R	0	RDATA Receive Data This register can be accessed in byte, half-word or word unit by AHB. In byte accessing method, if there are data in RXFIFO, the top word is returned and the RXFIFO depth is decreased by 1. In half-word accessing method, two SPI bursts are returned and the RXFIFO depth is decrease by 2. In word accessing method, the four SPI bursts are returned and the RXFIFO depth is decreased by 4. Note: This address is read-only if RF_TEST is '0', and if RF_TEST is set to '1', this address is readable and writable to test the RX FIFO through the AHB bus.

7.2.5. SPI Special Requirement

7.2.5.1. SPI Pin List

The direction of SPI pin is different in two work modes: Master Mode and Slave Mode.

Port Name	Width	Direction(M)	Direction(S)	Description
SPI_CLK	1	OUT	IN	SPI Clock
SPI_MOSI	1	OUT	IN	SPI Master Output Slave Input Data Signal
SPI_MISO	1	IN	OUT	SPI Master Input Slave Output Data Signal
SPI_CS	1	OUT	IN	SPI Chip Select Signal

7.2.5.2. SPI Module Clock Source and Frequency

The SPI module uses two clock source: AHB_CLK and SPI_CLK. The SPI_SCLK can in the range from 3Khz to 100 MHZ and $AHB_CLK \geq 2 \times SPI_SCLK$.

Clock Name	Description	Requirement
AHB_CLK	AHB bus clock, as the clock source of SPI module	$AHB_CLK \geq 2 \times SPI_SCLK$
SPI_CLK	SPI serial input clock	

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7.3. UART

7.3.1. Overview

The UART is used for serial communication with a peripheral, modem (data carrier equipment, DCE) or data set. Data is written from a master (CPU) over the APB bus to the UART and it is converted to serial form and transmitted to the destination device. Serial data is also received by the UART and stored for the master (CPU) to read back.

The UART contains registers to control the character length, baud rate, parity generation/checking, and interrupt generation. Although there is only one interrupt output signal from the UART, there are several prioritized interrupt types that can be responsible for its assertion. Each of the interrupt types can be separately enabled/disabled with the control registers.

The UART has 16450 and 16550 modes of operation, which are compatible with a range of standard software drivers. In 16550 mode, transmit and receive operations are both buffered by FIFOs. In 16450 mode, these FIFOs are disabled.

The UART supports data lengths from five to eight bits, an optional parity bit and 1, 1 ½ or 2 stop bits, and is fully programmable by an AMBA APB CPU interface. A 16-bit programmable baud rate generator and an 8-bit scratch register are included, together with separate transmit and receive FIFOs. Eight modem control lines and a diagnostic loop-back mode are provided.

Interrupts can be generated for a range of TX Buffer/FIFO, RX Buffer/FIFO, Modem Status and Line Status conditions.

The UART includes the following features:

- Compatible with industry-standard 16550 UARTs
- 64-Bytes Transmit and receive data FIFOs
- DMA controller interface
- Software/ Hardware Flow Control
- Programmable Transmit Holding Register Empty interrupt
- Interrupt support for FIFOs, Status Change
- Support IrDa 1.0 SIR

7.3.2. UART Timing Diagram

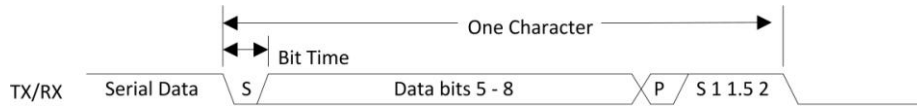


Figure 7-3. UART Serial Data Format

7.3.3. UART Controller Register List

There are 6 UART controllers. All UART controllers can be configured as Serial IrDA.

Module Name	Base Address
UART0	0x01C28000
UART1	0x01C28400
UART2	0x01C28800
UART3	0x01C28C00
UART4	0x01C29000
R-UART	0x01F02800

Register Name	Offset	Description
UART_RBR	0x00	UART Receive Buffer Register
UART_THR	0x00	UART Transmit Holding Register
UART_DLL	0x00	UART Divisor Latch Low Register
UART_DLH	0x04	UART Divisor Latch High Register
UART_IER	0x04	UART Interrupt Enable Register
UART_IIR	0x08	UART Interrupt Identity Register
UART_FCR	0x08	UART FIFO Control Register
UART_LCR	0x0C	UART Line Control Register
UART_MCR	0x10	UART Modem Control Register
UART_LSR	0x14	UART Line Status Register
UART_MSR	0x18	UART Modem Status Register
UART_SCH	0x1C	UART Scratch Register
UART_USR	0x7C	UART Status Register
UART_TFL	0x80	UART Transmit FIFO Level
UART_RFL	0x84	UART_RFL
UART_HALT	0xA4	UART Halt TX Register

7.3.4. UART Register Description

7.3.4.1. UART Receiver Buffer Register(Default Value: 0x0000_0000)

Offset: 0x0000			Register Name: UART_RBR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R	0	RBR Receiver Buffer Register Data byte received on the serial input port . The data in this register is valid only if the Data Ready (DR) bit in the Line Status Register (LCR) is set. If in FIFO mode and FIFOs are enabled (FCR[0] set to one), this register accesses the head of the receive FIFO. If the receive FIFO is full and this register is not read before the next data character arrives, then the data already in the FIFO is preserved, but any incoming data are lost and an overrun error occurs.

7.3.4.2. UART Transmit Holding Register(Default Value: 0x0000_0000)

Offset: 0x0000			Register Name: UART_THR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	W	0	THR Transmit Holding Register Data to be transmitted on the serial output port . Data should only be written to the THR when the THR Empty (THRE) bit (LSR[5]) is set. If in FIFO mode and FIFOs are enabled (FCR[0] = 1) and THRE is set, 16 number of characters of data may be written to the THR before the FIFO is full. Any attempt to write data when the FIFO is full results in the write data being lost.

7.3.4.3. UART Divisor Latch Low Register(Default Value: 0x0000_0000)

Offset: 0x0000			Register Name: UART_DLL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0	DLL Divisor Latch Low Lower 8 bits of a 16-bit, read/write, Divisor Latch register that contains the

			baud rate divisor for the UART. This register may only be accessed when the DLAB bit (LCR[7]) is set and the UART is not busy (USR[0] is zero). The output baud rate is equal to the serial clock (sclk) frequency divided by sixteen times the value of the baud rate divisor, as follows: baud rate = (serial clock freq) / (16 * divisor). Note that with the Divisor Latch Registers (DLL and DLH) set to zero, the baud clock is disabled and no serial communications occur. Also, once the DLL is set, at least 8 clock cycles of the slowest UART clock should be allowed to pass before transmitting or receiving data.
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7.3.4.4. UART Divisor Latch High Register(Default Value: 0x0000_0000)

Offset: 0x0004			Register Name: UART_DLH
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0	DLH Divisor Latch High Upper 8 bits of a 16-bit, read/write, Divisor Latch register that contains the baud rate divisor for the UART. This register may only be accessed when the DLAB bit (LCR[7]) is set and the UART is not busy (USR[0] is zero). The output baud rate is equal to the serial clock (sclk) frequency divided by sixteen times the value of the baud rate divisor, as follows: baud rate = (serial clock freq) / (16 * divisor). Note that with the Divisor Latch Registers (DLL and DLH) set to zero, the baud clock is disabled and no serial communications occur. Also, once the DLH is set, at least 8 clock cycles of the slowest UART clock should be allowed to pass before transmitting or receiving data.

7.3.4.5. UART Interrupt Enable Register(Default Value: 0x0000_0000)

Offset: 0x0004			Register Name: UART_IER
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W		PTIME Programmable THRE Interrupt Mode Enable This is used to enable/disable the generation of THRE Interrupt. 0: Disable 1: Enable
6:4	/	/	/
3	R/W	0	EDSSI Enable Modem Status Interrupt This is used to enable/disable the generation of Modem Status Interrupt.

			This is the fourth highest priority interrupt. 0: Disable 1: Enable
2	R/W	0	ELSI Enable Receiver Line Status Interrupt This is used to enable/disable the generation of Receiver Line Status Interrupt. This is the highest priority interrupt. 0: Disable 1: Enable
1	R/W	0	ETBEI Enable Transmit Holding Register Empty Interrupt This is used to enable/disable the generation of Transmitter Holding Register Empty Interrupt. This is the third highest priority interrupt. 0: Disable 1: Enable
0	R/W	0	ERBFI Enable Received Data Available Interrupt This is used to enable/disable the generation of Received Data Available Interrupt and the Character Timeout Interrupt (if in FIFO mode and FIFOs enabled). These are the second highest priority interrupts. 0: Disable 1: Enable

7.3.4.6. UART Interrupt Identity Register(Default Value: 0x0000_0000)

Offset: 0x0008			Register Name: UART_IIR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:6	R	0	FEFLAG FIFOs Enable Flag This is used to indicate whether the FIFOs are enabled or disabled. 00: Disable 11: Enable
5:4	/	/	/
3:0	R	0x1	IID Interrupt ID This indicates the highest priority pending interrupt which can be one of the following types: 0000: modem status 0001: no interrupt pending 0010: THR empty 0100: received data available 0110: receiver line status

			0111: busy detect 1100: character timeout Bit 3 indicates an interrupt can only occur when the FIFOs are enabled and used to distinguish a Character Timeout condition interrupt.
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Interrupt ID	Priority Level	Interrupt Type	Interrupt Source	Interrupt Reset
0001	-	None	None	-
0110	Highest	Receiver line status	Overflow/parity/ framing errors or break interrupt	Reading the line status register
0100	Second	Received data available	Receiver data available (non-FIFO mode or FIFOs disabled) or RCVR FIFO trigger level reached (FIFO mode and FIFOs enabled)	Reading the receiver buffer register (non-FIFO mode or FIFOs disabled) or the FIFO drops below the trigger level (FIFO mode and FIFOs enabled)
1100	Second	Character timeout indication	No characters in or out of the RCVR FIFO during the last 4 character times and there is at least 1 character in it during This time	Reading the receiver buffer register
0010	Third	Transmit holding register empty	Transmitter holding register empty (Program THRE Mode disabled) or XMIT FIFO at or below threshold (Program THRE Mode enabled)	Reading the IIR register (if source of interrupt); or, writing into THR (FIFOs or THRE Mode not selected or disabled) or XMIT FIFO above threshold (FIFOs and THRE Mode selected and enabled).
0000	Fourth	Modem status	Clear to send or data set ready or ring indicator or data carrier detect. Note that if auto flow control mode is enabled, a change in CTS (that is, DCTS set) does not cause an interrupt.	Reading the Modem status Register
0111	Fifth	Busy detect indication	UART_16550_COMPATIBLE = NO and master has tried to write to the Line Control Register while the UART is busy (USR[0] is set to one).	Reading the UART status register

7.3.4.7. UART FIFO Control Register(Default Value: 0x0000_0000)

Offset: 0x0008			Register Name: UART_FCR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:6	W	0	RT

			RCVR Trigger This is used to select the trigger level in the receiver FIFO at which the Received Data Available Interrupt is generated. In auto flow control mode it is used to determine when the rts_n signal is de-asserted. It also determines when the dma_rx_req_n signal is asserted in certain modes of operation. 00: 1 character in the FIFO 01: FIFO ¼ full 10: FIFO ½ full 11: FIFO-2 less than full
5:4	W	0	TFT TX Empty Trigger Writes have no effect when THRE_MODE_USER = Disabled. This is used to select the empty threshold level at which the THRE Interrupts are generated when the mode is active. It also determines when the dma_tx_req_n signal is asserted when in certain modes of operation. 00: FIFO empty 01: 2 characters in the FIFO 10: FIFO ¼ full 11: FIFO ½ full
3	W	0	DMAM DMA Mode 0: Mode 0 1: Mode 1
2	W	0	XFIFOR XMIT FIFO Reset This resets the control portion of the transmit FIFO and treats the FIFO as empty. This also de-asserts the DMA TX request. It is 'self-clearing'. It is not necessary to clear this bit.
1	W	0	RFIFOR RCVR FIFO Reset This resets the control portion of the receive FIFO and treats the FIFO as empty. This also de-asserts the DMA RX request. It is 'self-clearing'. It is not necessary to clear this bit.
0	W	0	FIFOE Enable FIFOs This enables/disables the transmit (XMIT) and receive (RCVR) FIFOs. Whenever the value of this bit is changed both the XMIT and RCVR controller portion of FIFOs is reset.

7.3.4.8. UART Line Control Register(Default Value: 0x0000_0000)

Offset: 0x000C			Register Name: UART_LCR
Bit	R/W	Default/Hex	Description
31:8	/	/	/

7	R/W	0	DLAB Divisor Latch Access Bit It is writeable only when UART is not busy (USR[0] is zero) and always readable. This bit is used to enable reading and writing of the Divisor Latch register (DLL and DLH) to set the baud rate of the UART. This bit must be cleared after initial baud rate setup in order to access other registers. 0: Select RX Buffer Register (RBR) / TX Holding Register(THR) and Interrupt Enable Register (IER) 1: Select Divisor Latch LS Register (DLL) and Divisor Latch MS Register (DLM)
6	R/W	0	BC Break Control Bit This is used to cause a break condition to be transmitted to the receiving device. If set to one the serial output is forced to the spacing (logic 0) state. When not in Loopback Mode, as determined by MCR[4], the sout line is forced low until the Break bit is cleared. If SIR_MODE = Enabled and active (MCR[6] set to one) the sir_out_n line is continuously pulsed. When in Loopback Mode, the break condition is internally looped back to the receiver and the sir_out_n line is forced low.
5:4	R/W	0	EPS Even Parity Select It is writeable only when UART is not busy (USR[0] is zero) and always writable readable. This is used to select between even and odd parity, when parity is enabled (PEN set to one). Setting the LCR[5] is to reverse the LCR[4]. 00: Odd Parity 01: Even Parity 1X: Reverse LCR[4]
3	R/W	0	PEN Parity Enable It is writeable only when UART is not busy (USR[0] is zero) and always readable. This bit is used to enable and disable parity generation and detection in transmitted and received serial character respectively. 0: parity disabled 1: parity enabled
2	R/W	0	STOP Number of stop bits It is writeable only when UART is not busy (USR[0] is zero) and always readable. This is used to select the number of stop bits per character that the peripheral transmits and receives. If set to zero, one stop bit is transmitted in the serial data. If set to one and the data bits are set to 5 (LCR[1:0] set to zero) one and a half stop bits is transmitted. Otherwise, two stop bits are transmitted. Note that regardless of the number of stop bits selected, the receiver checks only the first stop bit. 0: 1 stop bit 1: 1.5 stop bits when DLS (LCR[1:0]) is zero, else 2 stop bit
1:0	R/W	0	DLS

			Data Length Select It is writeable only when UART is not busy (USR[0] is zero) and always readable. This is used to select the number of data bits per character that the peripheral transmits and receives. The number of bit that may be selected areas follows: 00: 5 bits 01: 6 bits 10: 7 bits 11: 8 bits
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7.3.4.9. UART Modem Control Register(Default Value: 0x0000_0000)

Offset: 0x0010			Register Name: UART_MCR
Bit	R/W	Default/Hex	Description
31:6	/	/	/
5	R/W	0	AFCE Auto Flow Control Enable When FIFOs are enabled and the Auto Flow Control Enable (AFCE) bit is set, Auto Flow Control features are enabled. 0: Auto Flow Control Mode disabled 1: Auto Flow Control Mode enabled
4	R/W	0	LOOP Loop Back Mode 0: Normal Mode 1: Loop Back Mode This is used to put the UART into a diagnostic mode for test purposes. If operating in UART mode (SIR_MODE != Enabled or not active, MCR[6] set to zero), data on the sout line is held high, while serial data output is looped back to the sin line, internally. In this mode all the interrupts are fully functional. Also, in loopback mode, the modem control inputs (dsr_n, cts_n, ri_n, dcd_n) are disconnected and the modem control outputs (dtr_n, rts_n, out1_n, out2_n) are looped back to the inputs, internally. If operating in infrared mode (SIR_MODE == Enabled AND active, MCR[6] set to one), data on the sir_out_n line is held low, while serial data output is inverted and looped back to the sir_in line.
3:2	/	/	/
1	R/W	0	RTS Request to Send This is used to directly control the Request to Send (rts_n) output. The Request To Send (rts_n) output is used to inform the modem or data set that the UART is ready to exchange data. When Auto RTS Flow Control is not enabled (MCR[5] set to zero), the rts_n signal is set low by programming MCR[1] (RTS) to a high. In Auto Flow Control, AFCE_MODE == Enabled and active (MCR[5] set to one) and FIFOs enable (FCR[0] set to one), the rts_n

			output is controlled in the same way, but is also gated with the receiver FIFO threshold trigger (rts_n is inactive high when above the threshold). The rts_n signal is de-asserted when MCR[1] is set low. 0: rts_n de-asserted (logic 1) 1: rts_n asserted (logic 0) Note that in Loopback mode (MCR[4] set to one), the rts_n output is held inactive high while the value of this location is internally looped back to an input.
0	R/W	0	DTR Data Terminal Ready This is used to directly control the Data Terminal Ready (dtr_n) output. The value written to this location is inverted and driven out on dtr_n. 0: dtr_n de-asserted (logic 1) 1: dtr_n asserted (logic 0) The Data Terminal Ready output is used to inform the modem or data set that the UART is ready to establish communications. Note that in Loopback mode (MCR[4] set to one), the dtr_n output is held inactive high while the value of this location is internally looped back to an input.

7.3.4.10. UART Line Status Register(Default Value: 0x0000_0060)

Offset: 0x0014			Register Name: UART_LSR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R	0	FIFOERR RX Data Error in FIFO When FIFOs are disabled, this bit is always 0. When FIFOs are enabled, this bit is set to 1 when there is at least one PE, FE, or BI in the RX FIFO. It is cleared by a read from the LSR register provided there are no subsequent errors in the FIFO.
6	R	1	TEMT Transmitter Empty If the FIFOs are disabled, this bit is set to "1" whenever the TX Holding Register and the TX Shift Register are empty. If the FIFOs are enabled, this bit is set whenever the TX FIFO and the TX Shift Register are empty. In both cases, this bit is cleared when a byte is written to the TX data channel.
5	R	1	THRE TX Holding Register Empty If the FIFOs are disabled, this bit is set to "1" whenever the TX Holding Register is empty and ready to accept new data and it is cleared when the CPU writes to the TX Holding Register. If the FIFOs are enabled, this bit is set to "1" whenever the TX FIFO is empty and it is cleared when at least one byte is written

			to the TX FIFO.
4	R	0	BI Break Interrupt This is used to indicate the detection of a break sequence on the serial input data. It is set whenever the serial input, sin, is held in a logic '0' state for longer than the sum of start time + data bits + parity + stop bits. In the FIFO mode, the character associated with the break condition is carried through the FIFO and is revealed when the character is at the top of the FIFO. Reading the LSR clears the BI bit. In the non-FIFO mode, the BI indication occurs immediately and persists until the LSR is read.
3	R	0	FE Framing Error This is used to indicate the occurrence of a framing error in the receiver. A framing error occurs when the receiver does not detect a valid STOP bit in the received data. In the FIFO mode, since the framing error is associated with a character received, it is revealed when the character with the framing error is at the top of the FIFO. When a framing error occurs, the UART tries to resynchronize. It does this by assuming that the error was due to the start bit of the next character and then continues receiving the other bit i.e. data, and/or parity and stop. It should be noted that the Framing Error (FE) bit (LSR[3]) is set if a break interrupt has occurred, as indicated by Break Interrupt (BI) bit (LSR[4]). 0: no framing error 1: framing error Reading the LSR clears the FE bit.
2	R	0	PE Parity Error This is used to indicate the occurrence of a parity error in the receiver if the Parity Enable (PEN) bit (LCR[3]) is set. In the FIFO mode, since the parity error is associated with a character received, it is revealed when the character with the parity error arrives at the top of the FIFO. It should be noted that the Parity Error (PE) bit (LSR[2]) is set if a break interrupt has occurred, as indicated by Break Interrupt (BI) bit (LSR[4]). 0: no parity error 1: parity error Reading the LSR clears the PE bit.
1	R	0	OE Overrun Error This occurs if a new data character was received before the previous data was read. In the non-FIFO mode, the OE bit is set when a new character arrives in the receiver before the previous character was read from the RBR. When this happens, the data in the RBR is overwritten. In the FIFO mode, an overrun error occurs when the FIFO is full and a new character arrives at the

			receiver. The data in the FIFO is retained and the data in the receive shift register is lost. 0: no overrun error 1: overrun error Reading the LSR clears the OE bit.
0	R	0	DR Data Ready This is used to indicate that the receiver contains at least one character in the RBR or the receiver FIFO. 0: no data ready 1: data ready This bit is cleared when the RBR is read in non-FIFO mode, or when the receiver FIFO is empty, in FIFO mode.

7.3.4.11. UART Modem Status Register(Default Value: 0x0000_0000)

Offset: 0x0018			Register Name: UART_MSR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R	0	DCD Line State of Data Carrier Detect This is used to indicate the current state of the modem control line dcd_n. This bit is the complement of dcd_n. When the Data Carrier Detect input (dcd_n) is asserted it is an indication that the carrier has been detected by the modem or data set. 0: dcd_n input is de-asserted (logic 1) 1: dcd_n input is asserted (logic 0)
6	R	0	RI Line State of Ring Indicator This is used to indicate the current state of the modem control line ri_n. This bit is the complement of ri_n. When the Ring Indicator input (ri_n) is asserted it is an indication that a telephone ringing signal has been received by the modem or data set. 0: ri_n input is de-asserted (logic 1) 1: ri_n input is asserted (logic 0)
5	R	0	DSR Line State of Data Set Ready This is used to indicate the current state of the modem control line dsr_n. This bit is the complement of dsr_n. When the Data Set Ready input (dsr_n) is asserted it is an indication that the modem or data set is ready to establish communications with UART. 0: dsr_n input is de-asserted (logic 1) 1: dsr_n input is asserted (logic 0) In Loopback Mode (MCR[4] set to one), DSR is the same as MCR[0] (DTR).

4	R	0	CTS Line State of Clear To Send This is used to indicate the current state of the modem control line <code>cts_n</code>. This bit is the complement of <code>cts_n</code>. When the Clear to Send input (<code>cts_n</code>) is asserted it is an indication that the modem or data set is ready to exchange data with UART. 0: <code>cts_n</code> input is de-asserted (logic 1) 1: <code>cts_n</code> input is asserted (logic 0) In Loopback Mode (<code>MCR[4] = 1</code>), CTS is the same as <code>MCR[1]</code> (RTS).
3	R	0	DDCD Delta Data Carrier Detect This is used to indicate that the modem control line <code>dcd_n</code> has changed since the last time the MSR was read. 0: no change on <code>dcd_n</code> since last read of MSR 1: change on <code>dcd_n</code> since last read of MSR Reading the MSR clears the DDCD bit. Note: If the DDCD bit is not set and the <code>dcd_n</code> signal is asserted (low) and a reset occurs (software or otherwise), then the DDCD bit is set when the reset is removed if the <code>dcd_n</code> signal remains asserted.
2	R	0	TERI Trailing Edge Ring Indicator This is used to indicate that a change on the input <code>ri_n</code> (from an active-low to an inactive-high state) has occurred since the last time the MSR was read. 0: no change on <code>ri_n</code> since last read of MSR 1: change on <code>ri_n</code> since last read of MSR Reading the MSR clears the TERI bit.
1	R	0	DDSR Delta Data Set Ready This is used to indicate that the modem control line <code>dsr_n</code> has changed since the last time the MSR was read. 0: no change on <code>dsr_n</code> since last read of MSR 1: change on <code>dsr_n</code> since last read of MSR Reading the MSR clears the DDSR bit. In Loopback Mode (<code>MCR[4] = 1</code>), DDSR reflects changes on <code>MCR[0]</code> (DTR). Note: If the DDSR bit is not set and the <code>dsr_n</code> signal is asserted (low) and a reset occurs (software or otherwise), then the DDSR bit is set when the reset is removed if the <code>dsr_n</code> signal remains asserted.
0	R	0	DCTS Delta Clear to Send This is used to indicate that the modem control line <code>cts_n</code> has changed since the last time the MSR was read. 0: no change on <code>ctsdsr_n</code> since last read of MSR 1: change on <code>ctsdsr_n</code> since last read of MSR Reading the MSR clears the DCTS bit. In Loopback Mode (<code>MCR[4] = 1</code>), DCTS reflects changes on <code>MCR[1]</code> (RTS).

			Note: If the DCTS bit is not set and the cts_n signal is asserted (low) and a reset occurs (software or otherwise), then the DCTS bit is set when the reset is removed if the cts_n signal remains asserted.
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7.3.4.12. UART Scratch Register(Default Value: 0x0000_0000)

Offset: 0x001C			Register Name: UART_SCH
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0	SCRATCH_REG Scratch Register This register is for programmers to use as a temporary storage space. It has no defined purpose in the UART.

7.3.4.13. UART Status Register(Default Value: 0x0000_0006)

Offset: 0x007C			Register Name: UART_USR
Bit	R/W	Default/Hex	Description
31:5	/	/	/
4	R	0	RFF Receive FIFO Full This is used to indicate that the receive FIFO is completely full. 0: Receive FIFO not full 1: Receive FIFO Full This bit is cleared when the RX FIFO is no longer full.
3	R	0	RFNE Receive FIFO Not Empty This is used to indicate that the receive FIFO contains one or more entries. 0: Receive FIFO is empty 1: Receive FIFO is not empty This bit is cleared when the RX FIFO is empty.
2	R	1	TFE Transmit FIFO Empty This is used to indicate that the transmit FIFO is completely empty. 0: Transmit FIFO is not empty 1: Transmit FIFO is empty This bit is cleared when the TX FIFO is no longer empty.
1	R	1	TFNF Transmit FIFO Not Full This is used to indicate that the transmit FIFO is not full. 0: Transmit FIFO is full 1: Transmit FIFO is not full

			This bit is cleared when the TX FIFO is full.
0	R	0	BUSY UART Busy Bit 0: Idle or inactive 1: Busy

7.3.4.14. UART Transmit FIFO Level Register(Default Value: 0x0000_0000)

Offset: 0x0080			Register Name: UART_TFL
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6:0	R	0	TFL Transmit FIFO Level This is indicates the number of data entries in the transmit FIFO.

7.3.4.15. UART Receive FIFO Level Register(Default Value: 0x0000_0000)

Offset: 0x0084			Register Name: UART_RFL
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6:0	R	0	RFL Receive FIFO Level This is indicates the number of data entries in the receive FIFO.

7.3.4.16. UART Halt TX Register(Default Value: 0x0000_0000)

Offset: 0x00A4			Register Name: UART_HALT
Bit	R/W	Default/Hex	Description
31:6	/	/	/
5	R/W	0	SIR_RX_INVERT SIR Receiver Pulse Polarity Invert 0: Not invert receiver signal 1: Invert receiver signal
4	R/W	0	SIR_TX_INVERT SIR Transmit Pulse Polarity Invert 0: Not invert transmit pulse 1: Invert transmit pulse
3	/	/	/
2	R/W	0	CHANGE_UPDATE After the user using HALT[1] to change the baudrate or LCR configuration, write 1 to update the configuration and waiting this bit self clear to 0 to

			finish update process. Write 0 to this bit has no effect. 1: Update trigger, Self clear to 0 when finish update.
1	R/W	0	CHCFG_AT_BUSY This is an enable bit for the user to change LCR register configuration (except for the DLAB bit) and baudrate register (DLH and DLL) when the UART is busy (USB[0] is 1). 1: Enable change when busy
0	R/W	0	HALT_TX Halt TX This register is use to halt transmissions for testing, so that the transmit FIFO can be filled by the master when FIFOs are implemented and enabled. 0 : Halt TX disabled 1 : Halt TX enabled Note: If FIFOs are not enabled, the setting of the halt TX register has no effect on operation.

7.3.5. UART Pin List

Port Name	Width	Direction	Description
UART0_TX	1	OUT	UART Serial Bit output
UART0_RX	1	IN	UART Serial Bit input
UART1_TX	1	OUT	UART Serial Bit output
UART1_RX	1	IN	UART Serial Bit input
UART1_RTS	1	OUT	UART Request To Send This active low output signal informs Modem that the UART is ready to send data
UART1_CTS	1	IN	UART Clear To End This active low signal is an input showing when Modem is ready to accept data
UART2_TX	1	OUT	UART Serial Bit output
UART2_RX	1	IN	UART Serial Bit input
UART2_RTS	1	OUT	UART Request To Send This active low output signal informs Modem that the UART is ready to send data
UART2_CTS	1	IN	UART Clear To End This active low signal is an input showing when Modem is ready to accept data
UART3_TX	1	OUT	UART Serial Bit output
UART3_RX	1	IN	UART Serial Bit input
UART3_RTS	1	OUT	UART Request To Send

			This active low output signal informs Modem that the UART is ready to send data
UART3_CTS	1	IN	UART Clear To End This active low signal is an input showing when Modem is ready to accept data
UART4_TX	1	OUT	UART Serial Bit output
UART4_RX	1	IN	UART Serial Bit input
UART4_RTS	1	OUT	UART Request To Send This active low output signal informs Modem that the UART is ready to send data
UART4_CTS	1	IN	UART Clear To End This active low signal is an input showing when Modem is ready to accept data
R_UART_TX	1	OUT	UART Serial Bit output
R_UART_RX	1	IN	UART Serial Bit input

7.4. RSB

7.4.1. Overview

The RSB (reduced serial bus) Host Controller is designed to communicate with RSB Device using two push-pull wires. It supports a simplified two wire protocol (RSB) on a push-pull bus. The transfer speed can be up to 20MHz and the performance will be improved much.

The RSB includes the following features:

- Supports industry-standard AMBA Peripheral Bus (APB) and it is fully compliant with the AMBA Specification, Revision 2.0.
- Supports speed up to 20MHz with ultra low power
- Supports Push-Pull bus
- Supports Master mode
- Supports programmable output delay of CD signal
- Supports parity check for address and data transmission
- Supports multi-slaves

7.4.2. Terminology Definition

TERM	Description
CK	A line that is used to transmit clock from Host to Device
CD	A line that is used to transmit Command and Data between Host and Device
DA	Device Address is a 16bits address that is the ID of each type device.
RTA	Run-Time Address is an 8bits address that is used to address device during Read or Write transmission. The valid RTA is 0x17 0x2D 0x3A 0x4E 0x59 0x63 0x74 0x8B 0x9C 0xA6 0xB1 0xC5 0xD2 0xE8 and 0xFF.
HD	Host to Device Handshake is used to change the ownership of CD from Host to Device.
DH	Device to Host Handshake is used to change the ownership of CD from Device to Host.
SB	Start Bit: a HIGH to LOW transition on the CD while CK is high.

7.4.3. RSB Command Set

Command	Value	Description
SRTA	0xE8	Set Run-Time-Address
RD8	0x8B	Read one byte from Device
RD16	0x9C	Read two bytes from Device
RD32	0xA6	Read four bytes from Device
WR8	0x4E	Write one byte to Device
WR16	0x59	Write two bytes to Device
WR32	0x63	Write four bytes to Device

7.4.4. Software Operation Flow

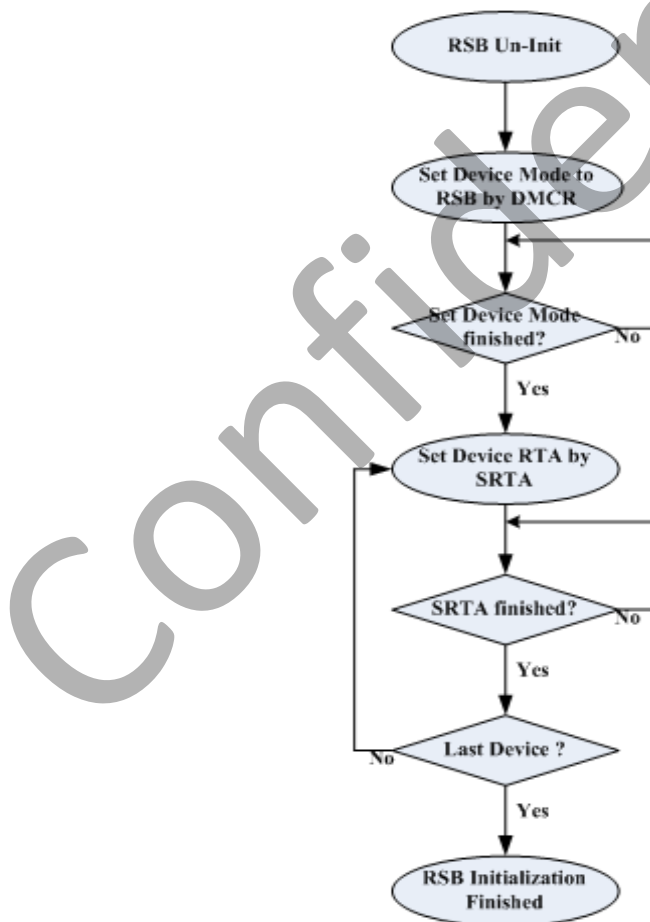


Figure 7-4. RSB System Initialization

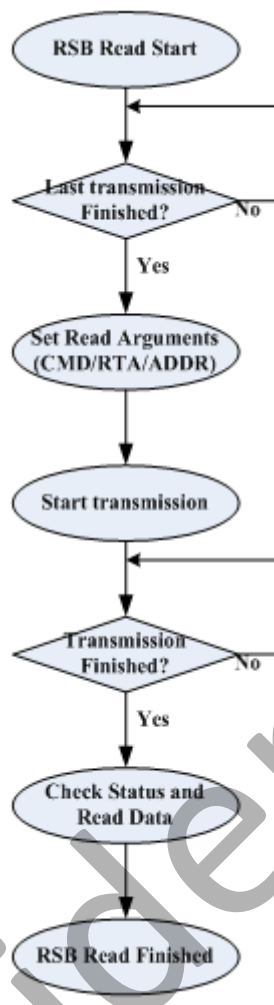


Figure 7-5. RSB Read from Device

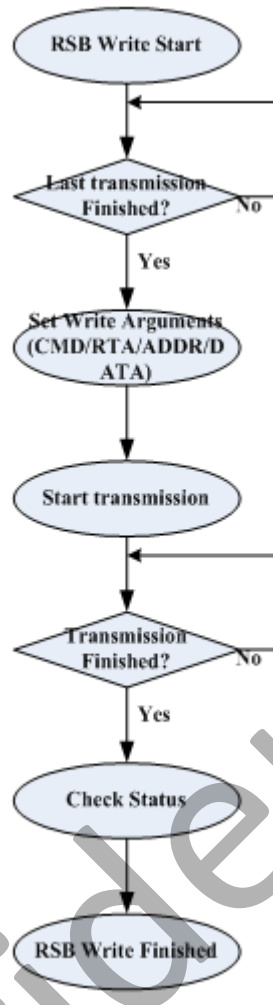


Figure 7-6. RSB Write to Device

7.4.5. RSB Controller Register List

Module Name	Base Address
RSB	0x01F03400

Register Name	Offset	Description
RSB_CTRL	0x0000	RSB Control Register
RSB_CCR	0x0004	RSB Clock Control Register
RSB_INTE	0x0008	RSB Interrupt Enable Register
RSB_STAT	0x000c	RSB Status Register
RSB_DADDR0	0x0010	RSB Data Access Address Register0
RSB_DLEN	0x0018	RSB Data Length Register

RSB_DATA0	0x001c	RSB Data Buffer0 Register
RSB_LCR	0x0024	RSB Line Control register
RSB_PMCR	0x0028	RSB PMU Mode Control register
RSB_CMD	0x002C	RSB Command Register
RSB_SADDR	0x0030	RSB Slave address Register

7.4.6. RSB Register Description

7.4.6.1. RSB Control Register (Default Value: 0x0000_0000)

Offset: 0x0000			Register Name: RSB_CTRL
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0	START_TRANS Write '1' to this bit will start a new transmission with the configuration of other registers. It is cleared to '0' automatically when the transaction completes or an error happens in the transmission.
6	R/W	0	ABORT_TRANS Write '1' to this bit will abort the current transmission. It is cleared to '0' automatically when the transmission has been aborted.
5:2	/	/	/
1	R/W	0	GLOBAL_INT_ENB Global interrupt enable bit 1 – enable interrupt 0 – disable interrupt
0	R/W	0	Soft Reset Write '1' to this bit will reset the controller into default state. All of the status of controller will be cleared. And this bit will be cleared to '0' automatically when reset operation completes.

7.4.6.2. RSB Clock Control Register (Default Value: 0x0000_0000)

Offset: 0x0004			Register Name: RSB_CCR
Bit	R/W	Default/Hex	Description
31:11	/	/	/
10:8	R/W	0	CD_ODLY CD output delay Delay time of n source clock cycles before output CD signal.
7:0	R/W	0	CK_DIV

			$F_{ck} = F_{source} / 2 * (divider + 1)$
--	--	--	---

7.4.6.3. RSB Interrupt Enable Register (Default Value: 0x0000_0000)

Offset: 0x0008			Register Name: RSB_INTE
Bit	R/W	Default/Hex	Description
31:3	/	/	/
2	R/W	0	LOAD_BSY_ENB Loading Busy Interrupt Enable 1 – enable 0 – disable
1	R/W	0	TRANS_ERR_ENB Transfer Error Interrupt Enable 1 – enable 0 – disable
0	R/W	0	TRANS_OVER_ENB Transfer complete Interrupt Enable 1 – enable 0 – disable

7.4.6.4. RSB Status Register (Default Value: 0x0000_0000)

Offset: 0x000C			Register Name: RSB_INTS
Bit	R/W	Default/Hex	Description
31:17	/	/	/
16	R	0	TRANS_ERR_ACK. If a negative ACK is received from Device, then this bit is set to '1' by hardware. This bit is cleared when a new transmission is started.
15:12	/	/	/
11:8	R	0	TRANS_ERR_DATA If the parity check of 1st byte is negative, then bit8 is set to '1' by hardware. If the parity check of 2nd byte is negative, then bit9 is set to '1' by hardware; and so on. These bits are cleared when a new transmission is started.
7:3	/	/	/
2	R/W	0	LOAD_BSY Loading Busy Flag If software writes any control registers during transmission, this bit will be set to '1'. If LOAD_BSY_ENB=1, an interrupt will be generated. Software can clear this flag by writing '1' to this bit.

1	R/W	0	TRANS_ERR Transfer Error Flag If an error happened during transmission, This bit will be set to '1'. If TRANS_ERR_ENB=1, an interrupt will be generated. Software can clear this flag by writing '1' to this bit.
0	R/W	0	TRANS_OVER Transfer Over Flag If the transmission has transfer over, this bit is set to '1'. If TRANS_OVER_ENB=1, an interrupt will be generated. Software can clear this flag by writing '1' to this bit.

7.4.6.5. RSB Address Register (Default Value: 0x0000_0000)

Offset: 0x0010			Register Name: RSB_AR
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0	ADDR The ADDR is send to device during Read and Write command.

7.4.6.6. RSB Data Length Register (Default Value: 0x0000_0000)

Offset: 0x0018			Register Name: RSB_DLEN
Bit	R/W	Default/Hex	Description
31:5	/	/	/
4	R/W	0	READ_WRITE_FLAG Read/Write flag 1:read 0:write
3	/	/	/
2:0	R/W	0	Data Access Length Only use 0,1,3 now- Package length is n+1 bytes

7.4.6.7. RSB Data Buffer0 Register (Default Value: 0x0000_0000)

Offset: 0x001C			Register Name: RSB_DATA0
Bit	R/W	Default/Hex	Description
31:24	R/W	0	Data Byte 4
23:16	R/W	0	Data Byte 3
15:8	R/W	0	Data Byte 2
7:0	R/W	0	Data Byte 1

7.4.6.8. RSB Line Control Register (Default Value: 0x0000_003A)

Offset: 0x0024			Register Name: RSB_LCR
Bit	R/W	Default/Hex	Description
31:6	/	/	/
5	R	1	CK_STATE Current state of CK pin 0 – low 1 - high
4	R	1	CD_STATE Current state of CD pin 0 – low 1 – high
3	R/W	1	CK_CTL CK line state control bit When line control mode is enabled (bit[2] set), value of this bit decide the output level of CK 0 – output low level 1 – output high level
2	R/W	0	CK_CTL_EN CK line state control enable When this bit is set, the state of CK is control by the value of bit[3]. 0-disable CK line control mode 1-enable CK line control mode
1	R/W	1	CD_CTL CD line state control bit When line control mode is enabled (bit[0] set), value of this bit decide the output level of CD 0 – output low level 1 – output high level
0	R/W	0	CD_CTL_EN CD line state control enable When this bit is set, the state of CD is control by the value of bit [1]. 0-disable CD line control mode 1-enable CD line control mode

7.4.6.9. RSB PMU Mode Control Register (Default Value: 0x003E_3E00)

Offset: 0x0028			Register Name: RSB_PMCR
Bit	R/W	Default/Hex	Description
31	R/W	0	PMU_INIT_SEND 1:Send initial sequence to PMU to switch PMU's bus mode from NTWI to RSB.

			0:write ignore This bit will be self-cleared when initial sequence is sent onto the RSB bus.
30:24	/	/	/
23:16	R/W	0x3E	PMU_INIT_DATA Value of PMU's initial data
15:8	R/W	0x3E	PMU MODE Control Register Address
7:0	R/W	0	PMU Device Address

7.4.6.10. RSB Command Register (Default Value: 0x0000_0000)

Offset: 0x002C			Register Name: RSB_CMD
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R/W	0	CMD_IDX command index

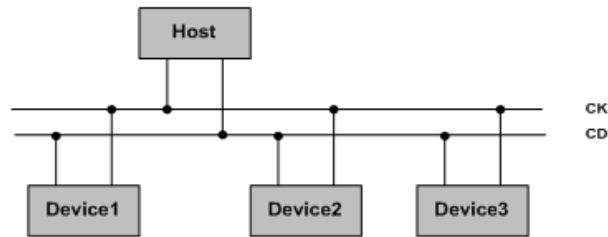
7.4.6.11. RSB Slave Address Register (Default Value: 0x0000_0000)

Offset: 0x0030			Register Name: RSB_SADDR
Bit	R/W	Default/Hex	Description
31:24	/	/	/
23:16	R/W	0	RTSADDR Run-Time Slave Address
15:0	R/W	0	SADDR Slave Address

7.4.7. RSB General Specification

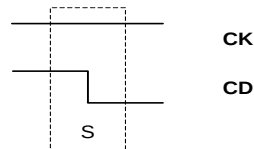
RSB uses push-pull bus, and supports multi-devices. It uses CK as clock and uses CD to transmit command and data. The Bus Topology is showed below:

RSB Bus Topology



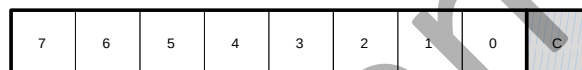
The start bit marks the beginning of a transaction. The Start bit is defined as a HIGH to LOW transition on the CD while CK is high.

Start signal



RSB protocol uses parity bit to check the correction of address and data.

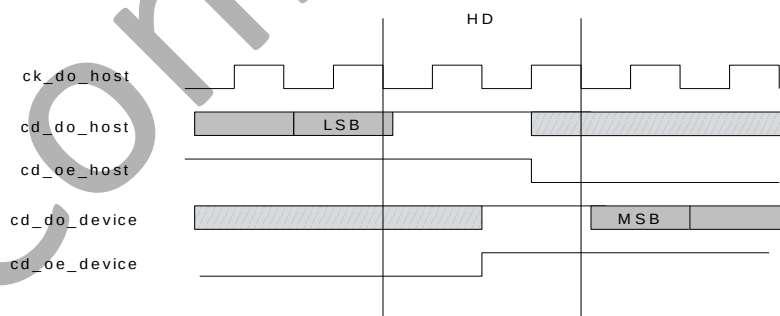
Parity bit



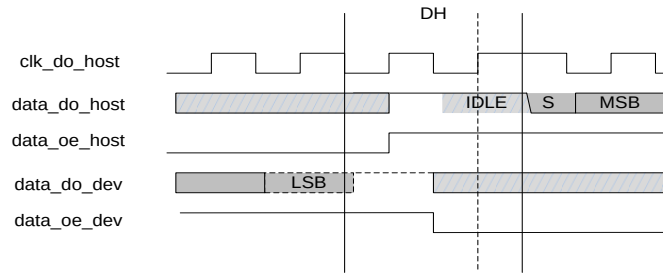
ACK bit is the acknowledgement from device to host, The ACK is low active. When device finds the parity bit is error, it will not send ACK to host, so host can know that an error happens in the transaction.

Both Host and Device can drive the CD, so there are two handshakes, HD (host to device) and DH (device to host), for Host and device to convert the direction of data transmission.

HD Handshake



DH Handshake



To improve transaction efficiency and to be flexible in device address assignment, RSB use Device Address (DA) and Run-Time Address (RTA). RTA is assigned dynamically by host. Host software shall ensure that different device has different RTA in the same system. Device's default RTA is 0 and 0 is the reserved address. If RTA is 0 when setting RTA, the setting is invalid.

There are three command types in RSB:

- 1) Set run-time address (RTA): It is used to set run time address (RTA) for different devices in the same system. There are 15 devices in a system at most. The RTA can be selected from the RTA code set and a device's RTA can be modified many times by using set run-time address command.

SRTA Timing



- 2) Read command: It is used to read data from device. It has byte, half word and word operation. When the device receives the command, they shall check if the command's RTA matches their own RTA.

Read Timing



Write command: It is used to write data to the devices. It has byte, half word and word operation. When the device receives the command, they shall check if the command's RTA matches their own RTA.

Write Timing



7.5. CIR Receiver

7.5.1. Overview

For saving CPU resource, CIR receiver is implemented in hardware. The CIR receiver samples the input signal on the programmable frequency and records these samples into RX FIFO when one CIR signal is found on the air. The CIR receiver uses Run-Length Code (RLC) to encode pulse width. The encoded data is buffered in a 64 levels and 8-bit width RX FIFO; the MSB bit is used to record the polarity of the receiving CIR signal. The high level is represented as '1' and the low level is represented as '0'. The rest 7 bits are used for the length of RLC. The maximum length is 128. If the duration of one level (high or low level) is more than 128, another byte is used.

In the air, there is always some noise. One threshold can be set to filter the noise to reduce system loading and improve the system stability.

The CIR includes the following features:

- Full physical layer implementation
- Support CIR for remote control
- 64x8 bits FIFO for data buffer
- Programmable FIFO thresholds

7.5.2. CIR Receiver Register List

Module Name	Base Address
CIR	0x01F02000

Register Name	Offset	Description
CIR_CTL	0x00	CIR Control Register
CIR_RXCTL	0x10	CIR Receiver Configure Register
CIR_RXFIFO	0x20	CIR Receiver FIFO Register
CIR_RXINT	0x2C	CIR Receiver Interrupt Control Register
CIR_RXSTA	0x30	CIR Receiver Status Register
CIR_CONFIG	0x34	CIR Configure Register

7.5.3. CIR Receiver Register Description

7.5.3.1. CIR Receiver Control Register(Default Value: 0x0000_0000)

Offset: 0x0000			Register Name: CIR_CTL
Bit	R/W	Default/Hex	Description
31:9	/	/	/
8	R/W	0	CGPO General Program Output (GPO) Control in CIR mode for TX Pin 0: Low level 1: High level
7:6	/	/	/
5:4	R/W	0	CIR ENABLE 00~10: Reserved 11: CIR mode enable
3:2	/	/	/
1	R/W	0	RXEN Receiver Block Enable 0: Disable 1: Enable
0	R/W	0	GEN Global Enable A disable on this bit overrides any other block or channel enables and flushes all FIFOs. 0: Disable 1: Enable

7.5.3.2. CIR Receiver Configure Register(Default Value: 0x0000_0004)

Offset: 0x0010			Register Name: CIR_RXCTL
Bit	R/W	Default/Hex	Description
31:3	/	/	/
2	R/W	1	RPPI Receiver Pulse Polarity Invert 0: Not invert receiver signal 1: Invert receiver signal
1:0	/	/	/

7.5.3.3. CIR Receiver FIFO Register(Default Value: 0x0000_0000)

Offset: 0x0020			Register Name: CIR_RXFIFO
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7:0	R	0	Receiver Byte FIFO

7.5.3.4. CIR Receiver Interrupt Control Register(Default Value: 0x0000_0000)

Offset: 0x002C			Register Name: CIR_RXINT
Bit	R/W	Default/Hex	Description
31:14	/	/	/
13:8	R/W	0	RAL RX FIFO Available Received Byte Level for interrupt and DMA request TRIGGER_LEVEL = RAL + 1
5	R/W	0	DRQ_EN RX FIFO DMA Enable 0: Disable 1: Enable When set to '1', the Receiver FIFO DRQ is asserted if reaching RAL. The DRQ is de-asserted when condition fails.
4	R/W	0	RAI_EN RX FIFO Available Interrupt Enable 0: Disable 1: Enable When set to '1', the Receiver FIFO IRQ is asserted if reaching RAL. The IRQ is de-asserted when condition fails.
3:2	/	/	/
1	R/W	0	RPEI_EN Receiver Packet End Interrupt Enable 0: Disable 1: Enable
0	R/W	0	ROI_EN Receiver FIFO Overrun Interrupt Enable 0: Disable 1: Enable

7.5.3.5. CIR Receiver Status Register(Default Value: 0x0000_0000)

Offset: 0x0030			Register Name: CIR_RXSTA
Bit	R/W	Default/Hex	Description
31:15	/	/	/

14:8	R	0	RAC RX FIFO Available Counter 0: No available data in RX FIFO 1: 1 byte available data in RX FIFO 2: 2 byte available data in RX FIFO ... 64: 64 byte available data in RX FIFO
7	R	0x0	STAT Status of CIR 0x0 – Idle 0x1 – busy
6:5	/	/	/
4	R/W	0	RA RX FIFO Available 0: RX FIFO not available according its level 1: RX FIFO available according its level This bit is cleared by writing a '1'.
3:2	/	/	/
1	R/W	0	RPE Receiver Packet End Flag 0: STO was not detected. In CIR mode, one CIR symbol is receiving or not detected. 1: STO field or packet abort symbol (7'b0000,000 and 8'b0000,0000 for MIR and FIR) is detected. In CIR mode, one CIR symbol is received. This bit is cleared by writing a '1'.
0	R/W	0	ROI Receiver FIFO Overrun 0: Receiver FIFO not overrun 1: Receiver FIFO overrun This bit is cleared by writing a '1'.

7.5.3.6. CIR Receiver Configure Register(Default Value: 0x0000_0000)

Offset: 0x0034			Register Name: CIR_RCR
Bit	R/W	Default/Hex	Description
31:25	/	/	/
24	R/W	0x0	SCS2 Bit2 of Sample Clock Select for CIR This bit is defined by SCS bits below.
23	R/W	0x0	ATHC Active Threshold Control for CIR 0x0 –ATHR in Unit of (Sample Clock) 0x1 –ATHR in Unit of (128*Sample Clocks)
22:16	R/W	0x0	ATHR

			Active Threshold for CIR These bits control the duration of CIR from Idle to Active State. The duration can be calculated by $((ATHR + 1) * (ATHC? \text{ Sample Clock: } 128 * \text{ Sample Clock}))$.																																				
15:8	R/W	0x18	ITHR Idle Threshold for CIR The Receiver uses it to decide whether the CIR command has been received. If there is no CIR signal on the air, the receiver is staying in IDLE status. One active pulse will bring the receiver from IDLE status to Receiving status. After the CIR is end, the inputting signal will keep the specified level (high or low level) for a long time. The receiver can use this idle signal duration to decide that it has received the CIR command. The corresponding flag is asserted. If the corresponding interrupt is enable, the interrupt line is asserted to CPU. When the duration of signal keeps one status (high or low level) for the specified duration $((ITHR + 1) * 128 \text{ sample_clk})$, this means that the previous CIR command has been finished.																																				
7:2	R/W	0xa	NTHR Noise Threshold for CIR When the duration of signal pulse (high or low level) is less than NTHR, the pulse is taken as noise and should be discarded by hardware. 0: all samples are recorded into RX FIFO 1: If the signal is only one sample duration, it is taken as noise and discarded. 2: If the signal is less than ($\leq$) two sample duration, it is taken as noise and discarded. ... 61: if the signal is less than ($\leq$) sixty-one sample duration, it is taken as noise and discarded.																																				
1:0	R/W	0	SCS Sample Clock Select for CIR <table border="1"> <thead> <tr> <th>SCS2</th><th>SCS[1]</th><th>SCS[0]</th><th>Sample Clock</th></tr> </thead> <tbody> <tr> <td>0</td><td>0</td><td>0</td><td>ir_clk/64</td></tr> <tr> <td>0</td><td>0</td><td>1</td><td>ir_clk/128</td></tr> <tr> <td>0</td><td>1</td><td>0</td><td>ir_clk/256</td></tr> <tr> <td>0</td><td>1</td><td>1</td><td>ir_clk/512</td></tr> <tr> <td>1</td><td>0</td><td>0</td><td>ir_clk</td></tr> <tr> <td>1</td><td>0</td><td>1</td><td>Reserved</td></tr> <tr> <td>1</td><td>1</td><td>0</td><td>Reserved</td></tr> <tr> <td>1</td><td>1</td><td>1</td><td>Reserved</td></tr> </tbody> </table>	SCS2	SCS[1]	SCS[0]	Sample Clock	0	0	0	ir_clk/64	0	0	1	ir_clk/128	0	1	0	ir_clk/256	0	1	1	ir_clk/512	1	0	0	ir_clk	1	0	1	Reserved	1	1	0	Reserved	1	1	1	Reserved
SCS2	SCS[1]	SCS[0]	Sample Clock																																				
0	0	0	ir_clk/64																																				
0	0	1	ir_clk/128																																				
0	1	0	ir_clk/256																																				
0	1	1	ir_clk/512																																				
1	0	0	ir_clk																																				
1	0	1	Reserved																																				
1	1	0	Reserved																																				
1	1	1	Reserved																																				

7.6. USB

7.6.1. USB Block Diagram

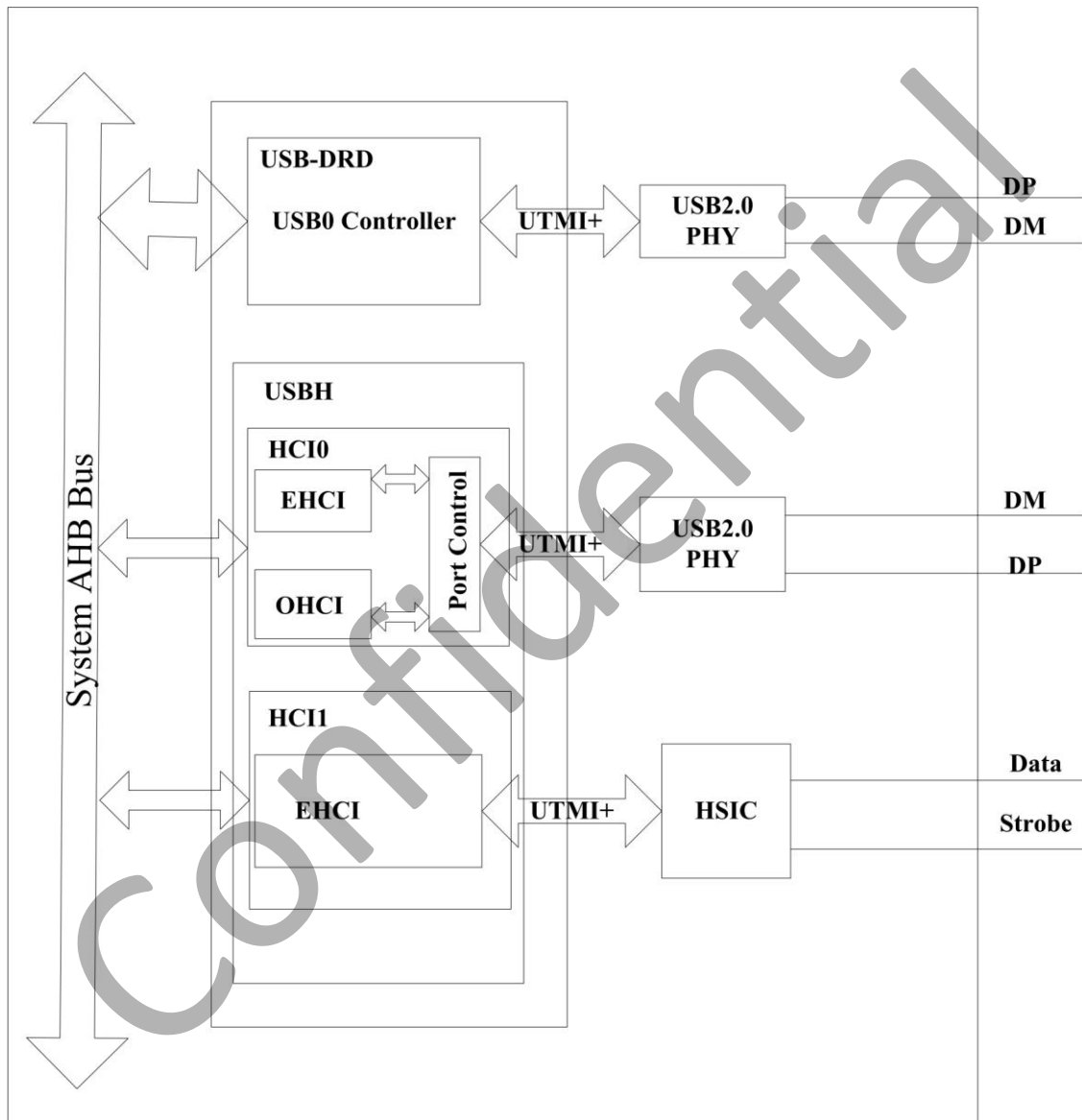


Figure 7-7. USB Block Diagram

7.6.2. USB DRD Controller

The USB2.0 controller has following features:

- Support Device or Host operation at a time
- Supports High-Speed (HS, 480-Mbps), Full-Speed (FS, 12-Mbps), and Low-Speed (LS, 1.5-Mbps) in Host mode and support High-Speed (HS, 480-Mbps), Full-Speed (FS, 12-Mbps) in Device mode
- Supports the UTMI+ Level 3 interface . The 8-bit bidirectional data buses are used
- Supports bi-directional endpoint0 for Control transfer
- Supports up to 10 User-Configurable Endpoints for Bulk , Isochronous and Interrupt bi-directional transfers (Endpoint1, Endpoint2, Endpoint3, Endpoint4, Endpoint5)
- Supports up to 8128Bytes (8KB-64B) FIFO for EPs (Excluding EP0)
- Supports High-Bandwidth Isochronous & Interrupt transfers
- Automated splitting/combining of packets for Bulk transfers
- Supports point-to-point and point-to-multipoint transfer in both Host and Peripheral mode
- Includes automatic ping capabilities
- Soft connect/disconnect function
- Performs all transaction scheduling in hardware
- Power Optimization and Power Management capabilities
- Includes interface to an external Normal DMA controller for every EPs

7.6.3. USB Host Controller

7.6.3.1. Overview

USB Host Controller is fully compliant with the USB 2.0 specification, Enhanced Host Controller Interface (EHCI) Specification, Revision 1.0, and the Open Host Controller Interface (OHCI) Specification Release 1.0a. The controller supports high-speed, 480-Mbps transfers (40 times faster than USB 1.1 full-speed mode) using an EHCI Host Controller, as well as full and low speeds through one or more integrated OHCI Host Controllers.

The USB host controller includes the following features:

- Supports industry-standard AMBA High-Performance Bus (AHB) and it is fully compliant with the AMBA Specification, Revision 2.0. Supports bus.
- Supports 32-bit Little Endian AMBA AHB Slave Bus for Register Access.
- Supports 32-bit Little Endian AMBA AHB Master Bus for Memory Access.
- Including an internal DMA Controller for data transfer with memory.
- Complies with Enhanced Host Controller Interface (EHCI) Specification, Version 1.0, and the Open Host Controller Interface (OHCI) Specification, Version 1.0a.
- Supports High-Speed (HS, 480-Mbps), Full-Speed (FS, 12-Mbps), and Low-Speed (LS, 1.5-Mbps) Device.
- Supports the UTMI+ Level 3 interface . The 8-bit bidirectional data buses are used.
- Supports only 1 USB Root Port shared between EHCI and OHCI.

7.6.3.2. Block Diagram

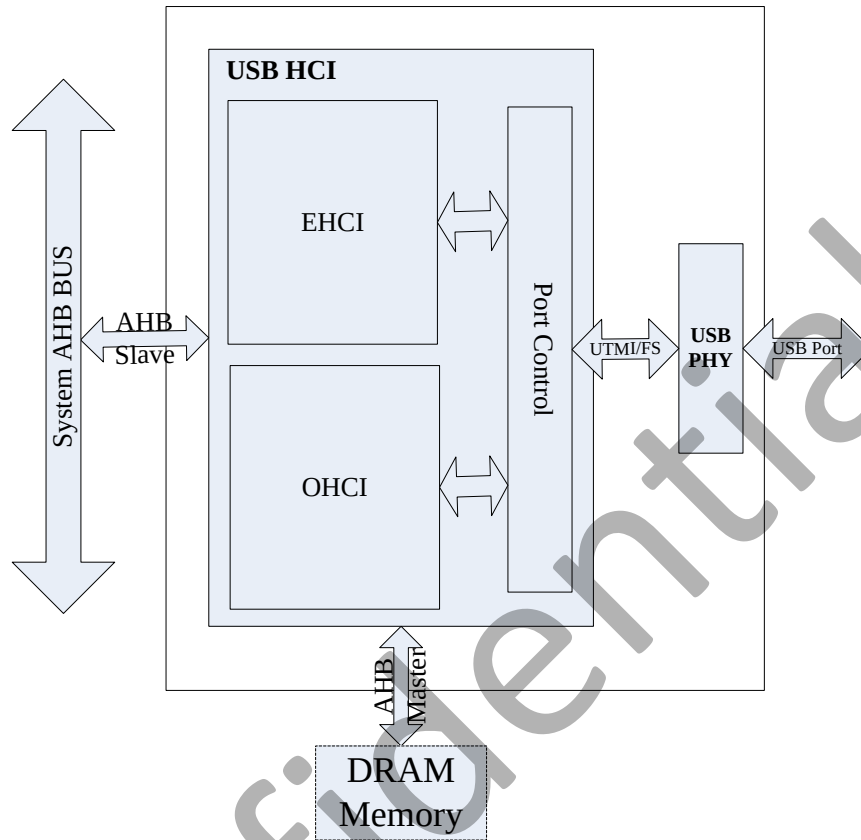


Figure 7-8. USB host controller System-Level block diagram

7.6.3.3. USB Host Timing Diagram

Please refer USB2.0 Specification, Enhanced Host Controller Interface (EHCI) Specification, Version 1.0, and the Open Host Controller Interface (OHCI) Specification, Version 1.0a.

7.6.3.4. USB Host Register List

Module Name	Base Address
USB_HCI0	0x01C1A000
USB_HCI1	0x01C1B000

Register Name	Offset	Description
EHCI Capability Register		
E_CAPLENGTH	0x000	EHCI Capability register Length Register
E_HCVERSION	0x002	EHCI Host Interface Version Number Register
E_HCSPARAMS	0x004	EHCI Host Control Structural Parameter Register
E_HCCPARAMS	0x008	EHCI Host Control Capability Parameter Register
E_HCSPPORTROUTE	0x00c	EHCI Companion Port Route Description
EHCI Operational Register		
E_USBCMD	0x010	EHCI USB Command Register
E_USBSTS	0x014	EHCI USB Status Register
E_USBINTR	0x018	EHCI USB Interrupt Enable Register
E_FRINDEX	0x01c	EHCI USB Frame Index Register
E_CTRLDSSEGMENT	0x020	EHCI 4G Segment Selector Register
E_PERIODICLISTBASE	0x024	EHCI Frame List Base Address Register
E_ASYNCLISTADDR	0x028	EHCI Next Asynchronous List Address Register
E_CONFIGFLAG	0x050	EHCI Configured Flag Register
E_PORTSC	0x054	EHCI Port Status/Control Register
OHCI Control and Status Partition Register		
O_HcRevision	0x400	OHCI Revision Register
O_HcControl	0x404	OHCI Control Register
O_HcCommandStatus	0x408	OHCI Command Status Register
O_HcInterruptStatus	0x40c	OHCI Interrupt Status Register
O_HcInterruptEnable	0x410	OHCI Interrupt Enable Register
O_HcInterruptDisable	0x414	OHCI Interrupt Disable Register
OHCI Memory Pointer Partition Register		
O_HcHCCA	0x418	OHCI HCCA Base
O_HcPeriodCurrentED	0x41c	OHCI Period Current ED Base
O_HcControlHeadED	0x420	OHCI Control Head ED Base
O_HcControlCurrentED	0x424	OHCI Control Current ED Base
O_HcBulkHeadED	0x428	OHCI Bulk Head ED Base
O_HcBulkCurrentED	0x42c	OHCI Bulk Current ED Base
O_HcDoneHead	0x430	OHCI Done Head Base
OHCI Frame Counter Partition Register		
O_HcFmInterval	0x434	OHCI Frame Interval Register
O_HcFmRemaining	0x438	OHCI Frame Remaining Register
O_HcFmNumber	0x43c	OHCI Frame Number Register
O_HcPeriodicStart	0x440	OHCI Periodic Start Register
O_HcLSThreshold	0x444	OHCI LS Threshold Register
OHCI Root Hub Partition Register		
O_HcRhDescriptorA	0x448	OHCI Root Hub Descriptor Register A
O_HcRhDescriptorB	0x44c	OHCI Root Hub Descriptor Register B
O_HcRhStatus	0x450	OHCI Root Hub Status Register
O_HcRhPortStatus	0x454	OHCI Root Hub Port Status Register

7.6.3.5. EHCI Register Description

7.6.3.5.1. EHCI Identification Register(Default Value: Implementation Dependent)

Offset: 0x0000			Register Name: CAPLENGTH
Bit	R/W	Default/Hex	Description
7:0	R	0x10	CAPLENGTH The value in these bits indicates an offset to add to register base to find the beginning of the Operational Register Space.

7.6.3.5.2. EHCI Host Interface Version Number Register(Default Value: 0x0100)

Offset: 0x0002			Register Name: HCVERSION
Bit	R/W	Default/Hex	Description
15:0	R	0x0100	HCVERSION This is a 16-bits register containing a BCD encoding of the EHCI revision number supported by this host controller. The most significant byte of this register represents a major revision and the least significant byte is the minor revision.

7.6.3.5.3. EHCI Host Control Structural Parameter Register(Default Value: Implementation Dependent)

Offset: 0x0004			Register Name: HCSPARAMS
Bit	R/W	Default/Hex	Description
31:24	/	0	Reserved. These bits are reserved and should be set to zero.
23:20	R	0	Debug Port Number This register identifies which of the host controller ports is the debug port. The value is the port number (one based) of the debug port. This field will always be '0'.
19:16	/	0	Reserved. These bits are reserved and should be set to zero.
15:12	R	0	Number of Companion Controller (N_CC) This field indicates the number of companion controllers associated with this USB2.0 host controller. A zero in this field indicates there are no companion host controllers. And a value larger than zero in this field indicates there are companion USB1.1 host controller(s). This field will always be '0'.

11:8	R	0	Number of Port per Companion Controller(N_PCC) This field indicates the number of ports supported per companion host controller host controller. It is used to indicate the port routing configuration to system software. This field will always fix with '0'.						
7	R	0	Port Routing Rules This field indicates the method used by this implementation for how all ports are mapped to companion controllers. The value of this field has the following interpretation: <table><tr><th>Value</th><th>Meaning</th></tr><tr><td>0</td><td>The first N_PCC ports are routed to the lowest numbered function companion host controller, the next N_PCC port are routed to the next lowest function companion controller, and so on.</td></tr><tr><td>1</td><td>The port routing is explicitly enumerated by the first N_PORTS elements of the HCSP-PORTTOUTE array.</td></tr></table> This field will always be '0'.	Value	Meaning	0	The first N_PCC ports are routed to the lowest numbered function companion host controller, the next N_PCC port are routed to the next lowest function companion controller, and so on.	1	The port routing is explicitly enumerated by the first N_PORTS elements of the HCSP-PORTTOUTE array.
Value	Meaning								
0	The first N_PCC ports are routed to the lowest numbered function companion host controller, the next N_PCC port are routed to the next lowest function companion controller, and so on.								
1	The port routing is explicitly enumerated by the first N_PORTS elements of the HCSP-PORTTOUTE array.								
6:4	/	0	Reserved. These bits are reserved and should be set to zero.						
3:0	R	1	N_PORTS This field specifies the number of physical downstream ports implemented on this host controller. The value of this field determines how many port registers are addressable in the Operational Register Space. Valid values are in the range of 0x1 to 0x0f. This field is always 1.						

7.6.3.5.4. EHCI Host Control Capability Parameter Register(Default Value: Implementation Dependent)

Offset: 0x0008			Register Name: HCCPARAMS
Bit	R/W	Default/Hex	Description
31:16	/	0	Reserved These bits are reserved and should be set to zero.
15:18	R	0	EHCI Extended Capabilities Pointer (EECP) This optional field indicates the existence of a capabilities list. A value of 00b indicates no extended capabilities are implemented. A non-zero value in this register indicates the offset in PCI configuration space of the first EHCI extended capability. The pointer value must be 40h or greater if implemented to maintain consistency of the PCI header defined for this class of device. The value of this field is always '00b'.
7:4	R		Isochronous Scheduling Threshold This field indicates, relative to the current position of the executing host controller, where software can reliably update the isochronous schedule. When bit[7] is zero, the value of the least significant 3 bits indicates the

			number of micro-frames a host controller can hold a set of isochronous data structures(one or more) before flushing the state. When bit[7] is a one, then host software assumes the host controller may cache an isochronous data structure for an entire frame.
3	R	0	Reserved These bits are reserved and should be set to zero.
2	R		Asynchronous Schedule Park Capability If this bit is set to a one, then the host controller supports the park feature for high-speed queue heads in the Asynchronous Schedule. The feature can be disabled or enabled and set to a specific level by using the Asynchronous Schedule Park Mode Enable and Asynchronous Schedule Park Mode Count fields in the USBCMD register.
1	R		Programmable Frame List Flag If this bit is set to a zero, then system software must use a frame list length of 1024 elements with this host controller.The USBCMD register Frame List Size field is a read-only register and should be set to zero. If set to 1,then system software can specify and use the frame list in the USBCMD register Frame List Size field to cofigure the host controller. The frame list must always aligned on a 4K page boundary.This requirement ensures that the frame list is always physically contiguous.
0	R	0	Reserved These bits are reserved for future use and should return a value of zero when read.

7.6.3.5.5. EHCI Companion Port Route Description (Default Value: UNDEFINED)

Offset: 0x000C			Register Name: HCSP-PORTROUTE
Bit	R/W	Default/Hex	Description
31:0	R		HCSP-PORTROUTE This optional field is valid only if Port Routing Rules field in HCSPARAMS register is set to a one. This field is used to allow a host controller implementation to explicitly describe to which companion host controller each implemented port is mapped. This field is a 15-element nibble array (each 4 bit is one array element). Each array location corresponds one-to-one with a physical port provided by the host controller (e.g. PORTROUTE [0] corresponds to the first PORTSC port, PORTROUTE [1] to the second PORTSC port, etc.). The value of each element indicates to which of the companion host controllers this port is routed. Only the first N_PORTS elements have valid information. A value of zero indicates that the port is routed to the lowest numbered function companion host controller. A value of one indicates that the port is routed to the next lowest numbered function companion host controller, and so on.

7.6.3.5.6. EHCI USB Command Register (Default Value: 0x00080000, 0x00080B00 if Asynchronous Schedule Park Capability is a one)

Offset: 0x0010			Register Name: USBCMD																		
Bit	R/W	Default/Hex	Description																		
31:24	/	0	Reserved These bits are reserved and should be set to zero.																		
23:16	R/W	0x08	Interrupt Threshold Control The value in this field is used by system software to select the maximum rate at which the host controller will issue interrupts. The only valid values are defined below: <table><tr><th>Value</th><th>Minimum Interrupt Interval</th></tr><tr><td>0x00</td><td>Reserved</td></tr><tr><td>0x01</td><td>1 micro-frame</td></tr><tr><td>0x02</td><td>2 micro-frame</td></tr><tr><td>0x04</td><td>4 micro-frame</td></tr><tr><td>0x08</td><td>8 micro-frame(default, equates to 1 ms)</td></tr><tr><td>0x10</td><td>16 micro-frame(2ms)</td></tr><tr><td>0x20</td><td>32 micro-frame(4ms)</td></tr><tr><td>0x40</td><td>64 micro-frame(8ms)</td></tr></table> Any other value in this register yields undefined results. The default value in this field is 0x08 . Software modifications to this bit while HC Halted bit is equal to zero results in undefined behavior.	Value	Minimum Interrupt Interval	0x00	Reserved	0x01	1 micro-frame	0x02	2 micro-frame	0x04	4 micro-frame	0x08	8 micro-frame(default, equates to 1 ms)	0x10	16 micro-frame(2ms)	0x20	32 micro-frame(4ms)	0x40	64 micro-frame(8ms)
			Value	Minimum Interrupt Interval																	
			0x00	Reserved																	
			0x01	1 micro-frame																	
			0x02	2 micro-frame																	
			0x04	4 micro-frame																	
			0x08	8 micro-frame(default, equates to 1 ms)																	
			0x10	16 micro-frame(2ms)																	
			0x20	32 micro-frame(4ms)																	
			0x40	64 micro-frame(8ms)																	
15:12	/	0	Reserved These bits are reserved and should be set to zero.																		
11	R/W or R	0	Asynchronous Schedule Park Mode Enable(OPTIONAL) If the Asynchronous Park Capability bit in the HCCPARAMS register is a one, then this bit defaults to a 1 and is R/W. Otherwise the bit must be a zero and is Read Only. Software uses this bit to enable or disable Park mode. When this bit is one, Park mode is enabled. When this bit is zero, Park mode is disabled.																		
10	/	0	Reserved These bits are reserved and should be set to zero.																		
9:8	R/W or R	0	Asynchronous Schedule Park Mode Count(OPTIONAL) Asynchronous Park Capability bit in the HCCPARAMS register is a one, Then this field defaults to 0x3 and is W/R. Otherwise it defaults to zero and is R. It contains a count of the number of successive transactions the host controller is allowed to execute from a high-speed queue head on the Asynchronous schedule before continuing traversal of the Asynchronous schedule. Valid value are 0x1 to 0x3. Software must not write a zero to this bit when Park Mode Enable is a one as it will result in undefined behavior.																		

7	R/W	0	Light Host Controller Reset(OPTIONAL) This control bit is not required. If implemented, it allows the driver to reset the EHCI controller without affecting the state of the ports or relationship to the companion host controllers. For example, the PORSTC registers should not be reset to their default values and the CF bit setting should not go to zero (retaining port ownership relationships). A host software read of this bit as zero indicates the Light Host Controller Reset has completed and it si safe for software to re-initialize the host controller. A host software read of this bit as a one indicates the Light Host						
6	R/W	0	Interrupt on Async Advance Doorbell This bit is used as a doorbell by software to tell the host controller to issue an interrupt the next time it advances asynchronous schedule. Soft-Ware must write a 1 to this bit to ring the doorbell. When the host controller has evicted all appropriate cached schedule state, it sets the Interrupt on Async Advance status bit in the USBSTS. if the Interrupt on Async Advance Enable bit in the USBINTR register is a one then the host controller will assert an interrupt at the next interrupt threshold. The host controller sets this bit to a zero after it has set the Interrupt on Async Advance status bit in the USBSTS register to a one. Software should not write a one to this bit when the asynchronous schedule is disabled. Doing so will yield undefined results.						
5	R/W	0	Asynchronous Schedule Enable This bit controls whether the host controller skips processing the Asynchronous Schedule. Values mean: <table><tr><th>Bit Value</th><th>Meaning</th></tr><tr><td>0</td><td>Do not process the Asynchronous Schedule.</td></tr><tr><td>1</td><td>Use the ASYNLISTADDR register to access the Asynchronous Schedule.</td></tr></table> The default value of this field is '0b'.	Bit Value	Meaning	0	Do not process the Asynchronous Schedule.	1	Use the ASYNLISTADDR register to access the Asynchronous Schedule.
Bit Value	Meaning								
0	Do not process the Asynchronous Schedule.								
1	Use the ASYNLISTADDR register to access the Asynchronous Schedule.								
4	R/W	0	Periodic Schedule Enable This bit controls whether the host controller skips processing the Periodic Schedule. Values mean: <table><tr><th>Bit Value</th><th>Meaning</th></tr><tr><td>0</td><td>Do not process the Periodic Schedule.</td></tr><tr><td>1</td><td>Use the PERIODICLISTBASE register to access the Periodic Schedule.</td></tr></table> The default value of this field is '0b'.	Bit Value	Meaning	0	Do not process the Periodic Schedule.	1	Use the PERIODICLISTBASE register to access the Periodic Schedule.
Bit Value	Meaning								
0	Do not process the Periodic Schedule.								
1	Use the PERIODICLISTBASE register to access the Periodic Schedule.								
3:2	R/W or R	0	Frame List Size This field is R/W only if Programmable Frame List Flag in the HCCPARAMS registers is set to a one. This field specifies the size of the Frame list. The size the frame list controls which bits in the Frame Index Register should be used for the Frame List Current index. Values mean: <table><tr><th>Bits</th><th>Meaning</th></tr><tr><td>00b</td><td>1024 elements(4096bytes)Default value</td></tr></table>	Bits	Meaning	00b	1024 elements(4096bytes)Default value		
Bits	Meaning								
00b	1024 elements(4096bytes)Default value								

			01b	512 elements(2048bytes)
			10b	256 elements(1024bytes)For resource-constrained condition
			11b	reserved
			The default value is '00b'.	
1	R/W	0	Host Controller Reset This control bit is used by software to reset the host controller. The effects of this on Root Hub registers are similar to a Chip Hardware Reset. When software writes a one to this bit, the Host Controller resets its internal pipelines, timers, counters, state machines, etc. to their initial value. Any transaction currently in progress on USB is immediately terminated. A USB reset is not driven on downstream ports. All operational registers, including port registers and port state machines are set to their initial values. Port ownership reverts to the companion host controller(s). Software must reinitialize the host controller as described in Section 4.1 of the CHEI Specification in order to return the host controller to an operational state. This bit is set to zero by the Host Controller when the reset process is complete. Software cannot terminate the reset process early by writing a zero to this register. Software should not set this bit to a one when the HC Halted bit in the USBSTS register is a zero. Attempting to reset an actively running host controller will result in undefined behavior.	
0	R/W	0	Run/Stop When set to a 1, the Host Controller proceeds with execution of the schedule. When set to 0, the Host Controller completes the current and any actively pipelined transactions on the USB and then halts. The Host Controller must halt within 16 micro-frames after software clears this bit. The HC Halted bit indicates when the Host Controller has finished its pending pipelined transactions and has entered the stopped state. Software must not write a one to this field unless the Host Controller is in the Halt State. The default value is 0x0.	

7.6.3.5.7. EHCI USB Status Register (Default Value: 0x00001000)

Offset: 0x0014			Register Name: USBSTS
Bit	R/W	Default/Hex	Description
31:16	/	0	Reserved These bits are reserved and should be set to zero.
15	R	0	Asynchronous Schedule Status The bit reports the current real status of Asynchronous Schedule. If this bit is a zero then the status of the Asynchronous Schedule is disabled. If this bit is a one then the status of the Asynchronous Schedule is enabled. The Host

			Controller is not required to immediately disable or enable the Asynchronous Schedule when software transitions the Asynchronous Schedule Enable bit in the USBCMD register. When this bit and the Asynchronous Schedule Enable bit are the same value, the Asynchronous Schedule is either enabled (1) or disabled (0).
14	R	0	Periodic Schedule Status The bit reports the current real status of the Periodic Schedule. If this bit is a zero then the status of the Periodic Schedule is disabled. If this bit is a one then the status of the Periodic Schedule is enabled. The Host Controller is not required to immediately disable or enable the Periodic Schedule when software transitions the Periodic Schedule Enable bit in the USBCMD register. When this bit and the Periodic Schedule Enable bit are the same value, the Periodic Schedule is either enabled (1) or disabled (0).
13	R	0	Reclamation This is a read-only status bit, which is used to detect an empty asynchronous schedule.
12	R	1	HC Halted This bit is a zero whenever the Run/Stop bit is a one. The Host Controller Sets this bit to one after it has stopped executing as a result of the Run/Stop bit being set to 0, either by software or by the Host Controller Hardware (e.g. internal error). The default value is '1'.
11:6	/	0	Reserved These bits are reserved and should be set to zero.
5	R/WC	0	Interrupt on Async Advance System software can force the host controller to issue an interrupt the next time the host controller advances the asynchronous schedule by writing a one to the Interrupt on Async Advance Doorbell bit in the USBCMD register. This status bit indicates the assertion of that interrupt source.
4	R/WC	0	Host System Error The Host Controller set this bit to 1 when a serious error occurs during a host system access involving the Host Controller module. When this error occurs, the Host Controller clears the Run/Stop bit in the Command register to prevent further execution of the scheduled TDs.
3	R/WC	0	Frame List Rollover The Host Controller sets this bit to a one when the Frame List Index rolls over from its maximum value to zero. The exact value at which the rollover occurs depends on the frame list size. For example, if the frame list size is 1024, the Frame Index Register rolls over every time FRINDEX [13] toggles. Similarly, if the size is 512, the Host Controller sets this bit to a one every time FRINDEX [12] toggles.
2	R/WC	0	Port Change Detect The Host Controller sets this bit to a one when any port for which the Port Owner bit is set to zero has a change bit transition from a zero to a one or a Force Port Resume bit transition from a zero to a one as a result of a J-K

			transition detected on a suspended port. This bit will also be set as a result of the Connect Status Chang being set to a one after system software has relinquished ownership of a connected port by writing a one to a port's Port Owner bit.
1	R/WC	0	USB Error Interrupt(USBERRINT) The Host Controller sets this bit to 1 when completion of USB transaction results in an error condition(e.g. error counter underflow).If the TD on which the error interrupt occurred also had its IOC bit set, both. This bit and USBINT bit are set.
0	R/WC	0	USB Interrupt(USBINT) The Host Controller sets this bit to a one on the completion of a USB transaction, which results in the retirement of a Transfer Descriptor that had its IOC bit set. The Host Controller also sets this bit to 1 when a short packet is detected (actual number of bytes received was less than the expected number of bytes)

7.6.3.5.8. EHCI USB Interrupt Enable Register (Default Value: 0x00000000)

Offset: 0x0018			Register Name: USBINTR
Bit	R/W	Default/Hex	Description
31:6	/	0	Reserved These bits are reserved and should be zero.
5	R/W	0	Interrupt on Async Advance Enable When this bit is 1, and the Interrupt on Async Advance bit in the USBSTS register is 1, the host controller will issue an interrupt at the next interrupt threshold. The interrupt is acknowledged by software clearing the Interrupt on Async Advance bit.
4	R/W	0	Host System Error Enable When this bit is 1, and the Host System Error Status bit in the USBSTS register is 1, the host controller will issue an interrupt. The interrupt is acknowledged by software clearing the Host System Error bit.
3	R/W	0	Frame List Rollover Enable When this bit is 1, and the Frame List Rollover bit in the USBSTS register is 1, the host controller will issue an interrupt. The interrupt is acknowledged by software clearing the Frame List Rollover bit.
2	R/W	0	Port Change Interrupt Enable When this bit is 1, and the Port Chang Detect bit in the USBSTS register is 1, the host controller will issue an interrupt. The interrupt is acknowledged by software clearing the Port Chang Detect bit.
1	R/W	0	USB Error Interrupt Enable When this bit is 1, and the USBERRINT bit in the USBSTS register is 1,the host controller will issue an interrupt at the next interrupt threshold. The interrupt is acknowledged by software clearing the USBERRINT bit.

0	R/W	0	USB Interrupt Enable When this bit is 1, and the USBINT bit in the USBSTS register is 1, the host controller will issue an interrupt at the next interrupt threshold. The interrupt is acknowledged by software clearing the USBINT bit
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7.6.3.5.9. EHCI Frame Index Register (Default Value: 0x00000000)

Offset: 0x001C			Register Name: FRINDEX															
Bit	R/W	Default/Hex	Description															
31:14	/	0	Reserved These bits are reserved and should be zero.															
13:0	R/W	0	Frame Index The value in this register increment at the end of each time frame (e.g. micro-frame).Bits[N:3] are used for the Frame List current index. It Means that each location of the frame list is accessed 8 times(frames or Micro-frames) before moving to the next index. The following illustrates Values of N based on the value of the Frame List Size field in the USBCMD register.															
			<table><tr><td>USBCMD[Frame List Size]</td><td>Number Elements</td><td>N</td></tr><tr><td>00b</td><td>1024</td><td>12</td></tr><tr><td>01b</td><td>512</td><td>11</td></tr><tr><td>10b</td><td>256</td><td>10</td></tr><tr><td>11b</td><td>Reserved</td><td></td></tr></table>	USBCMD[Frame List Size]	Number Elements	N	00b	1024	12	01b	512	11	10b	256	10	11b	Reserved	
			USBCMD[Frame List Size]	Number Elements	N													
			00b	1024	12													
			01b	512	11													
10b	256	10																
11b	Reserved																	

Note: This register must be written as a DWord. Byte writes produce undefined results.

7.6.3.5.10. EHCI Periodic Frame List Base Address Register (Default Value: Undefined)

Offset: 0x0024			Register Name: PERIODICLISTBASE
Bit	R/W	Default/Hex	Description
31:12	R/W		Base Address These bits correspond to memory address signals [31:12], respectively. This register contains the beginning address of the Periodic Frame List in the system memory. System software loads this register prior to starting the schedule execution by the Host Controller. The memory structure referenced by this physical memory pointer is assumed to be 4-K byte aligned. The contents of this register are combined with the Frame Index Register (FRINDEX) to enable the Host Controller to step through the Periodic Frame List in sequence.
11:0	/		Reserved Must be written as 0x0 during runtime, the values of these bits are undefined.

Note: Writes must be Dword Writes.

7.6.3.5.11. EHCI Current Asynchronous List Address Register (Default Value: Undefined)

Offset: 0x0028			Register Name: ASYNCLISTADDR
Bit	R/W	Default/Hex	Description
31:5	R/W		Link Pointer (LP) This field contains the address of the next asynchronous queue head to be executed. These bits correspond to memory address signals [31:5], respectively.
4:0	/	/	Reserved These bits are reserved and their value has no effect on operation. Bits in this field cannot be modified by system software and will always return a zero when read.

Note: Write must be DWord Writes.

7.6.3.5.12. EHCI Configure Flag Register (Default Value: 0x00000000)

Offset: 0x0050			Register Name: CONFIGFLAG						
Bit	R/W	Default/Hex	Description						
31:1	/	0	Reserved These bits are reserved and should be set to zero.						
0	R/W	0	Configure Flag(CF) Host software sets this bit as the last action in its process of configuring the Host Controller. This bit controls the default port-routing control logic as follow:						
			<table><tr><td>Value</td><td>Meaning</td></tr><tr><td>0</td><td>Port routing control logic default-routes each port to an implementation dependent classic host controller.</td></tr><tr><td>1</td><td>Port routing control logic default-routes all ports to this host controller.</td></tr></table>	Value	Meaning	0	Port routing control logic default-routes each port to an implementation dependent classic host controller.	1	Port routing control logic default-routes all ports to this host controller.
			Value	Meaning					
			0	Port routing control logic default-routes each port to an implementation dependent classic host controller.					
			1	Port routing control logic default-routes all ports to this host controller.					
The default value of this field is '0'.									

Note: This register is not use in the normal implementation.

7.6.3.5.13. EHCI Port Status and Control Register (Default Value: 0x00002000(w/PPC set to one);0x00003000

(w/PPC set to a zero))

Offset: 0x0054			Register Name: PORTSC
Bit	R/W	Default/Hex	Description

31:22	/	0	Reserved These bits are reserved for future use and should return a value of zero when read.																				
21	R/W	0	Wake on Disconnect Enable(WKDSCNNT_E) Writing this bit to a one enables the port to be sensitive to device disconnects as wake-up events. This field is zero if Port Power is zero. The default value in this field is '0'.																				
20	R/W	0	Wake on Connect Enable(WKCNNT_E) Writing this bit to a one enable the port to be sensitive to device connects as wake-up events. This field is zero if Port Power is zero. The default value in this field is '0'.																				
19:16	R/W	0	Port Test Control The value in this field specifies the test mode of the port. The encoding of the test mode bits are as follow: <table><tr><td>Bits</td><td>Test Mode</td></tr><tr><td>0000b</td><td>The port is NOT operating in a test mode.</td></tr><tr><td>0001b</td><td>Test J_STATE</td></tr><tr><td>0010b</td><td>Test K_STATE</td></tr><tr><td>0011b</td><td>Test SEO_NAK</td></tr><tr><td>0100b</td><td>Test Packet</td></tr><tr><td>0101b</td><td>Test FORCE_ENABLE</td></tr><tr><td>0110b</td><td></td></tr><tr><td>-</td><td>Reserved</td></tr><tr><td>1111b</td><td></td></tr></table> The default value in this field is '0000b'.	Bits	Test Mode	0000b	The port is NOT operating in a test mode.	0001b	Test J_STATE	0010b	Test K_STATE	0011b	Test SEO_NAK	0100b	Test Packet	0101b	Test FORCE_ENABLE	0110b		-	Reserved	1111b	
Bits	Test Mode																						
0000b	The port is NOT operating in a test mode.																						
0001b	Test J_STATE																						
0010b	Test K_STATE																						
0011b	Test SEO_NAK																						
0100b	Test Packet																						
0101b	Test FORCE_ENABLE																						
0110b																							
-	Reserved																						
1111b																							
15:14	R/W	0	Reserved These bits are reserved for future use and should return a value of zero when read.																				
13	R/W	1	Port Owner This bit unconditionally goes to a 0b when the Configured bit in the CONFIGFLAG register makes a 0b to 1b transition. This bit unconditionally goes to 1b whenever the Configured bit is zero. System software uses this field to release ownership of the port to selected host controller (in the event that the attached device is not a high-speed device).Software writes a one to this bit when the attached device is not a high-speed device. A one in this bit means that a companion host controller owns and controls the port. Default Value = 1b.																				
12	/	0	Reserved These bits are reserved for future use and should return a value of zero when read.																				
11:10	R	0	Line Status These bits reflect the current logical levels of the D+ (bit11) and D-(bit10)																				

			signal lines. These bits are used for detection of low-speed USB devices prior to port reset and enable sequence. This read only field is valid only when the port enable bit is zero and the current connect status bit is set to a one. The encoding of the bits are: <table><tr><th>Bit[11:10]</th><th>USB State</th><th>Interpretation</th></tr><tr><td>00b</td><td>SE0</td><td>Not Low-speed device, perform EHCI reset.</td></tr><tr><td>10b</td><td>J-state</td><td>Not Low-speed device, perform EHCI reset.</td></tr><tr><td>01b</td><td>K-state</td><td>Low-speed device, release ownership of port.</td></tr><tr><td>11b</td><td>Undefined</td><td>Not Low-speed device, perform EHCI reset.</td></tr></table> This value of this field is undefined if Port Power is zero.	Bit[11:10]	USB State	Interpretation	00b	SE0	Not Low-speed device, perform EHCI reset.	10b	J-state	Not Low-speed device, perform EHCI reset.	01b	K-state	Low-speed device, release ownership of port.	11b	Undefined	Not Low-speed device, perform EHCI reset.
Bit[11:10]	USB State	Interpretation																
00b	SE0	Not Low-speed device, perform EHCI reset.																
10b	J-state	Not Low-speed device, perform EHCI reset.																
01b	K-state	Low-speed device, release ownership of port.																
11b	Undefined	Not Low-speed device, perform EHCI reset.																
9	/	0	Reserved This bit is reserved for future use, and should return a value of zero when read.															
8	R/W	0	Port Reset 1=Port is in Reset. 0=Port is not in Reset. Default value = 0. When software writes a one to this bit (from a zero), the bus reset sequence as defined in the USB Specification Revision 2.0 is started. Software writes a zero to this bit to terminate the bus reset sequence. Software must keep this bit at a one long enough to ensure the reset sequence, as specified in the USB Specification Revision 2.0, completes. Notes: when software writes this bit to a one , it must also write a zero to the Port Enable bit. Note that when software writes a zero to this bit there may be a delay before the bit status changes to a zero. The bit status will not read as a zero until after the reset has completed. If the port is in high-speed mode after reset is complete, the host controller will automatically enable this port (e.g. set the Port Enable bit to a one). A host controller must terminate the reset and stabilize the state of the port within 2 milliseconds of software transitioning this bit from a one to a zero. For example: if the port detects that the attached device is high-speed during reset, then the host controller must have the port in the enabled state with 2ms of software writing this bit to a zero. The HC Halted bit in the USBSTS register should be a zero before software attempts to use this bit. The host controller may hold Port Reset asserted to a one when the HC Halted bit is a one. This field is zero if Port Power is zero.															
7	R/W	0	Suspend Port Enabled Bit and Suspend bit of this register define the port states as follows: <table><tr><th>Bits[Port Enables, Suspend]</th><th>Port State</th></tr><tr><td>0x</td><td>Disable</td></tr><tr><td>10</td><td>Enable</td></tr></table>	Bits[Port Enables, Suspend]	Port State	0x	Disable	10	Enable									
Bits[Port Enables, Suspend]	Port State																	
0x	Disable																	
10	Enable																	

			11 Suspend When in suspend state, downstream propagation of data is blocked on this port, except for port reset. The blocking occurs at the end of the current transaction, if a transaction was in progress when this bit was written to 1. In the suspend state, the port is sensitive to resume detection. Not that the bit status does not change until the port is suspend and that there may be a delay in suspending a port if there is a transaction currently in progress on the USB. A write of zero to this bit is ignored by the host controller. The host controller will unconditionally set this bit to a zero when: ① Software sets the Force Port Resume bit to a zero(from a one). ② Software sets the Port Reset bit to a one(from a zero). If host software sets this bit to a one when the port is not enabled(i.e. Port enabled bit is a zero), the results are undefined. This field is zero if Port Power is zero. The default value in this field is '0'.
6	R/W	0	Force Port Resume 1 = Resume detected/driven on port. 0 = No resume (K-state) detected/driven on port. Default value = 0. This functionality defined for manipulating this bit depends on the value of the Suspend bit. For example, if the port is not suspend and software transitions this bit to a one, then the effects on the bus are undefined. Software sets this bit to a 1 drive resume signaling. The Host Controller sets this bit to a 1 if a J-to-K transition is detected while the port is in the Suspend state. When this bit transitions to a one because a J-to-K transition is detected, the Port Change Detect bit in the USBSTS register is also set to a one. If software sets this bit to a one, the host controller must not set the Port Change Detect bit. Note that when the EHCI controller owns the port, the resume sequence follows the defined sequence documented in the USB Specification Revision 2.0. The resume signaling (Full-speed 'K') is driven on the port as long as this remains a one. Software must appropriately time the Resume and set this bit to a zero when the appropriate amount of time has elapsed. Writing a zero (from one) causes the port to return high-speed mode (forcing the bus below the port into a high-speed idle). This bit will remain a one until the port has switched to high-speed idle. The host controller must complete this transition within 2 milliseconds of software setting this bit to a zero. This field is zero if Port Power is zero.
5	R/WC	0	Over-current Change Default = 0. This bit gets set to a one when there is a change to Over-current Active. Software clears this bit by writing a one to this bit position.
4	R	0	Over-current Active 0 = This port does not have an over-current condition. 1 = This port currently has an over-current condition. This bit will automatically transition from a one to a zero when the over current condition is removed.

			The default value of this bit is '0'.
3	R/WC	0	Port Enable/Disable Change Default = 0. 1 = Port enabled/disabled status has changed. 0 = No change. For the root hub, this bit gets set to a one only when a port is disabled due to the appropriate conditions existing at the EOF2 point (See Chapter 11 of the USB Specification for the definition of a Port Error). Software clears this bit by writing a 1 to it. This field is zero if Port Power is zero.
2	R/W	0	Port Enabled/Disabled 1=Enable, 0=Disable. Ports can only be enabled by the host controller as a part of the reset and enable. Software cannot enable a port by writing a one to this field. The host controller will only set this bit to a one when the reset sequence determines that the attached device is a high-speed device. Ports can be disabled by either a fault condition(disconnect event or other fault condition) or by host software. Note that the bit status does not change until the port state actually changes. There may be a delay in disabling or enabling a port due to other host controller and bus events. When the port is disabled, downstream propagation of data is blocked on this port except for reset. The default value of this field is '0'. This field is zero if Port Power is zero.
1	R/WC	0	Connect Status Change 1=Change in Current Connect Status, 0=No change, Default=0. Indicates a change has occurred in the port's Current Connect Status. The host controller sets this bit for all changes to the port device connect status, even if system software has not cleared an existing connect status change. For example, the insertion status changes twice before system software has cleared the changed condition, hub hardware will be "setting" an already-set bit. Software sets this bit to 0 by writing a 1 to it. This field is zero if Port Power is zero.
0	R	0	Current Connect Status Device is present on port when the value of this field is a one, and no device is present on port when the value of this field is a zero. This value reflects the current state of the port, and may not correspond directly to the event that caused the Connect Status Change(Bit 1) to be set. This field is zero if Port Power zero.

Note: This register is only reset by hardware or in response to a host controller reset.

7.6.3.6. OHCI Register Description

7.6.3.6.1. HcRevision Register(Default Value: 0x10)

Offset: 0x400				Register Name: HcRevision
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31:8	/	/	0x00	Reserved
7:0	R	R	0x10	Revision This read-only field contains the BCD representation of the version of the HCI specification that is implemented by this HC. For example, a value of 0x11 corresponds to version 1.1. All of the HC implementations that are compliant with this specification will have a value of 0x10.

7.6.3.6.2. HcControl Register(Default Value: 0x0)

Offset: 0x404				Register Name: HcRevision			
Bit	Read/Write		Default/HEX	Description			
	HCD	HC					
31:11	/	/	0x00	Reserved			
10	R/W	R	0x0	RemoteWakeupEnable This bit is used by HCD to enable or disable the remote wakeup feature upon the detection of upstream resume signaling. When this bit is set and the ResumeDetected bit in HcInterruptStatus is set, a remote wakeup is signaled to the host system. Setting this bit has no impact on the generation of hardware interrupt.			
9	R/W	R/W	0x0	RemoteWakeupConnected This bit indicates whether HC supports remote wakeup signaling. If remote wakeup is supported and used by the system, it is the responsibility of system firmware to set this bit during POST. HC clear the bit upon a hardware reset but does not alter it upon a software reset. Remote wakeup signaling of the host system is host-bus-specific and is not described in this specification.			
8	R/W	R	0x0	InterruptRouting This bit determines the routing of interrupts generated by events registered in HcInterruptStatus. If clear, all interrupt are routed to the normal host bus interrupt mechanism. If set interrupts are routed to the System Management Interrupt. HCD clears this bit upon a hardware reset, but it does not alter this bit upon a software reset. HCD uses this bit as a tag to indicate the ownership of HC.			
7:6	R/W	R/W	0x0	HostControllerFunctionalState for USB <table><tr><td>00b</td><td>USBReset</td></tr></table>		00b	USBReset
00b	USBReset						

				01b	USBResume
				10b	USBOperational
				11b	USBSuspend
				A transition to USBOperational from another state causes SOF generation to begin 1 ms later. HCD may determine whether HC has begun sending SOFs by reading the StartoFrame field of HcInterruptStatus. This field may be changed by HC only when in the USBSUSPEND state. HC may move from the USBSUSPEND state to the USBRESUME state after detecting the resume signaling from a downstream port. HC enters USBSUSPEND after a software reset, whereas it enters USBRESET after a hardware reset. The latter also resets the Root Hub and asserts subsequent reset signaling to downstream ports.	
5	R/W	R	0x0	BulkListEnable This bit is set to enable the processing of the Bulk list in the next Frame. If cleared by HCD, processing of the Bulk list does not occur after the next SOF. HC checks this bit whenever it determines to process the list. When disabled, HCD may modify the list. If HcBulkCurrentED is pointing to an ED to be removed, HCD must advance the pointer by updating HcBulkCurrentED before re-enabling processing of the list.	
4	R/W	R	0x0	ControlListEnable This bit is set to enable the processing of the Control list in the next Frame. If cleared by HCD, processing of the Control list does not occur after the next SOF. HC must check this bit whenever it determines to process the list. When disabled, HCD may modify the list. If HcControlCurrentED is pointing to an ED to be removed, HCD must advance the pointer by updating HcControlCurrentED before re-enabling processing of the list.	
3	R/W	R	0x0	IsochronousEnable This bit is used by HCD to enable/disable processing of isochronous EDs. While processing the periodic list in a Frame, HC checks the status of this bit when it finds an Isochronous ED (F=1). If set (enabled), HC continues processing the EDs. If cleared (disabled), HC halts processing of the periodic list (which now contains only isochronous EDs) and begins processing the Bulk/Control lists. Setting this bit is guaranteed to take effect in the next Frame (not the current Frame).	
2	R/W	R	0x0	PeriodicListEnable This bit is set to enable the processing of periodic list in the next Frame. If cleared by HCD, processing of the periodic list does not occur after the next SOF. HC must check this bit before it starts processing the list.	
1:0	R/W	R	0x0	ControlBulkServiceRatio This specifies the service ratio between Control and Bulk EDs. Before processing any of the nonperiodic lists, HC must compare the ratio specified with its internal count on how many nonempty Control EDs have been processed, in determining whether to continue serving another	

				Control ED or switching to Bulk EDs. The internal count will be retained when crossing the frame boundary. In case of reset, HCD is responsible for restoring this value.										
				<table><tr><td>CBSR</td><td>No. of Control EDs Over Bulk EDs Served</td></tr><tr><td>0</td><td>1:1</td></tr><tr><td>1</td><td>2:1</td></tr><tr><td>2</td><td>3:1</td></tr><tr><td>3</td><td>4:1</td></tr></table>	CBSR	No. of Control EDs Over Bulk EDs Served	0	1:1	1	2:1	2	3:1	3	4:1
CBSR	No. of Control EDs Over Bulk EDs Served													
0	1:1													
1	2:1													
2	3:1													
3	4:1													
				The default value is 0x0.										

7.6.3.6.3. HcCommandStatus Register(Default Value: 0x0)

Offset: 0x408				Register Name: HcCommandStatus
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31:18	/	/	0x0	Reserved
17:16	R	R/W	0x0	SchedulingOverrunCount These bits are incremented on each scheduling overrun error. It is initialized to 00b and wraps around at 11b. This will be incremented when a scheduling overrun is detected even if SchedulingOverrun in HcInterruptStatus has already been set. This is used by HCD to monitor any persistent scheduling problem.
15:4	/	/	0x0	Reserved
3	R/W	R/W	0x0	OwnershipChangeRequest This bit is set by an OS HCD to request a change of control of the HC. When set HC will set the OwnershipChange field in HcInterruptStatus. After the changeover, this bit is cleared and remains so until the next request from OS HCD.
2	R/W	R/W	0x0	BulkListFilled This bit is used to indicate whether there are any TDs on the Bulk list. It is set by HCD whenever it adds a TD to an ED in the Bulk list. When HC begins to process the head of the Bulk list, it checks BLF. As long as BulkListFilled is 0, HC will not start processing the Bulk list. If BulkListFilled is 1, HC will start processing the Bulk list and will set BF to 0. If HC finds a TD on the list, then HC will set BulkListFilled to 1 causing the Bulk list processing to continue. If no TD is found on the Bulk list, and if HCD does not set BulkListFilled, then BulkListFilled will still be 0 when HC completes processing the Bulk list and Bulk list processing will stop.
1	R/W	R/W	0x0	ControlListFilled This bit is used to indicate whether there are any TDs on the Control list. It is set by HCD whenever it adds a TD to an ED in the Control list. When HC begins to process the head of the Control list, it checks CLF. As long as ControlListFilled is 0, HC will not start processing the Control list. If

				CF is 1, HC will start processing the Control list and will set ControlListFilled to 0. If HC finds a TD on the list, then HC will set ControlListFilled to 1 causing the Control list processing to continue. If no TD is found on the Control list, and if the HCD does not set ControlListFilled, then ControlListFilled will still be 0 when HC completes processing the Control list and Control list processing will stop.
0	R/W	R/E	0x0	HostControllerReset This bit is by HCD to initiate a software reset of HC. Regardless of the functional state of HC, it moves to the USBSuspend state in which most of the operational registers are reset except those stated otherwise; e.g, the InterruptRouting field of HcControl, and no Host bus accesses are allowed. This bit is cleared by HC upon the completion of the reset operation. The reset operation must be completed within 10 ms. This bit, when set, should not cause a reset to the Root Hub and no subsequent reset signaling should be asserted to its downstream ports.

7.6.3.6.4. HcInterruptStatus Register(Default Value: 0x0)

Offset: 0x40c				Register Name: HcInterruptStatus
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31:7	/	/	0x0	Reserved
6	R/W	R/W	0x0 0x1 ?	RootHubStatusChange This bit is set when the content of HcRhStatus or the content of any of HcRhPortStatus[NumberOfDownstreamPort] has changed.
5	R/W	R/W	0x0	FrameNumberOverflow This bit is set when the MSb of HcFmNumber (bit 15) changes value, from 0 to 1 or from 1 to 0, and after HccaFrameNumber has been updated.
4	R/W	R/W	0x0	UnrecoverableError This bit is set when HC detects a system error not related to USB. HC should not proceed with any processing nor signaling before the system error has been corrected. HCD clears this bit after HC has been reset.
3	R/W	R/W	0x0	ResumeDetected This bit is set when HC detects that a device on the USB is asserting resume signaling. It is the transition from no resume signaling to resume signaling causing this bit to be set. This bit is not set when HCD sets the USBRseume state.
2	R/W	R/W	0x0	StartofFrame This bit is set by HC at each start of frame and after the update of HccaFrameNumber. HC also generates a SOF token at the same time.
1	R/W	R/W	0x0	WritebackDoneHead This bit is set immediately after HC has written HcDoneHead to HccaDoneHead. Further updates of the HccaDoneHead will not occur until this bit has been cleared. HCD should only clear this bit after it has saved

				the content of HccaDoneHead.
0	R/W	R/W	0x0	SchedulingOverrun This bit is set when the USB schedule for the current Frame overruns and after the update of HccaFrameNumber. A scheduling overrun will also cause the SchedulingOverrunCount of HcCommandStatus to be Incremented.

7.6.3.6.5. HcInterruptEnable Register(Default Value: 0x0)

Offset: 0x410				Register Name: HcInterruptEnable Register	
Bit	Read/Write		Default	Description	
	HCD	HC			
31	R/W	R	0x0	MasterInterruptEnable A '0' writtern to this field is ignored by HC. A '1' written to this field enables interrupt generation due to events specified in the other bits of this register. This is used by HCD as Master Interrupt Enable.	
30:7	/	/	0x0	Reserved	
6	R/W	R	0x0	RootHubStatusChange Interrupt Enable	
				0	Ignore;
				1	Enable interrupt generation due to Root Hub Status Change;
5	R/W	R	0x0	FrameNumberOverflow Interrupt Enable	
				0	Ignore;
				1	Enable interrupt generation due to Frame Number Over Flow;
4	R/W	R	0x0	UnrecoverableError Interrupt Enable	
				0	Ignore;
				1	Enable interrupt generation due to Unrecoverable Error;
3	R/W	R	0x0	ResumeDetected Interrupt Enable	
				0	Ignore;
				1	Enable interrupt generation due to Resume Detected;
2	R/W	R	0x0	StartofFrame Interrupt Enable	
				0	Ignore;
				1	Enable interrupt generation due to Start of Flame;
1	R/W	R	0x0	WritebackDoneHead Interrupt Enable	
				0	Ignore;
				1	Enable interrupt generation due to Write back Done Head;
0	R/W	R	0x0	SchedulingOverrun Interrupt Enable	
				0	Ignore;
				1	Enable interrupt generation due to Scheduling Overrun;

7.6.3.6.6. HcInterruptDisable Register(Default Value: 0x0)

Offset: 0x414				Register Name: HcInterruptDisable Register
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31	R/W	R	0x0	MasterInterruptEnable A written '0' to this field is ignored by HC. A '1' written to this field disables interrupt generation due events specified in the other bits of this register. This field is set after a hardware or software reset.
30:7	/	/	0x00	Reserved
6	R/W	R	0x0	RootHubStatusChange Interrupt Disable
				0 Ignore; 1 Disable interrupt generation due to Root Hub Status Change;
5	R/W	R	0x0	FrameNumberOverflow Interrupt Disable
				0 Ignore; 1 Disable interrupt generation due to Frame Number Over Flow;
4	R/W	R	0x0	UnrecoverableError Interrupt Disable
				0 Ignore; 1 Disable interrupt generation due to Unrecoverable Error;
3	R/W	R	0x0	ResumeDetected Interrupt Disable
				0 Ignore; 1 Disable interrupt generation due to Resume Detected;
2	R/W	R	0x0	StartofFrame Interrupt Disable
				0 Ignore; 1 Disable interrupt generation due to Start of Flame;
1	R/W	R	0x0	WritebackDoneHead Interrupt Disable
				0 Ignore; 1 Disable interrupt generation due to Write back Done Head;
0	R/w	R	0x0	SchedulingOverrun Interrupt Disable
				0 Ignore; 1 Disable interrupt generation due to Scheduling Overrun;

7.6.3.6.7. HcHCCA Register(Default Value: 0x0)

Offset: 0x418				Register Name: HcHCCA
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31:8	R/W	R	0x0	HCCA[31:8] This is the base address of the Host Controller Communication Area. This area is used to hold the control structures and the Interrupt table that are accessed by both the Host Controller and the Host Controller Driver.
7:0	R	R	0x0	HCCA[7:0]

				The alignment restriction in HcHCCA register is evaluated by examining the number of zeros in the lower order bits. The minimum alignment is 256 bytes, therefore, bits 0 through 7 must always return 0 when read.
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7.6.3.6.8. HcPeriodCurrentED Register(Default Value: 0x0)

Offset: 0x41c				Register Name: HcPeriodCurrentED(PCED)
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31:4	R	R/W	0x0	PCED[31:4] This is used by HC to point to the head of one of the Periodic list which will be processed in the current Frame. The content of this register is updated by HC after a periodic ED has been processed. HCD may read the content in determining which ED is currently being processed at the time of reading.
3:0	R	R	0x0	PCED[3:0] Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.

7.6.3.6.9. HcControlHeadED Register(Default Value: 0x0)

Offset: 0x420				Register Name: HcControlHeadED[CHCD]
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31:4	R/W	R	0x0	EHCD[31:4] The HcControlHeadED register contains the physical address of the first Endpoint Descriptor of the Control list. HC traverse the Control list starting with the HcControlHeadED pointer. The content is loaded from HCCA during the initialization of HC.
3:0	R	R	0x0	EHCD[3:0] Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.

7.6.3.6.10. HcControlCurrentED Register(Default Value: 0x0)

Offset: 0x424				Register Name: HcControlCurrentED[CCED]
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31:4	R/W	R/W	0x0	CCED[31:4]

				The pointer is advanced to the next ED after serving the present one. HC will continue processing the list from where it left off in the last Frame. When it reaches the end of the Control list, HC checks the ControlListFilled of in HcCommandStatus. If set, it copies the content of HcControlHeadED to HcControlCurrentED and clears the bit. If not set, it does nothing. HCD is allowed to modify this register only when the ControlListEnable of HcControl is cleared. When set, HCD only reads the instantaneous value of this register. Initially, this is set to zero to indicate the end of the Control list.
3:0	R	R	0x0	CCED[3:0] Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.

7.6.3.6.11. HcBulkHeadED Register(Default Value: 0x0)

Offset: 0x428				Register Name: HcBulkHeadED[BHED]
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31:4	R/W	R	0x0	BHED[31:4] The HcBulkHeadED register contains the physical address of the first Endpoint Descriptor of the Bulk list. HC traverses the Bulk list starting with the HcBulkHeadED pointer. The content is loaded from HCCA during the initialization of HC.
3:0	R	R	0x0	BHED[3:0] Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.

7.6.3.6.12. HcBulkCurrentED Register(Default Value: 0x0)

Offset: 0x42c				Register Name: HcBulkCurrentED [BCED]
Bit	Read/Write		Default/HEX	Description
	HCD	HC		
31:4	R/W	R/W	0x0	BulkCurrentED[31:4] This is advanced to the next ED after the HC has served the present one. HC continues processing the list from where it left off in the last Frame. When it reaches the end of the Bulk list, HC checks the ControlListFilled of HcControl. If set, it copies the content of HcBulkHeadED to HcBulkCurrentED and clears the bit. If it is not set, it does nothing. HCD is only allowed to modify this register when the BulkListEnable of HcControl

				is cleared. When set, the HCD only reads the instantaneous value of this register. This is initially set to zero to indicate the end of the Bulk list.
3:0	R	R	0x0	BulkCurrentED [3:0] Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.

7.6.3.6.13. HcDoneHead Register(Default Value: 0x0)

Offset: 0x430				Register Name: HcDoneHead
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31:4	R	R/W	0x0	HcDoneHead[31:4] When a TD is completed, HC writes the content of HcDoneHead to the NextTD field of the TD. HC then overwrites the content of HcDoneHead with the address of this TD. This is set to zero whenever HC writes the content of this register to HCCA. It also sets the WritebackDoneHead of HcInterruptStatus.
3:0	R	R	0x0	HcDoneHead[3:0] Because the general TD length is 16 bytes, the memory structure for the TD must be aligned to a 16-byte boundary. So the lower bits in the PCED, through bit 0 to bit 3 must be zero in this field.

7.6.3.6.14. HcFmInterval Register(Default Value: 0x2EDF)

Offset: 0x434				Register Name: HcFmInterval Register
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31	R/W	R	0x0	FrameIntervalToggler HCD toggles this bit whenever it loads a new value to FrameInterval.
30:16	R/W	R	0x0	FSLargestDataPacket This field specifies a value which is loaded into the Largest Data Packet Counter at the beginning of each frame. The counter value represents the largest amount of data in bits which can be sent or received by the HC in a single transaction at any given time without causing scheduling overrun. The field value is calculated by the HCD.
15:14	/	/	0x0	Reserved
13:0	R/W	R	0x2edf	FrameInterval This specifies the interval between two consecutive SOFs in bit times. The nominal value is set to be 11,999. HCD should store the current value of this field before resetting HC. By setting the HostControllerReset field of HcCommandStatus as this will cause the HC to reset this field to its nominal value. HCD may choose to restore the stored value upon the

			completion of the Reset sequence.
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7.6.3.6.15. HcFmRemaining Register(Default Value: 0x0)

Offset: 0x438				Register Name: HcFmRemaining
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31	R	R/W	0x0	FrameRemaining Toggle This bit is loaded from the FrameIntervalToggle field of HcFmInterval whenever FrameRemaining reaches 0. This bit is used by HCD for the synchronization between FrameInterval and FrameRemaining.
30:14	/	/	0x0	Reserved
13:0	R	RW	0x0	FramRemaining This counter is decremented at each bit time. When it reaches zero, it is reset by loading the FrameInterval value specified in HcFmInterval at the next bit time boundary. When entering the USBOPERATIONAL state, HC re-loads the content with the FrameInterval of HcFmInterval and uses the updated value from the next SOF.

7.6.3.6.16. HcFmNumber Register(Default Value: 0x0)

Offset: 0x43c				Register Name: HcFmNumber
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31:16				Reserved
15:0	R	R/W	0x0	FrameNumber This is incremented when HcFmRemaining is re-loaded. It will be rolled over to 0x0 after 0x0ffff. When entering the USBOPERATIONAL state, this will be incremented automatically. The content will be written to HCCA after HC has incremented the FrameNumber at each frame boundary and sent a SOF but before HC reads the first ED in that Frame. After writing to HCCA, HC will set the StartofFrame in HcInterruptStatus.

7.6.3.6.17. HcPeriodicStart Register(Default Value: 0x0)

Offset: 0x440				Register Name: HcPeriodicStatus
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31:14				Reserved

13:0	R/W	R	0x0	PeriodicStart After a hardware reset, this field is cleared. This is then set by HCD during the HC initialization. The value is calculated roughly as 10% off from HcFmInterval. A typical value will be 0x2A3F (0x3e67??). When HcFmRemaining reaches the value specified, processing of the periodic lists will have priority over Control/Bulk processing. HC will therefore start processing the Interrupt list after completing the current Control or Bulk transaction that is in progress.
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7.6.3.6.18. HcLSThreshold Register(Default Value: 0x0628)

Offset: 0x444				Register Name: HcLSThreshold
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31:12				Reserved
11:0	R/W	R	0x0628	LSThreshold This field contains a value which is compared to the FrameRemaining field prior to initiating a Low Speed transaction. The transaction is started only if FrameRemaining ³ this field. The value is calculated by HCD with the consideration of transmission and setup overhead.

7.6.3.6.19. HcRhDescriptorA Register(Default Value: 0x0200_1201)

Offset: 0x448			Register Name: HcRhDescriptorA	
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31:24	R/W	R	0x2	PowerOnToPowerGoodTime[POTPGT] This byte specifies the duration HCD has to wait before accessing a powered-on port of the Root Hub. It is implementation-specific. The unit of time is 2 ms. The duration is calculated as POTPGT * 2ms.
23:13				Reserved
12	R/W	R	1	NoOverCurrentProtection This bit describes how the overcurrent status for the Root Hub ports are reported. When this bit is cleared, the OverCurrentProtectionMode field specifies global or per-port reporting.
				0 Over-current status is reported collectively for all downstream ports.
				1 No overcurrent protection supported.
11	R/W	R	0	OverCurrentProtectionMode This bit describes how the overcurrent status for the Root Hub ports are reported. At reset, these fields should reflect the same mode as PowerSwitchingMode. This field is valid only if the

				NoOverCurrentProtection field is cleared. <table><tr><td>0</td><td>Over-current status is reported collectively for all downstream ports.</td></tr><tr><td>1</td><td>Over-current status is reported on per-port basis.</td></tr></table>	0	Over-current status is reported collectively for all downstream ports.	1	Over-current status is reported on per-port basis.
0	Over-current status is reported collectively for all downstream ports.							
1	Over-current status is reported on per-port basis.							
10	R	R	0x0	Device Type This bit specifies that the Root Hub is not a compound device. The Root Hub is not permitted to be a compound device. This field should always read/write 0.				
9	R/W	R	1	PowerSwitchingMode This bit is used to specify how the power switching of the Root Hub ports is controlled. It is implementation-specific. This field is only valid if the NoPowerSwitching field is cleared. <table><tr><td>0</td><td>All ports are powered at the same time.</td></tr><tr><td>1</td><td>Each port is powered individually. This mode allows port power to be controlled by either the global switch or per-port switching. If the PortPowerControlMask bit is set, the port responds only to port power commands (Set/ClearPortPower). If the port mask is cleared, then the port is controlled only by the global power switch (Set/ClearGlobalPower).</td></tr></table>	0	All ports are powered at the same time.	1	Each port is powered individually. This mode allows port power to be controlled by either the global switch or per-port switching. If the PortPowerControlMask bit is set, the port responds only to port power commands (Set/ClearPortPower). If the port mask is cleared, then the port is controlled only by the global power switch (Set/ClearGlobalPower).
0	All ports are powered at the same time.							
1	Each port is powered individually. This mode allows port power to be controlled by either the global switch or per-port switching. If the PortPowerControlMask bit is set, the port responds only to port power commands (Set/ClearPortPower). If the port mask is cleared, then the port is controlled only by the global power switch (Set/ClearGlobalPower).							
8	R/W	R	0	NoPowerSwitcing These bits are used to specify whether power switching is supported or ports are always powered. It is implementation-specific. When this bit is cleared, the PowerSwitchingMode specifies global or per-port switching. <table><tr><td>0</td><td>Ports are power switched.</td></tr><tr><td>1</td><td>Ports are always powered on when the HC is powered on.</td></tr></table>	0	Ports are power switched.	1	Ports are always powered on when the HC is powered on.
0	Ports are power switched.							
1	Ports are always powered on when the HC is powered on.							
7:0	R	R	0x01	NumberDownstreamPorts These bits specify the number of downstream ports supported by the Root Hub. It is implementation-specific. The minimum number of ports is 1. The maximum number of ports supported.				

7.6.3.6.20. HcRhDescriptorB Register(Default Value: 0x0)

Offset: 0x44c				Register Name: HcRhDescriptorB Register
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31:16	R/W	R	0x0	PortPowerControlMask Each bit indicates if a port is affected by a global power control command when PowerSwitchingMode is set. When set, the port's power state is only affected by per-port power control (Set/ClearPortPower). When cleared, the port is controlled by the global power switch (Set/ClearGlobalPower). If the device is configured to global switching mode (PowerSwitchingMode = 0), this field is not valid.

				Bit0	Reserved
				Bit1	Ganged-power mask on Port #1.
				Bit2	Ganged-power mask on Port #2.
				...	
				Bit15	Ganged-power mask on Port #15.
15:0	R/W	R	0x0	DeviceRemovable	
				Each bit is dedicated to a port of the Root Hub. When cleared, the attached device is removable. When set, the attached device is not removable.	
				Bit0	Reserved
				Bit1	Device attached to Port #1.
				Bit2	Device attached to Port #2.
				...	
				Bit15	Device attached to Port #15.

7.6.3.6.21. HcRhStatus Register(Default Value: 0x0)

Offset: 0x450				Register Name: HcRhStatus Register				
Bit	Read/Write		Default/Hex	Description				
	HCD	HC						
31	W	R	0	(write)ClearRemoteWakeupEnable Write a '1' clears DeviceRemoteWakeupEnable. Write a '0' has no effect.				
30:18	/	/	0x0	Reserved				
17	R/W	R	0	OverCurrentIndicatorChang This bit is set by hardware when a change has occurred to the OverCurrentIndicator field of this register. The HCD clears this bit by writing a '1'.Writing a '0' has no effect.				
16	R/W	R	0x0	(read)LocalPowerStartusChange The Root Hub does not support the local power status features, thus, this bit is always read as '0'. (write)SetGlobalPower In global power mode (PowerSwitchingMode=0), This bit is written to '1' to turn on power to all ports (clear PortPowerStatus). In per-port power mode, it sets PortPowerStatus only on ports whose PortPowerControlMask bit is not set. Writing a '0' has no effect.				
15	R/W	R	0x0	(read)DeviceRemoteWakeupEnable This bit enables a ConnectStatusChange bit as a resume event, causing a USBSUSPEND to USBRESUME state transition and setting the ResumeDetected interrupt. <table><tr><td>0</td><td>ConnectStatusChange is not a remote wakeup event.</td></tr><tr><td>1</td><td>ConnectStatusChange is a remote wakeup event.</td></tr></table>	0	ConnectStatusChange is not a remote wakeup event.	1	ConnectStatusChange is a remote wakeup event.
0	ConnectStatusChange is not a remote wakeup event.							
1	ConnectStatusChange is a remote wakeup event.							

				(write)SetRemoteWakeupEnable Writing a '1' sets DeviceRemoveWakeupEnable. Writing a '0' has no effect.
14:2				Reserved
1	R	R/W	0x0	OverCurrentIndicator This bit reports overcurrent conditions when the global reporting is implemented. When set, an overcurrent condition exists. When cleared, all power operations are normal. If per-port overcurrent protection is implemented this bit is always '0'
0	R/W	R	0x0	(Read)LocalPowerStatus When read, this bit returns the LocalPowerStatus of the Root Hub. The Root Hub does not support the local power status feature; thus, this bit is always read as '0'. (Write)ClearGlobalPower When write, this bit is operated as the ClearGlobalPower. In global power mode (PowerSwitchingMode=0), This bit is written to '1' to turn off power to all ports (clear PortPowerStatus). In per-port power mode, it clears PortPowerStatus only on ports whose PortPowerControlMask bit is not set. Writing a '0' has no effect.

7.6.3.6.22. HcRhPortStatus Register(Default Value: 0x100)

Offset: 0x454				Register Name: HcRhPortStatus
Bit	Read/Write		Default/Hex	Description
	HCD	HC		
31:21	/	/	0x0	Reserved
20	R/W	R/W	0x0	PortResetStatusChange This bit is set at the end of the 10-ms port reset signal. The HCD writes a '1' to clear this bit. Writing a '0' has no effect.
				0 port reset is not complete
				1 port reset is complete
19	R/W	R/W	0x0	PortOverCurrentIndicatorChange This bit is valid only if overcurrent conditions are reported on a per-port basis. This bit is set when Root Hub changes the PortOverCurrentIndicator bit. The HCD writes a '1' to clear this bit. Writing a '0' has no effect.
				0 no change in PortOverCurrentIndicator
				1 PortOverCurrentIndicator has changed
18	R/W	R/W	0x0	PortSuspendStatusChange This bit is set when the full resume sequence has been completed. This sequence includes the 20-s resume pulse, LS EOP, and 3-ms resynchronization delay. The HCD writes a '1' to clear this bit. Writing a '0' has no effect. This bit is also cleared when ResetStatusChange is set.

				<table><tr><td>0</td><td>resume is not completed</td></tr><tr><td>1</td><td>resume completed</td></tr></table>	0	resume is not completed	1	resume completed
0	resume is not completed							
1	resume completed							
17	R/W	R/W	0x0	PortEnableStatusChange This bit is set when hardware events cause the PortEnableStatus bit to be cleared. Changes from HCD writes do not set this bit. The HCD writes a '1' to clear this bit. Writing a '0' has no effect. <table><tr><td>0</td><td>no change in PortEnableStatus</td></tr><tr><td>1</td><td>change in PortEnableStatus</td></tr></table>	0	no change in PortEnableStatus	1	change in PortEnableStatus
0	no change in PortEnableStatus							
1	change in PortEnableStatus							
16	R/W	R/W	0x0	ConnectStatusChange This bit is set whenever a connect or disconnect event occurs. The HCD writes a '1' to clear this bit. Writing a '0' has no effect. If CurrentConnectStatus is cleared when a SetPortReset, SetPortEnable, or SetPortSuspend write occurs, this bit is set to force the driver to re-evaluate the connection status since these writes should not occur if the port is disconnected. <table><tr><td>0</td><td>no change in PortEnableStatus</td></tr><tr><td>1</td><td>change in PortEnableStatus</td></tr></table> Note: If the DeviceRemovable[NDP] bit is set, this bit is set only after a Root Hub reset to inform the system that the device is attached.	0	no change in PortEnableStatus	1	change in PortEnableStatus
0	no change in PortEnableStatus							
1	change in PortEnableStatus							
15:10	/	/	0x0	Reserved				
				(read)LowSpeedDeviceAttached This bit indicates the speed of the device attached to this port. When set, a Low Speed device is attached to this port. When clear, a Full Speed device is attached to this port. This field is valid only when the CurrentConnectStatus is set. <table><tr><td>0</td><td>full speed device attached</td></tr><tr><td>1</td><td>low speed device attached</td></tr></table>	0	full speed device attached	1	low speed device attached
0	full speed device attached							
1	low speed device attached							
9	R/W	R/W	-	(write)ClearPortPower The HCD clears the PortPowerStatus bit by writing a '1' to this bit. Writing a '0' has no effect.				
8	R/W	R/W	0x1	(read)PortPowerStatus This bit reflects the port's power status, regardless of the type of power switching implemented. This bit is cleared if an overcurrent condition is detected. HCD sets this bit by writing SetPortPower or SetGlobalPower. HCD clears this bit by writing ClearPortPower or ClearGlobalPower. Which power control switches are enabled is determined by PowerSwitchingMode and PortPortControlMask[NumberDownstreamPort]. In global switching mode(PowerSwitchingMode=0), only Set/ClearGlobalPower controls this bit. In per-port power switching (PowerSwitchingMode=1), if the PortPowerControlMask[NDP] bit for the port is set, only Set/ClearPortPower commands are enabled. If the mask is not set, only				

				Set/ClearGlobalPower commands are enabled. When port power is disabled, CurrentConnectStatus, PortEnableStatus, PortSuspendStatus, and PortResetStatus should be reset. <table><tr><td>0</td><td>port power is off</td></tr><tr><td>1</td><td>port power is on</td></tr></table> (write)SetPortPower The HCD writes a '1' to set the PortPowerStatus bit. Writing a '0' has no effect. Note: This bit is always reads '1b' if power switching is not supported.	0	port power is off	1	port power is on
0	port power is off							
1	port power is on							
7:5	/	/	0x0	Reserved				
				(read)PortResetStatus When this bit is set by a write to SetPortReset, port reset signaling is asserted. When reset is completed, this bit is cleared when PortResetStatusChange is set. This bit cannot be set if CurrentConnectStatus is cleared. <table><tr><td>0</td><td>port reset signal is not active</td></tr><tr><td>1</td><td>port reset signal is active</td></tr></table> (write)SetPortReset The HCD sets the port reset signaling by writing a '1' to this bit. Writing a '0' has no effect. If CurrentConnectStatus is cleared, this write does not set PortResetStatus, but instead sets ConnectStatusChange. This informs the driver that it attempted to reset a disconnected port.	0	port reset signal is not active	1	port reset signal is active
0	port reset signal is not active							
1	port reset signal is active							
4	R/W	R/W	0x0					
				(read)PortOverCurrentIndicator This bit is only valid when the Root Hub is configured in such a way that overcurrent conditions are reported on a per-port basis. If per-port overcurrent reporting is not supported, this bit is set to 0. If cleared, all power operations are normal for this port. If set, an overcurrent condition exists on this port. This bit always reflects the overcurrent input signal. <table><tr><td>0</td><td>no overcurrent condition.</td></tr><tr><td>1</td><td>overcurrent condition detected.</td></tr></table> (write)ClearSuspendStatus The HCD writes a '1' to initiate a resume. Writing a '0' has no effect. A resume is initiated only if PortSuspendStatus is set.	0	no overcurrent condition.	1	overcurrent condition detected.
0	no overcurrent condition.							
1	overcurrent condition detected.							
3	R/W	R/W	0x0					
				(read)PortSuspendStatus This bit indicates the port is suspended or in the resume sequence. It is set by a SetSuspendState write and cleared when PortSuspendStatusChange is set at the end of the resume interval. This bit cannot be set if CurrentConnectStatus is cleared. This bit is also cleared when PortResetStatusChange is set at the end of the port reset or when the HC is placed in the USBRESUME state. If an upstream resume is in progress, it should propagate to the HC.				
2	R/W	R/W	0x0					

				<table><tr><td>0</td><td>port is not suspended</td></tr><tr><td>1</td><td>port is suspended</td></tr></table> (write)SetPortSuspend The HCD sets the PortSuspendStatus bit by writing a '1' to this bit. Writing a '0' has no effect. If CurrentConnectStatus is cleared, this write does not set PortSuspendStatus; instead it sets ConnectStatusChange. This informs the driver that it attempted to suspend a disconnected port.	0	port is not suspended	1	port is suspended
0	port is not suspended							
1	port is suspended							
1	R/W	R/W	0x0	(read)PortEnableStatus This bit indicates whether the port is enabled or disabled. The Root Hub may clear this bit when an overcurrent condition, disconnect event, switched-off power, or operational bus error such as babble is detected. This change also causes PortEnabledStatusChange to be set. HCD sets this bit by writing SetPortEnable and clears it by writing ClearPortEnable. This bit cannot be set when CurrentConnectStatus is cleared. This bit is also set, if not already, at the completion of a port reset when ResetStatusChange is set or port suspend when SuspendStatusChange is set. <table><tr><td>0</td><td>port is disabled</td></tr><tr><td>1</td><td>port is enabled</td></tr></table> (write)SetPortEnable The HCD sets PortEnableStatus by writing a '1'. Writing a '0' has no effect. If CurrentConnectStatus is cleared, this write does not set PortEnableStatus, but instead sets ConnectStatusChange. This informs the driver that it attempted to enable a disconnected Port.	0	port is disabled	1	port is enabled
0	port is disabled							
1	port is enabled							
0	R/W	R/W	0x0	(read)CurrentConnectStatus This bit reflects the current state of the downstream port. <table><tr><td>0</td><td>No device connected</td></tr><tr><td>1</td><td>Device connected</td></tr></table> (write)ClearPortEnable The HCD writes a '1' to clear the PortEnableStatus bit. Writing '0' has no effect. The CurrentConnectStatus is not affected by any write. Note: This bit is always read '1' when the attached device is nonremovable(DviceRemoveable[NumberDownstreamPort]).	0	No device connected	1	Device connected
0	No device connected							
1	Device connected							

7.6.3.7. HCI Interface Control and Status Register Description

7.6.3.7.1. HCI Interface Control Register(Default Value: 0x0)

Offset: 0x800	Register Name: HCI_ICR
---------------	-------------------------------

Bit	R/W	Default/Hex	Description
31:21	/	/	Reserved.
20	R/W	0	EHCI HS force Set 1 to this field force the ehci enter the high speed mode during bus reset. This field only valid when the bit 1 is set.
19:18	/	/	/
17	R/W	0	HSIC Connect detect 1 in this field enable the hsic phy to detect device connect pulse on the bus. This field only valid when the bit 1 is set.
16	R/W	0	HSIC Connect Interrupt Enable Enable the HSIC connect interrupt. This field only valid when the bit 1 is set.
15:13	/	/	/
12	/	/	/
11	R/W	0	AHB Master interface INCR16 enable 1: Use INCR16 when appropriate 0: do not use INCR16,use other enabled INCRX or unspecified length burst INCR
10	R/W	0	AHB Master interface INCR8 enable 1: Use INCR8 when appropriate 0: do not use INCR8,use other enabled INCRX or unspecified length burst INCR
9	R/W	0	AHB Master interface burst type INCR4 enable 1: Use INCR4 when appropriate 0: do not use INCR4,use other enabled INCRX or unspecified length burst INCR
8	R/W	0	AHB Master interface INCRX align enable 1: start INCRx burst only on burst x-align address 0: Start burst on any double word boundary Note: This bit must enable if any bit of 11:9 is enabled
7:2	/	/	Reserved
1	R/W	0	HSIC 0:/ 1:HSIC This meaning is only valid when the controller is HCI1.
0	R/W	0	ULPI bypass enable。 1: Enable UTMI interface, disable ULPI interface(SP used utmi interface) 0: Enable ULPI interface, disable UTMI interface

7.6.3.7.2. HSIC status Register(Default Value: 0x0)

Offset: 0x804	Register Name: HSIC_STATUS
---------------	----------------------------

Bit	R/W	Default/Hex	Description
31:17	/	/	/
16	R/W	0	HSIC Connect Status 1 in this field indicates a device connect pulse being detected on the bus. This field only valid when the EHCI HS force bit and the HSIC Phy Select bit is set. When the HSIC Connect Interrupt Enable is set, 1 in this bit will generate an interrupt to the system. This register is valid on HCI1.
15:0	/	/	/

7.6.3.8. HCI Clock Control Register Description

7.6.3.8.1. HCI SIE Control Register(Default Value: 0x0)

Offset: 0x00A08000			Register Name: HCI_SCR
Bit	R/W	Default/Hex	Description
31:20	/	/	/
19	R/W	0	USB HCI2 Module Reset 0: assert 1: de-assert
18	R/W	0	USB HCI1 Module Reset 0: assert 1: de-assert
17	R/W	0	USB HCI0 Module Reset 0: assert 1: de-assert
16:7	/	/	/
6	R/W	0	USB OHCI2 Special Clock(12M and 48M) Gating 0: mask 1: pass
5	R/W	0	USB HCI2 AHB Gating 0: mask 1: pass
4	/	/	/
3	R/W	0	USB HCI1 AHB Gating 0: mask 1: pass
2	R/W	0	USB OHCI0 Special Clock(12M and 48M) Gating 0: mask 1: pass
1	R/W	0	USB HCI0 AHB Gating

			0: mask 1: pass
0	/	/	/

7.6.3.8.2. HCI PHY Control Register(Default Value: 0x0)

Offset: 0x00A08004			Register Name: HCI_PCR
Bit	R/W	Default/Hex	Description
31:22	/	/	/
21	R/W	0	HCI2_UTMIPHY_RST 0: Assert 1: De-assert
20:19	/	/	/
18	R/W	0	HCI1_HSIC_RST 0: Assert 1: De-assert
17	R/W	0	HCI0_PHY_RST 0: Assert 1: De-assert
16:11	/	/	/
10	R/W	0	12M_GATING_HCI1_HSIC 0: Clock is OFF 1: Clock is ON
9:6	/	/	/
5	R/W	0	SCLK_GATING_HCI2_UTMIPHY 0: Clock is OFF 1: Clock is ON
4	R/W	0	480M_GATING_HCI2_HSIC 0: Clock is OFF 1: Clock is ON
3	/	/	/
2	R/W	0	480M_GATING_HCI1_HSIC 0: Clock is OFF 1: Clock is ON
1	R/W	0	SCLK_GATING_HCI0_PHY 0: Clock is OFF 1: Clock is ON
0	/	/	/

7.6.3.9. USB Host Special Requirement

Name	Description
HCLK	System clock (provided by AHB bus clock). This clock needs to be >30MHz.
CLK60M	Clock from PHY for HS SIE, is constant to be 60MHz.
CLK48M	Clock from PLL for FS/LS SIE, is constant to be 48MHz.

Confidential

7.7. TDM

7.7.1. Overview

The Digital Audio Interface Controller has been designed to transfer streaming audio-data between the system memory and the codec chip. The controller supports standard I2S format, Left-justified Mode format, Right-justified Mode format, PCM Mode format and TDM Mode format.

The digital audio interface controller includes the following features:

- Supports industry-standard AMBA Peripheral Bus (APB) and it is fully compliant with the AMBA Specification, Revision 2.0
- Support different sample period width in each interface when using LRCK and LRCKR at the same time
- Support full-duplex synchronous work mode
- Support Master / Slave mode
- Support adjustable interface voltage
- Support clock up to 100MHz
- Support adjustable audio sample rate from 8-bit to 32-bit.
- Support up to 8 slots which has adjustable width from 8-bit to 32-bit.
- Support sample rate from 8KHz to 192KHz
- Support up to 4 data output pin
- Support 8-bits or 16-bits linear sample, 8-bits u-law and 8-bits A-law companded sample
- One 128 x 24-bit width FIFO for data transmit, one 64 x 24-bit width FIFO for data receive
- Support programmable PCM frame width: 1 BCLK width (short frame) and 2 BCLKs width (long frame)
- Programmable FIFO thresholds
- Interrupt and DMA Support
- Support loopback mode for test

7.7.2. Signal Description

7.7.2.1. Digital Audio Interface Pin List

Signal Name	Direction(M)	Description	Pin
MCLK	O	Digital Audio 0 MCLK Output	PB8
BCLK	I/O	Digital Audio 0 Sample Rate Clock/Sync	PB5
LRCK	I/O	Digital Audio 0 Serial Clock	PB4
SDI	I	Digital Audio 0 Serial Data input	PB7
SDO	O	Digital Audio 0 Serial Data Output	PB6

7.7.2.2. Digital Audio Interface Clock Source and Frequency

	Description
Audio_PLL	24.576Mhz or 22.5792Mhz generated by AUDIO-PLL to produce 48KHz or 44.1KHz serial frequency

7.7.3. Functionalities Description

7.7.3.1. Typical Applications

The I2S and PCM which provides a serial bus interface for stereo and multichannel audio data. This interface is most commonly used by consumer audio market, including compact disc, digital audio tape, digital sound processors, and digital TV-sound.

7.7.3.2. Functional Block Diagram

The Digital Audio Interface block diagram is shown below:

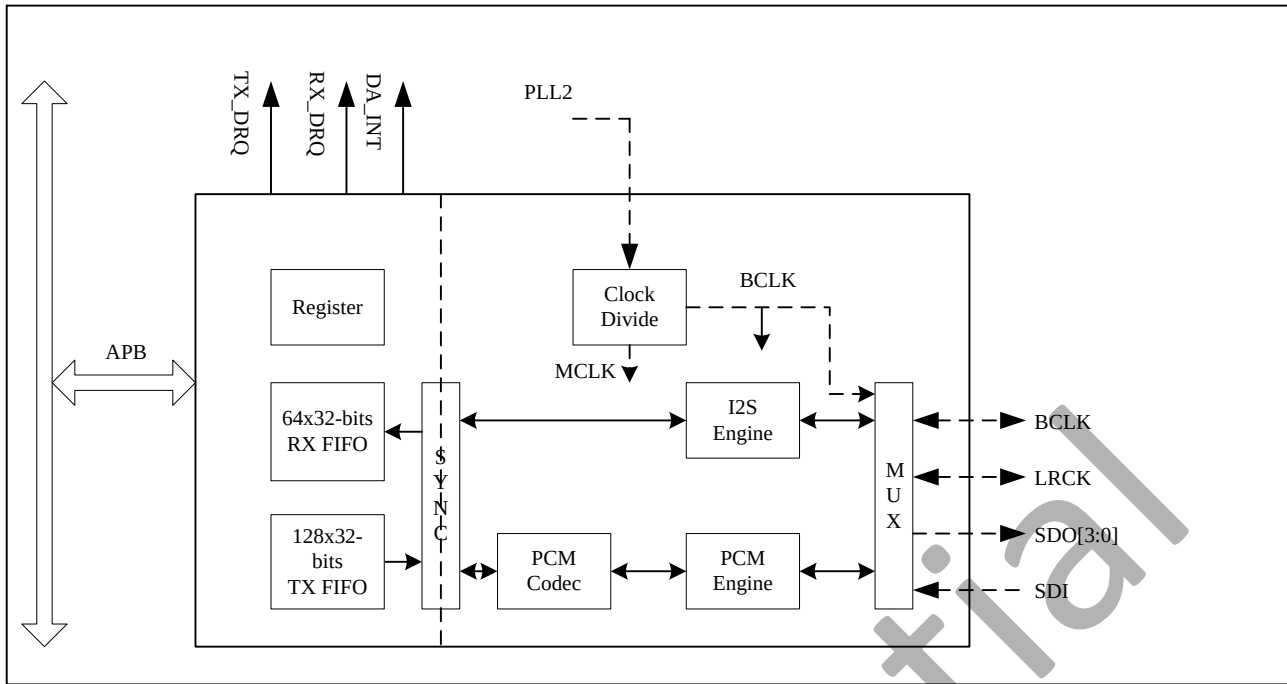


Figure 7-9. Digital Audio Interface System Block Diagram

7.7.4. Timing Diagram

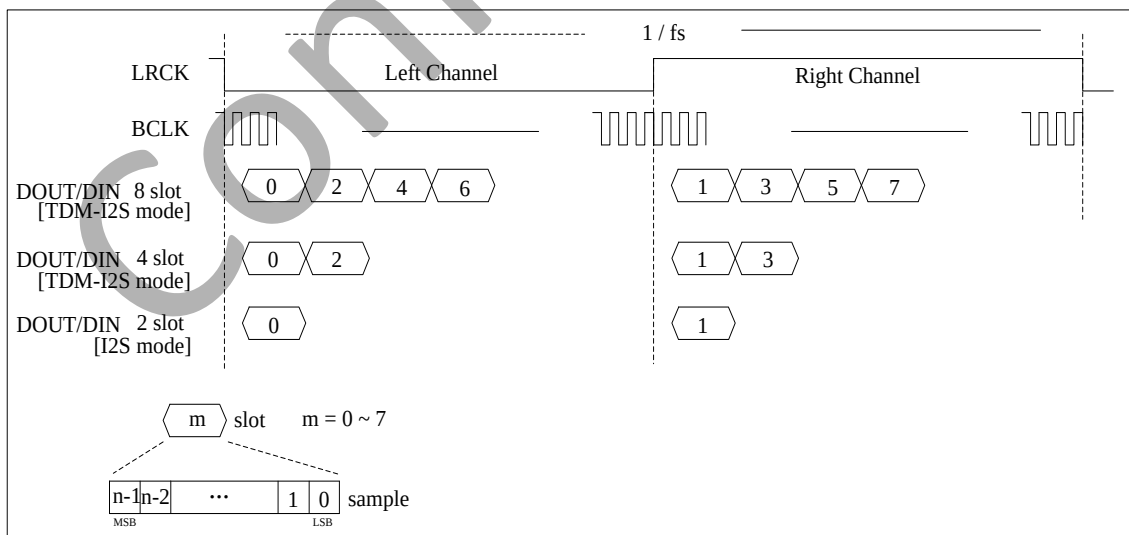


Figure 7-10. Timing diagram for I2S and Multi-Slot mode

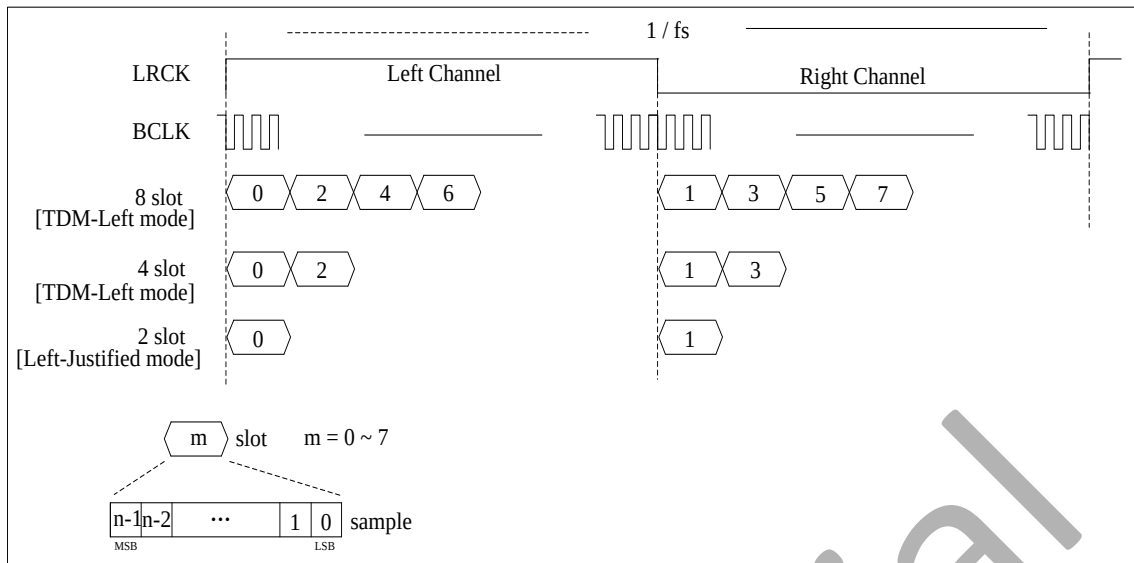


Figure 7-11. Timing diagram for Left-justified and Multi-Slot mode

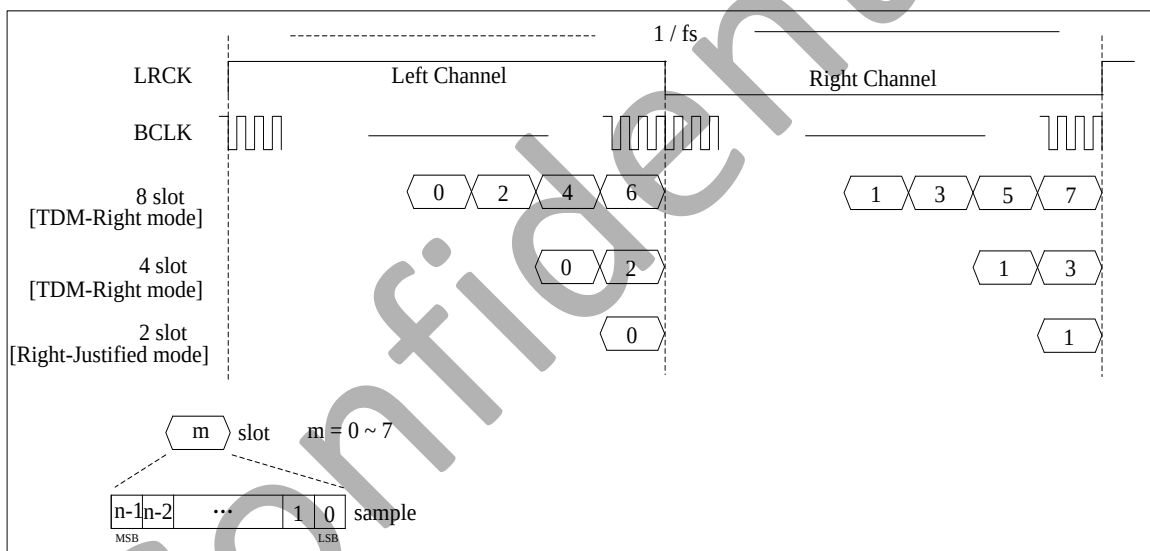


Figure 7-12. Timing diagram for Right-justified and Multi-Slot mode

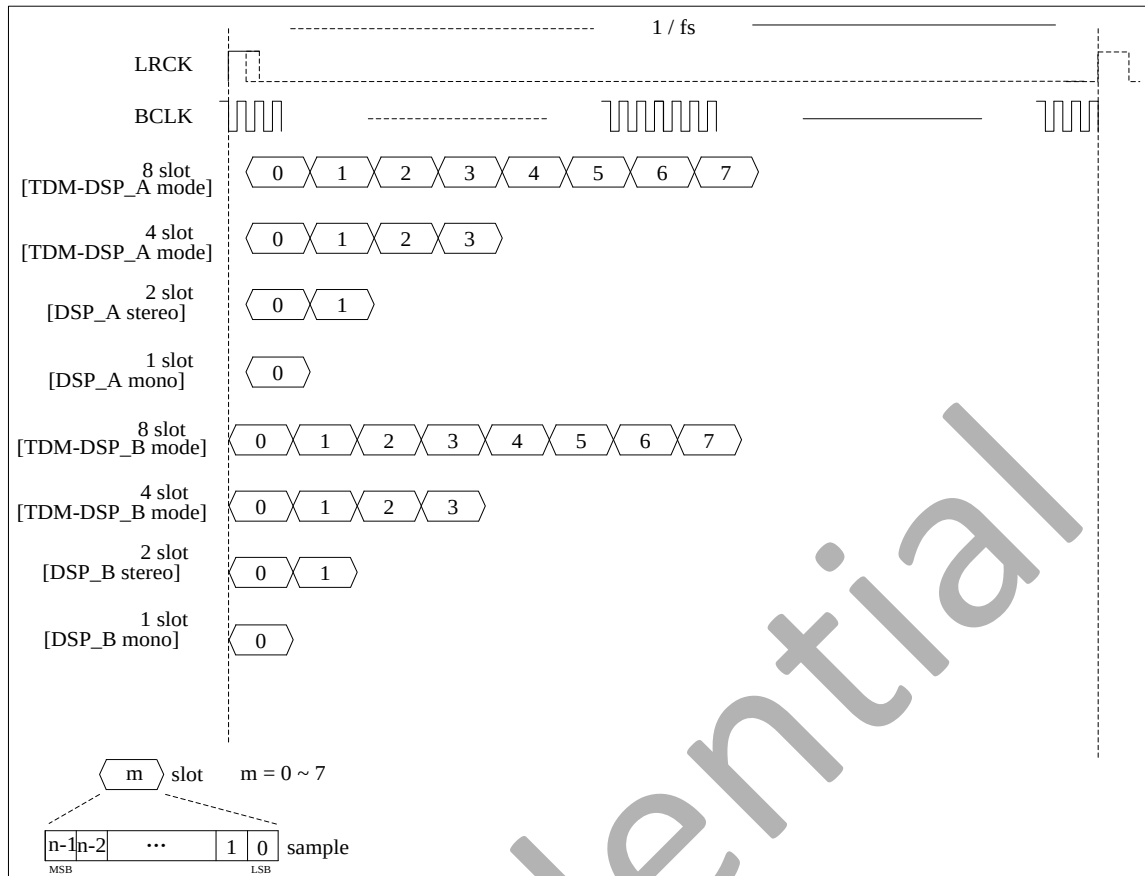


Figure 7-13. Timing diagram for PCM and Multi-Slot PCM mode

7.7.5. Operation Modes

The software operation of the PCM/I2S is divided into five steps: system setup, PCM/I2S initialization, the channel setup, DMA setup and Enable/Disable module. These five steps are described in detail in the following sections.

7.7.5.1. System setup and PCM/I2S initialization

The first step in the system setup is properly programming the GPIO. The PCM/I2S port is a multiplex pin and its function can be found in the [Port Controller](#). The clock source for the PCM/I2S should be followed. At first you must reset the audio PLL through the [PLL_ENABLE](#) bit of [PLL_AUDIO_CTRL_REG](#) in the [CCU](#). The second step, you must setup the frequency of the audio pll in the [PLL_AUDIO_CTRL_REG](#). After that, you must open the PCM/I2S gating through the [DAUDIO0_CLK_REG/DAUDIO1_CLK_REG](#) when you checkout that the LOCK bit of [PLL_AUDIO_CTRL_REG](#) become 1. At last, you must reset the PCM/I2S the [BUS_SOFT_RST_REG3](#)'s bit[13:12] and open the PCM/I2S bus gating in the [BUS_CLK_GATING_REG2](#)'s bit[13:12].

After the system setup, the register of PCM/I2S can be setup. At first, you should initialization the PCM/I2S. You should closed the [Globe Enable](#) bit([DA_CTL](#) [0]) , [Transmitter Block Enable](#) ([DA_CTL](#)[2]) and [Receiver Block Enable](#) ([DA_CTL](#)[1]) by writing 0 to it. After that, you must clear the TX/RX FIFO by writing 0 to register [DA_FCTL](#) [25:24]. At last, you can

clear the TX/RX FIFO counter by writing 0 to **DA_TXCNT/DA_RXCNT**.

7.7.5.2. The channel setup and DMA setup

At first, you can setup the PCM/I2S of mater and slave by set **DA_CTL**[18:16]. The configuration can be referred to the the protocol of PCM/I2S. Then, you can set the translation mode, the sample precision, the wide of slot, the frame mode and the trigger level.

The PCM/I2S support three methods to transfer the data. The most common way is DMA, the set of DMA can be found in the **DMA** part. In this module, you just to enable the DRQ. Because the PCM/I2S is in the CPUS domain, you can only use the rDMA which is also in the CPUS domain.

7.7.5.3. Enable and disable the PCM/I2S

To enable the function, you can enable TX/RX by writing the **DA_CTL**[2:1]. After that, you must enable PCM/I2S by writing the **Globe Enable** bit to 1 in the **DA_CTL**. Writting the **Globe Enable** to 0 can disable the PCM/I2S.

7.7.6. Digital Audio Interface Register List

Module Name	Base Address
TDM	0x01C2 3000

Register Name	Offset	Description
DA_CTL	0x00	Digital Audio Control Register
DA_FMT0	0x04	Digital Audio Format Register 0
DA_FMT1	0x08	Digital Audio Format Register 1
DA_ISTA	0x0C	Digital Audio Interrupt Status Register
DA_RXFIFO	0x10	Digital Audio RX FIFO Register
DA_FCTL	0x14	Digital Audio FIFO Control Register
DA_FSTA	0x18	Digital Audio FIFO Status Register
DA_INT	0x1C	Digital Audio DMA & Interrupt Control Register
DA_TXFIFO	0x20	Digital Audio TX FIFO Register
DA_CLKD	0x24	Digital Audio Clock Divide Register
DA_TXCNT	0x28	Digital Audio TX Sample Counter Register
DA_RXCNT	0x2C	Digital Audio RX Sample Counter Register
DA_CHCFG	0x30	Digital Audio Channel Configuration register

DA_CHCFG	0x34	Digital Audio Channel Configuration register
DA_TX1CHSEL	0x38	Digital Audio TX1 Channel Select Register
DA_TX2CHSEL	0x3C	Digital Audio TX2 Channel Select Register
DA_TX3CHSEL	0x40	Digital Audio TX3 Channel Select Register
DA_TX0CHMAP	0x44	Digital Audio TX0 Channel Mapping Register
DA_TX0CHMAP	0x48	Digital Audio TX1 Channel Mapping Register
DA_TX0CHMAP	0x4C	Digital Audio TX2 Channel Mapping Register
DA_TX0CHMAP	0x50	Digital Audio TX3 Channel Mapping Register
DA_RXCHSEL	0x54	Digital Audio RX Channel Select register
DA_RXCHMAP	0x58	Digital Audio RX Channel Mapping Register

7.7.7. Digital Audio Interface Register Description

7.7.7.1. Digital Audio Control Register(Default Value: 0x0006_0000)

Offset: 0x00			Register Name: DA_CTL
Bit	R/W	Default/Hex	Description
31:19	/	/	/
18	R/W	1	BCLK_OUT 0: input 1: output
17	R/W	1	LRCK_OUT 0: input 1: output
16	R/W	0	LRCKR_OUT(No Pin) 0: input 1: output
15:12	/	/	/
11	R/W	0	SDO3_EN(No Pin) 0: Disable, Hi-Z state 1: Enable
10	R/W	0	SDO2_EN(No Pin) 0: Disable, Hi-Z state 1: Enable
9	R/W	0	SDO1_EN(No Pin) 0: Disable, Hi-Z state 1: Enable
8	R/W	0	SDO0_EN(No Pin) 0: Disable, Hi-Z state

			1: Enable
7	/	/	/
6	R/W	0	OUT Mute 0: normal transfer 1: force DOUT to output 0
5:4	R/W	0	MODE_SEL Mode Selection 0: PCM mode (offset 0: DSP_B; offset 1: DSP_A) 1: Left mode (offset 0: LJ mode; offset 1: I2S mode) 2: Right-Justified mode 3: Reserved
3	R/W	0	LOOP Loop back test 0: Normal mode 1: Loop back test When set '1', connecting the SDO0 with the SDI
2	R/W	0	TXEN Transmitter Block Enable 0: Disable 1: Enable
1	R/W	0	RXEN Receiver Block Enable 0: Disable 1: Enable
0	R/W	0	GEN Globe Enable A disable on this bit overrides any other block or channel enables. 0: Disable 1: Enable

7.7.7.2. Digital Audio Format Register0 (Default Value: 0x0000_0033)

Offset: 0x04			Register Name: DA_FMT0
Bit	R/W	Default/Hex	Description
31	R/W	0	SDI_SYNC_SEL 0: SDI use LRCK 1: SDI use LRCKR
30	R/W	0	LRCK_WIDTH (only apply in PCM mode) LRCK width 0: LRCK = 1 BCLK width (short frame) 1: LRCK = 2 BCLK width (long frame)
29:20	R/W	0	LRCKR_PERIOD It is used to program the number of BCLKs per channel of sample frame. This value is interpreted as follow:

			PCM mode: Number of BCLKs within (Left + Right) channel width I2S / Left-Justified / Right-Justified mode: Number of BCLKs within each individual channel width (Left or Right) N+1 For example: n = 7: 8 BCLK width ... n = 1023: 1024 BCLKs width
19	R/W	0	LRCK_POLARITY/LRCKR_POLARITY When apply in I2S / Left-Justified / Right-Justified mode: 0: Left channel when LRCK is low 1: Left channel when LRCK is high When apply in PCM mode: 0: PCM LRCK/LRCKR asserted at the negative edge 1: PCM LRCK/LRCKR asserted at the positive edge
18	/	/	/
17:8	R/W	0	LRCK_PERIOD It is used to program the number of BCLKs per channel of sample frame. This value is interpreted as follow: PCM mode: Number of BCLKs within (Left + Right) channel width I2S / Left-Justified / Right-Justified mode: Number of BCLKs within each individual channel width (Left or Right) N+1 For example: n = 7: 8 BCLK width ... n = 1023: 1024 BCLKs width
7	R/W	0	BCLK_POLARITY 0: normal mode, negative edge drive and positive edge sample 1: invert mode, positive edge drive and negative edge sample
6:4	R/W	3	SR Sample Resolution 0: Reserved 1: 8-bit 2: 12-bit 3: 16-bit 4: 20-bit 5: 24-bit 6: 28-bit 7: 32-bit
3	R/W	0	EDGE_TRANSFER 0: SDO drive data and SDI sample data at the different BCLK edge 1: SDO drive data and SDI sample data at the same BCLK edge BCLK_POLARITY = 0, use negative edge BCLK_POLARITY = 1, use positive edge

			SW Slot Width Select 0: Reserved 1: 8-bit 2: 12-bit 3: 16-bit 4: 20-bit 5: 24-bit 6: 28-bit 7: 32-bit
2:0	R/W	0x3	

7.7.7.3. Digital Audio Format Register1 (Default Value: 0x0000_0030)

Offset: 0x08			Register Name: DA_FMT1
Bit	R/W	Default/Hex	Description
31:8	/	/	
7	R/W	0	RX MLS MSB / LSB First Select 0: MSB First 1: LSB First
6	R/W	0	TX MLS MSB / LSB First Select 0: MSB First 1: LSB First
5:4	R/W	3	SEXT Sign Extend in slot [sample resolution < slot width] 0: Zeros or audio gain padding at LSB position 1: Sign extension at MSB position 2: Reserved 3: Transfer 0 after each sample in each slot
3:2	R/W	0	RX_PDM PCM Data Mode 0: Linear PCM 1: reserved 2: 8-bits u-law 3: 8-bits A-law
1:0	R/W	0	TX_PDM PCM Data Mode 0: Linear PCM 1: reserved 2: 8-bits u-law 3: 8-bits A-law

7.7.7.4. Digital Audio Interrupt Status Register(Default Value: 0x0000_0010)

Offset: 0x0C			Register Name: DA_ISTA
Bit	R/W	Default/Hex	Description
31:7	/	/	/
6	R/W	0	TXU_INT TX FIFO Under run Pending Interrupt 0: No Pending Interrupt 1: FIFO Under run Pending Interrupt Write 1 to clear this interrupt
5	R/W	0	TXO_INT TX FIFO Overrun Pending Interrupt 0: No Pending Interrupt 1: FIFO Overrun Pending Interrupt Write '1' to clear this interrupt
4	R/W	1	TXE_INT TX FIFO Empty Pending Interrupt 0: No Pending IRQ 1: FIFO Empty Pending Interrupt when data in TX FIFO are less than TX trigger level Write '1' to clear this interrupt or automatic clear if interrupt condition fails.
3	/	/	/
2	R/W	0	R XU_INT RX FIFO Under run Pending Interrupt 0: No Pending Interrupt 1: FIFO Under run Pending Interrupt Write 1 to clear this interrupt
1	R/W	0	R XO_INT RX FIFO Overrun Pending Interrupt 0: No Pending IRQ 1: FIFO Overrun Pending IRQ Write '1' to clear this interrupt
0	R/W	0	R XA_INT RX FIFO Data Available Pending Interrupt 0: No Pending IRQ 1: Data Available Pending IRQ when data in RX FIFO are more than RX trigger level Write '1' to clear this interrupt or automatic clear if interrupt condition fails.

7.7.7.5. Digital Audio RX FIFO register(Default Value: 0x0000_0000)

Offset: 0x10			Register Name: DA_RXFIFO
Bit	R/W	Default/Hex	Description
31:0	R	0	RX_DATA RX Sample Host can get one sample by reading this register. The left channel sample data is first and then the right channel sample.

7.7.7.6. Digital Audio FIFO Control Register (Default Value: 0x0004_00F0)

Offset: 0x14			Register Name: DA_FCTL
Bit	R/W	Default/Hex	Description
31	R/W	0	HUB_EN Audio hub enable 0: Disable 1: Enable
30:26	/	/	/
25	R/W	0	FTX Write '1' to flush TX FIFO, self clear to '0'.
24	R/W	0	FRX Write '1' to flush RX FIFO, self clear to '0'.
23:19	/	/	/
18:12	R/W	0x40	TXTL TX FIFO Empty Trigger Level Interrupt and DMA request trigger level for TXFIFO normal condition Trigger Level = TXTL
11:10	/	/	/
9:4	R/W	0xF	RXTL RX FIFO Trigger Level Interrupt and DMA request trigger level for RXFIFO normal condition Trigger Level = RXTL + 1
3	/	/	/
2	R/W	0	TXIM TX FIFO Input Mode (Mode 0, 1) 0: Valid data at the MSB of TXFIFO register 1: Valid data at the LSB of TXFIFO register Example for 20-bits transmitted audio sample: Mode 0: FIFO_I[31:0] = {APB_WDATA[31:12], 12'h0} Mode 1: FIFO_I[31:0] = {APB_WDATA[19:0], 12'h0}
1:0	R/W	0	RXOM RX FIFO Output Mode (Mode 0, 1, 2, 3) 00: Expanding '0' at LSB of DA_RXFIFO register.

		01: Expanding received sample sign bit at MSB of DA_RXFIFO register. 10: Truncating received samples at high half-word of DA_RXFIFO register and low half-word of DA_RXFIFO register is filled by '0'. 11: Truncating received samples at low half-word of DA_RXFIFO register and high half-word of DA_RXFIFO register is expanded by its sign bit. Example for 20-bits received audio sample: Mode 0: APB_RDATA[31:0] = {FIFO_O[31:12], 12'h0} Mode 1: APB_RDATA [31:0] = {12{FIFO_O[31]}, FIFO_O[31:12]} Mode 2: APB_RDATA [31:0] = {FIFO_O[31:16], 16'h0} Mode 3: APB_RDATA [31:0] = {16{FIFO_O[31]}, FIFO_O[31:16]}
--	--	---

7.7.7.7. Digital Audio FIFO Status Register (Default Value: 0x1080_0000)

Offset: 0x18			Register Name: DA_FSTA
Bit	R/W	Default/Hex	Description
31:29	/	/	/
28	R	1	TXE TX FIFO Empty 0: No room for new sample in TX FIFO 1: More than one room for new sample in TX FIFO (>= 1 word)
27:24	/	/	/
23:16	R	0x80	TXE_CNT TX FIFO Empty Space Word Counter
15:9	/	/	/
8	R	0	RXA RX FIFO Available 0: No available data in RX FIFO 1: More than one sample in RX FIFO (>= 1 word)
7	/	/	/
6:0	R	0	RXA_CNT RX FIFO Available Sample Word Counter

7.7.7.8. Digital Audio DMA & Interrupt Control Register(Default Value: 0x0000_0000)

Offset: 0x1C			Register Name: DA_INT
Bit	R/W	Default/Hex	Description
31:8	/	/	/
7	R/W	0	TX_DRQ TX FIFO Empty DRQ Enable 0: Disable 1: Enable
6	R/W	0	TXUI_EN

			TX FIFO Under run Interrupt Enable 0: Disable 1: Enable
5	R/W	0	TXOI_EN TX FIFO Overrun Interrupt Enable 0: Disable 1: Enable When set to '1', an interrupt happens when writing new audio data if TX FIFO is full.
4	R/W	0	TXEI_EN TX FIFO Empty Interrupt Enable 0: Disable 1: Enable
3	R/W	0	RX_DRQ RX FIFO Data Available DRQ Enable 0: Disable 1: Enable When set to '1', RXFIFO DMA Request line is asserted if Data is available in RX FIFO.
2	R/W	0	RXUI_EN RX FIFO Under run Interrupt Enable 0: Disable 1: Enable
1	R/W	0	RXOI_EN RX FIFO Overrun Interrupt Enable 0: Disable 1: Enable
0	R/W	0	RXAI_EN RX FIFO Data Available Interrupt Enable 0: Disable 1: Enable

7.7.7.9. Digital Audio TX FIFO register(Default Value: 0x0000_0000)

Offset: 0x20			Register Name: DA_TXFIFO
Bit	R/W	Default/Hex	Description
31:0	W	0	TX_DATA TX Sample Transmitting left, right channel sample data should be written this register one by one. The left channel sample data is first and then the right channel sample.

7.7.7.10. Digital Audio Clock Divide Register(Default Value: 0x0000_0000)

Offset: 0x24			Register Name: DA_CLKD
Bit	R/W	Default/Hex	Description
31:9	/	/	/
8	R/W	0	MCLKO_EN 0: Disable MCLK Output 1: Enable MCLK Output Notes: Whether in Slave or Master mode, when this bit is set to 1, MCLK should be output.
7:4	R/W	0	BCLKDIV BCLK Divide Ratio from PLL2 0: reserved 1: Divide by 1 2: Divide by 2 3: Divide by 4 4: Divide by 6 5: Divide by 8 6: Divide by 12 7: Divide by 16 8: Divide by 24 9: Divide by 32 10: Divide by 48 11: Divide by 64 12: Divide by 96 13: Divide by 128 14: Divide by 176 15: Divide by 192
3:0	R/W	0	MCLKDIV MCLK Divide Ratio from PLL2 Output 0: reserved 1: Divide by 1 2: Divide by 2 3: Divide by 4 4: Divide by 6 5: Divide by 8 6: Divide by 12 7: Divide by 16 8: Divide by 24 9: Divide by 32 10: Divide by 48 11: Divide by 64 12: Divide by 96 13: Divide by 128 14: Divide by 176

			15: Divide by 192
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7.7.7.11. Digital Audio TX Counter register(Default Value: 0x0000_0000)

Offset: 0x28			Register Name: DA_TXCNT
Bit	R/W	Default/Hex	Description
31:0	R/W	0	TX_CNT TX Sample Counter The audio sample number of sending into TXFIFO. When one sample is put into TXFIFO by DMA or by host IO, the TX sample counter register increases by one. The TX sample counter register can be set to any initial value at any time. After been updated by the initial value, the counter register should count on base of this initial value.

7.7.7.12. Digital Audio RX Counter register(Default Value: 0x0000_0000)

Offset: 0x2C			Register Name: DA_RXCNT
Bit	R/W	Default/Hex	Description
31:0	R/W	0	RX_CNT RX Sample Counter The audio sample number of writing into RXFIFO. When one sample is written by Digital Audio Engine, the RX sample counter register increases by one. The RX sample counter register can be set to any initial value at any time. After been updated by the initial value, the counter register should count on base of this initial value.

7.7.7.13. Digital Audio Channel Configuration register(Default Value: 0x0000_0000)

Offset: 0x30			Register Name: DA_CHCFG
Bit	R/W	Default/Hex	Description
31:10	/	/	/
9	R/W	0	TX_SLOT_HIZ 0: normal mode for the last half cycle of BCLK in the slot 1: turn to hi-z state for the last half cycle of BCLK in the slot
8	R/W	0	TXn_STATE 0: transfer level 0 when not transferring slot 1: turn to hi-z state when not transferring slot
7	/	/	/
6:4	R/W	0	RX_SLOT_NUM RX Channel/Slot Number which between CPU/DMA and FIFO 0: 1 channel or slot

			...
			7: 8 channels or slots
3	/	/	/
			TX_SLOT_NUM TX Channel/Slot Number which between CPU/DMA and FIFO 0: 1 channel or slot ...
2:0	R/W	0	7: 8 channels or slots

7.7.7.14. Digital Audio TXn Channel Select register(Default Value: 0x0000_0000)

Offset: 0x34 + n*4 (n = 0, 1, 2, 3)			Register Name: DA_TXnCHSEL
Bit	R/W	Default/Hex	Description
31:14	/	/	/
13:12	R/W	0	TXn_OFFSET TXn offset tune, TXn data offset to LRCK 0: no offset n: data is offset by n BCLKs to LRCK
11:4	R/W	0	TXn_CHEN TXn Channel (slot) enable, bit[11:4] refer to slot [7:0]. When one or more slot(s) is(are) disabled, the affected slot(s) is(are) set to disable state 0: disable 1: enable
3	/	/	/
			TXn_CHSEL TXn Channel (slot) number Select for each output 0: 1 channel / slot ...
2:0	R/W	0	7: 8 channels / slots

7.7.7.15. Digital Audio TXn Channel Mapping Register(Default Value: 0x0000_0000)

Offset: 0x44 + n*4 (n = 0, 1, 2, 3)			Register Name: DA_TXnCHMAP
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0	TXn_CH7_MAP TXn Channel7 Mapping 0: 1st sample ... 7: 8th sample
27	/	/	/
26:24	R/W	0	TXn_CH6_MAP

			TXn Channel6 Mapping 0: 1st sample ... 7: 8th sample
23	/	/	/
22:20	R/W	0	TXn_CH5_MAP TXn Channel5 Mapping 0: 1st sample ... 7: 8th sample
19	/	/	/
18:16	R/W	0	TXn_CH4_MAP TXn Channel4 Mapping 0: 1st sample ... 7: 8th sample
15	/	/	/
14:12	R/W	0	TXn_CH3_MAP TXn Channel3 Mapping 0: 1st sample ... 7: 8th sample
11	/	/	/
10:8	R/W	0	TXn_CH2_MAP TXn Channel2 Mapping 0: 1st sample ... 7: 8th sample
7	/	/	/
6:4	R/W	0	TXn_CH1_MAP TXn Channel1 Mapping 0: 1st sample ... 7: 8th sample
3	/	/	/
2:0	R/W	0	TXn_CH0_MAP TXn Channel0 Mapping 0: 1st sample ... 7: 8th sample

7.7.7.16. Digital Audio RX Channel Select register(Default Value: 0x0000_0000)

Offset: 0x54	Register Name: DA_RXCHSEL
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Bit	R/W	Default/Hex	Description
31:14	/	/	/
13:12	R/W	0	RX_OFFSET RX offset tune, RX data offset to LRCK 0: no offset n: data is offset by n BCLKs to LRCK
11:3	/	/	
2:0	R/W	0	RX_CHSEL RX Channel (slot) number Select for input 0: 1 channel / slot ... 7: 8 channels / slots

7.7.7.17. Digital Audio RX Channel Mapping Register (Default Value: 0x0000_0000)

Offset: 0x58			Register Name: DA_RXCHMAP
Bit	R/W	Default/Hex	Description
31	/	/	/
30:28	R/W	0	RX_CH7_MAP RX Channel7 Mapping 0: 1st sample ... 7: 8th sample
27	/	/	/
26:24	R/W	0	RX_CH6_MAP RX Channel6 Mapping 0: 1st sample ... 7: 8th sample
23	/	/	/
22:20	R/W	0	RX_CH5_MAP RX Channel5 Mapping 0: 1st sample ... 7: 8th sample
19	/	/	/
18:16	R/W	0	RX_CH4_MAP RX Channel4 Mapping 0: 1st sample ... 7: 8th sample
15	/	/	/
14:12	R/W	0	RX_CH3_MAP

			RX Channel3 Mapping 0: 1st sample ... 7: 8th sample
11	/	/	/
10:8	R/W	0	RX_CH2_MAP RX Channel2 Mapping 0: 1st sample ... 7: 8th sample
7	/	/	/
6:4	R/W	0	RX_CH1_MAP TX Channel1 Mapping 0: 1st sample ... 7: 8th sample
3	/	/	/
2:0	R/W	0	RX_CH0_MAP RX Channel0 Mapping 0: 1st sample ... 7: 8th sample

7.8. EMAC

7.8.1. Overview

The Ethernet MAC(EMAC) controller enables a host to transmit and receive data over Ethernet in compliance with the IEEE 802.3-2002 standard. It supports 10M/100M/1000M external PHY with MII/ RGMII interface in both full and half duplex mode. The Ethernet MAC-DMA is designed for packet-oriented data transfers based on a linked list of descriptors. 4K Byte TXFIFO and 16K Byte RXFIFO are provided to keep continuous transmission and reception. Flow Control, CRC Pad & Stripping, and address filtering are also supported in this module.

The Ethernet MAC Controller includes the following features:

- Supports 10/100/1000Mbps data transfer rates
- Supports MII/RGMII PHY interface
- Supports both full-duplex and half-duplex operation
- Automatic CRC and pad generation controllable on a per-frame basis
- Options for Automatic Pad/CRC Stripping on receive frames
- Programmable frame length to support Standard or Jumbo Ethernet frames with sizes up to 16 KB
- Programmable Inter Frame Gap (40-96 bit times in steps of 8)
- Supports a variety of flexible address filtering modes
- Separate 32-bit status returned for transmission and reception packets
- Optimization for packet-oriented DMA transfers with frame delimiters
- Dual-buffer (ring) or linked-list (chained) descriptor chaining
- Descriptor architecture, allowing large blocks of data transfer with minimum CPU intervention; each descriptor can transfer up to 4 KB of data
- Comprehensive status reporting for normal operation and transfers with errors
- 4KB TXFIFO for transmission packets and 16KB RXFIFO for reception packets
- Programmable interrupt options for different operational conditions

7.8.2. Block Diagram

The EMAC Controller system block diagram is shown below:

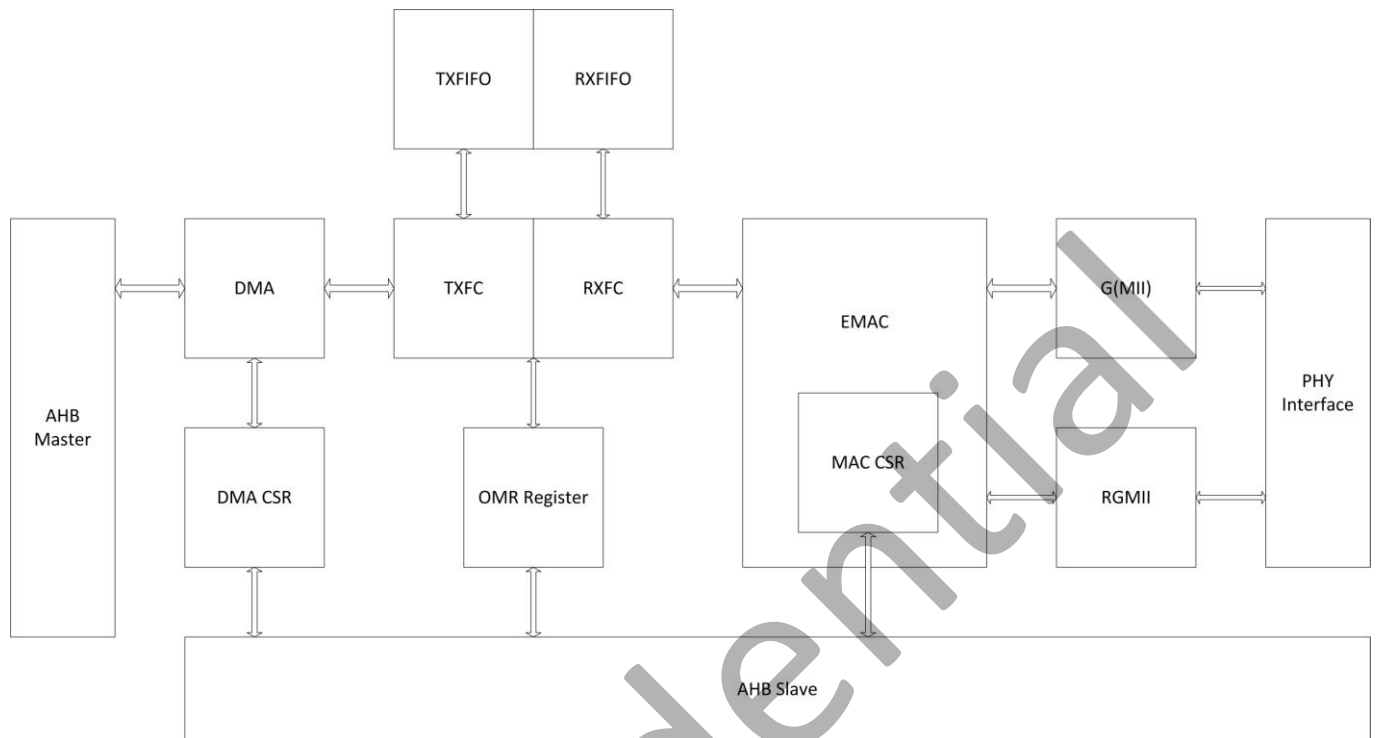


Figure 7-14. EMAC Block Diagram

7.8.3. EMAC Register List

Module Name	Base Address
EMAC	0x01C30000

EMAC_CORE:

Register Name	Offset	Description
EMAC_CONTROL	0x00	MAC Configuration Register
EMAC_FRAME_FILTER	0x04	MAC Frame Filter Register
EMAC_HASH_HIGH	0x08	Hash Table High Register
EMAC_HASH_LOW	0x0C	Hash Table Low Register
EMAC_GMII_ADDR	0x10	GMII Address Register
EMAC_GMII_DATA	0x14	GMII Data Register
EMAC_FLOW_CTRL	0x18	Flow Control Register
EMAC_INT_STATUS	0x38	Interrupt Register
EMAC_INT_MASK	0x3C	Interrupt Mask Register
EMAC_ADDR_HIGH_0	0x40	MAC Address High Register 0
EMAC_ADDR_LOW_0	0x44	MAC Address High Register 0

EMAC_ADDR_HIGH_x	0x40+8*x	MAC Address High Register x
EMAC_ADDR_LOW_x	0x44+8*x	MAC Address Low Register x
EMAC_RGMII_STATUS	0xD8	TBI Extended Status Register

EMAC_DMA:

Register Name	Offset	Description
EDMA_BUS_MODE	0x1000	Bus Mode Register
EDMA_XMT_POLL	0x1004	Transmit Poll Demand Register
EDMA_RCV_POLL	0x1008	Receive Poll Demand Register
EDMA_RCV_LIST	0x100C	Receive Descriptor List Address Register
EDMA_XMT_LIST	0x1010	Transmit Descriptor List Address Register
EDMA_STATUS	0x1014	Status Register
EDMA_OPERATION	0x1018	Operation Mode Register
EDMA_INTR_ENA	0x101C	Interrupt Enable Register
EDMA_MISSED_FRAME	0x1020	Missed Frame and Buffer Overflow Counter Register
EDMA_CUR_TX_DESC	0x1048	Current Host Transmit Descriptor Register
EDMA_CUR_RX_DESC	0x104C	Current Host Receive Descriptor Register
EDMA_CUR_TX_BUF	0x1050	Current Host Transmit Buffer Address Register
EDMA_CUR_RX_BUF	0x1054	Current Host Receive Buffer Address Register

7.8.4. EMAC Core Register Description

7.8.4.1. EMAC MAC Configuration Register(Default Value: 0x0000_0000)

Offset: 0x00			Register Name: EMAC_CONTROL
Bit	Read/Write	Default	Description
31:25	/	/	/
24	R/W	0	TC Transmit Configuration in RGMII 0: No transmission information is driven to the PHY. 1: Enables the transmission of duplex mode, link speed, and link up/down information to the PHY in the RGMII ports.
23	R/W	0	WD Watchdog Disable 0: Allows no more than 2,048 bytes (10,240 if JE is set high) of the frame being received and cuts off any bytes received after that 1: Disable disables the watchdog timer on the receiver, and can receive frames of up to 16,384 bytes
22	R/W	0	JD Jabber Disable 0: Cuts off the transmitter if the application sends out more than 2,048 bytes of data (10,240 if JE is set high) during transmission.

			1: Disables the jabber timer on the transmitter, and can transfer frames of up to 16,384 bytes.
21	R/W	0	BE Frame Burst Enable When this bit is set, the EMAC allows frame bursting during transmission in GMII Half- Duplex mode.
20	R/W	0	JE Jumbo Frame Enable When this bit is set, EMAC allows Jumbo frames of 9,018 bytes (9,022 bytes for VLAN tagged frames) without reporting a giant frame error in the receive frame status.
19:17	R/W	0	IFG Inter-Frame Gap These bits control the minimum IFG between frames during transmission. 000: 96 bit times 001: 88 bit times 010: 80 bit times 111: 40 bit times Note that in Half-Duplex mode, the minimum IFG can be configured for 64 bit times (IFG = 100) only. Lower values are not considered. In 1000-Mbps mode, the minimum IFG supported is 64 bit times (and above) in the EMAC-CORE configuration and 80 bit times (and above) in other system configurations.
16	R/W	0	DCRS Disable Carrier Sense During Transmission When set high, this bit makes the MAC transmitter ignore the (G)MII CRS signal during frame transmission in Half-Duplex mode.
15	R/W	0	PS Port Select 0: GMII (1000 Mbps) 1: MII (10/100 Mbps)
14	R/W	0	FES Indicates the speed in Fast Ethernet (MII) mode 0: 10 Mbps 1: 100 Mbps
13	R/W	0	DO Disable Receive Own When this bit is set, the EMAC disables the reception of frames when the gmii_txen_o is asserted in Half-Duplex mode. When this bit is reset, the EMAC receives all packets that are given by the PHY while transmitting. This bit is not applicable if the EMAC is operating in Full-Duplex mode.
12	R/W	0	LM Loopback Mode When this bit is set, the EMAC operates in loopback mode at GMII/MII.
11	R/W	0	DM

			Duplex Mode When this bit is set, the EMAC operates in a Full-Duplex mode where it can transmit and receive simultaneously.
10	R/W	0	IPC Checksum Offload When this bit set, the EMAC calculates the 16-bit one's complement of the one's complement sum of all received Ethernet frame payloads, and checks whether the IPv4 Header Checksum is correct for received frame and gives the status in the receive status word.
9	R/W	0	DR Disable Retry When this bit is set, the EMAC will attempt only 1 transmission. When a collision occurs on the GMII/MII, the EMAC will ignore the current frame transmission and report a Frame Abort with excessive collision error in the transmit frame status. When this bit is reset, the EMAC will attempt retries based on the settings of BL. This bit is applicable only to Half-Duplex mode and is reserved (RO with default value) in Full-Duplex-only configuration.
8	R/W	0	LUD Link Up/Down Indicates whether the link is up or down during the transmission of configuration in RGMII/SGMII interface 0: Link Down 1: Link Up
7	R/W	0	ACS Automatic Pad/CRC Stripping When this bit is set, the EMAC strips the Pad/FCS field on incoming frames only if the length's field value is less than or equal to 1,500 bytes. All received frames with length field greater than or equal to 1,501 bytes are passed to the application without stripping the Pad/FCS field. When this bit is reset, the EMAC will pass all incoming frames to the Host unmodified. When this bit is reset, the EMAC will pass all incoming frames to the Host unmodified
6:5	R/W	0	BL Back-Off Limit The Back-Off limit determines the random integer number (r) of slot time delays (4,096 bit times for 1000 Mbps and 512 bit times for 10/100 Mbps) the EMAC waits before rescheduling a transmission attempt during retries after a collision. This bit is applicable only to Half-Duplex mode. 00: $k = \min(n, 10)$ 01: $k = \min(n, 8)$ 10: $k = \min(n, 4)$ 11: $k = \min(n, 1)$ where n = retransmission attempt. The random integer r takes the value in the range $0 \leq r < 2k$
4	R/W	0	DC

			Deferral Check 0: Disable 1: Enable
3	R/W	0	TE Transmitter Enable When this bit is set, the transmitter state machine of the EMAC is enabled for transmission on the GMII/MII. When this bit is reset, the EMAC transmit state machine is disabled after the completion of the transmission of the current frame, and will not transmit any further frames.
2	R/W	0	RE Receiver Enable When this bit is set, the receiver state machine of the EMAC is enabled for receiving frames from the GMII/MII. When this bit is reset, the EMAC receive state machine is disabled after the completion of the reception of the current frame, and will not receive any further frames from the GMII/MII
0:1	/	/	/

7.8.4.2. EMAC MAC Frame Filter Register(Default Value: 0x0000_0000)

Offset: 0x04			Register Name: EMAC_FRAME_FILTER
Bit	Read/Write	Default	Description
31	R/W	0	RA Receive All When this bit is set, the EMAC Receiver module passes to the Application all frames received irrespective of whether they pass the address filter. The result of the SA/DA filtering is updated (pass or fail) in the corresponding bits in the Receive Status Word. When this bit is reset, the Receiver module passes to the Application only those frames that pass the SA/DA address filter
30:11	/	/	/
10	R/W	0	HPF Hash or Perfect Filter When set, this bit configures the address filter to pass a frame if it matches either the perfect filtering or the hash filtering as set by HMC or HUC bits. When low and if the HUC/HMC bit is set, the frame is passed only if it matches the Hash filter. This bit is reserved (and RO) if the Hash filter is not selected during core configuration.
9	R/W	0	SAF Source Address Filter Enable The EMAC core compares the SA field of the received frames with the values programmed in the enabled SA registers. If the comparison matches, then the SAMatch bit of RxStatus Word is set high. When this bit is set high and the SA filter fails, the EMAC drops the frame. When this bit is reset, then the EMAC Core forwards the received frame to the application and with the updated SA Match bit of the RxStatus depending on the SA address

			comparison.
8	R/W	0	SAIF SA Inverse Filtering When this bit is set, the Address Check block operates in inverse filtering mode for the SA address comparison. The frames whose SA matches the SA registers will be marked as failing the SA Address filter. When this bit is reset, frames whose SA does not match the SA registers will be marked as failing the SA Address filter.
7:6	R/W	0	PCF Pass Control Frames These bits control the forwarding of all control frames (including unicast and multicast PAUSE frames). Note that the processing of PAUSE control frames depends only on RFE of EMAC Flow Control Register[2]. 00: EMAC filters all control frames from reaching the application 01: EMAC filters all control frames from reaching the application 10: EMAC forwards all control frames to application even if they fail the Address Filter 11: EMAC forwards control frames that pass the Address Filter
5	R/W	0	DBF Disable Broadcast Frames When this bit is set, the AFM module filters all incoming broadcast frames. When this bit is reset, the AFM module passes all received broadcast frames.
4	R/W	0	PM Pass All Multicast When set, this bit indicates that all received frames with a multicast destination address (first bit in the destination address field is '1') are passed. When reset, filtering of multicast frame depends on HMC bit.
3	R/W	0	DAIF DA Inverse Filtering When this bit is set, the Address Check block operates in inverse filtering mode for the DA address comparison for both unicast and multicast frames. When reset, normal filtering of frames is performed.
2	R/W	0	HMC Hash Multicast When set, MAC performs destination address filtering of received multicast frames according to the hash table. When reset, the MAC performs a perfect destination address filtering for multicast frames, that is, it compares the DA field with the values programmed in DA registers.
1	R/W	0	HUC Hash Unicast When set, MAC performs destination address filtering of unicast frames according to the hash table. When reset, the MAC performs a perfect destination address filtering for unicast frames, that is, it compares the DA field with the values programmed in DA registers.
0	R/W	0	PR

			Promiscuous Mode When this bit is set, the Address Filter module passes all incoming frames regardless of its destination or source address. The SA/DA Filter Fails status bits of the Receive Status Word will always be cleared when PR is set.
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7.8.4.3. EMAC Hash Table High Register(Default Value: 0x0000_0000)

Offset: 0x08			Register Name: EMAC_HASH_HIGH
Bit	Read/Write	Default	Description
31:0	R/W	0	HTH Hash Table High This field contains the upper 32 bits of Hash table.

7.8.4.4. EMAC Hash Table Low Register(Default Value: 0x0000_0000)

Offset: 0x0C			Register Name: EMAC_HASH_LOW
Bit	Read/Write	Default	Description
31:0	R/W	0	HTL Hash Table Low This field contains the lower 32 bits of Hash table.

7.8.4.5. EMAC GMII Address Register(Default Value: 0x0000_0000)

Offset: 0x10			Register Name: EMAC_GMII_ADDR												
Bit	Read/Write	Default	Description												
31:16	/	/	/												
15:11	R/W	0	PA PHY Address This field tells which of the 32 possible PHY devices are being accessed												
10:6	R/W	0	GR GMII Register These bits select the desired GMII register in the selected PHY device												
5	/	/	/												
4:2	R/W	0	CR CSR Clock Range The CSR Clock Range selection determines the AHB frequency and is used to decide the frequency of the MDC clock: <table><tr><th>Selection</th><th>ahb_clk</th><th>MDC Clock</th></tr><tr><td>000</td><td>60-100 MHz</td><td>ahb_clk /42</td></tr><tr><td>001</td><td>100-150 MHz</td><td>ahb_clk /62</td></tr><tr><td>010</td><td>20-35 MHz</td><td>ahb_clk /16</td></tr></table>	Selection	ahb_clk	MDC Clock	000	60-100 MHz	ahb_clk /42	001	100-150 MHz	ahb_clk /62	010	20-35 MHz	ahb_clk /16
Selection	ahb_clk	MDC Clock													
000	60-100 MHz	ahb_clk /42													
001	100-150 MHz	ahb_clk /62													
010	20-35 MHz	ahb_clk /16													

			011 35-60 MHz ahb_clk /26 100 150-250 MHz ahb_clk /102 101 250-300 MHz ahb_clk /124 Others Reserved
1	R/W	0	GW GMII Write When set, this bit tells the PHY that this will be a Write operation using the GMII Data register. If this bit is not set, this will be a Read operation, placing the data in the GMII Data register.
0	R/W	0	GB GMII Busy This bit should read a logic 0 before writing to EMAC_GMII_ADDR and EMAC_GMII_DATA. This bit must also be set to 0 during a Write to EMAC_GMII_ADDR. During a PHY register access, this bit will be set to 1'b1 by the Application to indicate that a Read or Write access is in progress. EMAC_GMII_DATA should be kept valid until this bit is cleared by the EMAC during a PHY Write operation. The EMAC_GMII_DATA is invalid until this bit is cleared by the EMAC during a PHY Read operation. The EMAC_GMII_ADDR should not be written to until this bit is cleared

7.8.4.6. EMAC GMII Data Register(Default Value: 0x0000_0000)

Offset: 0x14			Register Name: EMAC_GMII_DATA
Bit	Read/Write	Default	Description
31:16	/	/	/
15:0	R/W	0	GD GMII Data This contains the 16-bit data value read from the PHY after a Management Read operation or the 16-bit data value to be written to the PHY before a Management Write operation.

7.8.4.7. EMAC Flow Control Register(Default Value: 0x0000_0000)

Offset: 0x18			Register Name: EMAC_FLOW_CTRL
Bit	Read/Write	Default	Description
31:16	R/W	0	PT Pause Time This field holds the value to be used in the Pause Time field in the transmit control frame.
15:8	/	/	/
7	R/W	0	DZPQ Disable Zero-Quanta Pause

			When set, this bit disables the automatic generation of Zero-Quanta Pause Control frames. When this bit is reset, normal operation with automatic Zero-Quanta Pause Control frame generation is enabled.
6	/	/	/
5:4	R/W	0	PLT Pause Low Threshold This field configures the threshold of the PAUSE timer at which the input flow control signal is checked for automatic retransmission of PAUSE Frame. The threshold values should be always less than the Pause Time configured in Bits[31:16].
3	R/W	0	UP Unicast Pause Frame Detect When this bit is set, the EMAC will detect the Pause frames with the station's unicast address specified in MAC Address0 High Register and MAC Address0 Low Register, in addition to the detecting Pause frames with the unique multicast address. When this bit is reset, the EMAC will detect only a Pause frame with the unique multicast address specified in the 802.3x standard.
2	R/W	0	RFE Receive Flow Control Enable When this bit is set, the EMAC will decode the received Pause frame and disable its transmitter for a specified (Pause Time) time. When this bit is reset, the decode function of the Pause frame is disabled.
1	R/W	0	TFE Transmit Flow Control Enable In Full-Duplex mode, when this bit is set, the EMAC enables the flow control operation to transmit Pause frames. When this bit is reset, the flow control operation in the EMAC is disabled, and the EMAC will not transmit any Pause frames. In Half-Duplex mode, when this bit is set, the EMAC enables the back-pressure operation. When this bit is reset, the backpressure feature is disabled.
0	R/W	0	FCB/BPA Flow Control Busy/Backpressure Activate This bit initiates a Pause Control frame in Full-Duplex mode and activates the backpressure function in Half-Duplex mode if TFE bit is set. In Full-Duplex mode, this bit should be read as 1'b0 before writing to the Flow Control register. To initiate a Pause control frame, the Application must set this bit to 1'b1. During a transfer of the Control Frame, this bit will continue to be set to signify that a frame transmission is in progress. After the completion of Pause control frame transmission, the EMAC will reset this bit to 1'b0. The Flow Control register should not be written to until this bit is cleared. In Half-Duplex mode, when this bit is set (and TFE is set), then backpressure is asserted by the EMAC Core. During backpressure, when the EMAC receives a new frame, the transmitter starts sending a JAM pattern resulting in a collision.

7.8.4.8. EMAC Interrupt Status Register(Default Value: 0x0000_0000)

Offset: 0x38			Register Name: EMAC_INT_STATUS
Bit	Read/Write	Default	Description
31:1	/	/	/
0	R/W	0	RIS RGMII Interrupt Status This bit is set due to any change in value of the Link Status of RGMII interface. This bit is cleared when the user makes a read operation the RGMII Status register. This bit is valid only when the optional RGMII PHY interface is selected during configuration and operation.

7.8.4.9. EMAC Interrupt Mask Register(Default Value: 0x0000_0000)

Offset: 0x3C			Register Name: EMAC_INT_MASK
Bit	Read/Write	Default	Description
31:1	/	/	/
0	R/W	0	RIM RGMII Interrupt Mask This bit when set, will disable the assertion of the interrupt signal due to the setting of RGMII Interrupt Status bit.

7.8.4.10. EMAC MAC Address 0 High Register(Default Value: 0x8000_FFFF)

Offset: 0x40			Register Name: EMAC_ADDR0_HIGH
Bit	Read/Write	Default	Description
31	R	1	MO Always 1.
30:16	/	/	/
15:0	R/W	0	A[47:32] MAC Address0 [47:32] This field contains the upper 16 bits (47:32) of the 6-byte first MAC address. This is used by the MAC for filtering for received frames and for inserting the MAC address in the Transmit Flow Control (PAUSE) Frames

7.8.4.11. EMAC MAC Address 0 Low Register(Default Value: 0xFFFF_FFFF)

Offset: 0x44			Register Name: EMAC_ADDR0_LOW
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Bit	Read/Write	Default	Description
31:0	R/W	0	A[31:0] MAC Address0 [31:0] This field contains the lower 32 bits of the 6-byte first MAC address. This is used by the MAC for filtering for received frames and for inserting the MAC address in the Transmit Flow Control (PAUSE) Frames

7.8.4.12. EMAC MAC Address x High Register(Default Value: 0x0000_FFFF)

Offset: 0x40+8*x (x=1~7)			Register Name: EMAC_ADDRx_HIGH
Bit	Read/Write	Default	Description
31	R/W	0	AE Address Enable When this bit is set, this address will be used for address filter. When reset, the address filter will ignore this address.
30	R/W	0.	SA Source Address When this bit is set, the address is used to compare with the source address field of the received frame. When this bit is reset, this address is used to compare with the destination address field for the received frame.
29:24	R/W	0	MBC Mask Byte Control When set high, the EMAC core does not compare the corresponding byte of received DA/SA with this address. Each bit controls the masking of the bytes as follows: Bit 29: MAC Address High Reg x[15:8] Bit 28: MAC Address High Reg x[7:0] Bit 27: MAC Address Low Reg x[31:24] ... Bit 24: MAC Address Low Reg x[7:0]
23:16	/	/	/
15:0	R/W	0	A[47:32] MAC Address0 [47:32] This field contains the upper 16 bits(47:32) of number x MAC address.

7.8.4.13. EMAC MAC Address x Low Register(Default Value: 0xFFFF_FFFF)

Offset: 0x44+8*x (x=1~7)			Register Name: EMAC_ADDRx_LOW
Bit	Read/Write	Default	Description
31:0	R/W	0	A[31:0] MAC Address0 [31:0]

			This field contains the lower 32 bits(31:0) of number x MAC address.
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Note:

- 1.MAC Address 0~7 can be used for unicast destination address filter;
- 2.MAC Address 0 can not be used for multicast destination address filter and unicast source address filter;

7.8.4.14. EMAC RGMII Status Register(Default Value: 0x0000_0000)

Offset: 0xD8			Register Name: EMAC_RGMII_STATUS
Bit	Read/Write	Default	Description
31:4	/	/	/
3	R	0	LST Link Status. Indicates whether the link is: 0: down 1: up
2:1	R	0	LSP Link Speed Indicates the current speed of the link: 00: 2.5 MHz 01: 25 MHz 10: 125 MHz.
0	R	0	LM Link Mode Indicates the current mode of operation of the link: 0: Half-Duplex mode 1: Full-Duplex mode

7.8.5. EMAC DMA Register Description
7.8.5.1. EDMA Bus Mode Register(Default Value: 0x0000_0000)

Offset: 0x1000			Register Name: EDMA_BUS_MODE
Bit	Read/Write	Default	Description
31:26	/	/	/
25	R/W	0	AAL Address-Aligned Beats When this bit is set high and the FB bit equals 1, the AHB interface generates all bursts aligned to the start address LS bits. If the FB bit equals 0, the first burst (accessing the data buffer's start address) is not aligned, but subsequent bursts are aligned to the address. This bit is valid only in EMAC-AHB configuration, and reserved (RO with default value 0) in all other

			configurations.
24	R/W	0	4xPBL Mode When set high, this bit multiplies the PBL value programmed (bits [22:17] and bits [13:8]) four times. Thus the DMA will transfer data in to a maximum of 4, 8, 16, 32, 64 and 128 beats depending on the PBL value.
23	R/W	0	USP Use Separate PBL When set high, it configures the RxDMA to use the value configured in bits [22:17] as PBL while the PBL value in bits [13:8] is applicable to TxDMA operations only. When reset to low, the PBL value in bits [13:8] is applicable for both DMA engines.
22:17	R/W	0	RPBL RxDMA PBL These bits indicate the maximum number of beats to be transferred in one RxDMA transaction. This will be the maximum value that is used in a single block Read/Write. The RxDMA will always attempt to burst as specified in RPBL each time it starts a Burst transfer on the host bus. RPBL can be programmed with permissible values of 1, 2, 4, 8, 16, and 32. Any other value will result in undefined behavior. These bits are valid and applicable only when USP is set high.
16	R/W	0	FB Fixed Burst This bit controls whether the AHB Master interface performs fixed burst transfers or not. When set, the AHB will use only SINGLE, INCR4, INCR8 or INCR16 during start of normal burst transfers. When reset, the AHB will use SINGLE and INCR burst transfer operations.
15:14	R/W	0	PR Rx:Tx priority ratio. RxDMA requests given priority over TxDMA requests in the following ratio. This is valid only when the DA bit is reset. 00: 1:1 01: 2:1 10: 3:1 11: 4:1
13:8	R/W	0	PBL Programmable Burst Length These bits indicate the maximum number of beats to be transferred in one DMA transaction. This will be the maximum value that is used in a single block Read/Write. The DMA will always attempt to burst as specified in PBL each time it starts a Burst transfer on the host bus. PBL can be programmed with permissible values of 1, 2, 4, 8, 16, and 32. Any other value will result in undefined behavior.
7	/	/	/
6:2	R/W	0	DSL Descriptor Skip Length

			This bit specifies the number of Word/Dword/Lword (depending on 32/64/128-bit bus) to skip between two unchained descriptors. The address skipping starts from the end of current descriptor to the start of next descriptor. When DSL value equals zero, then the descriptor table is taken as contiguous by the DMA, in Ring mode
1	R/W	0	DA DMA Arbitration scheme 0: Round-robin with Rx:Tx priority given in bits [15:14] 1: Rx has priority over Tx
0	R/W	0	SWR Software Reset When this bit is set, the MAC DMA Controller resets all EMAC Subsystem internal registers and logic. It is cleared automatically after the reset operation has completed in all of the core clock domains. Read a 0 value in this bit before re-programming any register of the core.

7.8.5.2. EDMA Transmit Receive Poll Demand Register(Default Value: 0x0000_0000)

Offset: 0x1004			Register Name: EDMA_XMT_POLL
Bit	Read/Write	Default	Description
31:0	R/W	0	TPD Transmit Poll Demand When these bits are written with any value, the DMA reads the current descriptor. If that descriptor is not available (owned by Host), transmission returns to the Suspend state. If the descriptor is available, transmission resumes.

7.8.5.3. EDMA Receive Poll Demand Register(Default Value: 0x0000_0000)

Offset: 0x1008			Register Name: EDMA_RCV_POLL
Bit	Read/Write	Default	Description
31:0	R/W	0	RPD Receive Poll Demand When these bits are written with any value, the DMA reads the current descriptor. If that descriptor is not available (owned by Host), reception returns to the Suspended state. If the descriptor is available, the Receive DMA returns to active state.

7.8.5.4. EDMA Receive Descriptor List Address Register(Default Value: 0x0000_0000)

Offset: 0x100C	Register Name: EDMA_RCV_LIST
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Bit	Read/Write	Default	Description
31:0	R/W	0	SRL Start of Receive List This field contains the base address of the First Descriptor in the Receive Descriptor list. The LSB bits [1:0] (for 32-bit bus width) will be ignored and taken as all-zero by the DMA internally. Hence these LSB bits are Read Only

7.8.5.5. EDMA Transmit Receive Descriptor List Address Register(Default Value: 0x0000_0000)

Offset: 0x1010			Register Name: EDMA_XMT_LIST
Bit	Read/Write	Default	Description
31:0	R/W	0	STL Start of Transmit List This field contains the base address of the First Descriptor in the Transmit Descriptor list. The LSB bits [1:0] (for 32-bit bus width) will be ignored and taken as all-zero by the DMA internally. Hence these LSB bits are Read Only.

7.8.5.6. EDMA Status Register(Default Value: 0x0000_0000)

Offset: 0x1014			Register Name: EDMA_STATUS
Bit	Read/Write	Default	Description
31:27	/	/	/
26	R	0	GLI EMAC Line interface Interrupt This bit reflects an interrupt event in the EMAC Core's PCS or RGMII interface block.
25:23	R	0	EB Error Bits These bits indicate the type of error that caused a Bus Error (error response on the AHB interface).
22:20	R	0	TS Transmit Process State These bits indicate the Transmit DMA FSM state. This field does not generate an interrupt. 000: Stopped; Reset or Stop Transmit Command issued. 001: Running; Fetching Transmit Transfer Descriptor. 010: Running; Waiting for status. 011: Running; Reading Data from host memory buffer and queuing it to transmit buffer (Tx FIFO). 100: Reserved 101: Reserved 110: Suspended; Transmit Descriptor Unavailable or Transmit Buffer Underflow.

			111: Running; Closing Transmit Descriptor.
19:17	R	0	RS Receive Process State These bits indicate the Receive DMA FSM state. This field does not generate an interrupt. 000: Stopped: Reset or Stop Receive Command issued. 001: Running: Fetching Receive Transfer Descriptor. 010: Reserved for future use. 011: Running: Waiting for receive packet. 100: Suspended: Receive Descriptor Unavailable. 101: Running: Closing Receive Descriptor. 110: Reserved for future use. 111: Running: Transferring the receive packet data from receive buffer to host memory.
16	R	0	NIS Normal Interrupt Summary Normal Interrupt Summary bit value is the logical OR of the following when the corresponding interrupt bits are enabled: • Transmit Interrupt • Transmit Buffer Unavailable • Receive Interrupt • Early Receive Interrupt Only unmasked bits affect the Normal Interrupt Summary bit. This is a sticky bit and must be cleared (by writing a 1 to this bit) each time a corresponding bit that causes NIS to be set is cleared.
15	R	0	AIS Abnormal Interrupt Summary Abnormal Interrupt Summary bit value is the logical OR of the following when the corresponding interrupt bits are enabled: • Transmit Process Stopped • Transmit Jabber Timeout • Receive FIFO Overflow • Transmit Underflow • Receive Buffer Unavailable • Receive Process Stopped • Receive Watchdog Timeout • Early Transmit Interrupt • Fatal Bus Error Only unmasked bits affect the Abnormal Interrupt Summary bit. This is a sticky bit and must be cleared each time a corresponding bit that causes AIS to be set is cleared.
14	R	0	ERI Early Receive Interrupt This bit indicates that the DMA had filled the first data buffer of the packet.
13	R	0	FBI

			Fatal Bus Error Interrupt This bit indicates that a bus error occurred. When this bit is set, the corresponding DMA engine disables all its bus accesses.
12:11	/	/	/
10	R	0	ETI Early Transmit Interrupt This bit indicates that the frame to be transmitted was fully transferred to the MTL Transmit FIFO.
9	R	0	RWT Receive Watchdog Timeout This bit is asserted when a frame with a length greater than 2,048 bytes is received (10,240 when Jumbo Frame mode is enabled).
8	R	0	RPS Receive Process Stopped This bit is asserted when the Receive Process enters the Stopped state.
7	R	0	RU Receive Buffer Unavailable This bit indicates that the Next Descriptor in the Receive List is owned by the host and cannot be acquired by the DMA. Receive Process is suspended. To resume processing Receive descriptors, the host should change the ownership of the descriptor and issue a Receive Poll Demand command. If no Receive Poll Demand is issued, Receive Process resumes when the next recognized incoming frame is received. Register 5[7] is set only when the previous Receive Descriptor was owned by the DMA.
6	R	0	RI Receive Interrupt This bit indicates the completion of frame reception. Specific frame status information has been posted in the descriptor. Reception remains in the Running state.
5	R	0	UNF Transmit Underflow This bit indicates that the Transmit Buffer had an Underflow during frame transmission. Transmission is suspended and an Underflow Error TDES0[1] is set.
4	R	0	OVF Receive Overflow This bit indicates that the Receive Buffer had an Overflow during frame reception. If the partial frame is transferred to application, the overflow status is set in RDES0[11].
3	R	0	TJT Transmit Jabber Timeout This bit indicates that the Transmit Jabber Timer expired, meaning that the transmitter had been excessively active. The transmission process is aborted and placed in the Stopped state. This causes the Transmit Jabber Timeout TDES0[14] flag to assert.
2	R	0	TU

			Transmit Buffer Unavailable This bit indicates that the Next Descriptor in the Transmit List is owned by the host and cannot be acquired by the DMA. Transmission is suspended. Bits[22:20] explain the Transmit Process state transitions. To resume processing transmit descriptors, the host should change the ownership of the bit of the descriptor and then issue a Transmit Poll Demand command.
1	R	0	TPS Transmit Process Stopped This bit is set when the transmission is stopped
0	R	0	TI: Transmit Interrupt This bit indicates that frame transmission is finished and TDES1[31] is set in the First Descriptor.

7.8.5.7. EDMA Operation Mode Register(Default Value: 0x0000_0000)

Offset: 0x1018			Register Name: EDMA_OPERATION
Bit	Read/Write	Default	Description
31:26	/	/	/
25	R/W	0	RSF Receive Store and Forward When this bit is set, the MTL only reads a frame from the Rx FIFO after the complete frame has been written to it, ignoring RTC bits. When this bit is reset, the Rx FIFO operates in Cut-Through mode, subject to the threshold specified by the RTC bits.
24	R/W	0	DFF Disable Flushing of Received Frames When this bit is set, the RxDMA does not flush any frames due to the unavailability of receive descriptors/buffers as it does normally when this bit is reset.
23	R/W	0	RFA[2] MSB of Threshold for Activating Flow Control If the EMAC-UNIV is configured for an Rx FIFO depth of 8 KB or more, this bit (when set) provides additional threshold levels for activating the Flow Control in both Half- Duplex and Full-Duplex modes. This bit (as Most Significant Bit) along with the RFA (bits [10:9]) give the following thresholds for activating flow control. 100: Full minus 5 KB 101: Full minus 6 KB 110: Full minus 7 KB 111: Reserved
22	R/W	0	RFD[2] MSB of Threshold for Deactivating Flow Control If the EMAC-UNIV is configured for an Rx FIFO depth of 8 KB or more, this bit (when set) provides additional threshold levels for deactivating the Flow Control

			in both Half- Duplex and Full-Duplex modes. This bit (as Most Significant Bit) along with the RFD (bits [12:11]) give the following thresholds for deactivating flow control. 100: Full minus 5 KB 101: Full minus 6 KB 110: Full minus 7 KB 111: Reserved
21	R/W	0	TSF Transmit Store and Forward When this bit is set, transmission starts when a full frame resides in the MTL Transmit FIFO. The TTC value is ignored.
20	R/W	0	FTF Flush Transmit FIFO When this bit is set, the transmit FIFO controller logic is reset to its default values and thus all data in the Tx FIFO is lost/flushed. This bit is cleared internally when the flushing operation is completed fully. The Operation Mode register should not be written to until this bit is cleared.
19:17	/	/	/
16:14	R/W	0	TTC Transmit Threshold Control These three bits control the threshold level of the MTL Transmit FIFO. Transmission starts when the frame size within the MTL Transmit FIFO is larger than the threshold. In addition, full frames with a length less than the threshold are also transmitted. These bits are used only when the TSF bit (Bit 21) is reset. 000: 64 001: 128 010: 192 011: 256 100: 40 101: 32 110: 24 111: 16
13	R/W	0	ST Start/Stop Transmission Command When this bit is set, transmission is placed in the Running state. When this bit is reset, the transmission process is placed in the Stopped state after completing the transmission of the current frame.
12:11	R/W	0	RFD Threshold for deactivating flow control (in both HD and FD) These bits control the threshold (Fill-level of Rx FIFO) at which the flow-control is deasserted after activation. 00: Full minus 1 KB 01: Full minus 2 KB 10: Full minus 3 KB 11: Full minus 4 KB

			Note that the deassertion is effective only after flow control is asserted. An additional bit (RFD[2]) is used for more threshold levels.
10:9	R/W	0	RFA Threshold for activating flow control (in both HD and FD) These bits control the threshold (Fill level of Rx FIFO) at which flow control is activated. 00: Full minus 1 KB 01: Full minus 2 KB 10: Full minus 3 KB 11: Full minus 4 KB Note that an additional bit (RFA[2]) is used for more threshold levels.
8	R/W	0	EFC Enable HW flow control When this bit is set, the flow control signal operation based on fill-level of Rx FIFO is enabled. When reset, the flow control operation is disabled.
7	R/W	0	FEF Forward Error Frames When this bit is reset, the Rx FIFO drops frames with error status (CRC error, collision error, GMII_ER, giant frame, watchdog timeout, overflow).
6	R/W	0	FUF Forward Undersized Good Frames When set, the Rx FIFO will forward Undersized frames (frames with no Error and length less than 64 bytes) including pad-bytes and CRC).
5	/	/	/
4:3	R/W	0	RTC Receive Threshold Control These two bits control the threshold level of the MTL Receive FIFO. Transfer (request) to DMA starts when the frame size within the MTL Receive FIFO is larger than the threshold. In addition, full frames with a length less than the threshold are transferred automatically. Note that value of 11 is not applicable if the configured Receive FIFO size is 128 bytes. These bits are valid only when the RSF bit is zero, and are ignored when the RSF bit is set to 1. 00: 64 01: 32 10: 96 11: 128
2	R/W	0	OSF Operate on Second Frame When this bit is set, this bit instructs the DMA to process a second frame of Transmit data even before status for first frame is obtained.
1	R/W	0	SR Start/Stop Receive When this bit is set, the Receive process is placed in the Running state. When this bit is cleared, RxDMA operation is stopped after the transfer of the current frame.
0	/	/	/

7.8.5.8. EDMA Interrupt Enable Register(Default Value: 0x0000_0000)

Offset: 0x101C			Register Name: EDMA_INTR_ENA
Bit	Read/Write	Default	Description
31:17	/	/	/
16	R/W	0	NIE Normal Interrupt Summary Enable When this bit is set, a normal interrupt is enabled. When this bit is reset, a normal interrupt is disabled. This bit enables the following bits: • Transmit Interrupt • Transmit Buffer Unavailable • Receive Interrupt • Early Receive Interrupt
15	R/W	0	AIE Abnormal Interrupt Summary Enable When this bit is set, an Abnormal Interrupt is enabled. When this bit is reset, an Abnormal Interrupt is disabled. This bit enables the following bits • Transmit Process Stopped • Transmit Jabber Timeout • Receive Overflow • Transmit Underflow • Receive Buffer Unavailable • Receive Process Stopped • Receive Watchdog Timeout • Early Transmit Interrupt • Fatal Bus Error
14	R/W	0	ERE Early Receive Interrupt Enable When this bit is set with Normal Interrupt Summary Enable, Early Receive Interrupt is enabled. When this bit is reset, Early Receive Interrupt is disabled
13	R/W	0	FBE Fatal Bus Error Enable When this bit is set with Abnormal Interrupt Summary Enable, the Fatal Bus Error Interrupt is enabled. When this bit is reset, Fatal Bus Error Enable Interrupt is disabled.
12:11	/	/	/
10	R/W	0	ETE Early Transmit Interrupt Enable When this bit is set with an Abnormal Interrupt Summary Enable, Early Transmit Interrupt is enabled. When this bit is reset, Early Transmit Interrupt is disabled
9	R/W	0	RWE Receive Watchdog Timeout Enable When this bit is set with Abnormal Interrupt Summary Enable, the Receive

			Watchdog Timeout Interrupt is enabled. When this bit is reset, Receive Watchdog Timeout Interrupt is disabled
8	R/W	0	RSE Receive Stopped Enable When this bit is set with Abnormal Interrupt Summary Enable, Receive Stopped Interrupt is enabled. When this bit is reset, Receive Stopped Interrupt is disabled
7	R/W	0	RUE Receive Buffer Unavailable Enable When this bit is set with Abnormal Interrupt Summary Enable, Receive Buffer Unavailable Interrupt is enabled. When this bit is reset, the Receive Buffer Unavailable Interrupt is disabled
6	R/W	0	RIE Receive Interrupt Enable When this bit is set with Normal Interrupt Summary Enable, Receive Interrupt is enabled. When this bit is reset, Receive Interrupt is disabled
5	R/W	0	UNE Underflow Interrupt Enable When this bit is set with Abnormal Interrupt Summary Enable, Transmit Underflow Interrupt is enabled. When this bit is reset, Underflow Interrupt is disabled.
4	/	/	OVE Overflow Interrupt Enable When this bit is set with Abnormal Interrupt Summary Enable, Receive Overflow Interrupt is enabled. When this bit is reset, Overflow Interrupt is disabled
3	R/W	0	TJE Transmit Jabber Timeout Enable When this bit is set with Abnormal Interrupt Summary Enable, Transmit Jabber Timeout Interrupt is enabled. When this bit is reset, Transmit Jabber Timeout Interrupt is disabled.
3	R/W	0	THE Transmit Jabber Timeout Enable When this bit is set with Abnormal Interrupt Summary Enable, Transmit Jabber Timeout Interrupt is enabled. When this bit is reset, Transmit Jabber Timeout Interrupt is disabled.
2	R/W	0	TUE Transmit Buffer Unavailable Enable When this bit is set with Normal Interrupt Summary Enable, Transmit Buffer Unavailable Interrupt is enabled. When this bit is reset, Transmit Buffer Unavailable Interrupt is disabled.
1	R/W	0	TSE Transmit Stopped Enable When this bit is set with Abnormal Interrupt Summary Enable, Transmission Stopped Interrupt is enabled. When this bit is reset, Transmission Stopped Interrupt is disabled.
0	R/W	0	TIE

			Transmit Interrupt Enable When this bit is set with Normal Interrupt Summary Enable, Transmit Interrupt is enabled. When this bit is reset, Transmit Interrupt is disabled.
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7.8.5.9. EDMA Missed Frame and Buffer Overflow Counter Register(Default Value: 0x0000_0000)

Offset: 0x1020			Register Name: EDMA_MISSED_FRAME
Bit	Read/Write	Default	Description
31:29	/	/	/
28	R/W	0	OFBO Overflow bit for FIFO Overflow Counter
27:17	R/W	0	MFA Missed Frame Counter by Application Indicates the number of frames missed by the application.
16	R/W	0	OFBM Overflow bit for Missed Frame Counter
15:0	R/W	0	MFC Missed Frame Counter by controller Indicates the number of frames missed by the controller due to the Host Receive Buffer being unavailable.

7.8.5.10. EDMA Current Host Transmit Descriptor Register(Default Value: 0x0000_0000)

Offset: 0x1048			Register Name: EDMA_CUR_TX_DESC
Bit	Read/Write	Default	Description
31:0	R	0	Host Transmit Descriptor Address Pointer Cleared on Reset. Pointer updated by DMA during operation

7.8.5.11. EDMA Current Host Receive Descriptor Register(Default Value: 0x0000_0000)

Offset: 0x104C			Register Name: EDMA_CUR_RX_DESC
Bit	Read/Write	Default	Description
31:0	R	0	Host Receive Descriptor Address Pointer Cleared on Reset. Pointer updated by DMA during operation.

7.8.5.12. EDMA Current Host Transmit Buffer Address Register(Default Value: 0x0000_0000)

Offset: 0x1050			Register Name: EDMA_CUR_TX_BUF
Bit	Read/Write	Default	Description

31:0	R	0	Host Transmit Buffer Address Pointer Cleared on Reset. Pointer updated by DMA during operation.
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7.8.5.13. EDMA Current Host Receive Buffer Address Register(Default Value: 0x0000_0000)

Offset: 0x1054			Register Name: EDMA_CUR_RX_BUF
Bit	Read/Write	Default	Description
31:0	R	0	Host Receive Buffer Address Pointer Cleared on Reset. Pointer updated by DMA during operation.

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Appendix

Control signal and data port mapping

	SYNC RGB					CPU cmd	CPU 18bit	CPU 16bit								CPU 8bit				CPU 9bit	Single LVDS	TTL			
I/O	Para RGB	Serial RGB			CCIR 656		256K	256K								65K	256K			65K			256K		
		1 st	2 nd	3 rd				1 st	2 nd	3 rd	1 st	2 nd	1 st	2 nd	1 st		2 nd	3 rd	1 st	2 nd			1 st	2 nd	
IO0	VSYNC					CS																D3N	STV		
IO1	HSYNC					RD																D3P	SKV		
IO2	DCLK					WR																CKP	STH		
IO3	DE					RS																CKN	OEH		
D23	R7					D23	R5	R5	B5	G5	R5		R5	B5	R4									D2N	R7
D22	R6					D22	R4	R4	B4	G4	R4		R4	B4	R3									D2P	R6
D21	R5					D21	R3	R3	B3	G3	R3		R3	B3	R2									D1N	R5
D20	R4					D20	R2	R2	B2	G2	R2		R2	B2	R1									D1P	R4
D19	R3					D19	R1	R1	B1	G1	R1		R1	B1	R0									D0N	R3
D18	R2					D18	R0	R0	B0	G0	R0		R0	B0	G5									D0P	R2
D17	R1					D17																			CKH
D16	R0					D16																			REV
D15	G7					D15	G5								G4										G7
D14	G6					D14	G4								G3										G6
D13	G5					D13	G3																		G5
D12	G4	D17	D27	D37	D7	D12	G2	G5	R5	B5	G5	B5	G5		G2	R5	G5	B5	R4	G2	R5	G2			G4
D11	G3	D16	D26	D36	D6	D11	G1	G4	R4	B4	G4	B4	G4		G1	R4	G4	B4	R3	G1	R4	G1			G3
D10	G2	D15	D25	D35	D5	D10	G0	G3	R3	B3	G3	B3	G3		G0	R3	G3	B3	R2	G0	R3	G0			G2
D9	G1					D9																			REVB
D8	G0					D8																			CKH1
D7	B7	D14	D24	D34	D4	D7	B5	G2	R2	B2	G2	B2	G2		B4	R2	G2	B2	R1	B4	R2	B5			B7
D6	B6	D13	D23	D33	D3	D6	B4	G1	R1	B1	G1	B1	G1		B3	R1	G1	B1	R0	B3	R1	B4			B6
D5	B5	D12	D22	D32	D2	D5	B3	G0	R0	B0	G0	B0	G0		B2	R0	G0	B0	G5	B2	R0	B3			B5
D4	B4	D11	D21	D31	D1	D4	B2								B1				G4	B1	G5	B2			B4
D3	B3	D10	D20	D30	D0	D3	B1								B0				G3	B0	G4	B1			B3
D2	B2					D2	B0														G3	B0			B2
D1	B1					D1																			OEV
D0	B0					D0																			CKH2