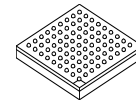


MIMX8QPnAVUxxAx

i.MX 8QuadPlus Automotive and Infotainment Applications Processors



Package Information
29 x 29 mm package case outline

Ordering Information
See Table 2 on page 5

1 Introduction

The i.MX 8 Family consists of two processors: i.MX 8QuadMax and 8QuadPlus. This data sheet covers the i.MX 8QuadPlus processor, which is composed of seven cores (one Arm[®] Cortex[®]-A72, four Arm Cortex[®]-A53, and two Arm Cortex[®]-M4F), dual 32-bit GPU subsystems, 4K H.265 capable VPU, and dual failover-ready display controllers. This processor supports a single 4K display (with multiple display output options, including MIPI-DSI, HDMI, eDP/DP, and LVDS), or multiple smaller displays. Memory interfaces supporting LPDDR4, Quad SPI/Octal SPI (FlexSPI), eMMC 5.1, RAW NAND, SD 3.0, and a wide range of peripheral I/Os such as PCIe 3.0, provide wide flexibility. Advanced multicore audio processing is supported by the Arm cores and a high performance Tensilica[®] HiFi 4 DSP for pre- and post-audio processing as well as voice recognition.

1	Introduction	1
1.1	Ordering Information	5
1.2	System Controller Firmware (SCFW) Requirements	5
1.3	Related resources	5
2	Architectural Overview	5
2.1	Block Diagram	6
3	Modules List	7
3.1	Special Signal Considerations	13
3.2	Recommended Connections for Unused Interfaces	13
4	Electrical characteristics	14
4.1	Chip-level conditions	14
4.2	Power supplies requirements and restrictions	26
4.3	PLL electrical characteristics	29
4.4	On-chip oscillators	33
4.5	I/O DC Parameters	36
4.6	I/O AC Parameters	42
4.7	Output Buffer Impedance Parameters	45
4.8	System Modules Timing	49
4.9	General-Purpose Media Interface (GPMI) Timing	53
4.10	External Peripheral Interface Parameters	62
4.11	Analog-to-digital converter (ADC)	111
5	Boot mode configuration	115
5.1	Boot mode configuration inputs	115
5.2	Boot devices interfaces allocation	115
6	Package information and contact assignments	117
6.1	FCPBGA, 29 x 29 mm, 0.75 mm pitch	117
7	Release Notes	144



Introduction

The i.MX 8QuadPlus processor offers numerous advanced features as shown in this table.

Table 1. i.MX 8QuadPlus advanced features

Function	Feature
Multicore architecture provides 4× Cortex-A53, 1× Cortex-A72 cores, and 2× Cortex-M4F cores	AArch64 for 64-bit support and new architectural features
	AArch32 for full backward compatibility with ARMv7
	Cortex-A72 and Cortex-A53 cores support ARM virtualization extensions. sMMU provides address virtualization to all subsystems.
	Cortex-M4F cores for real-time applications
Graphics Processing Unit (GPU)	16× Vec4 shaders with 64 execution units. Split GPU architecture allows for dual independent 8-Vec4 shader GPUs or a combined 16-Vec4 shader GPU.
	Supports OpenGL 3.0, 2.1,; OpenGL ES 3.2, 3.1 (with AEP), 3.0, 2.0, and 1.1; OpenCL 1.2 Full Profile and 1.1; OpenVG 1.1; and Vulkan
	High-performance 2D Blit Engine
Video Processing Unit (VPU)	H.265 decode (4Kp60)
	H.264 decode (4Kp30)
	WMV9/VC-1 imple decode
	MPEG 1 and 2 decode
	AVS decode
	MPEG4.2 ASP, H.263, Sorenson Spark decode
	Divx 3.11 including GMC decode
	ON2/Google VP6/VP8 decode
	RealVideo 8/9/10 decode
	JPEG and MJPEG decode
	H.264 encode (1080p30)
Tensilica HiFi 4 DSP for pre- and post-processing	666 MHz Fixed-point and vector-floating-point support 32 KB instruction cache, 48 KB data cache, 512 KB SRAM (448 KB of OCRAM and 64 KB of TCM)
Memory	64-bit LPDDR4 @1600 MHz
	1× Quad SPI which can be used to connect to an FPGA
	2× Quad SPI or 1× Octal SPI (FlexSPI) for fast boot from SPI NOR flash
	2× SD 3.0 card interfaces
	1× eMMC5.1/SD3.0
	RAW NAND (62-bit ECC support via BCH-62 module)

Table 1. i.MX 8QuadPlus advanced features (continued)

Function	Feature
Display Controller	Supports single UltraHD 4Kp60 display or up to 4 independent FullHD 1080p60 displays
	Up to 18-layer composition
	Complementary 2D blitting engines and online warping functionality
	Integrated Failover Path (SafeAssure) to ensure display content stays valid even in event of a software failure
Display I/O	2× MIPI-DSI with 4 lanes each
	1× HDMI-TX/DisplayPort compliant with: <ul style="list-style-type: none"> • HDMI • eDP 1.4 • DP 1.3
	This high performance serializer supports a pair of LVDS displays with 8 lanes each. Each port can be configured for 2x Tx with 4 lanes each.
Camera I/O and video	2× MIPI-CSI with 4-lanes each
Security	Advanced High Assurance Boot (AHAB) secure & encrypted boot
	Random Number Generator with a high-quality entropy source generator and Hash_DRBG (based on hash functions)
	RSA up to 4096, Elliptic Curve up to 1023
	AES-128/192/256, DES, 3DES, MD5, SHA-1, SHA-224/256/384/512
	Dedicated Security Controller for Flashless SHE and HSM support, Trustzone
	Built-in ECDSA/DSA protocol support
	See the security reference manual for this chip for a full list of security features.
System Control	<ul style="list-style-type: none"> • 2× I²C tightly coupled with Cortex-M4 cores (1× per Cortex M4F core) <ul style="list-style-type: none"> • The tightly coupled M4 I²C ports cannot be used for general-purpose use • System Control Unit (SCU): <ul style="list-style-type: none"> • Power control, clocks, reset • Boot ROMs • PMIC interface • Resource Domain Controller

Table 1. i.MX 8QuadPlus advanced features (continued)

Function	Feature
I/O	1× PCIe 3.0 (2-lanes). Can be used as two PCIe 3.0 controllers with one-lane, independent operation. PCIe 1.0 and 2.0 compliant. PCIe 3.0 capable, contact your NXP representative.
	1× USB 3.0 with PHY
	2× USB 2.0 (1 with PHY, 1 with HSIC)
	1× SATA 3.0 can be used as PCIe one-lane. This is in addition to the standard PCIe controller. PCIe 1.0 and 2.0 compliant. PCIe 3.0 capable, contact your NXP representative.
	2× 1Gb Ethernet with AVB (can be used as 10/100 Mbps ENET with AVB)
	3× CAN/CAN-FD
	8× UARTs: <ul style="list-style-type: none"> • 5× UARTs (2× with hardware flow control) • 2× UARTs tightly coupled with Cortex-M4F cores (1× per Cortex-M4F core) • 1× UART tightly coupled with SCU
	18× I ² C: <ul style="list-style-type: none"> • 5× General-Purpose I²C (full-speed with DMA support) • Low-speed I²C without DMA support: <ul style="list-style-type: none"> • 2× master I²C in MIPI-DSI (1× per instance) • 4× master I²C in LVDS (2× per instance) • 2× master I²C in HDMI-TX • 2× master I²C in MIPI-CSI (1× per instance) <p>Note: Although low-speed I²Cs can be made available for general purpose use which requires the associated PHY (for example, MIPI) to be powered on, it is not recommended.</p> <p>Note: I/O muxing constraints prevent using all I²Cs simultaneously.</p> <ul style="list-style-type: none"> • 2× I2C tightly coupled with Cortex-M4 cores (1× per Cortex M4F core) <p>Note: The tightly coupled M4 I2C ports cannot be used for general purpose use.</p> <ul style="list-style-type: none"> • 1× I²C tightly coupled with SCU for communication with the PMIC. Not general purpose and not available for non-PMIC uses.
	4× SAI (SAI0 and SAI1 are transmit/receive; SAI2 and SAI3 are receive only)
	2× Enhanced Serial Audio Interface (ESAI)
	× ASRC (Asynchronous Sample Rate Converter) (note: no I/O signals are directly connected to this module)
	1× SPDIF (Tx and Rx)
	2× 4-channel ADC converters
	3.3 V/1.8 V GPIO
	4× PWM channels
	1× 6×8 KPP (Key Pad Port)
	1× MQS (Medium Quality Sound)
4× SPI	
Packaging	Case FCPBGA 29 x 29 mm, 0.75 mm pitch

1.1 Ordering Information

The following table provides the ordering information.

Table 2. i.MX 8QuadPlus Orderable part numbers

Part Number	Options	Cortex-A72	Cortex-A53	Cortex-M4F	GPU	Qualification Tier	Package
MIMX8QP5AVUFFAB	1 x VPU	One @ 1.6 GHz	Four @ 1.2 GHz	Two @ 264 MHz	Two @ 625 MHz	Automotive AEC-Q100	29 mm × 29 mm 0.75 mm pitch FCPBGA (lidded)
MIMX8QP6AVUFFAB	1 x VPU 1 x DSP						

1.2 System Controller Firmware (SCFW) Requirements

The i.MX 8 and 8X families require a minimum SCFW release version for correct operation and to prevent potential reliability issues.

The SCFW is released as part of a Board Support Package (e.g. Linux, Android) which may vary in version number for a specific BSP.

For example, 5.4.70_2.3.0 GA contains SCFW version 1.7.1. Whereas 5.10.0_1.0.0 GA contains SCFW version 1.8.0.

The released SCFW version associated within each BSP is the minimum version required to correctly support the wider BSP functionality.

Customers should always check that they are using the specific SCFW binary delivered within their chosen BSP release. Customers should not mix newer BSP versions with older revisions of the SCFW.

1.3 Related resources

Table 3. Related resources

Type	Description
Reference manual	The <i>i.MX 8QuadMax Applications Processor Reference Manual (IMX8QMRM)</i> contains a comprehensive description of the structure and function (operation) of the QuadPlus SoC.
Data sheet	This data sheet includes electrical characteristics and signal connections.
Chip Errata	The chip mask set errata provides additional and/or corrective information for a particular device mask set.
Package drawing	Package dimensions are provided in Section 6, "Package information and contact assignments" .
Hardware guide	The <i>i.MX 8QuadMax/8QuadPlus Hardware Developer's Guide (IMX8HWDG)</i> provides system design guidelines.

2 Architectural Overview

The following subsections provide an architectural overview of the i.MX 8QuadPlus processor system.

2.1 Block Diagram

The following figure shows the functional modules in the processor system.

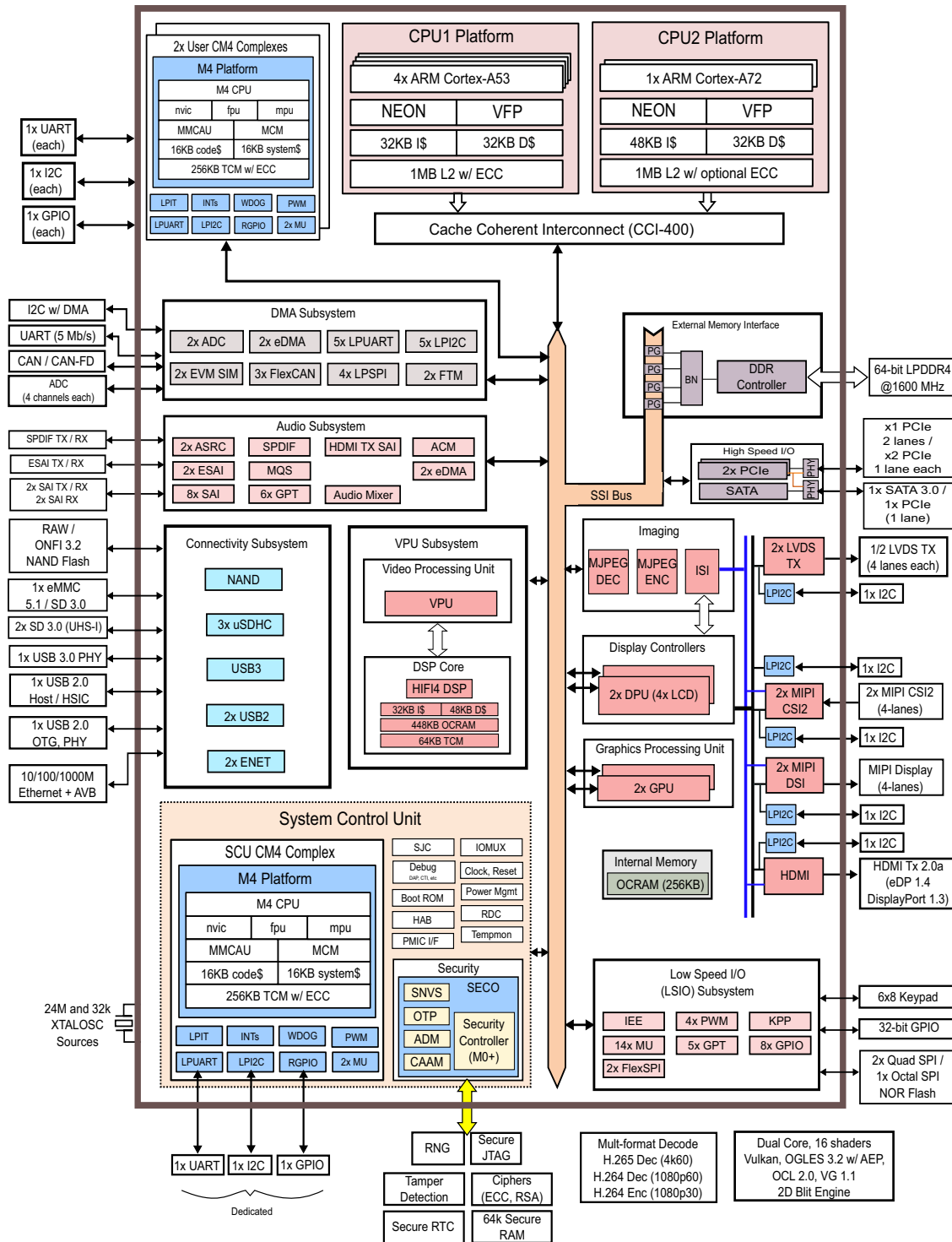


Figure 1. i.MX 8QuadPlus System Block Diagram

3 Modules List

The i.MX 8QuadPlus processors contain a variety of digital and analog modules. This table describes the processor modules in alphabetical order.

Table 4. i.MX 8QuadPlus modules list

Block Mnemonic	Block Name	Brief Description
ADC	Analog-to-Digital Converter	The analog-to-digital converter (ADC) is a successive approximation ADC designed for operation within a SoC.
APBH-DMA	NAND Flash and BCH ECC DMA Controller	The AHB-to-APBH bridge provides the chip with a peripheral attachment bus running on the AHB's HCLK, which includes the AHB-to-APB PIO bridge for a memory-mapped I/O to the APB devices, as well as a central DMA facility for devices on this bus and a vectored interrupt controller for the Arm core.
A53	Arm (CPU1)	CPU cluster embedding 4x Cortex-A53 CPUs with a 32KB L1 instruction cache and a 32KB data cache. The CPUs share a 1 MB L2 cache.
A72	Arm (CPU2)	CPU cluster embedding 1x Cortex-A72 CPU with a 48 KB L1 instruction cache and 32 KB data cache. The CPU has a 1MB L2 cache.
ASRC	Asynchronous Sample Rate Converter	The Asynchronous Sample Rate Converter (ASRC) converts the sampling rate of a signal associated to an input clock into a signal associated to a different output clock. The ASRC supports concurrent sample rate conversion of up to 10 channels of about -120dB THD+N. The sample rate conversion of each channel is associated to a pair of incoming and outgoing sampling rates. The ASRC supports up to three sampling rate pairs.
BCH-62	Binary-BCH ECC Processor	The BCH62 module provides up to 62-bit ECC for NAND Flash controller (GPMI2)
CAAM	Cryptographic Accelerator and Assurance Module	CAAM is a cryptographic accelerator and assurance module. CAAM implements several encryption and hashing functions, a run-time integrity checker, and a Pseudo Random Number Generator (PRNG). CAAM also implements a Secure Memory mechanism. In this device the security memory provided is 64 KB.
CTI	Cross Trigger Interface	CTI sends signals across the chip indicating that debug events have occurred. It is used by features of the Coresight infrastructure.
CTM	Cross Trigger Matrix	Cross Trigger Matrix IP is used to route triggering events between CTIs.
DAP	Debug Access Port	The DAP provides real-time access for the debugger without halting the core to: <ul style="list-style-type: none"> • System memory and peripheral registers • All debug configuration registers The DAP also provides debugger access to JTAG scan chains.
DC	Display Controller	Dual display controller
DDR Controller	DRAM Controller	<ul style="list-style-type: none"> • Memory types: LPDDR4 • Two channels of 32-bit memory: <ul style="list-style-type: none"> • LPDDR4 up to 1.6 GHz

Table 4. i.MX 8QuadPlus modules list (continued)

Block Mnemonic	Block Name	Brief Description
DPR	Display/Prefetch/Resolve	The DPR prefetches data from memory and converts the data to raster format for display output. Raster source buffers can also be prefetched unconverted. The resolve process supports graphics and video formatted tile frame buffers and converts them to raster format. Embedded display memory is used as temporary storage for data which is sourced by the display controller to drive the display.
eDMA	Enhanced Direct Memory Access	<ul style="list-style-type: none"> • 4× eDMA with a total of 128 channels (note: all channels are not assigned; see the product reference manual for more information): <ul style="list-style-type: none"> • 4× instances with 32 channels each • Programmable source, destination addresses, transfer size, plus support for enhanced addressing modes • Internal data buffer, used as temporary storage to support 64-byte burst transfers, one outstanding transaction per DMA controller. • Transfer control descriptor organized to support two-deep, nested transfer operations • Channel service request via one of three methods: <ul style="list-style-type: none"> • Explicit software initiation • Initiation via a channel-to-channel linking mechanism for continuous transfers • Peripheral-paced hardware requests (one per channel) • Support for fixed-priority and round-robin channel arbitration • Channel completion reported via interrupt requests • Support for scatter/gather DMA processing • Support for complex data structures via transfer descriptors • Support to cancel transfers via software or hardware • Each eDMA instance can be uniquely assigned to a different resource domain, security (TZ) state, and virtual machine • In scatter-gather mode, each transfer descriptor's buffers can be assigned to different SMMU translation
ENET	Ethernet Controller	2× 1 Gbps Ethernet controllers supporting RGMII + AVB (Audio Video Bridging, IEEE 802.1Qav)
ESAI	Enhanced Serial Audio Interface	The Enhanced Serial Audio Interface (ESAI) provides a full-duplex serial port for serial communication with a variety of serial devices, including industry-standard codecs, SPDIF transceivers, and other processors. The ESAI consists of independent transmitter and receiver sections, each section with its own clock generator. All serial transfers are synchronized to a clock. Additional synchronization signals are used to delineate the word frames. The normal mode of operation is used to transfer data at a periodic rate, one word per period. The network mode is also intended for periodic transfers; however, it supports up to 32 words (time slots) per period. This mode can be used to build time division multiplexed (TDM) networks. In contrast, the on-demand mode is intended for non-periodic transfers of data and to transfer data serially at high speed when the data becomes available. The ESAI has 12 pins for data and clocking connection to external devices.
FTM	FlexTimer	Provides input signal capture and PWM support
FlexCAN	Flexible Controller Area Network	Communication controller implementing the CAN with Flexible Data rate (CAN FD) protocol and the CAN protocol according to the CAN 2.0B protocol specification.

Table 4. i.MX 8QuadPlus modules list (continued)

Block Mnemonic	Block Name	Brief Description
FlexSpi (Quad SPI/Octal SPI)	Flexible Serial Peripheral Interface	<ul style="list-style-type: none"> • Flexible sequence engine to support various flash vendor devices, including HyperBus™ devices: • Support for FPGA interface • Single, dual, quad, and octal mode of operation. • DDR/DTR mode wherein the data is generated on every edge of the serial flash clock. • Support for flash data strobe signal for data sampling in DDR and SDR mode. • Two identical serial flash devices can be connected and accessed in parallel for data read operations, forming one (virtual) flash memory with doubled readout bandwidth.
GIC	Generic Interrupt Controller	The GIC-500 handles all interrupts from the various subsystems and is ready for virtualization.
GPIO	General Purpose I/O Modules	Used for general purpose input/output to external devices. Each GPIO module supports 32 bits of I/O.
GPMI	General Purpose Media Interface	The GPMI module supports up to 8× NAND devices. 62-bit ECC (BCH) encryption/decryption for NAND Flash controller (GPMI). The GPMI supports separate DMA channels per NAND device.
GPT	General Purpose Timer	Each GPT is a 32-bit “free-running” or “set and forget” mode timer with programmable prescaler and compare and capture register. A timer counter value can be captured using an external event and can be configured to trigger a capture event on either the leading or trailing edges of an input pulse. When the timer is configured to operate in “set and forget” mode, it is capable of providing precise interrupts at regular intervals with minimal processor intervention. The counter has output compare logic to provide the status and interrupt at comparison. This timer can be configured to run either on an external clock or on an internal clock.
GPU	Graphics Processing	2× GC7000XSVX GPUs with 8 shaders each that can run either independently or in “dual-mode” with 16 shaders.
HDMI Tx/DP/eDP	HDMI Tx interface	HDMI transmitter, Display Port 1.3 and embedded Display Port 1.4
HiFi 4 DSP	Audio Processor	A highly optimized audio processor geared for efficient execution of audio and voice codecs and pre- and post-processing modules to offload the Arm core.
I ² C	I ² C Interface	I ² C provides serial interface for external devices.
IEE		<ul style="list-style-type: none"> • Supports direct encryption and decryption of FlexSPI memory type • Provides decryption services (lower performance) for DRAM traffic • Supports I/O direct encrypted storage and retrieval • Support for a number of cryptographic standards: <ul style="list-style-type: none"> • 128/256-bit AES Encryption (AES-CTR, AES-XTS mode options) • Multiple keys supported: <ul style="list-style-type: none"> • Loaded via secure key channel from security block • Key selection is per access and based on source of transaction
IOMUXC	IOMUX Control	This module enables flexible I/O multiplexing. Each I/O pad has default and several alternate functions. The alternate functions are software configurable.
JPEG/dec	MJPEG engine for decode	Provides up to 4-stream decoding in parallel.

Table 4. i.MX 8QuadPlus modules list (continued)

Block Mnemonic	Block Name	Brief Description
JPEG/enc	MJPEG engine for encode	Provides up to 4-stream encoding in parallel.
KPP	Key Pad Port	The Keypad Port (KPP) is a 16-bit peripheral that can be used as a 6 x 8 keypad matrix interface or as general purpose input/output (I/O).
LPIT-1 LPIT-2	Low-Power Periodic Interrupt Timer	Each LPIT is a 32-bit “set and forget” timer that starts counting after the LPIT is enabled by software. It is capable of providing precise interrupts at regular intervals with minimal processor intervention. It has a 12-bit prescaler for division of input clock frequency to get the required time setting for the interrupts to occur, and counter value can be programmed on the fly.
LPSPi 0–3	Configurable SPI	Full-duplex enhanced Synchronous Serial Interface. It is configurable to support Master/Slave modes, four chip selects to support multiple peripherals.
LVDS	LVDS Display Bridge	This high performance serializer supports a pair of LVDS displays with 8 lanes each. Each port can be configured for 2x Tx with 4 lanes each.
M4F	Arm (CPU3)	<ul style="list-style-type: none"> • Cortex-M4F core • AHB LMEM (Local Memory Controller) including controllers for TCM and cache memories • 256 KB embedded tightly coupled memory(TCM) (128 KB TCMU, 128 KB TCML) • 16 KB Code Bus Cache • 16 KB System Bus Cache • ECC for TCM memories and parity for code and system caches • Integrated Nested Vector Interrupt Controller (NVIC) • Wakeup Interrupt Controller (WIC) • FPU (Floating Point Unit) • Core MPU (Memory Protection Unit) • Support for exclusive access on the system bus • MMCAU (Crypto Acceleration Unit) • MCM (Miscellaneous Control Module)
MIPI CSI-2	MIPI CSI-2 Interface	The MIPI CSI-2 IP provides MIPI CSI-2 standard camera interface ports. The MIPI CSI-2 interface supports up to 1.5 Gbps for up to 4 data lanes
MIPI-DSI	MIPI DSI interface	The MIPI DSI IP provides DSI standard display serial interface. The DSI interface supports 80 Mbps to 1.5 Gbps speed per data lane.
MQS	Medium Quality Sound	Medium Quality Sound (MQS) is used to generate 2-channel medium quality PWM-like audio via two standard digital GPIO pins.
OCOTP_CTRL	OTP Controller	The On-Chip OTP controller (OCOTP_CTRL) provides an interface for reading, programming, and/or overriding identification and control information stored in on-chip fuse elements. The module supports electrically-programmable poly fuses (eFUSES). The OCOTP_CTRL also provides a set of volatile software-accessible signals that can be used for software control of hardware elements, not requiring non-volatility. The OCOTP_CTRL provides the primary user-visible mechanism for interfacing with on-chip fuse elements. Among the uses for the fuses are unique chip identifiers, mask revision numbers, cryptographic keys, JTAG secure mode, boot characteristics, and various control signals requiring permanent nonvolatility.

Table 4. i.MX 8QuadPlus modules list (continued)

Block Mnemonic	Block Name	Brief Description
OCRAM	On-Chip Memory Controller	The On-Chip Memory controller (OCRAM) module is designed as an interface between the system's AXI bus and the internal (on-chip) SRAM memory module. The OGRAM is used for controlling the 256 KB multimedia RAM through a 64-bit AXI bus.
PCIe	PCI Express 3.0	PCIe 1.0 and 2.0 compliant. PCIe 3.0 capable; contact your NXP representative.
PRG	Prefetch/Resolve Gasket	The PRG is a gasket which translates system memory accesses to local display RTRAM accesses for display refresh. It works with the DPR to complete the prefetch and resolving operations needed to drive the display.
PWM	Pulse Width Modulation	The pulse-width modulator (PWM) has a 16-bit counter and is optimized to generate sound from stored sample audio images and it can also generate tones. It uses 16-bit resolution and a 4x16 data FIFO to generate square waveforms.
RAM 64 KB Secure RAM	Secure/non-secure RAM	Secure/non-secure Internal RAM, interfaced through the CAAM.
RAM 256 KB	Internal RAM	Internal RAM, which is accessed through OGRAM memory controllers.
RNG	Random Number Generator	The purpose of the RNG is to generate cryptographically strong random data. It uses a true random number generator (TRNG) and a pseudo-random number generator (PRNG) to achieve true randomness and cryptographic strength. The RNG generates random numbers for secret keys, per message secrets, random challenges, and other similar quantities used in cryptographic algorithms.
SAI	I2S/SSI/AC97 Interface	The SAI module provides a synchronous audio interface that supports full duplex serial interfaces with frame synchronization, such as I2S, AC97, TDM, and codec/DSP interfaces.
SECO	Security Controller	Core and associated memory and hardware responsible for key management.
SJC	Secure JTAG Controller	The SJC provides the JTAG interface, which is compatible with JTAG TAP standards, to internal logic. This device uses JTAG port for production, testing, and system debugging. Additionally, the SJC provides BSR (Boundary Scan Register) standard support, which is compatible with IEEE1149.1 and IEEE1149.6 standards. The JTAG port must be accessible during platform initial laboratory bring-up, for manufacturing tests and troubleshooting, as well as for software debugging by authorized entities. The SJC incorporates three security modes for protecting against unauthorized accesses. Modes are selected through eFUSE configuration.
sMMU	System MMU	The System MMU is an MMU-500 from Arm. It supports two-stage address translation and multiple translation contexts.
SNVS	Secure Non-Volatile Storage	Secure Non-Volatile Storage, including Secure Real Time Clock, Security State Machine, Master Key Control.
SPDIF	Sony Philips Digital Interconnect Format	The Sony/Philips Digital Interface (SPDIF) audio block is a stereo transceiver that allows the processor to receive and transmit digital audio. The SPDIF transceiver allows the handling of both SPDIF channel status (CS) and User (U) data and includes a frequency measurement block that allows the precise measurement of an incoming sampling frequency.

Table 4. i.MX 8QuadPlus modules list (continued)

Block Mnemonic	Block Name	Brief Description
TEMPMON	Temperature Monitor	The temperature monitor/sensor IP module for detecting high temperature conditions. The temperature read out does not reflect case or ambient temperature. It reflects the temperature in proximity of the sensor location on the die. Temperature distribution may not be uniformly distributed; therefore, the read-out value may not be the reflection of the temperature value for the entire die.
UART	UART Interface	<ul style="list-style-type: none"> • High-speed TIA/EIA-232-F compatible, up to 5.0 Mbps • Serial IR interface low-speed, IrDA-compatible (up to 115.2 Kbit/s) • 9-bit or Multidrop mode (RS-485) support (automatic slave address detection) • 7, 8, 9, or 10-bit data characters (7-bits only with parity) • 1 or 2 stop bits • Programmable parity (even, odd, and no parity) • Hardware flow control support for request to send (RTS_B) and clear to send (CTS_B) signals
USB3/USB2		<p>The USB3/USB2 OTG module has been specified to perform USB 3.0 dual role and USB 2.0 On-The-Go (OTG) compatible with the USB 3.0, and USB 2.0 specification with OTG supplementary specifications. This controller supports two independent USB cores (1× USB3.0 dual-role, 1× USB2.0 OTG) and includes the PHY and I/O interfaces to support this operation. The full pinout of the USB 3.0 controller includes the signaling for both USB 3.0 and USB 2.0. This does not mean there is a separate USB 2.0 controller that can be used independently and simultaneously with USB 3.0. This device has an additional separate, independent USB 2.0 OTG controller which can be used simultaneously with this USB 3.0. Specific features requested for this updated module:</p> <ul style="list-style-type: none"> • Super Speed (5 Gbps), High Speed (480 Mbps), full speed (12 Mbps) and low speed (1.5 Mbps) • Fully compatible with the USB 3.0 specification (backward compatible with USB 2.0) • Fully compatible with the USB On-The-Go supplement to the USB 2.0 specification • Hardware support for OTG signaling • Host Negotiation Protocol (HNP) and Session Request Protocol (SRP) implemented in hardware, which can also be controlled by software
USBOH		<p>The USBOH module has been specified which performs USB 2.0 On-The-Go (OTG) and USB 2.0 Host functionality compatible with the USB 2.0 with OTG supplement and HS IC-USB specification. This controller supports two independent USB cores (1× USB2.0 OTG, 1× USB2.0 Host) and includes the PHY and I/O interfaces to support this operation.</p> <p>Key features:</p> <ul style="list-style-type: none"> • One USB2.0 OTG controller • High Speed (480 Mbps), full speed (12 Mbps) and low speed (1.5 Mbps) • Fully compatible with the USB 2.0 specification • Fully compatible with the USB On-The-Go supplement to the USB 2.0 specification • Hardware support for OTG signaling • Host Negotiation Protocol (HNP) and Session Request Protocol (SRP) implemented in hardware, which can also be controlled by software • USB2.0 Host with HS IC-USB specification • HS IC-USB transceiver-less downstream support (Host only).

Table 4. i.MX 8QuadPlus modules list (continued)

Block Mnemonic	Block Name	Brief Description
uSDHC	SD/eMMC and SDXC Enhanced Multi-Media Card / Secure Digital Host Controller	<p>i.MX 8 Family SoC-specific characteristics: All three MMC/SD/SDIO controller IPs are identical and are based on the uSDHC IP.</p> <p>The uSDHC is a host controller used to communicate with external low cost data storage and communication media. It supports the previous versions of the MultiMediaCard (MMC) and Secure Digital Card (SD) standards. Specifically, the uSDHC supports:</p> <ul style="list-style-type: none"> • SD Host Controller Standard Specification v3.0 with the exception that all the registers do not match the standards address mapping. • SD Physical Layer Specification v3.0 UHS-I (SDR104/DDR50) • SDIO specification v3.0 • eMMC System Specification v5.1
VPU	Video Processing Unit	See the device reference manual for the complete list of the VPU's decoding/encoding capabilities.
WDOG	Watchdog	The Watchdog Timer supports two comparison points during each counting period. Each of the comparison points is configurable to evoke an interrupt to the Arm core, and a second point evokes an external event on the WDOG line.
XTAL OSC24M		The 24 MHz clock source is an external crystal that acts as the main system clock. The OSC24M is used as the source clock for subsystem PLLs. OSC24M can be turned off by the System Control Unit (SCU) during sleep mode.
XTAL OSC32K		The 32.768 kHz clock source is an external crystal. The OSC32K is intended to be always on and is distributed by the SCU to modules in the chip.

3.1 Special Signal Considerations

Special signal considerations can be found in the Hardware Developer's Guide for this device in the Design Checklist section.

3.2 Recommended Connections for Unused Interfaces

The recommended connections for unused analog interfaces can be found in the section, "Unused Input/Output Terminations," in the Hardware Developer's Guide for this device.

4 Electrical characteristics

This section provides the device and module-level electrical characteristics for these processors.

4.1 Chip-level conditions

This section provides the device-level electrical characteristics for the SoC. See the following table for a quick reference to the individual tables and sections.

Table 5. Chip-level conditions

For these characteristics, ...	Topic appears ...
Absolute maximum ratings	on page 15
FCPBGA package thermal resistance data	on page 17
Operating ranges	on page 17
External Input Clock Frequency	on page 21
Maximum supply currents	on page 21
Standby use cases	on page 48
USB 2.0 PHY typical current consumption in Power-Down Mode	on page 25
USB 3.0 PHY typical current consumption in Power-Down Mode	on page 25
Typical current consumption in Power-Down mode for USB 2.0 PHY embedded in USB 3.0 PHY	on page 25

4.1.1 Absolute Maximum Ratings

CAUTION

Stresses beyond those listed under [Table 6](#) may affect reliability or cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the “[Operating ranges](#)” or other parameter tables is not implied. Exposure to absolute-maximum-rated conditions for extended periods will affect device reliability.

Table 6. Absolute maximum ratings

Parameter Description	Symbol	Min	Max	Units
Core Supplies Input Voltage	VDD_A72	-0.3	1.2	V
	VDD_A53			
	VDD_GPU0			
	VDD_GPU1			
	VDD_MAIN			
	VDD_MEMC			
DDR PHY supplies	VDD_DDR_VDDQ	-0.3	1.75	V
1.0V IO supplies	VDD_MIPI_1P0	-0.3	1.2	V
	VDD_USB_OTG_1P0			
IO Supply for GPIO Type 1.8V IO Single supply	VDD_ADC_1P8	-0.5	2.1	V
	VDD_ADC_DIG_1P8			
	VDD_ANA0_1P8 (IO, analog,OSC SCU)			
	VDD_ANA1_1P8 (IO, analog,OSC SCU)			
	VDD_DDR_PLL_1P8 (memory PLLs)			
	VDD_MIPI_1P8 (PHY, GPIO)			
	VDD_MIPI_CSI_DIG_1P8 (PHY, GPIO)			
	VDD_PCIE_1P8 (PHY)			
	VDD_USB_1P8 (PHY, GPIO)			
IO Supply for GPIO Type 1.8 / 2.5 / 3.3V IO Tri-voltage Supply	VDD_ENET1_1P8_2P5_3P3	-0.3	3.8	V
	VDD_ENET0_1P8_3P3			

Table 6. Absolute maximum ratings (continued)

Parameter Description	Symbol	Min	Max	Units
IO Supply for GPIO Type 1.8 / 3.3V IO Dual Voltage Supply	VDD_CAN_UART_1P8_3P3	-0.3	3.8	V
	VDD_CSI_1P8_3P3			
	VDD_EMMC0_1P8_3P3			
	VDD_EMMC0_VSELECT_1P8_3P3			
	VDD_ENET_MDIO_1P8_3P3			
	VDD_MIPI_DSI_DIG_1P8_3P3			
	VDD_PCIE_DIG_1P8_3P3			
	VDD_QSPI0A_1P8_3P3			
	VDD_QSPI0B_1P8_3P3			
	VDD_SPI_MCLK_UART_1P8_3P3			
	VDD_SPI_SAI_1P8_3P3			
	VDD_TMPR_CSI_1P8_3P3			
	VDD_USB_3P3 (PHY & GPIO)			
	VDD_USDHC1_1P8_3P3			
	VDD_USDHC1_VSELECT_1P8_3P3			
SNVS Coin Cell	VDD_SNVS_4P2	-0.3	4.3	V
USB VBUS (OTG2)	USB_OTG2_VBUS	-0.3	3.63	V
USB VBUS (OTG1)	USB_OTG1_VBUS	-0.3	5.5	V
I/O Voltage for USB Drivers	USB_OTG1_DP/USB_OTG1_DN	-0.3	3.63	V
	USB_OTG2_DP/USB_OTG2_DN			
I/O Voltage for ADC	ADC_INx	-0.1	2.1	V
Vin/Vout input/output voltage range (GPIO Type Pins)	Vin/Vout	See Section 4.6.1		V
Vin/Vout input/output voltage range (DDR pins)	Vin/Vout	See Section 4.6.1		V
ESD immunity (HBM).	Vesd_HBMX	—	1000	V
ESD immunity (CDM).	Vesd_CDM	—	250	V
Storage temperature range	Tstorage	-40	150	°C

NOTE

HDMI CEC is 3.3V tolerant. HDMI DDC signals and HPD are 5V tolerant. Refer to the Hardware Developer's Guide for proper terminations.

4.1.2 Thermal resistance

4.1.2.1 FCPBGA package thermal resistance

This table provides the FCPBGA package thermal resistance data.

Table 7. FCPBGA package thermal resistance data

Rating	Board Type ¹	Symbol	29x29 mm package	Unit
Junction to Ambient Thermal Resistance ²	JESD51-9, 2s2p	$R_{\theta JA}$	12.9	°C/W
Junction to Package Top Thermal Resistance ²	JESD51-9, 2s2p	Ψ_{JT}	0.1	°C/W
Junction to Case Thermal Resistance ³	JESD51-9, 1s	$R_{\theta JC}$	0.3	°C/W

¹ Thermal test board meets JEDEC specification for this package (JESD51-9).

² Determined in accordance to JEDEC JESD51-2A natural convection environment. Thermal resistance data in this report is solely for a thermal performance comparison of one package to another in a standardized specified environment. It is not meant to predict the performance of a package in an application-specific environment.

³ Junction-to-Case thermal resistance determined using an isothermal cold plate. Case temperature refers to the mold surface temperature at the package top side dead center.

4.1.3 Operating Ranges

The following table provides the operating ranges of these processors.

Table 8. Operating ranges¹

Symbol	Description	Mode	Min	Typ	Max	Unit	Comments
VDD_A72 ²	Power supply of Cortex-A72 cluster	Overdrive	1.05	1.10	1.15	V	Min frequency = 208.5 MHz Max frequency = 1.6 GHz
		Nominal	0.95	1.00	1.10	V	Max frequency = 1.06 GHz
VDD_A53 ²	Power supply of Cortex-A53 cluster	Overdrive	1.05	1.10	1.15	V	Min frequency = 208.5 MHz Max frequency = 1.2 GHz
		Nominal	0.95	1.00	1.10	V	Max frequency = 900 MHz
VDD_GPU0	Power supply of first GPU instance	Nominal	0.95	1.00	1.10	V	Max frequencies: Shaders = 625 MHz; Core = 625 MHz
VDD_GPU1	Power supply of second GPU instance	Nominal	0.95	1.00	1.10	V	Max frequencies.: Shaders = 625 MHz; Core = 625 MHz
VDD_MEMC	Power supply of memory controller	N/A	1.05	1.10	1.15	V	—

Electrical characteristics

Table 8. Operating ranges¹ (continued)

Symbol	Description	Mode	Min	Typ	Max	Unit	Comments
VDD_MAIN ³	Power supply of remaining core logic	N/A	0.95	1.00	1.10	V	Max frequencies: HiFi4 DSP = 666 MHz M4 = 264 MHz VPU = 600 MHz
VDD_DDR_CH0_VDDQ, VDD_DDR_CH0_VDDQ_CKE, VDD_DDR_CH1_VDDQ, VDD_DDR_CH1_VDDQ_CKE,	Power supplies of memory I/Os	LPDDR4	1.06	1.10	1.17	V	Max frequency = 1.6 GHz Supports LPDDR4-3200
VDD_DDR_CH0_VDDA_PLL_1P8, VDD_DDR_CH1_VDDA_PLL_1P8	Power supplies of memory PLLs	N/A	1.65	1.80	1.95	V	PLL supply can be merged with other 1.8V supplies with proper on board decoupling.
VDD_MIPI_CSI0_1P0, VDD_MIPI_CSI1_1P0, VDD_MIPI_DSI0_1P0, VDD_MIPI_DSI0_PLL_1P0, VDD_MIPI_DSI1_1P0, VDD_MIPI_DSI1_PLL_1P0, VDD_LVDS0_1P0, VDD_LVDS1_1P0	Power supplies of PHYs (1.0 V part)	N/A	0.95	1.00	1.10	V	These balls shall be connected to the same power supply as VDD_MAIN. It shall be a star connection from the power supply. Each VDD power supply ball shall have its own dedicated decoupling caps.
VDD_ANA1_1P8, VDD_ANA2_1P8, VDD_ANA3_1P8, VDD_CP_1P8, VDD_SCU_1P8, VDD_SCU_ANA_1P8, VDD_SCU_XTAL_1P8	Power supplies of I/Os, analog and oscillator of the SCU	N/A	1.65	1.70	1.75	V	These balls shall be powered by a dedicated supply. Note: The disconnect between the ball naming, implying a 1.8 V supply, and the actual required operating voltage of 1.7 V is known and correct as shown.
VDD_PCIE_IOB_1P8, VDD_ADC_1P8, VDD_ADC_DIG_1P8, VDD_HDMI_RX0_1P8 ⁴ , VDD_HDMI_TX0_1P8, VDD_LVDS0_1P8, VDD_LVDS1_1P8, VDD_MIPI_CSI0_1P8, VDD_MIPI_CSI1_1P8, VDD_MIPI_DSI0_1P8, VDD_MIPI_DSI1_1P8, VDD_MLB_1P8 ⁵ , VDD_PCIE_LDO_1P8, VDD_PCIE_SATA0_PLL_1P8 ⁴ , VDD_PCIE0_PLL_1P8, VDD_PCIE1_PLL_1P8, VDD_USB_HSIC0_1P8, VDD_ANA0_1P8, VDD_MIPI_CSI_DIG_1P8	Power supplies of PHYs (1.8 V part) and GPIO operating at 1.8 V only.	N/A	1.65	1.80	1.95	V	—

Table 8. Operating ranges¹ (continued)

Symbol	Description	Mode	Min	Typ	Max	Unit	Comments
VDD_HDMI_RX0_VH_RX_3P3 ⁴ , VDD_HDMI_TX0_DIG_3P3, VDD_USB_OTG1_3P3, VDD_USB_OTG2_3P3, VDD_USB_SS3_TC_3P3	Power supplies of PHYs (3.3 V part) and GPIO operating at 3.3 V only	N/A	3.00	3.30	3.60	V	—
VDD_PCIE_DIG_1P8_3P3, VDD_ENET0_1P8_3P3, VDD_ENET_MDIO_1P8_3P3, VDD_EMMC0_1P8_3P3, VDD_USDHC1_1P8_3P3, VDD_USDHC2_1P8_3P3, VDD_USDHC_VSELECT_1P8_3P3, VDD_SIM0_1P8_3P3, VDD_ESAI0_MCLK_1P8_3P3, VDD_ESAI1_SPDIF_SPI_1P8_3P3, VDD_FLEXCAN_1P8_3P3, VDD_LVDS_DIG_1P8_3P3, VDD_M4_GPT_UART_1P8_3P3, VDD_MIPI_DSI_DIG_1P8_3P3, VDD_MLB_DIG_1P8_3P3 ⁶ , VDD_QSPI0_1P8_3P3, VDD_QSPI1A_1P8_3P3, VDD_SPI_SAI_1P8_3P3	Power supplies of GPIO supporting both 1.8 V or 3.3 V	1.8 V 3.3 V	1.65 3.00	1.80 3.30	1.95 3.60	V V	When VDD_USDHC1_1P8_3P3 or VDD_USDHC2_1P8_3P3 is used to support an SD card then it shall be on a dedicated 1.8V/3.3V regulator. When VDD_SIM0_1P8_3P3 is used to support a SIM card, it shall be on a dedicated 1.8V/3.3V regulator. VDDs of this list targeting 1.8V can share 1.8V regulator of 1.8V only VDDs VDDs of this list targeting 3.3V can share 3.3V regulator of 3.3V only VDDs
VDD_ENET1_1P8_2P5_3P3	Power supplies of ethernet I/Os	1.8 V 2.5 V 3.3 V	1.65 2.38 3.00	1.80 2.50 3.30	1.95 2.63 3.60	V V V	— — —
VDD_USB_HSIC0_1P2	Power supply of USB-HSIC I/Os	N/A	1.1	1.2	1.3	V	—
VDD_SNV5_4P2	Power supply of SNVS	N/A	2.80	3.30	4.20	V	It can be supplied by a backup battery: a coin cell or a super cap.
Output of embedded LDOs and negative charge pump							
VDD_USB_SS3_LDO_1P0_CAP, VDD_HDMI_RX0_LDO0_1P0_CAP ⁴ , VDD_HDMI_RX0_LDO1_1P0_CAP ⁴ , VDD_HDMI_TX0_LDO_1P0_CAP, VDD_PCIE_LDO_1P0_CAP	1.0 V output of embedded LDOs	N/A	—	1.00	—	V	—
VDD_SNV5_LDO_1P8_CAP	1.8 V output of SNVS embedded LDO	N/A	—	1.80	—	V	—

Table 8. Operating ranges¹ (continued)

Symbol	Description	Mode	Min	Typ	Max	Unit	Comments
VDD_M1P8_CAP	-1.8 V output of embedded charge pump	N/A	—	-1.80	—	V	—
Power supplies that shall be connected to output of an embedded LDO							
VDD_HDMI_TX0_1P0	—	N/A	—	1.00	—	V	Shall be externally connected to VDD_HDMI_TX0_LDO_1P0_CAP
VDD_PCIE_SATA0_1P0 ⁴ , VDD_PCIE0_1P0, VDD_PCIE1_1P0	—	N/A	—	1.00	—	V	Shall be externally connected to VDD_PCIE_LDO_1P0_CAP
VDD_USB_OTG1_1P0, VDD_USB_OTG2_1P0	—	N/A	—	1.00	—	V	Shall be externally connected to VDD_USB_SS3_LDO_1P0_CAP
Junction temperature							
Junction temperature	—	—	-40		125	°C	—

¹ Voltage ranges are defined to group as many supplies as possible. Individual supplies may have a wider range than listed here.

² These are the supported frequencies included in the Linux, Android, and all other operating systems using the SCU defined DVFS (Dynamic Voltage and Frequency Scaling) set points. An additional Overdrive set point is included to provide a more balanced power-versus-performance trade-off, where the A72 runs at 1.3 GHz and the A53 runs at 1.1 GHz. Likewise, an additional Nominal set point is included where both the A72 and A53 run at 600 MHz.

³ During low power state, this voltage can be dropped to 0.8 V +/- 3% for retention.

⁴ HDMI-RX is not currently supported, the related power and signal connections are provided for future use when it is expected HDMI-RX support will be enabled.

⁵ MLB is not supported on this product. This MLB power rail may be tied to the power supply voltage indicated or may be terminated, per the Hardware Developer's Guide power supplies of unused functions.

⁶ MLB is not supported on this product. The MLB power rail must be tied to the power supply voltage indicated if other I/O functions are used, as determined by IOMUX selection. Alternately, terminate the MLB supply per the Hardware Developer's Guide power supplies of unused functions.

4.1.4 External clock sources

Each processor has two external input system clocks: a low frequency (RTC_XTALI) and a high frequency (XTALI).

The RTC_XTALI is used for real time functions. It supplies the clock for real time clock operation and for slow-system and watchdog counters. The clock input can be connected to either an external oscillator or a crystal using the internal oscillator amplifier.

The system clock input XTALI is used to generate the main system clock. It supplies the PLLs and other peripherals. The system clock input requires a crystal using the internal oscillator amplifier.

The PCIe oscillator can be sourced internally or input to the chip. In both cases, it is a 100 MHz nominal clock using HCSL signaling to provide the PCIe reference clock.

The following table shows the interface frequency requirements.

Table 9. External Input Clock Frequency

Parameter Description	Symbol	Min	Typ	Max	Unit
RTC_XTALI Oscillator ^{1,2}	f_{ckil}	—	32.768 ³ /32.0	—	kHz
XTALI Oscillator ^{4,2}	f_{xtal}	—	24	—	MHz
PCIe oscillator ⁵	f_{100M}	—	100	—	MHz
Frequency accuracy	—	—	—	±300	ppm

¹ External oscillator or a crystal with internal oscillator amplifier.

² The required frequency stability of this clock source is application dependent. For recommendations, see the hardware development guide for this device.

³ Recommended nominal frequency 32.768 kHz.

⁴ Fundamental frequency crystal with internal oscillator amplifier.

⁵ If using an external clock instead of the internal clock source, an HCSL-compatible clock is required. Concerning EMI/EMC, note that internal source is not spread-spectrum capable.

The typical values shown in [Table 9](#) are required for use with NXP board support packages (BSPs) to ensure precise time keeping and USB and HDMI operations.

4.1.5 Maximum Supply Currents

NOTE

Some of the numbers shown in this table are based on the companion regulator limits and not actual use cases. Current-drain application note AN13249 is also available for reference. This document contains measured results for i.MX 8QuadMax and should be used as a guideline for i.MX 8QuadPlus.

Table 10. Maximum supply currents

Symbol	Value	Unit	Comments
VDD_A72	3500	mA	Value based on max current delivered by PMIC
VDD_A53	2500	mA	Value based on max current delivered by PMIC
VDD_GPU0	3500	mA	Value based on max current delivered by PMIC
VDD_GPU1	3500	mA	Value based on max current delivered by PMIC
VDD_MAIN	5000	mA	Value based on max current delivered by PMIC
VDD_MEMC	3200	mA	Value based on max current delivered by PMIC
VDD_DDR_CH0_VDDQ	800	mA	Does not include current used by external memory.
VDD_DDR_CH0_VDDQ_CKE	200	mA	Does not include current used by external memory.
VDD_DDR_CH0_VDDA_PLL_1P8	20	mA	

Electrical characteristics

Table 10. Maximum supply currents (continued)

Symbol	Value	Unit	Comments
VDD_DDR_CH1_VDDQ	800	mA	Does not include current used by external memory.
VDD_DDR_CH1_VDDQ_CKE	200	mA	Does not include current used by external memory.
VDD_DDR_CH1_VDDA_PLL_1P8	20	mA	
VDD_SCU_ANA_1P8	5	mA	
VDD_SCU_1P8	20	mA	Digital I/Os of SCU
VDD_CP_1P8	60	ma	There is a peak current of 60mA over 140 μ s.
VDD_SCU_XTAL_1P8	10	mA	Supply of crystal oscillator and integrated 200 MHz oscillator
VDD_ANA0_1P8	175	mA	
VDD_ANA1_1P8	45	mA	
VDD_ANA2_1P8	140	mA	
VDD_ANA3_1P8	110	mA	
VDD_SIM0_1P8_3P3	15	mA	
VDD_M4_GPT_UART_1P8_3P3	45	mA	
VDD_ESAI1_SPDIF_SPI_1P8_3P3	40	mA	
VDD_ESAI0_MCLK_1P8_3P3	25	mA	
VDD_SPI_SAI_1P8_3P3	35	mA	
VDD_FLEXCAN_1P8_3P3	15	mA	
VDD_QSPI1A_1P8_3P3	20	mA	
VDD_QSPI0_1P8_3P3	35	mA	
VDD_EMMC0_1P8_3P3	55	mA	
VDD_USDHC_VSELECT_1P8_3P3	5	mA	
VDD_USDHC1_1P8_3P3	55	mA	
VDD_USDHC2_1P8_3P3	35	mA	
VDD_ENET_MDIO_1P8_3P3	15	mA	
VDD_ENET0_1P8_3P3	25	mA	
VDD_ENET1_1P8_2P5_3P3	25	mA	
VDD_LVDS_DIG_1P8_3P3	25	mA	
VDD_LVDSx_1P8	100	mA	x is 0 or 1
VDD_LVDSx_1P0	5	mA	x is 0 or 1
VDD_MIPI_DSI_DIG_1P8_3P3	20	mA	
VDD_MIPI_DSIx_1P8	5	mA	x is 0 or 1
VDD_MIPI_DSIx_1P0	35	mA	x is 0 or 1
VDD_MIPI_DSIx_PLL_1P0	5	mA	x is 0 or 1

Table 10. Maximum supply currents (continued)

Symbol	Value	Unit	Comments
VDD_MIPI_CSI_DIG_1P8	20	mA	
VDD_MIPI_CSI _x _1P8	5	mA	x is 0 or 1
VDD_MIPI_CSI _x _1P0	20	mA	x is 0 or 1
VDD_HDMI_TX0_DIG_3P3	5	mA	
VDD_HDMI_TX0_1P8	80	mA	
VDD_HDMI_TX0_1P0	80	mA	Shall be externally connected to VDD_HDMI_TX0_LDO_1P0_CAP
VDD_ADC_1P8	5	mA	
VDD_ADC_DIG_1P8	1	mA	
VDD_MLB_DIG_1P8_3P3 ¹	10	mA	
VDD_MLB_1P8 ²	50	mA	
VDD_USB_OTG1_1P0	1	mA	Shall be externally connected to VDD_USB_SS3_LDO_1P0_CAP
VDD_USB_OTG1_3P3	30	mA	
VDD_USB_OTG2_1P0	35	mA	Shall be externally connected to VDD_USB_SS3_LDO_1P0_CAP
VDD_USB_OTG2_3P3	10	mA	
VDD_USB_SS3_TC_3P3	10	mA	
VDD_USB_HSIC0_1P2	10	mA	
VDD_USB_HSIC0_1P8	5	mA	
VDD_PCIE_DIG_1P8_3P3	5	mA	
VDD_PCIE_IOB_1P8	45	mA	
VDD_PCIE_LDO_1P8	190	mA	
VDD_PCIE_SATA0_PLL_1P8	20	mA	
VDD_PCIE0_PLL_1P8	20	mA	
VDD_PCIE1_PLL_1P8	20	mA	
VDD_PCIE_SATA0_1P0	65	mA	Shall be externally connected to VDD_PCIE_LDO_1P0_CAP
VDD_PCIE0_1P0	65	mA	Shall be externally connected to VDD_PCIE_LDO_1P0_CAP
VDD_PCIE1_1P0	60	mA	Shall be externally connected to VDD_PCIE_LDO_1P0_CAP
VDD_SNVS_4P2 ³	5	mA	Start-up current

¹ MLB is not supported on this product. This MLB power rail must be tied to the voltage specified in [Table 8](#) if other I/O functions are used, as determined by IOMUX selection. Alternately, terminate the MLB supply per the Hardware Developer's Guide power supplies of unused functions.

² MLB is not supported on this product. The MLB power rail must be tied to the voltage specified in [Table 8](#) or may be terminated, per the Hardware Developer's Guide power supplies of unused tables.

³ Under normal operating conditions, the maximum current on VDD_SNVS_4P2 is shown [Table 11](#). During initial power on, VDD_SNVS_4P2 can draw up to 5 mA if the supply is capable of sourcing that current. If less than 5 mA is available, the VDD_SNVS_LDO_1P8_CAP charge time will increase.

4.1.6 Low power mode supply currents

The following table shows the current core consumption (not including I/O) in selected low power modes.

Table 11. i.MX 8QuadPlus Key State (KSx) power consumption

Mode	Test conditions	Supply	Max	Unit
KS0	SNVS only, all other supplies OFF. RTC running, tamper not active, external 32K crystal.	VDD_SNVS_4P2 (4.2 V)	50	μA
KS1 ¹	RAM and IO state retained. DRAM in self-refresh, associated I/O's OFF. 32K running, 24M, PLLs and ring oscillators OFF PHYs are in idle state. MEMC, A53, A72, and GPU supplies OFF. MAIN ² dropped to 0.8 V.	VDD_ANAx_1P8, VDD_SCUx_1P8, VDD_CP_1P8 (1.7V)	6	mA
		VDD_A53 (OFF)	—	mA
		VDD_A72 (OFF)	—	mA
		VDD_GPU0 (OFF)	—	mA
		VDD_GPU1 (OFF)	—	mA
		VDD_MEMC (OFF)	—	mA
		VDD_DDR_CHx_VDDQ (1.1V)	1.4	mA
		VDD_MAIN (0.8V)	12	mA
		Total	21.94	mW
KS4 ³	Leakage test, not intended as a customer use case. Overdrive conditions set, memories active, all sub-systems powered ON. Active power minimized.	VDD_A53 (1.1V)	1066	mA
		VDD_A72 (1.1V)	2000	mA
		VDD_GPU0 (1.0V)	See footnote ⁴	mA
		VDD_GPU1 (1.0V)	See footnote ⁴	mA
		VDD_MEMC (1.1V)	1800	mA
		VDD_MAIN (1.0V)	1500	mA
		Total		mW

¹ Maximum values are for 25 °C T_{ambient} .

² 0.8 V nominal—voltage specification under this case is ± 3%.

³ Maximum values are for 125 °C T_{junction} . Stated supply voltages do not exceed +2% during test.

⁴ Unavailable at time of publication.

4.1.7 USB 2.0 PHY typical current consumption in Power-Down mode

In power down mode, everything is powered down, including the VBUS valid detectors, typical condition. The following table shows the USB interface typical current consumption in Power-Down mode.

Table 12. USB 2.0 PHY typical current consumption in Power-Down Mode

	VDD_USB_OTG1_3P3 (3.3 V)	VDD_ANA0_1P8 (1.8 V)	VDD_USB_OTG1_1P0 (1.0 V)
Current	1 μ A	0.06 μ A	0.5 μ A

4.1.8 USB 3.0 PHY typical current consumption in Power-Down mode

In power down mode, everything is powered down, including the VBUS valid detectors, typical condition. The following table shows the USB interface typical current consumption in Power-Down mode.

Table 13. USB 3.0 PHY typical current consumption in Power-Down Mode

	—	VDD_ANA0_1P8 (1.8 V)	VDD_USB_OTG2_1P0 (1.0 V)
Current	—	10 μ A	70 μ A

The following table shows the current consumption for the USB 2.0 PHY embedded in the USB 3.0 PHY.

Table 14. Typical current consumption in Power-Down mode for USB 2.0 PHY embedded in USB 3.0 PHY

	VDD_USB_OTG2_3P3 (3.3 V)	VDD_ANA0_1P8 (1.8 V)	VDD_USB_OTG2_1P0 (1.0 V)
Current—Host mode	22.6 μ A	12.7 μ A	81.5 μ A
Current—Device mode	12.6 μ A	85.7 μ A	78.5 μ A

4.2 Power supplies requirements and restrictions

The system design must comply with power-up sequence, power-down sequence, and steady state guidelines as described in this section to ensure the reliable operation of the device. Any deviation from these sequences may result in the following situations:

- Excessive current during power-up phase
- Prevention of the device from booting
- Irreversible damage to the processor

4.2.1 Power-up sequence

The device has the following power-up sequence requirements:

- Supply group 0 (SNVS) must be powered first. It is expected that group 0 will typically remain always on after the first power-on.
- Supply group 1 (MAIN and SCU) and group 0 must both be powered to their nominal values prior to boot. They must power up after or simultaneously with group 0.
- Supply group 2 (I/O's and DDR interface) consists of those modules required to start the boot process by accessing external storage devices. These must be fully powered prior to POR release if booting from one of these supplies interfaces. They must power up after or simultaneously with group 1.
- Supply group 3 consists of the remaining portions of the SoC. This includes nonboot I/O voltages and supplies for the major computational units. These can be sequenced in any order and as required to perform the desired functions for the intended application. They must power up after or simultaneously with group 2.

NOTE

The definition of “power-up” refers to a stable voltage operating within the range defined in [Table 8](#). This should be taken into consideration, along with the different capacitive loading on each rail, if considering simultaneous switch-on of the different supply groups.

4.2.2 Power-down sequence

The device processor has the following power-down sequence requirements:

- Supply group 0 must be turned off last, after all other supplies.
- Supply group 1 can be turned off just prior to group 0.

All remaining supplies can be turned off prior to group 1.

NOTE

When switching off supply group 0 (SNVS), VDD_SNVS_LDO_1P8_CAP must be fully discharged to 0 V before starting the next power-up sequence to ensure correct operation.

4.2.3 Power Supplies Usage

The following table shows the power supplies usage by group.

Table 15. Power supplies usage

Supply Groups	Voltage					
Group 0	2.4 - 4.2v					
	VDD_SNV5_4P2					
Group 1	1.0v	1.8v				
	VDD_MAIN	VDD_ANA1_1P8				
	VDD_LVDSx_1P0	VDD_ANA2_1P8				
	VDD_MIPI_CSix_1P0	VDD_ANA3_1P8				
	VDD_MIPI_DSix_1P0	VDD_CP_1P8				
	VDD_MIPI_DSix_PLL_1P0	VDD_SCU_1P8				
		VDD_SCU_x_1P8				
Group 2	1.1V		1.8v	1.8v or 3.3v	1.8v or 3.3v switchable	3.3v
	VDD_MEMC		VDD_ADC_DIG_1P8	VDD_EMMC0_1P8_3P3	VDD_USDHCx_1P8_3P3	VDD_HDMI_RX0_VH_RX_3P3
	VDD_DDR_CHx_VDDQ		VDD_ADC_1P8	VDD_ESAI0_MCLK_1P8_3P3	VDD_SIM0_1P8_3P3	VDD_HDMI_TX0_DIG_3P3
	VDD_DDR_CHx_VDDQ_CKE		VDD_ANA0_1P8	VDD_ESAI1_SPDIF_SPI_1P8_3P3		VDD_USB_OTGx_3P3
			VDD_DDR_CHx_VDDA_PLL_1P8	VDD_FLEXCAN_1P8_3P3		VDD_USB_SS3_TC_3P3
			VDD_HDMI_x_1P8	VDD_LVDS_DIG_1P8_3P3		
			VDD_LVDSx_1P8	VDD_M4_GPT_UART_1P8_3P3		
			VDD_MIPI_CSI_DIG_1P8	VDD_MIPI_DSI_DIG_1P8_3P3		
			VDD_MIPI_x_1P8	VDD_MLB_DIG_1P8_3P3 ¹		
			VDD_MLB_1P8 ²	VDD_PCIE_DIG_1P8_3P3		
			VDD_PCIE_SATA0_PLL_1P8	VDD_QSPIx_1P8_3P3		
			VDD_PCIE_x_1P8	VDD_SPI_SAI_1P8_3P3		
			VDD_PCIEx_PLL_1P8	VDD_USDHC_VSELECT_1P8_3P3		
			VDD_USB_HSIC0_1P8			
	Group 3	1.1 - 1.1v	1.0v internal LDO's	1.2v	1.8v or 2.5v or 3.3v	
VDD_A53		VDD_HDMI_TX0_1P0	VDD_USB_HSIC0_1P2	VDD_ENET_MDIO_1P8_3P3		
VDD_A72		VDD_PCIE_SATA0_1P0		VDD_ENET0_1P8_3P3		
				VDD_ENET1_1P8_2P5_3P3		
VDD_GPUx		VDD_PCIEx_1P0				
	VDD_USB_OTGx_1P0					

¹ MLB is not supported on this product. This MLB power rail must be tied to the voltage specified in Table 8 if other I/O functions are used as determined by IOMUX selection. Alternately, terminate the MLB supply, per the Hardware Developer's Guide power supplies usage of unused features.

² MLB is not supported on this product. The MLB power rail must be tied to the voltage specified in Table 8 or may be terminated, per the Hardware Developer's Guide power supplies of unused functions.

4.3 PLL electrical characteristics

4.3.1 PLLs of subsystems

i.MX 8QuadPlus embeds a large number of PLLs to address clocking requirements of the various subsystems. These PLLs are controlled through the SCU and not directly by Cortex-A or Cortex-M4F processors. A software API shall be used by those processors to access the PLL settings. Additional PLLs are specific to high-performance interfaces. These are described in the following sections.

This table summarizes the PLLs controlled by the SCU.

Table 16. PLLs controlled by SCU

Subsystem	PLL usage	Source clock	Locking range ¹		Lock freq.	Unit
			Min freq.	Max freq.		
Cortex-A53 ²	Subsystem	24	1250	2500	<ul style="list-style-type: none"> • Overdrive: 2400 • Nominal: 1800 	MHz
Cortex-A72 ³	Subsystem	24	1250	2500	<ul style="list-style-type: none"> • Overdrive: 1600 • Nominal: 2120 	MHz
CCI	Subsystem	24	650	1300	1000	MHz
GPU	PLL #0: subsystem	24	1250	2500	<ul style="list-style-type: none"> • Nominal: 2500 • Underdrive: 1600⁴ 	MHz
	PLL #1: shaders	24	1250	2500	<ul style="list-style-type: none"> • Nominal: 2500 • Underdrive: 1600⁴ 	MHz
DRC (DRAM Controller)	Subsystem	24	1250	2500	<ul style="list-style-type: none"> • LPDDR4: 1600 	MHz
DB (DRAM Block)	Subsystem	24	650	1300	750	MHz
DBLog	Subsystem	24	650	1300	800	MHz
Display Controller 0	PLL #0: subsystem	24	650	1300	800	MHz
	PLL #1: display clock #0	24	650	1300	User-configurable	MHz
	PLL #2: display clock #1	24	650	1300	User-configurable	MHz
Display Controller 1	PLL #0: subsystem	24	650	1300	800	MHz
	PLL #1: display clock #0	24	650	1300	User-configurable	MHz
	PLL #2: display clock #1	24	650	1300	User-configurable	MHz
Imaging	Subsystem	24	650	1300	1200	MHz
Audio	PLL #0: subsystem	24	650	1300	700	MHz
	PLL #1: audio PLL #0	24	650	1300	User-configurable	MHz
	PLL #2: audio PLL #1	24	650	1300	User-configurable	MHz
Connectivity	Subsystem	24	650	1300	792	MHz

Table 16. PLLs controlled by SCU (continued)

Subsystem	PLL usage	Source clock	Locking range ¹		Lock freq.	Unit
			Min freq.	Max freq.		
HSIO (High-speed I/O)	Subsystem	24	650	1300	800	MHz
LSIO (Low-speed I/O)	Subsystem	24	650	1300	800	MHz
Cortex-M4	Subsystem	24	650	1300	792	MHz
VPU	PLL #0: subsystem	24	650	1300	1200	MHz
	PLL #1: Audio DSP (HiFi 4)	24	650	1300	666	MHz
HDMI-TX / eDP	Subsystem	24	650	1300	User-configurable	MHz
MIPI-DSI	Subsystem	24	650	1300	864	MHz
MIPI-CSI	Subsystem	24	650	1300	720	MHz
DMA	Subsystem	24	650	1300	960	MHz
SCU (System Controller Unit)	Subsystem	24	650	1300	1056	MHz

¹ Operating frequencies are limited to only those supported by the SCFW.

² 2400 MHz is used to generate the 1200 MHz maximum and 600 MHz slow operating points; 1800 MHz is used to generate the 900 MHz typical operating point. See [Table 8](#) to get associated voltages.

³ 1600 MHz is used for max operating point, 2120 MHz is used to generate 1060 MHz for typical operating point, and 2400 MHz is used to generate the 600 MHz slow operating point. See [Table 8](#) to get associated voltages.

⁴ 2500 MHz is used to generate 625 MHz for the max operating point, 1600 MHz is used to generate 400 MHz for the slow operating point. See [Table 8](#) to get associated voltages.

4.3.2 PLLs dedicated to specific interfaces

The following sections cover PLLs used for specific interfaces. Clock output frequency and clock output range refer to the output of the PLL. Additional clock dividers may be on the output path to divide the output frequency down to the targeted frequency. See the related sections in the reference manual for settings of these clock dividers.

4.3.2.1 Ethernet PLL

This PLL is controlled by the SCU.

Table 17. Ethernet PLL

Parameter	Value	Unit
Reference clock	24	MHz
Clock output frequency	1	GHz

4.3.2.2 USB 3.0 PLLs

USB 3.0 has two PLLs. One is embedded in Super-Speed PHY. The other one is embedded in the USB 2.0 OTG PHY that is part of the USB 3.0 interface.

The table below describes the PLL embedded in the Super-Speed PHY.

Table 18. USB 3.0 PLL embedded in Super Speed PHY

Parameter	Value	Unit
Reference clock	24	MHz
Clock output frequency	5	GHz

The table below describes the PLL embedded in the USBOTG PHY.

Table 19. USB 3.0 PLL embedded in USBOTG PHY

Parameter	Value	Unit
Reference clock	24	MHz
Clock output frequency	480	MHz

4.3.2.3 USB 2.0 OTG and USB-HSIC PLLs

This PLL is embedded in the USB 2.0 OTG PHY (the one which is not part of the USB 3.0 feature). It is also used to supply the 480 MHz clock to the HSIC interface.

Table 20. USB 2.0 OTG and USB-HSIC PLLs

Parameter	Value	Unit
Reference clock	24	MHz
Clock output frequency	480	MHz

4.3.2.4 PCIe PLLs

The PCIe interface has seven PLLs:

- One is used to generate the single, common 100 MHz reference clock to each lane
- One Transmit and one Receive PLL per lane (three lanes)

Electrical characteristics

The table below shows the characteristics for the reference clock PLL.

Table 21. PCIe reference clock PLLs

Parameter	Value	Unit	Comments
Reference clock	24	MHz	—
Clock output frequency	100	MHz	Used to generate internal 100 MHz reference clock to PCIe lanes

The table below shows characteristics of the TX and RX PLLs used in each lane.

Table 22. PCIe Transmit and Receive PLLs¹

Parameter	Value	Unit	Comments
Reference clock	100	MHz	From differential input clock pads or from internal PLL
Clock output range	6 ~ 10	GHz	PCIe gen3: 8GHz to get 8GHz baud clock PCIe gen2: 10GHz to get 5GHz baud clock PCIe gen1: 10GHz to get 2.5GHz baud clock

¹ PCIe 1.0 and 2.0 compliant. PCIe 3.0 capable, contact your NXP representative.

4.3.2.5 HDMI-TX / DP PLLs

The HDMI-TX interface uses two PLLs. One is used to generate the reference clock when using the HDMI PHY itself in HDMI mode. In DP mode, this PLL is bypassed and only the PLL embedded in the PHY is used.

The table below shows characteristics of the reference clock PLL for HDMI.

Table 23. HDMI reference clock PLL

Parameter	Value	Unit	Comments
Reference clock	24	MHz	—
Clock output range	1.25 ~ 2.5	GHz	Refer to HDMI / DP section of reference manual

The table below shows characteristics of the PLL embedded in HDMI/DP PHY.

Table 24. PLL embedded in HDMI/DP PHY

Parameter	Value	Unit	Comments
Reference clock	24MHz / derived from HDMI-TX PLL	MHz	24MHz: when in DP mode derived from HDMI-TX PLL: when in HDMI mode
Clock output range	≤5.4	GHz	Dependent on targeted display configuration

4.3.2.6 MIPI-DSI PLL

The table below shows characteristics of the PLL embedded in the MIPI-DSI PHY.

Table 25. MIPI-DSIPHY PLL

Parameter	Value	Unit	Comments
Reference clock	24	MHz	—
Clock output range	0.75 ~ 1.5	GHz	Dependent on targeted display configuration

4.3.2.7 LVDS PLL

The table below shows characteristics of the PLL embedded in LVDS PHY.

Table 26. LVDS PHY PLL

Parameter	Value	Unit	Comments
Reference clock	25 ~ 160	MHz	—
Data rate range	175 ~ 1120	Mbps	Dependent on targeted display configuration

4.4 On-chip oscillators

4.4.1 OSC24M

This block integrates trimmable internal loading capacitors and driving circuitry. When combined with a suitable 24 MHz external quartz element, it can generate a low-jitter clock. The oscillator is powered from VDD_SCU_XTAL_1P8. The internal loading capacitors are trimmable to provide fine adjustment of the 24 MHz oscillation frequency. It is expected that customers burn appropriate trim values for the selected crystal and board parasitics.

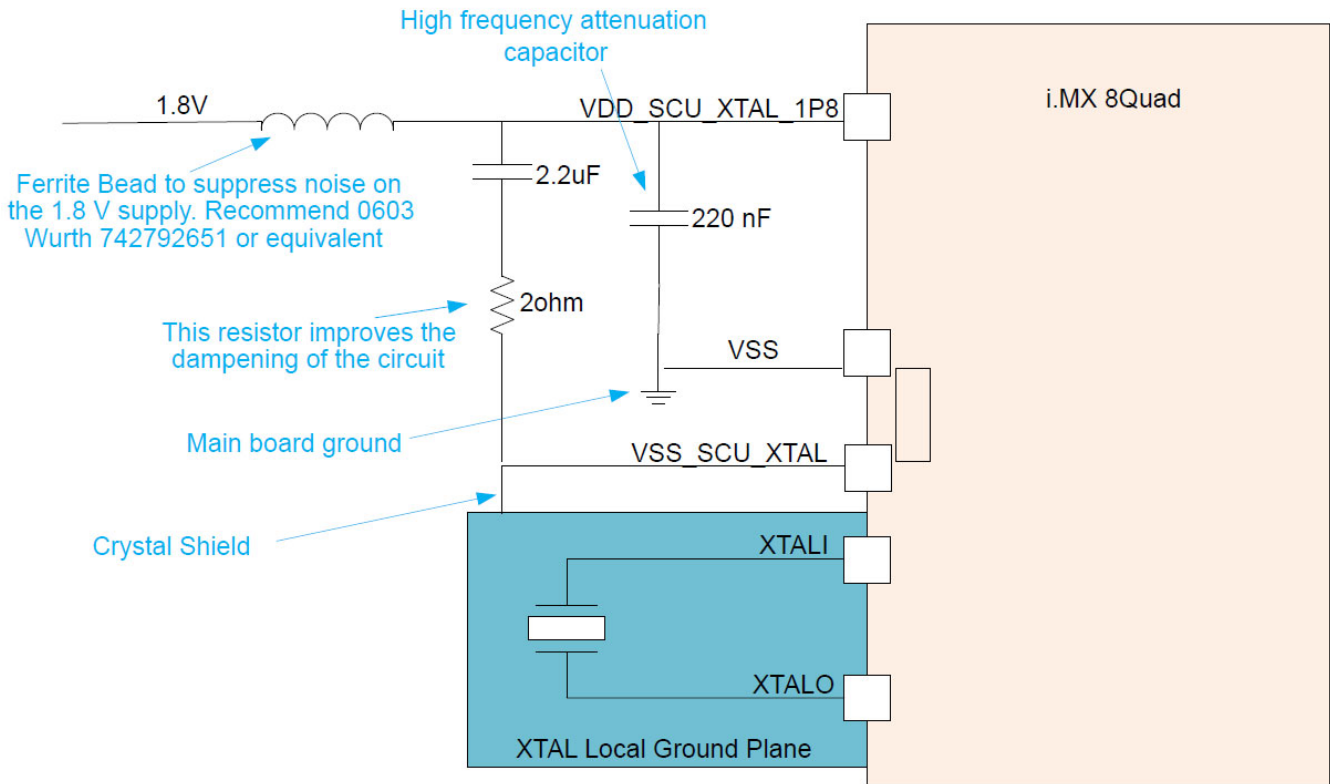


Figure 2. Normal Crystal Oscillation mode

Table 27. Crystal specifications

Parameter description	Min	Typ	Max	Unit
Frequency ¹	—	24	—	MHz
Cload ²	—	18	—	pF
Maximum drive level	200	—	—	μW
ESR	—	—	60	Ω

¹ The required frequency accuracy is set by the serial interfaces utilized for a specific application and is detailed in the respective standard documents.

² Cload is the specification of the quartz element, not for the capacitors coupled to the quartz element.

4.4.2 OSC32K

This block implements an internal amplifier, trimmable load capacitors and a bias network that when combined with a suitable quartz crystal implements a low power oscillator.

Additionally, if the clock monitor determines that the 32KHz oscillation is not present, then the source of the 32 KHz clock will automatically switch to the internal relaxation oscillator of lesser frequency accuracy.

CAUTION

The internal ring oscillator is not meant to be used in customer applications, due to gross frequency variation over wafer processing, temperature, and supply voltage. These variations will cause timing issues to many different circuits that use the internal ring oscillator for reference; and, if this timing is critical, application issues will occur. To prevent application issues, it is recommended to only use an external crystal or an accurate external clock. If this recommendation is not followed, NXP cannot guarantee full compliance of any circuit using this clock. The OSC32K runs from VDD_SNVS_LDO_1P8_CAP, which is regulated from VDD_SNVS. The target battery/voltage range is 2.8 to 4.2 V for VDD_SNVS, with a regulated output of approximately 1.75 V.

Table 28. OSC32K main characteristics

Parameter	Min	Typ	Max	Comments
Fosc	—	32.768 kHz	—	This frequency is nominal and determined mainly by the crystal selected. 32.0 KHz is also supported.
Current consumption	—	<ul style="list-style-type: none"> • xtal oscillator mode: 5 μA • 32K internal oscillator mode: 10 μA 	—	These values are for typical process and room temperature. Values will be updated after silicon characterization.
Bias resistor	—	200 M Ω	—	This the integrated bias resistor that sets the amplifier into a high gain state. Any leakage through the ESD network, external board leakage, or even a scope probe that is significant relative to this value will debias the amplifier. The debiasing will result in low gain, and will impact the circuit's ability to start up and maintain oscillations.
Target Crystal Properties				
Cload	—	10 pF	—	Usually crystals can be purchased tuned for different Cloads. This Cload value is typically 1/2 of the capacitances realized on the PCB on either side of the quartz. A higher Cload will decrease oscillation margin, but increases current oscillating through the crystal.
ESR	—	50 k Ω	100 k Ω	Equivalent series resistance of the crystal. Choosing a crystal with a higher value will decrease the oscillating margin.

Table 29. External input clock for OSC32K

	Min	Typ	Max	Unit	Notes
Frequency	—	32.768 or 32	—	kHz	—
V _{PP} RTC_XTALI	700	—	VDD_SNVS_LDO_1P8_CAP	mV	1,2,3
Rise/fall time	—	—	—	ns	4

Electrical characteristics

- ¹ The external clock is fed into the chip from the RTC_XTALI pin; the RTC_XTALO pin should be left floating.
- ² The parameter specified here is a peak-to-peak value and V_{IH}/V_{IL} specifications do not apply.
- ³ The voltage applied on RTC_XTALI must be within the range of VSS to VDD_SNV5_LDO_1P8_CAP.
- ⁴ The rise/fall time of the applied clock are not strictly confined.

4.5 I/O DC Parameters

This section includes the DC parameters of the following I/O types:

- XTALI and RTC_XTALI (clock inputs) DC parameters
- General Purpose I/O (GPIO) DC parameters

NOTE

The term ‘OVDD’ in this section refers to the associated supply rail of an input or output.

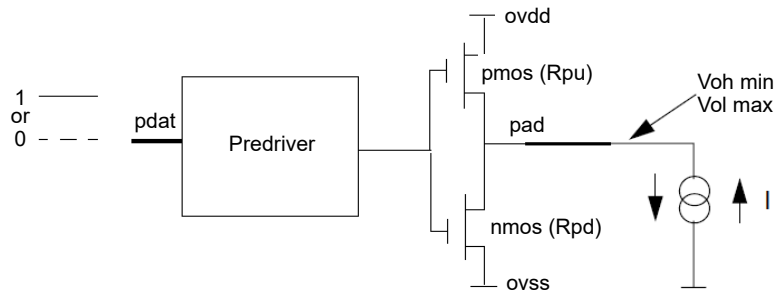


Figure 3. Circuit for Parameters Voh and Vol for I/O Cells

4.5.1 XTALI and RTC_XTALI (Clock Inputs) DC Parameters

For RTC_XTALI, V_{IH}/V_{IL} specifications do not apply. The high and low levels of the applied clock on this pin are not strictly defined, as long as the input's peak-to-peak amplitude meet the requirements and the input's voltage value does not exceed the limits.

4.5.2 General-purpose I/O (GPIO) DC parameters

NOTE

The term “OVDD” in this section refers to the associated supply rail of an input or output. The association is shown in [Table 127](#).

4.5.2.1 Tri-voltage GPIO DC parameters

The following tables show tri-voltage 1.8V, 2.5 V, and 3.3 V DC parameters, respectively, for GPIO pads. These parameters are guaranteed per the operating ranges in [Table 8](#), unless otherwise noted.

Table 30. Tri-voltage 1.8 V GPIO DC parameters¹

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level output voltage ^{2,3}	V _{OH}	I _{OH} = 0.1mA PDRV=1	0.8 × OVDD	—	V
		I _{OH} = 2mA PDRV=0			
Low-level output voltage ^{2,3}	V _{OL}	I _{OL} = -0.1mA PDRV=1	—	0.125 × OVDD	V
		I _{OL} = -2mA PDRV=0			
High-Level input voltage ^{2,4}	V _{IH}	—	0.625 × OVDD	OVDD	V
Low-Level input voltage	V _{IL}	—	0	0.25 × OVDD	V
Pull-up resistance	R _{PU}	V _{IN} =0V (Pullup Resistor) PUN = "L", PDN = "H"	15	50	kΩ
Pull-down resistance	R _{DOWN}	V _{IN} =OVDD (Pulldown Resistor) PUN = "H", PDN = "L"	15	50	kΩ
Input current (no PU/PD)	I _{IN}	V _I = 0, V _I = OVDD PUN = "H", PDN = "H"	-1	1	μA

¹ For tri-voltage I/O, the associated IOMUXD compensation control register PSW_OVR and COMP bits must be set correctly. For 1.8 or 3.3 V operation, the SCFW API must be used to set PSW_OVR = 0b0 and COMP=0b000. For 2.5 V operation, PSW_OVR = 0b1 and COMP = 0b010.

² Refer to [Section 4.6.1](#) for undershoot and overshoot specifications.

³ As programmed in the associated IOMUX (PDRV field) register. High Drive mode is recommended for 3v3 and 2v5 modes. Low Drive mode is recommended for 1v8 mode.

⁴ Refer to [Section 4.6.2](#) for monotonic requirements.

Table 31. Tri-voltage 2.5 V GPIO DC parameters¹

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level output voltage ^{2,3}	V _{OH}	I _{OH} = 2mA PDRV=0	0.8 × OVDD	—	V
Low-level output voltage ^{2,3}	V _{OL}	I _{OL} = -2mA PDRV=0	—	0.125 × OVDD	V
High-Level input voltage ^{2,4}	V _{IH}	—	0.625 × OVDD	OVDD	V
Low-Level input voltage	V _{IL}	—	0	0.25 × OVDD	V
Pull-up resistance	R _{PU}	V _{IN} =0V (Pullup Resistor) PUN = "L", PDN = "H"	10	100	kΩ

Electrical characteristics

Table 31. Tri-voltage 2.5 V GPIO DC parameters¹ (continued)

Parameter	Symbol	Test Conditions	Min	Max	Units
Pull-down resistance	R_{DOWN}	$V_{IN}=OVDD$ (Pulldown Resistor) PUN = "H", PDN = "L"	10	100	$k\Omega$
Input current (no PU/PD)	I_{IN}	$V_I = 0, V_I = OVDD$ PUN = "H", PDN = "H"	-1	1	μA

¹ For tri-voltage I/O, the associated IOMUXD compensation control register PSW_OVR and COMP bits must be set correctly. For 1.8 or 3.3 V operation, the SCFW API must be used to set PSW_OVR = 0b0 and COMP=0b000. For 2.5 V operation, PSW_OVR = 0b1 and COMP = 0b010.

² Refer to [Section 4.6.1](#) for undershoot and overshoot specifications.

³ As programmed in the associated IOMUX (PDRV field) register. High Drive mode is recommended for 3v3 and 2v5 modes. Low Drive mode is recommended for 1v8 mode.

⁴ Refer to [Section 4.6.2](#) for monotonic requirements.

Table 32. Tri-voltage 3.3 V GPIO DC parameters¹

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level output voltage ^{2,3}	V_{OH}	$I_{OH}= 0.1mA$ PDRV=1	$0.8 \times OVDD$		V
		$I_{OH}= 2mA$ PDRV=0			
Low-level output voltage ^{2,3}	V_{OL}	$I_{OL}= -0.1mA$ PDRV ³ =1	—	$0.125 \times OVDD$	V
		$I_{OL}= -2mA$ PDRV=0			
High-Level input voltage ^{2,4,3}	V_{IH}	—	$0.725 \times OVDD$	OVDD	V
Low-Level input voltage	V_{IL}	—	0	$0.25 \times OVDD$	V
Pull-up resistance	RPU	$V_{IN}=0V$ (Pullup Resistor) PUN = "L", PDN = "H"	10	100	$k\Omega$
Pull-down resistance	R_{DOWN}	$V_{IN}=OVDD$ (Pulldown Resistor) PUN = "H", PDN = "L"	10	100	$k\Omega$
Input current (no PU/PD)	IIN	$V_I = 0, V_I = OVDD$ PUN = "H", PDN = "H"	-2	2	μA

¹ For tri-voltage I/O, the associated IOMUXD compensation control register PSW_OVR and COMP bits must be set correctly. For 1.8 or 3.3 V operation, the SCFW API must be used to set PSW_OVR = 0b0 and COMP=0b000. For 2.5 V operation, PSW_OVR = 0b1 and COMP = 0b010.

² Refer to [Section 4.6.1](#) for undershoot and overshoot specifications.

³ As programmed in the associated IOMUX (PDRV field) register. High Drive mode recommended for 3v3 and 2v5 modes. Low Drive mode is recommended for 1v8 mode.

⁴ Refer to [Section 4.6.2](#) for monotonic requirements.

4.5.2.2 Dual-voltage GPIO DC parameters

The following two tables show dual-voltage 1.8 V and 3.3 V DC parameters, respectively, for GPIO pads. These parameters are guaranteed per the operating ranges in [Table 8](#), unless otherwise noted.

Table 33. Dual-voltage 1.8 V GPIO DC parameters

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level output voltage ^{1,2}	V _{OH}	I _{oh} = 0.1mA PDRV=1	0.8 × OVDD	—	V
		I _{oh} = 2mA PDRV=0			
Low-level output voltage ^{1,2}	V _{OL}	I _{ol} = -0.1mA PDRV=1	—	0.125 × OVDD D	V
		I _{ol} = -2mA PDRV=0			
High-Level input voltage ^{1,3}	V _{IH}	—	0.625 × OVDD D	OVDD	V
Low-Level input voltage	V _{IL}	—	0	0.25 × OVDD	V
Pull-up resistance	R _{PU}	V _{in} =0 V (Pullup Resistor) PUN = "L", PDN = "H"	15	50	kΩ
Pull-down resistance	R _{down}	V _{in} =OVDD (Pulldown Resistor) PUN = "H", PDN = "L"	15	50	kΩ
Input current (no PU/PD)	I _{IN}	V _I = 0, V _I = OVDD PUN = "H", PDN = "H"	-1	1	μA

¹ Refer to [Section 4.6.1](#) for undershoot and overshoot specifications.

² As programmed in the associated IOMUX (PDRV field) register. High Drive mode is recommended for SD standard (3v3 mode) and MMC standard (1v8/3v3 modes). Low Drive mode is recommended for SD standard (1v8 mode).

³ Refer to [Section 4.6.2](#) for monotonic requirements.

Table 34. Dual-voltage 3.3 V GPIO DC parameters

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level output voltage ^{1,2}	V _{OH}	I _{oh} = 0.1mA PDRV=1	0.8 × OVDD	—	V
		I _{oh} = 2mA PDRV=0			
Low-level output voltage ^{1,2}	V _{OL}	I _{ol} = -0.1mA PDRV=1	—	0.125 × OVDD	V
		I _{ol} = -2mA PDRV=0			
High-Level input voltage ^{1,3}	V _{IH}	—	0.725 × OVDD	OVDD	V
Low-Level input voltage	V _{IL}	—	0	0.25 × OVDD	V

Electrical characteristics

Table 34. Dual-voltage 3.3 V GPIO DC parameters (continued)

Parameter	Symbol	Test Conditions	Min	Max	Units
Pull-upresistance	R_{PU}	$V_{in}=0V$ (Pullup Resistor) PUN = "L", PDN = "H"	10	100	$k\Omega$
Pull-down resistance	R_{down}	$V_{in}=OVDD$ (Pulldown Resistor) PUN = "H", PDN = "L"	10	100	$k\Omega$
Input current (no PU/PD)	I_{IN}	$V_I = 0, V_I = OVDD$ PUN = "H", PDN = "H"	-2	2	μA

¹ Refer to [Section 4.6.1](#) for undershoot and overshoot specifications.

² As programmed in the associated IOMUX (PDRV field) register. High Drive mode is recommended for SD standard (3v3 mode) and MMC standard (1v8/3v3 modes). Low Drive mode is recommended for SD standard (1v8 mode).

³ Refer to [Section 4.6.2](#) for monotonic requirements.

4.5.2.3 Single-voltage GPIO DC parameters

[Table 35](#) and [Table 36](#) show single-voltage 1.8 V and 3.3 V DC parameters, respectively, for GPIO pads. These parameters are guaranteed per the operating ranges in [Table 8](#) unless otherwise noted.

Table 35. Single-voltage 1.8 V GPIO DC parameters

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level output voltage ^{1,2}	V_{OH}	$I_{OH}= 0.1mA$ DSE = 000 or 001	OVDD × 0.8	—	V
		$I_{OH}= 2mA$ DSE = 010 or 011			
		$I_{OH}= 4mA$ DSE = 100 to 110			
Low-level output voltage ^{1,2}	V_{OL}	$I_{OL}= -0.1mA$ DSE = 000 or 001	—	OVDD × 0.2	V
		$I_{OL}= -2mA$ DSE = 010 or 011			
		$I_{OL}= -4mA$ DSE = 100 to 110			
High-Level input voltage ^{2,3}	V_{IH}	—	$0.65 \times OVDD$	OVDD	V
Low-Level input voltage ^{2,3}	V_{IL}	—	0	$0.35 \times OVDD$	V
Pull-up resistance	R_{PU}	$V_{in}=0V$ (Pullup Resistor) PUN = "L", PDN = "H"	20	90	$k\Omega$
Pull-down resistance	R_{down}	$V_{in}=OVDD$ (Pulldown Resistor) PUN = "H", PDN = "L"	20	90	$k\Omega$
Input current (no PU/PD)	I_{IN}	$V_I = 0, V_I = OVDD$ PUN = "H", PDN = "H"	-5	5	μA
Keeper Circuit Resistance	$R_{_Keeper}$	$V_I = .3xOVDD, V_I = .7x OVDD$ PUN = "L", PDN = "L"	20	90	$k\Omega$

- ¹ As programmed in the associated IOMUX (DSE field) register.
² Refer to [Section 4.6.1](#) for undershoot and overshoot specifications.
³ Refer to [Section 4.6.2](#) for monotonic requirements.

Table 36. Single-voltage 3.3 V GPIO DC parameters

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level output voltage ^{1,2}	V_{OH}	$I_{OH} = 0.1\text{mA}$ DSE = 00 or 01	$0.8 \times \text{OVDD}$	—	V
		$I_{OH} = 2\text{mA}$ DSE = 10 or 11			
Low-level output voltage ^{1,2}	V_{OL}	$I_{OL} = -0.1\text{mA}$ DSE = 00 or 01	—	$0.2 \times \text{OVDD}$	V
		$I_{OL} = -2\text{mA}$ DSE = 10 or 11			
High-Level input voltage ^{2,3}	V_{IH}	—	$0.75 \times \text{OVDD}$	OVDD	V
Low-Level input voltage ^{2,3}	V_{IL}	—	0	$0.25 \times \text{OVDD}$	V
Pull-upresistance	R_{PU}	$V_{in} = 0\text{ V}$ (Pullup Resistor) PUN = "L", PDN = "H"	20	90	k Ω
Pull-down resistance	R_{down}	$V_{in} = \text{OVDD}$ (Pulldown Resistor) PUN = "H", PDN = "L"	20	90	k Ω
Input current (no PU/PD)	I_{IN}	$V_I = 0, V_I = \text{OVDD}$ PUN = "H", PDN = "H"	-5	5	μA
Keeper Circuit Resistance	R_{Keeper}	$V_I = .3 \times \text{OVDD}, V_I = .7 \times \text{OVDD}$ PUN = "L", PDN = "L"	20	90	k Ω

- ¹ As programmed in the associated IOMUX (DSE field) register.
² Refer to [Section 4.6.1](#) for undershoot and overshoot specifications.
³ Refer to [Section 4.6.2](#) for monotonic requirements.

4.5.3 HDMI control signals parameters

The following table shows HDMI control signals DC parameters. These parameters are guaranteed per the operating ranges in [Table 8](#), unless otherwise noted.

Table 37. HDMI DDC and HPD DC parameters

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level input voltage	V_{IH}	—	2	5.3	V
Low-level input voltage	V_{IL}	—	0	0.8	V

4.5.4 DDR I/O DC parameters

4.5.4.1 LPDDR4 mode I/O DC parameters

These parameters are guaranteed per the operating ranges in [Table 8](#) unless otherwise noted.

Table 38. LPDDR4 DC parameters

Parameter	Symbol	Test Conditions	Min	Max	Units
High-level output voltage ¹	V_{OH}	Output Drive = All settings (40,48,60,80,120,240) unterminated outputs	$0.9 \times V_{DDQ}$	—	V
Low-level output voltage ¹	V_{OL}	Output Drive = All settings (40,48,60,80,120,240) unterminated outputs	—	$0.1 \times V_{DDQ}$	V
Input current (no ODT)	I_{IN}	$V_I = V_{SSQ}, V_I = V_{DDQ}$	-2	2	μA
DC High-Level input voltage	V_{IH_DC}	—	$V_{REF} + 0.1$	V_{DDQ}	V
DC Low-Level input voltage	V_{IL_DC}	—	V_{SSQ}	$V_{REF} - 0.1$	V

¹ Refer to [Section 4.6.1](#) for undershoot and overshoot specifications.

4.6 I/O AC Parameters

The GPIO and DDR I/O load circuit and output transition time waveforms are shown in [Figure 4](#) and [Figure 5](#).

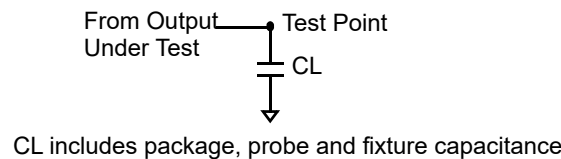


Figure 4. Load Circuit for Output

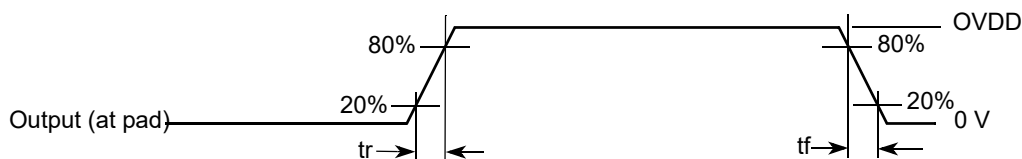


Figure 5. Output Transition Time Waveform

4.6.1 I/O Overshoot and Undershoot Parameters

For all inputs/outputs, maximum peak amplitude allowed for overshoot and undershoot is specified in [Table 39](#). OVDD is the I/O Supply.

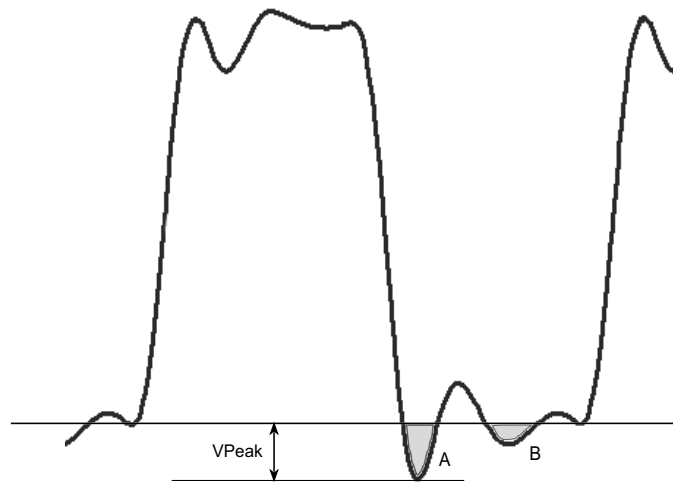
NOTE

If a signal edge produces more than one overshoot/undershoot event, the sum of all areas following the transition must be less than the area specified.

Table 39. Overshoot and Undershoot Parameters

Parameter	Symbol	Min	Max	Units
Amplitude above OVDD or below GND	V_{Peak}	—	0.35	V
Area above OVDD or below GND (A + B)	V_{Area}	—	0.8	V-ns

Overshoot/undershoot must be controlled through printed circuit board layout, transmission line impedance matching, signal line termination, and other methods. Noncompliance to this specification may affect device reliability or cause permanent damage to the device.

**Figure 6. Undershoot Waveform Example****4.6.2 Input Signal Monotonic Requirements**

Processor input signal monotonic requirements are illustrated in the following figure.

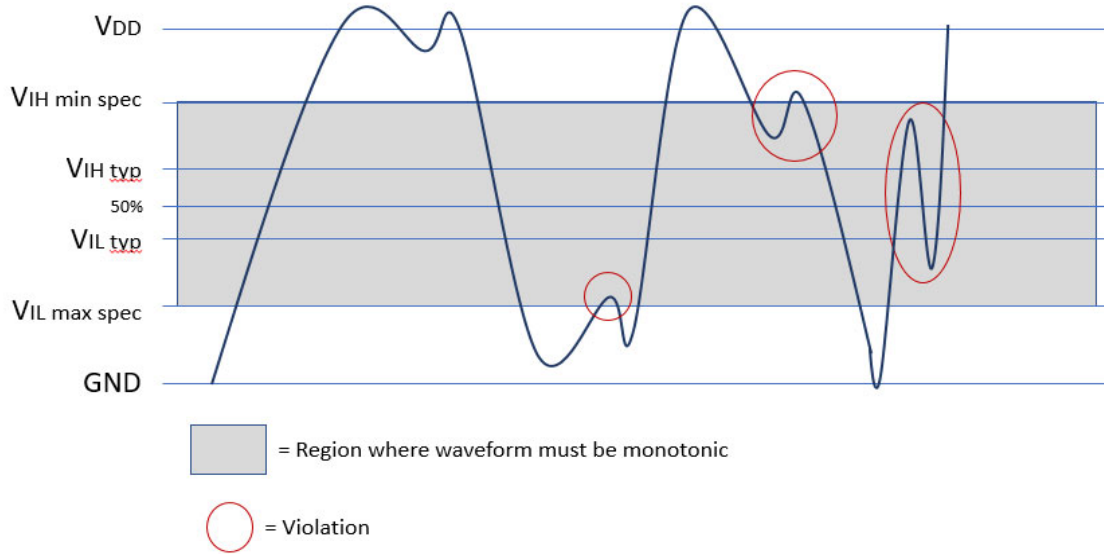


Figure 7. Input Waveform Monotonic Requirement

V_{IH_min} and V_{IL_max} are the guaranteed minimum logic-high and maximum logic-low voltage specifications, respectively. NXP devices are typically better than guaranteed specifications; these values are shown in the diagram as “typ”. Nominally, lower voltages than the guaranteed specification are accepted by the device as logic high and higher voltages than the guaranteed specification are accepted as logic low.

4.6.3 General Purpose I/O (GPIO) AC Parameters

Table 40. General Purpose I/O AC Parameters¹

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
1.8 V application²						
f_{max}	Maximum frequency	Load = 21 pF (PDRV = L, high drive, 33 Ω)	—	—	208	MHz
		Load = 15 pF (PDRV = H, low drive, 50 Ω)				
t_r	Rise time	Measured between V_{OL} and V_{OH}	0.4	—	1.32	ns
t_f	Fall time	Measured between V_{OH} and V_{OL}	0.4	—	1.32	ns
Driver 3.3 V application³						
f_{max}	Maximum frequency	Load = 30 pF	—	—	52	MHz

Table 40. General Purpose I/O AC Parameters¹ (continued)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
tr	Rise time	Measured between V_{OL} and V_{OH}	—	—	3	ns
tf	Fall time	Measured between V_{OH} and V_{OL}	—	—	3	ns

¹ All output I/O specifications are guaranteed for Accurate mode of the compensation cell operation. This is applicable for both DC and AC specifications.

² All timing specifications in 1.8 V application are valid for High Drive mode (PDRV = L). In Low Drive mode (PDRV = H), the driver is functional.

³ All timing specifications in 3.3 V application are valid for Low Drive only. For High Drive setting, the driver is functional.

Table 41. Dynamic input characteristics

Symbol	Parameter	Condition ^{1,2}	Min	Max	Unit
Dynamic Input Characteristics for 3.3 V Application					
f_{op}	Input frequency of operation	—	—	52	MHz
INPSL	Slope of input signal at I/O	Measured between 10% to 90% of the I/O swing	—	3.5	ns
Dynamic Input Characteristics for 1.8 V Application					
f_{op}	Input frequency of operation	—	—	208	MHz
INPSL	Slope of input signal at I/O	Measured between 10% to 90% of the I/O swing	—	1.5	ns

¹ For all supply ranges of operation.

² The dynamic input characteristic specifications are applicable for the digital bidirectional cells.

4.7 Output Buffer Impedance Parameters

This section defines the I/O impedance parameters for the following I/O types:

- General Purpose I/O (GPIO) output buffer impedance
- Double Data Rate I/O (DDR) output buffer impedance for LPDDR4

NOTE

GPIO and DDR I/O output driver impedance is measured with “long” transmission line of impedance Z_{tl} attached to I/O pad and incident wave launched into transmission line. R_{pu}/R_{pd} and Z_{tl} form a voltage divider that defines specific voltage of incident wave relative to OVDD. Output driver impedance is calculated from this voltage divider (see [Figure 8](#)).

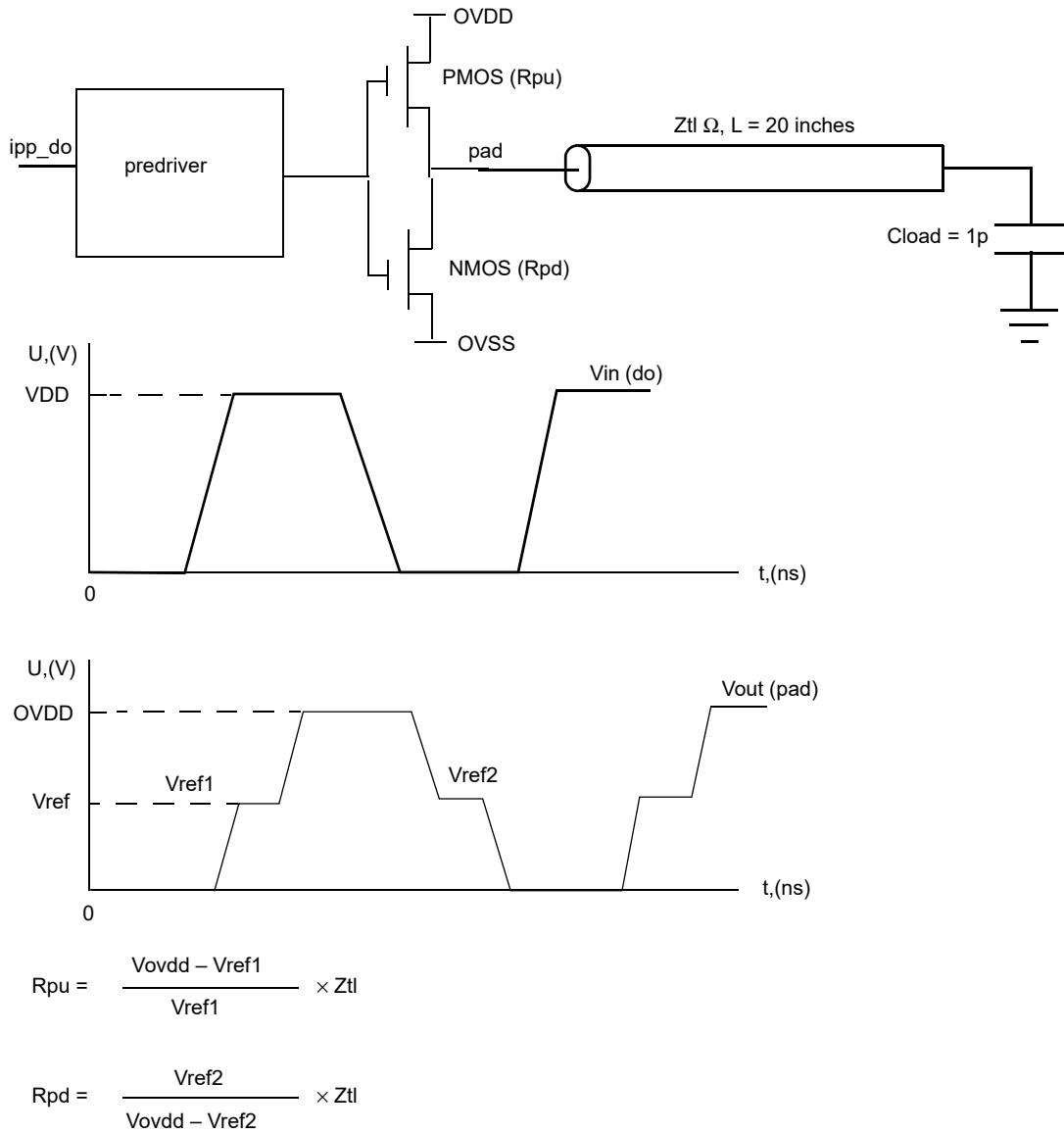


Figure 8. Impedance Matching Load for Measurement

4.7.1 GPIO output buffer impedance

4.7.1.1 Tri-voltage GPIO output buffer impedance

Table 42. Tri-voltage 1.8 V GPIO output impedance DC parameters

Parameter	Symbol	Test conditions	Typical	Units
Output impedance	Z_O	¹ DSE=0	33	Ω
Output impedance	Z_O	¹ DSE=1	50	Ω

¹ As programmed in the associated IOMUX (PDRV field) register.

Table 43. Tri-voltage 2.5 V GPIO output impedance DC parameters

Parameter	Symbol	Test conditions	Typical	Units
Output impedance	Z_O	¹ DSE=0	25	Ω
Output impedance	Z_O	¹ DSE=1	33	Ω

¹ As programmed in the associated IOMUX (PDRV field) register.

Table 44. Tri-voltage 3.3 V GPIO output impedance DC parameters

Parameter	Symbol	Test conditions	Typical	Units
Output impedance	Z_O	¹ DSE=0	25	Ω
Output impedance	Z_O	¹ DSE=1	37	Ω

¹ As programmed in the associated IOMUX (PDRV field) register.

4.7.1.2 Dual-voltage GPIO output buffer impedance

Table 45. Dual-voltage 1.8 V GPIO output impedance DC parameters

Parameter	Symbol	Test conditions	Typical	Units
Output impedance	Z_O	¹ DSE=0	33	Ω
Output impedance	Z_O	¹ DSE=1	50	Ω

¹ 'As programmed in the associated IOMUX (PDRV field) register.

Table 46. Dual-voltage 3.3 V GPIO output impedance DC parameters

Parameter	Symbol	Test conditions	Typical	Units
Output impedance	Z_O	¹ DSE=0	25	Ω
Output impedance	Z_O	¹ DSE=1	37	Ω

¹ As programmed in the associated IOMUX (PDRV field) register.

4.7.1.3 Single-voltage 1.8 V GPIO output buffer drive strength

The following table shows the GPIO output buffer drive strength (OVDD 1.8 V).

Table 47. Single-voltage GPIO 1.8 V output impedance DC parameters

Parameter	Symbol	Test conditions	Typical	Units
Output impedance	Z_O	¹ DSE=000	200	Ω
		¹ DSE=001	100	
		¹ DSE=010	55	
		¹ DSE=011	40	
		¹ DSE=100	30	
		¹ DSE=101	24	
		¹ DSE=110	20	
		¹ DSE=111	18	

¹ As programmed in the associated IOMUX (DSE field) register.

4.7.1.4 Single-voltage 3.3 V GPIO output buffer drive strength

The following table shows the GPIO output buffer drive strength (OVDD 3.3 V).

Table 48. Single-voltage GPIO 3.3 V output impedance DC parameters

Parameter	Symbol	Test conditions	Typical	Units
Output impedance	Z_O	¹ DSE=00	400	Ω
		¹ DSE=01	200	
		¹ DSE=10	100	
		¹ DSE=11	50	

¹ As programmed in the associated IOMUX (DSE field) register.

4.7.2 DDR I/O output buffer impedance

The following tables show LPDDR4 I/O output buffer impedance of the device.

The ZQ Calibration cell uses a single register (ZQnPR0) to determine the target output buffer impedances of the pull-up driver and the pull-down driver, as well as the target on-die termination impedance. The resulting calibration setting is then applied to all DDR pads within the PHY complex.

Table 49 shows the recommended ZQnPR0 field settings for the LPDDR4 I/Os to achieve the desired output buffer impedances.

Table 49. LPDDR4 I/O output buffer impedance

Parameter	Typical			
	ZQnPR0 ZPROG_ASYM_PU_DRV	Impedance	ZQnPR0 ZPROG_ASYM_PD_DRV	Impedance
Recommended combinations for DQ /CA pins	5	80 Ω	3	120 Ω
	7	60 Ω	5	80 Ω
	9	48 Ω	7	60 Ω
	11	40 Ω	9	48 Ω

Table 50. LPDDR4 I/O on-die termination impedance

Parameter	Typical Impedance	ZQnPR0. ZPROG_HOST_ODT
Recommended combinations for DQ/CA pins	120.0 Ω	3
	80.0 Ω	5
	60.0 Ω	7
	48.0 Ω	9
	40.0 Ω	11

4.8 System Modules Timing

This section contains the timing and electrical parameters for the modules in each processor.

4.8.1 Reset Timing Parameters

The following figure shows the reset timing and [Table 51](#) lists the timing parameters.

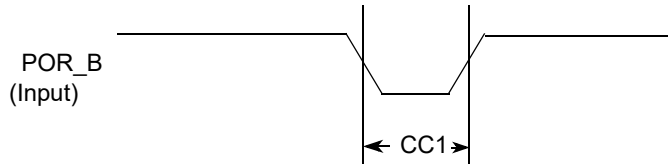


Figure 9. Reset timing diagram

Table 51. Reset timing parameters

ID	Parameter	Min	Max	Unit
CC1	Duration of SRC_POR_B to be qualified as valid	1	—	XTALOSC_RTC_XTALI cycle

4.8.2 WDOG reset timing parameters

The following figure shows the WDOG reset timing and [Table 52](#) lists the timing parameters.

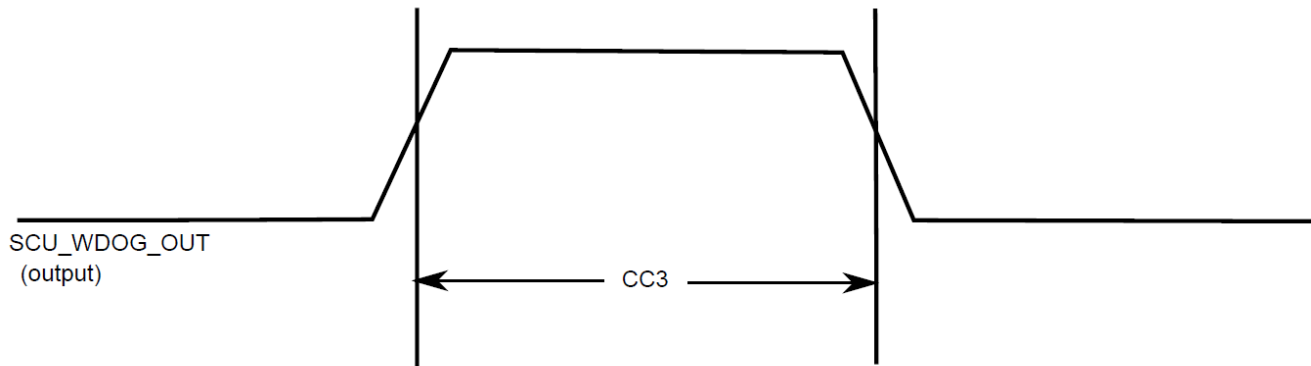


Figure 10. SCU_WDOG_OUT timing diagram

Table 52. WDOG1_B timing parameters

ID	Parameter	Min	Max	Unit
CC3	Duration of SCU_WDOG_OUT assertion	1	—	XTALOSC_RTC_XTALI cycle

NOTE

XTALOSC_RTC_XTALI is approximately 32 kHz.
 XTALOSC_RTC_XTALI cycle is one period or approximately 30 μs.

4.8.3 DDR SDRAM–specific parameters (LPDDR4)

The i.MX 8 Family of processors have been designed and tested to work with JEDEC JESD209-4A–compliant LPDDR4 memory . Timing diagrams and tolerances required to work with these memories are specified in the respective documents and are not reprinted here.

Meeting the necessary timing requirements for a DDR memory system is highly dependent on the components chosen and the design layout of the system as a whole. NXP cannot cover in this document all the requirements needed to achieve a design that meets full system performance over temperature, voltage, and part variation; PCB trace routing, PCB dielectric material, number of routing layers used, placement of bulk/decoupling capacitors on critical power rails, VIA placement, GND and Supply planes layout, and DDR controller/PHY register settings all are factors affecting the performance of the memory system. Consult the hardware user guide for this device and NXP validated design layouts for information on how to properly design a PCB for best DDR performance. NXP strongly recommends duplicating an NXP validated design as much as possible in the design of critical power rails, placement of bulk/decoupling capacitors and DDR trace routing between the processor and the selected DDR memory. All supporting material is readily available on the device web page on <https://www.nxp.com/products/processors-and-microcontrollers/applications-processors/i.mx-applications-processors/i.mx-8-processors:IMX8-SERIES> .

Processors that demonstrate full DDR performance on NXP validated designs, but do not function on customer designs, are not considered marginal parts. A report detailing how the returned part behaved on an NXP validated system will be provided to the customer as closure to a customer’s reported DDR issue. Customers bear the responsibility of properly designing the Printed Circuit Board, correctly simulating and modeling the designed DDR system, and validating the system under all expected operating conditions (temperatures, voltages) prior to releasing their product to market.

Table 53. i.MX 8 Family DRAM controller supported SDRAM configurations

Parameter	LPDDR4
Number of Controllers	2
Number of Channels	2 per controller
Number of Chip Selects	2 per channel
Bus Width	16 bit per channel ¹
Number of Address Rows	16 (R0-R15)
Maximum Clock Frequency	1600 MHz

¹ Only 16-bit external memory configurations are supported.

4.8.3.1 Clock/data/command/address pin allocations

These processors uses generic names for clock, data and command address bus (DCF—DRAM controller functions); the following table provides mapping of clock, data and command address signals for LPDDR4 modes.

Table 54. Clock, data, and command address signals for LPDDR4 modes

Signal name	LPDDR4
DDR_CH[1:0].CK0_P	CK_t_A
DDR_CH[1:0].CK0_N	CK_c_A
DDR_CH[1:0].CK1_P	CK_t_B
DDR_CH[1:0].CK1_N	CK_c_B
DDR_CH[1:0].DQ_[15:0]	DQ[15:0]_A
DDR_CH[1:0].DQ_[31:16]	DQ[15:0]_B
DDR_CH[1:0].DQS_N_[3:0]	DQS_N_[3:0]
DDR_CH[1:0].DQS_P_[3:0]	DQS_P_[3:0]
DDR_CH[1:0].DM_[3:0]	DM_[3:0]
DDR_CH[1:0].DCF00	CA2_A
DDR_CH[1:0].DCF01	CA4_A
DDR_CH[1:0].DCF02	
DDR_CH[1:0].DCF03	CA5_A
DDR_CH[1:0].DCF04	
DDR_CH[1:0].DCF05	
DDR_CH[1:0].DCF06	
DDR_CH[1:0].DCF07	
DDR_CH[1:0].DCF08	CA3_A
DDR_CH[1:0].DCF09	ODT_CA_A
DDR_CH[1:0].DCF10	CS0_A
DDR_CH[1:0].DCF11	CA0_A
DDR_CH[1:0].DCF12	CS1_A
DDR_CH[1:0].DCF13	
DDR_CH[1:0].DCF14	CKE0_A
DDR_CH[1:0].DCF15	CKE1_A
DDR_CH[1:0].DCF16	CA1_A
DDR_CH[1:0].DCF17	CA4_B
DDR_CH[1:0].DCF18	RESET_N
DDR_CH[1:0].DCF19	CA5_B
DDR_CH[1:0].DCF20	
DDR_CH[1:0].DCF21	
DDR_CH[1:0].DCF22	

Table 54. Clock, data, and command address signals for LPDDR4 modes (continued)

Signal name	LPDDR4
DDR_CH[1:0].DCF23	
DDR_CH[1:0].DCF24	
DDR_CH[1:0].DCF25	ODT_CA_B
DDR_CH[1:0].DCF26	CA3_B
DDR_CH[1:0].DCF27	CA0_B
DDR_CH[1:0].DCF28	CS0_B
DDR_CH[1:0].DCF29	CS1_B
DDR_CH[1:0].DCF30	CKE0_B
DDR_CH[1:0].DCF31	CKE1_B
DDR_CH[1:0].DCF32	CA1_B
DDR_CH[1:0].DCF33	CA2_B

4.9 General-Purpose Media Interface (GPMI) Timing

The GPMI controller is a flexible interface NAND Flash controller with 8-bit data width, up to 400 MB/s I/O speed, and individual chip select. It supports Asynchronous Timing mode, Source Synchronous Timing mode, and Toggle Timing mode, as described in the following subsections.

4.9.1 GPMI Asynchronous mode AC timing (ONFI 1.0 compatible)

Asynchronous mode AC timings are provided as multiplications of the clock cycle and fixed delay. The Maximum I/O speed of GPMI in Asynchronous mode is about 50 MB/s. Figure 11 through Figure 14 depict the relative timing between GPMI signals at the module level for different operations under Asynchronous mode. Table 55 describes the timing parameters (NF1–NF17) that are shown in the figures.

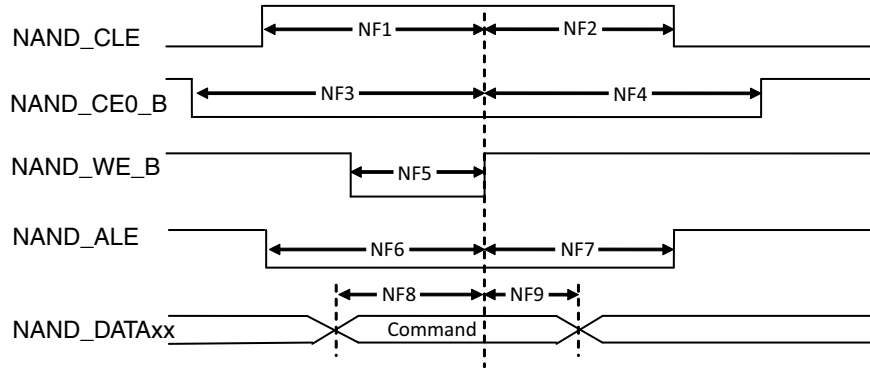


Figure 11. Command Latch Cycle Timing Diagram

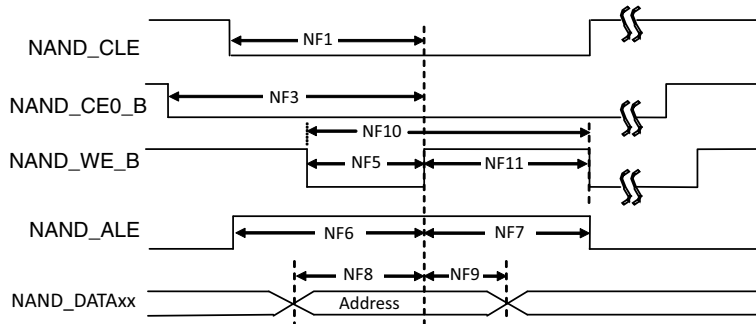


Figure 12. Address Latch Cycle Timing Diagram

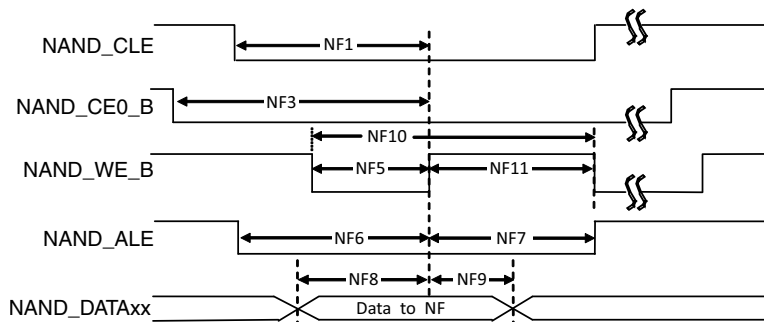


Figure 13. Write Data Latch Cycle Timing Diagram

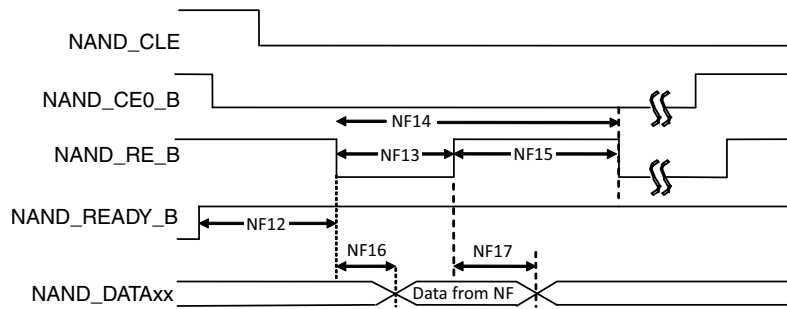


Figure 14. Read Data Latch Cycle Timing Diagram (Non-EDO Mode)

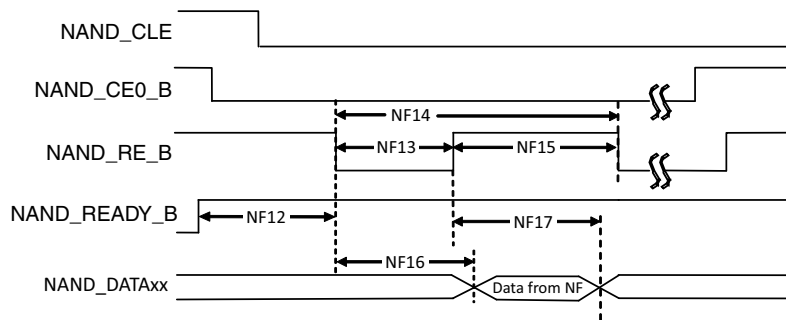


Figure 15. Read Data Latch Cycle Timing Diagram (EDO Mode)

Table 55. Asynchronous Mode Timing Parameters¹

ID	Parameter	Symbol	Timing T = GPMI Clock Cycle		Unit
			Min	Max	
NF1	NAND_CLE setup time	tCLS	$(AS + DS) \times T - 0.12$ [see ^{2,3}]		ns
NF2	NAND_CLE hold time	tCLH	$DH \times T - 0.72$ [see ²]		ns
NF3	NAND_CEx_B setup time	tCS	$(AS + DS + 1) \times T$ [see ^{3,2}]		ns
NF4	NAND_CEx_B hold time	tCH	$(DH+1) \times T - 1$ [see ²]		ns
NF5	NAND_WE_B pulse width	tWP	$DS \times T$ [see ²]		ns
NF6	NAND_ALE setup time	tALS	$(AS + DS) \times T - 0.49$ [see ^{3,2}]		ns
NF7	NAND_ALE hold time	tALH	$(DH \times T - 0.42)$ [see ²]		ns
NF8	Data setup time	tDS	$DS \times T - 0.26$ [see ²]		ns
NF9	Data hold time	tDH	$DH \times T - 1.37$ [see ²]		ns
NF10	Write cycle time	tWC	$(DS + DH) \times T$ [see ²]		ns
NF11	NAND_WE_B hold time	tWH	$DH \times T$ [see ²]		ns
NF12	Ready to NAND_RE_B low	tRR ⁴	$(AS + 2) \times T$ [see ^{3,2}]	—	ns
NF13	NAND_RE_B pulse width	tRP	$DS \times T$ [see ²]		ns
NF14	READ cycle time	tRC	$(DS + DH) \times T$ [see ²]		ns
NF15	NAND_RE_B high hold time	tREH	$DH \times T$ [see ²]		ns

Table 55. Asynchronous Mode Timing Parameters¹ (continued)

ID	Parameter	Symbol	Timing T = GPMI Clock Cycle		Unit
			Min	Max	
NF16	Data setup on read	tDSR	—	$(DS \times T - 0.67)/18.38$ [see ^{5,6}]]	ns
NF17	Data hold on read	tDHR	0.82/11.83 [see ^{5,6}]]	—	ns

¹ The GPMI asynchronous mode output timing can be controlled by the module's internal registers HW_GPMI_TIMING0_ADDRESS_SETUP, HW_GPMI_TIMING0_DATA_SETUP, and HW_GPMI_TIMING0_DATA_HOLD. This AC timing depends on these registers settings. In the table, AS/DS/DH represents each of these settings.

² AS minimum value can be 0, while DS/DH minimum value is 1.

³ T = GPMI clock period -0.075ns (half of maximum p-p jitter).

⁴ NF12 is met automatically by the design.

⁵ Non-EDO mode.

⁶ EDO mode, GPMI clock \approx 100 MHz
(AS=DS=DH=1, GPMI_CTL1 [RDN_DELAY] = 8, GPMI_CTL1 [HALF_PERIOD] = 0).

In EDO mode (Figure 15), NF16/NF17 are different from the definition in non-EDO mode (Figure 14). They are called tREA/tRHOH (NAND_RE_B access time/NAND_RE_B HIGH to output hold). The typical value for them are 16 ns (max for tREA)/15 ns (min for tRHOH) at 50 MB/s EDO mode. In EDO mode, GPMI will sample NAND_DATAxx at rising edge of delayed NAND_RE_B provided by an internal DPLL. The delay value can be controlled by GPMI_CTRL1.RDN_DELAY (see the GPMI chapter of the device reference manual. The typical value of this control register is 0x8 at 50 MT/s EDO mode. However, if the board delay is large enough and cannot be ignored, the delay value should be made larger to compensate the board delay.

4.9.2 GPMI Source Synchronous mode AC timing (ONFI 2.x compatible)

The following figure shows the write and read timing of Source Synchronous mode.

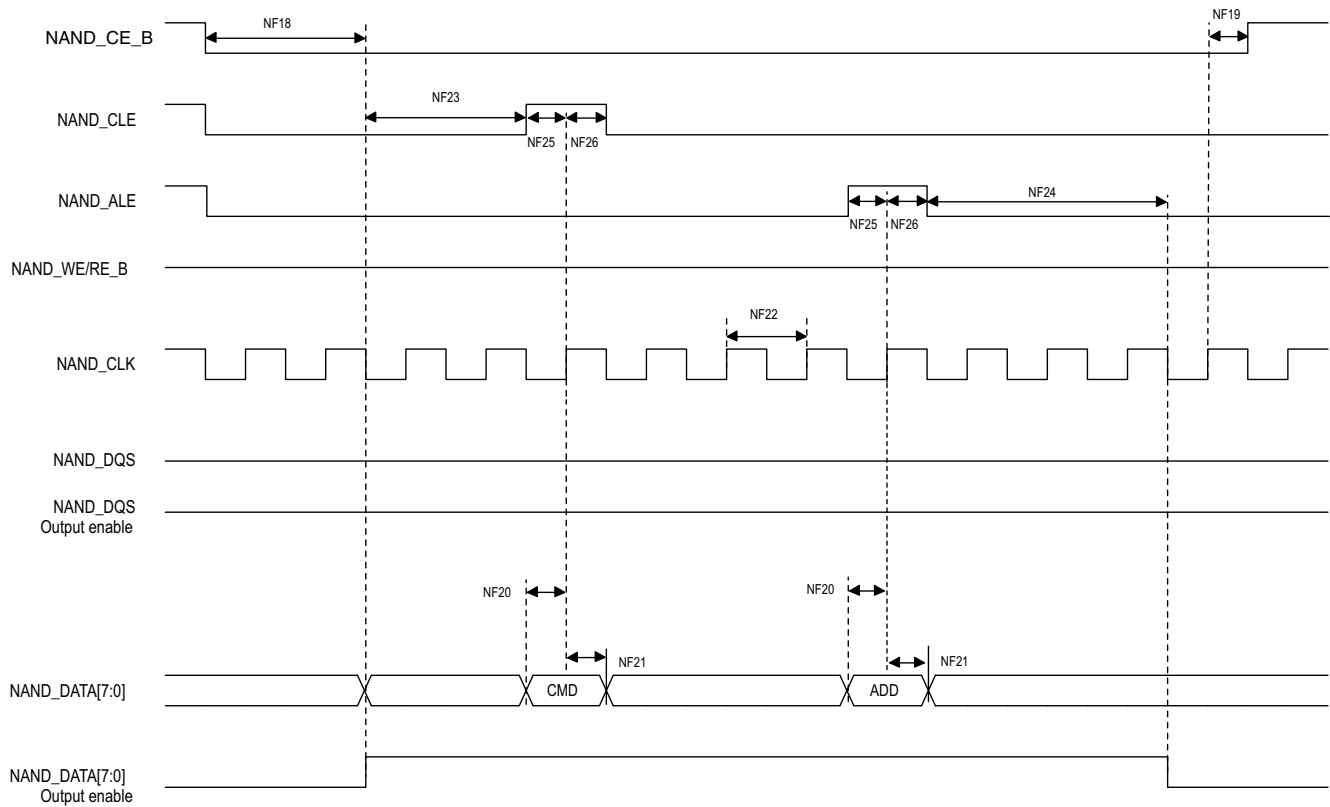


Figure 16. Source Synchronous Mode Command and Address Timing Diagram

Electrical characteristics

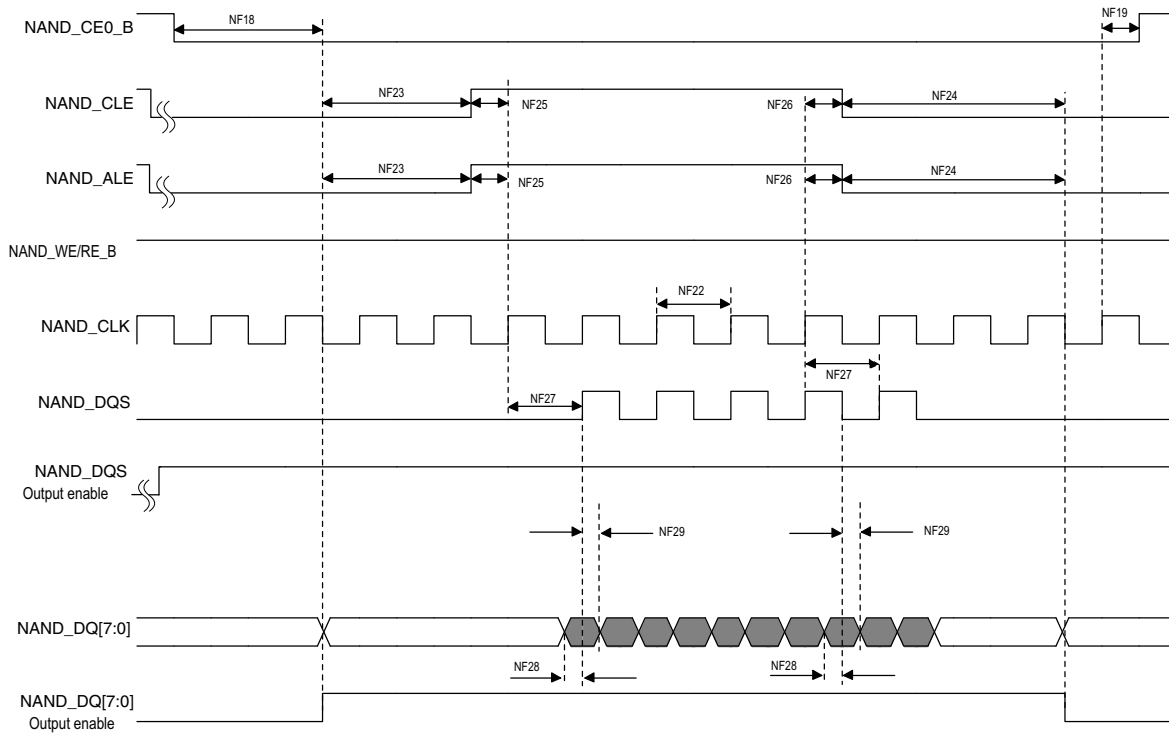


Figure 17. Source Synchronous Mode Data Write Timing Diagram

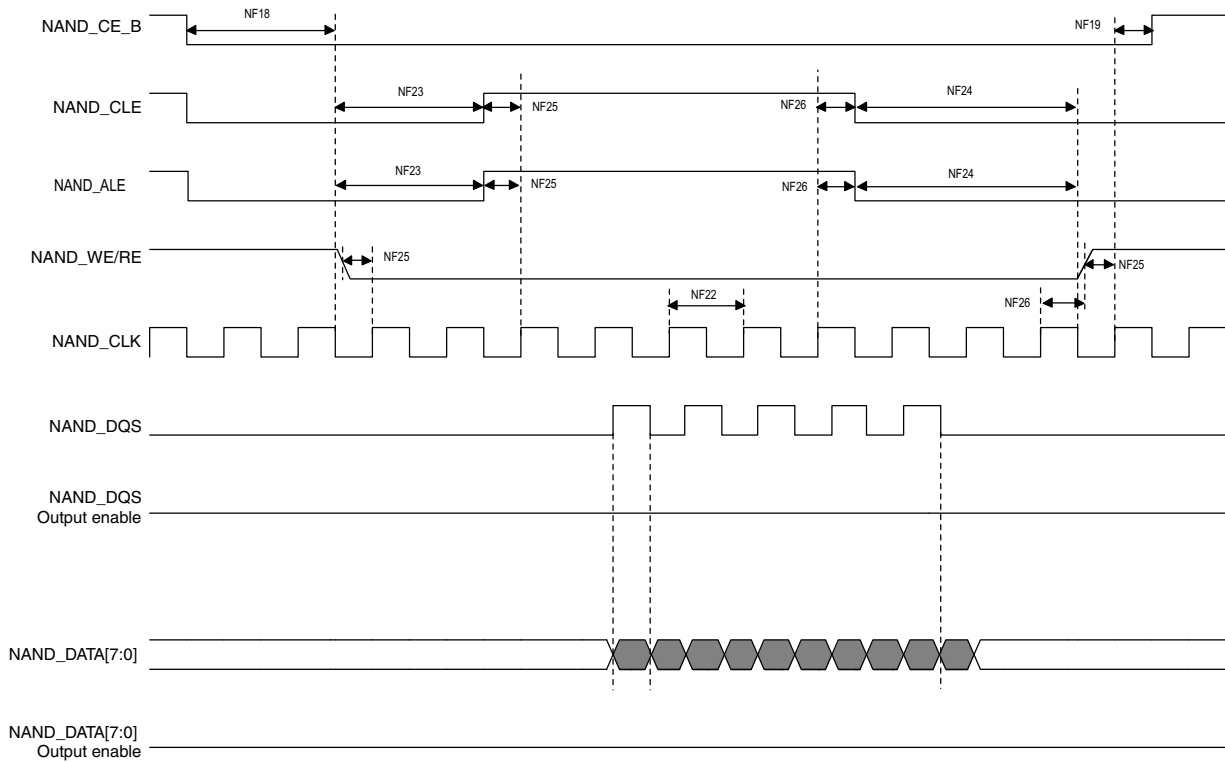


Figure 18. Source Synchronous Mode Data Read Timing Diagram

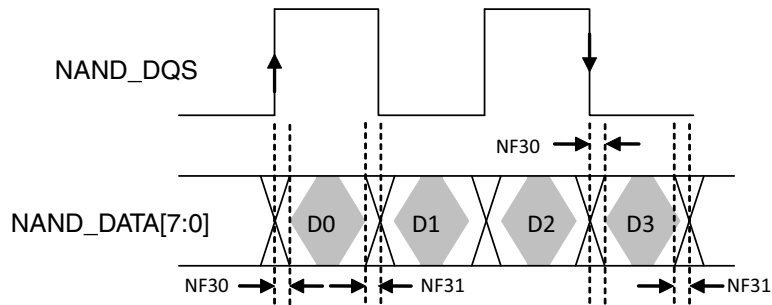


Figure 19. NAND_DQS/NAND_DQ Read Valid Window

Table 56. Source Synchronous Mode Timing Parameters¹

ID	Parameter	Symbol	Timing T = GPMI Clock Cycle		Unit
			Min	Max	
NF18	NAND_CEx_B access time	tCE	$CE_DELAY \times T - 0.79$ [see ²]		ns
NF19	NAND_CEx_B hold time	tCH	$0.5 \times tCK - 0.63$ [see ²]		ns
NF20	Command/address NAND_DATAxx setup time	tCAS	$0.5 \times tCK - 0.05$		ns
NF21	Command/address NAND_DATAxx hold time	tCAH	$0.5 \times tCK - 1.23$		ns
NF22	clock period	tCK	—		ns
NF23	preamble delay	tPRE	$PRE_DELAY \times T - 0.29$ [see ²]		ns
NF24	postamble delay	tPOST	$POST_DELAY \times T - 0.78$ [see ²]		ns
NF25	NAND_CLE and NAND_ALE setup time	tCALs	$0.5 \times tCK - 0.86$		ns
NF26	NAND_CLE and NAND_ALE hold time	tCALH	$0.5 \times tCK - 0.37$		ns
NF27	NAND_CLK to first NAND_DQS latching transition	tDQSS	$T - 0.41$ [see ²]		ns
NF28	Data write setup	tDS	$0.25 \times tCK - 0.35$		ns
NF29	Data write hold	tDH	$0.25 \times tCK - 0.85$		ns
NF30	NAND_DQS/NAND_DQ read setup skew	tDQSQ	—	2.06	—
NF31	NAND_DQS/NAND_DQ read hold skew	tQHS	—	1.95	—

¹ The GPMI source synchronous mode output timing can be controlled by the module's internal registers GPMI_TIMING2_CE_DELAY, GPMI_TIMING2_PREAMBLE_DELAY, GPMI_TIMING2_POST_DELAY. This AC timing depends on these registers settings. In the table, CE_DELAY/PRE_DELAY/POST_DELAY represents each of these settings.

² T = tCK (GPMI clock period) - 0.075ns (half of maximum p-p jitter).

Figure 19 shows the timing diagram of NAND_DQS/NAND_DATAxx read valid window. For Source Synchronous mode, the typical value of tDQSQ is 0.85 ns (max) and 1 ns (max) for tQHS at 200 MB/s. GPMI will sample NAND_DATA[7:0] at both rising and falling edge of a delayed NAND_DQS signal, which can be provided by an internal DPLL. The delay value can be controlled by GPMI register GPMI_READ_DDR_DLL_CTRL.SLV_DLY_TARGET (see the GPMI chapter of the device reference manual. Generally, the typical delay value of this register is equal to 0x7 which means 1/4 clock cycle delay expected. However, if the board delay is large enough and cannot be ignored, the delay value should be made larger to compensate the board delay.

4.9.3 ONFI NV-DDR2 mode (ONFI 3.2 compatible)

4.9.3.1 Command and address timing

ONFI 3.2 mode command and address timing is the same as ONFI 1.0 compatible Async mode AC timing. See [Section 4.9.1, “GPMI Asynchronous mode AC timing \(ONFI 1.0 compatible\)”](#), for details.

4.9.3.2 Read and write timing

ONFI 3.2 mode read and write timing is the same as Toggle mode AC timing. See [Section 4.9.4, “Toggle mode AC Timing”](#), for details.

4.9.4 Toggle mode AC Timing

4.9.4.1 Command and address timing

NOTE

Toggle mode command and address timing is the same as ONFI 1.0 compatible Asynchronous mode AC timing. See [Section 4.9.1, “GPMI Asynchronous mode AC timing \(ONFI 1.0 compatible\)”](#), for details.

4.9.4.2 Read and write timing

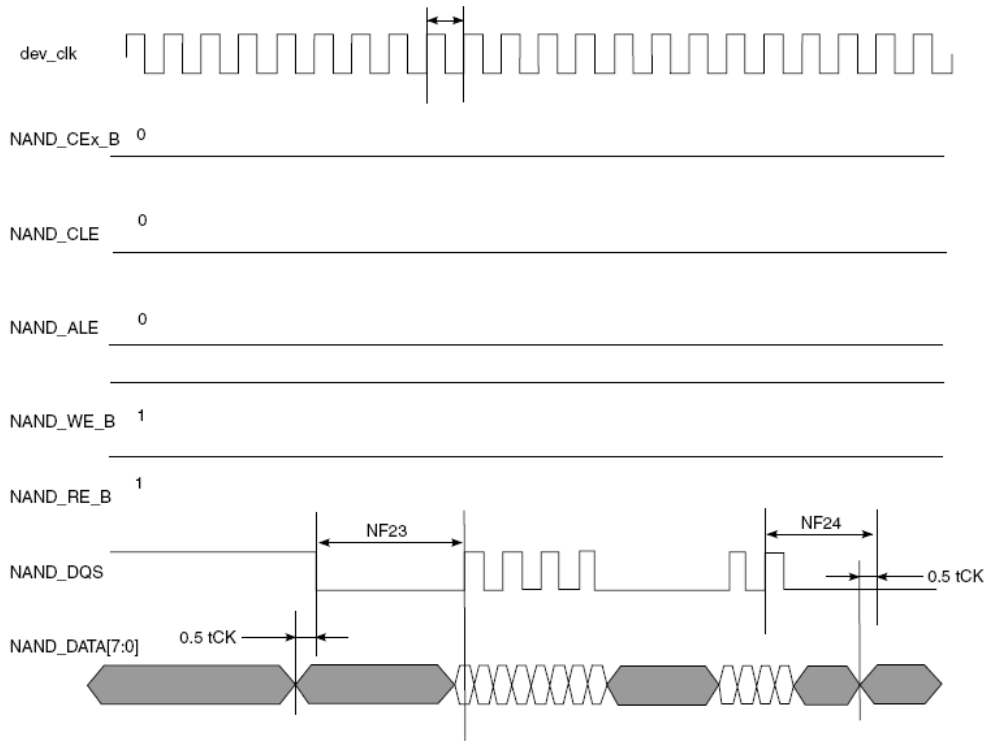


Figure 20. Toggle mode data write timing

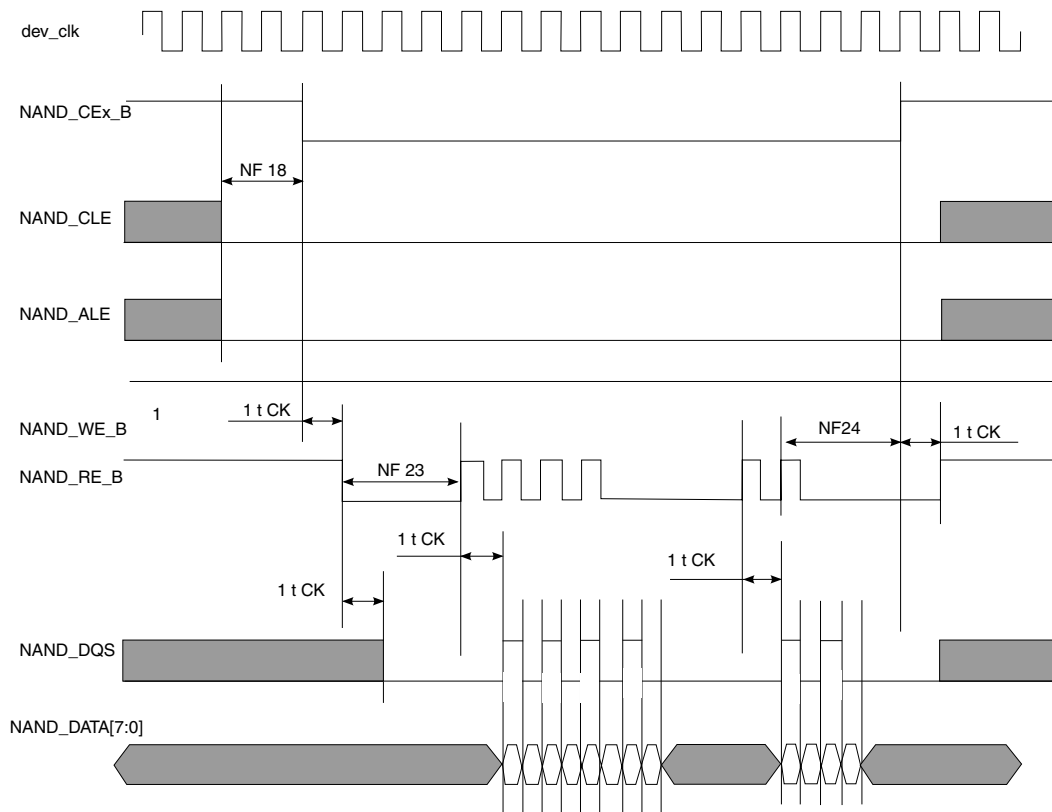


Figure 21. Toggle mode data read timing

Table 57. Toggle mode timing parameters¹

ID	Parameter	Symbol	Timing T = GPMI Clock Cycle		Unit
			Min.	Max.	
NF1	NAND_CLE setup time	tCLS	$(AS + DS) \times T - 0.12$ [see note ^{2,3}]		
NF2	NAND_CLE hold time	tCLH	$DH \times T - 0.72$ [see note ²]		
NF3	NAND_CE0_B setup time	tCS	$(AS + DS) \times T - 0.58$ [see notes ²]		
NF4	NAND_CE0_B hold time	tCH	$DH \times T - 1$ [see note ²]		
NF5	NAND_WE_B pulse width	tWP	$DS \times T$ [see note ²]		
NF6	NAND_ALE setup time	tALS	$(AS + DS) \times T - 0.49$ [see notes ²]		
NF7	NAND_ALE hold time	tALH	$DH \times T - 0.42$ [see note ²]		
NF8	Command/address NAND_DATAxx setup time	tCAS	$DS \times T - 0.26$ [see note ²]		
NF9	Command/address NAND_DATAxx hold time	tCAH	$DH \times T - 1.37$ [see note ²]		
NF18	NAND_CEx_B access time	tCE	$CE_DELAY \times T$ [see notes ^{4,2}]	—	ns
NF22	clock period	tCK	—	—	ns
NF23	preamble delay	tPRE	$PRE_DELAY \times T$ [see notes ^{5,2}]	—	ns
NF24	postamble delay	tPOST	$POST_DELAY \times T + 0.43$ [see note ²]	—	ns

Table 57. Toggle mode timing parameters¹ (continued)

ID	Parameter	Symbol	Timing T = GPMI Clock Cycle		Unit
			Min.	Max.	
NF28	Data write setup	tDS ⁶	0.25 × tCK - 0.32	—	ns
NF29	Data write hold	tDH ⁶	0.25 × tCK - 0.79	—	ns
NF30	NAND_DQS/NAND_DQ read setup skew	tDQSQ ⁷	—	3.18	
NF31	NAND_DQS/NAND_DQ read hold skew	tQHS ⁷	—	3.27	

¹ The GPMI toggle mode output timing can be controlled by the module's internal registers HW_GPMI_TIMING0_ADDRESS_SETUP, HW_GPMI_TIMING0_DATA_SETUP, and HW_GPMI_TIMING0_DATA_HOLD. This AC timing depends on these registers settings. In the table, AS/DS/DH represents each of these settings.

² AS minimum value can be 0, while DS/DH minimum value is 1.

³ T = tCK (GPMI clock period) - 0.075 ns (half of maximum p-p jitter).

⁴ CE_DELAY represents HW_GPMI_TIMING2[CE_DELAY]. NF18 is guaranteed by the design. Read/Write operation is started with enough time of ALE/CLE assertion to low level.

⁵ PRE_DELAY+1) ≥ (AS+DS)

⁶ Shown in [Figure 20](#).

⁷ Shown in [Figure 21](#).

For DDR Toggle mode, [Figure 21](#) shows the timing diagram of NAND_DQS/NAND_DATA_{xx} read valid window. The typical value of tDQSQ is 1.4 ns (max) and 1.4 ns (max) for tQHS at 133 MB/s. GPMI will sample NAND_DATA[7:0] at both rising and falling edge of an delayed NAND_DQS signal, which is provided by an internal DPLL. The delay value of this register can be controlled by GPMI register GPMI_READ_DDR_DLL_CTRL.SLV_DLY_TARGET (see the GPMI chapter of the device reference manual. Generally, the typical delay value is equal to 0x7 which means 1/4 clock cycle delay expected. But if the board delay is big enough and cannot be ignored, the delay value should be made larger to compensate the board delay.

4.10 External Peripheral Interface Parameters

The following subsections provide information on external peripheral interfaces.

4.10.1 LPSPI timing parameters

All LPSPI interfaces do not have the same maximum serial clock frequency. There are two groups. LPSPI interfaces which can operate at 60 MHz in Master mode and 40 MHz in Slave mode and the other group where interfaces operate at 40 MHz in Master mode and 20 MHz in Slave mode. The same performance is achieved at 1.8 V and 3.3 V unless otherwise stated.

Below are the LPSPI interfaces and their respective chip selects:

Table 58. LPSPI interfaces and chip selects

LPSPI interface	Chip select	Comment
60 MHz in Master mode and 40 MHz in Slave mode	SPI0, SPI1, SPI2, SPI3 (primary mode)	SPI1 is muxed behind ADC pins so it operates at 1.8 V only.
40 MHz in Master mode and 20 MHz in Slave mode	SPI3b (behind UART1)	—

4.10.1.1 LPSPI Master mode

Waveform is assuming LPSPI is configured in mode 0, i.e. TCR.CPOL=0b0 and TCR.CPHA=0b0. Timing parameters are valid for all modes using appropriate edge of the clock.

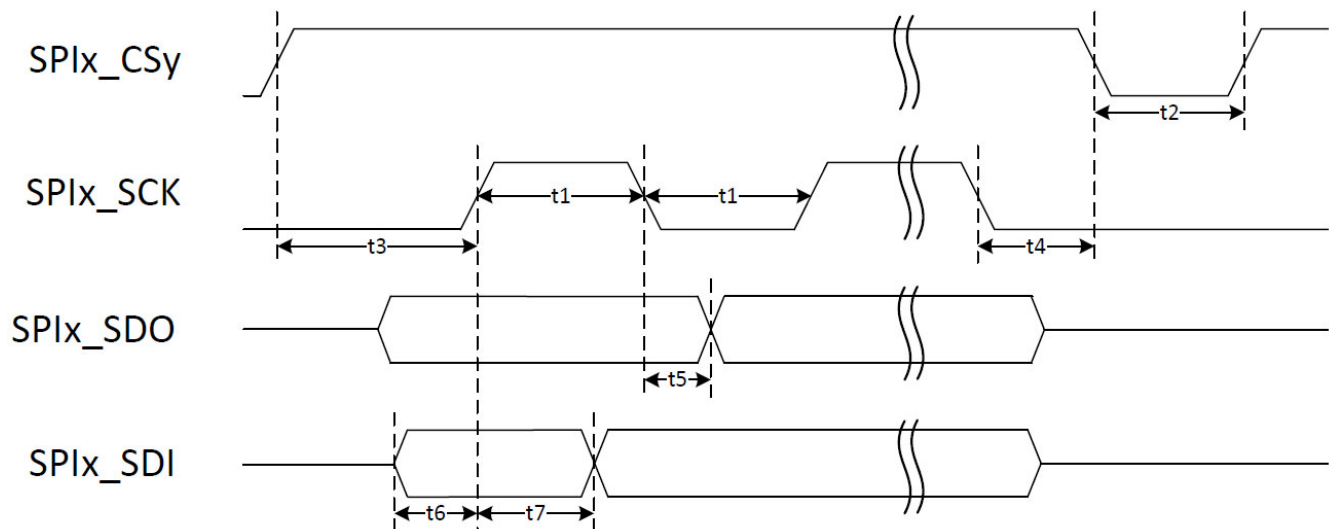


Figure 22. LPSPI Master mode

Table 59. LPSPI timings—Master mode at 60 MHz

ID	Parameter	Min	Max	Unit
—	SPIx_SCLK Cycle frequency	—	60	MHz
t1	SPIx_SCLK High or Low Time—Read SPIx_SCLK High or Low Time—Write	7.5	—	ns
t2	SPIx_CSy pulse width	7.5	—	ns
t3	SPIx_CSy Lead Time ⁽¹⁾	$FCLK_PERIOD^{(2)} \times (PCSSCK + 1) / 2^{PRESCALE - 3}$	—	ns
t4	SPIx_CSy Lag Time ⁽³⁾	$FCLK_PERIOD^{(2)} \times (SCKPCS + 1) / 2^{PRESCALE + 3}$	—	ns

Electrical characteristics

Table 59. LPSPI timings—Master mode at 60 MHz (continued)

ID	Parameter	Min	Max	Unit
t5	SPIx_SDO output Delay (CLOAD = 20 pF)	—	3	ns
t6	SPIx_SDI Setup Time	2	—	ns
t7	SPIx_SDI Hold Time	2	—	ns

¹ This timing is controllable through CCR.PCSSCK and TCR.PRESCALE registers.

² FCLK_PERIOD is the period of the functional clock provided to LPSPI module. Maximum allowed frequency is 240 MHz.

³ This timing is controllable through CCR.SCKPCS and TCR.PRESCALE registers.

Table 60. LPSPI timings—Master mode at 40 MHz

ID	Parameter	Min	Max	Unit
—	SPIx_SCLK Cycle frequency	—	40	MHz
t1	SPIx_SCLK High or Low Time—Read SPIx_SCLK High or Low Time—Write	11	—	ns
t2	SPIx_CSy pulse width	11	—	ns
t3	SPIx_CSy Lead Time ⁽¹⁾	$FCLK_PERIOD^{(2)} \times (PCSSCK + 1) / 2^{PRESCALE + 3}$	—	ns
t4	SPIx_CSy Lag Time ⁽³⁾	$FCLK_PERIOD^{(2)} \times (SCKPCS + 1) / 2^{PRESCALE + 3}$	—	ns
t5	SPIx_SDO output Delay (CLOAD = 20 pF)	—	5	ns
t6	SPIx_SDI Setup Time	5	—	ns
t7	SPIx_SDI Hold Time	4	—	ns

¹ This timing is controllable through CCR.PCSSCK and TCR.PRESCALE registers.

² FCLK_PERIOD is the period of the functional clock provided to LPSPI module. Maximum allowed frequency is 240 MHz.

³ This timing is controllable through CCR.SCKPCS and TCR.PRESCALE registers.

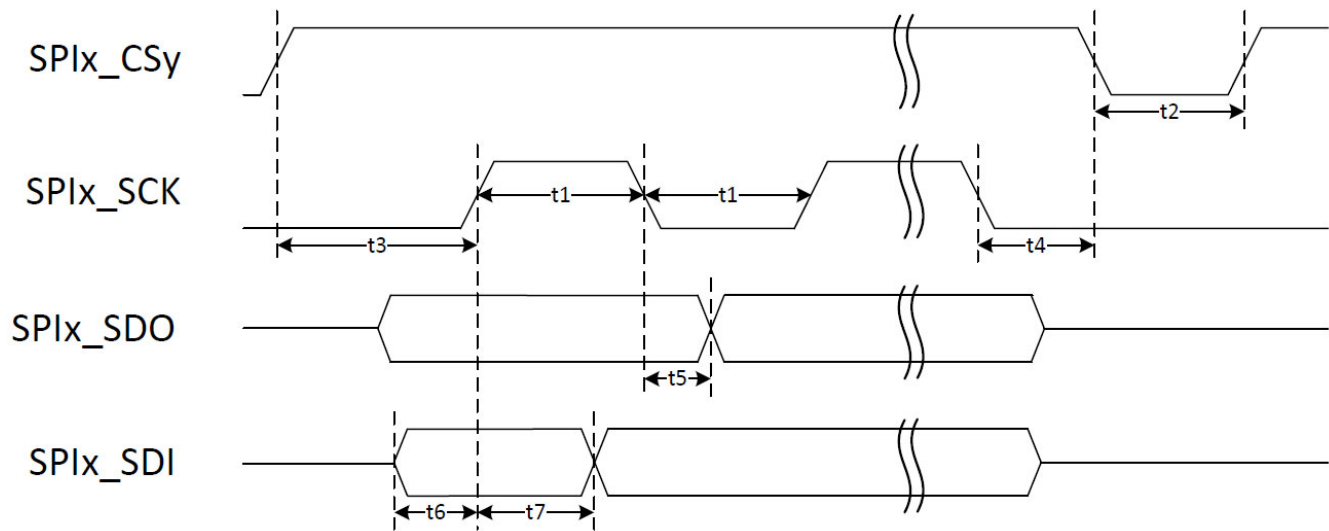


Figure 23. LPSPI Slave mode

Table 61. LPSPI timings—Slave mode at 40 MHz

ID	Parameter	Min	Max	Unit
—	SPIx_SCLK Cycle frequency	—	40	MHz
t1	SPIx_SCLK High or Low Time—Read SPIx_SCLK High or Low Time—Write	11	—	ns
t2	SPIx_CSy pulse width	11	—	ns
t3	SPIx_CSy Lead Time (CS setup time)	4	—	ns
t4	SPIx_CSy Lag Time (CS hold time)	2	—	ns
t5	SPIx_SDO output Delay (CLOAD = 20 pF)	—	5	ns
t6	SPIx_SDI Setup Time	2	—	ns
t7	SPIx_SDI Hold Time	2	—	ns

Table 62. LPSPI timings—Slave mode at 20 MHz

ID	Parameter	Min	Max	Unit
—	SPIx_SCLK Cycle frequency	—	20	MHz
t1	SPIx_SCLK High or Low Time—Read SPIx_SCLK High or Low Time—Write	22	—	ns
t2	SPIx_CSy pulse width	22	—	ns
t3	SPIx_CSy Lead Time (CS setup time)	4	—	ns

Table 62. LPSPi timings—Slave mode at 20 MHz (continued)

ID	Parameter	Min	Max	Unit
t4	SPIx_CSy Lag Time (CS hold time)	2	—	ns
t5	SPIx_SDO output Delay (CLOAD = 20 pF)	—	18	ns
t6	SPIx_SDI Setup Time	2	—	ns
t7	SPIx_SDI Hold Time	2	—	ns

4.10.2 Serial audio interface (SAI) timing parameters

The timings and figures in this section are valid for noninverted clock polarity (I2S_TCR2.BCP = 0b0, I2S_RCR2.BCP = 0b0) and non-inverted frame sync polarity (I2S_TCR4.FSP = 0b0, I2S_RCR4.FSP = 0b0). If the polarity of the clock and/or the frame sync have been inverted, all the timings remain valid by inverting the clock signal (SAI_TXC / SAI_RXC) and/or the frame sync (SAI_TXFS / SAI_RXFS) shown in the figures below.

The same performance is achieved at both 1.8 V and 3.3 V unless otherwise stated.

NOTE

SAI0 and SAI1 are transmit/receive capable. SAI2 and SAI3 are receive only.

4.10.2.1 SAI Master Synchronous mode

In this mode, transmitter clock and frame sync are used by both transmitter and receiver (I2S_TCR2.SYNC=0b00, I2S_RCR2.SYNC=0b01). In that case, SAI interface requires only 4 signals to be routed: SAI_TXC, SAI_TXFS, SAI_TXD and SAI_RXD. SAI_RXC and SAI_RXFS can be left unconnected. I2S_RCR2.BCI shall be set to 0b1 to get setup and hold times provided in Table 63.

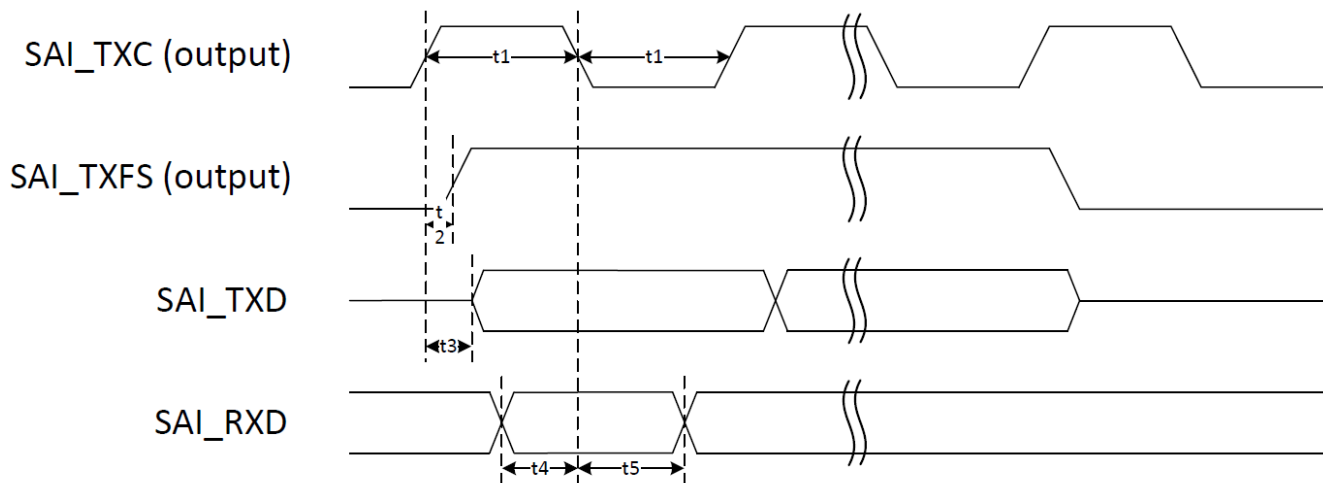


Figure 24. SAI Master Synchronous mode

Table 63. SAI timings—Master Synchronous mode

ID	Parameters	Min	Max	Unit
—	SAI TXC clock frequency	—	49.152	MHz
t1	SAI TXC pulse width low / high	45%	55%	SAI_TXC period
t2	SAI TXFS output valid	—	2	ns
t3	SAI TXD output valid	—	2	ns
t4	SAI RXD input setup	1	—	ns
t5	SAI RXD input hold	4	—	ns

4.10.2.2 SAI Master mode

In this mode, transmitter and/or receiver part are set to bring out transmit and/or receive clock. Frame sync can be either input or output.

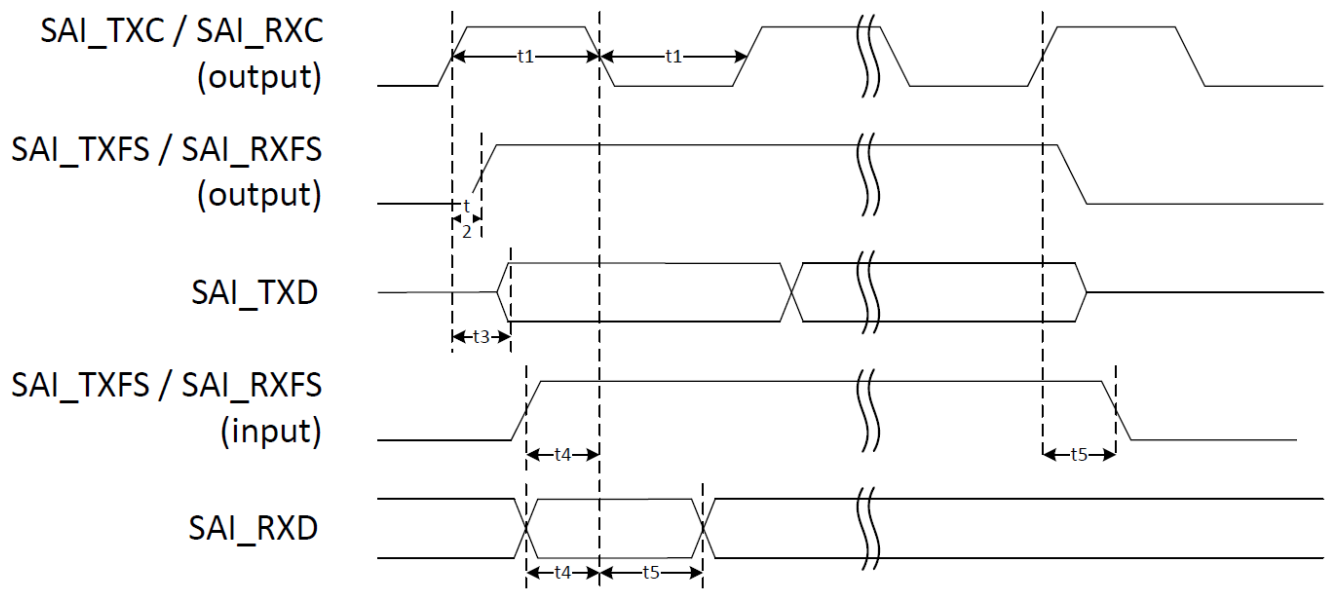


Figure 25. SAI Master mode

Table 64. SAI timings—Master mode

ID	Parameters	Min	Max	Unit
—	SAI TXC / RXC clock frequency ¹	—	49.152	MHz
t1	SAI TXC / RXC pulse width low / high	45%	55%	TXC/RXC period
t2	SAI TXFS / RXFS output valid	—	2	ns

Table 64. SAI timings—Master mode (continued)

ID	Parameters	Min	Max	Unit
t3	SAI TXD output valid	—	2	ns
t4	SAI RXD/RXFS/TXFS input setup	6	—	ns
t5	SAI RXD/RXFS/TXFS input hold	0	—	ns

¹ Given the high setup time requirement on inputs, receiver and transmitter, when using frame sync in input, are likely to run at a lower frequency. This frequency will be driven by characteristics of the external component connected to the interface.

4.10.2.3 SAI Slave mode

In this mode, transmitter and/or receiver parts are set to receive transmit and/or receive clock from external world. Frame sync can be either input or output.

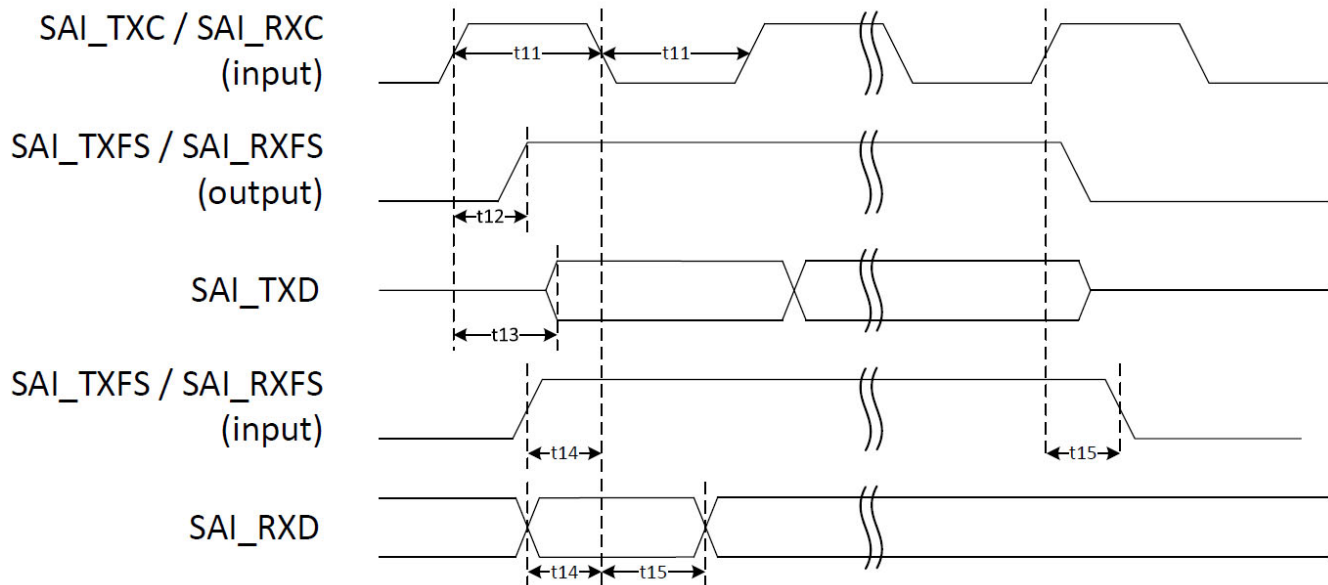


Figure 26. SAI Slave mode

Table 65. SAI timings—Slave mode

ID	Parameters	Min	Max	Unit
—	SAI TXC/RXC clock frequency	—	24.576	MHz
t11	SAI TXC/RXC pulse width low/high	45%	55%	TXC/RXC period
t12	SAI TXFS/RXFS output valid	—	13	ns
t13	SAI TXD output valid	—	13	ns
t14	SAI RXD/RXFS/TXFS input setup	1	—	ns
t15	SAI RXD/RXFS/TXFS input hold	4	—	ns

4.10.3 Enhanced serial audio interface (ESAI)

The same performance is achieved at both 1.8 V and 3.3 V unless otherwise stated.

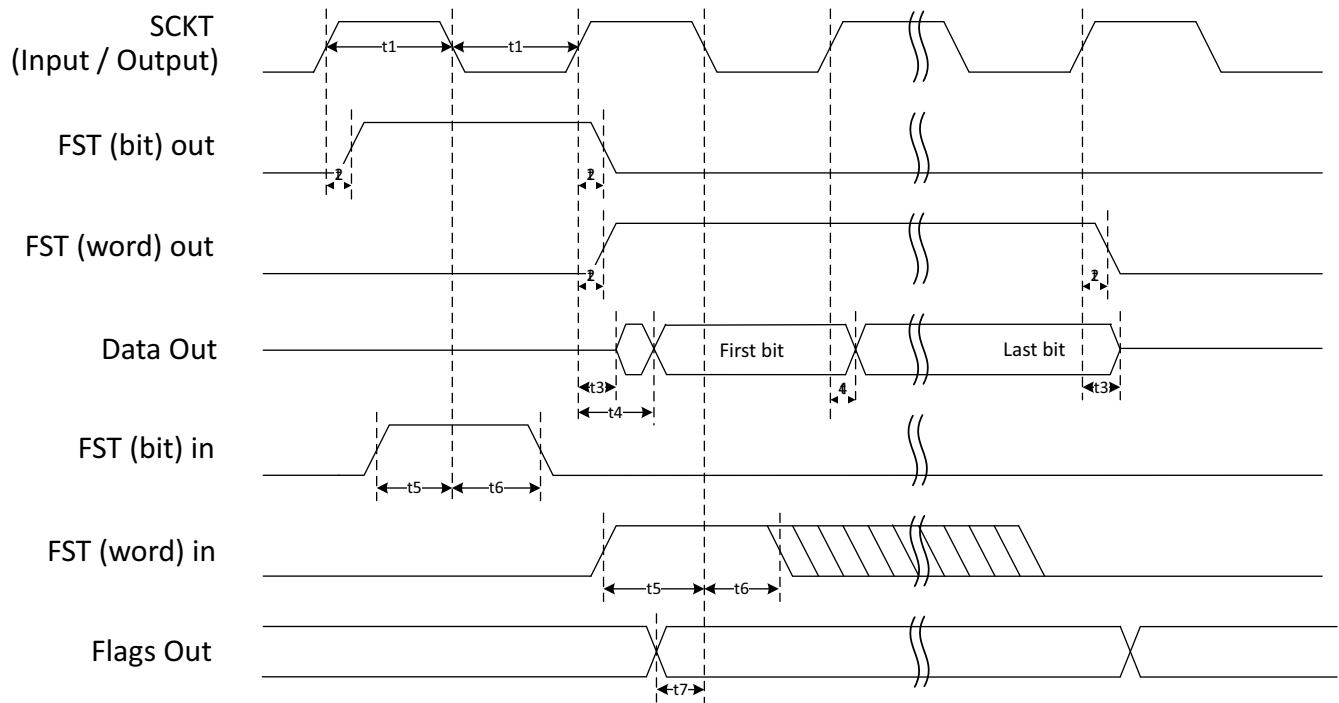


Figure 27. ESAI Transmit timing

Electrical characteristics

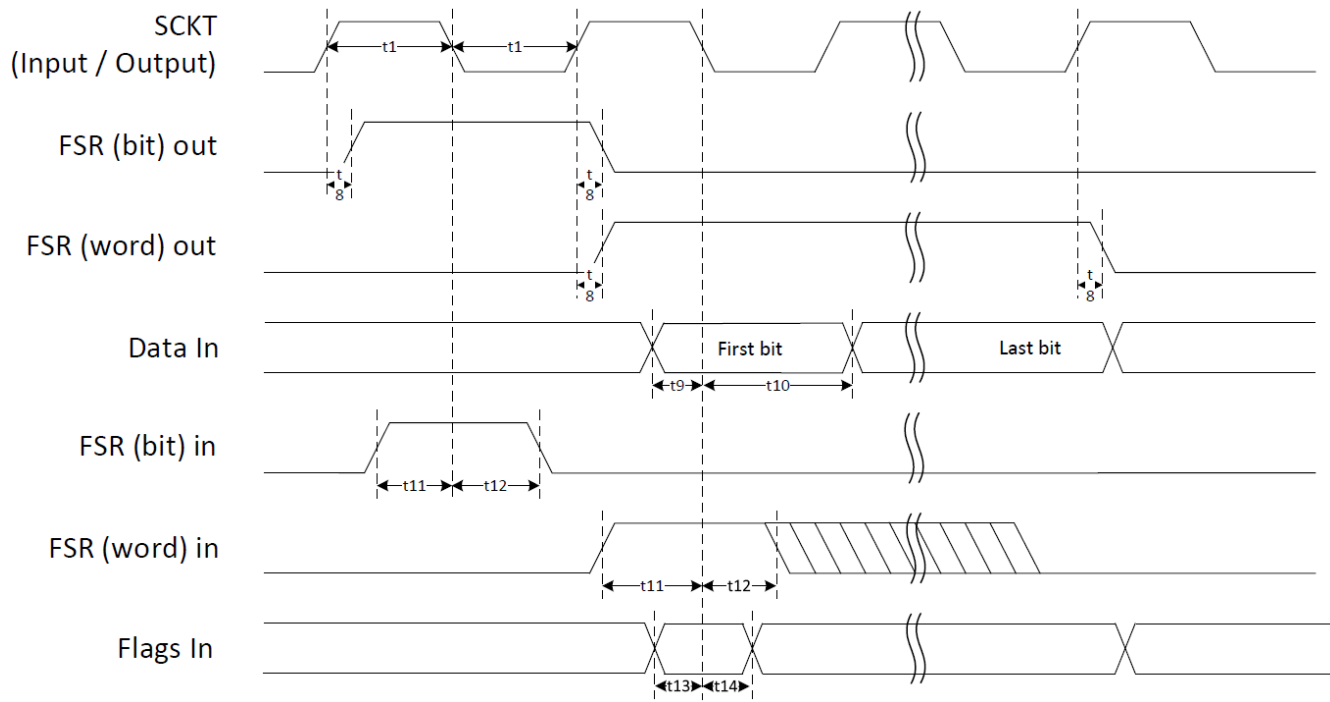


Figure 28. ESAI Receive timing

The following table shows the interface timing values. The ID field in the table refers to timing signals found in [Figure 27](#) and [Figure 28](#).

Table 66. Enhanced Serial Audio Interface (ESAI) Timing

ID	Parameters	Min	Max	Condition ¹	Unit
—	Clock frequency	—	24.576	—	MHz
t1	SCKT / SCKT pulse width high / low	45%	55%	—	SCKT / SCKR period
t2	FST output delay	—	10 2	x ck i ck	ns
t3	TX data - high impedance / valid data	—	9 1	x ck i ck	ns
t4	TX data output delay	—	10 2	x ck i ck	ns
t5	FST - setup requirement	—	2 10	x ck i ck	ns
t6	FST - hold requirement	—	2 0	x ck i ck	ns
t7	Flag output delay	—	10 2	x ck i ck	ns

Table 66. Enhanced Serial Audio Interface (ESAI) Timing (continued)

ID	Parameters	Min	Max	Condition ¹	Unit
t8	FSR output delay		7 4	x ck i ck a	ns
t9	RX data pins - setup requirement	2 10	—	x ck i ck	ns
t10	RX data pins - hold requirement	2 0	—	x ck i ck	ns
t11	FSR - setup requirement	2 10	—	x ck i ck a	ns
t12	FSR - hold requirement	2 0	—	x ck i ck a	ns
t13	Flags - setup requirement	2 10	—	x ck i ck s	ns
t14	Flags - hold requirement	2 0	—	x ck i ck s	ns
—	RX_HF_CLK / TX_HX_CLK clock cycle	20	—	—	ns
—	TX_HF_CLK input to SCKT		10	—	ns
—	RX_HF_CLK input to SCKR		10	—	ns

¹ i ck = internal clock
x ck = external clock
i ck a = internal clock, asynchronous mode (SCKT and SCKR are two different clocks)
i ck s = internal clock, synchronous mode (SCKT and SCKR are the same clock)

4.10.4 Ultra High Speed SD/SDIO/MMC Host Interface (uSDHC) AC Timing

This section describes the electrical information of the uSDHC, including:

- [SD3.1/eMMC5.1 High-Speed mode AC Timing](#)
- [eMMC5.1 DDR 52 mode/SD3.1 DDR 50 mode timing](#)
- [HS400 AC timing—eMMC 5.1 only](#)
- [HS200 Mode Timing](#)
- [SDR50/SDR104 AC Timing](#)

4.10.4.1 SD3.1/eMMC5.1 High-Speed mode AC Timing

The following figure depicts the timing of SD3.1/eMMC5.1 High-Speed mode, and [Table 67](#) lists the timing characteristics.

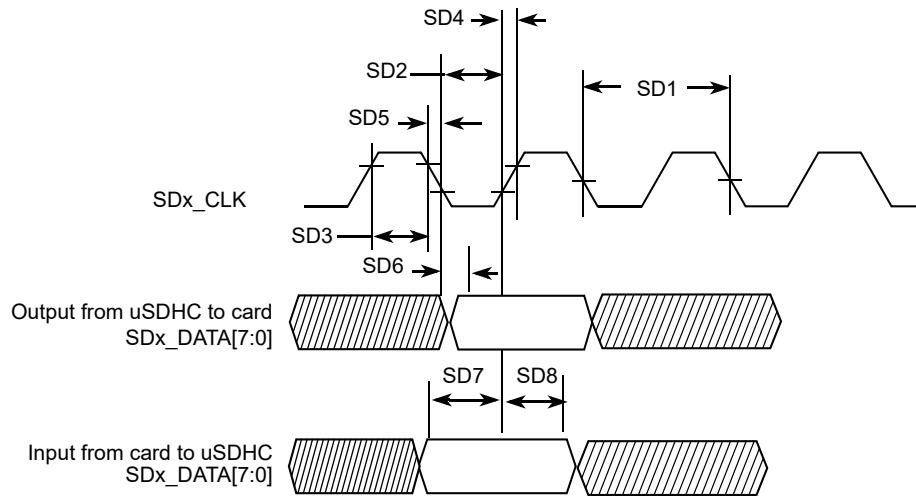


Figure 29. SD3.1/eMMC5.1 High-Speed mode Timing

Table 67. SD3.1/eMMC5.1 High-Speed mode interface timing specification

ID	Parameter	Symbols	Min	Max	Unit
Card Input Clock					
SD1	Clock Frequency (Low Speed)	f_{PP}^1	0	400	kHz
	Clock Frequency (SD/SDIO Full Speed/High Speed)	f_{PP}^2	0	25/50	MHz
	Clock Frequency (MMC Full Speed/High Speed)	f_{PP}^3	0	20/52	MHz
	Clock Frequency (Identification Mode)	f_{OD}	100	400	kHz
SD2	Clock Low Time	t_{WL}	7	—	ns
SD3	Clock High Time	t_{WH}	7	—	ns
SD4	Clock Rise Time	t_{TLH}	—	3	ns
SD5	Clock Fall Time	t_{THL}	—	3	ns
eSDHC Output/Card Inputs SD_CMD, SD_DATA (Reference to SD_CLK)					
SD6	eSDHC Output Delay	t_{OD}	-6.6	3.6	ns
eSDHC Input/Card Outputs SD_CMD, SD_DATA (Reference to SD_CLK)					
SD7	eSDHC Input Setup Time	t_{ISU}	2.5	—	ns
SD8	eSDHC Input Hold Time ⁴	t_{IH}	1.5	—	ns

¹ In low speed mode, card clock must be lower than 400 kHz, voltage ranges from 2.7 to 3.6 V.

² In normal (full) speed mode for SD/SDIO card, clock frequency can be any value between 0–25 MHz. In high-speed mode, clock frequency can be any value between 0–50 MHz.

³ In normal (full) speed mode for MMC card, clock frequency can be any value between 0–20 MHz. In high-speed mode, clock frequency can be any value between 0–52 MHz.

⁴ To satisfy hold timing, the delay difference between clock input and cmd/data input must not exceed 2 ns.

4.10.4.2 eMMC5.1 DDR 52 mode/SD3.1 DDR 50 mode timing

The following figure depicts the timing of eMMC5.1 DDR 52 mode/SD3.1 DDR 50 mode, and [Table 68](#) lists the timing characteristics. Be aware that only SD_x_DATA is sampled on both edges of the clock (not applicable to SD_CMD).

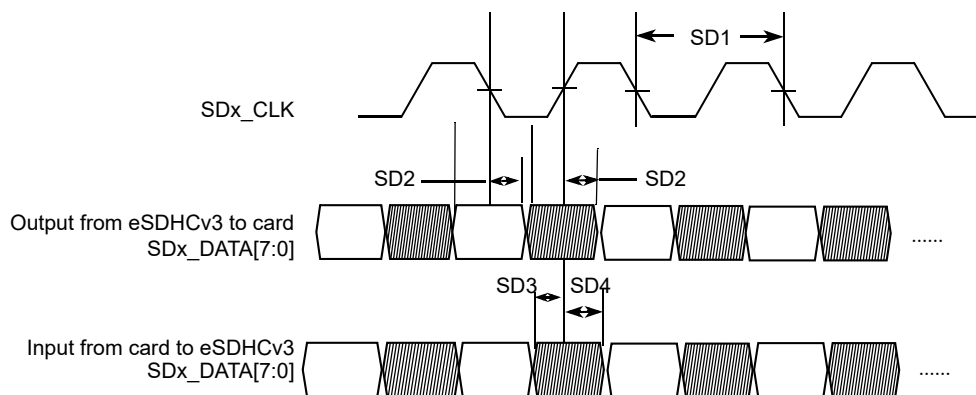


Figure 30. eMMC 5.1 timing

Figure 31. eMMC5.1 DDR 52 mode/SD3.1 DDR 50 mode interface timing

Table 68. eMMC5.1 DDR 52 mode/SD3.150 mode interface timing specification

ID	Parameter	Symbols	Min	Max	Unit
Card Input Clock¹					
SD1	Clock Frequency (eMMC5.1 DDR)	f_{PP}	0	52	MHz
SD1	Clock Frequency (SD3.1 DDR)	f_{PP}	0	50	MHz
uSDHC Output / Card Inputs SD_CMD, SD_x_DATA_x (Reference to CLK)					
SD2	uSDHC Output Delay	t_{OD}	2.8	6.8	ns
uSDHC Input / Card Outputs SD_CMD, SD_x_DATA_x (Reference to CLK)					
SD3	uSDHC Input Setup Time	t_{ISU}	1.7	—	ns
SD4	uSDHC Input Hold Time	t_{IH}	1.5	—	ns

¹ Clock duty cycle will be in the range of 47% to 53%.

4.10.4.3 HS400 AC timing—eMMC 5.1 only

[Figure 32](#) depicts the timing of HS400. [Table 69](#) lists the HS400 timing characteristics. Be aware that only data is sampled on both edges of the clock (not applicable to CMD). The CMD input/output timing for

Electrical characteristics

HS400 mode is the same as CMD input/output timing for SDR104 mode. Check SD5, SD6 and SD7 parameters in [Table 71 SDR50/SDR104 Interface Timing Specification for CMD input/output timing for HS400 mode](#).

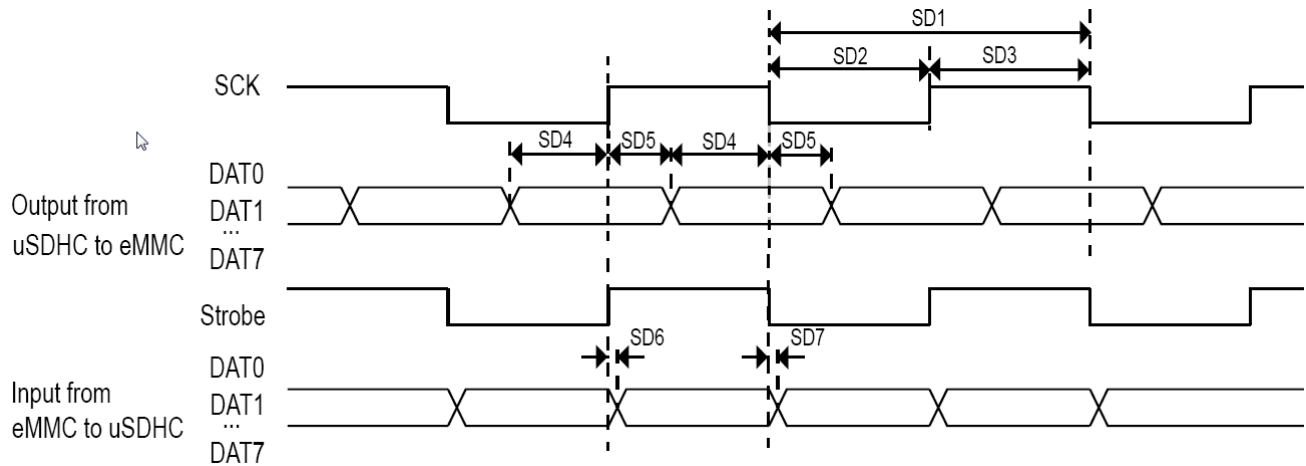


Figure 32. HS400 timing

Table 69. HS400 interface timing specifications

ID	Parameter	Symbols	Min	Max	Unit
Card Input clock					
SD1	Clock Frequency	f_{PP}	0	200	Mhz
SD2	Clock Low Time	t_{CL}	$0.46 \times t_{CLK}$	$0.54 \times t_{CLK}$	ns
SD3	Clock High Time	t_{CH}	$0.46 \times t_{CLK}$	$0.54 \times t_{CLK}$	ns
uSDHC Output/Card inputs DAT (Reference to SCK)					
SD4	Output Skew from Data of Edge of SCK	t_{OSkew1}	0.45	—	ns
SD5	Output Skew from Edge of SCK to Data	t_{OSkew2}	0.45	—	ns
uSDHC input/Card Outputs DAT (Reference to Strobe)					
SD6	uSDHC input skew	t_{RQ}	—	0.45	ns
SD7	uSDHC hold skew	t_{RQH}	—	0.45	ns

4.10.4.4 HS200 Mode Timing

The following figure depicts the timing of HS200 mode, and [Table 70](#) lists the HS200 timing characteristics.

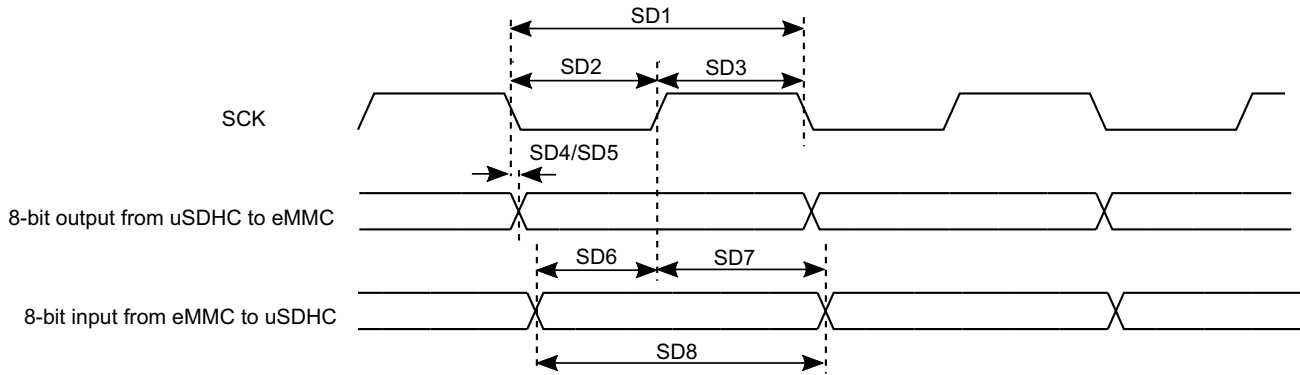


Figure 33. HS200 Mode Timing

Table 70. HS200 Interface Timing Specification

ID	Parameter	Symbols	Min	Max	Unit
Card Input Clock					
SD1	Clock Frequency Period	t_{CLK}	5.0	—	ns
SD2	Clock Low Time	t_{CL}	$0.46 \times t_{CLK}$	$0.54 \times t_{CLK}$	ns
SD2	Clock High Time	t_{CH}	$0.46 \times t_{CLK}$	$0.54 \times t_{CLK}$	ns
uSDHC Output/Card Inputs SD_CMD, SDx_DATAx in HS200 (Reference to CLK)					
SD5	uSDHC Output Delay	t_{OD}	-1.6	1	ns
uSDHC Input/Card Outputs SD_CMD, SDx_DATAx in HS200 (Reference to CLK)¹					
SD8	Card Output Data Window	t_{ODW}	$0.5 \times t_{CLK}$	—	ns

¹HS200 is for 8 bits while SDR104 is for 4 bits.

4.10.4.5 SDR50/SDR104 AC Timing

The following figure depicts the timing of SDR50/SDR104, and [Table 71](#) lists the SDR50/SDR104 timing characteristics.

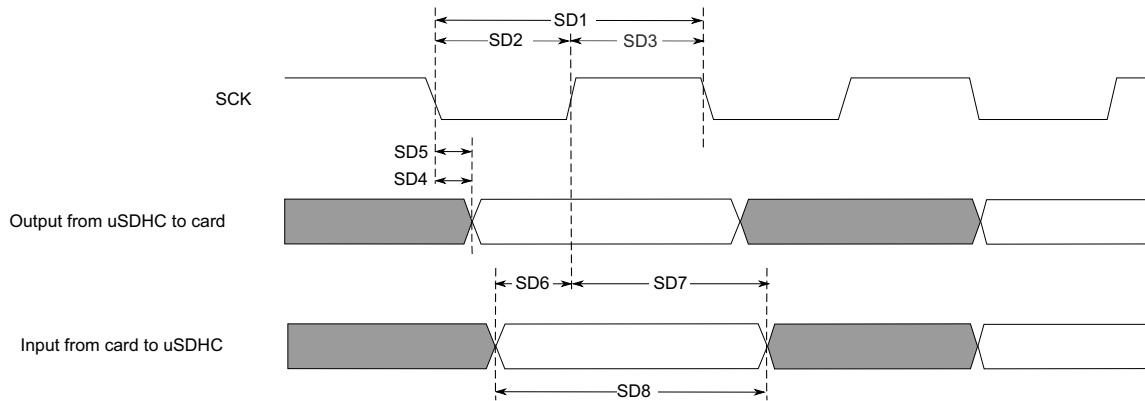


Figure 34. SDR50/SDR104 timing

Table 71. SDR50/SDR104 Interface Timing Specification

ID	Parameter	Symbols	Min	Max	Unit
Card Input Clock					
SD1	Clock Frequency Period	t_{CLK}	4.8	—	ns
SD2	Clock Low Time	t_{CL}	$0.46 \times t_{CLK}$	$0.54 \times t_{CLK}$	ns
SD3	Clock High Time	t_{CH}	$0.46 \times t_{CLK}$	$0.54 \times t_{CLK}$	ns
uSDHC Output/Card Inputs SD_CMD, SDx_DATAx in SDR50 (Reference to SDx_CLK)					
SD4	uSDHC Output Delay	t_{OD}	-3	1	ns
uSDHC Output/Card Inputs SD_CMD, SDx_DATAx in SDR104 (Reference to SDx_CLK)					
SD5	uSDHC Output Delay	t_{OD}	-1.6	1	ns
uSDHC Input/Card Outputs SD_CMD, SDx_DATAx in SDR50 (Reference to SDx_CLK)					
SD6	uSDHC Input Setup Time	t_{ISU}	2.5	—	ns
SD7	uSDHC Input Hold Time	t_{IH}	1.5	—	ns
uSDHC Input/Card Outputs SD_CMD, SDx_DATAx in SDR104 (Reference to SDx_CLK)¹					
SD8	Card Output Data Window	t_{ODW}	$0.5 \times t_{CLK}$	—	ns

¹Data window in SDR100 mode is variable.

4.10.4.6 Bus Operation Condition for 3.3 V and 1.8 V Signaling

Signaling level of SD/eMMC 5.1 and eMMC 5.1 modes is 3.3 V. Signaling level of SDR104/SDR50 mode is 1.8 V. The DC parameters for the NVCC_SD1, NVCC_SD2, and NVCC_SD3 supplies are identical to those shown in “,” and Table 33, "Dual-voltage 1.8 V GPIO DC parameters," on page 39 Table 34, "Dual-voltage 3.3 V GPIO DC parameters," on page 39.

4.10.5 Ethernet Controller (ENET) AC Electrical Specifications

ENET interface supporting RGMII protocol in delay and non-delay mode. RGMII is used to support up to 1000 Mbps Ethernet as well as RMII protocol. RMII is used to support up to 100 Mbps Ethernet.

NOTE

ENET1 supports RGMII at 1.8 V and 2.5 V, and RMII at 3.3 V. ENET0 supports RGMII at 1.8 V only and RMII at 3.3 V.

Table 72. RGMII/RMII pin mapping

Pin name ¹	RGMII	RMII	Comment ²
ENETx_RGMII_TXC	RGMII_TXC	RCLK50M	RCLK50M can be an input or an output. It's using different Alternate pin muxing modes. Refer to pin muxing for details.
ENETx_RGMII_TX_CTL	RGMII_TX_CTL	RMII_TXEN	—
ENETx_RGMII_TXD0	RGMII_TXD0	RMII_TXD0	—
ENETx_RGMII_TXD1	RGMII_TXD1	RMII_TXD1	—
ENETx_RGMII_TXD2	RGMII_TXD2	N/A	—
ENETx_RGMII_TXD3	RGMII_TXD3	N/A	—
ENETx_RGMII_RXC	RGMII_RXC	N/A	—
ENETx_RGMII_RX_CTL	RGMII_RX_CTL	RMII_CRSDV	—
ENETx_RGMII_RXD0	RGMII_RXD0	RMII_RXD0	—
ENETx_RGMII_RXD1	RGMII_RXD1	RMII_RXD1	—
ENETx_RGMII_RXD2	RGMII_RXD2	RMII_RXER	RMII_RXER is mapped on ALT1 mode of pin muxing.
ENETx_RGMII_RXD3	RGMII_RXD3	N/A	—
ENETx_REFCLK_125M_25M	RGMII_REF_CLK	N/A	RGMII_REF_CLK is optional for RGMII operation and dependent on the intended clock configuration.
ENETx_MDIO	RGMII_MDIO	RMII_MDIO	—
ENETx_MDC	RGMII_MDC	RMII_MDC	—

¹ x can be 0 or 1.

Electrical characteristics

² Except for RCLK50M and RMII_RXER, all other RMII functions are using the same pin muxing mode as RGMII.

4.10.5.1 RGMII

4.10.5.1.1 No-Internal-Delay mode

This mode corresponds to the RGMIIv1.3 specification.

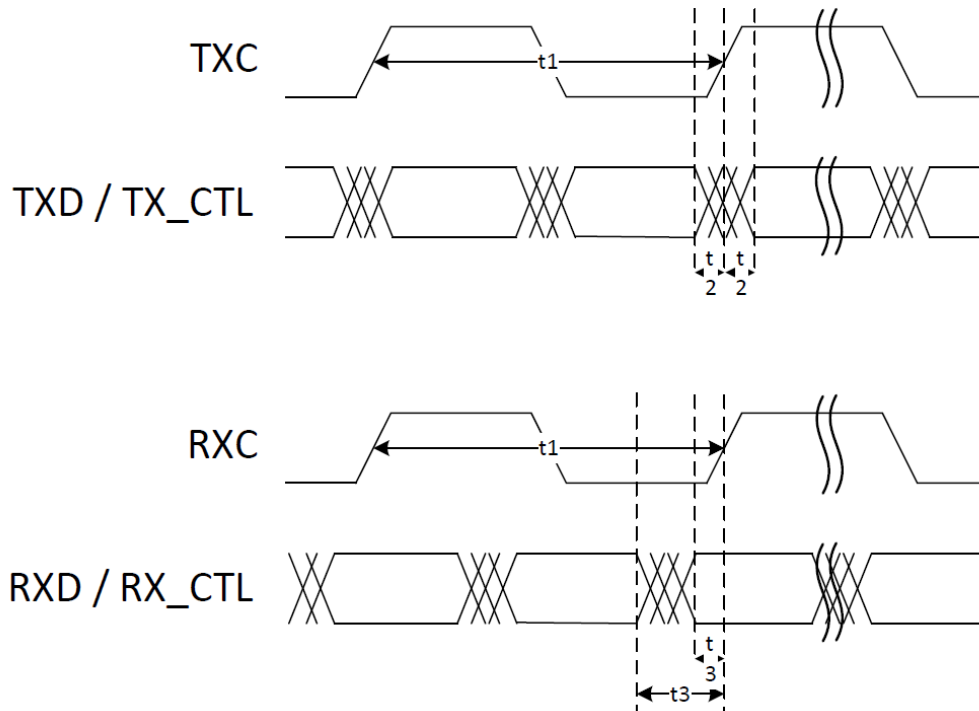


Figure 35. RGMII timing diagram—No-Internal-Delay mode

Table 73. RGMII timings—No-Internal-Delay mode

ID	Parameter	Min	Typ	Max	Unit
	TXC / RXC frequency	—	125	—	MHz
t1	Clock cycle	7.2	8	8.8	ns
t2	Data to clock output skew	-500	—	500	ps
t3	Data to clock input skew ¹⁽¹⁾	1	—	2.6	ns

¹ This implies that PC board design requires clocks to be routed such that an additional trace delay of greater than 1.5 ns and less than 2.0 ns is added to the associated clock signal.

4.10.5.1.2 Internal-delay mode

This mode corresponds to RGMIIv2.0 specification. The interface is still operating at 2.5 V. 1.5 V is not supported.

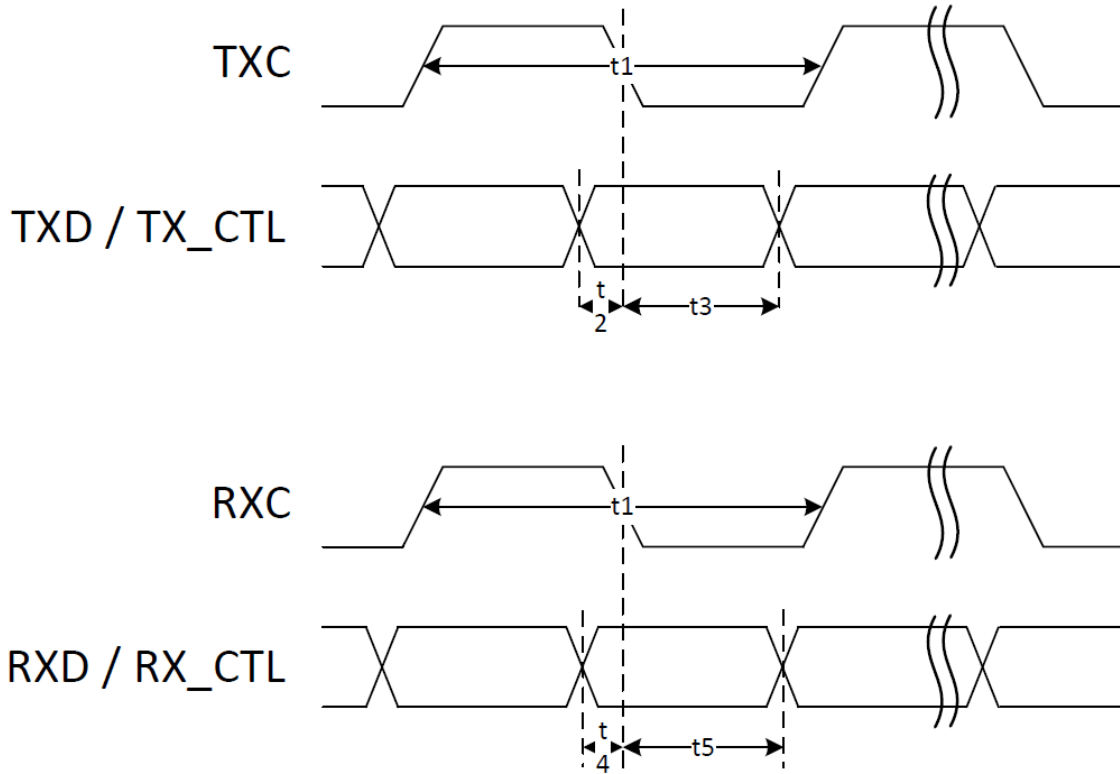


Figure 36. RGMII timing diagram—Internal-Delay mode

Table 74. RGMII timing—Internal-Delay mode

ID	Parameter	Min	Typ	Max	Unit
	TXC / RXC frequency	—	125	—	MHz
t1	Clock cycle	7.2	8	8.8	ns
t2	TXD setup time	1.2	—	—	ns
t3	TXD hold time	1.2	—	—	ns
t4	RXD setup time	0	—	—	ns
t5	RXD hold time	2.5	—	—	ns

4.10.5.2 RMII

RMII interface is matching RMII v1.2 specification. In RMII mode, the reference clock can be generated internally and provided to the PHY through RCLK50M_OUT. Or, it come from and external 50MHz clock generator which is connected to the PHY and to i.MX8 through RCLK50M_IN pin.

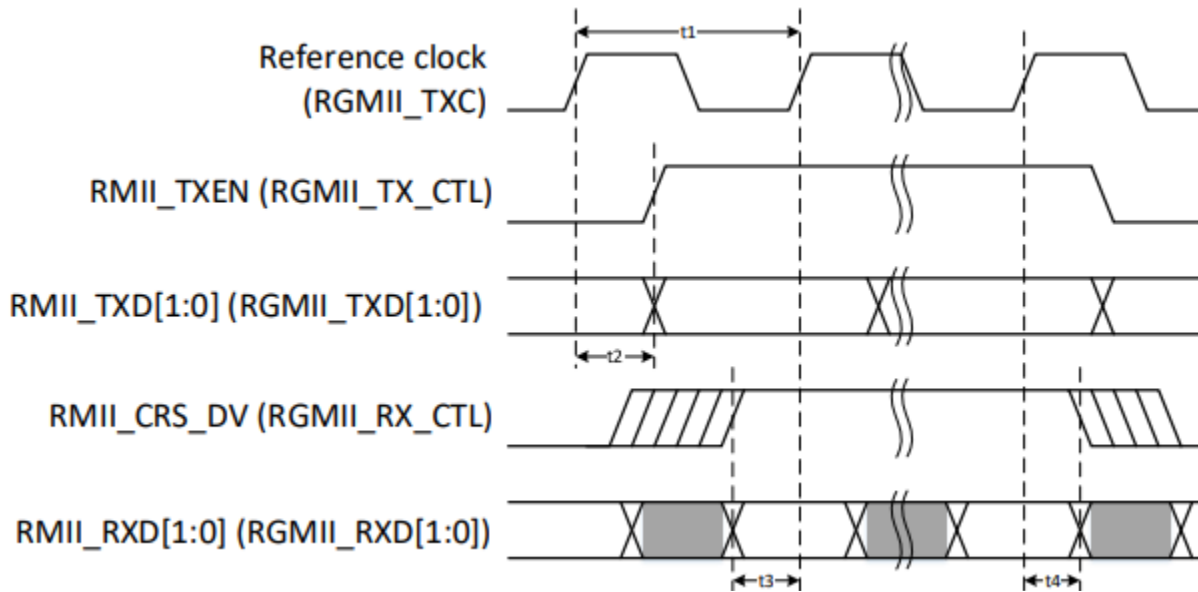


Figure 37. RMII timing diagram

Timings in table below are covering both cases: reference clock generated internally or externally.

Table 75. RMII timing

ID	Parameter	Min	Typ	Max	Unit
t1	Reference clock	—	50	—	MHz
	Reference clock accuracy	—	—	50	ppm
	Reference clock duty-cycle	35	—	65	%
t2	RMII_TXEN, RMII_TXD output delay	2	—	12	ns
t3	RMII_CRS_DV, RMII_RXD setup time	4	—	—	ns
t4	RMII_CRS_DV, RMII_RXD hold time	2	—	—	ns

4.10.5.3 MDIO

MDIO is the control link used to configure Ethernet PHY connected to i.MX8 device.

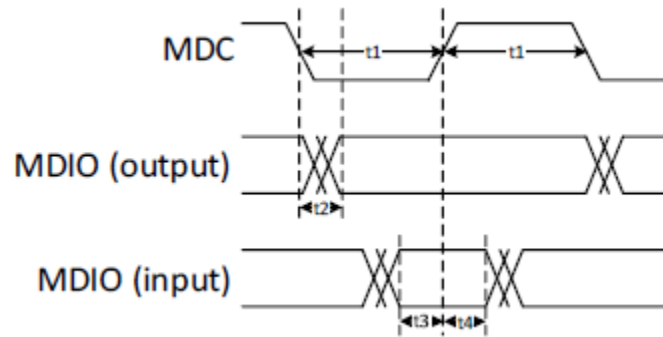


Figure 38. MDIO timing diagram

Table 76. MDIO timing

ID	Parameter	Min	Typ	Max	Unit
	MDC frequency	—	2.5	—	MHz
t1	MDC high / low pulse width	180	—	—	%
t2	MDIO output delay	0	—	20	ns
t3	MDIO setup time	10	—	—	ns
t4	MDIO hold time	10	—	—	ns

4.10.6 CAN network AC Electrical Specifications

The Flexible Controller Area Network (FlexCAN) module is a communication controller implementing the CAN protocol according to the CAN with Flexible Data rate (CAN FD) protocol and the CAN 2.0B protocol specification. The processor has three CAN modules available for systems design. Tx and Rx ports for both modules are multiplexed with other I/O pins. See the IOMUXC chapter of the device reference manual to see which pins expose Tx and Rx pins; these ports are named FLEXCAN_TX and FLEXCAN_RX, respectively.

4.10.7 HDMI Tx module timing parameters

See the following specifications:

- DisplayPort 1.3 standard (VESA.org)
- Embedded DisplayPort 1.4 standard (VESA.org)

Electrical characteristics

The DDC link requires external pull-up resistors to be connected to a 5 V supply. The following table provides the range for those pull-ups.

Table 77. HDMI—Pull-up resistors for DDC link

Ball name	Min	Typ	Max	Unit
HDMI_TX0_DDC_SCL	1.5	—	2	k Ω
HDMI_TX0_DDC_SDA	1.5	—	2	k Ω

4.10.8 HDMI Tx and Rx REXT reference resistor connection

Table 78. HDMI_REXT reference resistor connection

Name	Min	Typ	Max	Unit	Descriptions
REXT	497.50	500	502.50	Ω	REXT resistor is 500 $\Omega \pm 0.5\%$. It shall be connected to ground.

4.10.9 I²C Module Timing Parameters

This section describes the timing parameters of the I²C module. The following figure depicts the timing of the I²C module, and [Table 79](#) lists the I²C module timing characteristics.

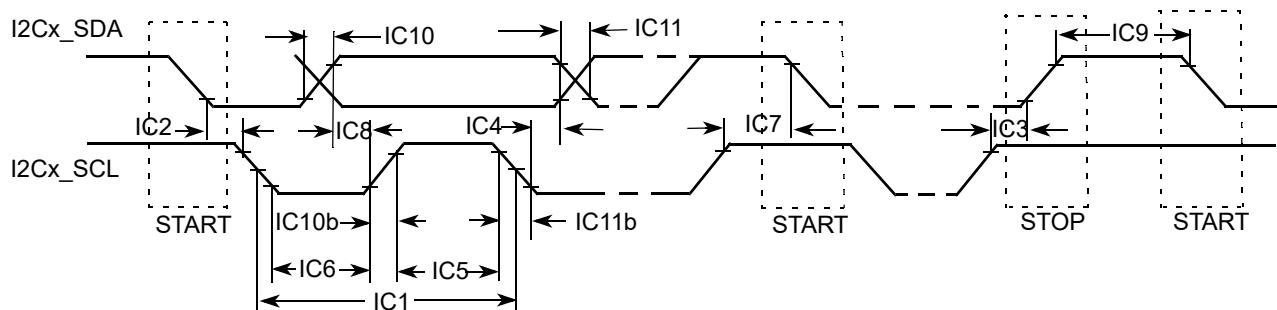


Figure 39. I²C bus timing

Table 79. I²C Module Timing Parameters

ID	Parameter	Standard Mode		Fast Mode		Unit
		Min	Max	Min	Max	
IC1	I2Cx_SCL cycle time	10	—	2.5	—	μ s
IC2	Hold time (repeated) START condition	4.0	—	0.6	—	μ s
IC3	Set-up time for STOP condition	4.0	—	0.6	—	μ s
IC4	Data hold time	0 ¹	3.45 ²	0 ¹	0.9 ²	μ s

Table 79. I²C Module Timing Parameters (continued)

ID	Parameter	Standard Mode		Fast Mode		Unit
		Min	Max	Min	Max	
IC5	HIGH Period of I2Cx_SCL Clock	4.0	—	0.6	—	μs
IC6	LOW Period of the I2Cx_SCL Clock	4.7	—	1.3	—	μs
IC7	Set-up time for a repeated START condition	4.7	—	0.6	—	μs
IC8	Data set-up time	250	—	100 ³	—	ns
IC9	Bus free time between a STOP and START condition	4.7	—	1.3	—	μs
IC10/IC10b	Rise time of both I2Cx_SDA and I2Cx_SCL signals	—	1000	20 + 0.1C _b ⁴	300	ns
IC11/IC11b	Fall time of both I2Cx_SDA and I2Cx_SCL signals	—	300	20 + 0.1C _b ⁴	300	ns
IC12	Capacitive load for each bus line (C _b)	—	400	—	400	pF

¹ A device must internally provide a hold time of at least 300 ns for I2Cx_SDA signal in order to bridge the undefined region of the falling edge of I2Cx_SCL.

² The maximum hold time has only to be met if the device does not stretch the LOW period (ID no IC5) of the I2Cx_SCL signal.

³ A Fast-mode I2C-bus device can be used in a Standard-mode I2C-bus system, but the requirement of Set-up time (ID No IC7) of 250 ns must be met. This automatically is the case if the device does not stretch the LOW period of the I2Cx_SCL signal. If such a device does stretch the LOW period of the I2Cx_SCL signal, it must output the next data bit to the I2Cx_SDA line $\text{max_rise_time (IC9) + data_setup_time (IC7) = 1000 + 250 = 1250 ns}$ (according to the Standard-mode I2C-bus specification) before the I2Cx_SCL line is released.

⁴ C_b = total capacitance of one bus line in pF.

Table 80. I2C timing

ID	Parameter	Fast Mode Plus		High Speed ¹		Unit
		Min	Max	Min	Max	
IC1	SCL clock frequency	—	1	—	3.4	MHz
IC2	Hold time (repeated) START condition	260	—	160	—	ns
IC3	Set-up time for STOP condition	260	—	160	—	ns
IC4	Data hold time	0	—	0	70	ns
IC5	HIGH Period of I2Cx_SCL Clock	260	—	60	—	ns
IC6	LOW Period of the I2Cx_SCL Clock	500	—	160	—	ns
IC7	Set-up time for a repeated START condition	260	—	160	—	ns
IC8	Data set-up time	50	—	10	—	ns
IC9	Bus free time between a STOP and START condition	500	—	150	—	ns
IC10	Rise time of I2Cx_SDA signals	—	120	10	80	ns
IC11	Fall time of I2Cx_SDA signals	12 (@3.3 V) 6.5 (@1.8 V)	120	10	80	ns
IC10b	Rise time of I2Cx_SCL signals	—	120	10	40	ns
IC11b	Fall time of I2Cx_SCL signals	12 (@3.3 V) 6.5 (@1.8 V)	120	10	40	ns
IC12	Capacitive load for each bus line (Cb)	—	550	—	100	pF

¹ High-speed mode is only available for I2C modules in DMA, SCU and Cortex-M4 subsystems.

4.10.10 LVDS and MIPI-DSI display output specifications

4.10.10.1 LVDS display bridge module parameters

Maximum frequency support for dedicated LVDS channels on this device:

Table 81. LVDS pins

Function ¹	Channel A	Channel B
Single channel	4 pairs LVDS up to 1.12 Gbps per pair	4 pairs LVDS up to 1.12 Gbps per pair
Dual channel	8 pairs LVDS up to 595 Mbps per pair	

¹ In single channel operation the maximum clock speed is 160 MHz; in dual channel operation with a single synchronized clock the maximum clock speed is 85 MHz.

4.10.10.2 MIPI-DSI display bridge module parameters

Maximum frequency support for dedicated MIPI-DSI channels on this device:

Table 82. MIPI-DSI pins

Function ¹	Channel A
DSI	DSI up to 1.5 Gb/per lane

¹ Maximum clock speed is 1.5 GHz.

4.10.10.3 LVDS display bridge (LDB) module electrical specifications

The LVDS interface is compatible with TIA/EIA 644-A standard. For more details, see TIA/EIA STANDARD 644-A, “Electrical Characteristics of Low Voltage Differential Signaling (LVDS) Interface Circuits.”

Table 83. LVDS Display Bridge (LDB) Electrical Specifications

Parameter	Symbol	Test Condition	Min	Max	Units
Differential Voltage Output Voltage	V_{OD}	100 Ω Differential load	0.25	0.4	V
Output Voltage High	V_{OH}	100 Ω differential load (0 V Diff—Output High Voltage static)	—	1.475	V
Output Voltage Low	V_{OL}	100 Ω differential load (0 V Diff—Output Low Voltage static)	0.925	—	V
Offset Static Voltage	V_{OS}	Two 49.9 Ω resistors in series between N-P terminal, with output in either Zero or One state, the voltage measured between the 2 resistors.	1.125	1.275	V
VOS Differential	V_{OSDIFF}	Difference in V_{OS} between a One and a Zero state	—	—	mV
Output short-circuited to GND	ISA ISB	With the output common shorted to GND	—	40	mA
Output short current	ISAB		—	12	mA

4.10.10.4 MIPI-DSI HS-TX specifications

Table 84. MIPI high-speed transmitter DC specifications

Symbol	Parameter	Min	Typ	Max	Unit
V_{CMTX} ¹	High Speed Transmit Static Common Mode Voltage	150	200	250	mV
$ \Delta V_{CMTX} _{(1,0)}$	V_{CMTX} mismatch when Output is Differential-1 or Differential-0	—	—	5	mV
$ V_{OD} $ ¹	High Speed Transmit Differential Voltage	140	200	270	mV
$ \Delta V_{OD} $	V_{OD} mismatch when Output is Differential-1 or Differential-0	—	—	10	mV

Electrical characteristics

Table 84. MIPI high-speed transmitter DC specifications (continued)

Symbol	Parameter	Min	Typ	Max	Unit
V_{OHHS}^1	High Speed Output High Voltage	—	—	360	mV
Z_{OS}	Single Ended Output Impedance	40	50	62.5	Ω
ΔZ_{OS}	Single Ended Output Impedance Mismatch	—	—	10	%

¹ Value when driving into load impedance anywhere in the Z_{ID} range.

Table 85. MIPI high-speed transmitter AC specifications

Symbol	Parameter	Min	Typ	Max	Unit
$\Delta V_{CMTX(HF)}$	Common-level variations above 450 MHz	—	—	15	mVRMS
$\Delta V_{CMTX(LF)}$	Common-level variation between 50-450 MHz	—	—	25	mVPEAK
t_R and t_F^1	Rise Time and Fall Time (20% to 80%)	100	—	0.35 UI	ps

¹ UI is the long-term average unit interval.

4.10.10.5 MIPI-DSI LP-TX specifications

Table 86. MIPI low-power transmitter DC specifications

Symbol	Parameter	Min	Typ	Max	Unit
V_{OH}^1	Thevenin Output High Level	1.1	1.2	1.3	V
V_{OL}	Thevenin Output Low Level	-50	—	50	mV
Z_{OLP}^2	Output Impedance of Low Power Transmitter	110	—	—	Ω

¹ This specification can only be met when limiting the core supply variation from 1.1 V till 1.3 V.

² Although there is no specified maximum for Z_{OLP} , the LP transmitter output impedance ensures the TRLP/TFLP specification is met.

Table 87. MIPI low-power transmitter AC specifications

Symbol	Parameter	Min	Typ	Max	Unit
T_{RLP}/T_{FLP}^1	15% to 85% Rise Time and Fall Time	—	—	25	ns
$T_{REOT}^{1,2,3}$	30% to 85% Rise Time and Fall Time	—	—	35	ns
$T_{LP-PULSE-TX}^4$	Pulse width of the LP exclusive-OR clock: First LP exclusive-OR clock pulse after Stop state or last pulse before Stop state	40	—	—	ns
	Pulse width of the LP exclusive-OR clock: All other pulses	20	—	—	ns
$T_{LP-PER-TX}$	Period of the LP exclusive-OR clock	90	—	—	ns

Table 87. MIPI low-power transmitter AC specifications (continued)

Symbol	Parameter	Min	Typ	Max	Unit
$\delta V/\delta t_{SR}^{1,5,6,7}$	Slew Rate @ $C_{LOAD}= 0$ pF	30	—	500	mV/ns
	Slew Rate @ $C_{LOAD}= 5$ pF	30	—	200	mV/ns
	Slew Rate @ $C_{LOAD}= 20$ pF	30	—	150	mV/ns
	Slew Rate @ $C_{LOAD}= 70$ pF	30	—	100	mV/ns
C_{LOAD}	Load Capacitance	0	—	70	pF

¹ C_{LOAD} includes the low equivalent transmission line capacitance. The capacitance of TX and RX are assumed to always be < 10 pF. The distributed line capacitance can be up to 50 pF for a transmission line with 2 ns delay.

² The rise-time of TREOT starts from the HS common-level at the moment of the differential amplitude drops below 70 mV, due to stopping the differential drive.

³ With an additional load capacitance CCM between 0 to 60 pF on the termination center tap at RX side of the lane.

⁴ This parameter value can be lower than TLPX due to differences in rise vs. fall signal slopes and trip levels and mismatches between Dp and Dn LP transmitters. Any LP exclusive-OR pulse observed during HS EoT (transition from HS level to LP-11) is glitch behavior as described in Low-Power Receiver section.

⁵ When the output voltage is between 15% and below 85% of the fully settled LP signal levels.

⁶ Measured as average across any 50 mV segment of the output signal transition.

⁷ This value represents a corner point in a piecewise linear curve.

4.10.10.6 MIPI-DSI LP-RX specifications

Table 88. MIPI low power receiver DC specifications

Symbol	Parameter	Min	Typ	Max	Unit
V_{IH}	Logic 1 input voltage	880	—	1.3	mV
V_{IL}	Logic 0 input voltage, not in ULP state	—	—	550	mV
$V_{IL-ULPS}$	Logic 0 input voltage, ULP state	—	—	300	mV
V_{HYST}	Input hysteresis	25	—	—	mV

Table 89. MIPI low power receiver AC specifications

Symbol	Parameter	Min	Typ	Max	Unit
$e_{SPIKE}^{1,2}$	Input pulse rejection	—	—	300	V.ps
T_{MIN-RX}^3	Minimum pulse width response	20	—	—	ns
V_{INT}	Peak Interference amplitude	—	—	200	mV
f_{INT}	Interference frequency	450	—	—	MHz

¹ Time-voltage integration of a spike above V_{IL} when in LP-0 state or below V_{IH} when in LP-1 state.

² An impulse below this value will not change the receiver state.

³ An input pulse greater than this value shall toggle the output.

4.10.10.7 MIPI-DSI LP-CD specifications

Table 90. MIPI contention detector DC specifications

Symbol	Parameter	Min	Typ	Max	Unit
V_{IHCD}	Logic 1 contention threshold	450	—	—	mV
V_{ILCD}	Logic 0 contention threshold	—	—	200	mV

4.10.10.8 MIPI-DSI DC specifications

Table 91. MIPI input characteristics DC specifications

Symbol	Parameter	Min	Typ	Max	Unit
V_{PIN}	Pad signal voltage range	-50	—	1350	mV
I_{LEAK}^1	Pin leakage current	-10	—	10	μ A
V_{GNDSH}	Ground shift	-50	—	50	mV
$V_{PIN(absmax)}^2$	Maximum pin voltage level	-0.15	—	1.45	V
$T_{VPIN(absmax)}^3$	Maximum transient time above $V_{PIN(max)}$ or below $V_{PIN(min)}$	—	—	20	ns

¹ When the pad voltage is within the signal voltage range between $V_{GNDSH(min)}$ to $VOH + V_{GNDSH(max)}$ and the Lane Module is in LP receive mode.

² This value includes ground shift.

³ The voltage overshoot and undershoot beyond the V_{PIN} is only allowed during a single 20 ns window after any LP-0 to LP-1 transition or vice versa. For all other situations it must stay within the V_{PIN} range.

4.10.11 PCIe PHY Parameters

The TX and RX eye diagrams specifications are per the template shown in the following figure. The summary of specifications is shown in [Table 92](#) and [Table 93](#). Note that the time closure (1-A OPENING) in the eye templates needs not match jitter specifications in the Standards Specifications, as there are such discrepancies in some Standards Specifications. The design meets the tightest of specifications in case of discrepancy.

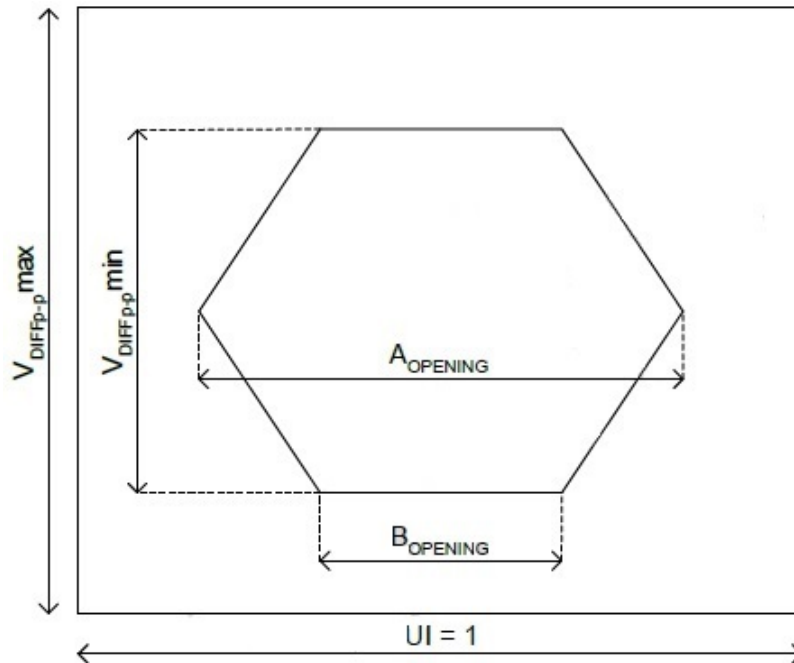


Figure 40. TX and RX eye diagram template

Table 92. PCIe transmitter eye specifications for example standards

	UI	A _{OPENING}	B _{OPENING}	A _{OPENING}	B _{OPENING}	V _{DIFFp-p} min	V _{DIFFp-p} max
	ps	UI		ps		mV	
PCI Express Gen 1 Transition Bit	400	0.75	0	300	0	800	1200 ¹
PCI ExpressGen 1 De-emphasized Bit	400	0.75	0	300	0	505	757
PCI Express Gen 2 Transition Bit	200	0.75	0	150	0	800	1200 ¹
PCI Express Gen 2 De-emphasized Bit	200	0.75	0	150	0	379	850

¹ V_{DIFFp-p} eye opening is limited to VDDIO under matched termination conditions.

Table 93. PCIe receiver eye specifications for example standards

	UI	A _{OPENING}	B _{OPENING}	A _{OPENING}	B _{OPENING}	V _{DIFFp-p} min	V _{DIFFp-p} max
	ps	UI		ps		mV	
PCI Express Gen 1 Transition Bit	400	0.4	0	160	0	175	1200
PCI Express Gen 2 Transition Bit ¹	200	0.32	0	64	0	100	1200
PCI Express Gen 3 Virtual EYE ²	125	0.3	0	38	0	25	1300

Electrical characteristics

- ¹ For a lossy channel, the default DFE setting may not work for PCIe Gen1 -3.5dB TX de-emphasis. It is recommended to use a higher DFE setting (reg241[7]=A1_force=1 and reg241[5:0]=A1_init) in this case.
- ² PCIe 3.0 8 GT/s measured using PCIe reference equalizer + CDR per PCIe specification. PCIe 1.0 and 2.0 compliant. PCIe 3.0 capable, contact your NXP representative.

Table 94. PCIe differential output driver characteristics (including board and load)

Parameter	Min	Typ	Max	Units	Notes
Output Rise and fall time T_R, T_F	175	—	350	ps	1
Output Rise/Fall matching	—	—	20	%	1, 2
Output skew T_{OSKEW}	—	—	50	ps	—
Initialization time from assertion of TXOE	100	—	—	ns	—
Initialization time from assertion of TXENA	—	10	—	μ s	—
Transmission line characteristic impedance (Z_0)	—	50	—	Ω	—
Driver output impedance, single ended (small signal @ $V_{out}=V_{cm}$)	—	1000	—	Ω	—
Output single ended voltage (RS= 33, RT= 50 Ω) V_{OH} $I_{OH@ 6 * I_R}$ V_{OL}	0.65 -13 -0.20	0.71 -14.2 0.00	0.85 -17 0.05	V mA V	3, 4 3
Output common mode voltage (RS = 33, RT= 50 Ω) $ V_{OCM} $ ΔV_{OCM} (DC) ΔV_{OCM} (AC)	0.25 -0.015 -0.050	0.375	0.55 0.015 0.050	V	5 6
Buffer induced deterministic jitter (absolute, pk-pk)	—	—	4	ps	7,8
Reference Buffer Dynamic Power (Digital)	—	0.015	0.66	μ A	9
Reference Buffer Dynamic Power (Analog)	—	2.8	3.14	mA	9
Output Buffer Dynamic Power (Digital)	—	0.035	1.8	μ A	9
Output Buffer Dynamic Power (Analog)	—	18.9	22.11	mA	9

- ¹ When the output is transitioning between logic 0 and logic 1, or logic 1 and logic 0, and driving a terminated transmission line, the outputs monotonically transition between V_{OL} and V_{OH} , V_{OH} , and V_{OL} respectively. Target rise and fall times observed at the receiver and are primarily set by board trace impedance and Load capacitance. Rise and fall times are defined by 25% and 75% crossing points.
- ² Calculated as: $2 \times (T_R - T_F) / (T_R + T_F)$
- ³ I_R is proportional to the reference current. Measured across RT. The primary contributor to output voltage spread is VDD spread, and so a VDD tighter than $\pm 10\%$ may be required to achieve this spread.
- ⁴ Higher output voltages may occur depending on load, power supply, and selected output drive. Higher output voltages may transiently occur during initialization period following TXENA assertion.
- ⁵ Peak change in output differential voltage when driving a logic 0 and when driving a logic 1 under DC conditions.
- ⁶ Peak change in output differential voltage when driving a logic 0 and when driving a logic 1 under AC conditions.
- ⁷ Measured under “clean power supply and ground” conditions, and after de-embedding the jitter of the input, measured over a time span of 1000 cycles
- ⁸ Power supply induced jitter is included under this category, and the power supply variation is to be less than 8mVpp. Note that customer has to be uncommonly careful with power supply fidelity due to the small jitter numbers.

- ⁹ Power consumption is simulated under the following conditions:
 Typ: TT, VDD=1.0 V, VD18=1.8 V, 25 °C
 Max: FF, VDD=1.1 V, VD18=1.98 V, 125 °C
 Dynamic: TXENA=1, TXOE=1
 Static: TXENA=0, TXOE=1

4.10.11.1 PCIE_REXT reference resistor connection

The following figure shows the PCIE_REXT reference resistor connection.

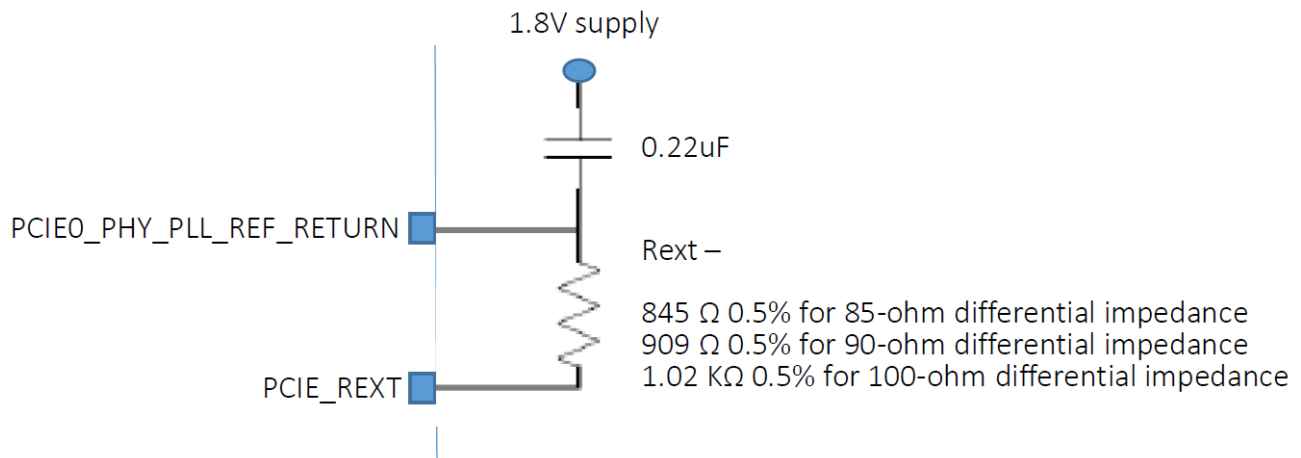


Figure 41. PCIE_REXT reference resistor connection

4.10.11.2 PCIE_REF_CLK

Contact an NXP representative to obtain the hardware development guide for this device, which contains details on the PCIe reference clock requirements.

4.10.12 Pulse Width Modulator (PWM) Timing Parameters

This section describes the electrical information of the PWM. The PWM can be programmed to select one of three clock signals as its source frequency. The selected clock signal is passed through a prescaler before being input to the counter. The output is available at the pulse-width modulator output (PWMO) external pin.

The following figure depicts the timing of the PWM, and [Table 95](#) lists the PWM timing parameters.

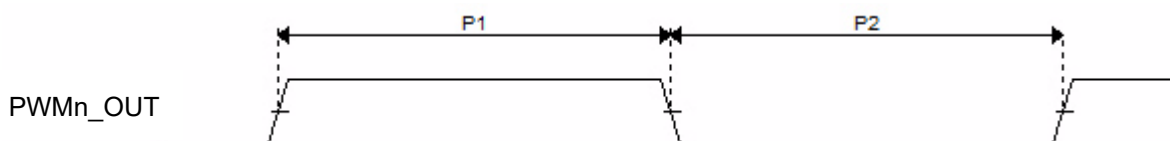


Figure 42. PWM Timing

Table 95. PWM Output Timing Parameters

ID	Parameter	Min	Max	Unit
—	PWM Module Clock Frequency	0	ipg_clk	MHz
P1	PWM output pulse width high	15	—	ns
P2	PWM output pulse width low	15	—	ns

4.10.13 FlexSPI (Quad SPI/Octal SPI) timing parameters

The FlexSPI interface can work in SDR or DDR modes. It can operate up to 60 MHz at 3.3 V, 166 MHz at 1.8 V SDR mode or 200 MHz at 1.8 V DDR mode. It supports single-ended and differential DQS signaling.

FlexSPI supports the following clocking scheme for a read data path:

- Dummy read strobe generated by FlexSPI controller and looped back internally (FlexSPIn_MCR0[RXCLKSRC] = 0x0)
- Dummy read strobe generated by FlexSPI controller and looped back through the DQS pad (FlexSPIn_MCR0[RXCLKSRC] = 0x1). It means the I/O cannot be used for another feature.
- Read strobe provided by memory device and input from DQS pad (FlexSPIn_MCR0[RXCLKSRC] = 0x3)

4.10.13.1 SDR mode

4.10.13.1.1 SDR mode timing diagrams

The following write timing diagram is valid for any FlexSPIn_MCR0[RXCLKSRC] value.

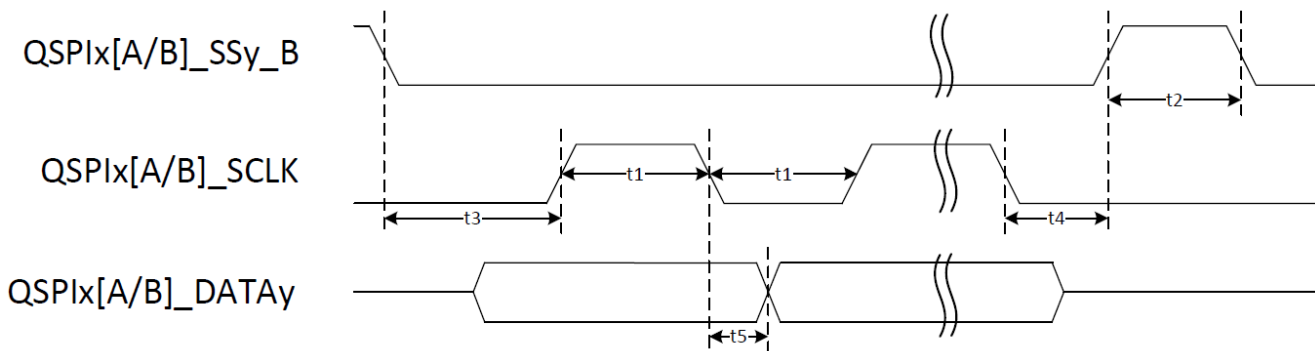


Figure 43. FlexSPI write timing diagram (SDR mode)

The following read timing diagram is valid for FlexSPI $_n$ _MCR0[RXCLKSRC] = 0x0 or 0x1.

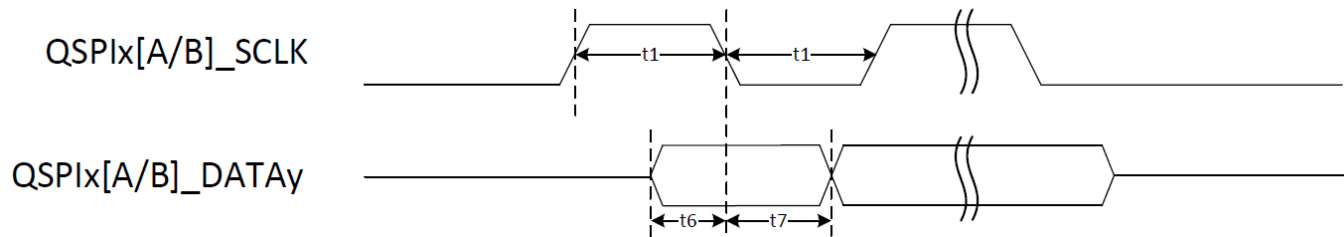


Figure 44. FlexSPI read timing diagram (SDR mode)

The following read timing diagram is valid for FlexSPI $_n$ _MCR0[RXCLKSRC] = 0x3.

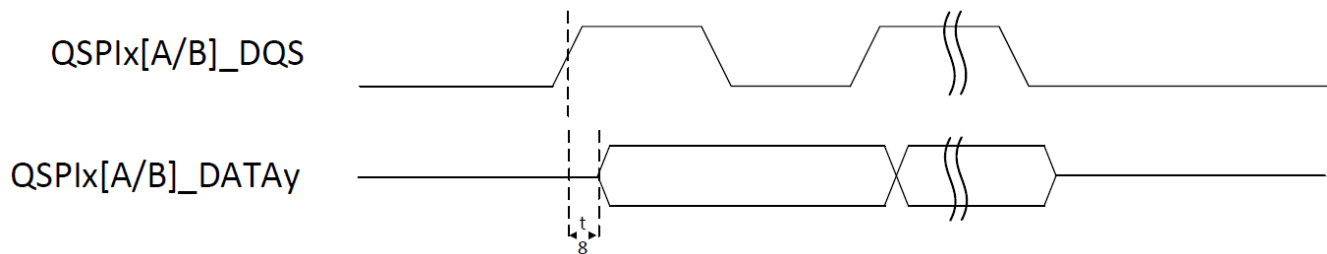


Figure 45. FlexSPI read with DQS timing diagram (SDR mode)

4.10.13.1.2 SDR mode timing parameter tables

Table 96. FlexSPI timings with FlexSPI $_n$ _MCR0[RXCLKSRC] = 0x0 (SDR mode)

ID	Parameter	Min	Max	Unit
—	QSPiX[A/B]_SCLK Cycle frequency	—	60	MHz
t1	QSPiX[A/B]_SCLK High or Low Time	7.5	—	ns
t2	QSPiX[A/B]_SSy_B pulse width	1	—	SCLK
t3	QSPiX[A/B]_SSy_B Lead Time ¹	TCSS+0.5	—	SCLK
t4	QSPiX[A/B]_SSy_B Lag Time ¹	TCSH	—	SCLK
t5	QSPiX[A/B]_DATAy output Delay	—	1	ns
t6	QSPiX[A/B]_DATAy Setup Time	6	—	ns
t7	QSPiX[A/B]_DATAy Hold Time	0	—	ns

¹ Timing is controlled from FLSHxCR1 register (x=A1, A2, B1, or B2).

Electrical characteristics

Table 97. FlexSPI timings with FlexSPIn_MCR0[RXCLKSRC] = 0x1 (SDR mode)

ID	Parameter	Min	Max	Unit
—	QSPiX[A/B]_SCLK Cycle frequency	—	166	MHz
t1	QSPiX[A/B]_SCLK High or Low Time	2.7	—	ns
t2	QSPiX[A/B]_SSy_B pulse width	1	—	SCLK
t3	QSPiX[A/B]_SSy_B Lead Time ¹	TCSS+0.5	—	SCLK
t4	QSPiX[A/B]_SSy_B Lag Time ¹	TCSH	—	SCLK
t5	QSPiX[A/B]_DATAy output Delay	—	1	ns
t6	QSPiX[A/B]_DATAy Setup Time	1	—	ns
t7	QSPiX[A/B]_DATAy Hold Time	2	—	ns

¹ Timing is controlled from FLSHxCR1 register (x=A1, A2, B1, or B2).

Table 98. FlexSPI timings with FlexSPIn_MCR0[RXCLKSRC] = 0x3 (SDR mode)

ID	Parameter	Min	Max	Unit
—	QSPiX[A/B]_DQS Cycle frequency	—	200	MHz
t1	QSPiX[A/B]_SCLK High or Low Time	2.25	—	ns
t2	QSPiX[A/B]_SSy_B pulse width ¹	CSINTERVAL	—	SCLK
t3	QSPiX[A/B]_SSy_B Lead Time ²	TCSS+0.5	—	SCLK
t4	QSPiX[A/B]_SSy_B Lag Time ²	TCSH	—	SCLK
t5	QSPiX[A/B]_DATAy output Delay	—	1	ns
t8	QSPiX[A/B]_DQS / QSPiX[A/B]_DATAy delta	-0.65	0.65	ns

¹ Minimum is 2 SCLK cycles even if CSINTERVAL value is less than 2.

² Timing is controlled from FLSHxCR1 register (x=A1, A2, B1, or B2).

4.10.13.2 DDR mode

4.10.13.2.1 DDR mode timing diagrams

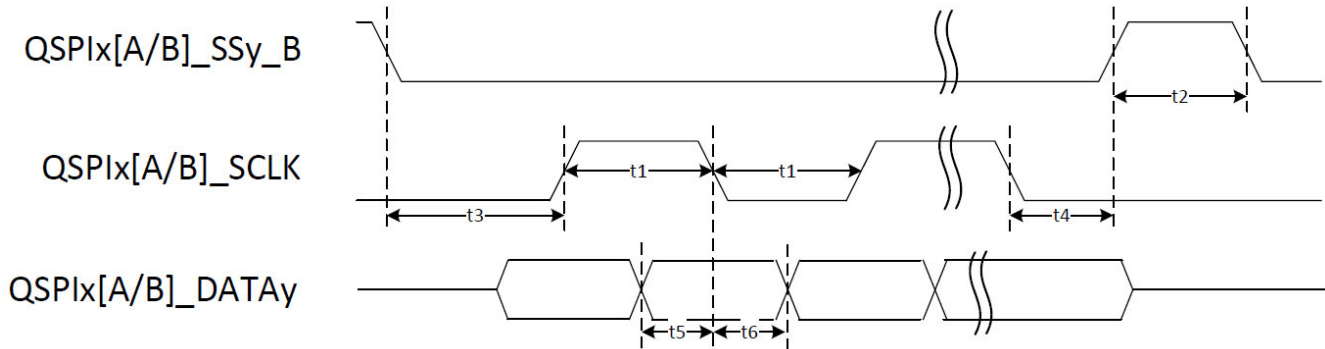


Figure 46. FlexSPI write timing diagram (DDR mode)

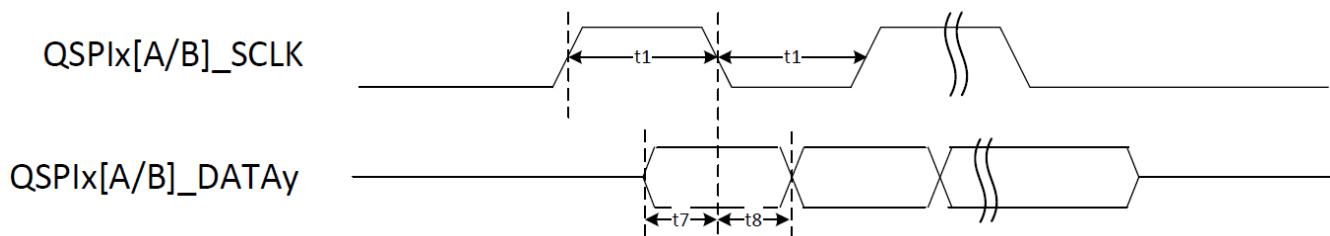


Figure 47. FlexSPI read timing diagram (DDR mode)

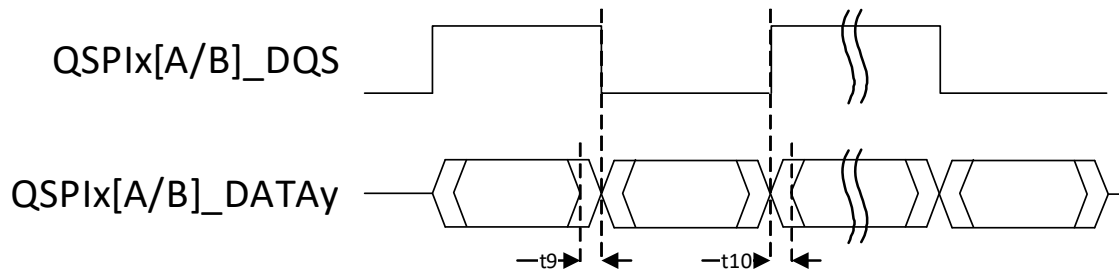


Figure 48. FlexSPI read with DQS timing diagram (DDR mode)

Table 99. FlexSPI timings with FlexSPIn_MCR0[RXCLKSRC] = 0x0 (DDR mode)

ID	Parameter	Min	Max	Unit
—	QSPIx[A/B]_SCLK Cycle frequency	—	30	MHz
t1	QSPIx[A/B]_SCLK High or Low Time	15	—	ns

Electrical characteristics

Table 99. FlexSPI timings with FlexSPI_n_MCR0[RXCLKSRC] = 0x0 (DDR mode) (continued)

ID	Parameter	Min	Max	Unit
t2	QSPIx[A/B]_SSy_B pulse width	1	—	SCLK
t3	QSPIx[A/B]_SSy_B Lead Time ¹	(TCSS+0.5)/2	—	SCLK
t4	QSPIx[A/B]_SSy_B Lag Time ¹	TCSH/2	—	SCLK
t5	QSPIx[A/B]_DATAy output valid time	6.5	—	ns
t6	QSPIx[A/B]_DATAy output hold time	6.5	—	ns
t7	QSPIx[A/B]_DATAy Setup Time	6	—	ns
t8	QSPIx[A/B]_DATAy Hold Time	0	—	ns

¹ Timing is controlled from FLSHxCR1 register (x=A1, A2, B1, or B2).

Table 100. FlexSPI timings with FlexSPI_n_MCR0[RXCLKSRC] = 0x1 (DDR mode)

ID	Parameter	Min	Max	Unit
—	QSPIx[A/B]_SCLK Cycle frequency	—	83	MHz
t1	QSPIx[A/B]_SCLK High or Low Time	5.4	—	ns
t2	QSPIx[A/B]_SSy_B pulse width	1	—	SCLK
t3	QSPIx[A/B]_SSy_B Lead Time ¹	(TCSS+0.5)/2	—	SCLK
t4	QSPIx[A/B]_SSy_B Lag Time ¹	TCSH/2	—	SCLK
t5	QSPIx[A/B]_DATAy output valid time	2	—	ns
t6	QSPIx[A/B]_DATAy output hold time	2	—	ns
t7	QSPIx[A/B]_DATAy Setup Time	1	—	ns
t8	QSPIx[A/B]_DATAy Hold Time	1	—	ns

¹ Timing is controlled from FLSHxCR1 register (x=A1, A2, B1, or B2).

Table 101. FlexSPI timings with FlexSPI_n_MCR0[RXCLKSRC] = 0x3 (DDR mode)

ID	Parameter	Min	Max	Unit
—	QSPIx[A/B]_SCLK Cycle frequency	—	200	MHz
t1	QSPIx[A/B]_SCLK High or Low Time	2.25	—	ns
t2	QSPIx[A/B]_SSy_B pulse width	1	—	SCLK
t3	QSPIx[A/B]_SSy_B Lead Time ¹	(TCSS+0.5)/2	—	SCLK
t4	QSPIx[A/B]_SSy_B Lag Time ¹	TCSH/2	—	SCLK
t5	QSPIx[A/B]_DATAy output valid time	0.65	—	ns
t6	QSPIx[A/B]_DATAy output hold time	0.65	—	ns

Table 101. FlexSPI timings with FlexSPIn_MCR0[RXCLKSRC] = 0x3 (DDR mode) (continued)

ID	Parameter	Min	Max	Unit
t9	QSPIx[A/B]_DATAy Setup Skew	—	0.65	ns
t10	QSPIx[A/B]_DATAy Hold Skew	—	0.65	ns

¹ Timing is controlled from FLSHxCR1 register (x=A1, A2, B1, or B2).

4.10.14 Secure JTAG controller (SJC)

4.10.14.1 Internal pull-up/pull-down configuration

The following table describes the default configuration of internal pull-ups and pull-downs of the JTAG interface. External pull-ups and pull-downs are needed when this interface is routed to a connector.

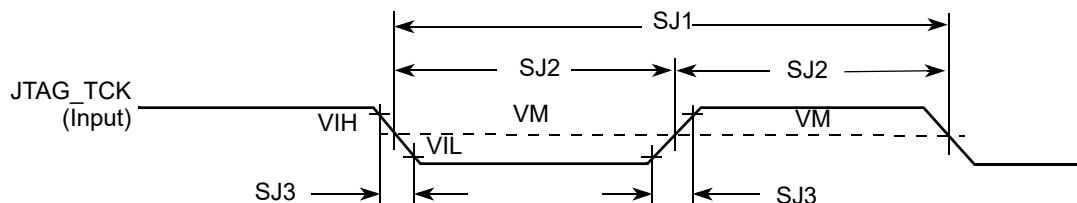
Table 102. JTAG default configuration for internal pull-up/pull-down

Ball name	Internal pull setting ¹	Typical pull value	Unit
JTAG_TMS	PU	50	K Ω
JTAG_TCK	PD		
JTAG_TDI	PU		
JTAG_TRST_B	PU		
TEST_MODE_SELECT	PD		

¹ PU = pull-up; PD = pull-down

4.10.14.2 JTAG timing parameters

Figure 49 depicts the SJC test clock input timing. Figure 50 depicts the SJC boundary scan timing. Figure 51 depicts the SJC test access port. Figure 52 depicts the JTAG_TRST_B timing. Signal parameters are listed in Table 103.

**Figure 49. Test Clock Input Timing Diagram**

Electrical characteristics

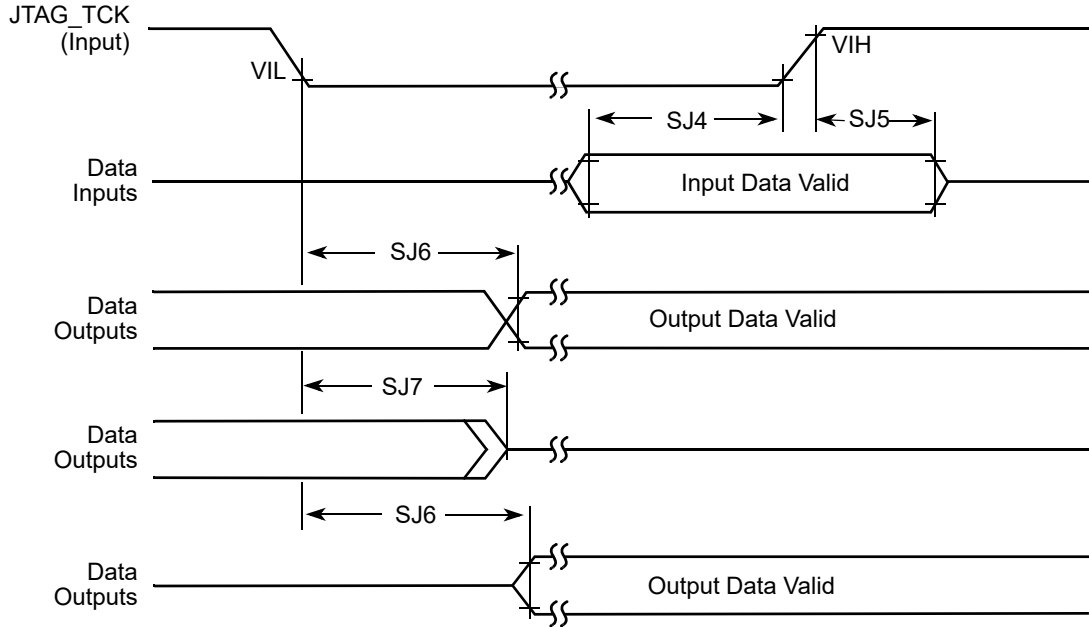


Figure 50. Boundary system (JTAG) timing diagram

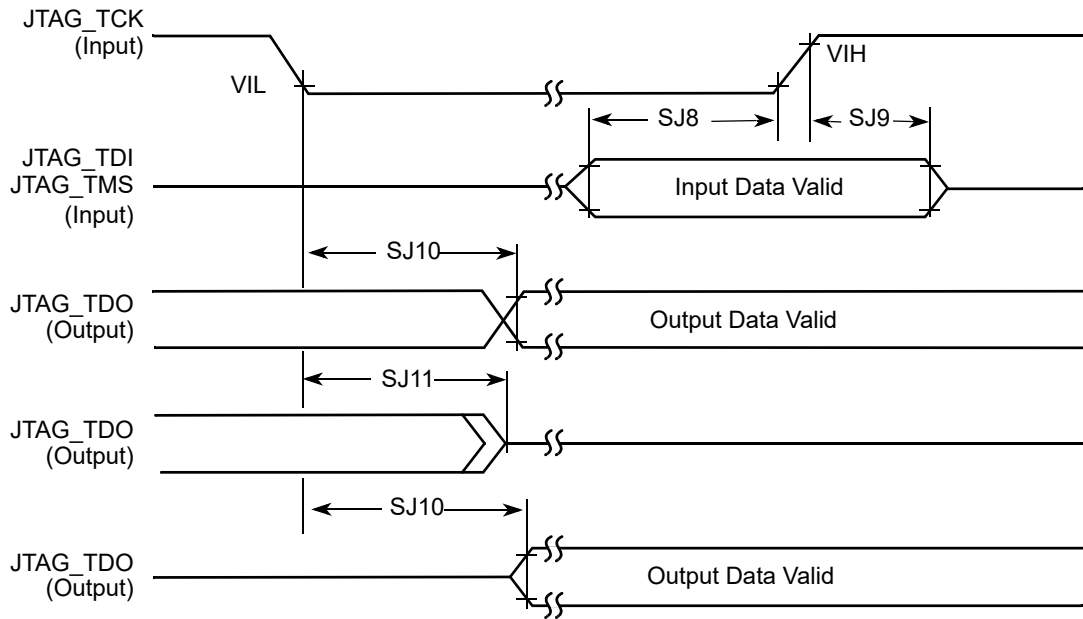


Figure 51. Test Access Port Timing Diagram

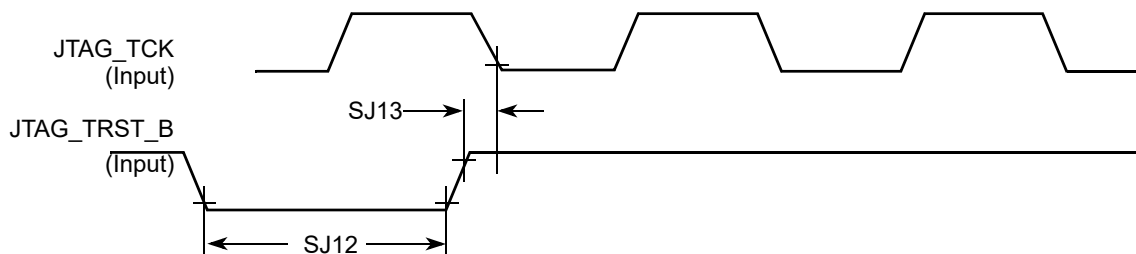


Figure 52. JTAG_TRST_B Timing Diagram

Table 103. JTAG Timing

ID	Parameter ^{1,2}	All Frequencies		Unit
		Min	Max	
SJ0	JTAG_TCK frequency of operation $1/(3 \times T_{DC})^1$	0.001	22	MHz
SJ1	JTAG_TCK cycle time in crystal mode	45	—	ns
SJ2	JTAG_TCK clock pulse width measured at V_M^2	22.5	—	ns
SJ3	JTAG_TCK rise and fall times	—	3	ns
SJ4	Boundary scan input data set-up time	5	—	ns
SJ5	Boundary scan input data hold time	24	—	ns
SJ6	JTAG_TCK low to output data valid	—	40	ns
SJ7	JTAG_TCK low to output high impedance	—	40	ns
SJ8	JTAG_TMS, JTAG_TDI data set-up time	5	—	ns
SJ9	JTAG_TMS, JTAG_TDI data hold time	25	—	ns
SJ10	JTAG_TCK low to JTAG_TDO data valid	—	44	ns
SJ11	JTAG_TCK low to JTAG_TDO high impedance	—	44	ns
SJ12	JTAG_TRST_B assert time	100	—	ns
SJ13	JTAG_TRST_B set-up time to JTAG_TCK low	40	—	ns

¹ T_{DC} = target frequency of SJC

² V_M = mid-point voltage

4.10.15 SPDIF Timing Parameters

The Sony/Philips Digital Interconnect Format (SPDIF) data is sent using the bi-phase marking code. When encoding, the SPDIF data signal is modulated by a clock that is twice the bit rate of the data signal.

Table 104, Figure 53, and Figure 54 show SPDIF timing parameters for the Sony/Philips Digital Interconnect Format (SPDIF), including the timing of the modulating Rx clock (SPDIF_SR_CLK) for SPDIF in Rx mode and the timing of the modulating Tx clock (SPDIF_ST_CLK) for SPDIF in Tx mode.

Table 104. SPDIF Timing Parameters

Parameter	Symbol	Timing Parameter Range		Unit
		Min	Max	
SPDIF_IN Skew: asynchronous inputs, no specs apply	—	—	0.7	ns
SPDIF_OUT output (Load = 50pf) • Skew • Transition rising • Transition falling	— — —	— — —	1.5 24.2 31.3	ns
SPDIF_OUT output (Load = 30pf) • Skew • Transition rising • Transition falling	— — —	— — —	1.5 13.6 18.0	ns
Modulating Rx clock (SPDIF_SR_CLK) period	srckp	40.0	—	ns
SPDIF_SR_CLK high period	srckph	16.0	—	ns
SPDIF_SR_CLK low period	srckpl	16.0	—	ns
Modulating Tx clock (SPDIF_ST_CLK) period	stckp	40.0	—	ns
SPDIF_ST_CLK high period	stckph	16.0	—	ns
SPDIF_ST_CLK low period	stckpl	16.0	—	ns

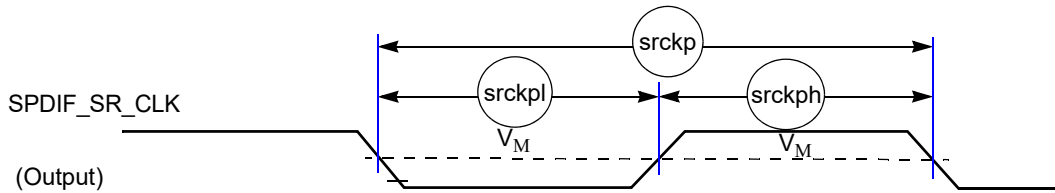


Figure 53. SPDIF_SR_CLK Timing Diagram

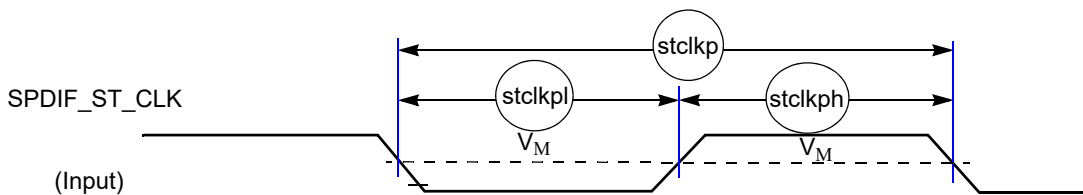


Figure 54. SPDIF_ST_CLK Timing Diagram

4.10.16 UART I/O configuration and timing parameters

4.10.16.0.1 UART Transmitter

The following figure depicts the transmit timing of UART in the RS-232 serial mode, with 8 data bit/1 stop bit format. [Table 105](#) lists the UART RS-232 serial mode transmit timing characteristics.

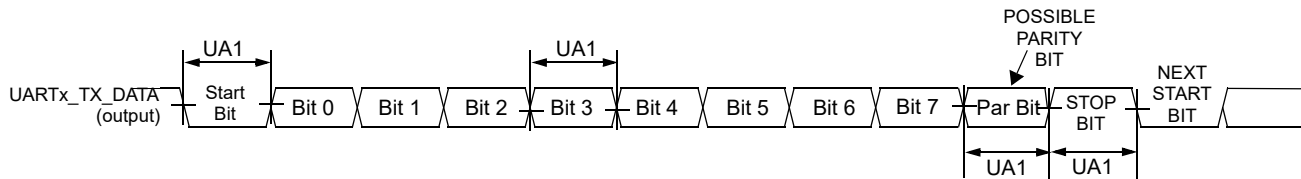


Figure 55. UART RS-232 Serial Mode Transmit Timing Diagram

Table 105. UART RS-232 Serial Mode Transmit Timing Parameters

ID	Parameter	Symbol	Min	Max	Unit
UA1	Transmit Bit Time	t_{Tbit}	$1/F_{baud_rate}^1 - T_{ref_clk}^2$	$1/F_{baud_rate} + T_{ref_clk}$	—

¹ F_{baud_rate} : Baud rate frequency. The maximum baud rate the UART can support is $(LPUART_clk \text{ frequency}) / (SBR[12:0] \times (OSR+1))$.

² T_{ref_clk} : The period of UART reference clock ref_clk (LPUART_clk after SBR divider).

4.10.16.0.2 UART Receiver

The following figure depicts the RS-232 serial mode receive timing with 8 data bit/1 stop bit format. [Table 106](#) lists serial mode receive timing characteristics.

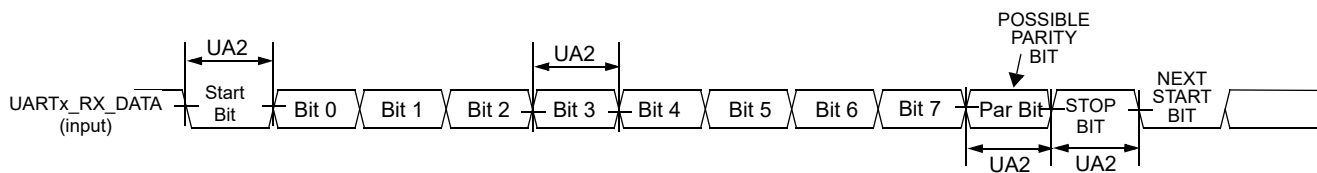


Figure 56. UART RS-232 Serial Mode Receive Timing Diagram

Table 106. RS-232 Serial Mode Receive Timing Parameters

ID	Parameter	Symbol	Min	Max	Unit
UA2	Receive Bit Time ¹	t_{Rbit}	$1/F_{baud_rate}^2 - 1/(16 \times F_{baud_rate})$	$1/F_{baud_rate} + 1/(16 \times F_{baud_rate})$	—

¹ The UART receiver can tolerate $1/((OSR+1) \times F_{baud_rate})$ tolerance in each bit, but accumulation tolerance in one frame must not exceed $3/((OSR+1) \times F_{baud_rate})$.

² F_{baud_rate} : Baud rate frequency. The maximum baud rate the UART can support is $(LPUART_clk \text{ frequency}) / (SBR[12:0] \times (OSR+1))$.

4.10.16.0.3 UART IrDA Mode Timing

The following subsections give the UART transmit and receive timings in IrDA mode.

UART IrDA Mode Transmitter

The following figure depicts the UART IrDA mode transmit timing, with 8 data bit/1 stop bit format.

Table 107 lists the transmit timing characteristics.

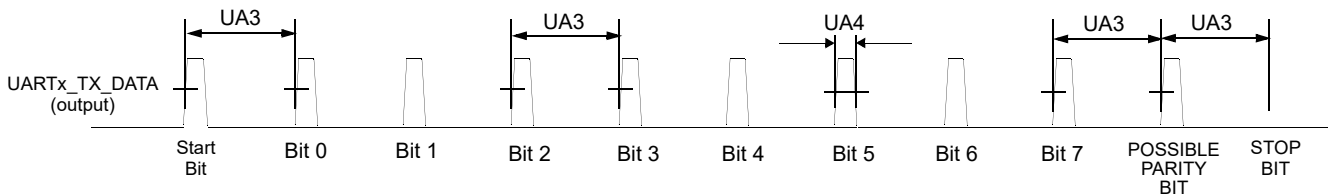


Figure 57. UART IrDA Mode Transmit Timing Diagram

Table 107. IrDA Mode Transmit Timing Parameters

ID	Parameter	Symbol	Min	Max	Unit
UA3	Transmit Bit Time in IrDA mode	t_{TIRbit}	$1/F_{baud_rate}^1 - T_{ref_clk}^2$	$1/F_{baud_rate} + T_{ref_clk}$	—
UA4	Transmit IR Pulse Duration	$t_{TIRpulse}$	$(TNP+1)/(OSR+1) \times (1/F_{baud_rate} - T_{ref_clk})$	$(TNP+1)/(OSR+1) \times (1/F_{baud_rate} + T_{ref_clk})$	—

¹ F_{baud_rate} : Baud rate frequency. The maximum baud rate the UART can support is (LPUART_clk frequency)/(SBR[12:0] × (OSR+1)).

² T_{ref_clk} : The period of UART reference clock ref_clk (LPUART_clk after SBR divider).

UART IrDA Mode Receiver

The following figure depicts the UART IrDA mode receive timing, with 8 data bit/1 stop bit format.

Table 108 lists the receive timing characteristics.

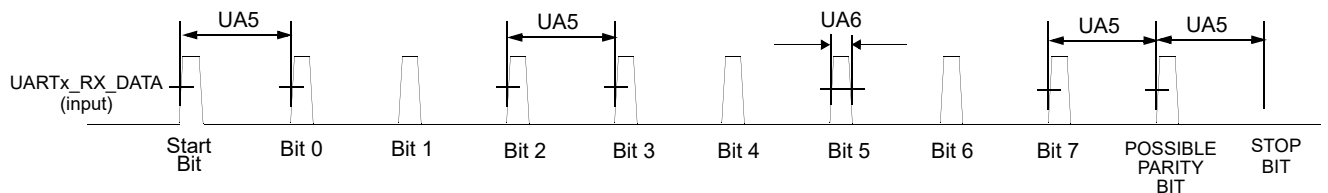


Figure 58. UART IrDA Mode Receive Timing Diagram

Table 108. IrDA Mode Receive Timing Parameters

ID	Parameter	Symbol	Min	Max	Unit
UA5	Receive Bit Time ¹ in IrDA mode	t_{RIRbit}	$1/F_{baud_rate}^2 - 1/(16 \times F_{baud_rate})$	$1/F_{baud_rate} + 1/(16 \times F_{baud_rate})$	—
UA6	Receive IR Pulse Duration	$t_{RIRpulse}$	1.41 μs	$(5/16) \times (1/F_{baud_rate})$	—

¹ The UART receiver can tolerate $1/((OSR+1) \times F_{baud_rate})$ tolerance in each bit. But accumulation tolerance in one frame must not exceed $3/((OSR+1) \times F_{baud_rate})$.

² Fbaud_rate: Baud rate frequency. The maximum baud rate the UART can support is (LPUART_clk frequency)/(SBR[12:0] × (OSR+1)).

4.10.17 USB HSIC Timings

This section describes the electrical information of the USB HSIC port.

NOTE

HSIC is a DDR signal. The following timing specification is for both rising and falling edges.

4.10.17.1 USB HSIC Transmit Timing

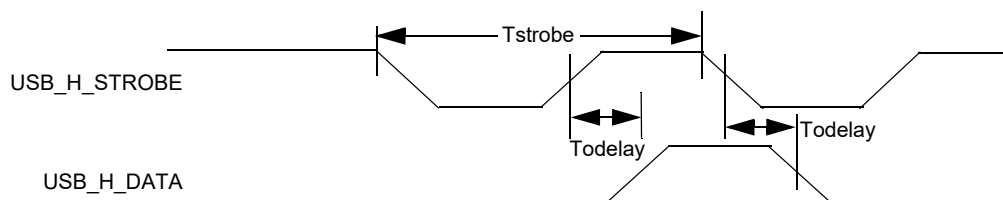


Figure 59. USB HSIC Transmit Waveform

Table 109. USB HSIC Transmit Parameters

Name	Parameter	Min	Max	Unit	Comment
Tstrobe	strobe period	4.165	4.168	ns	—
Todelay	data output delay time	550	1350	ps	Measured at 50% point
Tslew	strobe/data rising/falling time	0.7	2	V/ns	Averaged from 30% – 70% points

4.10.17.2 USB HSIC Receive Timing

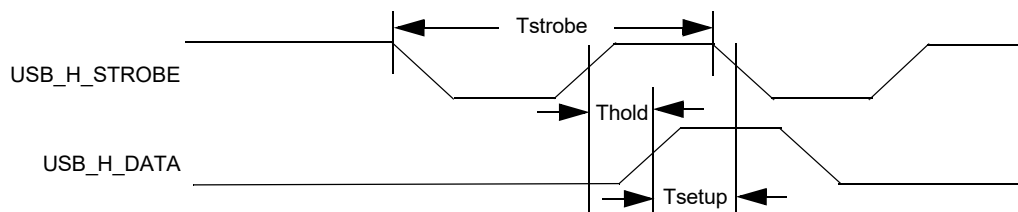


Figure 60. USB HSIC Receive Waveform

Table 110. USB HSIC Receive Parameters¹

Name	Parameter	Min	Max	Unit	Comment
Tstrobe	strobe period	4.165	4.168	ns	—
Thold	data hold time	300	—	ps	Measured at 50% point

Electrical characteristics

Table 110. USB HSIC Receive Parameters¹ (continued)

Name	Parameter	Min	Max	Unit	Comment
Tsetup	data setup time	300	—	ps	Measured at 50% point
Tslew	strobe/data rising/falling time	0.7	2	V/ns	Averaged from 30% – 70% points

¹ The timings in the table are guaranteed when:
 —AC I/O voltage is between 0.9× to 1× the I/O supply
 —DDR_SEL configuration bits of the I/O are set to (10)b

4.10.18 USB 2.0 PHY Parameters

4.10.18.1 USB 2.0 PHY Transmitter specifications

This section describes the transmitter specifications for USB2.0 PHY.

4.10.18.1.1 USB 2.0 PHY full-speed/low-speed transmitter specifications

The following table lists the full-speed/low-speed (FS/LS) transmitter specifications for USB2.0 PHY.

Table 111. USB 2.0 PHY FS/LS transmitter specifications

Symbol	Description	Min	Typ	Max	Units
VOL	Output Voltage Low	0	—	0.3	V
VOH	Output Voltage High (Driven)	2.8	—	3.6	V
VOSE1	Single Ended One (SE1)	0.8	—	—	V
VCRS	Output Signal Cross Over Voltage	1.3	—	2.0	V
TFR	Driver Rise Time - FS	4	—	20	ns
TLR	Driver Rise Time - LS	75	—	300	ns
TFF	Driver Fall Time - FS	4	—	20	ns
TLF	Driver Fall Time - LS	75	—	300	ns
TFRFM	Differential Rise and Fall Time Matching - FS	90	—	111.11	%
TLRFM	Differential Rise and Fall Time Matching - LS	80	—	125	%
ZHSDRV	Driver Output Resistance (Also serves as HS Termination)	40.5	—	49.5	Ω
TDJ1	Source Jitter (Next Transition) - FS	-3.5	—	3.5	ns
TDJ2	Source Jitter (Paired Transition) - FS	-4	—	4	ns
TFDEOP	Source Jitter (Differential to SE0 transition) - FS	-2	—	5	ns
TFEOPT	Source SE0 interval of EOP - FS	160	—	175	ns
TDDJ1	Source Jitter in downstream direction (Next Transition) - LS	-25	—	25	ns
TDDJ2	Source Jitter in downstream direction (Paired Transition) - LS	-14	—	14	ns
TUDJ1	Source Jitter in upstream direction (Next Transition) - LS	-95	—	95	ns

Table 111. USB 2.0 PHY FS/LS transmitter specifications (continued)

Symbol	Description	Min	Typ	Max	Units
TUDJ2	Source Jitter in upstream direction (Paired Transition) - LS	-150	—	150	ns
TLDEOP	Source Jitter in upstream direction (Differential to SE0 transition) - LS	-40	—	100	ns
TLEOPT	Source SE0 interval of EOP - LS	1.25	—	1.5	μs

4.10.18.2 USB 2.0 PHY high-speed transmitter specifications

The following table lists the high-speed (HS) transmitter specifications for USB 2.0 PHY.

Table 112. USB 2.0 PHY HS transmitter specifications

Symbol/Parameter	Description	Min	Typ	Max	Units
HSOI	High Speed Idle Level	-10	—	10	mV
VHSTERM	Termination Voltage in High Speed	-10	—	10	mV
VHSOL	High Speed Data Signaling Low	-10	—	10	mV
VCHIRPJ	Chirp J (Differential Voltage)	700	—	1100	mV
VCHIRPK	Chirp K (Differential Voltage)	-900	—	-500	mV
ZHSDRV	Driver Output Resistance	40.5	—	49.5	Ω
THSR	Rise Time (10% to 90%)	100	—	—	ps
THSF	Fall Time (10% to 90%)	100	—	—	ps
HS Eye Opening: Template 1	Differential eye opening at 37.5% US and 62.5% UI for a hub measured at TP2 and for a device without a captive cable measured at TP3.	-300	—	300	mV
HS Eye Opening: Template 2	Differential eye opening at 37.5% US and 62.5% UI for a device with a captive cable measured at TP2.	-175	—	175	mV
HS Jitter: Template 1	Peak-Peak Jitter at Zero crossing for a hub measured at TP2 and for a device without captive cable measured at TP3.	—	—	15	%UI
		—	—	312.5	ps
HS Jitter: Template 2	Peak-Peak Jitter at Zero crossing for a device with captive cable measured at TP2.	—	—	25	%UI
		—	—	520.83	ps

4.10.18.3 USB 2.0 PHY receiver specifications

This section describes the receiver specifications implemented in USB 2.0 PHY.

4.10.18.3.1 USB 2.0 PHY full-speed/low-speed (FS/LS) receiver specifications

Table 113. USB 2.0 PHY FS/LS receiver specifications

Symbol	Description	Min	Typ	Max	Units
VIH	Input Voltage Level - High (Driven)	2	—	—	V
VIHZ	Input Voltage Level - High (Floating)	2.7	—	3.6	V
VIL	Input Voltage Level - Low	—	—	0.8	V
VTH	Switching Threshold	0.8	—	2.0	V
VCM	Common Mode Range	0.8	—	2.5	V
TJR1	Receiver Jitter Budget (Next Transition) - FS	-18.5	—	18.5	ns
TJR2	Receiver Jitter Budget (Paired Transition) - FS	-9	—	9	ns
TFEOPR	Receiver EOP Interval of EOP - FS	82	—	—	ns
TUJR1	US Port Differential Receiver Jitter (Next Transition) - LS	-152	—	152	ns
TUJR2	US Port Differential Receiver Jitter (Paired Transition) - LS	-200	—	200	ns
TDJR1	DS Port Differential Receiver Jitter (Next Transition) - LS	-75	—	75	ns
TDJR2	DS Port Differential Receiver Jitter (Paired Transition) - LS	-45	—	45	ns
TLEOPR	Receiver EOP Interval of EOP - LS	670	—	—	ns

4.10.18.3.2 USB 2.0 PHY high-speed receiver specifications

The following table lists the high-speed (HS) receiver specifications for USB 2.0 PHY.

Table 114. USB 2.0 PHY HS receiver specifications

Symbol/Parameter	Description	Min	Typ	Max	Units
VHSCM	HS RX input common mode voltage range.	-50	—	500	mV
ZHSDRV	HS RX input termination (Same as Driver output resistance).	40.5	—	49.5	Ω
HSRX Jitter: Template 3	HS RX Peak-Peak Jitter specification at differential zero crossing for a device with captive cable when signal applied at TP2.	—	—	20	%UI
		—	—	416.66	ps
HSRX Jitter: Template 4	HS RX Peak-Peak Jitter specification at differential zero crossing for a device without captive cable at TP3 and for a hub at TP2.	—	—	30	%UI
		—	—	625	ps
HSRX Input Eye Opening: Template 3	HS RX differential sensitivity specification at 40% and 60% UI for a device with captive cable when signal is applied at TP2.	-275	—	275	mV
HSRX Input Eye Opening: Template 4	HS RX differential sensitivity specification at 35% and 65% UI for a device without captive cable when signal is applied at TP3 and for a hub when a signal is applied at TP2.	-150	—	150	mV

4.10.18.3.3 USB 2.0 PHY high-speed envelope detector specifications

The following table lists the high-speed (HS) Envelope Detector Specifications of USB 2.0 PHY.

Table 115. USB 2.0 PHY HS envelope detector specifications

Symbol	Description	Min	Typ	Max	Units
VHSSQ	HS Squelch Detection threshold (differential signal amplitude)	100	—	150	mV
VHSDSC	HS Disconnect Detection threshold (differential signal amplitude)	525	—	625	mV

4.10.18.4 USB 2.0 PHY full-speed/high-speed terminations specification

The following table lists the full-speed/low-speed (FS/LS) Terminations Specification of USB 2.0 PHY.

Table 116. USB 2.0 PHY FS/LS terminations specification

Symbol	Description	Min	Typ	Max	Units
RPU	Bus Pull-Up resistor on US Port in IDLE State	900	—	1575	Ω
	Bus Pull-Up resistor on US Port in ACTIVE State	1425	—	3090	Ω
RPD	Bus Pull-Down resistor on DS Port	14.25	—	24.8	K Ω
VTERM	Termination Voltage for US Port Pull-Up (RPU)	3.0	—	3.6	V

4.10.18.5 Voltage threshold specification

The following table lists the OTG Comparator Specifications of USB2.0 PHY.

Table 117. USB 2.0 PHY OTG comparator specifications

Symbol	Description	Min	Typ	Max	Units
sessvld	B-Device Session Valid threshold	0.8	—	4.0	V
vbusvalid	VBUS Valid threshold	4.4	—	4.75	V

4.10.19 USB 3.0 PHY parameters

The following content is from the USB 3.0 PHY specifications.

4.10.19.1 USB 3.0 PHY external component

Table 118. USB 3.0 PHY external component specifications

Name	Min	Typ	Max	Units	Descriptions
rext	497.5	500	502.5	Ω	There needs to be an external resistor component connected at rext ball while the internal resistor or current is getting calibrated. Package routing from rext ball to its respective bump should not contribute more than 0.05 Ω .

4.10.19.2 USB 3.0 PHY transmitter module

Table 119. USB 3.0 PHY transmitter module electrical specifications

Symbol	Description	Min	Typ	Max	Unit
Voltage/current parameters					
$V_{TX-DIFFp}$	Programmable output voltage swing (single-ended)	50	—	500	mV
$V_{TX-DIFFp-p}$	Programmable differential peak-to-peak output voltage	100	—	1000	mV
$V_{TX-DIFFp-p-LOW}^1$	Low power differential p-p TX voltage swing	400	—	1200	mV
$I_{TX-SHORT}$	Transmit lane short-circuit current	—	—	100	mA
$RL_{TX-DIFF}$	Transmitter differential return loss	—	—	0 < -20dB < 100Mhz 100Mhz < -18dB < 300Mhz 300Mhz < -16dB < 600Mhz 600Mhz < -10dB < 2500Mhz 2500Mhz < -9dB < 4875Mhz 4875Mhz < -8dB < 11200Mhz 11200Mhz < -5dB < 16800Mhz and -3dB beyond that	Db
RL_{TX-CM}	Transmitter common mode return loss	—	—	50Hz < -8dB < 15000Mhz	dB
$Z_{TX-DIFF-DC}$	DC differential TX impedance	80	100	120	Ω
UI	Unit Interval	199.94	—	200.06	ps
$T_{TX-MAX-JITTER}$	Transmitter total jitter (peak-to-peak) (T_j)	—	—	0.4	UI
$T_{TX-RJ-PLL-sigma}$	After application of TX jitter transfer function	—	—	2.42	ps
LTLAT-10	Transmitter data latency	—	—	210	UI

Table 119. USB 3.0 PHY transmitter module electrical specifications (continued)

Symbol	Description	Min	Typ	Max	Unit
Voltage parameters					
$V_{TX-CM-DC-ACTIVE-IDLE-DELTA}$	Absolute Delta of DC Common Mode Voltage during L0 and Electrical Idle.	0	—	100	mV
$V_{TX-IDLE-DIFF-AC-p}$	Electrical Idle Differential Peak Output Voltage	0	—	20	mV
$V_{TX-CM-DC-LINE-DELTA}$	Absolute Delta of DC Common Mode Voltage between D+ and D-	0	—	25	mV
$V_{TX-RCV-DETECT}$	The amount of voltage change allowed during Receiver Detection	0	—	600	mV
$T_{TX-IDLE-SET-TO-IDLE}$	Maximum time to transition to a valid Electrical Idle after sending an EIOS	—	—	8	ns
$T_{TX-IDLE-TO-DIFF-DATA}$	Maximum time to transition to valid diff signaling after leaving Electrical Idle	—	—	8	ns
$V_{TX-CM-AC-PP}$	Tx AC peak-peak common mode voltage (5.0 GT/s)	20	—	150	mVpp
T_{EIExit}	Time to exit Electrical Idle (L0s) state and to enter L0	—	—	5	Txsysclk
Tx signal characteristics					
f_{tol}	TX Frequency Long Term Accuracy	-300	—	300	ppm of Fbaud
f_{SSC}	Spread-Spectrum Modulation Frequency	30	—	33	kHz
$t_{20-80TX}$	TX Rise/Fall Time	0.2	—	0.41	UI
t_{skewTX}	TX Differential Skew	—	—	20	ps

¹ For USB 3.0, no EQ is required

4.10.19.3 USB 3.0 PHY receiver module

Table 120. USB 3.0 PHY receiver module electrical specifications

Symbol	Description	Min	Typ	Max	Unit	Comments
Voltage Parameters						
$V_{RX-DIFF(p-p)}$	Differential input voltage (peak-to-peak) (that is, receiver eye voltage opening)	100	—	1200	mV	—

Electrical characteristics

Table 120. USB 3.0 PHY receiver module electrical specifications (continued)

Symbol	Description	Min	Typ	Max	Unit	Comments
$V_{RX-IDLE-DET-DIFF(p-p)}$	Differential input threshold voltage (peak-to-peak) to detect idle (LFPS)	100	—	300	mV	USB3 LFPS
$V_{cm, acRX}$	RX AC Common Mode Voltage	—	—	100	mVp-p	Simulated at 250 MHz
$V_{RX-CM-AC}$	Receiver common-mode voltage for AC coupling	—	0	150	mV	—
$Z_{RX-DIFF-DC}$	Differential input impedance (DC)	80	100	120	W	$100 \Omega \pm 10\%$
$RL_{RX-DIFF}$	Receiver differential return loss	Same as TX RL	—	—	dB	—
Jitter Parameters						
$T_{RX-MAX-JITTER}$	Receiver total jitter tolerance	0	—	0.66	UI	Incoming Jitter: USB3 = 0.43UI DJ + 0.23UI RJ USB3 numbers are with REFC-TLE

Table 121. PLL module electrical specifications

Parameter	Symbol	Description	Min	Typ	Max	Units
Input Reference Clock						
REF CLK Frequency	REF CLK	—	19.2	19.2/24/25/26/38.4	38.4	MHz
REF CLK Duty Cycle	—	—	47	—	53	MHz
REF CLK Frequency	REF CLK	—	40	40/48/50/52/100	100	MHz
REF CLK RJ Tolerance	—	Integrated jitter from 10 kHz to 16 MHz after applying appropriate PLL ref clock transfer function and the protocol JTF	—	—	0.5	ps
REF CLK Duty Cycle	—	—	37	—	63	%
Divided Reference Frequency	—	—	19.2	—	38.4	MHz
Dividers						
Input division	IPDIV<7:0>	—	1	—	255	Counts
Feedback division	pll_fbdiv_high<9:0>	—	2	—	1025	Counts
	pll_fbdiv_low<9:0>	—	2	—	1025	Counts
Feedback fractional division range	—	—	>-2	—	<2	Counts

Table 121. PLL module electrical specifications (continued)

Parameter	Symbol	Description	Min	Typ	Max	Units
Number of fractional bits	—	This includes one bit for sign	—	27	—	Bits
VCO						
Clock frequency	—	Output full rate clocks	—	5000	—	MHz
VCO frequency	—	VCO oscillation frequency	—	5000	—	MHz
Output clock frequency tolerance	—	This includes SSC deviation	-5300	—	300	ppm
SSC modulation rate	—	As applicable for USB3.0	30	—	33	kHz
Output clock RJ sigma for TX	—	After application of TX jitter transfer function	—	—	2.42	ps
Output clock RJ sigma for RX	—	After application of RX jitter transfer function	—	—	1.40	ps

4.11 Analog-to-digital converter (ADC)

The following table shows the ADC electrical specifications for VREFH=VDD_ADC_1P8.

Table 122. ADC electrical specifications (VREFH=VDD_ADC_1P8)

Symbol	Description	Min	Typ ¹	Max	Unit	Notes
V _{ADIN}	Input Voltage	VREFL	—	VREFH	V	—
C _{ADIN}	Input capacitance	—	4.5	—	pF	—
R _{ADIN}	Input Resistance	—	500	—	Ω	—
R _{AS}	Analog Source Resistance	—	—	5	kΩ	2
f _{ADCK}	ADC Conversion Clock Frequency	—	24	—	MHz	—
C _{sample}	Sample cycles	3.5	—	131.5	—	3
C _{compare}	Fixed compare cycles	—	17.5	—	cycles	—
C _{conversion}	Conversion cycles	C _{conversion} = C _{sample} + C _{compare}			cycles	—
DNL	Differential Non-Linearity	—	± 0.6	-0.5 to +1.1	LSB	4
INL	Integral Non-Linearity	—	± 0.9	±1.1	LSB	4
ENOB	Effective Number of Bits	—	—	—	—	5,6,7
	Avg = 1	10.1	10.4	—	Bits	
	Avg = 2	10.5	10.7	—	Bits	
	Avg = 16	11.1	11.3	—	Bits	
SINAD	Signal to Noise plus Distortion	SINAD=6.02 x ENOB + 1.76			dB	—

Electrical characteristics

Table 122. ADC electrical specifications (VREFH=VDD_ADC_1P8) (continued)

Symbol	Description	Min	Typ ¹	Max	Unit	Notes
E _G	Gain error	—	-0.29	—	%FSV	8
E _O	Offset error	—	0.01	—	%FSV	9
I _{VDDA18}	Supply Current	—	480	—	μA	10
I _{in,ext,leak}	External Channel Leakage Current	—	30	500	nA	—
E _{IL}	Input leakage error	RAS * I _{in}			mV	—

- ¹ Typical values assume VDD_ADC_1P8 = 1.8 V, Temp = 25 °C, f_{ACLK} = Max, unless otherwise stated. Typical values are for reference only. All values, including Min and Max, are derived from lab characterization and are not tested in production.
- ² This resistance is external to the input pad. To achieve the best results, the analog source resistance must be kept as low as possible. The results in this data sheet were derived from a system that had < 15 Ω analog source resistance. The RAS/CAS (analog source capacitance) time constant should be kept to < 1 ns.
- ³ See [Figure 61](#).
- ⁴ ADC conversion clock at max frequency and using linear histogram.
- ⁵ Input data used for test was 1 kHz sine wave.
- ⁶ Measured at VREFH = 1.8 V and pwrsel = 2.
- ⁷ ENOB can be lower than shown, if an ADC channel corrupts other ADC channels through capacitive coupling. This coupling may be dominated by board parasitics. Care must be taken not to corrupt the desired channel being measured. This coupling becomes worse at higher analog frequencies and with switching waveforms due to the harmonic content.
- ⁸ Error measured at fullscale at 1.8 V.
- ⁹ Error measured at zero scale at 0 V.
- ¹⁰ Power Configuration Select, PWRSEL, is set to 10 binary.

The following table shows the ADC electrical specifications for $1V \leq VREFH < VDD_ADC_1P8$.

Table 123. ADC electrical specifications (1V ≤ VREFH < VDD_ADC_1P8)

Symbol	Description	Min	Typ ¹	Max	Unit	Notes
V _{ADIN}	Input Voltage	VREFL	—	VREFH	V	—
C _{ADIN}	Input capacitance	—	4.5	—	pF	—
R _{ADIN}	Input Resistance	—	500	—	Ω	—
R _{AS}	Analog Source Resistance	—	—	5	kΩ	2
f _{ADCK}	ADC Conversion Clock Frequency	—	24	—	MHz	—
C _{sample}	Sample cycles	3.5	—	131.5	—	3
C _{compare}	Fixed compare cycles	—	17.5	—	cycles	—
C _{conversion}	Conversion cycles	C _{conversion} = C _{sample} + C _{compare}			cycles	—
DNL	Differential Non-Linearity	—	± 0.6	-0.5 to +1.1	LSB	4
INL	Integral Non-Linearity	—	± 0.9	±1.1	LSB	4

Table 123. ADC electrical specifications ($1V \leq VREFH < VDD_ADC_1P8$) (continued)

Symbol	Description	Min	Typ ¹	Max	Unit	Notes
ENOB	Effective Number of Bits	—	—	—	—	5,6,7
	Avg = 1	9.5	9.7	—	Bits	
	Avg = 2	9.9	10.1	—	Bits	
	Avg = 16	10.8	11	—	Bits	
SINAD	Signal to Noise plus Distortion	SINAD = 6.02 x ENOB + 1.76			dB	—
E _G	Gain error	—	0.29	—	%FSV	8
E _O	Offset error	—	0.01	—	%FSV	9
I _{VDDA18}	Supply Current	—	480	—	μA	10
I _{in,ext,leak}	External Channel Leakage Current	—	30	500	nA	—
E _{IL}	Input leakage error	RAS * I _{in}			mV	—

¹ Typical values assume VDD_ANA_1P8 = 1.8 V, Temp = 25 °C, fACLK = Max, unless otherwise stated. Typical values are for reference only. All values, including Min and Max, are derived from lab characterization and are not tested in production.

² This resistance is external to the input pad. To achieve the best results, the analog source resistance must be kept as low as possible. The results in this data sheet were derived from a system that had < 15 Ω analog source resistance. The RAS/CAS (analog source capacitance) time constant should be kept to < 1 ns.

³ See Figure 61.

⁴ ADC conversion clock at max frequency and using linear histogram.

⁵ Input data used for test was 1 kHz sine wave.

⁶ Measured at VREFH = 1 V and pwrsel = 2.

⁷ ENOB can be lower than shown, if an ADC channel corrupts other ADC channels through capacitive coupling. This coupling may be dominated by board parasitics. Care must be taken not to corrupt the desired channel being measured. This coupling becomes worse at higher analog frequencies and with switching waveforms due to the harmonic content.

⁸ Error measured at fullscale at 1.0 V.

⁹ Error measured at zero scale at 0 V.

¹⁰ Power Configuration Select, PWRSEL, is set to 10 binary.

Electrical characteristics

The following figure shows a plot of the ADC sample time versus R_{AS} .

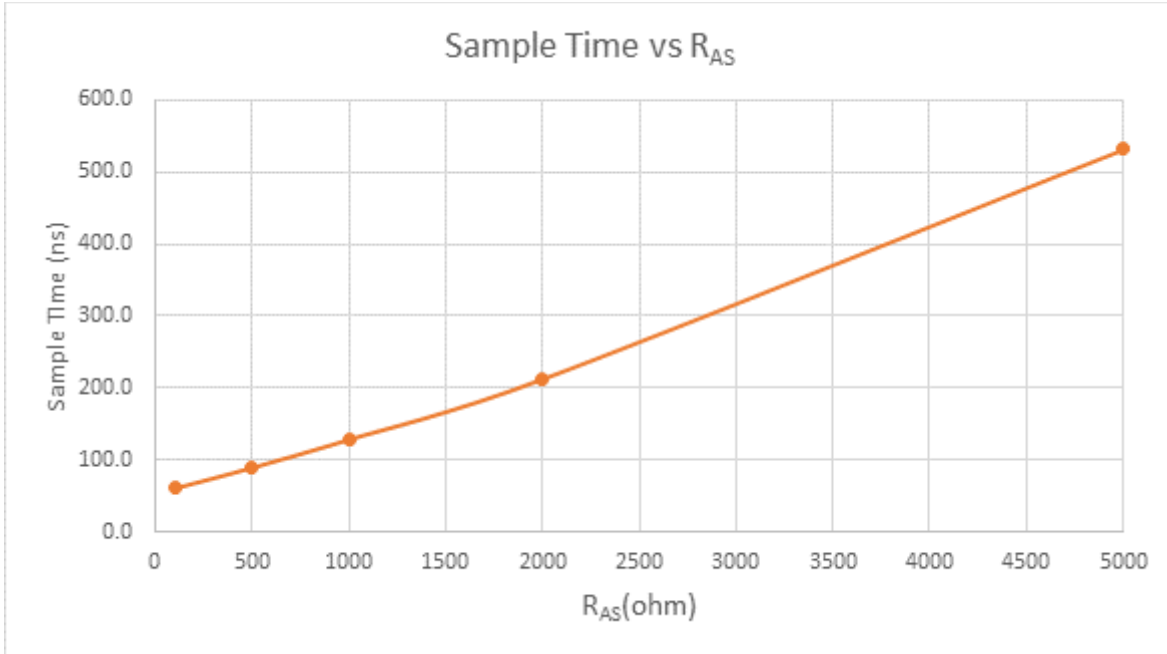


Figure 61. Sample time vs. R_{AS}

5 Boot mode configuration

This section provides information on boot mode configuration pins allocation and boot devices interfaces allocation.

5.1 Boot mode configuration inputs

The following table lists boot option dedicated inputs. These inputs are sampled at reset and can be used to override fuse values, depending on the value of FORCE_BOOT_FROM_FUSE. After this fuse is blown, the Boot mode inputs are ignored by ROM; ROM receives 'boot mode' from the BT_MODE_FUSES fuse. The boot option inputs are in effect when BT_FUSE_SEL fuse is '0' (cleared, which is the case for an unblown fuse). For detailed boot mode options configured by the Boot mode pins, see the “System Boot, Fusemap, and eFuse” chapter of the device reference manual.

Table 124. Boot options and associated inputs used for Boot

Interface	IP Instance	Allocated Pads During Boot	Comment
BOOT_MODE[0]	Input	SCU_BOOT_MODE0	Boot mode selection
BOOT_MODE[1]	Input	SCU_BOOT_MODE1	
BOOT_MODE[2]	Input	SCU_BOOT_MODE2	
BOOT_MODE[3]	Input	SCU_BOOT_MODE3	
BOOT_MODE[4]	Input	SCU_BOOT_MODE4	
BOOT_MODE[5]	Input	SCU_BOOT_MODE5	

5.2 Boot devices interfaces allocation

The following table lists the interfaces that can be used by the boot process in accordance with the specific Boot mode configuration. The table also describes the interface's specific modes and IOMUXC allocation, which are configured during boot when appropriate.

Table 125. Interface allocation during boot

Interface	IP Instance	Allocated Pads During Boot	Comment
MMC	USDHC-0	EMMC0_CLK, EMMC0_CMD, EMMC0_DATA0, EMMC0_DATA1, EMMC0_DATA2, EMMC0_DATA3, EMMC0_DATA4, EMMC0_DATA5, EMMC0_DATA6, EMMC0_DATA7, EMMC0_RESET_B	4 or 8 bit
SD/MMC	USDHC-1	USDHC1_CLK, USDHC1_CMD, USDHC1_DATA0, USDHC1_DATA1, USDHC1_DATA2, USDHC1_DATA3, USDHC1_DATA4, USDHC1_DATA5, USDHC1_DATA6, USDHC1_DATA7, USDHC1_VSELECT, USDHC1_RESET_B	4 or 8 bit

Table 125. Interface allocation during boot (continued)

Interface	IP Instance	Allocated Pads During Boot	Comment
SD	USDHC-2	USDHC2_CLK, USDHC2_CMD, USDHC2_DATA0, USDHC2_DATA1, USDHC2_DATA2, USDHC2_DATA3, USDHC2_RESET_B, USDHC2_VSELECT, USDHC2_CD_B	4 bit
QSPI	QSPI0	QSPI0A_DATA0, QSPI0A_DATA1, QSPI0A_DATA2, QSPI0A_DATA3, QSPI0A_DQS, QSPI0A_SS0_B, QSPI0A_SS1_B, QSPI0A_SCLK, QSPI0B_SCLK, QSPI0B_DATA0, QSPI0B_DATA1, QSPI0B_DATA2, QSPI0B_DATA3, QSPI0B_DQS, QSPI0B_SS0_B, QSPI0B_SS1_B	4, dual-4, or 8 bit During boot, QSPI0B can only be used in combination with QSPI0A, i.e. booting with 4-bit QSPI0B is not supported.
NAND	GPMI	EMMC0_CLK, EMMC0_CMD, EMMC0_DATA0, EMMC0_DATA1, EMMC0_DATA2, EMMC0_DATA3, EMMC0_DATA4, EMMC0_DATA5, EMMC0_DATA6, EMMC0_DATA7, EMMC0_STROBE, EMMC0_RESET_B,, USDHC1_DATA0, USDHC1_DATA1 USDHC1_DATA2, USDHC1_DATA3, USDHC1_DATA4, USDHC1_DATA5 USDHC1_DATA6, USDHC1_DATA7 USDHC1_STROBE	8 bit Boot from CS0 only, but will drive CS1 to high when booting if specified in fuse, this is for Multi-CS NAND chip. <ul style="list-style-type: none"> • Single-ended DQS—use EMMC0_CMD • Single-ended RE—use USDHC1_DATA5 • Differential DQS— <ul style="list-style-type: none"> • _N use USDHC1_DATA2 • _P use USDHC1_DATA3 • Differential RE— <ul style="list-style-type: none"> • _N use USDHC1_DATA0 • _P use USDHC1_DATA1
USB	USB-OTG PHY	USB_OTG1_VBUS, USB_OTG1_DP, USB_OTG1_DN, USB_OTG2_VBUS, USB_OTG2_DP, USB_OTG2_DN	—

6 Package information and contact assignments

This section contains package information and contact assignments for the following package(s):

- [FCPBGA, 29 x 29 mm, 0.75 mm pitch](#)

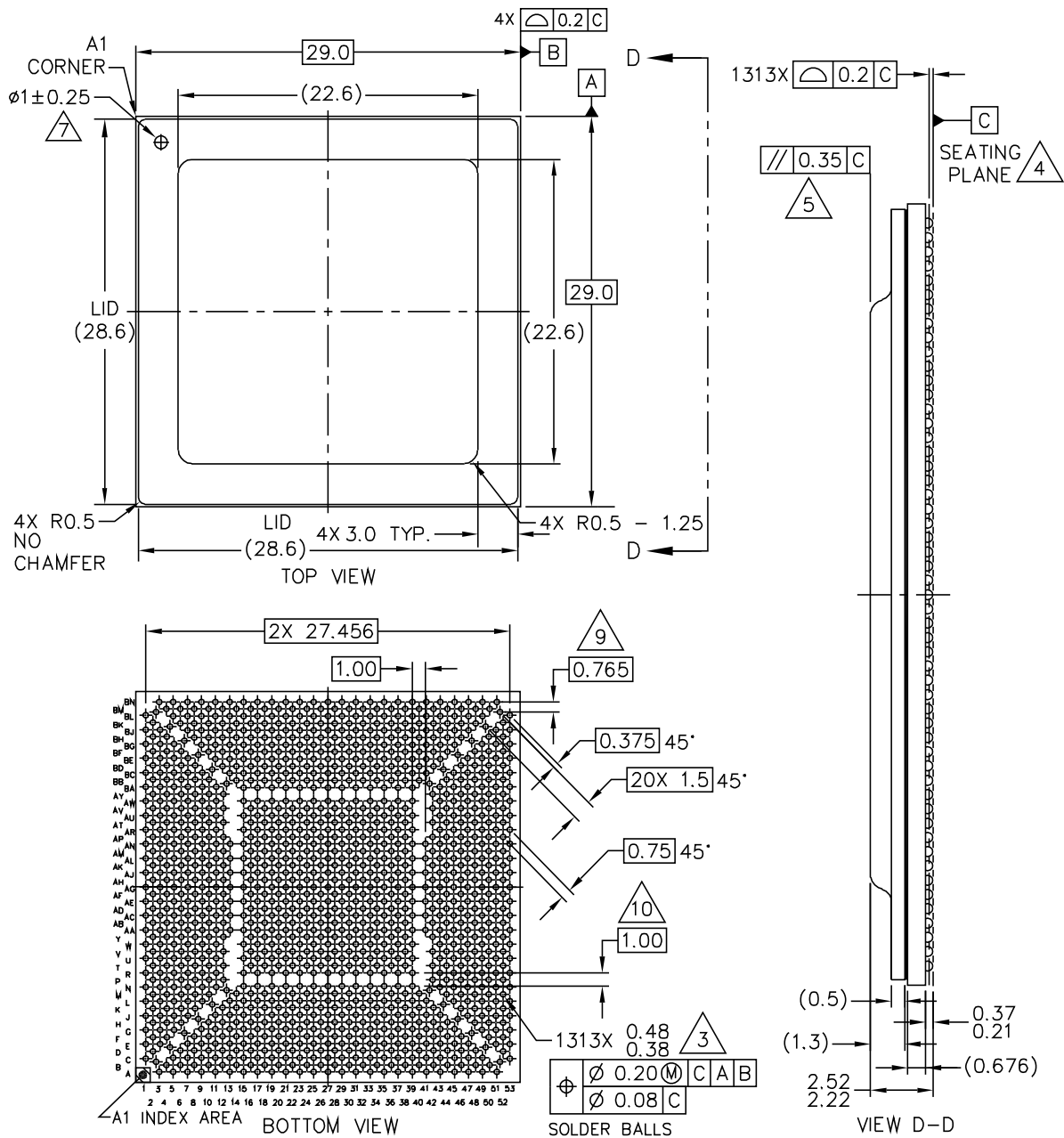
6.1 FCPBGA, 29 x 29 mm, 0.75 mm pitch

This section includes the following information for the 29 x 29 mm, 0.75 mm pitch package:

- Mechanical package drawing
- Ball map
- Contact assignments

6.1.1 29 x 29 mm package case outline

The following figure shows the top, bottom, and side views of the 29 × 29 mm package.



RELEASED FOR EXTERNAL ASSEMBLY ONLY. THIS DESIGN ONLY MEETS EXTERNAL DESIGN AND ASSEMBLY RULES. MUST BE REVIEWED AND UPDATED BEFORE BEING ASSEMBLED INTERNALLY.

TITLE: FCPBGA, WITH LID, 29 X 29 X 2.37 PKG, 0.75 MM PITCH, 1313 I/O	DOCUMENT NO: 98ASA00969D	REV: A
	STANDARD: NON-JEDEC	
	SOT1899-1	SHEET: 1 OF 3

Figure 62. 29 x 29 mm Package Top, Bottom, and Side Views

The notes in the following figure pertain to the preceding figure., “29 x 29 mm Package Top, Bottom, and Side Views.”

NOTES:

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M–1994.
3. MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM C.
4. DATUM C, THE SEATING PLANE, IS DETERMINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
5. PARALLELISM MEASUREMENT SHALL EXCLUDE ANY EFFECT OF MARK ON TOP SURFACE OF PACKAGE.
6. ALL DIMENSIONS ARE SYMMETRIC ACROSS THE PACKAGE CENTER LINES, UNLESS DIMENSIONED OTHERWISE.
7. PIN 1 THRU HOLE SHALL BE CENTERED WITHIN FOOT AREA.
8. LID OVERHANG ON SUBSTRATE NOT ALLOWED.
9. EACH OF THE SIX BALLS IN THE FOUR DIAGONAL LANES BETWEEN DIE CORNER AND PACKAGE CORNER (24 TOTAL BALLS) ARE EQUAL DISTANCE TO THE FOUR CLOSEST SURROUNDING BALLS.
10. 1MM BALL CENTER TO BALL CENTER BETWEEN INNER ARRAY AND OUTER ARRAY FOR ALL FOUR SIDES.

TITLE:	FCPBGA, WITH LID, 29 X 29 X 2.37 PKG, 0.75 MM PITCH, 1313 I/O	DOCUMENT NO: 98ASA00969D	REV: A
		STANDARD: NON–JEDEC	
		SOT1899–1	SHEET: 2

Figure 63. Notes on 29 x 29 mm Package Top, Bottom, and Side Views

6.1.2 29 x 29 mm, 0.75 mm pitch ball map

The following page shows the 29 x 29 mm, 0.75 mm pitch ball map.

6.1.3 29 x 29 mm power supplies and functional contact assignments

The following table shows power supplies contact assignments for the 29 × 29 mm package.

Table 126. 29 x 29 mm power supplies contact assignments

Power rail	Ball reference
VDD_A53	AM22, AM26, AN23, AP24, AR21, AR25, AT22
VDD_A72	AL29, AL33, AM30, AM34, AN27, AN31, AN35, AP28, AP32, AR29, AR33, AT34
VDD_ADC_1P8	AL15
VDD_ADC_DIG_1P8	AK16
VDD_ANA0_1P8	U29, U31
VDD_ANA1_1P8	U25
VDD_ANA2_1P8	AJ35
VDD_ANA3_1P8	AK20
VDD_CP_1P8	AN37
VDD_DDR_CH0_VDDA_PLL_1P8	AE43
VDD_DDR_CH0_VDDQ	AA39, AE39, AF38, AG39, AH38, AJ39, U39, V38, W39, Y38
VDD_DDR_CH0_VDDQ_CKE	AB38, AC39, AD38
VDD_DDR_CH1_VDDA_PLL_1P8	AE11
VDD_DDR_CH1_VDDQ	AA15, AE15, AF16, AG15, AH16, AJ15, U15, V16, W15, Y16
VDD_DDR_CH1_VDDQ_CKE	AB16, AC15, AD16
VDD_EMMC0_1P8_3P3	N35
VDD_ENET_MDIO_1P8_3P3	N17
VDD_ENET0_1P8_3P3	M40, N39
VDD_ENET1_1P8_2P5_3P3	T38
VDD_ESAI0_MCLK_1P8_3P3	AP16, AR15
VDD_ESAI1_SPDIF_SPI_1P8_3P3	AU15
VDD_FLEXCAN_1P8_3P3	N15
VDD_GPU0	AA19, AB20, AC21, AD18, AD22, AE19, V20, W21, Y18, Y22
VDD_GPU1	AA35, AB32, AB36, AC33, AD34, AE35, U35, V36, W33, Y34
VDD_HDMI_RX0_LDO0_1P0_CAP ¹	AU19
VDD_HDMI_RX0_LDO1_1P0_CAP ¹	AU21
VDD_HDMI_RX0_VH_RX_3P3 ¹	AV20
VDD_HDMI_TX0_1P0	AV16
VDD_HDMI_TX0_1P8	AW17

Table 126. 29 x 29 mm power supplies contact assignments (continued)

Power rail	Ball reference
VDD_HDMI_TX0_DIG_3P3	AW21
VDD_HDMI_TX0_LDO_1P0_CAP	AW15
VDD_LVDS_DIG_1P8_3P3	AV32
VDD_LVDS0_1P0	AV36
VDD_LVDS0_1P8	AV34
VDD_LVDS1_1P0	AW35
VDD_LVDS1_1P8	AW33
VDD_M1P8_CAP	AP42
VDD_M4_GPT_UART_1P8_3P3	AL39, AM38
VDD_MAIN	AA23, AA27, AA31, AB24, AB28, AC25, AC29, AD26, AD30, AE23, AE27, AE31, AF20, AF24, AF28, AF32, AF36, AG21, AG33, AH18, AH34, AJ19, AJ31, AK32, AK36, AL17, AL21, AL25, AL37, AM18, AN19, AP20, AP36, AR17, AR37, AT18, AT26, AT30, AU35, T34, U19, U23, V24, V32, W25, W29, Y26, Y30
VDD_MEMC	AC17, AC37, AG17, AG25, AG29, AG37, AH22, AH26, AH30, AJ23, AJ27, AK24, AK28, W17, W37
VDD_MIPI_CSI_DIG_1P8	AV22
VDD_MIPI_CSI0_1P0	AV26
VDD_MIPI_CSI0_1P8	AV24
VDD_MIPI_CSI1_1P0	AW25
VDD_MIPI_CSI1_1P8	AU23
VDD_MIPI_DSI_DIG_1P8_3P3	AU27
VDD_MIPI_DSI0_1P0	AU29
VDD_MIPI_DSI0_1P8	AW31
VDD_MIPI_DSI0_PLL_1P0	AW29
VDD_MIPI_DSI1_1P0	AV28
VDD_MIPI_DSI1_1P8	AV30
VDD_MIPI_DSI1_PLL_1P0	AW27
VDD_MLB_1P8 ²	T30
VDD_MLB_DIG_1P8_3P3 ³	M14
VDD_PCIE_DIG_1P8_3P3	T22
VDD_PCIE_IOB_1P8	T26
VDD_PCIE_LDO_1P0_CAP	N29
VDD_PCIE_LDO_1P8	U27
VDD_PCIE_SATA0_1P0 ¹	M24

Table 126. 29 x 29 mm power supplies contact assignments (continued)

Power rail	Ball reference
VDD_PCIE_SATA0_PLL_1P8 ¹	N21
VDD_PCIE0_1P0	M26
VDD_PCIE0_PLL_1P8	N27
VDD_PCIE1_1P0	N25
VDD_PCIE1_PLL_1P8	M22
VDD_QSPI0_1P8_3P3	N19
VDD_QSPI1A_1P8_3P3	M18
VDD_SCU_1P8	AN39, AP38
VDD_SCU_ANA_1P8	AR39
VDD_SCU_XTAL_1P8	AU39
VDD_SIM0_1P8_3P3	AK42
VDD_SNVS_4P2	AT38
VDD_SNVS_LDO_1P8_CAP	AW39
VDD_SPI_SAI_1P8_3P3	AM16, AN15
VDD_USB_HSIC0_1P2	V26
VDD_USB_HSIC0_1P8	V28
VDD_USB_OTG1_1P0	M32
VDD_USB_OTG1_3P3	N33
VDD_USB_OTG2_1P0	N31
VDD_USB_OTG2_3P3	M34
VDD_USB_SS3_LDO_1P0_CAP	M30
VDD_USB_SS3_TC_3P3	M16
VDD_USDHC_VSELECT_1P8_3P3	T18
VDD_USDHC1_1P8_3P3	M36, N37
VDD_USDHC2_1P8_3P3	M38
VREFH_ADC	AL11
VREFL_ADC	AM10

Table 126. 29 x 29 mm power supplies contact assignments (continued)

Power rail	Ball reference
VSS_MAIN	A23, A3, A31, A51, AA1, AA11, AA13, AA17, AA21, AA25, AA29, AA3, AA33, AA37, AA41, AA43, AA45, AA47, AA49, AA5, AA51, AA53, AA7, AA9, AB12, AB18, AB22, AB26, AB30, AB34, AB42, AC13, AC19, AC23, AC27, AC31, AC35, AC41, AD10, AD12, AD2, AD20, AD24, AD28, AD32, AD36, AD4, AD42, AD44, AD46, AD48, AD50, AD52, AD6, AD8, AE13, AE17, AE21, AE25, AE29, AE33, AE37, AE41, AF12, AF18, AF22, AF26, AF30, AF34, AF42, AG1, AG11, AG13, AG19, AG23, AG27, AG3, AG31, AG35, AG41, AG43, AG45, AG47, AG49, AG5, AG51, AG53, AG7, AG9, AH12, AH20, AH24, AH28, AH32, AH36, AH42, AJ13, AJ17, AJ21, AJ25, AJ29, AJ33, AJ37, AJ41, AK10, AK12, AK18, AK2, AK22, AK26, AK30, AK34, AK38, AK4, AK44, AK46, AK48, AK50, AK52, AK6, AK8, AL13, AL19, AL23, AL27, AL31, AL35, AL41, AM12, AM20, AM24, AM28, AM32, AM36, AM42, AM46, AM8, AN1, AN13, AN17, AN21, AN25, AN29, AN3, AN33, AN41, AN43, AN47, AN49, AN5, AN51, AN53, AN7, AP12, AP18, AP22, AP26, AP30, AP34, AR11, AR19, AR23, AR27, AR31, AR35, AR49, AR5, AT12, AT16, AT2, AT20, AT24, AT28, AT32, AT36, AT4, AT42, AT46, AT50, AT52, AT6, AT8, AU17, AU25, AU31, AU33, AU37, AV12, AV38, AV42, AW11, AW19, AW23, AW3, AW37, AW43, AW47, AW51, AW7, B12, B14, B18, B28, B36, B46, B6, BA13, BA15, BA17, BA19, BA21, BA23, BA25, BA27, BA29, BA31, BA33, BA35, BA37, BA39, BA41, BA45, BB10, BB14, BB16, BB18, BB2, BB20, BB22, BB24, BB26, BB28, BB30, BB32, BB34, BB36, BB38, BB40, BB48, BB52, BB6, BC11, BC13, BC15, BC17, BC19, BC21, BC23, BC25, BC27, BC29, BC31, BC33, BC35, BC37, BC39, BC41, BC43, BD14, BD16, BD18, BD20, BD22, BD24, BD26, BD48, BD50, BE3, BE45, BE7, BE9, BF26, BF28, BF30, BF32, BF34, BF36, BF38, BF4, BF40, BF42, BF44, BF52, BG11, BG13, BG15, BG17, BG19, BG21, BG23, BG47, BG7, BH22, BH4, BJ25, BJ27, BJ29, BJ3, BJ31, BJ33, BJ35, BJ37, BJ39, BJ41, BJ43, BJ45, BJ47, BJ49, BJ5, BJ51, BK10, BK12, BK14, BK16, BK18, BK20, BK22, BK46, BK6, BK8, BL1, BL21, BL53, BM10, BM46, BN21, BN3, C1, C11, C15, C19, C21, C23, C29, C31, C33, C41, C43, C49, C53, C9, D16, D18, D24, D26, D28, D34, D36, D38, D40, D6, E19, E21, E47, E9, F12, F2, F24, F32, F36, F4, F44, F50, F52, G15, G21, G23, G27, G33, G39, G49, G5, G9, J1, J13, J15, J17, J19, J21, J23, J25, J29, J3, J31, J35, J37, J41, J47, J49, J5, J51, J53, J7, K12, K14, K16, K18, K20, K22, K24, K26, K28, K30, K32, K34, K36, K38, K40, K42, K46, K8, L11, L13, L15, L17, L19, L21, L23, L25, L27, L29, L31, L33, L35, L37, L39, L41, L43, M10, M2, M4, M44, M46, M48, M50, M52, M6, M8, N13, N41, P12, P42, R1, R11, R15, R17, R19, R21, R23, R25, R27, R29, R3, R31, R33, R35, R37, R39, R43, R45, R47, R49, R5, R51, R53, R7, R9, T12, T16, T20, T24, T28, T32, T36, T42, U17, U21, U33, U37, V10, V12, V18, V2, V22, V30, V34, V4, V42, V44, V46, V48, V50, V52, V6, V8, W19, W23, W27, W31, W35, Y12, Y20, Y24, Y28, Y32, Y36, Y42
VSS_SCU_XTAL	BK48, BM48, BM50, BN51

- ¹ HDMI-RX is not currently supported, the related power and signal connections are provided for future use when it is expected HDMI-RX support will be enabled.
- ² MLB is not supported on this product. The MLB power rail must be tied to the voltage specified in [Table 8](#) or may be terminated, per the Hardware Developer's Guide power supplies of unused functions.
- ³ MLB is not supported on this product. This MLB power rail must be tied to the voltage specified in [Table 8](#) if other I/O functions are used, as determined by IOMUX selection. Alternately, terminate the MLB supply, per the Hardware Developer's Guide power supplies of unused functions.

Package information and contact assignments

The following table shows functional contact assignments for the 29 × 29 mm package.

Table 127. 29 × 29 mm functional contact assignments

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition			
				Default mode	Default function	State ²	
AP10	ADC_IN0	VDD_ADC_3P3	GPIO	ALT0	ADC_IN0	PD	
AN11	ADC_IN1				ADC_IN1		
AP8	ADC_IN2				ADC_IN2		
AR9	ADC_IN3				ADC_IN3		
AN9	ADC_IN4				ADC_IN4		
AR7	ADC_IN5				ADC_IN5		
AL9	ADC_IN6				ADC_IN6		
AP6	ADC_IN7				ADC_IN7		
BH52	ANA_TEST_OUT0_N	VDD_SCU_ANA_1P8	ANA	NXP Internal Use Only (Leave Unconnected)			
BG53	ANA_TEST_OUT0_P						
BD2	ANA_TEST_OUT1_N	VDD_SCU_ANA_1P8					
BE1	ANA_TEST_OUT1_P						
H28	EMMC0_CLK	VDD_EMMC0_1P8_3P3	FASTD	ALT1	NAND_READY_B	PU	
J27	EMMC0_CMD			ALT0	EMMC0_CMD	PD	
G29	EMMC0_DATA0			EMMC0_DATA0			
H30	EMMC0_DATA1			EMMC0_DATA1			
G31	EMMC0_DATA2			EMMC0_DATA2			
H32	EMMC0_DATA3			EMMC0_DATA3			
J33	EMMC0_DATA4			EMMC0_DATA4			
H34	EMMC0_DATA5			EMMC0_DATA5			
H36	EMMC0_DATA6		EMMC0_DATA6				
G35	EMMC0_DATA7		EMMC0_DATA7				
H38	EMMC0_RESET_B		GPIO	ALT3	LSIO.GPIO5.IO13	PU	
G37	EMMC0_STROBE		FASTD	ALT0	EMMC0_STROBE	PD	
A9	ENET0_MDC		VDD_ENET_MDIO_1P8_3P3	GPIO	ALT3	LSIO.GPIO4.IO14	PD
D10	ENET0_MDIO				ALT0	ENET0_MDIO	PU
B10	ENET0_REFCLK_125M_25M	ALT3			LSIO.GPIO4.IO15	PD	
E43	ENET0_RGMII_RX_CTL	VDD_ENET0_1P8_3P3	FASTD	ALT0	ENET0_RGMII_RX_CTL	PD	
B44	ENET0_RGMII_RXC				ENET0_RGMII_RXC		
A47	ENET0_RGMII_RXD0				ENET0_RGMII_RXD0		

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition								
				Default mode	Default function	State ²						
D44	ENET0_RGMII_RXD1	VDD_ENET0_1P8_3P3	FASTD	ALT0	ENET0_RGMII_RXD1	PD						
C45	ENET0_RGMII_RXD2				ENET0_RGMII_RXD2							
E45	ENET0_RGMII_RXD3				ENET0_RGMII_RXD3							
E41	ENET0_RGMII_TX_CTL					ALT3	LSIO.GPIO5.IO31	PD				
A41	ENET0_RGMII_TXC						LSIO.GPIO5.IO30					
A43	ENET0_RGMII_TXD0						LSIO.GPIO6.IO00					
B42	ENET0_RGMII_TXD1						LSIO.GPIO6.IO01					
A45	ENET0_RGMII_TXD2						LSIO.GPIO6.IO02					
D42	ENET0_RGMII_TXD3						LSIO.GPIO6.IO03					
A13	ENET1_MDC	VDD_ENET_MDIO_1P8_3P3	GPIO	ALT3	LSIO.GPIO4.IO18	PD						
C13	ENET1_MDIO			ALT0	ENET1_MDIO	PU						
A11	ENET1_REFCLK_125M_25M			ALT3	LSIO.GPIO4.IO16	PD						
E49	ENET1_RGMII_RX_CTL	VDD_ENET1_1P8_2P5_3P3	FASTD	ALT0	ENET1_RGMII_RX_CTL	PD						
B50	ENET1_RGMII_RXC				ENET1_RGMII_RXC							
E51	ENET1_RGMII_RXD0				ENET1_RGMII_RXD0							
C51	ENET1_RGMII_RXD1				ENET1_RGMII_RXD1							
D52	ENET1_RGMII_RXD2				ENET1_RGMII_RXD2							
E53	ENET1_RGMII_RXD3				ENET1_RGMII_RXD3							
B48	ENET1_RGMII_TX_CTL					ALT3	LSIO.GPIO6.IO11	PD				
D46	ENET1_RGMII_TXC						LSIO.GPIO6.IO10					
A49	ENET1_RGMII_TXD0						LSIO.GPIO6.IO12					
C47	ENET1_RGMII_TXD1						LSIO.GPIO6.IO13					
G47	ENET1_RGMII_TXD2						LSIO.GPIO6.IO14					
D48	ENET1_RGMII_TXD3						LSIO.GPIO6.IO15					
AW9	ESAI0_FSR						VDD_ESAI0_MCLK_1P8_3P3		GPIO	ALT0	ESAI0_FSR	PD
BG9	ESAI0_FST										ESAI0_FST	
BB8	ESAI0_SCKR	ESAI0_SCKR										
AY8	ESAI0_SCKT	ESAI0_SCKT										
BA9	ESAI0_TX0	ESAI0_TX0										
BA7	ESAI0_TX1	ESAI0_TX1										
AU9	ESAI0_TX2_RX3	ESAI0_TX2_RX3										
BC5	ESAI0_TX3_RX2	ESAI0_TX3_RX2										

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition						
				Default mode	Default function	State ²				
AV8	ESAI0_TX4_RX1	VDD_ESAI0_MCLK_1P8_3P3	GPIO	ALT0	ESAI0_TX4_RX1	PD				
AU7	ESAI0_TX5_RX0				ESAI0_TX5_RX0					
BE11	ESAI1_FSR	VDD_ESAI1_SPDIF_SPI_1P8_3P3	GPIO	ALT0	ESAI1_FSR	PD				
BF12	ESAI1_FST				ESAI1_FST					
BD12	ESAI1_SCKR				ESAI1_SCKR					
AY10	ESAI1_SCKT				ESAI1_SCKT					
BF10	ESAI1_TX0				ESAI1_TX0					
BA11	ESAI1_TX1				ESAI1_TX1					
AU11	ESAI1_TX2_RX3				ESAI1_TX2_RX3					
AV10	ESAI1_TX3_RX2				ESAI1_TX3_RX2					
AY12	ESAI1_TX4_RX1				ESAI1_TX4_RX1					
AT10	ESAI1_TX5_RX0				ESAI1_TX5_RX0					
C5	FLEXCAN0_RX				VDD_FLEXCAN_1P8_3P3		GPIO	ALT0	FLEXCAN0_RX	PD
H6	FLEXCAN0_TX							ALT3	LSIO.GPIO3.IO30	PD
E5	FLEXCAN1_RX	ALT0	FLEXCAN1_RX	PD						
G7	FLEXCAN1_TX	ALT3	LSIO.GPIO4.IO00	PD						
C3	FLEXCAN2_RX	ALT0	FLEXCAN2_RX	PD						
E7	FLEXCAN2_TX	ALT3	LSIO.GPIO4.IO02	PD						
AV52	GPT0_CAPTURE	VDD_M4_GPT_UART_1P8_3P3	GPIO	ALT0		GPT0_CAPTURE		PD		
AY52	GPT0_CLK				GPT0_CLK					
AW53	GPT0_COMPARE				GPT0_COMPARE					
AY50	GPT1_CAPTURE				GPT1_CAPTURE					
BA53	GPT1_CLK				GPT1_CLK					
BA51	GPT1_COMPARE				GPT1_COMPARE					
BL13	HDMI_RX0_ARC_N ³	VDD_HDMI_RX0_1P8	HDMI	Not muxed						
BM14	HDMI_RX0_ARC_P ³									
BJ9	HDMI_RX0_CEC ³									
BL11	HDMI_RX0_CLK_N ³									
BM12	HDMI_RX0_CLK_P ³									
BL15	HDMI_RX0_DATA0_N ³									
BM16	HDMI_RX0_DATA0_P ³									
BL17	HDMI_RX0_DATA1_N ³									
BM18	HDMI_RX0_DATA1_P ³									

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition							
				Default mode	Default function	State ²					
BL19	HDMI_RX0_DATA2_N ³	VDD_HDMI_RX0_1P8	HDMI	Not muxed							
BM20	HDMI_RX0_DATA2_P ³										
BH10	HDMI_RX0_DDC_SCL ³										
BE13	HDMI_RX0_DDC_SDA ³										
BF14	HDMI_RX0_HPD ³										
BN11	HDMI_RX0_MON_5V ³										
BJ11	HDMI_RX0_REXT ³										
BG3	HDMI_TX0_AUX_N	VDD_HDMI_TX0_1P8	HDMI	Not muxed							
BH2	HDMI_TX0_AUX_P										
BJ1	HDMI_TX0_CEC										
BK2	HDMI_TX0_CLK_EDP3_N										
BL3	HDMI_TX0_CLK_EDP3_P										
BM4	HDMI_TX0_DATA0_EDP2_N										
BL5	HDMI_TX0_DATA0_EDP2_P										
BM6	HDMI_TX0_DATA1_EDP1_N										
BL7	HDMI_TX0_DATA1_EDP1_P										
BM8	HDMI_TX0_DATA2_EDP0_N										
BL9	HDMI_TX0_DATA2_EDP0_P										
BG1	HDMI_TX0_DDC_SCL										
BN5	HDMI_TX0_DDC_SDA										
BH8	HDMI_TX0_HPD										
BJ7	HDMI_TX0_REXT										
BN9	HDMI_TX0_TS_SCL						VDD_HDMI_TX0_DIG_3P3	GPIO	ALT0	HDMI_TX0_TS_SCL	PU
BN7	HDMI_TX0_TS_SDA									HDMI_TX0_TS_SDA	
BC51	JTAG_TCK	VDD_SCU_1P8	TEST	Not muxed							
BE51	JTAG_TDI										
BD52	JTAG_TDO										
BA49	JTAG_TMS										
BE53	JTAG_TRST_B										
						PD					
						PU					
						Drive-0					
						PU					

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition							
				Default mode	Default function	State ²					
BL41	LVDS0_CH0_CLK_N	VDD_LVDS0_1P8	LVDS	Not muxed							
BN41	LVDS0_CH0_CLK_P										
BK42	LVDS0_CH0_TX0_N										
BM42	LVDS0_CH0_TX0_P										
BL43	LVDS0_CH0_TX1_N	VDD_LVDS0_1P8	LVDS	Not muxed							
BN43	LVDS0_CH0_TX1_P										
BK44	LVDS0_CH0_TX2_N										
BM44	LVDS0_CH0_TX2_P										
BL45	LVDS0_CH0_TX3_N										
BN45	LVDS0_CH0_TX3_P										
BG45	LVDS0_CH1_CLK_N										
BH46	LVDS0_CH1_CLK_P										
BG43	LVDS0_CH1_TX0_N										
BH44	LVDS0_CH1_TX0_P										
BG41	LVDS0_CH1_TX1_N										
BH42	LVDS0_CH1_TX1_P										
BG39	LVDS0_CH1_TX2_N										
BH40	LVDS0_CH1_TX2_P										
BG37	LVDS0_CH1_TX3_N										
BH38	LVDS0_CH1_TX3_P										
BE39	LVDS0_GPIO00						VDD_LVDS_DIG_1P8_3P3	GPIO	ALT0	LVDS0_GPIO00	PD
BD40	LVDS0_GPIO01									LVDS0_GPIO01	
BD38	LVDS0_I2C0_SCL	ALT0	LVDS0_I2C0_SCL	LVDS0_I2C0_SDA	PU						
BD36	LVDS0_I2C0_SDA										
BE37	LVDS0_I2C1_SCL										
BE35	LVDS0_I2C1_SDA										

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition							
				Default mode	Default function	State ²					
BK36	LVDS1_CH0_CLK_N	VDD_LVDS1_1P8	LVDS	Not muxed							
BM36	LVDS1_CH0_CLK_P										
BL37	LVDS1_CH0_TX0_N										
BN37	LVDS1_CH0_TX0_P										
BK38	LVDS1_CH0_TX1_N										
BM38	LVDS1_CH0_TX1_P										
BL39	LVDS1_CH0_TX2_N										
BN39	LVDS1_CH0_TX2_P										
BK40	LVDS1_CH0_TX3_N										
BM40	LVDS1_CH0_TX3_P										
BK34	LVDS1_CH1_CLK_N										
BM34	LVDS1_CH1_CLK_P						VDD_LVDS1_1P8	LVDS	Not muxed		
BL33	LVDS1_CH1_TX0_N										
BN33	LVDS1_CH1_TX0_P										
BK32	LVDS1_CH1_TX1_N										
BM32	LVDS1_CH1_TX1_P										
BL31	LVDS1_CH1_TX2_N										
BN31	LVDS1_CH1_TX2_P										
BK30	LVDS1_CH1_TX3_N										
BM30	LVDS1_CH1_TX3_P										
BD34	LVDS1_GPIO00	VDD_LVDS_DIG_1P8_3P3	GPIO	ALT0	LVDS1_GPIO00	PD					
BH36	LVDS1_GPIO01				LVDS1_GPIO01						
BL35	LVDS1_I2C0_SCL			ALT0	LVDS1_I2C0_SCL	LVDS1_I2C0_SDA					
BE33	LVDS1_I2C0_SDA										
BD32	LVDS1_I2C1_SCL										
BN35	LVDS1_I2C1_SDA										

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition		
				Default mode	Default function	State ²
AR47	M40_GPIO0_00	VDD_M4_GPT_UART_1P8_3P3	GPIO	ALT0	M40_GPIO0_00	PD
AU53	M40_GPIO0_01				M40_GPIO0_01	
AM44	M40_I2C0_SCL				M40_I2C0_SCL	PU
AU51	M40_I2C0_SDA				M40_I2C0_SDA	
AP44	M41_GPIO0_00				M41_GPIO0_00	PD
AU47	M41_GPIO0_01				M41_GPIO0_01	
AR45	M41_I2C0_SCL				M41_I2C0_SCL	PU
AU49	M41_I2C0_SDA				M41_I2C0_SDA	
BC3	MCLK_IN0				VDD_ESAI0_MCLK_1P8_3P3	GPIO
BD4	MCLK_OUT0	ALT3	LSIO.GPIO3.IO01	PD		
BE21	MIPI_CSI0_CLK_N	VDD_MIPI_CSI0_1P8	CSI	Not muxed		
BF20	MIPI_CSI0_CLK_P					
BE23	MIPI_CSI0_DATA0_N					
BF22	MIPI_CSI0_DATA0_P					
BE19	MIPI_CSI0_DATA1_N					
BF18	MIPI_CSI0_DATA1_P					
BE25	MIPI_CSI0_DATA2_N					
BF24	MIPI_CSI0_DATA2_P					
BE17	MIPI_CSI0_DATA3_N	VDD_MIPI_CSI0_1P8	CSI	Not muxed		
BF16	MIPI_CSI0_DATA3_P					
BL23	MIPI_CSI0_GPIO0_00	VDD_MIPI_CSI_DIG	GPIO	ALT0	MIPI_CSI0_GPIO0_00	PD
BM22	MIPI_CSI0_GPIO0_01				MIPI_CSI0_GPIO0_01	
BH24	MIPI_CSI0_I2C0_SCL				MIPI_CSI0_I2C0_SCL	PU
BN19	MIPI_CSI0_I2C0_SDA				MIPI_CSI0_I2C0_SDA	
BJ23	MIPI_CSI0_MCLK_OUT			ALT3	LSIO.GPIO1.IO29	PD

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition		
				Default mode	Default function	State ²
BH16	MIPI_CSI1_CLK_N	VDD_MIPI_CSI1_1P8	CSI	Not muxed		
BJ17	MIPI_CSI1_CLK_P					
BH18	MIPI_CSI1_DATA0_N					
BJ19	MIPI_CSI1_DATA0_P					
BH14	MIPI_CSI1_DATA1_N					
BJ15	MIPI_CSI1_DATA1_P					
BH20	MIPI_CSI1_DATA2_N					
BJ21	MIPI_CSI1_DATA2_P					
BH12	MIPI_CSI1_DATA3_N					
BJ13	MIPI_CSI1_DATA3_P					
BN15	MIPI_CSI1_GPIO0_00					
BN13	MIPI_CSI1_GPIO0_01	MIPI_CSI1_GPIO0_01				
BN17	MIPI_CSI1_I2C0_SCL	MIPI_CSI1_I2C0_SCL	PU			
BE15	MIPI_CSI1_I2C0_SDA	MIPI_CSI1_I2C0_SDA				
BN23	MIPI_CSI1_MCLK_OUT		ALT3	LSIO.GPIO1.IO29	PD	
BN27	MIPI_DSI0_CLK_N	VDD_MIPI_DSI0_1P8	DSI	Not muxed		
BL27	MIPI_DSI0_CLK_P					
BM28	MIPI_DSI0_DATA0_N					
BK28	MIPI_DSI0_DATA0_P					
BM26	MIPI_DSI0_DATA1_N					
BK26	MIPI_DSI0_DATA1_P					
BN29	MIPI_DSI0_DATA2_N					
BL29	MIPI_DSI0_DATA2_P					
BN25	MIPI_DSI0_DATA3_N					
BL25	MIPI_DSI0_DATA3_P					
BD30	MIPI_DSI0_GPIO0_00	VDD_MIPI_DSI_DIG_1P8_3P3	GPIO	ALT0	MIPI_DSI0_GPIO0_00	PD
BD28	MIPI_DSI0_GPIO0_01	VDD_MIPI_DSI_DIG_1P8_3P3	GPIO	ALT0	MIPI_DSI0_GPIO0_01	PD
BE29	MIPI_DSI0_I2C0_SCL				MIPI_DSI0_I2C0_SCL	PU
BE31	MIPI_DSI0_I2C0_SDA				MIPI_DSI0_I2C0_SDA	

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition			
				Default mode	Default function	State ²	
BH30	MIPI_DSI1_CLK_N	VDD_MIPI_DSI1_1P8	DSI	Not muxed			
BG31	MIPI_DSI1_CLK_P						
BH32	MIPI_DSI1_DATA0_N						
BG33	MIPI_DSI1_DATA0_P						
BH28	MIPI_DSI1_DATA1_N						
BG29	MIPI_DSI1_DATA1_P						
BH34	MIPI_DSI1_DATA2_N						
BG35	MIPI_DSI1_DATA2_P						
BH26	MIPI_DSI1_DATA3_N						
BG27	MIPI_DSI1_DATA3_P						
BM24	MIPI_DSI1_GPIO0_00	VDD_MIPI_DSI_DIG_1P8_3P3	GPIO	ALT0	MIPI_DSI1_GPIO0_00	PD	
BK24	MIPI_DSI1_GPIO0_01				MIPI_DSI1_GPIO0_01		
BE27	MIPI_DSI1_I2C0_SCL			MIPI_DSI1_I2C0_SCL	PU		
BG25	MIPI_DSI1_I2C0_SDA					MIPI_DSI1_I2C0_SDA	
D2	MLB_CLK ⁴	VDD_MLB_DIG_1P8_3P3	GPIO	ALT0	MLB_CLK	PD	
E3	MLB_DATA ⁴				MLB_DATA		
E1	MLB_SIG ⁴				MLB_SIG		
E33	MLB_CLK_N ⁵	VDD_MLB_1P8	MLB	Not muxed			
D32	MLB_CLK_P ⁵						
E35	MLB_DATA_N ⁵						
F34	MLB_DATA_P ⁵						
E31	MLB_SIG_N ⁵						
D30	MLB_SIG_P ⁵						
BE47	ON_OFF_BUTTON	VDD_SNVLS_LDO_1P8_CAP	ANA	Not muxed		PU	
A17	PCIE_CTRL0_CLKREQ_B	VDD_PCIE_DIG_1P8_3P3	GPIO	ALT0	PCIE_CTRL0_CLKREQ_B	PD	
D20	PCIE_CTRL0_PERST_B				PCIE_CTRL0_PERST_B		
A15	PCIE_CTRL0_WAKE_B			PCIE_CTRL0_WAKE_B	PU		
A25	PCIE_CTRL1_CLKREQ_B					PCIE_CTRL1_CLKREQ_B	PD
G25	PCIE_CTRL1_PERST_B						
A27	PCIE_CTRL1_WAKE_B					PCIE_CTRL1_WAKE_B	PU

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition					
				Default mode	Default function	State ²			
E23	PCIE_REF_QR	VDD_PCIE_LDO_1P8	PCIE	Not muxed					
D22	PCIE_REXT								
M20	PCIE_SATA0_PHY_PLL_REF_RETURN ³								
M28	PCIE0_PHY_PLL_REF_RETURN								
N23	PCIE1_PHY_PLL_REF_RETURN								
E25	PCIE_SATA_REFCLK100M_N ³	VDD_PCIE_LDO_1P0_CAP	PCIE	HCSL compatible clock Not muxed					
F26	PCIE_SATA_REFCLK100M_P ³			Not muxed					
B20	PCIE_SATA0_RX0_N ³								
A19	PCIE_SATA0_RX0_P ³								
C17	PCIE_SATA0_TX0_N ³								
B16	PCIE_SATA0_TX0_P ³								
B30	PCIE0_RX0_N								
A29	PCIE0_RX0_P								
C27	PCIE0_TX0_N								
B26	PCIE0_TX0_P								
B22	PCIE1_RX0_N								
A21	PCIE1_RX0_P								
C25	PCIE1_TX0_N								
B24	PCIE1_TX0_P								
BF50	PMIC_EARLY_WARNING						VDD_SCU_1P8	SCU	ALT0
AY46	PMIC_I2C_SCL	PMIC_I2C_SCL	PU						
BG51	PMIC_I2C_SDA	PMIC_I2C_SDA							
BH50	PMIC_INT_B	PMIC_INT_B							
BL51	PMIC_ON_REQ	VDD_SNVS_LDO_1P8_CAP	ANA	Not muxed		Drive-1			
BE49	POR_B	VDD_SCU_1P8	SCU			PU			

Package information and contact assignments

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition		
				Default mode	Default function	State ²
G13	QSPI0A_DATA0	VDD_QSPI0_1P8_3P3	FASTD	ALT0	QSPI0A_DATA0	PD
F14	QSPI0A_DATA1				QSPI0A_DATA1	
H14	QSPI0A_DATA2				QSPI0A_DATA2	
H16	QSPI0A_DATA3				QSPI0A_DATA3	
G17	QSPI0A_DQS				QSPI0A_DQS	
E17	QSPI0A_SCLK				QSPI0A_SCLK	
E15	QSPI0A_SS0_B				QSPI0A_SS0_B	
F16	QSPI0A_SS1_B				QSPI0A_SS1_B	
H18	QSPI0B_DATA0	VDD_QSPI0_1P8_3P3	FASTD	ALT0	QSPI0B_DATA0	PD
H20	QSPI0B_DATA1				QSPI0B_DATA1	
G19	QSPI0B_DATA2				QSPI0B_DATA2	
F20	QSPI0B_DATA3				QSPI0B_DATA3	
H22	QSPI0B_DQS				QSPI0B_DQS	
F18	QSPI0B_SCLK				QSPI0B_SCLK	
F22	QSPI0B_SS0_B				QSPI0B_SS0_B	
H24	QSPI0B_SS1_B				QSPI0B_SS1_B	
D12	QSPI1A_DATA0	VDD_QSPI1A_1P8_3P3	FASTD	ALT0	QSPI1A_DATA0	PD
D14	QSPI1A_DATA1				QSPI1A_DATA1	
E13	QSPI1A_DATA2				QSPI1A_DATA2	
E11	QSPI1A_DATA3				QSPI1A_DATA3	
H12	QSPI1A_DQS				QSPI1A_DQS	
F10	QSPI1A_SCLK				QSPI1A_SCLK	
J11	QSPI1A_SS0_B				QSPI1A_SS0_B	
G11	QSPI1A_SS1_B				QSPI1A_SS1_B	
BN47	RTC_XTALI	VDD_SNVS_LDO_1P8_CAP	ANA	Not muxed		
BL47	RTC_XTALO					
AV6	SAI1_RXC	VDD_SPI_SAI_1P8_3P3	GPIO	ALT0	SAI1_RXC	PD
AV4	SAI1_RXD				SAI1_RXD	
AU3	SAI1_RXFS				SAI1_RXFS	
AU5	SAI1_TXC				SAI1_TXC	
AU1	SAI1_TXD				SAI1_TXD	
AV2	SAI1_TXFS				SAI1_TXFS	

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition		
				Default mode	Default function	State ²
BB44	SCU_BOOT_MODE0	VDD_SCU_1P8	SCU		Not muxed	PD
BC45	SCU_BOOT_MODE1					
BJ53	SCU_BOOT_MODE2					
BA43	SCU_BOOT_MODE3					
AY42	SCU_BOOT_MODE4					
BK52	SCU_BOOT_MODE5					
AU43	SCU_GPIO0_00	VDD_SCU_1P8	GPIO	ALT0	SCU_GPIO0_00	PD
AV44	SCU_GPIO0_01				SCU_GPIO0_01	PU
AW45	SCU_GPIO0_02				SCU_GPIO0_02	PD
BB46	SCU_GPIO0_03	VDD_SCU_1P8	GPIO	ALT0	SCU_GPIO0_03	PD
BC47	SCU_GPIO0_04				SCU_GPIO0_04	
AY44	SCU_GPIO0_05				SCU_GPIO0_05	
BG49	SCU_GPIO0_06				SCU_GPIO0_06	
BF48	SCU_GPIO0_07				SCU_GPIO0_07	
BC53	SCU_PMIC_MEMC_ON				VDD_SCU_1P8	
BA47	SCU_PMIC_STANDBY					
BB50	SCU_WDOG_OUT					
AL45	SIM0_CLK	VDD_SIM0_1P8_3P3	GPIO	ALT3	LSIO.GPIO0.IO00	PD
AP46	SIM0_GPIO0_00				LSIO.GPIO0.IO05	
AN45	SIM0_IO				LSIO.GPIO0.IO02	
AL43	SIM0_PD				SIM0_PD	PD
AT48	SIM0_POWER_EN				LSIO.GPIO0.IO04	PD
AP48	SIM0_RST				SIM0_RST	
BE41	SNVS_TAMPER_IN0	VDD_SNVS_LDO_1P8_CAP	ANA		Not muxed	Hi-Z
BE43	SNVS_TAMPER_IN1					
BD46	SNVS_TAMPER_OUT0					
BD42	SNVS_TAMPER_OUT1					
BD6	SPDIF0_EXT_CLK	VDD_ESAI1_SPDIF_SPI_1P8_3P3	GPIO	ALT0	SPDIF0_EXT_CLK	PD
BC7	SPDIF0_RX				SPDIF0_RX	
BC9	SPDIF0_TX			ALT3	LSIO.GPIO2.IO15	PD

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition		
				Default mode	Default function	State ²
BC1	SPI0_CS0	VDD_SPI_SAI_1P8_3P3	GPIO	ALT0	SPI0_CS0	PD
BA3	SPI0_CS1				SPI0_CS1	
BB4	SPI0_SCK				SPI0_SCK	
BA5	SPI0_SDI				SPI0_SDI	
AY6	SPI0_SDO			ALT3	LSIO.GPIO3.IO03	PD
AW1	SPI2_CS0			ALT0	SPI2_CS0	PD
AY2	SPI2_CS1				SPI2_CS1	
AW5	SPI2_SCK				SPI2_SCK	
AY4	SPI2_SDI				SPI2_SDI	
BA1	SPI2_SDO			ALT3	LSIO.GPIO3.IO08	PD
BG5	SPI3_CS0			VDD_ESAI1_SPDIF_SPI_1P8_3P3	GPIO	ALT0
BD8	SPI3_CS1	SPI3_CS1				
BF6	SPI3_SCK	VDD_ESAI1_SPDIF_SPI_1P8_3P3	GPIO	ALT0	SPI3_SCK	PD
BE5	SPI3_SDI				SPI3_SDI	
BF2	SPI3_SDO			ALT3	LSIO.GPIO2.IO18	PD
BC49	TEST_MODE_SELECT	VDD_SCU_1P8	SCU	Not muxed		PD
AW49	UART0_CTS_B	VDD_M4_GPT_UART_1P8_3P3	GPIO	ALT0	UART0_CTS_B	PD
AU45	UART0_RTS_B			ALT3	LSIO.GPIO0.IO22	PD
AV50	UART0_RX			ALT0	UART0_RX	PD
AV48	UART0_TX			ALT3	LSIO.GPIO0.IO21	PD
AV46	UART1_CTS_B			ALT0	UART1_CTS_B	PD
AR43	UART1_RTS_B			ALT3	LSIO.GPIO0.IO26	PD
AT44	UART1_RX			ALT0	UART1_RX	PD
AY48	UART1_TX			ALT3	LSIO.GPIO0.IO24	PD
H26	USB_HSIC0_DATA	VDD_USB_HSIC0_1P2	FASTD	ALT0	USB_HSIC0_DATA	Hi-Z
F28	USB_HSIC0_STROBE				USB_HSIC0_STROBE	
C39	USB_OTG1_DN	VDD_USB_OTG1_3P3	OTG	Not muxed		
B40	USB_OTG1_DP					
A37	USB_OTG1_ID					
A39	USB_OTG1_VBUS					

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition		
				Default mode	Default function	State ²
C37	USB_OTG2_DN	VDD_USB_OTG2_3P3	OTG	Not muxed		
B38	USB_OTG2_DP					
F30	USB_OTG2_ID					
E29	USB_OTG2_REXT					
A35	USB_OTG2_VBUS					
E27	USB_SS3_REXT	VDD_USB_SS3_LDO_1P0_CAP	USB3	Not muxed		
B34	USB_SS3_RX_N					
C35	USB_SS3_RX_P					
B32	USB_SS3_TX_N					
A33	USB_SS3_TX_P					
J9	USB_SS3_TC0	VDD_USB_SS3_TC_3P3	GPIO	ALT0	USB_SS3_TC0	PU
L9	USB_SS3_TC1				USB_SS3_TC1	
F8	USB_SS3_TC2				USB_SS3_TC2	
H10	USDHC1_TC3				USB_SS3_TC3	
J39	USDHC1_CLK	VDD_USDHC1_1P8_3P3	FASTD	ALT0	USDHC1_CLK	Drive-0
G41	USDHC1_CMD	VDD_USDHC1_1P8_3P3	FASTD	ALT0	USDHC1_CMD	PD
E37	USDHC1_DATA0				USDHC1_DATA0	PU
F38	USDHC1_DATA1				USDHC1_DATA1	
E39	USDHC1_DATA2				USDHC1_DATA2	
F40	USDHC1_DATA3				USDHC1_DATA3	
H40	USDHC1_DATA4				USDHC1_DATA4	
G43	USDHC1_DATA5				USDHC1_DATA5	
F42	USDHC1_DATA6				USDHC1_DATA6	
H42	USDHC1_DATA7				USDHC1_DATA7	
J43	USDHC1_STROBE					
A5	USDHC1_RESET_B	VDD_USDHC_VSELECT_1P8_3P3	GPIO	ALT3	LSIO.GPIO4.IO07	PU
B4	USDHC1_VSELECT				LSIO.GPIO4.IO07	
B8	USDHC2_CD_B				ALT0	USDHC2_CD_B

Table 127. 29 × 29 mm functional contact assignments (continued)

Ball	Ball Name	Power Domain	Ball Type ¹	Reset Condition			
				Default mode	Default function	State ²	
F46	USDHC2_CLK	VDD_USDHC2_1P8_3P3	FASTD	ALT3	LSIO.GPIO5.IO24	PD	
H44	USDHC2_CMD			ALT0	USDHC2_CMD	PD	
H48	USDHC2_DATA0				USDHC2_DATA0	PU	
G45	USDHC2_DATA1					USDHC2_DATA1	
L45	USDHC2_DATA2						USDHC2_DATA2
J45	USDHC2_DATA3						
C7	USDHC2_RESET_B	VDD_USDHC_VSELECT_1P8_3P3	GPIO	ALT3	LSIO.GPIO4.IO09	PU	
A7	USDHC2_VSELECT			LSIO.GPIO4.IO10			
D8	USDHC2_WP			ALT0	USDHC2_WP	PD	
BN49	XTALI	VDD_SCU_XTAL_1P8	ANA	Not muxed			
BL49	XTALO						

¹ FASTD are GPIO balls configured for high speed operation using the FASTFRZ control.

² Reset condition shown is before boot code execution. For pad changes after boot code execution, see the “System Boot” chapter of the device reference manual,

³ HDMI-RX is not currently supported, the related power and signal connections are provided for future use when it is expected HDMI-RX support will be enabled.

⁴ MLB is not supported on this device. Users may choose alternate functions as determined by the IOMUX.

⁵ MLB is not supported on this device. Terminate these outputs per the Hardware Developer’s Guide for unused I/O signals.

The following table shows the DRAM pin function for the 29 x 29 mm package.

Table 128. 29 x 29 mm DRAM pin function

Ball Name	x = 0	x = 1	LPDDR4 Function	Notes
DDR_CHx_ATO	AF46	AF8	—	NXP Internal Use Only (Leave Unconnected)
DDR_CHx_CK0_N	Y50	Y4	CK_c_A	The exact clock and control line connections will be dependent on the memory configuration in use. Refer to the Hardware Developers Guide (HDG) for further details.
DDR_CHx_CK0_P	W49	W5	CK_t_A	
DDR_CHx_CK1_N	AB50	AB4	CK_c_B	
DDR_CHx_CK1_P	AC49	AC5	CK_t_B	
DDR_CHx_DCF00	U47	U7	CA2_A	
DDR_CHx_DCF01	W47	W7	CA4_A	
DDR_CHx_DCF02	Y48	Y6	—	
DDR_CHx_DCF03	Y46	Y8	CA5_A	
DDR_CHx_DCF04	W43	W11	—	
DDR_CHx_DCF05	Y44	Y10	—	
DDR_CHx_DCF06	W45	W9	—	
DDR_CHx_DCF07	W51	W3	—	
DDR_CHx_DCF08	T48	T6	CA3_A	
DDR_CHx_DCF09	T52	T2	—	
DDR_CHx_DCF10	T50	T4	CS0_A	
DDR_CHx_DCF11	U51	U3	CA0_A	
DDR_CHx_DCF12	U49	U5	CS1_A	
DDR_CHx_DCF13	T46	T8	—	
DDR_CHx_DCF14	W53	W1	CKE0_A	
DDR_CHx_DCF15	Y52	Y2	CKE1_A	
DDR_CHx_DCF16	U53	U1	CA1_A	
DDR_CHx_DCF17	AC47	AC7	CA4_B	
DDR_CHx_DCF18	AB48	AB6	RESET_N	
DDR_CHx_DCF19	AB46	AB8	CA5_B	
DDR_CHx_DCF20	AC43	AC11	—	
DDR_CHx_DCF21	AE45	AE9	—	
DDR_CHx_DCF22	AC51	AC3	—	
DDR_CHx_DCF23	AC45	AC9	—	
DDR_CHx_DCF24	AB44	AB10	—	

Table 128. 29 x 29 mm DRAM pin function (continued)

Ball Name	x = 0	x = 1	LPDDR4 Function	Notes
DDR_CHx_DCF25	AF52	AF2	—	The exact clock and control line connections will be dependent on the memory configuration in use. Refer to the Hardware Developers Guide (HDG) for further details.
DDR_CHx_DCF26	AE47	AE7	CA3_B	
DDR_CHx_DCF27	AE51	AE3	CA0_B	
DDR_CHx_DCF28	AF50	AF4	CS0_B	
DDR_CHx_DCF29	AE49	AE5	CS1_B	
DDR_CHx_DCF30	AC53	AC1	CKE0_B	
DDR_CHx_DCF31	AB52	AB2	CKE1_B	
DDR_CHx_DCF32	AE53	AE1	CA1_B	
DDR_CHx_DCF33	AF48	AF6	CA2_B	
DDR_CHx_DM0	H52	H2	DMI[3..0]	
DDR_CHx_DM1	N47	N7		
DDR_CHx_DM2	AJ47	AJ7		
DDR_CHx_DM3	AP52	AP2	DQ[31..0]	
DDR_CHx_DQ00	P44	P10		
DDR_CHx_DQ01	N45	N9		
DDR_CHx_DQ02	L47	L7		
DDR_CHx_DQ03	K48	K6		
DDR_CHx_DQ04	H50	H4		
DDR_CHx_DQ05	G53	G1		
DDR_CHx_DQ06	G51	G3		
DDR_CHx_DQ07	N43	N11		
DDR_CHx_DQ08	L49	L5		
DDR_CHx_DQ09	K50	K4		
DDR_CHx_DQ10	N51	N3		
DDR_CHx_DQ11	L51	L3		
DDR_CHx_DQ12	P46	P8		
DDR_CHx_DQ13	N49	N5		
DDR_CHx_DQ14	P50	P4		
DDR_CHx_DQ15	P48	P6		
DDR_CHx_DQ16	AM50	AM4		
DDR_CHx_DQ17	AL49	AL5		
DDR_CHx_DQ18	AL51	AL3		
DDR_CHx_DQ19	AJ51	AJ3		

Table 128. 29 x 29 mm DRAM pin function (continued)

Ball Name	x = 0	x = 1	LPDDR4 Function	Notes	
DDR_CHx_DQ20	AJ49	AJ5	DQ[31..0]	The exact mask, strobe and data connections to memory are flexible as long as the correct byte mapping is used, there is no restriction on the bit connections within each byte. DM0 -> DQS0(_N/P) -> DQ[7..0] DM1 -> DQS1(_N/P) -> DQ[15..8] DM2 -> DQS2(_N/P) -> DQ[23..16] DM3 -> DQS3(_N/P) -> DQ[31..24]	
DDR_CHx_DQ21	AH46	AH8			
DDR_CHx_DQ22	AH48	AH6			
DDR_CHx_DQ23	AH50	AH4			
DDR_CHx_DQ24	AJ45	AJ9			
DDR_CHx_DQ25	AH44	AH10			
DDR_CHx_DQ26	AM48	AM6			
DDR_CHx_DQ27	AL47	AL7			
DDR_CHx_DQ28	AR53	AR1			
DDR_CHx_DQ29	AP50	AP4			
DDR_CHx_DQ30	AJ43	AJ11			
DDR_CHx_DQ31	AR51	AR3			
DDR_CHx_DQS0_N	L53	L1			DQS[3..0]_c maps to _N DQS[3..0]_t maps to _P
DDR_CHx_DQS0_P	K52	K2			
DDR_CHx_DQS1_N	P52	P2			
DDR_CHx_DQS1_P	N53	N1			
DDR_CHx_DQS2_N	AH52	AH2			
DDR_CHx_DQS2_P	AJ53	AJ1			
DDR_CHx_DQS3_N	AL53	AL1			
DDR_CHx_DQS3_P	AM52	AM2			
DDR_CHx_DTO0	U45	U9	—	NXP Internal Use Only (Leave Unconnected)	
DDR_CHx_DTO1	T44	T10	—		
DDR_CHx_VREF	U43	U11	—	—	
DDR_CHx_ZQ	AF44	AF10	—	—	

7 Release Notes

This table provides release notes for the data sheet.

Table 129. Data sheet release notes

Rev. Number	Date	Substantive Change(s)
2	05/2021	<ul style="list-style-type: none"> • Clarified LVDS Tx port information in Table 1, "i.MX 8QuadPlus advanced features" under Display I/O. • Updated Table 2, "i.MX 8QuadPlus Orderable part numbers" information. • Updated the example in Section 1.2, "System Controller Firmware (SCFW) Requirements". • Corrected document IDs in Table 3, "Related resources". • Updated LVDS information and clarified KHz for XTAL OSC32K in Table 4, "i.MX 8QuadPlus modules list". • In Table 8, "Operating ranges", added min frequency for VDD_A72 and VDD_A53. • Updated note in Section 4.1.5, "Maximum Supply Currents". • Updated the value ranges in Table 26, "LVDS PHY PLL". • Updated footnotes pointing to Section 4.6.2, "Input Signal Monotonic Requirements" in Table 30, Table 31, Table 32, Table 33, Table 34, Table 35, and Table 36. • Corrected test conditions in Table 38, "LPDDR4 DC parameters". • Added Section 4.6.2, "Input Signal Monotonic Requirements". • Corrected maximum frequency test conditions and footnotes 2 and 3 in Table 40, "General Purpose I/O AC Parameters". • In Table 81, "LVDS pins", updated single channel values. • Updated PCI Express Gen 2 values for A_{OPENING} and added footnote to Table 93, "PCIe receiver eye specifications for example standards". • Rewrote introductory paragraph for Section 5.1, "Boot mode configuration inputs". • Clarified QSPI information in Table 125, "Interface allocation during boot". • Corrected default function for Ball AP46 in Table 127, "29 x 29 mm functional contact assignments". • Corrected x=0 column value for DDR_CHx_DTO1 in Table 128, "29 x 29 mm DRAM pin function".

How To Reach Us

Home Page:

nxp.com

Web Support:

nxp.com/support

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors. In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes - NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Security — Customer understands that all NXP products may be subject to unidentified or documented vulnerabilities. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer's applications and products. Customer's responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer's applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately.

Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP. NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Suitability for use in automotive applications — This NXP Semiconductors product has been qualified for use in automotive applications. Unless otherwise agreed in writing, the product is not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors and its suppliers accept no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

Table continues on the next page...

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.nxp.com/profile/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Bare die — All die are tested on compliance with their related technical specifications as stated in this data sheet up to the point of wafer sawing and are handled in accordance with the NXP Semiconductors storage and transportation conditions. If there are data sheet limits not guaranteed, these will be separately indicated in the data sheet. There are no post-packing tests performed on individual die or wafers.

NXP Semiconductors has no control of third party procedures in the sawing, handling, packing or assembly of the die. Accordingly, NXP Semiconductors assumes no liability for device functionality or performance of the die or systems after third party sawing, handling, packing or assembly of the die. It is the responsibility of the customer to test and qualify their application in which the die is used. All die sales are conditioned upon and subject to the customer entering into a written die sale agreement with NXP Semiconductors through its legal department.

Quick reference data — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Translations — A non-English (translated) version of a document is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

NXP, the NXP logo, NXP SECURE CONNECTIONS FOR A SMARTER WORLD, COOLFLUX, EMBRACE, GREENCHIP, HITAG, ICODE, JCOP, LIFE, VIBES, MIFARE, MANTIS, MIGLO, NTAG, ROADLINK, SMARTLX, SMARTMX, STARPLUG, TOPFET, TRENCHMOS, UCODE, Freescale, the Freescale logo, Altivec, CodeWarrior, ColdFire, ColdFire+, the Energy Efficient Solutions logo, Kinetis, Layerscape, MagniV, mobileGT, PEG, PowerQUICC, Processor Expert, QorIQ, QorIQ Qonverge, SafeAssure, the SafeAssure logo, StarCore, Symphony, VortiQa, Airfast, BeeKit, BeeStack, CoreNet, Flexis, MXC, Platform in a Package, QUICC Engine, Tower, TurboLink, EdgeScale, EdgeLock, eIQ, and Immersive3D are trademarks of NXP B.V. All other product or service names are the property of their respective owners. AMBA, Arm, Arm7, Arm7TDMI, Arm9, Arm11, Artisan, big.LITTLE, Cordio, CoreLink, CoreSight, Cortex, DesignStart, DynamiQ, Jazelle, Keil, Mali, Mbed, Mbed Enabled, NEON, POP, RealView, SecurCore, Socrates, Thumb, TrustZone, ULINK, ULINK2, ULINK-ME, ULINK-PLUS, ULINKpro, μ Vision, Versatile are trademarks or registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere. The related technology may be protected by any or all of patents, copyrights, designs and trade secrets. All rights reserved. Oracle and Java are registered trademarks of Oracle and/or its affiliates. M, M Mobileye and other Mobileye trademarks or logos appearing herein are trademarks of Mobileye Vision Technologies Ltd. in the United States, the EU and/or other jurisdictions.