

# S32G2

## S32G2 Data Sheet

Rev. 7 — 09/2024

Data Sheet: Technical Data

- This document provides electrical specifications for S32G2.
- For functional characteristics and the programming model, see S32G Reference Manual.



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# 1 Introduction

## 1.1 Overview

S32G2 is a family of high-performance vehicle network processors that combine controller area network (CAN), local interconnect network (LIN), and FlexRay networking with high-data-rate Ethernet networking. It also combines a functional safe-core infrastructure with MPU cores and includes high-level security features.

S32G2 family includes the following variants:

- S32G234M
- S32G233A
- S32G254A
- S32G274A

This document primarily represents the features offered by the superset S32G274A.

## 1.2 Applications

Combining ASIL D safety, hardware security, high-performance real-time and application processing and network acceleration, this chip targets applications that includes:

- Central gateways and domain controllers connecting various networks and translating their protocols
- Safety processor for ADAS and autonomous driving
- High-performance central compute nodes
- FOTA masters controlling secure software image downloads and their distribution to the ECUs in the network
- Secure key management
- Smart antennas

# 2 Block diagram

The following figure shows the block diagram for S32G274A, the superset chip in the S32G2 family.

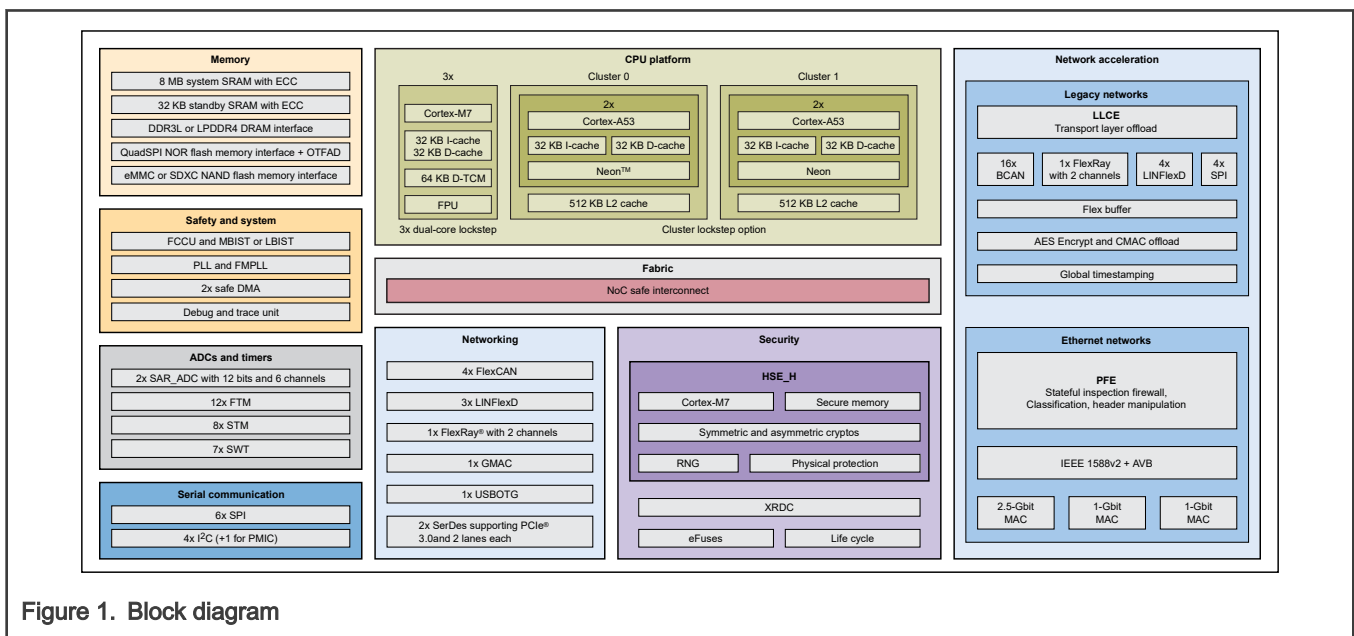


Figure 1. Block diagram

### 3 Feature comparison

The following table compares the features of chips in the S32G2 family.

**Table 1. Feature comparison**

Feature	S32G234M	S32G233A	S32G254A	S32G274A
Compute and bus modules				
CPUs: applications	N/A	Cluster 0: single Cortex-A53 core (only core 0 is available on these chips)		Cluster 0: dual Cortex-A53 core
		Cluster 1: single Cortex-A53 core (only Core 0 is available on these chips)		Cluster 1: dual Cortex-A53 core
L1 cache	N/A	32 KB I-cache and 32 KB D-cache per Cortex-A53 core		
L2 cache	N/A	512 KB per cluster		
Cache coherency interconnect	N/A	Yes		
Interrupt controller for Cortex-A53 core	N/A	Generic interrupt controller (CoreLink™ GIC-500)		
Core maximum frequencies	Cortex-M7 core: 400 MHz	Cortex-A53 core: 1 GHz Cortex-M7 core: 400 MHz		
Lockstep support for Cortex-A53 cores	N/A	Configurable: lockstep clusters or two independent clusters		
CPUs: real-time	3 Cortex-M7 cores in lockstep	1 Cortex-M7 core in lockstep (only the Cortex-M7 core 0 is available on these chips)	3 Cortex-M7 cores in lockstep	
L1 cache	32 KB I-cache and 32 KB D-cache per Cortex-M7 core			
DTCM	64 KB per Cortex-M7 core			
Interrupt controller for Cortex-M7 core	3 NVICs	1 NVIC	3 NVICs	
DMA	2 eDMA (supporting lockstep), each with 32 channels			
DMAMUX inputs	128 per DMA			
Debug run control	Arm CoreSight™ JTAG (IEEE 1149.1)			
Debug trace	Aurora 4-lane			
SWT	7			
STM	8			
Memory modules				
System RAM	8 MB	6 MB	8 MB	
System RAM ports	16 ports, interleaved 64-byte			

*Table continues on the next page...*

**Table 1. Feature comparison (continued)**

Feature	S32G234M	S32G233A	S32G254A	S32G274A
DRAM	N/A	LPDDR4 and DDR3L		
DRAM physical interface (PHY)	N/A	×32		
QuadSPI	1 (supports two identical devices)			
uSDHC	1			
Fuses <sup>1</sup>	2 banks at 4k Bits each			
Standby SRAM with ECC	32 KB			
Security modules				
Security subsystem	HSE_H			
Resource isolation	XRDC supporting 8 domains			
Arm TrustZone®	N/A	Yes		
Life cycle	Yes			
Secure debug	Yes			
OTFAD	Yes			
Communication interface modules				
Comms acceleration	LLCE			
CAN with flexible data rate	16 (in LLCE) + 4			
FlexRay with dual-channel support for protocol version 2.1	1 (in LLCE) + 1			
LINFlexD	4 (in LLCE) + 3			
SPI	4 (in LLCE, can be enabled with firmware) + 6			
Ethernet acceleration	PFE			
MAC	4 (3 PFE_MAC + 1 GMAC_0)			
Supported Ethernet interfaces	MII, RMII, RGMII, and SGMII			
SerDes subsystem with PCIe	1 supporting Gen2 in X1 and X2 modes (PCIe_0 only)	2 supporting Gen3 in X1 and X2 modes		
SerDes subsystem lanes	4 configurable for PCIe or SGMII			
USBOTG	N/A	1 supporting USB 2.0 and ULPI interfaces		
I <sup>2</sup> C	5			
CRC	1			
Generic modules				

*Table continues on the next page...*

Table 1. Feature comparison (continued)

Feature	S32G234M	S32G233A	S32G254A	S32G274A
PIT	2			
SAR_ADC	2, each supporting 12 bits and 6 channels			
FTM	2, each supporting 6 channels			
CTU	1			
SEMA42	1			
Clocking, power, and reset				
FIRC frequency	48 MHz			
SIRC frequency	32 kHz			
FXOSC frequency	20–40 MHz			
PLL	5			
Low-power mode	Yes			
RTC	1 with API function			
Wake-up sources	24			
Miscellaneous				
Package	525 flip chip plastic ball grid array (525 FC-PBGA), 19 mm × 19 mm, 0.8 mm pitch			

1. The first 4k Bits bank is assigned exclusively to the HSE. The second 4k Bits bank is solely for system configuration and not free for other user purposes.

## 4 Ordering Parts

### 4.1 Ordering information

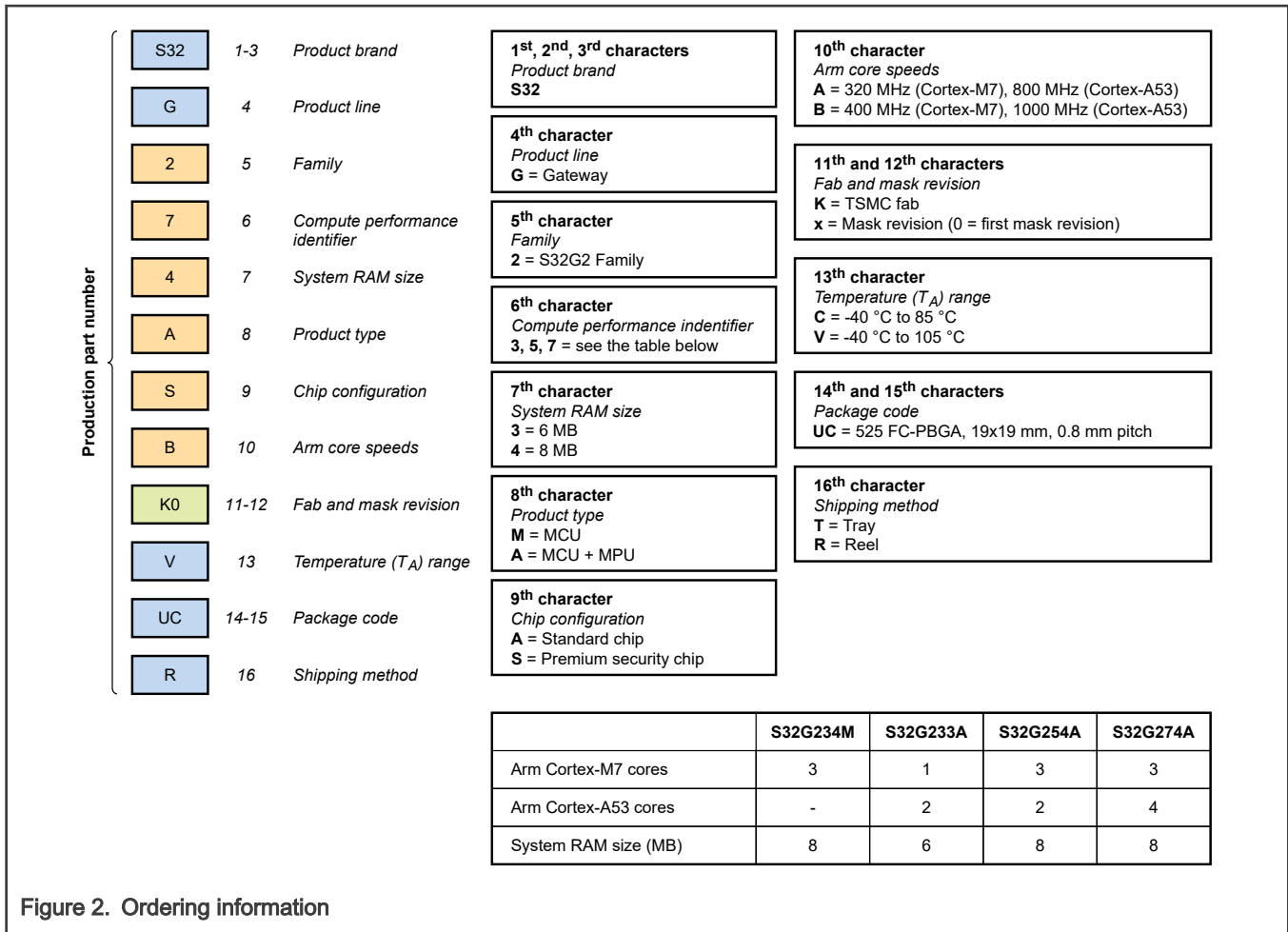


Figure 2. Ordering information

## 5 Electrostatic Discharge (ESD) Characteristics

The following table gives the ESD ratings and test conditions for the device.

Table 2. Electrostatic Discharge (ESD) Characteristics

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
—	ESD Human Body Model (HBM) <sup>1,2,3</sup>	—	—	2000	V	All pins	—
—	ESD Charged Device Model (CDM) <sup>1,2,4</sup>	—	—	250	V	All pins	—

1. Device failure is defined as: "If after exposure to ESD pulses, the device does not meet the device specification requirements."
2. All ESD testing conforms with AEC-Q100 Stress Test Qualification for Automotive Grade Integrated Circuits.
3. This parameter is tested in conformity with AEC-Q100-002
4. This parameter is tested in conformity with AEC-Q100-011.



## 6 Maximum Ratings

### 6.1 Absolute Max Ratings

This table defines the absolute maximum ratings for the device in terms of reliability characteristics. Absolute maximum rating specifications are stress ratings only, and functional operation is not guaranteed under these conditions. Functional operating conditions are given in the Operating Conditions section of this document.

**NOTE**

All specifications associated with VIN are measured at the SoC pin.

**Table 3. Absolute Max Ratings**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VDD	Core voltage Supply <sup>1,2</sup>	-0.3	—	0.96	V	—	—
VSS	Ground Supply <sup>1</sup>	-0.3	—	0.3	V	—	—
VDD_STBY	Standby domain supply voltage <sup>1,2</sup>	-0.3	—	0.96	V	—	—
VDD_LV_PLL	PLL digital voltage supply <sup>1,2,3</sup>	-0.3	—	0.96	V	—	—
VDD_LV_PLL_AUR	Aurora PLL digital voltage supply <sup>1,2</sup>	-0.3	—	0.96	V	—	—
VDD_LV_PLL_DDR0	DDR0 PLL digital voltage supply <sup>1,2</sup>	-0.3	—	0.96	V	—	—
VDD_VP_PCIEEn	PCIE0/1 core voltage supply (n=0, 1) <sup>1,2</sup>	-0.3	—	0.96	V	—	—
VDD_FIRC	FIRC high voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VDD_EFUSE	EFUSE high voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VDD_IO_x	GPIO 3.3V supply <sup>1,5</sup>	-0.3	—	4	V	—	—
VDD_IO_A	GPIO A 3.3V supply <sup>1,5</sup>	-0.3	—	4	V	—	—
VDD_IO_B	GPIO B 3.3V supply <sup>1,5</sup>	-0.3	—	4	V	—	—
VDD_IO_GMAC0	GMAC0 I/O voltage supply <sup>1,5</sup>	-0.3	—	4	V	—	—
VDD_IO_GMAC1	GMAC1 I/O voltage supply <sup>1,5</sup>	-0.3	—	4	V	—	—
VDD_IO_QSPI	QSPI A I/O voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—

*Table continues on the next page...*

**Table 3. Absolute Max Ratings (continued)**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VDD_IO_SDHC	uSDHC / QSPI B I/O voltage supply <sup>1,5</sup>	-0.3	—	4	V	—	—
VDD_IO_CLKOUT	CLKOUT 1.8V I/O supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VDD_IO_AUR	Aurora 1.8V I/O supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VDD_IO_DDR0	DDR0 I/O voltage supply <sup>1</sup>	-0.3	—	2.16	V	—	—
VDD_IO_USB	USB I/O voltage supply <sup>1,5</sup>	-0.3	—	4	V	—	—
VDD_IO_STBY	Standby domain I/O voltage supply <sup>1,5</sup>	-0.3	—	4	V	—	—
VDD_VREF	Supply detector high voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VDD_ADC	ADC voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	Reference to VSS_ ADC	—
VSS_ADC	ADC ground supply <sup>1</sup>	-0.3	—	0.3	V	Reference to VSS	—
VDD_HV_PLL	PLL high voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VDD_HV_PLL_AUR	Aurora PLL high voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VDD_HV_PLL_DDR0	DDR PLL voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VDD_DDR0	DDR0 high voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	DDR PHY PLL	—
VDD_FXOSC	FXOSC high voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	Reference to VSS_ FXOSC	—
VSS_FXOSC	FXOSC ground supply <sup>1</sup>	-0.3	—	0.3	V	Reference to VSS	—
VEXTAL	FXOSC EXTAL input voltage range <sup>1,4,6</sup>	-0.3	—	2.16	V	—	—
VXTAL	FXOSC XTAL input voltage range <sup>1,4,6</sup>	-0.3	—	2.16	V	—	—
VDD_IO_PCIE <sub>n</sub>	PCIE0/1 high voltage supply (n=0, 1) <sup>1,4</sup>	-0.3	—	2.16	V	—	—

*Table continues on the next page...*

Table 3. Absolute Max Ratings (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VDD_TMU	Thermal Monitoring Unit (TMU) high voltage supply <sup>1,4</sup>	-0.3	—	2.16	V	—	—
VREFH_ADC	ADC reference high voltage <sup>1,4</sup>	-0.3	—	2.16	V	Reference to VREFL_ADC	—
VREFL_ADC	ADC reference low voltage <sup>1</sup>	-0.3	—	0.3	V	Reference to VSS	—
VAD_INPUT	ADC input voltage range <sup>1,7,8</sup>	VREFL_ADC -0.6	—	VREFH_ADC +0.5	V	—	—
VIN	GPIO input voltage range <sup>1,9,10,11</sup>	VSS - 0.3	—	VDD_IO_* + 0.3	V	—	—
IINJ_D	Maximum DC current injection digital I/O pin <sup>1,12</sup>	-3	—	3	mA	—	—
IINJ_A	Maximum DC current injection analog input pin <sup>1,7,13</sup>	-1	—	1	mA	—	—
IINJ_LVDS	Max LVDS RX or TX pin injection current <sup>1,14</sup>	0	—	100	uA	—	—
IMAXSEG	Maximum RMS current per GPIO supply domain (VDD_IO_*) <sup>1</sup>	—	—	140	mA	—	—
TSTG	Storage temperature range <sup>1</sup>	-55	—	150	C	—	—
TSDR	Maximum solder temperature <sup>1,15</sup>	—	—	260	C	Pb free	—
MSL	Moisture Sensitivity Level <sup>1,16</sup>	—	—	3	—	—	—
V_OS_US_10	Voltage at 10 % of t <sub>SIGNAL</sub> <sup>17</sup>	-0.4	—	3.7	V	3.3V, See "SoC-pin overshoot/undershoot voltage for each GPIO pad type" figure below	—
V_OS_US_7p5	Voltage at 7.50 % of t <sub>SIGNAL</sub> <sup>17</sup>	-0.5	—	3.8	V	3.3V, See "SoC-pin overshoot/undershoot voltage for each GPIO pad type" figure below	—

Table continues on the next page...

Table 3. Absolute Max Ratings (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
V_OS_US_2p5	Voltage at 2.50 % of t <sub>SIGNAL</sub> <sup>17</sup>	-0.6	—	3.9	V	3.3V, See "SoC-pin overshoot/undershoot voltage for each GPIO pad type" figure below	—
V_OS_US_1p6	Voltage at 1.60 % of t <sub>SIGNAL</sub> <sup>17</sup>	-0.7	—	4	V	3.3V, See "SoC-pin overshoot/undershoot voltage for each GPIO pad type" figure below	—
V_OS_US_10	Voltage at 10 % of t <sub>SIGNAL</sub> <sup>18</sup>	-0.7	—	2.31	V	1.8V, See "SoC-pin overshoot/undershoot voltage for each GPIO pad type" figure below	—

1. Absolute maximum ratings are stress ratings only, and functional operation beyond the operating condition maxima is not guaranteed. Stress beyond the listed maxima may affect device reliability or cause permanent damage to the device. See the operating conditions table for functional specifications.
2. Allowed 0.88V – 0.96V for 60 seconds cumulative over lifetime with no operating restrictions, 2.0 hours cumulative over lifetime with device in reset, at maximum T<sub>j</sub> = 125 °C
3. VDD\_LV\_PLL must be connected to VDD, and not powered independently. It must share any filters with VDD.
4. Allowed 1.92V - 2.16V for 60 seconds cumulative over lifetime with no operating restrictions, 2.6 hours cumulative over lifetime with device in reset, at maximum T<sub>j</sub> = 125 °C
5. Allowed 3.52V - 4.0V for 60 seconds cumulative over lifetime with no operating restrictions, 2.6 hours cumulative over lifetime with device in reset, at maximum T<sub>j</sub> = 125 °C
6. VEXTAL/ VXTAL (min) is for powered condition. VEXTAL/VXTAL (min) can be lower in unpowered condition.
7. Allowed for a cumulative duration of 50 hours operation over the lifetime of the device at maximum T<sub>j</sub>, with VREFH\_ADC <= 1.92V, VREFL\_ADC = 0V. Allowed for unlimited duration if the device is unpowered.
8. The maximum input voltage on an I/O pin tracks with the associated I/O supply maximum. For the injection current condition on a pin, the voltage equals the supply plus the voltage drop across the internal ESD diode from I/O pin to supply.
9. DC case limit. Overshoot/Undershoot beyond this range is allowed, but only for the limited durations as constrained by temporal percentages of t<sub>SIGNAL</sub>.
10. Absolute minimum DC VIN level for a powered device is -0.3V. For unpowered devices, the allowed VIN min level is -0.9V. Unpowered devices must simultaneously follow IINJ\_D unpowered current injection constraints.
11. Absolute maximum DC VIN levels for a powered device are 3.82V and 2.22V, for 3.3V and 1.8V domains, respectively. For powered devices when VIN ≥ VDD\_IO\*, VIN must simultaneously follow the constraint that VIN-VDD\_IO\* ≤ 0.3V for the DC case. For unpowered devices, the allowed VIN max level is +0.9V. Unpowered devices must simultaneously follow IINJ\_D unpowered current injection constraints.
12. IINJ\_D specifications are per pin for an unpowered condition of the associated supply. The maximum simultaneous injection per supply is 30mA.
13. Non-disturb of ADC channels during current injection cannot be guaranteed. The degradation in channel performance cannot be specified due to the dynamic operation of the ADC input mux and potential for varying charge distribution. For the max +/-1mA DC injection quoted here, VAD\_INPUT would be +0.5/-0.6V relative to VREFH\_ADC/VREFL\_ADC at max T<sub>j</sub>. ADC Output of the channel into which injection occurs will saturate depending on the direction of injection and for the channels not subject to current injection Offset error would be -12 LSB to 6 LSB and TUE would be -12 LSB to 8 LSB.
14. Applies exclusively to ZipWire and does not apply to Aurora. Allowed for a cumulative of 14 hours over the life of the part. The voltage on the RX or TX pin must not exceed 2.16 V at any time during the power-cycling or normal operation.
15. Solder profile per IPC/JEDEC J-STD-020D.
16. Moisture sensitivity per JEDEC test method A112.
17. For AC Signals in a 3.3V supply domain, if VDD\_IO ≤ 3.3V, max VIN overshoot is limited to VDD\_IO+20%. If VDD\_IO > 3.3V, then max VIN overshoot is limited to 4V.
18. For AC Signals in a 1.8V supply domain, max VIN overshoot is limited to VDD\_IO+20% for 10% of t<sub>SIGNAL</sub>.

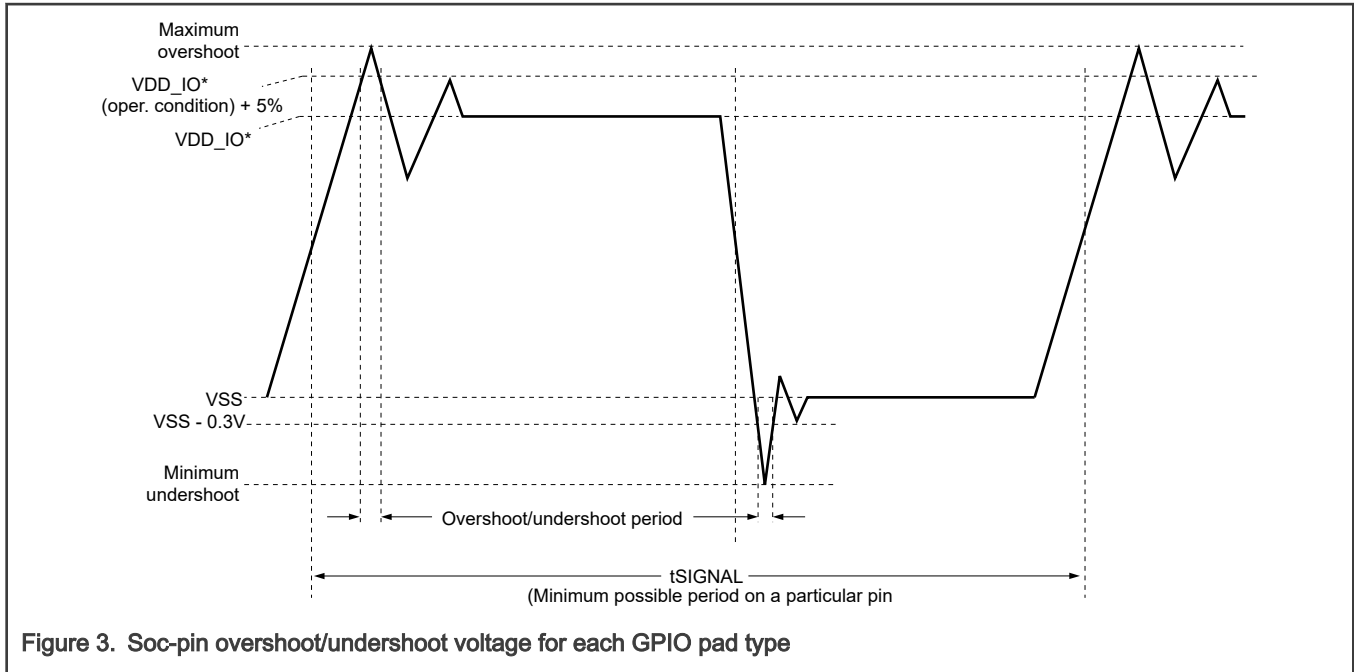


Figure 3. Soc-pin overshoot/undershoot voltage for each GPIO pad type

## 7 Operating Conditions

### 7.1 Operating Conditions

The following table describes the functional operating conditions for the device, and for which all specifications in this datasheet are valid, except where explicitly noted. Device behavior is not guaranteed for operation outside of the conditions in this table.

**NOTE**

$\Delta VDD^*$  specifications are applicable to the supplies mentioned in the condition column when the device is not in standby mode. VDD\_IO\_B, VDD\_IO\_QSPI and VDD\_DDR0 may stay powered in standby mode as applicable to the group.

**NOTE**

All specifications associated with VIN are measured at the SoC pin.

Table 4. Operating Conditions

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSYS_A53	Cortex-A53 core operating frequency <sup>1,2</sup>	—	—	1000	MHz	—	—
fSYS_CM7	Cortex-M7 core operating frequency <sup>1,2</sup>	—	—	400	MHz	—	—
fSYS_PFE_PE	PFE PE operating frequency <sup>1,2</sup>	—	—	600	MHz	—	—

Table continues on the next page...

Table 4. Operating Conditions (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
Tj	Junction Temperature Range <a href="#">2,3,4</a>	-40	—	125	C	—	—
Ta	Ambient Temperature Range <a href="#">2,4</a>	-40	—	105	C	—	—
VDD	Core voltage Supply <a href="#">2,5</a>	0.72	0.77	0.87	V	DIE_PROCESS[1:0] fuse setting = b01	—
VDD	Core voltage Supply <a href="#">2,5</a>	0.75	0.8	0.87	V	DIE_PROCESS[1:0] fuse setting = b00	—
VSS	Ground Supply <a href="#">2</a>	—	0	—	V	—	—
VDD_STBY	Standby domain supply voltage <a href="#">2,5,6</a>	0.72	0.77	0.87	V	DIE_PROCESS[1:0] fuse setting = b01	—
VDD_STBY	Standby domain supply voltage <a href="#">2,5,6</a>	0.75	0.8	0.87	V	DIE_PROCESS[1:0] fuse setting = b00	—
VDD_LV_PLL	PLL digital voltage supply <a href="#">2,5,7</a>	0.72	0.77	0.87	V	DIE_PROCESS[1:0] fuse setting = b01	—
VDD_LV_PLL	PLL digital voltage supply <a href="#">2,5,7</a>	0.75	0.8	0.87	V	DIE_PROCESS[1:0] fuse setting = b00	—
VDD_LV_PLL_AUR	Aurora PLL digital voltage supply <a href="#">2,5</a>	0.72	0.77	0.87	V	DIE_PROCESS[1:0] fuse setting = b01	—
VDD_LV_PLL_AUR	Aurora PLL digital voltage supply <a href="#">2,5</a>	0.75	0.8	0.87	V	DIE_PROCESS[1:0] fuse setting = b00	—
VDD_LV_PLL_DDR0	DDR0 PLL digital voltage supply <a href="#">2,5</a>	0.72	0.77	0.87	V	DIE_PROCESS[1:0] fuse setting = b01, reference PLL only - DDR PLL LV supply tied to LV power grid.	—
VDD_LV_PLL_DDR0	DDR0 PLL digital voltage supply <a href="#">2,5</a>	0.75	0.8	0.87	V	DIE_PROCESS[1:0] fuse setting = b00, reference PLL only - DDR PLL LV supply tied to LV power grid.	—
VDD_VP_PCIEEn	PCIE0/1 core voltage supply <a href="#">2,5,8</a>	0.72	0.77	0.87	V	DIE_PROCESS[1:0] fuse setting = b01	—
VDD_VP_PCIEEn	PCIE0/1 core voltage supply <a href="#">2,5,8</a>	0.75	0.8	0.87	V	DIE_PROCESS[1:0] fuse setting = b00	—
VDD_IO_A	GPIO A 3.3V supply <a href="#">2</a>	3.08	3.3	3.52	V	—	—

Table continues on the next page...

Table 4. Operating Conditions (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VDD_IO_B	GPIO B 3.3V supply <sup>2,9</sup>	3.08	3.3	3.52	V	—	—
VDD_IO_GMAC0	GMAC0 I/O voltage supply <sup>2</sup>	1.68	1.8	1.92	V	1.8V	—
VDD_IO_GMAC0	GMAC0 I/O voltage supply <sup>2</sup>	3.08	3.3	3.52	V	3.3V	—
VDD_IO_GMAC1	GMAC1 I/O voltage supply <sup>2</sup>	1.68	1.8	1.92	V	1.8V	—
VDD_IO_GMAC1	GMAC1 I/O voltage supply <sup>2</sup>	3.08	3.3	3.52	V	3.3V	—
VDD_IO_QSPI	QuadSPI A I/O voltage supply <sup>2,10</sup>	1.68	1.8	1.92	V	1.8V	—
VDD_IO_SDHC	uSDHC / QSPI B I/O voltage supply <sup>2</sup>	1.68	1.8	1.92	V	1.8V	—
VDD_IO_SDHC	uSDHC I/O voltage supply <sup>2</sup>	3.08	3.3	3.52	V	3.3V	—
VDD_IO_CLKOUT	CLKOUT 1.8V I/O supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
VDD_IO_AUR	Aurora 1.8V I/O supply <sup>2</sup>	1.68	1.8	1.92	V	Aurora LVDS Tx + ref clock	—
VDD_IO_STBY	Standby domain I/O voltage supply <sup>2,9</sup>	3.08	3.3	3.52	V	—	—
VDD_IO_USB	USB I/O voltage supply <sup>2</sup>	1.68	1.8	1.92	V	1.8V	—
VDD_IO_USB	USB I/O voltage supply <sup>2</sup>	3.08	3.3	3.52	V	3.3V	—
VDD_IO_DDR0	DDR3L I/O voltage supply <sup>2</sup>	1.283	1.35	1.45	V	—	—
VDD_IO_DDR0	LPDDR4 I/O voltage supply <sup>2</sup>	1.06	1.1	1.17	V	—	—
$\delta$ VDD_IO_DDR0	DDR3L I/O supply ripple voltage <sup>2</sup>	-5	—	5	%	—	—
$\delta$ VDD_IO_DDR0	LPDDR4 I/O supply ripple voltage <sup>2</sup>	-2.5	—	2.5	%	—	—
VDD_DDR0	DDR0 high voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
VDD_FIRC	FIRC high voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—

Table continues on the next page...

Table 4. Operating Conditions (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VDD_VREF	PMC high voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
VDD_EFUSE	EFUSE high voltage supply <sup>2,11,12,13</sup>	1.68	1.8	1.92	V	—	—
VDD_ADC	ADC high voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
VDD_HV_PLL	PLL high voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
VDD_HV_PLL_AUR	Aurora PLL high voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
VDD_HV_PLL_DDR0	DDR PLL voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
δVDD_HV_PLL_DDR0	DDR PLL supply ripple voltage <sup>2</sup>	-2.5	—	2.5	%	—	—
VDD_FXOSC	FXOSC high voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
VDD_IO_PCIEn	PCIe0/1 high voltage supply <sup>2,8</sup>	1.68	1.8	1.92	V	—	—
VDD_TMU	Thermal Monitoring Unit (TMU) high voltage supply <sup>2</sup>	1.68	1.8	1.92	V	—	—
VREFH_ADCn	ADC reference high voltage (n=0, 1) <sup>2</sup>	1.68	1.8	1.92	V	—	—
VREFL_ADCn	ADC reference low voltage (n=0, 1) <sup>2</sup>	VSS_HV_ADC - 0.025	—	VSS_HV_ADC + 0.025	V	DC value	—
VIN_33	3.3V GPIO input voltage range <sup>2,14,15,16</sup>	VSS - 0.3	—	VDD_IO_* + 0.3	V	—	—
VIN_18	1.8V GPIO input voltage range <sup>2,14,15,16</sup>	VSS - 0.3	—	VDD_IO_* + 0.3	V	—	—
ΔVDD	0.8V supply voltage differential <sup>2,17</sup>	-25	—	25	mV	Applies to all 0.8V supplies on the device.	—
ΔVDD_HV_18_IO	1.8V I/O supply voltage differential group <sup>2,17,18,19</sup>	-25	—	25	mV	Applies to VDD_IO_QSPI, VDD_IO_SDHC, VDD_IO_GMAC0, VDD_IO_GMAC1, VDD_IO_USB	—

Table continues on the next page...



Table 4. Operating Conditions (continued)

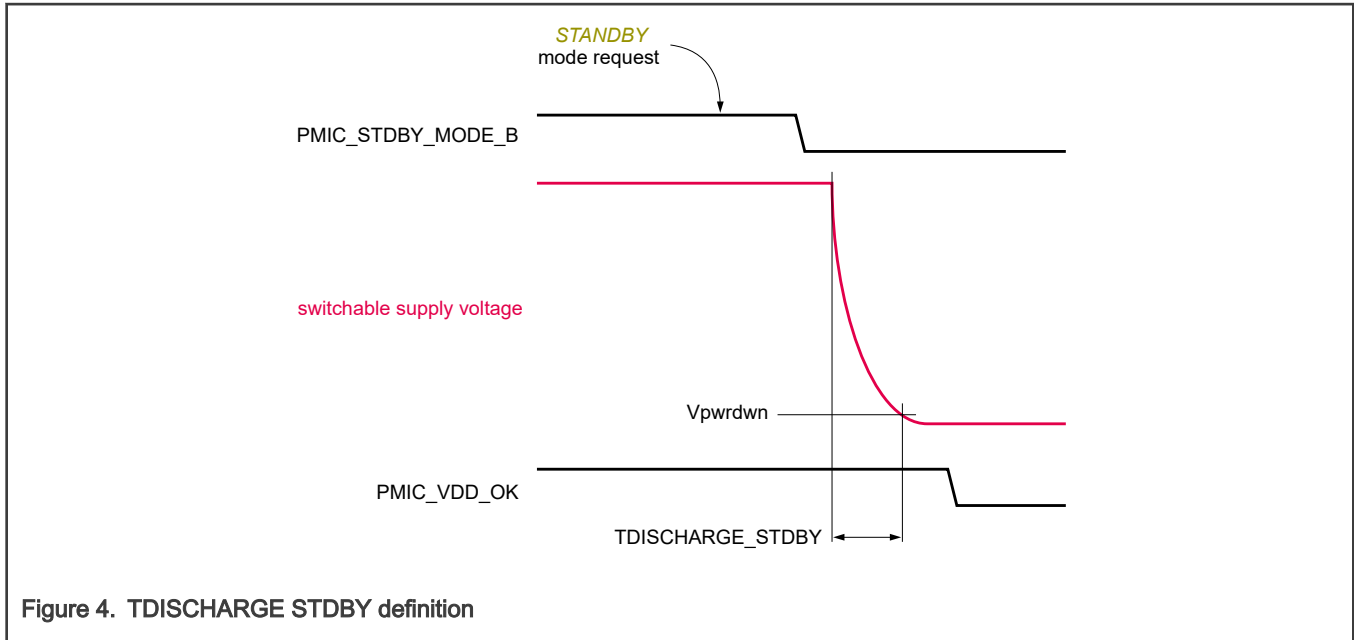
Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
$\Delta$ VDD_HV_18_ANA	1.8V analog supply voltage differential group <a href="#">2,11,12,13,17,18,20</a>	-25	—	25	mV	Applies to VDD_IO_CLKOUT, VDD_IO_AUR, VDD_TMU, VREFH_ADC*, VDD_ADC, VDD_HV_PLL*, VDD_VREF, VDD_FXOSC, VDD_FIRC, VDD_EFUSE, VDD_DDR0, VDD_IO_PCIE0, VDD_IO_PCIE1	—
$\Delta$ VDD_HV_33_IO	3.3V I/O supply voltage differential group <a href="#">2,17,18,21</a>	-25	—	25	mV	VDD_IO_A, VDD_IO_B	—
$\Delta$ VSS_HV_18	1.8V supply ground voltage differential <a href="#">2,17</a>	-25	—	25	mV	Applies to VSS, VREFL_ADCn, VSS_ADC, VSS_FXOSC	—
VRAMP_LV	LV supply voltage ramp-up rate <a href="#">2,22</a>	0.001	—	24	V / ms	Applies to 0.8V supplies	—
VRAMP_HV	HV supply voltage ramp-up rate <a href="#">2</a>	0.001	—	24	V / ms	Applies to 1.8V supplies and DDR I/O supplies.	—
VRAMP_HV_33_IO	3.3V I/O supply voltage ramp-up rate <a href="#">2</a>	0.001	—	50	V / ms	Applies to 3.3V I/O supplies.	—
TDISCHARGE_STDBY	Supply discharge time during Standby mode entry <a href="#">2</a>	100	—	—	us	Applies to all switchable supplies during Standby mode entry	—
VAD_INPUT	ADC input voltage range <a href="#">2,23</a>	VREFL_ADC - 0.35	—	VREFH_ADC + 0.25	V	—	—
IINJ_D	GPIO Input DC Injection Current <a href="#">2,24</a>	-3	—	3	mA	Unpowered	—
IINJ_D	GPIO Input DC Injection Current <a href="#">2,25</a>	0	—	5	uA	Powered	—
IINJ_A	SAR ADC Input DC Injection Current <a href="#">2,26</a>	-20	—	20	uA	—	—
IMAXSEG	Maximum RMS current per GPIO supply domain <a href="#">2</a>	—	—	120	mA	—	—

- The stated maximum operating frequency must be observed when using the PLL with frequency modulation enabled. Center-spread modulation is supported in cases where the nominal operating frequency plus half the modulation depth is less than the stated maximum frequency.

2. The operating conditions in this table apply as required conditions for all other specifications in this document, unless explicitly noted as an exception in another section of this document.
3. Lifetime operation at  $T_j$  max not guaranteed. Standard automotive temperature profile assumed for performance and reliability guarantees.
4. The junction temperature ( $T_j$ ) range specification cannot be violated. The ambient temperature shown in the table, is a rough indicative value, for a typical system. Customers must ensure there is an appropriate thermal solution in their system to keep  $T_j$  within the spec range
5. SVS guidelines apply to all LV supplies on the device. See power management chapter of device reference manual for details on SVS.
6. The operating voltage range applies when the device is not in standby mode.
7. VDD\_LV\_PLL must be connected to VDD, and not powered independently. It must share any filters with VDD.
8. Both PCIe supplies must ramp for the SerDes PHY to safely power up into its reset state. Until both supplies are ramped, the SerDes PHY will be in an undefined state.
9. A minimum of 2.91V is supported on this supply when the device is in low-power standby mode if it is kept powered during this mode.
10. The device supports QSPI interface to 3.3V memories on the QSPI B bank, which is multiplexed with uSDHC functions on the VDD\_IO\_SDHC supply. QSPI A signals on VDD\_IO\_QSPI are limited to 1.8V.
11. The VDD\_EFUSE supply must be maintained within specification during fuse programming. Failure to do this may result in improper functionality of the device after fuse programming.
12. VDD\_EFUSE must be grounded when not actively programming the fuses. This supply is not required to be powered for fuse reads. See device hardware design guidelines document for more details.
13. Refer to the Power Sequencing section for the relationship of VDD\_EFUSE powering up/down relative to the core, high-voltage, and I/O supplies.
14. For AC signals, allowed max  $V_{IN} \leq VDD\_IO^*$  for lifetime operation. If AC overshoot beyond  $VDD\_IO^*$  occurs, then refer to the Abs Max duration constraints as a function of the amount of overshoot. For DC signals  $\geq VDD\_IO$ ,  $V_{IN} - VDD\_IO^* \leq 0.3V$  is allowed for lifetime operation.
15. DC case limit. Overshoot/Undershoot beyond this range is allowed, but only for the limited durations as constrained by temporal percentages of tSIGNAL.
16. The min DC  $V_{IN}$  level for a powered device is -0.3V. If AC undershoot below -0.3V occurs, then refer to the Abs Max duration constraints as a function of the amount of undershoot.
17. The "voltage differential" refers to the difference between the lowest and highest voltages across all supplies within the supply group as defined under Condition column.
18. Applies only during power up while POR\_B is asserted.
19. Applies to multi-voltage supplies when operating in 1.8V range.
20. VREFH\_ADCn allows a differential voltage of +/-100mV.
21. Applies to multi-voltage supplies when operating in 3.3V range
22. On slow ramps, the RESET\_B pin may be observed to be asserted multiple times during the supply ramping. In order to prevent these pulses from being propagated into the system, it is recommended that the PMIC drives RESET\_B low during supply ramp or whenever POR\_B is asserted.
23. The maximum input voltage on an I/O pin tracks with the associated I/O supply maximum. For the injection current condition on a pin, the voltage equals the supply plus the voltage drop across the internal ESD diode from I/O pin to supply.
24. IINJ\_D specifications are per pin for an unpowered condition of the associated supply. The maximum simultaneous injection per supply is 30mA.
25. You must ensure that neither IINJ nor  $V_{IN}$  specs are violated. Negligible DC injection currents are expected to flow during normal powered operation.
26. The SAR ADC electrical specifications are not guaranteed during any period when the operating injection current limit is violated. These specifications are at maximum  $T_j$  and  $VREFH\_ADC=1.8V$ ; the injected current will reduce with reduced  $T_j$ .

The "fuse setting" values/conditions in above table correspond with the DIE\_PROCESS[1:0] fuses which NXP programs during manufacturing. See Reference Manual and it's Fuse Map for further details about the purpose. Example: Value "b01" represents DIE\_PROCESS[1]=0 and DIE\_PROCESS[0]=1".

The device hardware design guidelines document summarizes mandatory board design rules in table "Decoupling caps values" and section "PDN (Power Delivery Network) Guidelines".



## 7.2 Clock frequency ranges

The following table gives the frequency range minimum and maximums to use when programming the clock dividers on the device.

Table 5. Clock frequency ranges

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fA53_CORE_DIV2_CLK	Cortex-A53 core div2 clock frequency	24	—	500	MHz	A53_CORE_DIV2_CLK	—
fA53_CORE_DIV10_CLK	Cortex-A53 core div10 clock frequency	4.8	—	100	MHz	A53_CORE_DIV10_CLK	—
fLBIST_CLK	LBIST[7:0] clock frequency	—	—	50	MHz	LBIST_CLK[7:0]	—
fXBAR_CLK	XBAR clock frequency	24	—	400	MHz	XBAR_CLK	—
fXBAR_DIV2_CLK	XBAR div2 clock frequency	12	—	200	MHz	XBAR_DIV2_CLK	—
fXBAR_DIV3_CLK	XBAR div3 clock frequency	8	—	133	MHz	XBAR_DIV3_CLK	—
fXBAR_DIV4_CLK	XBAR div4 clock frequency	6	—	100	MHz	XBAR_DIV4_CLK	—
fXBAR_DIV6_CLK	XBAR div6 clock frequency	4	—	66.7	MHz	XBAR_DIV6_CLK	—
fDAPB_CLK	Debug clock frequency	—	—	133	MHz	fDAPB_CLK	—

Table continues on the next page...

Table 5. Clock frequency ranges (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fFRAY_CHI	FlexRay CHI clock frequency	—	—	133	MHz	—	—
fSERDES_REF_CLK	SERDES reference clock frequency	100	—	125	MHz	SERDES_REF_CLK	—
fPER_CLK	Peripheral clock frequency	—	—	80	MHz	PER_CLK	—
fFTM_0_REF_CLK	FlexTimer 0 external clock frequency	—	—	20	MHz	FTM_0_REF_CLK	—
fFTM_1_REF_CLK	FlexTimer 1 external clock frequency	—	—	20	MHz	FTM_1_REF_CLK	—
fFLEXRAY_PE_CLK	FlexRay PE clock frequency	—	—	40	MHz	FLEXRAY_PE_CLK	—
fCAN_PE_CLK	CAN PE clock frequency	40	—	80	MHz	CAN_PE_CLK	—
fLIN_BAUD_CLK	LIN baud clock frequency	—	—	133	MHz	LIN_BAUD_CLK	—
fLINFLEXD_CLK	LIN clock frequency	—	—	66.7	MHz	LINFLEXD_CLK	—
fGMAC_TS_CLK	GMAC timestamp clock frequency	5	—	200	MHz	GMAC_TS_CLK	—
fGMAC_0_TX_CLK	GMAC_0 transmit clock frequency	2.5	—	125	MHz	GMAC_0_TX_CLK	—
fGMAC_0_RX_CLK	GMAC_0 receive clock frequency	2.5	—	125	MHz	GMAC_0_RX_CLK	—
fGMAC_0_REF_CLK	GMAC_0 reference clock frequency	—	—	50	MHz	GMAC_0_REF_CLK	—
fPFE_MAC_0_TX_CLK	PFE MAC_0 transmit clock frequency	2.5	—	312.5	MHz	PFE_MAC_0_TX_CLK	—
fPFE_MAC_0_RX_CLK	PFE MAC_0 receive clock frequency	2.5	—	312.5	MHz	PFE_MAC_0_RX_CLK	—
fPFE_MAC_0_REF_CLK	PFE MAC_0 reference clock frequency	—	—	50	MHz	PFE_MAC_0_REF_CLK	—
fPFE_MAC_1_TX_CLK	PFE MAC_1 transmit clock frequency	2.5	—	125	MHz	PFE_MAC_1_TX_CLK	—
fPFE_MAC_1_RX_CLK	PFE MAC_1 receive clock frequency	2.5	—	125	MHz	PFE_MAC_1_RX_CLK	—

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Table 5. Clock frequency ranges (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fPFE_MAC_1_REF_CLK	PFE MAC_1 reference clock frequency	—	—	50	MHz	PFE_MAC_1_REF_CLK	—
fPFE_MAC_2_TX_CLK	PFE MAC_2 transmit clock frequency	2.5	—	125	MHz	PFE_MAC_2_TX_CLK	—
fPFE_MAC_2_RX_CLK	PFE MAC_2 receive clock frequency	2.5	—	125	MHz	PFE_MAC_2_RX_CLK	—
fPFE_MAC_2_REF_CLK	PFE MAC_2 reference clock frequency	—	—	50	MHz	PFE_MAC_2_REF_CLK	—
fSPI_CLK	SPI clock frequency	10	—	100	MHz	SPI_CLK	—
fQSPI_2X_CLK	QSPI 2X clock frequency	—	—	400	MHz	QSPI_2X_CLK - DDR 200MHz	—
fQSPI_2X_CLK	QSPI 2X clock frequency	—	—	333	MHz	QSPI_2X_CLK - DDR 166MHz	—
fQSPI_2X_CLK	QSPI 2X clock frequency	—	—	266	MHz	QSPI_2X_CLK - DDR / SDR 133MHz	—
fQSPI_2X_CLK	QSPI 2X clock frequency	—	—	208	MHz	QSPI_2X_CLK - SDR 104MHz	—
fQSPI_2X_CLK	QSPI 2X clock frequency	—	—	200	MHz	QSPI_2X_CLK - SDR 100MHz	—
fQSPI_2X_CLK	QSPI 2X clock frequency	—	—	133	MHz	QSPI_2X_CLK - DDR 66MHz	—
fQSPI_1X_CLK	QSPI 1X clock frequency	—	—	200	MHz	QSPI_1X_CLK - DDR 200MHz	—
fQSPI_1X_CLK	QSPI 1X clock frequency	—	—	166	MHz	QSPI_1X_CLK - DDR 166MHz	—
fQSPI_1X_CLK	QSPI 1X clock frequency	—	—	133	MHz	QSPI_1X_CLK - DDR / SDR 133MHz	—
fQSPI_1X_CLK	QSPI 1X clock frequency	—	—	104	MHz	QSPI_1X_CLK - SDR 104MHz	—
fQSPI_1X_CLK	QSPI 1X clock frequency	—	—	100	MHz	QSPI_1X_CLK - SDR 100MHz	—
fQSPI_1X_CLK	QSPI 1X clock frequency	—	—	66	MHz	QSPI_1X_CLK - DDR 66MHz	—
fSDHC_CLK	uSDHC clock frequency	133	—	200	MHz	SDHC_CLK - DDR HS400	—

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Table 5. Clock frequency ranges (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSDHC_CLK	uSDHC clock frequency	—	—	200	MHz	SDHC_CLK - SDR HS200	—
fSDHC_CLK	uSDHC clock frequency	—	—	100	MHz	SDHC_CLK - SDR 100MHz	—
fSDHC_CLK	uSDHC clock frequency	—	—	50	MHz	SDHC_CLK - DDR / SDR 52MHz	—
fPFE_PE_CLK	PFE PE clock frequency	—	—	600	MHz	PFE_PE_CLK	—
fPFE_SYS_CLK	PFE system clock frequency	—	—	300	MHz	PFE_SYS_CLK	—

## 8 Thermal Characteristics

Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.

Table 6. Thermal Resistance

Board type <sup>1</sup>	Symbol	Description	Value	Unit
JESD51-9, 2s2p	$R_{\theta JA}$	Junction to ambient Thermal Resistance <sup>2</sup>	16.5	°C/W
JESD51-9, 2s2p	$\Psi_{JT}$	Junction to Lid Top Thermal Resistance <sup>2</sup>	1.1	°C/W
N/A	$R_{\theta JC}$	Junction to Case Thermal Resistance <sup>3</sup>	1.3	°C/W

1. Thermal test board meets JEDEC specification for this package (JESD51-9).
2. Determined in accordance with 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 lid surface temperature.

## 9 DC Electricals

### 9.1 Total power specifications for 0.8V and 1.8V Analog Domains

The following table contains the individual max and thermal 0.8V power figures for each device in the S32G2 family as well as a 1.8V analog total which applies to all devices. For I/O power specifications please see dedicated I/O table.

**Table 7. Total power specifications for 0.8V and 1.8V Analog Domains**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
—	0.8V Supply Rail Power: S32G274A Max Usecase <sup>1,2</sup>	—	—	4.5	W	Tj=125C, All 0.8v supplies at 0.8V, Sum of VDD, VDD_STBY, VDD_VP_PCIE0/1, VDD_LV_PLL, VDD_LV_PLL_DDR0, VDD_LV_PLL_AUR	—
—	0.8V Supply Rail Power: S32G274A Thermal Usecase <sup>1,3</sup>	—	—	4.36	W	Tj=125C, All 0.8v supplies at 0.8V, Sum of VDD, VDD_STBY, VDD_VP_PCIE0/1, VDD_LV_PLL, VDD_LV_PLL_DDR0, VDD_LV_PLL_AUR	—
—	0.8V Supply Rail Power: S32G254A Max Usecase <sup>1,2,4</sup>	—	—	4.37	W	Tj=125C, All 0.8v supplies at 0.8V, Sum of VDD, VDD_STBY, VDD_VP_PCIE0/1, VDD_LV_PLL, VDD_LV_PLL_DDR0, VDD_LV_PLL_AUR	—
—	0.8V Supply Rail Power: S32G254A Thermal Usecase <sup>1,3,4</sup>	—	—	4.22	W	Tj=125C, All 0.8v supplies at 0.8V, Sum of VDD, VDD_STBY, VDD_VP_PCIE0/1, VDD_LV_PLL, VDD_LV_PLL_DDR0, VDD_LV_PLL_AUR	—
—	0.8V Supply Rail Power: S32G233A Max Usecase <sup>1,2,4</sup>	—	—	4.25	W	Tj=125C, All 0.8v supplies at 0.8V, Sum of VDD, VDD_STBY, VDD_VP_PCIE0/1, VDD_LV_PLL, VDD_LV_PLL_DDR0, VDD_LV_PLL_AUR	—
—	0.8V Supply Rail Power: S32G233A Thermal Usecase <sup>1,3,4</sup>	—	—	4.16	W	Tj=125C, All 0.8v supplies at 0.8V, Sum of VDD, VDD_STBY, VDD_VP_PCIE0/1, VDD_LV_PLL, VDD_LV_PLL_AUR	—

*Table continues on the next page...*

Table 7. Total power specifications for 0.8V and 1.8V Analog Domains (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
						DDR0, VDD_LV_PLL_AUR	
—	0.8V Supply Rail Power: S32G234M Max Usecase <a href="#">1,2,4</a>	—	—	3.79	W	Tj=125C, All 0.8v supplies at 0.8V, Sum of VDD, VDD_STBY, VDD_VP_PCIE0/1, VDD_LV_PLL, VDD_LV_PLL_DDR0, VDD_LV_PLL_AUR	—
—	0.8V Supply Rail Power: S32G234M Thermal Usecase <a href="#">1,3,4</a>	—	—	3.67	W	Tj=125C, All 0.8v supplies at 0.8V, Sum of VDD, VDD_STBY, VDD_VP_PCIE0/1, VDD_LV_PLL, VDD_LV_PLL_DDR0, VDD_LV_PLL_AUR	—
—	1.8V Analog Supply Rail power: All devices <a href="#">5</a>	—	—	0.135	W	Tj=125C, All 1.8V supplies at 1.8V, Sum of VDD_FXOSC, VDD_HV_PLL_AUR, VDD_HV_PLL_DDR0, VDD_ADC, VREFH_ADC0/1, VDD_FIRC, VDD_VREF, VDD_HV_PLL, VDD_TMU, VDD_DDR0	—

1. On a device with DIE\_PROCESS[1:0] = 01b, VDD will be 0.77V. The MAX and THERMAL specs will be unchanged.
2. Max usecase: This is provided for power supply design. It is the realistic peak power consumption in an application. Shall only be maintained for a very short time (approx. 100us).
3. Thermal usecase: This is provided for designing a thermal solution. This is a realistic maximum sustained usecase which would be maintained for a longer duration.
4. Note that during Self Test execution, the power consumption for this device could exceed the stated spec. The S32G274A device Max Usecase spec will apply for the duration of the self test.
5. 1.8V total does not include additional consumption during a fuse programming operation. See IDD\_EFUSE\_PGM spec for max additional current.

## 9.2 Static power specifications for I/O Domains

The following table contains the static power consumption for each I/O power domain. This data does not include the usage dependent dynamic current of GPIO-pins. To estimate the dynamic GPIO current for a specific use-case, an IO calculator tool is available. For IO calculator, contact your NXP sales representative. The " Device Power and Operating Current Specifications" table contains pre-calculated total I/O power (static + dynamic) for common usecases.



Table 8. Static power specifications for I/O Domains

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
SPVDD_IO_A	3.3V Static Power on VDD_IO_A	—	—	1	mW	VDD_IO_A = 3.3V	—
SPVDD_IO_B	3.3V Static Power on VDD_IO_B	—	—	1.3	mW	VDD_IO_B = 3.3V	—
SPVDD_IO_STBY	3.3V Static Power on VDD_IO_STBY	—	—	2.4	mW	VDD_IO_STBY = 3.3V	—
SPVDD_IO_SDHC	3.3V Static Power on VDD_IO_SDHC	—	—	155	mW	VDD_IO_SDHC = 3.3V	—
SPVDD_IO_SDHC	1.8V Static Power on VDD_IO_SDHC	—	—	58	mW	VDD_IO_SDHC = 1.8V	—
SPVDD_IO_GMAC0	3.3V Static Power on VDD_IO_GMAC0	—	—	154	mW	VDD_IO_GMAC0 = 3.3V	—
SPVDD_IO_GMAC0	1.8V Static Power on VDD_IO_GMAC0	—	—	55	mW	VDD_IO_GMAC0 = 1.8V	—
SPVDD_IO_GMAC1	3.3V Static Power on VDD_IO_GMAC1	—	—	150	mW	VDD_IO_GMAC1 = 3.3V	—
SPVDD_IO_GMAC1	1.8V Static Power on VDD_IO_GMAC1	—	—	55	mW	VDD_IO_GMAC1 = 1.8V	—
SPVDD_IO_USB	3.3V Static Power on VDD_IO_USB	—	—	147	mW	VDD_IO_USB = 3.3V	—
SPVDD_IO_USB	1.8V Static Power on VDD_IO_USB	—	—	53.5	mW	VDD_IO_USB = 1.8V	—
SPVDD_IO_QSPI	1.8V Static Power on VDD_IO_QSPI	—	—	0.9	mW	VDD_IO_QSPI = 1.8V	—
SPVDD_IO_CLKOUT	1.8V Static Power on VDD_IO_CLKOUT	—	—	0.9	mW	VDD_IO_CLKOUT = 1.8V	—
SPVDD_IO_PCIE0	1.8V Static Power on VDD_IO_PCIE0	—	—	2.6	mW	VDD_IO_PCIE0 = 1.8V	—
SPVDD_IO_PCIE1	1.8V Static Power on VDD_IO_PCIE1	—	—	2.6	mW	VDD_IO_PCIE1 = 1.8V	—
SPVDD_IO_AUR	1.8V Static Power on VDD_IO_AUR	—	—	1.1	mW	VDD_IO_AUR = 1.8V	—
SPVDD_IO_DDR	1.1V Static Power on VDD_IO_DDR - LPDDR4	—	—	8.2	mW	VDD_IO_DDR = 1.1V	—
SPVDD_IO_DDR	1.35V Static Power on VDD_IO_DDR - DDR3L	—	—	10.1	mW	VDD_IO_DDR = 1.35V	—

### 9.3 Device Power and Operating Current Specifications

The device power consumption, operating current, and applicable conditions are given in the following table.

**NOTE**

All measurements are at Tj=125C, unless otherwise specified.

**Table 9. Device Power and Operating Current Specifications**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
PVDD_STBY	Standby mode core supply power	—	48	—	uW	Ta = 25C, VDD_STBY = 0.8V, typical silicon, all pull up/down disabled	—
PVDD_IO_STBY	Standby mode I/O supply power <sup>1</sup>	—	120	—	uW	Ta = 25C, VDD_IO_STBY = 3.0V, typical silicon, all pull up/down disabled	—
IDD_FXOSC	VDD_FXOSC operating current	—	0.6	—	mA	1.8V, 40MHz	—
IDD_HV_PLL_AUR	VDD_HV_PLL_AUR operating current	—	4.3	—	mA	1.8V, fPLL_VCO = 5GHz	—
IDD_HV_PLL_DDR0	VDD_HV_PLL_DDR0 operating current (DDR reference PLL only)	—	2	—	mA	fPLL_DDR_PHI0 = 800MHz, fDDR_PLL = 1600MHz, 1.8V	—
IDD_ADC	VDD_ADC operating current	—	1.8	—	mA	1.8V, 2 ADCs @ 1Msps	—
IDD_ADC	VDD_ADC operating current	—	200	—	uA	1.8V, Disabled (per ADC)	—
IVREFH_ADC	VREFH_ADC operating current	—	210	—	uA	VREFH_ADC = 1.8V	—
IDD_FIRC	VDD_FIRC operating current	—	0.6	—	mA	FIRC trimmed frequency (48MHz typical)	—
IDD_VREF	VDD_VREF operating current	—	0.7	—	mA	1.8V	—
IDD_HV_PLL	VDD_HV_PLL operating current	—	8.9	—	mA	1.8V, fPLL_VCO = 2GHz, Core / Peripheral/Accelerator PLLs	—
IDD_EFUSE_PGM	VDD_EFUSE programming current	—	—	140	mA	VDD_EFUSE=1.8V, VDD=0.8V	—
IDD_TMU	VDD_TMU operating current	—	4.6	—	mA	1.8V, central unit and remote sensors operating	—

*Table continues on the next page...*

Table 9. Device Power and Operating Current Specifications (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
IDD_DDR0	VDD_DDR0 operating current	—	5.0	—	mA	1.8V, fPLL_DDR_PHI0 = 800MHz, fDDR_PLL = 1600MHz	—
PVDD_IO_PCIEEn	VDD_IO_PCIE0 operating power <sup>2</sup>	—	—	76	mW	All circuits enabled, VDD_IO_PCIEEn=1.8V, Gen3 8Gbps, 2 lanes. Per IP instance	—
PVDD_IO_PCIEEn	VDD_IO_PCIE0 operating power	—	—	72	mW	All circuits enabled, VDD_IO_PCIEEn=1.8V, Gen2.1 5Gbps, 2 lanes. Per IP instance	—
PVDD_IO_PCIEEn	VDD_IO_PCIE0 operating power	—	—	68	mW	All circuits enabled, VDD_IO_PCIEEn=1.8V, Gen1.1 2.5Gbps, 2 lanes. Per IP instance	—
PVDD_IO_PCIEEn	VDD_IO_PCIE0 operating power	—	—	1.5	mW	Powered down state, VDD_IO_PCIEEn=1.8V, Per IP instance	—
PVDD_IO_DDR	VDD_IO_DDR 100% write operating power	—	—	625	mW	LPDDR4, VDD_IO_DDR = 1.1V, 3200 MT/s, 100% write, 1/2 data lines switching, 60 Ohm transmit termination driving a 60 Ohm load	—
PVDD_IO_DDR_IDLE	VDD_IO_DDR idle power	—	55	—	mW	LPDDR4, VDD_IO_DDR = 1.1V, Tj = 25C	—
PVDD_IO_DDR_RET	VDD_IO_DDR data retention power	—	0.02	—	mW	LPDDR4, VDD_IO_DDR = 1.1V, Standby mode and DRAM in self-refresh, Tj=25C.	—
PVDD_IO_DDR_RET	VDD_IO_DDR data retention power	—	0.030	—	mW	DDR3L, VDD_IO_DDR = 1.35V, Standby mode and DRAM in self-refresh, Tj=25C.	—
PVDD_IO_DDR	VDD_IO_DDR 100% write operating power	—	—	598	mW	DDR3L, VDD_IO_DDR = 1.35V, 1600 MT/s, 100% Write operation, 1/2 data lines switching, 60 Ohm transmit termination driving a 60 ohm load	—

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Table 9. Device Power and Operating Current Specifications (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
PVDD_IO_DDR_IDLE	VDD_IO_DDR idle power	—	57	—	mW	DDR3L, VDD_IO_DDR = 1.35V, Tj=25C	—
PVDD_IO_QSPI	QSPI A I/O voltage supply operating power	—	58	—	mW	1.8V, 200MHz - clocks 100% activity rate, 50% data rate, 1/2 data switching per cycle, does not include power for other I/O ins on the VDD_IO_QSPI supply. 15.5pF.	—
PVDD_IO_SDHC	VDD_IO_SDHC operating power	—	128	—	mW	1.8V, HS400, SD_CLK 100%, SD_D(8) 50%, 1/2 data switching per cycle, does not include power for other I/O pins on the VDD_IO_SDHC supply, 15.5pF	—
PVDD_IO_GMACn	VDD_IO_GMACn operating power	—	81	—	mW	1.8V, RGMII 125MHz, 100% clock rate, 50% data rate, 1/2 data switching per cycle, per IP instance, does not include power for other I/O pins on the VDD_IO_GMACn supply. 15.5pF	—
PVDD_IO_GMACn	VDD_IO_GMACn operating power	—	292	—	mW	3.3V, RGMII 125MHz, 100% clock rate, 50% data rate, 1/2 data switching per cycle, per IP instance, does not include power for other I/O pins on the VDD_IO_GMACn supply, 15.5pF.	—
PVDD_IO_USB_TYP	USB I/O voltage supply operating power	—	59	—	mW	1.8V, modem - 8 outputs @60MHz, 50% data rate, 1/2 data switching per cycle, does not include power for other I/O pins on the VDD_IO_USB supply. 15.5pF.	—

Table continues on the next page...

Table 9. Device Power and Operating Current Specifications (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
PVDD_IO_USB_TYP	USB I/O voltage supply operating power	—	174	—	mW	3.3V, modem - 8 outputs @60MHz, 50% data rate, 1/2 data switching per cycle, does not include power for the other I/O pins on the VDD_IO_USB supply. 15.5pF	—
PVDD_IO_AUR	Aurora I/O voltage supply operating power	—	164	—	mW	1.8V, 5Gbps on 4 lanes, 50% Activity Rate, 1/2 data switching per cycle	—

1. This spec includes the consumption on pins in VDD\_STBY\_IO domain only. See the hardware design guide for more details.
2. This specification can be considered a worst case maximum for any valid 2 x lane SerDes configuration (including PCIe/SGMII or SGMII only modes).

## 10 Power Sequencing

### 10.1 Power-up

The following sequence has been validated by NXP and is to be followed when powering up the device. Each supply within a step must be within its specified operating voltage range before the next step in the sequence is started, except as noted below.

1. Set POR\_B input to low value.
2. Ramp up VDD\_IO\_STBY supply.

VDD\_IO\_B can optionally be included with VDD\_IO\_STBY in the first step.

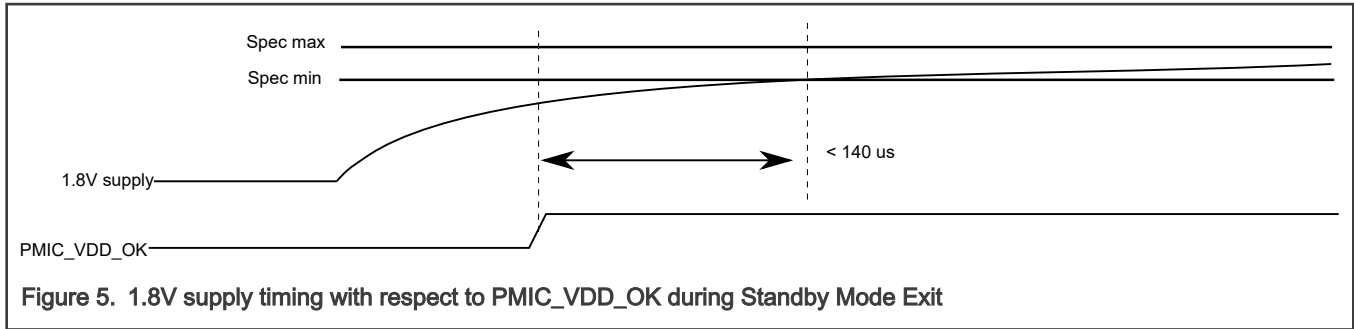
3. Ramp up all GPIO supplies powered to 3.3V.
4. Ramp up all 1.8V supplies including GPIO supplies powered to 1.8V

Step 5 and 6 can commence in the following sequence prior to all 1.8V supplies reaching DC tolerance. Step 5 must still reach DC tolerance before Step 6.

5. Ramp up VDD\_DDR\_IO supply
6. Ramp up all 0.8V supplies
7. Set POR\_B and PMIC\_VDD\_OK inputs to high value once all supplies have reached their specified levels.

#### NOTE

For step 4, it is acceptable for the 1.8V supplies to not yet be within their specified range at the time of asserting the PMIC\_VDD\_OK input when exiting Standby mode if it is ensured that they are within their specified range no later than 140 us after the PMIC\_VDD\_OK input assertion. VDD\_IO\_QSPI (a 1.8V GPIO supply) has the additional option to ramp with step 3 instead of step 4.



**NOTE**

While powering up the device, the VDD\_EFUSE supply pin must be kept powered down. While the device is already powered up, the VDD\_EFUSE supply pin can be powered up/down independent of the other supplies on the device. The VDD\_EFUSE supply pin must be powered down prior to Standby mode entry or, at the latest, powered down together with the other 1.8V supplies during Standby mode entry.

The power-up sequence on Standby exit is the same except that only the switchable supplies that were powered down during Standby mode are ramped up again, and the POR\_B input is kept high throughout the sequence.

### 10.2 Power-down

When powering down the SoC, it is recommended to use the reverse order from the power-up sequence. If this cannot be achieved, ensure that all supplies are below the Vpwrdsn level before powering up again.

Table 10. Power-down

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
Vpwrdsn	Maximum voltage on a supply pin in powerdown mode	—	—	100	mV	—	—

## 11 Electromagnetic compatibility (EMC)

EMC measurements to IC-level IEC standards are available from NXP Semiconductor on request.

## 12 I/O Pad Characteristics

### 12.1 GPIO Pads

Table 11. GPIO Pads

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VIH	Input high level DC voltage threshold	0.7 * VDD_IO_*	—	—	V	1.8V / 3.3V	—
VIL	Input low level DC voltage threshold	—	—	0.3 * VDD_IO_*	V	1.8V / 3.3V	—

Table continues on the next page...

Table 11. GPIO Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VOL	GPIO output low voltage <sup>1</sup>	—	—	20% * VDD_IO_*	V	—	—
VOH	GPIO output high voltage <sup>1</sup>	80% * VDD_IO_*	—	—	V	—	—
VHYS_33	3.3V GPIO input hysteresis voltage	100	—	—	mV	Always enabled.	—
ILKG_18	1.8V GPIO pad input leakage current	-17	—	17	uA	1.8V, Tj = 125C	—
ILKG_33	3.3V GPI / GPIO pad input leakage current	-30	—	30	uA	3.3V, Tj = 125C	—
ILKG_3318	1.8V/3.3V GPIO pad input leakage current (3.3V)	-50	—	50	uA	3.3V, Tj = 125C	—
ILKG_3318	1.8V/3.3V GPIO pad input leakage current (1.8V)	-17	—	17	uA	1.8V, Tj = 125C	—
CIN_18	Input capacitance (1.8V GPIO)	—	6	8	pF	—	—
CIN_33	Input capacitance (3.3V GPI / GPIO)	—	7	11	pF	—	—
CIN_3318	Input capacitance (1.8V/3.3V GPIO)	—	7	11	pF	—	—
ISLEW	Input signal slew rate <sup>2</sup>	1	—	4	V/ns	—	—
ITR_TF	Input signal rise/fall time <sup>2,3</sup>	0.5	—	2	ns	—	—
TPW_MIN	Input minimum pulse width	2	—	—	ns	—	—
FMAX_IN_18	1.8V GPIO maximum input frequency <sup>4</sup>	—	—	50	MHz	CMOS Receiver	—
FMAX_IN_18	1.8V GPIO maximum input frequency <sup>4</sup>	—	—	208	MHz	VREF Receiver	—
FMAX_IN_3318	1.8V/3.3V GPIO maximum input frequency <sup>4</sup>	—	—	208	MHz	1.8V	—

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Table 11. GPIO Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
FMAX_IN_3318	1.8V/3.3V GPIO maximum input frequency <sup>4</sup>	—	—	166.7	MHz	3.3V	—
FMAX_IN_33	3.3V GPIO maximum input frequency <sup>4</sup>	—	—	50	MHz	—	—
IPU_18	1.8V GPIO pull up/down resistance	9	18	23	kΩ	pull up @ 0.3 * VDD_HV_IO, pull down @ 0.7 * VDD_HV_IO	—
IPU_33	3.3V GPIO pull up/down resistance	9	18	23	kΩ	pull up @ 0.3 * VDD_HV_IO, pull down @ 0.7 * VDD_HV_IO	—
IPU_3318	1.8V/3.3V GPIO pull up/down resistance	9	18	23	kΩ	pull up @ 0.3 * VDD_HV_IO, pull down @ 0.7 * VDD_HV_IO	—
RDSON_18	1.8V GPIO output impedance (NMOS & PMOS) <sup>5</sup>	27.0	36.3	48.0	Ω	SRE[2:0] = xxx, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 1.8V <sup>5</sup>	18.0	30.0	43.0	Ω	SRE[2:0] = 000, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 1.8V <sup>5</sup>	19.0	30.0	44.0	Ω	SRE[2:0] = 100, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 1.8V <sup>5</sup>	21.0	33.0	49.0	Ω	SRE[2:0] = 101, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 1.8V <sup>5</sup>	23.0	37.5	58.0	Ω	SRE[2:0] = 110, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 1.8V <sup>5</sup>	24.0	37.5	57.0	Ω	SRE[2:0] = 111, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 3.3V <sup>5</sup>	18.0	30.0	43.0	Ω	SRE[2:0] = 000, 50% * VDD_IO_*	—

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Table 11. GPIO Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 3.3V <sup>5</sup>	19.0	30.0	44.0	Ω	SRE[2:0] = 100, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 3.3V <sup>5</sup>	21.0	33.4	50.0	Ω	SRE[2:0] = 101, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 3.3V <sup>5</sup>	23.0	39.5	61.0	Ω	SRE[2:0] = 110, 50% * VDD_IO_*	—
RDSON_3318	1.8V/3.3V GPIO output impedance (NMOS & PMOS) at 3.3V <sup>5</sup>	26.0	39.5	61.0	Ω	SRE[2:0] = 111, 50% * VDD_IO_*	—
RDSON_33	3.3V GPIO output impedance (NMOS & PMOS) <sup>5</sup>	16.5	26.5	42.0	Ω	SRE[2:0] = 100, 50% * VDD_IO_*	—
RDSON_33	3.3V GPIO output impedance (NMOS & PMOS) <sup>5</sup>	19.2	30.5	49.5	Ω	SRE[2:0] = 101, 50% * VDD_IO_*	—
RDSON_33	3.3V GPIO output impedance (NMOS & PMOS) <sup>5</sup>	24.5	38.0	61.5	Ω	SRE[2:0] = 110, 50% * VDD_IO_*	—
RDSON_33	3.3V GPIO output impedance (NMOS & PMOS) <sup>5</sup>	32.0	48.0	75.5	Ω	SRE[2:0] = 111, 50% * VDD_IO_*	—
IOH_18	1.8V GPIO output high current <sup>5</sup>	-15.0	—	-6.0	mA	SRE[2:0] = xxx, 80% * VDD_IO_*	—
IOL_18	1.8V GPIO output low current <sup>5</sup>	6.0	—	15.0	mA	SRE[2:0] = xxx, 20% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 1.8V <sup>5</sup>	-22	—	-8	mA	SRE[2:0] = 000, 80% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 1.8V <sup>5</sup>	-21	—	-8	mA	SRE[2:0] = 100, 80% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 1.8V <sup>5</sup>	-19	—	-6	mA	SRE[2:0] = 101, 80% * VDD_IO_*	—

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Table 11. GPIO Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
IOH_3318	1.8V/3.3V GPIO output high current at 1.8V <sup>5</sup>	-17	—	-6	mA	SRE[2:0] = 110, 80% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 1.8V <sup>5</sup>	-17	—	-6	mA	SRE[2:0] = 111, 80% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 1.8V <sup>5</sup>	8	—	22	mA	SRE[2:0] = 000, 20% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 1.8V <sup>5</sup>	8	—	21	mA	SRE[2:0] = 100, 20% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 1.8V <sup>5</sup>	6	—	20	mA	SRE[2:0] = 101, 20% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 1.8V <sup>5</sup>	6	—	18	mA	SRE[2:0] = 110, 20% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 1.8V <sup>5</sup>	6	—	17	mA	SRE[2:0] = 111, 20% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 3.3V <sup>5</sup>	-40	—	-14	mA	SRE[2:0] = 000, 80% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 3.3V <sup>5</sup>	-40	—	-14	mA	SRE[2:0] = 100, 80% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 3.3V <sup>5</sup>	-35	—	-10	mA	SRE[2:0] = 101, 80% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 3.3V <sup>5</sup>	-32	—	-10	mA	SRE[2:0] = 110, 80% * VDD_IO_*	—
IOH_3318	1.8V/3.3V GPIO output high current at 3.3V <sup>5</sup>	-32	—	-10	mA	SRE[2:0] = 111, 80% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 3.3V <sup>5</sup>	15	—	40	mA	SRE[2:0] = 000, 20% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 3.3V <sup>5</sup>	15	—	40	mA	SRE[2:0] = 100, 20% * VDD_IO_*	—

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Table 11. GPIO Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
IOL_3318	1.8V/3.3V GPIO output low current at 3.3V <sup>5</sup>	13	—	36	mA	SRE[2:0] = 101, 20% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 3.3V <sup>5</sup>	12	—	33	mA	SRE[2:0] = 110, 20% * VDD_IO_*	—
IOL_3318	1.8V/3.3V GPIO output low current at 3.3V <sup>5</sup>	11	—	32	mA	SRE[2:0] = 111, 20% * VDD_IO_*	—
IOH_33	3.3V GPIO output high current <sup>5</sup>	-40.1	—	-14.0	mA	SRE[2:0] = 100, 80% * VDD_IO_*	—
IOH_33	3.3V GPIO output high current <sup>5</sup>	-36.2	—	-12.1	mA	SRE[2:0] = 101, 80% * VDD_IO_*	—
IOH_33	3.3V GPIO output high current <sup>5</sup>	-32.0	—	-10.3	mA	SRE[2:0] = 110, 80% * VDD_IO_*	—
IOH_33	3.3V GPIO output high current <sup>5</sup>	-29.0	—	-9.0	mA	SRE[2:0] = 111, 80% * VDD_IO_*	—
IOL_33	3.3V GPIO output low current <sup>5</sup>	14.6	—	39.4	mA	SRE[2:0] = 000, 20% * VDD_IO_*	—
IOL_33	3.3V GPIO output low current <sup>5</sup>	14.6	—	39.4	mA	SRE[2:0] = 100, 20% * VDD_IO_*	—
IOL_33	3.3V GPIO output low current <sup>5</sup>	13.0	—	35.5	mA	SRE[2:0] = 101, 20% * VDD_IO_*	—
IOL_33	3.3V GPIO output low current <sup>5</sup>	11.2	—	32.0	mA	SRE[2:0] = 110, 20% * VDD_IO_*	—
IOL_33	3.3V GPIO output low current <sup>5</sup>	10.0	—	29.0	mA	SRE[2:0] = 111, 20% * VDD_IO_*	—
FMAX_18	1.8V GPIO maximum output frequency <sup>5,6</sup>	—	—	208	MHz	SRE[2:0] = 000	—
FMAX_18	1.8V GPIO maximum output frequency <sup>5,6</sup>	—	—	150	MHz	SRE[2:0] = 100	—
FMAX_18	1.8V GPIO maximum output frequency <sup>5,6</sup>	—	—	133	MHz	SRE[2:0] = 101	—
FMAX_18	1.8V GPIO maximum output frequency <sup>5,6</sup>	—	—	100	MHz	SRE[2:0] = 110	—

Table continues on the next page...

Table 11. GPIO Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
FMAX_18	1.8V GPIO maximum output frequency <sup>5,6</sup>	—	—	50	MHz	SRE[2:0] = 111	—
FMAX_33	3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	50	MHz	SRE[2:0] = 100	—
FMAX_33	3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	50	MHz	SRE[2:0] = 101, reduced slew relative to the SRE[2:0] = 100 setting for the same output load.	—
FMAX_33	3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	50	MHz	SRE[2:0] = 110	—
FMAX_33	3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	1	MHz	SRE[2:0] = 111	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	208	MHz	SRE[2:0] = 000, 1.8V	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	166.7	MHz	SRE[2:0] = 100, 1.8V	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	150	MHz	SRE[2:0] = 101, 1.8V	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	133.3	MHz	SRE[2:0] = 110, 1.8V	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	100	MHz	SRE[2:0] = 111, 1.8V	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	166.7	MHz	SRE[2:0] = 000, 3.3V	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	150	MHz	SRE[2:0] = 100, 3.3V	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <sup>5,6</sup>	—	—	133.3	MHz	SRE[2:0] = 101, 3.3V	—

Table continues on the next page...

Table 11. GPIO Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <a href="#">5,6</a>	—	—	100	MHz	SRE[2:0] = 110, 3.3V	—
FMAX_3318	1.8V/3.3V GPIO maximum output frequency <a href="#">5,6</a>	—	—	83.3	MHz	SRE[2:0] = 111, 3.3V	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 1.8V <a href="#">5,6,7</a>	1.0	—	5.5	V/ns	SRE[2:0] = 000	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 1.8V <a href="#">5,6,7</a>	1.0	—	5.75	V/ns	SRE[2:0] = 100	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 1.8V <a href="#">5,6,7</a>	0.75	—	4.75	V/ns	SRE[2:0] = 101	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 1.8V <a href="#">5,6,7</a>	0.5	—	4.5	V/ns	SRE[2:0] = 110	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 1.8V <a href="#">5,6,7</a>	0.5	—	4.0	V/ns	SRE[2:0] = 111	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 3.3V <a href="#">5,6,7</a>	2.0	—	10.5	V/ns	SRE[2:0] = 000	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 3.3V <a href="#">5,6,7</a>	2.0	—	9.25	V/ns	SRE[2:0] = 100	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 3.3V <a href="#">5,6,7</a>	1.5	—	9.5	V/ns	SRE[2:0] = 101	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 3.3V <a href="#">5,6,7</a>	0.75	—	7.5	V/ns	SRE[2:0] = 110	—
TR_TF_3318	1.8V/3.3V GPIO rise/fall time at 3.3V <a href="#">5,6,7</a>	0.75	—	7.25	V/ns	SRE[2:0] = 111	—
TR_TF_18	1.8V GPIO rise/fall time <a href="#">5,6,7</a>	0.75	—	3.75	V/ns	SRE[2:0] = 000	—
TR_TF_18	1.8V GPIO rise/fall time <a href="#">5,6,7</a>	0.75	—	3.75	V/ns	SRE[2:0] = 100	—
TR_TF_18	1.8V GPIO rise/fall time <a href="#">5,6,7</a>	0.75	—	3.25	V/ns	SRE[2:0] = 101	—
TR_TF_18	1.8V GPIO rise/fall time <a href="#">5,6,7</a>	0.75	—	3.25	V/ns	SRE[2:0] = 110	—
TR_TF_18	1.8V GPIO rise/fall time <a href="#">5,6,7</a>	0.25	—	3.25	V/ns	SRE[2:0] = 111	—
TR_TF_33	3.3V GPIO rise/fall time <a href="#">5,6,7</a>	1.90	—	9.0	V/ns	SRE[2:0] = 100	—

Table continues on the next page...

Table 11. GPIO Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
TR_TF_33	3.3V GPIO rise/fall time <sup>5,6,7</sup>	1.00	—	8.50	V/ns	SRE[2:0] = 101	—
TR_TF_33	3.3V GPIO rise/fall time <sup>5,6,7</sup>	0.50	—	7.30	V/ns	SRE[2:0] = 110	—
TR_TF_33	3.3V GPIO rise/fall time <sup>5,6,7</sup>	0.40	—	6.0	V/ns	SRE[2:0] = 111	—
WISE_33	3.3V GPIO pad indeterminate state end threshold	—	2.35	—	V	See 1.8V and 3.3V GPIO pad detailed behavior diagram below	—
WISE_3318	1.8V/3.3V GPIO pad indeterminate state end threshold	—	1.53	—	V	See 1.8V/3.3V GPIO pad detailed behavior diagram below	—
WISE_18	1.8V GPIO pad indeterminate state end threshold	—	0.6	—	V	See 1.8V and 3.3V GPIO pad detailed behavior diagram below	—

1. For current at this voltage see IOL/IOH specs respectively.
2. Fastest slew rate and lowest rise/fall time constraint required to meet high-speed interface timing such as QSPI, RGMII, and uSDHC. Slower input transitions can be used for input signals with slow switching rates (<40 MHz).
3. The ISLEW has precedence over ITR\_TF if the ITR\_TF violates the implied range for a given ISLEW.
4. Input slew rate and rise/fall time limits must be adhered to in conjunction with the max input frequency limits given for proper operation.
5. GPIO output transition time information can be obtained from the device IBIS model. IBIS models are recommended for system level simulations, as discrete values for I/O transition times are not representative of the I/O pad behavior when connected to an actual transmission line load.
6. I/O timing specifications are valid for the un-terminated 50ohm transmission line reference load given in the figure below. A lumped 8pF load is assumed at the end of a 5 inch microstrip trace on standard FR4 with approximately 3.3pF/inch. For signals with frequency greater than 63MHz, a maximum 2 inch PCB trace is assumed. For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.
7. Rise/fall time specifications are derived from simulation model for the defined operating points (between 20% and 80% of VDD\_HV\_IO level). Actual application rise/fall time should be extracted from IBIS model simulations with the microcontroller models and application PCB.

**NOTE**

In the Standby mode exit case, the rising edge of the PMIC\_VDD\_OK pin determines when the pads enter their 'POR value' state instead of the POR\_B pin.

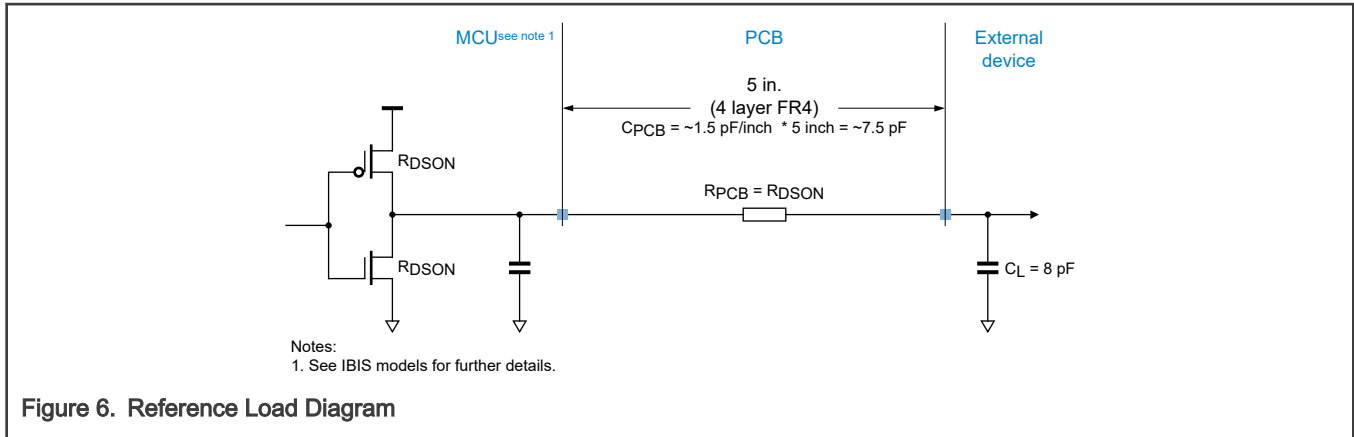


Figure 6. Reference Load Diagram

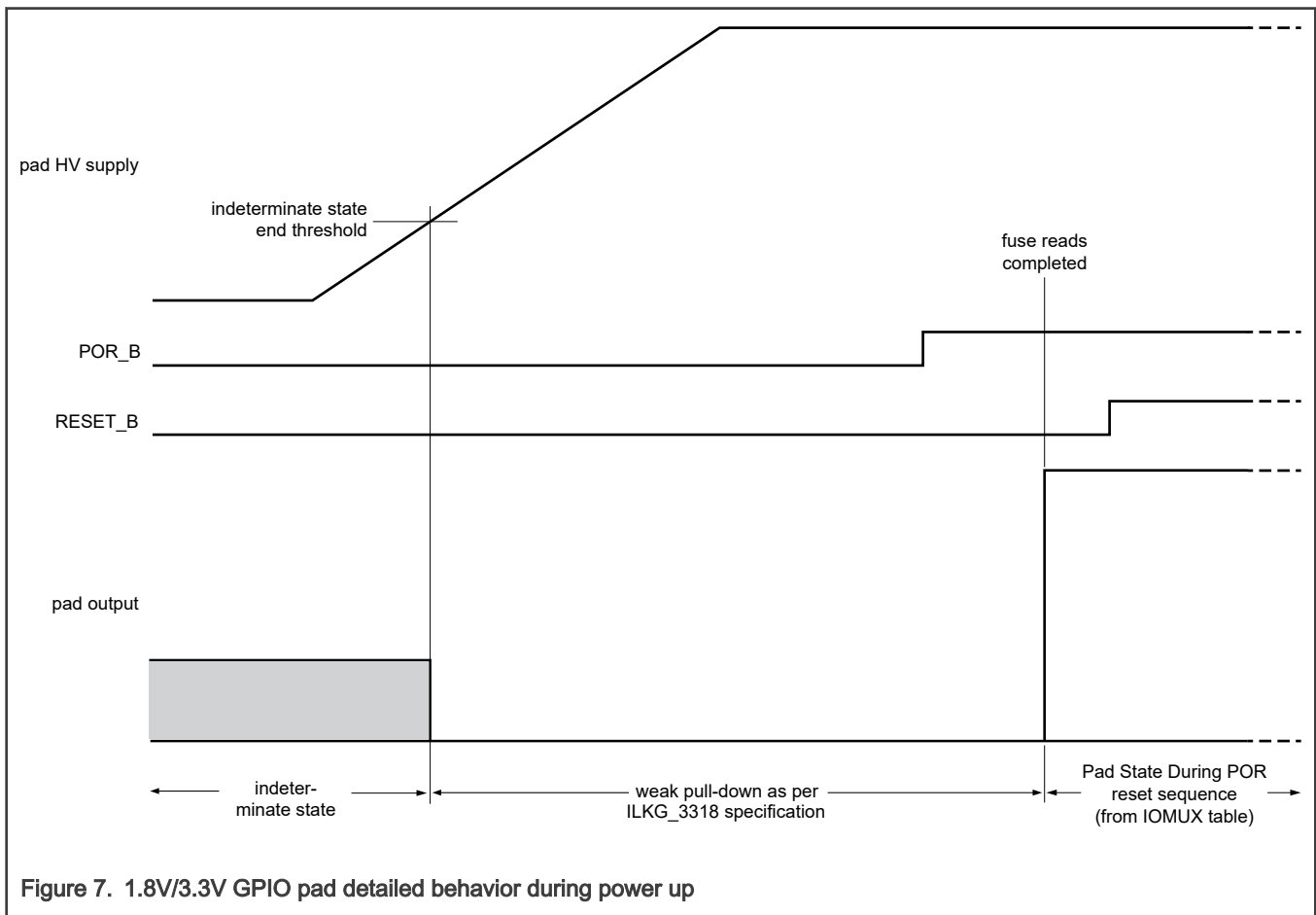


Figure 7. 1.8V/3.3V GPIO pad detailed behavior during power up

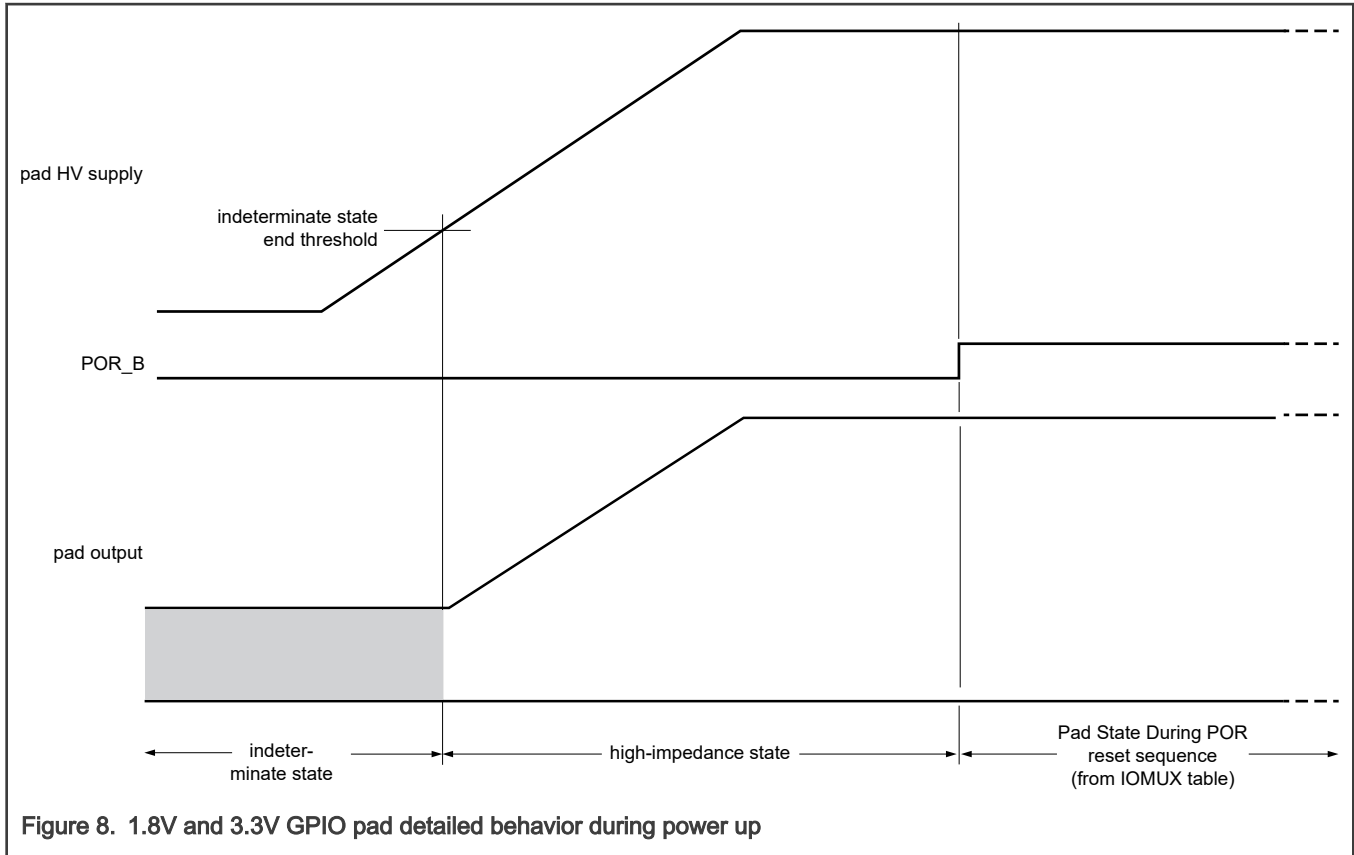


Figure 8. 1.8V and 3.3V GPIO pad detailed behavior during power up

The high-impedance state level is shown based on the external pull-up being on the corresponding pad supply.

## 13 Aurora specifications

### 13.1 Aurora Pads

Table 12. Aurora Pads

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fAURORA	Data Rate	0.05	—	5.0	Gbps	100Ω external termination ( Not on board but inside receiver after AC coupling )	—
IDD_HV_AUR	Transmitter HV supply current consumption (No pre-emphasis)	18	22	31	mA	max fAURORA per active transmit lane	—
IDD_HV_AUR	Transmitter HV supply current consumption (pre-emphasis enabled ,	25	30	40	mA	max fAURORA per active transmit lane	—

Table continues on the next page...



Table 12. Aurora Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
	pre-emphasis gain=11)						
VOD_AURORA_AC	Transmitter Differential output voltage (end termination) <sup>1,2,3</sup>	400	600	900	mV	max fAURORA, 100Ω termination, 100Ω differential transmission line delay, matched network	—
VOD_AURORA_DC	DC range for the VOD (Transmitter Differential Output Voltage)	800	—	—	mV	ipp_obe=1 DC condition	—
VOD_AURORA_AC_PRE_EMPH	Transmitter Differential output voltage (end termination, preemph=11) <sup>1,2,4</sup>	600	900	1200	mV	max fAURORA, 100Ω termination, 100Ω differential transmission line delay, matched network	—
VCM_AURORA	Transmitter Common mode voltage	0.775	—	1.025	V	—	—
VCM_LVDS_RX	Receiver input signal common mode range	0.6	—	1.0	V	—	—
VDIFF_LVDS_RX	Receiver input differential signal	400	—	—	mV	—	—
CLOAD_AURORA	Maximum transmission line load ( Lumped Load at any point on Tline )	—	—	0.1	pF	—	—
RTERM_AURORA	Internal termination resistance	80	100	130	Ohm	enabled	—
VSLEW_AURORA	Differential output slew rate	—	30	50	ps / 200mV	max fAURORA	—
TSTARTUP_AURORA	Transmitter startup time (assertion of ipp_obe to common mode settling of differential output)	—	—	500	ns	—	—
TEYE_AURORA	Valid data region ( Including PLL Jitter for Aurora ) <sup>5</sup>	0.55	—	—	UI	max fAURORA	—

Table continues on the next page...

Table 12. Aurora Pads (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VOH_AURORA	Transmitter output high indicator <sup>6</sup>	$V_{DD\_IO}/2 + 0.2$	—	—	V	100Ω termination at receiver end	—
VOL_AURORA	Transmitter output low indicator <sup>6</sup>	—	—	$V_{DD\_IO}/2 - 0.2$	V	100Ω termination at receiver end	—
PAD_P_BIAS	Pad_p voltage output level when Tx disabled	—	—	0.6	V	lpp_obe_lv=0 lpp_term_en_lv=0	—
PAD_N_BIAS	Pad_n voltage output level when Tx disabled	1.1	—	—	V	lpp_obe_lv=0 lpp_term_en_lv=0	—

- When operating at max speed, there will be losses and differential output will be smaller as against DC condition. Aurora Interface Min differential swing is 400mV which is always guaranteed but the max limit is dependent on board design/ losses. For boards with negligible losses , if differential output (P-N) goes higher than 800mV (Aurora max differential input spec) , user must use “dual termination” scheme as highlighted in the Source Termination Circuit Figure to get the differential swing back within Range. The termination in the source side can be enabled through software in the transmitter pad design. Direct end termination without AC coupling is not allowed.
- Termination scheme as shown in the End Termination Circuit Figure. Direct end termination without AC coupling is not allowed.
- Differential output is with pre-emphasis disabled, and a 10mA output stage current.
- Differential output is with pre-emphasis enabled, and a ~15mA avg output stage current
- UI @ 5Gbps equals 200ps. The valid eye is expected to be > 110ps in width. ISI jitter spec is 20-30ps for the LVDS transmitter across PVT in a delay matched differential transmission line impedance of 100Ω.
- VDD\_IO maps to corresponding supply name on the device.

Termination scheme as shown in “End Termination Circuit” applies to debug tool hardware and is not recommended to be placed on the PC.

Source termination Circuit – Transmitter side 100 ohm termination is present inside the Tx pad and should not be placed on the PCB.

Direct 100 ohm board termination not allowed between AUR\_TXn\_N and AUR\_TXn\_N (n=0,1,2,3). Source termination is only allowed through the internal termination inside LVDS Tx pad.

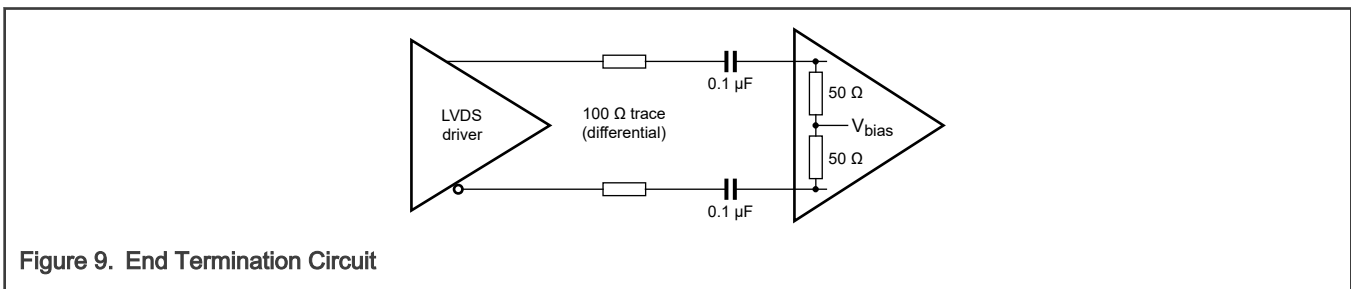


Figure 9. End Termination Circuit

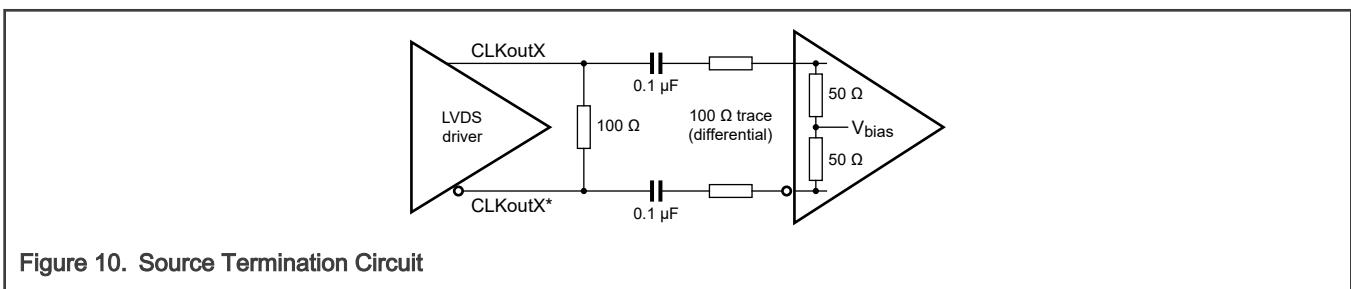


Figure 10. Source Termination Circuit

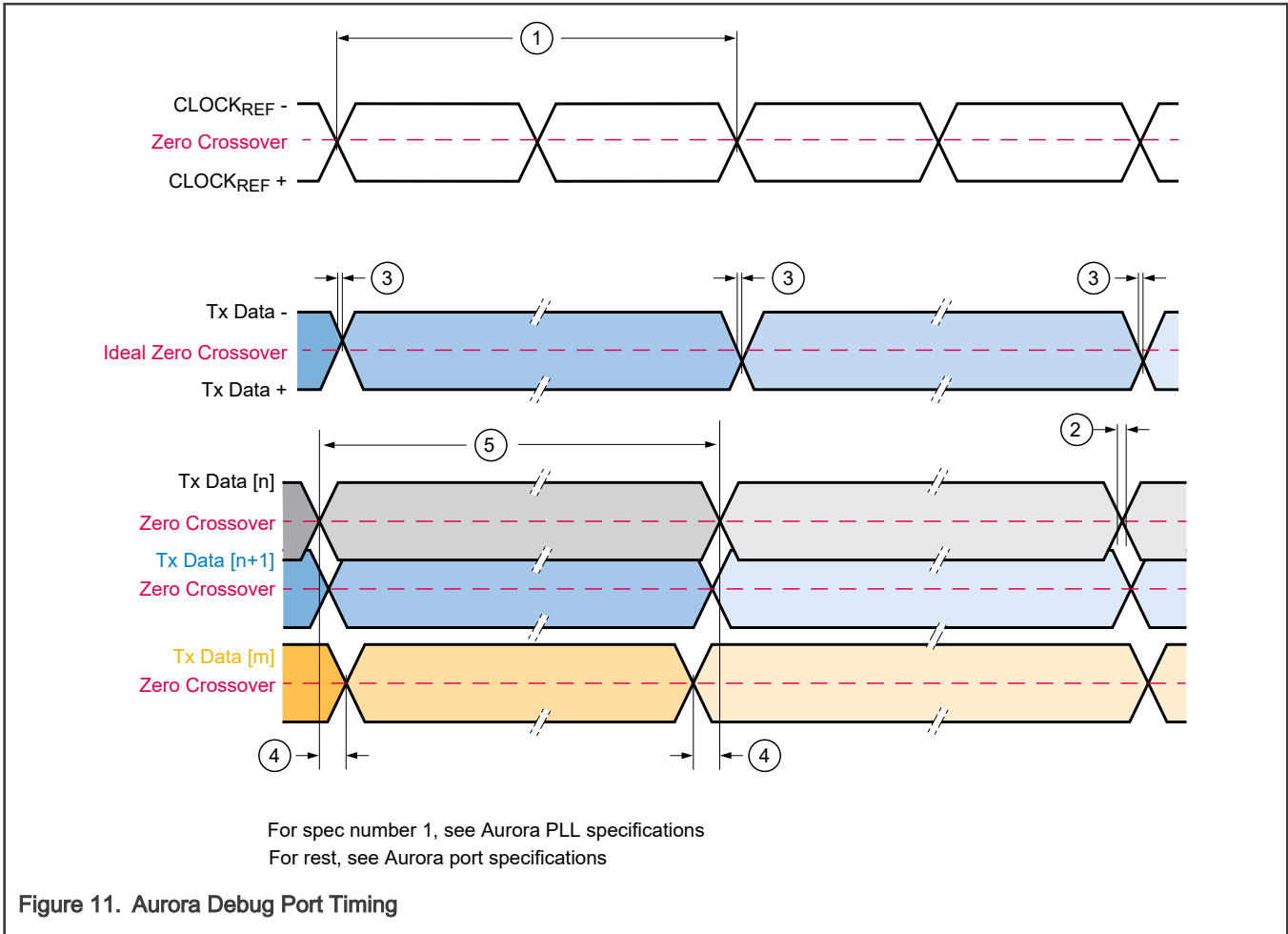
### 13.2 Aurora Port Timing

The following table gives the Aurora Port interface timing specifications for the device.

Table 13. Aurora Port Timing

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
BER	Bit Error Rate	—	—	10e-12	—	—	—
JD	Transmit line deterministic jitter	—	—	0.17	OUI	data rate <=3.0 Gbps	—
JD	Transmit line deterministic jitter	—	—	0.25	OUI	3.0Gbps < data rate <= 5.0Gbps	—
JT	Transmit line total jitter	—	—	0.35	OUI	data rate <= 3.0 Gbps	2
JT	Transmit line total jitter	—	—	0.45	OUI	3.0Gbps < data rate <= 5.0Gbps	2
SO	Differential output skew	—	—	20	ps	—	3
SMO	Lane to lane output skew	—	—	1000	ps	—	4
OUI	Aurora lane unit interval <sup>1,2</sup>	—	500	—	ps	2.0 Gbps	5
OUI	Aurora lane unit interval <sup>1,2</sup>	—	400	—	ps	2.5 Gbps	5
OUI	Aurora lane unit interval <sup>1,2</sup>	—	333	—	ps	3.0 Gbps	5
OUI	Aurora lane unit interval <sup>1,2</sup>	—	294	—	ps	3.4 Gbps	5
OUI	Aurora lane unit interval <sup>1,2</sup>	—	250	—	ps	4.0 Gbps	5
OUI	Aurora lane unit interval <sup>1,2</sup>	—	200	—	ps	5.0 Gbps	5

1. +/- 100 PPM.
2. The Aurora interface supports data rates of 2.0, 2.5, 3.0, 3.4, 4.0, and 5.0 Gbps.



### 13.3 Aurora PLL

The following table gives the operating frequencies and characteristics of the Aurora PLL. The operating frequencies correspond to the supported Aurora data trace lane speed. The Aurora PLL works from an external 100MHz input reference clock, and achieves a maximum output frequency of 5GHz.

Table 14. Aurora PLL

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fPLL_CLKIN	Aurora PLL Input Reference Clock Frequency <sup>1,2,3</sup>	—	100	—	MHz	—	—
fPLL_CLKIN_PFD	Aurora PLL Phase Detector Clock Frequency <sup>4</sup>	—	100	—	MHz	—	—
ΔfPLL_CLKIN	Aurora PLL Input Reference Clock Duty Cycle <sup>2</sup>	40	—	60	%	—	—

Table continues on the next page...

Table 14. Aurora PLL (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
JRCDC	Reference clock period jitter	—	—	5	ps	RMS, 0.5MHz - 20MHz	—
fPLL_VCO	Aurora PLL VCO Frequency Range	3000	—	5000	MHz	—	—
fPLL_CLKOUT0	Aurora PLL Output Clock 0 Frequency Range <sup>5</sup>	—	—	5000	MHz	5.0Gbps Aurora lane data rate, VCO frequency divided by 1	—
fPLL_CLKOUT0	Aurora PLL Output Clock 0 Frequency Range <sup>5</sup>	—	—	4000	MHz	4.0Gbps Aurora lane data rate, VCO frequency divided by 1	—
fPLL_CLKOUT0	Aurora PLL Output Clock 0 Frequency Range <sup>5</sup>	—	—	3400	MHz	3.4Gbps Aurora lane data rate, VCO frequency divided by 1	—
fPLL_CLKOUT0	Aurora PLL Output Clock 0 Frequency Range <sup>5</sup>	—	—	3000	MHz	3.0Gbps Aurora lane data rate, VCO frequency divided by 1	—
fPLL_CLKOUT0	Aurora PLL Output Clock 0 Frequency Range <sup>5</sup>	—	—	2500	MHz	2.5Gbps Aurora lane data rate, VCO frequency divided by 2.	—
fPLL_CLKOUT0	Aurora PLL Output Clock 0 Frequency Range <sup>5</sup>	—	—	2000	MHz	2.0Gbps Aurora lane data rate, VCO frequency divided by 2.	—
fPLL_CLKOUT0	Aurora PLL Output Clock 0 Frequency Range	—	—	500	MHz	No tool connected - trace logic clock with FXOSC reference clock.	—
tLOCK	Aurora PLL Lock Time	—	—	150	us	—	—
PER_jitter	Aurora PLL Period Jitter	-21	—	21	ps	fPLL_CLKIN = 100MHz, VCO = 5GHz, fPLL_CLKOUT = 5GHz, 6-sigma	—
LT_jitter	Aurora PLL Long Term Jitter	-120	—	120	ps	Saturated, 6-sigma	—

- 40MHz is the only internal input reference frequency supported for the Aurora PLL.
- Refer to the LVDS Pad specifications for additional Aurora PLL reference clock electrical specifications. Also see "Aurora Debug Port Timing" figure for fPLL\_CLKIN as spec number 1.
- 100MHz is the only input reference frequency supported for the Aurora PLL.
- It is Aurora PLL Input Reference Clock Frequency after pre-divider.
- The Aurora PLL is only validated at the frequencies specified within this table - these frequencies correspond to the limited set of Aurora data lane rates that are supported for the device.

## 14 Power Management Controller (PMC)

### 14.1 PMC Bandgap

Table 15. PMC Bandgap

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VBG_SCALED	Scaled version of bandgap reference voltage measured by SAR ADC <sup>1</sup>	1.127	1.150	1.173	V	Both bandgap and buffer are trimmed	—

1. ADC conversion error must be included when reading the bandgap reference voltage via the chip ADC.

## 15 Reset

### 15.1 Reset Duration

The durations specified "Reset Duration" table and the corresponding figures refer to standard reset sequences. A reset sequence is no longer standard when it is interrupted by another power-on or destructive reset event, in which case the reset sequence restarts from the beginning of the reset sequence corresponding to that event, and the total duration is the time already spent in reset plus the duration of the new sequence.

The diagrams in this section are not to scale.

Table 16. Reset Duration

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
TFR	Functional Reset Sequence Duration	—	—	545	us	FIRC_CLK, trimmed	—
TDR	Destructive Reset Sequence Duration	—	—	1370	us	FIRC_CLK, trimmed during destructive reset phase	—
POR	Power On Reset Sequence Duration	—	—	1500	us	FIRC_CLK, trimmed during destructive reset phase	—

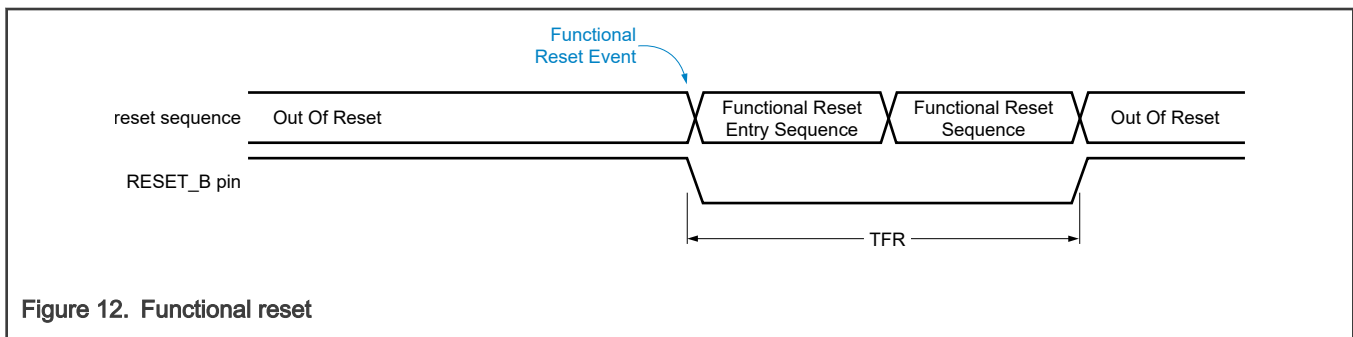
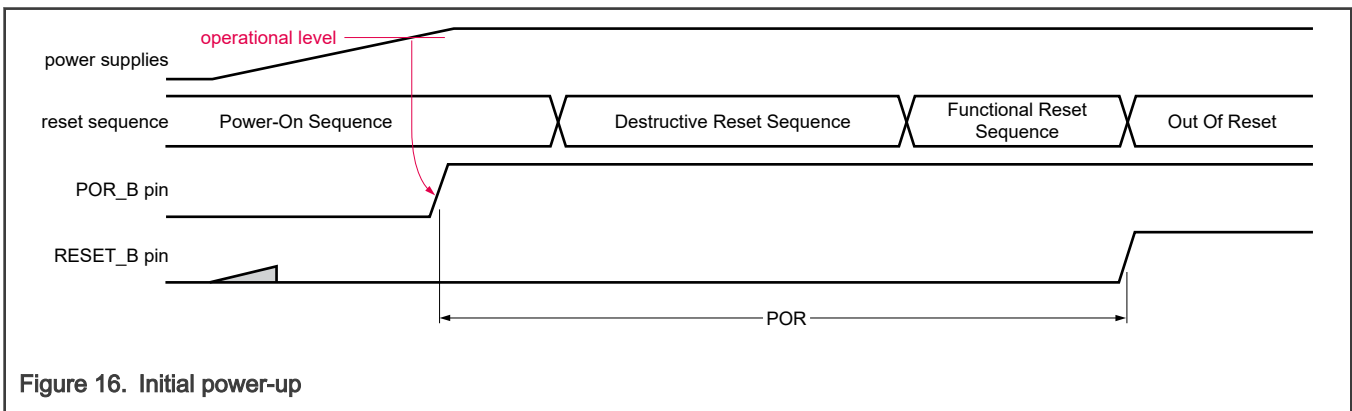
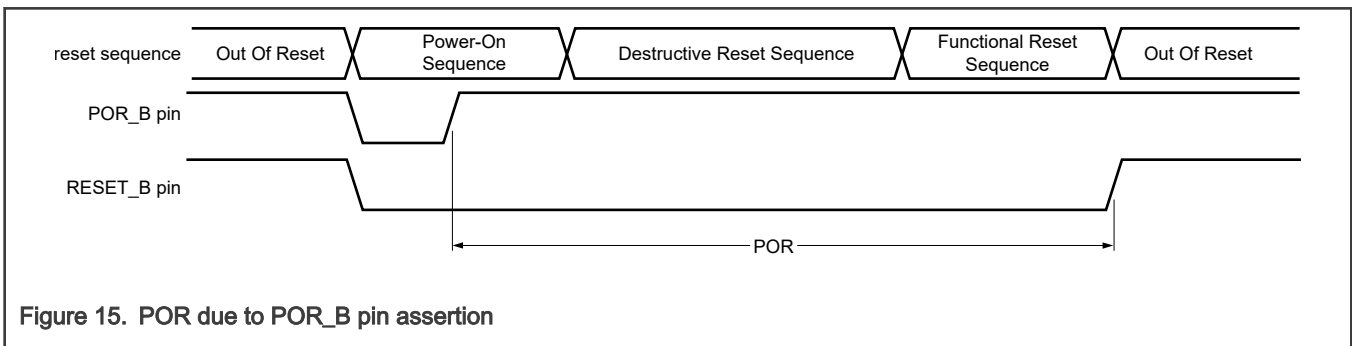
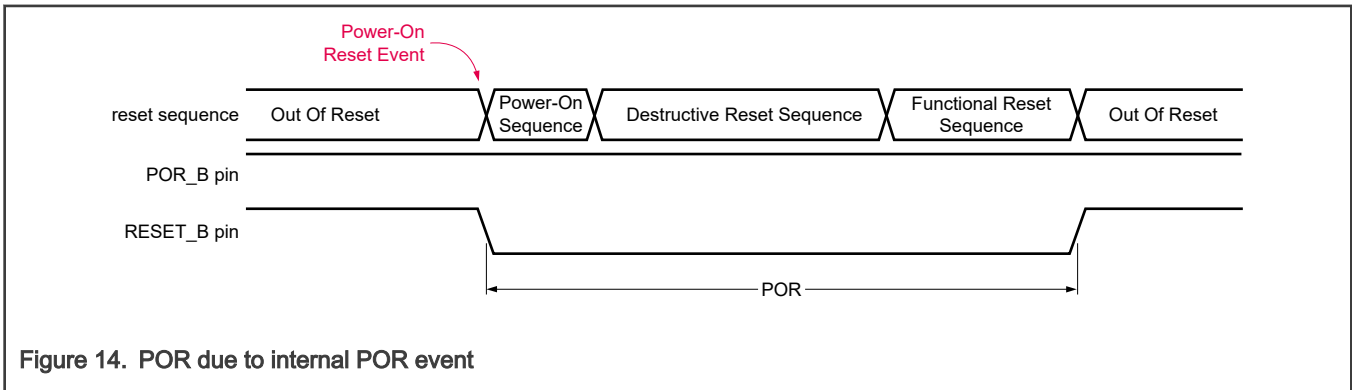
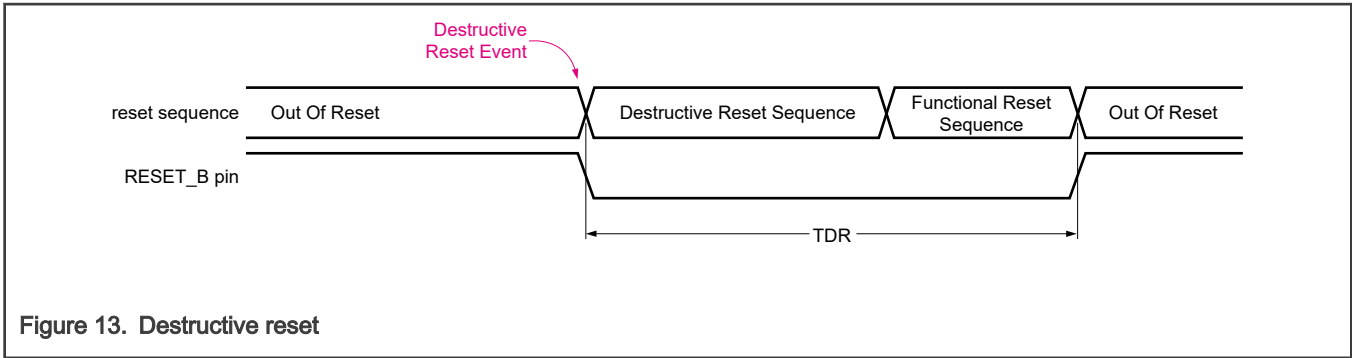


Figure 12. Functional reset



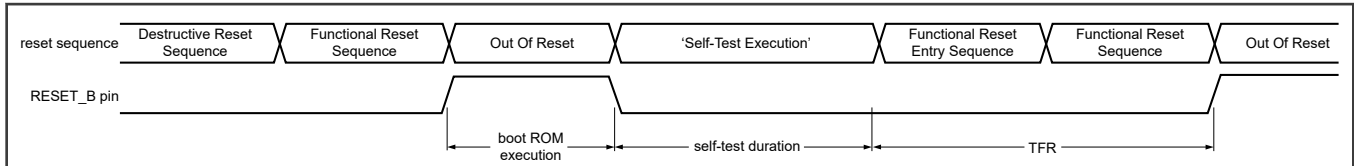


Figure 17. Start-up self-test

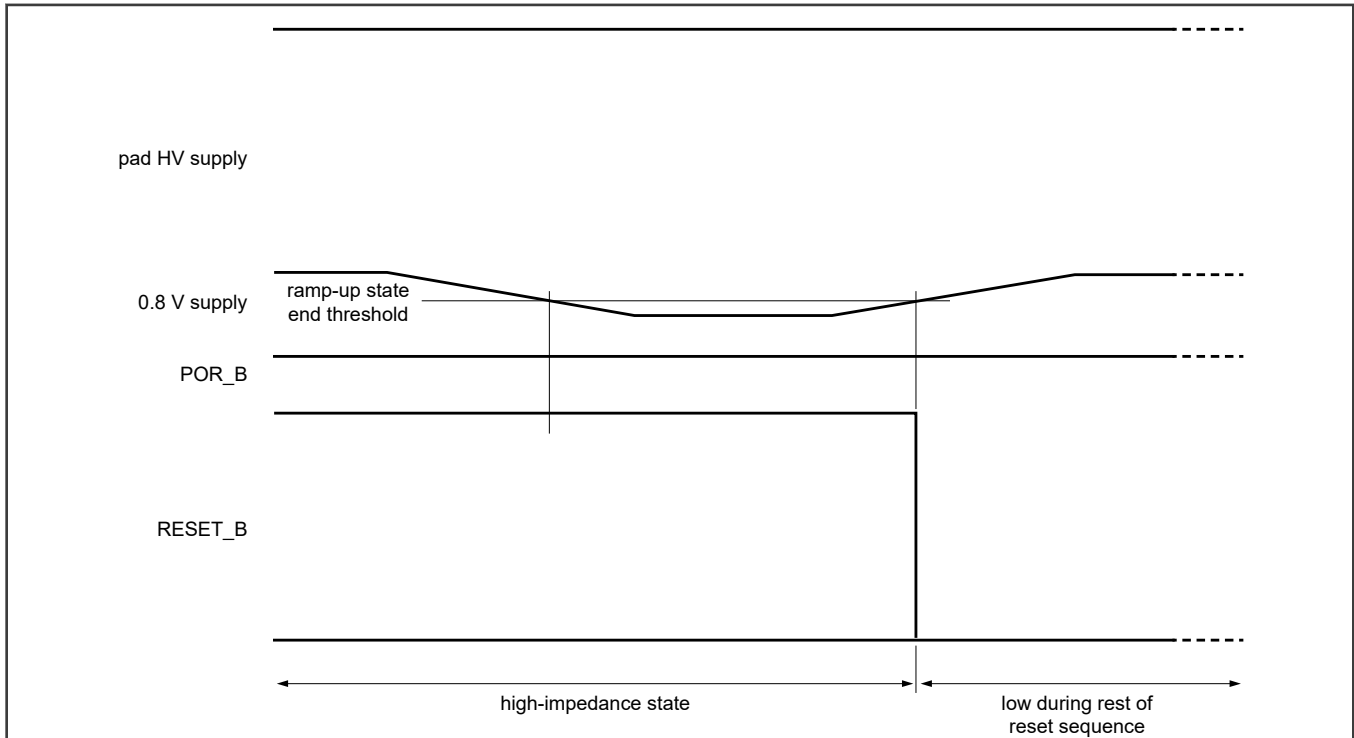
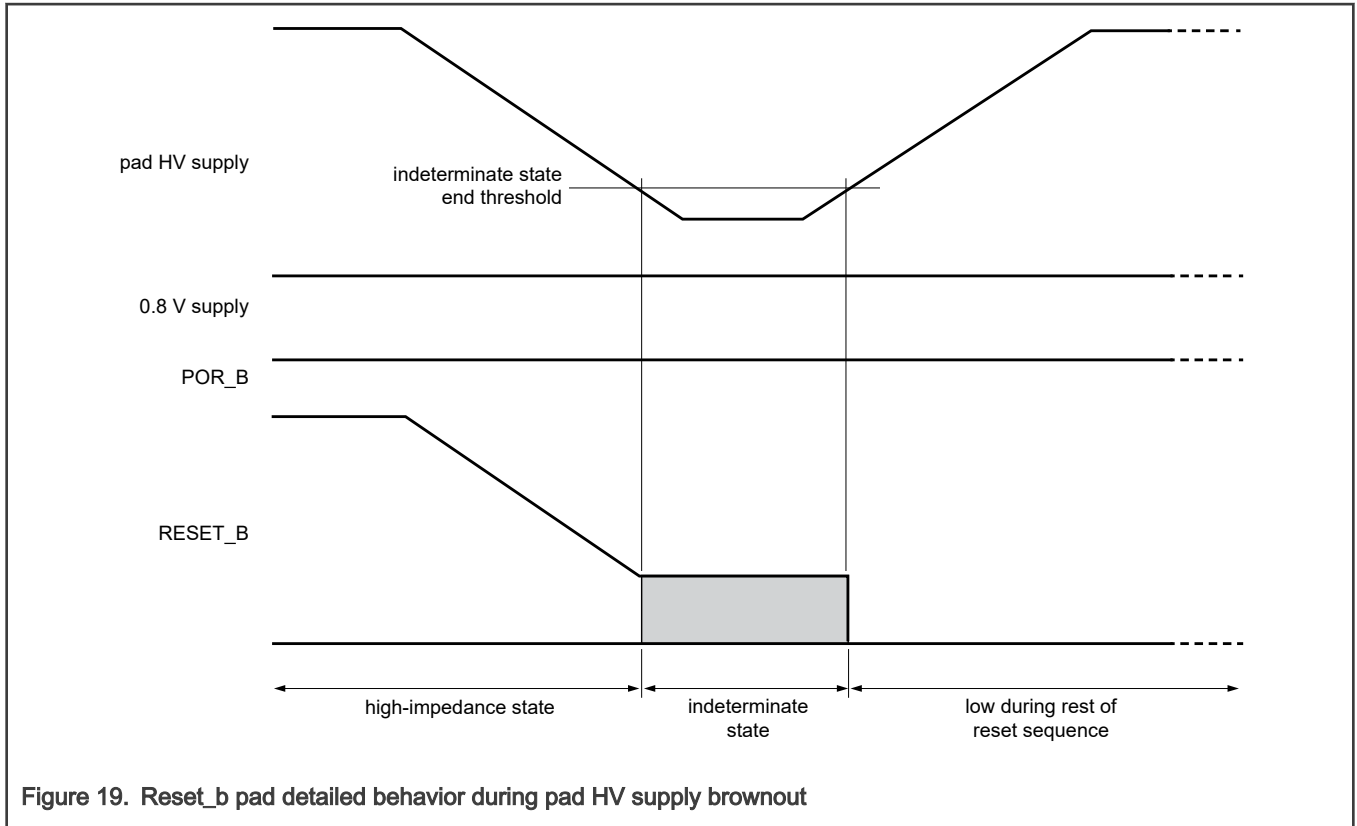
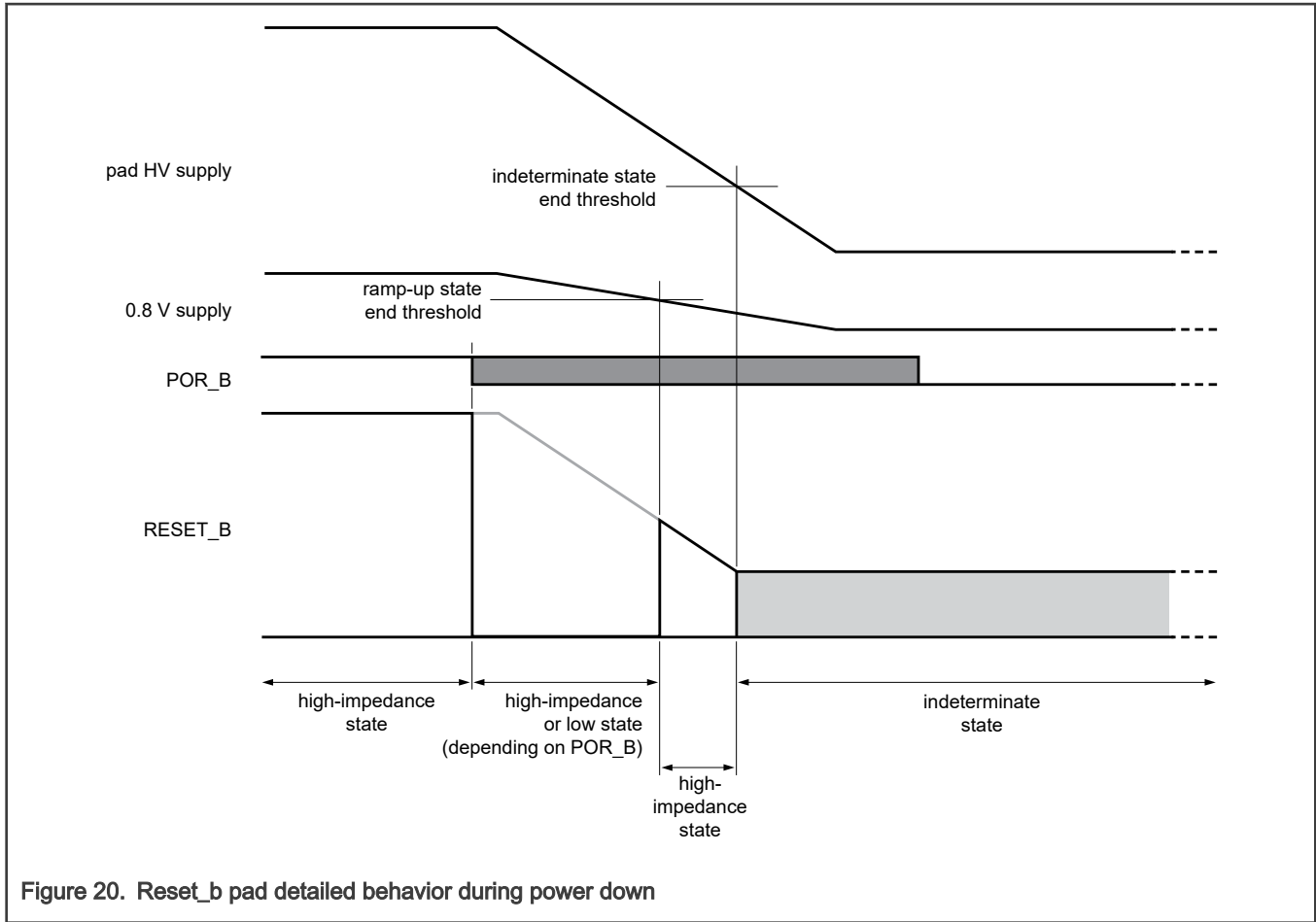


Figure 18. Reset\_b pad detailed behavior during core supply brownout







## 15.2 Reset and Standby related pad electrical characteristics

The following table gives the characteristics of the POR\_B, RESET\_B, PMIC\_STBY\_MODE\_B, and PMIC\_VDD\_OK pads. Values not explicitly listed in this table can be found in the 'GPIO Pads' section.

**Table 17. Reset and Standby related pad electrical characteristics**

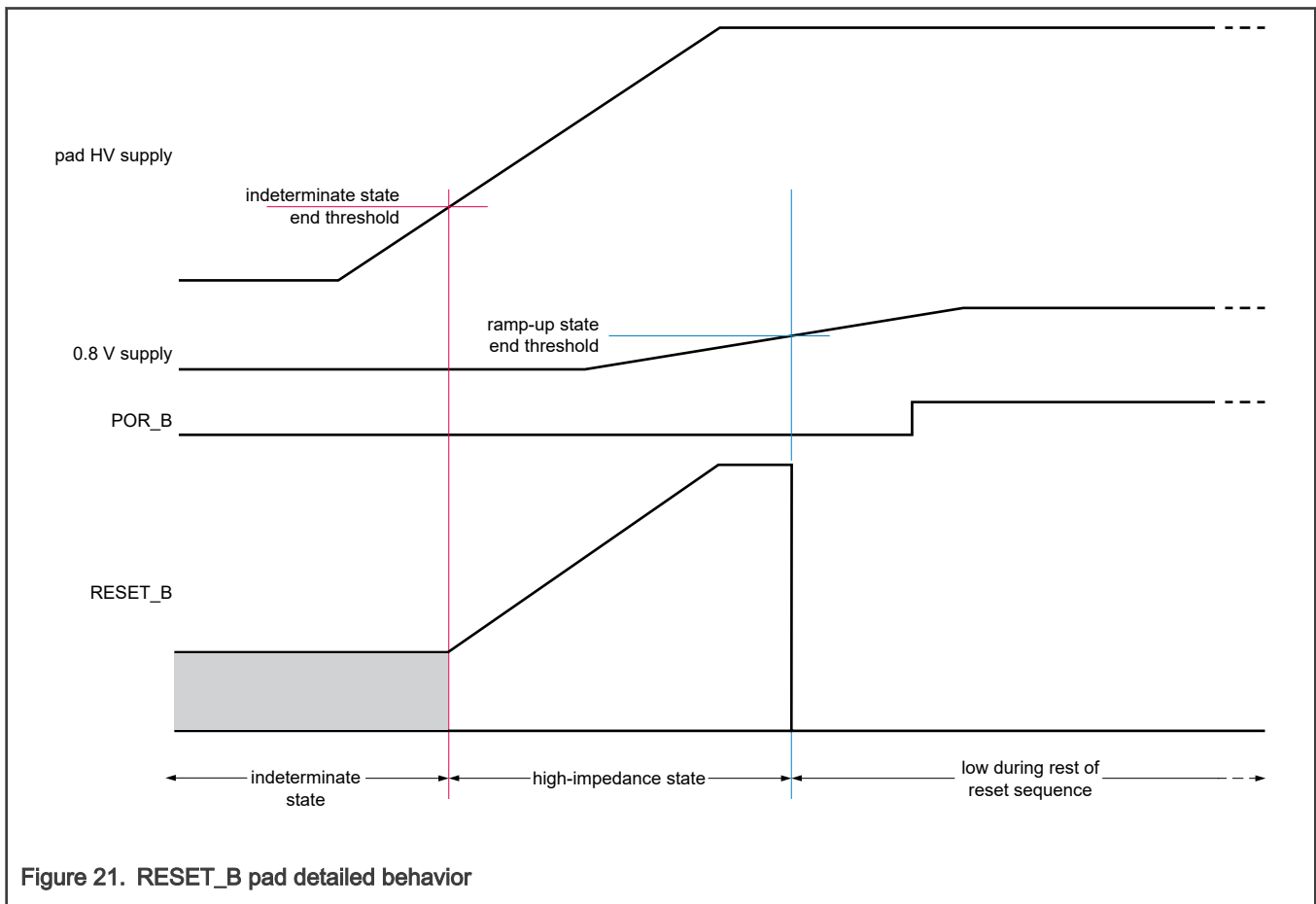
Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
ISLEW_POR_B	POR_B slew rate	30e-06	—	4	V/ns	—	—
ISLEW_RESET_B	RESET_B slew rate <sup>1</sup>	30e-06	—	4	V/ns	Noise on RESET_B <100mV peak-peak.	—
WISE_RESET_B	RESET_B pad indeterminate state end threshold	—	2.35	—	V	See RESET_B pad detailed behavior diagram below	—
VRSE_RESET_B	RESET_B pad ramp-up state end threshold	—	460	—	mV	See RESET_B pad detailed behavior diagram below	—
WF_RESET_B	RESET_B input filtered pulse	—	—	17	ns	—	—

*Table continues on the next page...*

**Table 17. Reset and Standby related pad electrical characteristics (continued)**

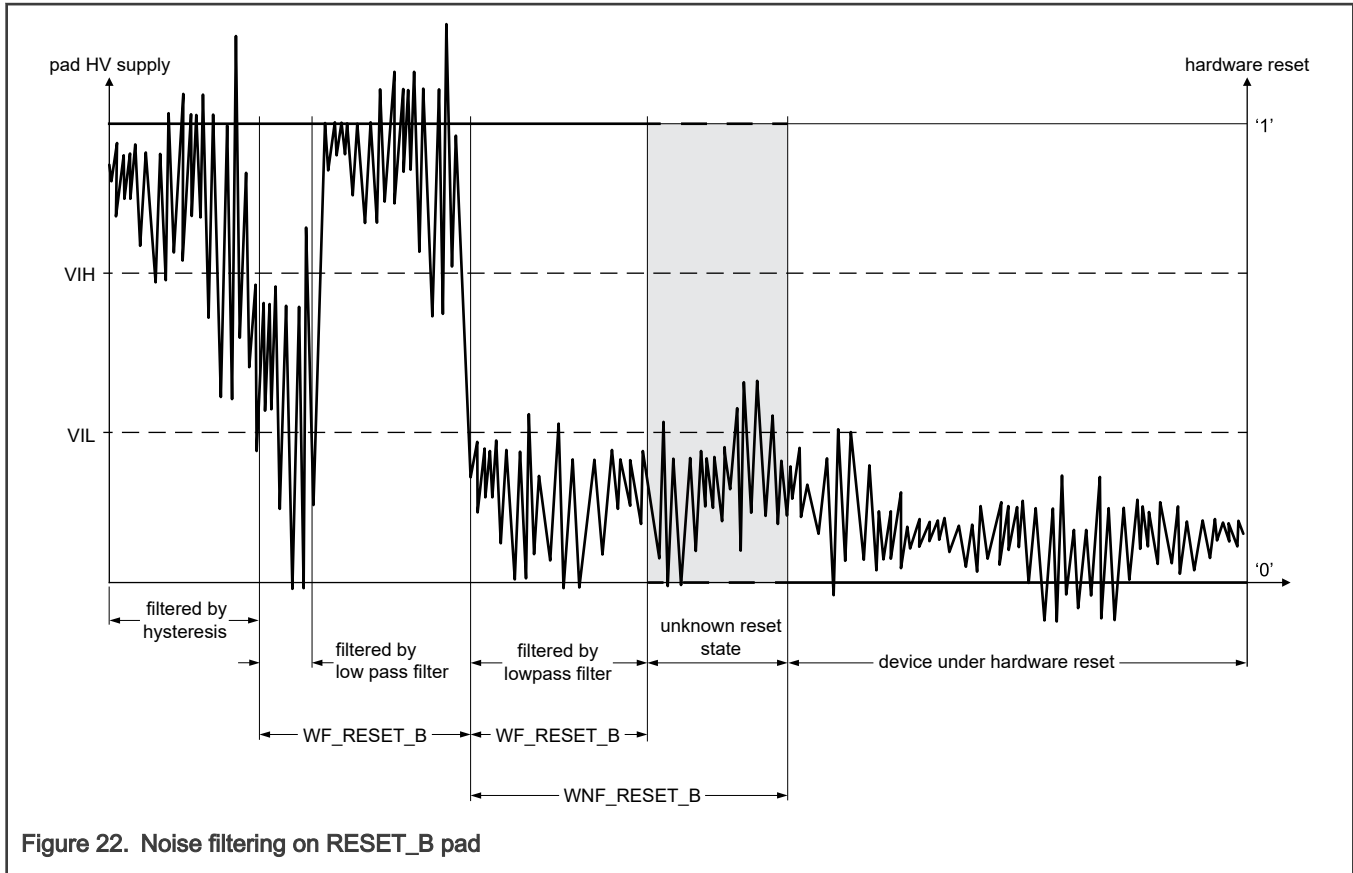
Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
WNF_RESET_B	RESET_B input not filtered pulse	400	—	—	ns	—	—
MLP_POR_B	POR_B minimum low pulse	5	—	—	us	—	—
MLP_PMIC_VDD_OK	PMIC_VDD_OK minimum low pulse	36	—	—	us	during Standby mode entry	—
MHP_PMIC_VDD_OK	PMIC_VDD_OK minimum high pulse	36	—	—	us	during Standby mode exit	—

1.  $ISLEW\_RESET\_B(\text{Min}) = \text{MAX}[30\text{e-}06, 0.002 * V_{\text{noise\_p\_p}} * F_{\text{noise}}]$ , where  $V_{\text{noise\_p\_p}}$  is peak-peak noise magnitude (in V) and  $F_{\text{noise}}$  is max noise frequency (in MHz).



**Figure 21. RESET\_B pad detailed behavior**

The RESET\_B pad behavior described in the diagram and the related VRSE\_RESET\_B parameter spec also apply to the case of core VDD droop after power-up.



During SoC power-up, the PMIC asserts the POR\_B input before the SoC supplies are turned on and kept asserted until all SoC supplies have reached their operational levels (i.e., all the corresponding voltage monitors in the PMIC have been satisfied) and any required PMIC BIST has completed. See the 'Power Sequencing' section for details.

The PMIC asserts the POR\_B input whenever one of its voltage detectors detects an SoC supply's voltage is outside its operational range (i.e., a corresponding PMIC LVD or HVD event occurs).

### 15.2.1 PMIC Standby Mode Entry / Exit Protocol

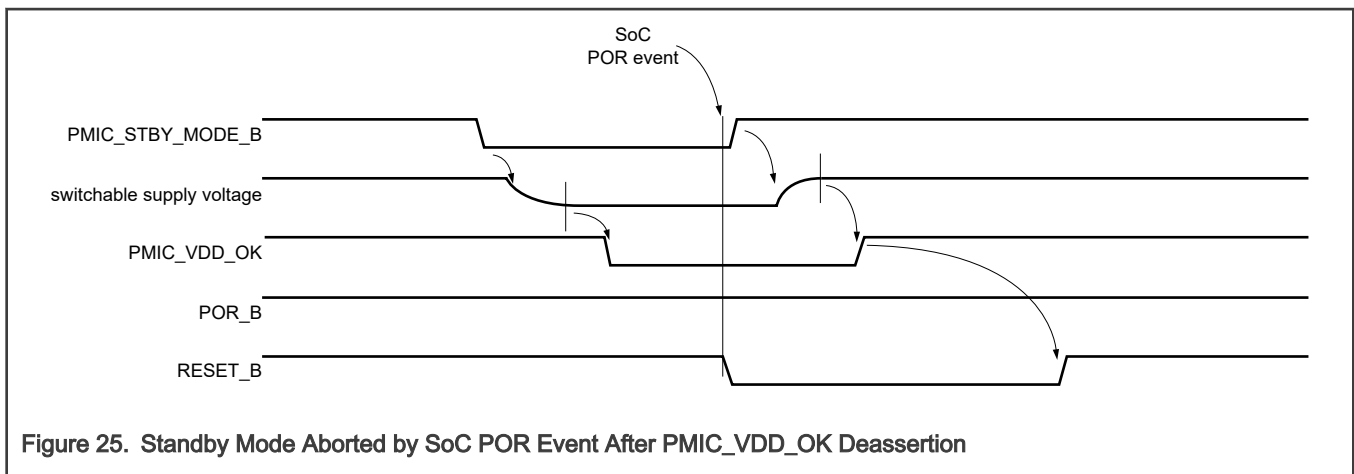
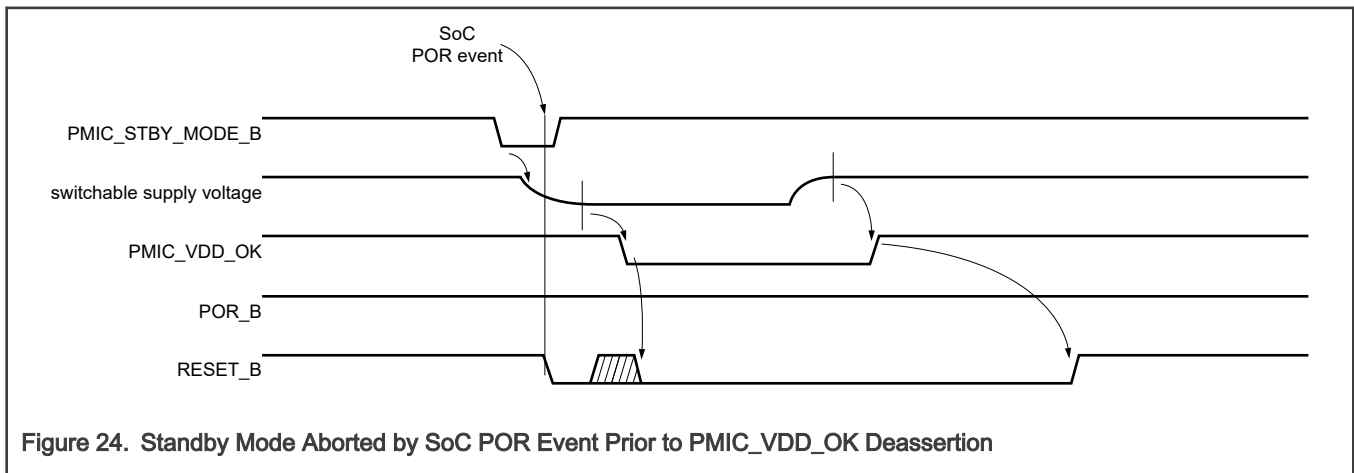
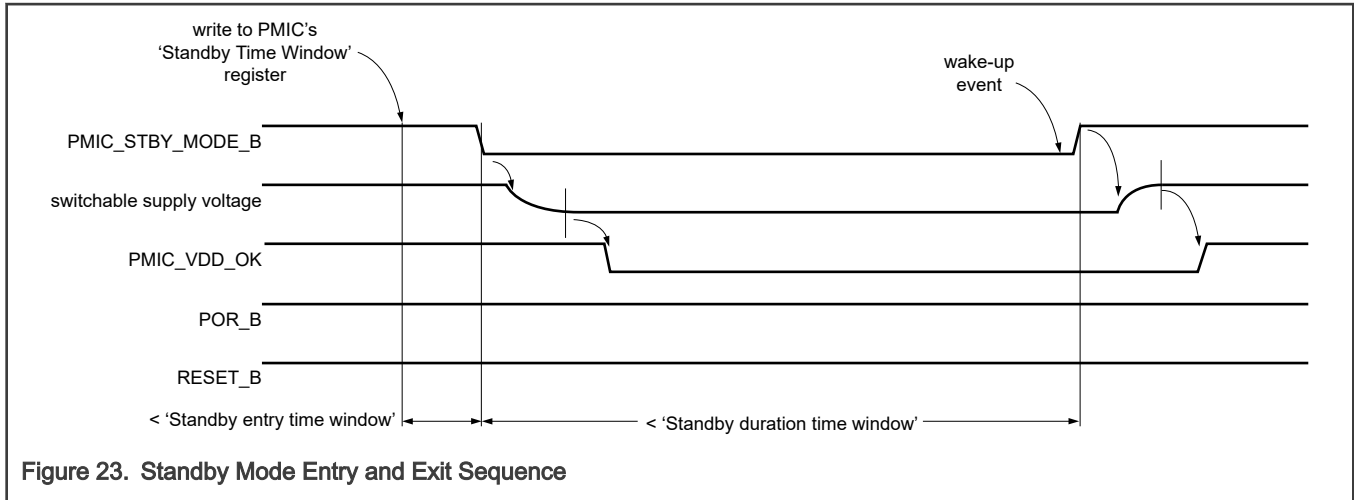
The PMIC\_STBY\_MODE\_B output is:

1. asserted by the SoC when the power domains that are not needed during Standby mode are to be turned off
2. deasserted by the SoC when the power domains that are not needed during Standby mode are to be turned on

The PMIC\_VDD\_OK input is:

1. deasserted by the PMIC when the power domains that are not needed during Standby mode have been turned off
2. asserted by the PMIC when the power domains that are not needed during Standby mode have been turned on and have reached their operational levels (e.g., all the corresponding voltage monitors in the PMIC have been satisfied) and any required PMIC BIST has completed. See the "Power Sequencing" section for any exceptions.

This implies that the PMIC\_VDD\_OK input is asserted and deasserted together with the POR\_B input during non-Standby modes. Deasserting PMIC\_VDD\_OK during non-Standby modes while not also asserting POR\_B will cause the SoC to start a power-on reset sequence.



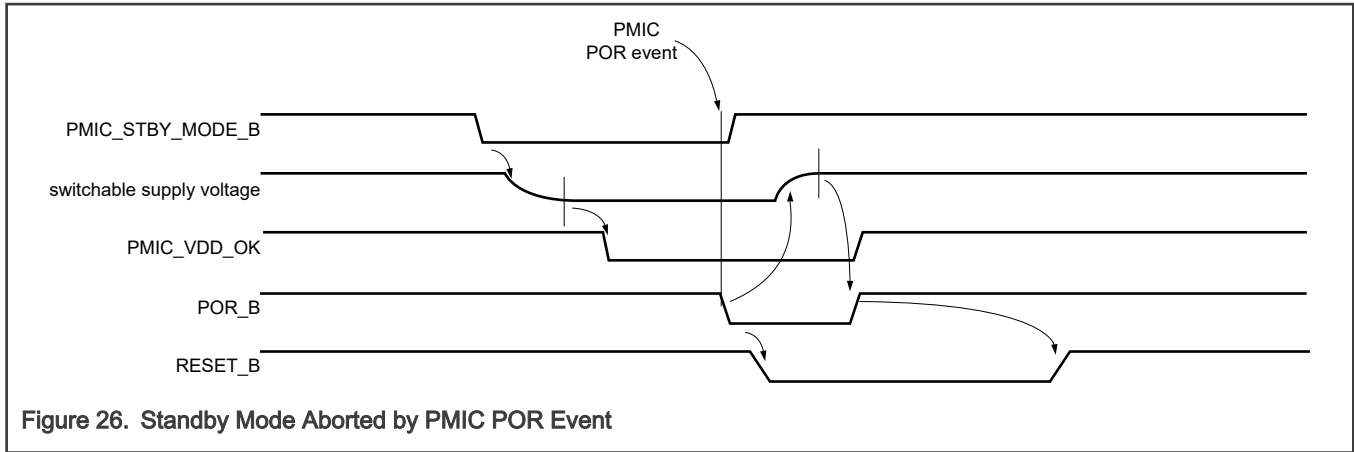


Figure 26. Standby Mode Aborted by PMIC POR Event

## 16 Peripheral specifications

### 16.1 Analog Modules

#### 16.1.1 SAR ADC

ADC performance specifications are only guaranteed when the injection current limits in the operating conditions table of this electrical specification are met.

Although functionally supported on devices with 2 ADCs, ADC performance specifications are not guaranteed for shared channels between the 2 ADCs if the input channel is sampled or converted simultaneously by both ADCs. For best performance in this case, the external capacitance at the input pin and reference pin should be maximized.

Table 18. SAR ADC

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VAD_INPUT	ADC Input Voltage <sup>1</sup>	VREFL_ ADC	—	VREFH_ ADC	V	on or off channels	—
fAD_CK	ADC Clock Frequency	20	—	80	MHz	—	—
tSAMPLE	ADC Input Sampling Time <sup>2</sup>	275	—	—	ns	—	—
tCONV	ADC Total Conversion Time <sup>3</sup>	1	—	—	us	—	—
tRECOVERY	ADC Initialization Time from power-down	—	—	1	us	—	—
CAD_INPUT	ADC Input Capacitance	—	—	7	pF	ADC component plus pad capacitance (~2pF)	—
RAD_INPUT	ADC Input Series Resistance	—	—	1.25	kΩ	—	—
OFS	ADC Offset Error <sup>4</sup>	-6	—	6	LSB	after calibration	—

Table continues on the next page...

Table 18. SAR ADC (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
GNE	ADC Gain Error (full scale) <sup>4</sup>	-6	—	6	LSB	after calibration	—
DNL	ADC Differential Non-linearity <sup>4,5,6</sup>	-1	—	2	LSB	after calibration	—
INL	ADC Integral Non-linearity <sup>4,5</sup>	-3	—	3	LSB	after calibration	—
TUE	ADC Total Unadjusted Error <sup>4,5</sup>	-8	—	8	LSB	after calibration	—
SNR	Signal-to-Noise Ratio <sup>4</sup>	—	65	—	dBFS	input signal frequency <= 50KHz	—
THD	Total Harmonic Distortion <sup>4</sup>	—	72	—	dBFS	Input signal frequency <= 50KHz.	—
IAD_LKG	ADC Input Leakage Current <sup>7</sup>	-1	—	1	uA	TJ = 125C, Dedicated input channel, channel selection switch open	—
IAD_LKG	ADC Input Leakage Current <sup>7</sup>	-2	—	2	uA	TJ = 125C, Shared channel, channel selection switch open	—
CP1	ADC input pin capacitance 1	—	—	4	pF	—	—
CP2	ADC input pin capacitance 2	—	—	0.5	pF	—	—
CS	ADC input sampling capacitance	—	—	4	pF	—	—
RSW1	Internal resistance of analog source	—	—	600	ohm	—	—
RAD	Internal resistance of analog source	—	—	150	ohm	—	—

1. The reduced limits for VAD\_INPUT in this table are recommended for normal operation.
2. During the sample time the input capacitance CS can be charged/discharged by the external source. The internal resistance of the analog source must allow the capacitance to reach its final voltage level within t<sub>sample</sub>. After the end of the sample time t<sub>sample</sub>, changes of the analog input voltage have no effect on the conversion result. Values for the sample clock t<sub>sample</sub> depend on programming.
3. 1MSPS is the ADC output rate and includes both sampling and analog to digital conversion.
4. ADC performance specifications are guaranteed when calibration uses maximum averaging i.e. when AVGEN = 1 and NRSMPPL = 3.
5. This specification is taken with averaging through post process ADC data.
6. During calibration, the ADC determines its (positive or negative) offset value and stores the result in an internal register. During each conversion, the offset value is subtracted from the raw result to compensate the individual ADC offset. Since the ADC cannot generate negative numbers, a negative calibration offset results in a minimum output code between 0 and 6. A positive calibration offset does not impact the max. code output of 4095. Calibration fails if it determines an offset larger than +/- 6 LSB.
7. The maximum and minimum leakage current values are reached when V<sub>in</sub>=V<sub>REF</sub> and V<sub>in</sub>=0, respectively.

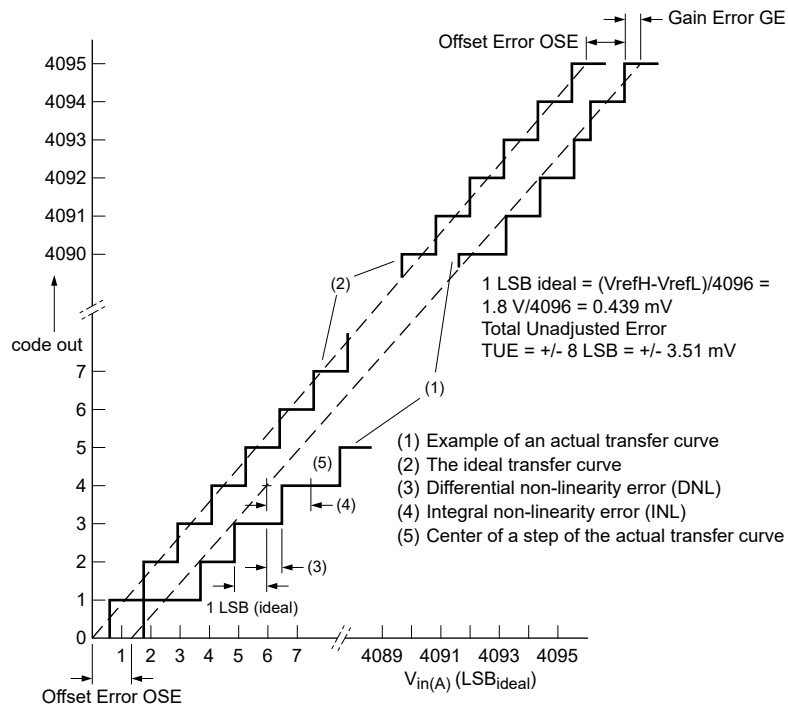


Figure 27. SAR ADC Specification Characteristics

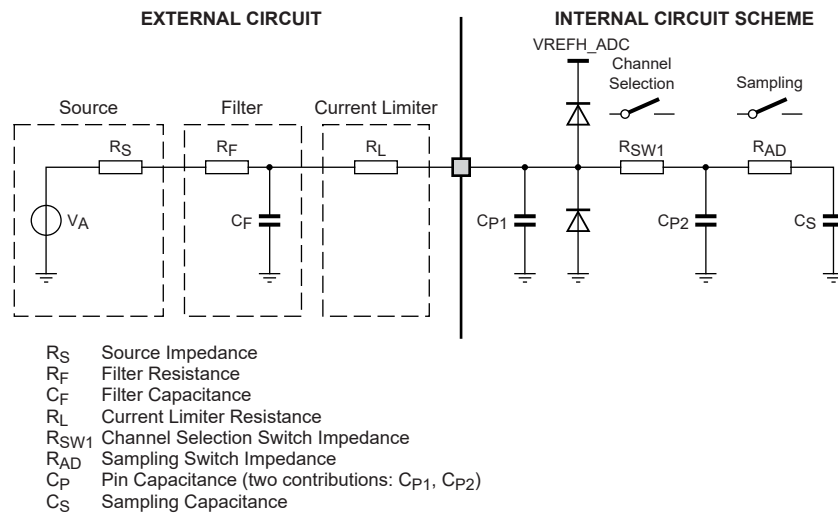


Figure 28. SAR ADC Input Circuit

### 16.1.2 Temperature Monitoring Unit (TMU)

The table below gives the specification for the Temperature Monitoring Unit (TMU). Specifications apply to all remote temperature sensors connected to the TMU on the device.



Table 19. Temperature Monitoring Unit (TMU)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
TRANGE	Temperature monitoring range	-40	—	125	C	—	—
TERR	Temperature sensor error	-8	—	8	C	TRANGE = -40C to 84C	—
TERR	Temperature sensor error	-5	—	5	C	TRANGE = 85C to 110C	—
TERR	Temperature sensor error	-3	—	3	C	TRANGE = 111C to 125C	—

### 16.1.3 Glitch Filter

Table 20. Glitch Filter

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
TFILT	Glitch filter max filtered pulse width <a href="#">1,2,3,4</a>	—	—	17	ns	—	—
TUNFILT	Glitch filter min unfiltered pulse width <a href="#">1,3,4,5</a>	400	—	—	ns	—	—

1. An input signal pulse is defined by the duration between the input signal's crossing of a  $V_{il}/V_{ih}$  threshold voltage level, and the next crossing of the opposite level.
2. Pulses shorter than defined by the maximum value are guaranteed to be filtered (not passed).
3. Pulses in between the max filtered and min unfiltered may or may not be passed through.
4. See the device reference manual for which package pins include glitch filters on the pin input.
5. Pulses larger than defined by the minimum value are guaranteed to not be filtered (passed).

### 16.1.4 IRQ

The following table gives the input specifications for the external interrupt pins.

tCYC refers to FIRC\_CLK.

Table 21. IRQ

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tIPWL	IRQ pulse width low	4	—	—	tCYC	MAXCNT = 3	1
tIPWH	IRQ pulse width high	4	—	—	tCYC	MAXCNT = 3	2

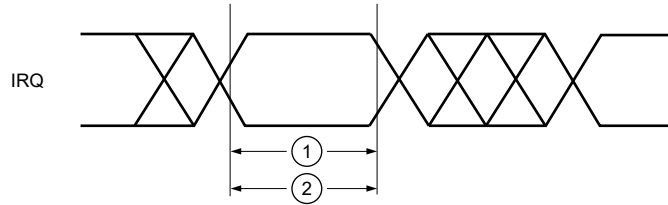


Figure 29. External Interrupt Timing (IRQ)

## 16.2 Clock and PLL Interfaces

### 16.2.1 DFS

The following table specifies the output frequency ranges and characteristics of the Digital Frequency Synthesizer (DFS).

Table 22. DFS

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fDFS_CORE_CLK1	Core DFS Output Clock 1 Frequency	40	—	800	MHz	CORE_DFS1	—
fDFS_PER_CLK1	Peripheral DFS Output Clock 1 Frequency	532	—	800	MHz	PERIPH_DFS1	—
fDFS_PER_CLK2	Peripheral DFS Output Clock 2 Frequency	40	—	628	MHz	PERIPH_DFS2	—
fDFS_PER_CLK3	Peripheral DFS Output Clock 3 Frequency	416	—	800	MHz	PERIPH_DFS3	—
fDFS_PER_CLK5	Peripheral DFS Output Clock 5 Frequency	2.54	—	80	MHz	PERIPH_DFS5	—
fDFS_CLKIN	DFS Input Clock Frequency	1300	—	2000	MHz	—	—
PER_jitter	DFS Period Jitter <sup>1,2</sup>	-30	—	30	ps	Even MFN	—
PER_jitter	DFS Period Jitter <sup>1,2</sup>	-45	—	45	ps	fDFS_CLKIN = 2000 MHz, Odd MFN	—
PER_jitter	DFS Period Jitter <sup>1,2</sup>	-60	—	60	ps	fDFS_CLKIN = 1300 MHz, Odd MFN	—

- For SoC clocks that are further divided down from the DFS output clock, the jitter is multiplied by a factor of  $\sqrt{N}$ , where N is the ratio of the DFS output clock and destination clock periods.
- Jitter value does not apply when the DFS clock is output on an external pin. In this case, the rise and fall time variations in the I/O pad are orders of magnitude more than the DFS and SoC mux jitter contributions.

Peripheral DFS output clock min jitter= $\text{Min}(\text{PER\_jitter}(\text{PLL})) \cdot (\sqrt{N}) + \text{Min}(\text{PER\_jitter}(\text{DFS}))$ . Peripheral DFS output clock max jitter= $\text{Max}(\text{PER\_jitter}(\text{PLL})) \cdot (\sqrt{N}) + \text{Max}(\text{PER\_jitter}(\text{DFS}))$ . Where N is the DFS division factor. All jitter numbers are in ps.

## 16.2.2 FIRC

Table 23. FIRC

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fFIRC	FIRC Target Frequency	—	48	—	MHz	—	—
δfVAR	FIRC Frequency Variation <sup>1</sup>	-5	—	5	%	Trimmed	—
TSTART	Startup Time	—	10	20	us	After valid supply level reached	—

1. δfVAR defines how much the output frequency can shift over the specified temperature and voltage ranges of the device after initial factory trim.

## 16.2.3 SIRC

Table 24. SIRC

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSIRC	SIRC Target Frequency Trimmed	—	32	—	KHz	Trimmed	—
PTA	SIRC Trimming Resolution <sup>1</sup>	-1	—	1	%	Trimmed 32KHz, 25C, 0.8V Core	—
δfVAR	SIRC Frequency Variation <sup>2</sup>	-5	—	5	%	Frequency variation across voltage and temperature range after trimming.	—
TSTART	SIRC Startup Time	—	—	50	us	—	—

1. PTA defines how close the output frequency is to target after the initial factory trim.  
 2. δfVAR defines how much the output frequency can shift over the specified temperature and voltage ranges of the device.

## 16.2.4 FXOSC

Table 25. FXOSC

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fXTAL	Input Frequency Range <sup>1,2</sup>	20	—	40	MHz	Crystal mode	—
TCST	Crystal Startup Time	—	—	2	ms	Crystal mode - time to stable duty cycle when EOCV is set to 1 ms period	—
fBYP_SE	FXOSC Bypass Frequency <sup>3</sup>	—	40	—	MHz	single-ended bypass mode	—

*Table continues on the next page...*

Table 25. FXOSC (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VIH_EXTAL	EXTAL Input High Level <sup>4</sup>	VCM_SE + 0.3	—	VDD_FX OSC	V	Single-ended bypass mode	—
VIL_EXTAL	EXTAL Input Low Level <sup>4</sup>	0	—	VCM_SE - 0.3	V	Single-ended bypass mode	—
CLOAD	XTAL/EXTAL pin load capacitance <sup>5</sup>	—	8	—	pF	Crystal mode	—
CS_XTAL	XTAL/EXTAL pin on-chip stray capacitance <sup>5</sup>	—	—	3	pF	—	—
VCM_SE	Common Mode Voltage for Single ended Bypass	—	VDD_FX OSC / 2	—	mV	—	—
Leakage_injection	EXTAL injection current	-50	—	100	nA	Mean current flowing into EXTAL in crystal mode	—
Leakage_extal	External Leakage on EXTAL Pin	-20	—	20	nA	Bypass mode, 0.5V	—
EXTAL_AMP	EXTAL_amplitude (p k-pk)	300	—	900	mV	Crystal mode	—
LT_Jitter	Long term jitter	-120	—	120	ps	gm_sel=1111 with 40MHz crystal (NX5032GA and NX3225GA)	—

1. All specifications only valid for this frequency range if the correct FXOSC transconductance setting is used.
2. Recommended crystal frequencies are 20MHz, 24MHz, and 40MHz.
3. The input clock must be 40 MHz nominal frequency.
4. The input clock signal should be symmetric around common mode voltage.
5. Account for on-chip stray capacitance (CS\_XTAL) and PCB capacitance in the total XTAL/EXTAL pin load capacitance. CS\_XTAL don't include miller capacitance.

In crystal mode NX5032GA crystal at 20 MHz has a load cap of 8 pF and configure gm\_sel[3:0]=4'b0100 and NX3225GA crystal has a load cap of 8 pF and configure gm\_sel[3:0]=4'b100.

In crystal mode NX5032GA crystal at 24 MHz has a load cap of 8 pF and configure gm\_sel[3:0]=4'b0101 and NX3225GA has a load cap of 8 pF and configure gm\_sel[3:0]=4'b0110.

In crystal mode NX5032GA and NX3225GA crystal at 40 MHz (ALC enable) has a load cap of 8 pF and configure gm\_sel[3:0]=4'b1111.

In ALC disable mode the minimum crystal drive level should be greater than 500uW.

Duty cycle of the FXOSC clock when output on either the single-ended or LVDS CLKOUT pins is given in the I/O pad specifications.

See Hardware design guide for the recommended circuit for each mode.

RGMII specifications require clock source to have tolerance of +/- 50ppm. When using this mode, the crystal selected for system clock (FXOSC) should adhere to this specification.

## 16.2.5 PLL

The following table gives the operating frequencies and characteristics of the PLL, and applies to instances on the device. Actual operating frequencies for the device are constrained to the values given below.

PLL refers to the Core, Peripheral, Accelerator, and DDR reference PLLs on the device.

Spread spectrum clock modulation is only available on the Core, Accelerator and DDR reference PLLs.

**Table 26. PLL**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fPLL_CLKIN	PLL Input Clock Frequency <sup>1</sup>	20	—	100	MHz	Before PLL input divider.	—
fPLL_CLKIN_PFD	PLL Phase Detector Clock Frequency <sup>2</sup>	20	—	40	MHz	After PLL input divider.	—
fPLL_CORE_VCO	Core PLL VCO Frequency Range <sup>3,4,5,6</sup>	1300	—	2000	MHz	without center-spread SSCG enabled	—
fPLL_CORE_PHI0	Core PLL PHI0 Frequency <sup>4</sup>	—	—	1000	MHz	CORE_PLL_PHI0, without center-spread SSCG enabled	—
fPLL_PER_VCO	Peripheral PLL VCO Frequency Range	1300	—	2000	MHz	—	—
fPLL_PER_PHI0	Peripheral PLL PHI0 Frequency	100	—	125	MHz	PERIPH_PLL_PHI0	—
fPLL_PER_PHI1	Peripheral PLL PHI1 Frequency	—	—	80	MHz	PERIPH_PLL_PHI1	—
fPLL_PER_PHI2	Peripheral PLL PHI2 Frequency	40	—	80	MHz	PERIPH_PLL_PHI2	—
fPLL_PER_PHI3	Peripheral PLL PHI3 Frequency	—	—	133	MHz	PERIPH_PLL_PHI3	—
fPLL_PER_PHI4	Peripheral PLL PHI4 Frequency	—	—	200	MHz	PERIPH_PLL_PHI4	—
fPLL_PER_PHI5	Peripheral PLL PHI5 Frequency	—	—	500	MHz	PERIPH_PLL_PHI5	—
fPLL_PER_PHI7	Peripheral PLL PHI7 Frequency	—	—	100	MHz	PERIPH_PLL_PHI7	—
fPLL_ACCEL_VCO	Accelerator PLL VCO Frequency Range <sup>4,6</sup>	1300	—	2400	MHz	without center-spread SSCG enabled	—
fPLL_ACCEL_PHI1	Accelerator PLL PHI1 Frequency <sup>4</sup>	—	—	600	MHz	ACCEL_PHI1, without center-spread SSCG enabled	—

*Table continues on the next page...*

Table 26. PLL (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fPLL_DDR_VCO	DDR PLL VCO Frequency Range <sup>4,6,7</sup>	1300	—	1600	MHz	without center-spread SSCG enabled	—
fPLL_DDR_PHI0	DDR PLL PHI0 Frequency <sup>4,8</sup>	800	—	800	MHz	DDR_CLK (3200 MT/s), without center-spread SSCG enabled	—
fPLL_DDR_PHI0	DDR PLL PHI0 Frequency <sup>8</sup>	758	—	758	MHz	DDR_CLK (3032 MT/s)	—
fPLL_DDR_PHI0	DDR PLL PHI0 Frequency <sup>8</sup>	666.5	—	666.5	MHz	DDR_CLK (2666 MT/s)	—
fPLL_DDR_PHI0	DDR PLL PHI0 Frequency <sup>8</sup>	533.3	—	533.3	MHz	DDR_CLK (2133 MT/s)	—
fPLL_DDR_PHI0	DDR PLL PHI0 Frequency <sup>8</sup>	466.6	—	466.6	MHz	DDR_CLK (1866 MT/s)	—
fPLL_DDR_PHI0	DDR PLL PHI0 Frequency <sup>8</sup>	400	—	400	MHz	DDR_CLK (1600 MT/s)	—
tLOCK	PLL Lock Time	—	—	100	us	—	—
PER_jitter	PLL Period Jitter <sup>9,10,11,12</sup>	-23	—	23	ps	fPLL_CLKIN = 40MHz, fVCO = 2GHz, 6-sigma, SSCG & Frac mode disabled	—
LT_jitter	PLL Long Term Jitter <sup>9,12,13</sup>	-120	—	120	ps	Saturated, 6-sigma	—
fPLL_MOD	Spread Spectrum Clock Modulation Frequency <sup>7</sup>	30	—	64	KHz	—	—

1. This refers to spec number 1 which is shown in the figure in Aurora port specifications
2. This specification is PLL input reference clock frequency after pre-divider.
3. Duty cycle of the PLL clock when output on an external pin is given in the I/O pad specifications.
4. The max frequency in case of center-spread SSCG enabled for a modulation depth can be calculated as: Max frequency(with center-spread SSCG disabled) – (Modulation Depth(in %)/(2\*100))\* Max frequency (with center-spread SSCG disabled). For details, see section “Frequency modulation programming” in reference manual.
5. The frequencies are the nominal frequencies (i.e., what the PLL's VCO is configured to).
6. Same min frequency value applies for center-spread SSCG enabled as provided for center-spread SSCG disabled.
7. DDR PLL allows center-spread SSCG at fPLL\_MOD 32KHz @2% MD (modulation depth) and fPLL\_MOD 64KHz @ 1% MD
8. The DDR PHY internally multiplies the PLL\_DDR\_PHI0 by factor of two.
9. Jitter is dependent on supply noise. Specified jitter values are valid for the FXOSC reference clock input only - not valid for FIRC reference clock input.
10. Jitter is dependent on the period of the PLL output clock, and the division ratio of the clock at the destination module.
11. For chip clocks that are further divided down from the PLL output clock, the jitter is multiplied by a factor of SQRT(N), where N is the ratio of the PLL output clock and destination clock periods.
12. Jitter value does not apply when a PLL clock is output on an external pin. In this case, the rise and fall time variations in the I/O pad are orders of magnitude more than the PLL and SoC mux jitter contributions.
13. This specification is valid when all clock sources are stable.

**NOTE**

fPLL\_DDR\_PHI0 frequencies and data rate mentioned in this table are for LPDDR4. DDR3L frequencies and data rates are half of the LPDDR4.

**16.3 Communication modules****16.3.1 SPI**

SRE[2:0]=101 is the required drive setting to meet the timing.

**Table 27. SPI**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tSCK	SPI cycle time <sup>1,2</sup>	40	—	10000	ns	Master, MTFE=0	1
tSCK	SPI cycle time <sup>2</sup>	25	—	10000	ns	Master, MTFE=1	1
tSCK	SPI cycle time <sup>2,3</sup>	16.67	—	10000	ns	Slave Receive Mode	1
tSCK	SPI cycle time <sup>2</sup>	40	—	10000	ns	Slave Transmit Mode	1
tCSC	PCS to SCK delay <sup>4</sup>	20	—	10000	ns	—	2
tASC	After SCK delay <sup>5</sup>	20	—	10000	ns	—	3
tSDC	SCK duty cycle	40	—	60	%	—	4
tA	Slave access time	—	—	40	ns	SS active to SOUT valid	5
tDIS	Slave SOUT disable time	—	—	15	ns	SS inactive to SOUT hi-z or invalid	6
tPCSC	PCSx to PCSS time	13	—	—	ns	—	7
tPASC	PCSS to PCSx time	13	—	—	ns	—	8
tSUI	Input data setup time <sup>6,7</sup>	15	—	—	ns	Master, MTFE=0	9
tSUI	Input data setup time <sup>7,8</sup>	15 - N * ipg_clk_d spi_perio d	—	—	ns	Master, MTFE=1, CPHA=0, SMPL_PTR = 1	9
tSUI	Input data setup time <sup>7</sup>	15	—	—	ns	Master, MTFE=1, CPHA=1, SMPL_PTR = 1	9
tSUI	Input data setup time <sup>7</sup>	2	—	—	ns	Slave Receive Mode	9
tHI	Input data hold time <sup>7</sup>	0	—	—	ns	Master, MTFE=0	10
tHI	Input data hold time <sup>7</sup>	0 + N * ipg_clk_d spi_perio d	—	—	ns	Master, MTFE=1, CPHA=0, SMPL_PTR = 1	10

*Table continues on the next page...*

Table 27. SPI (continued)

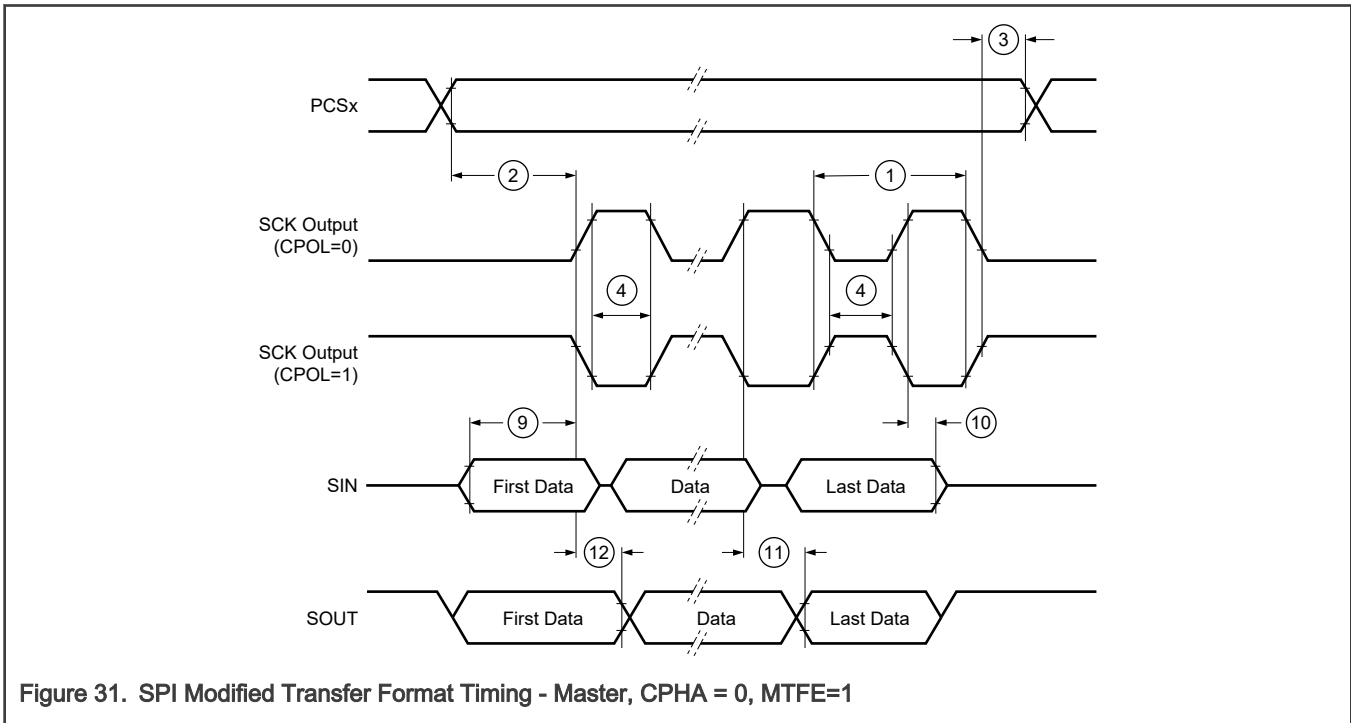
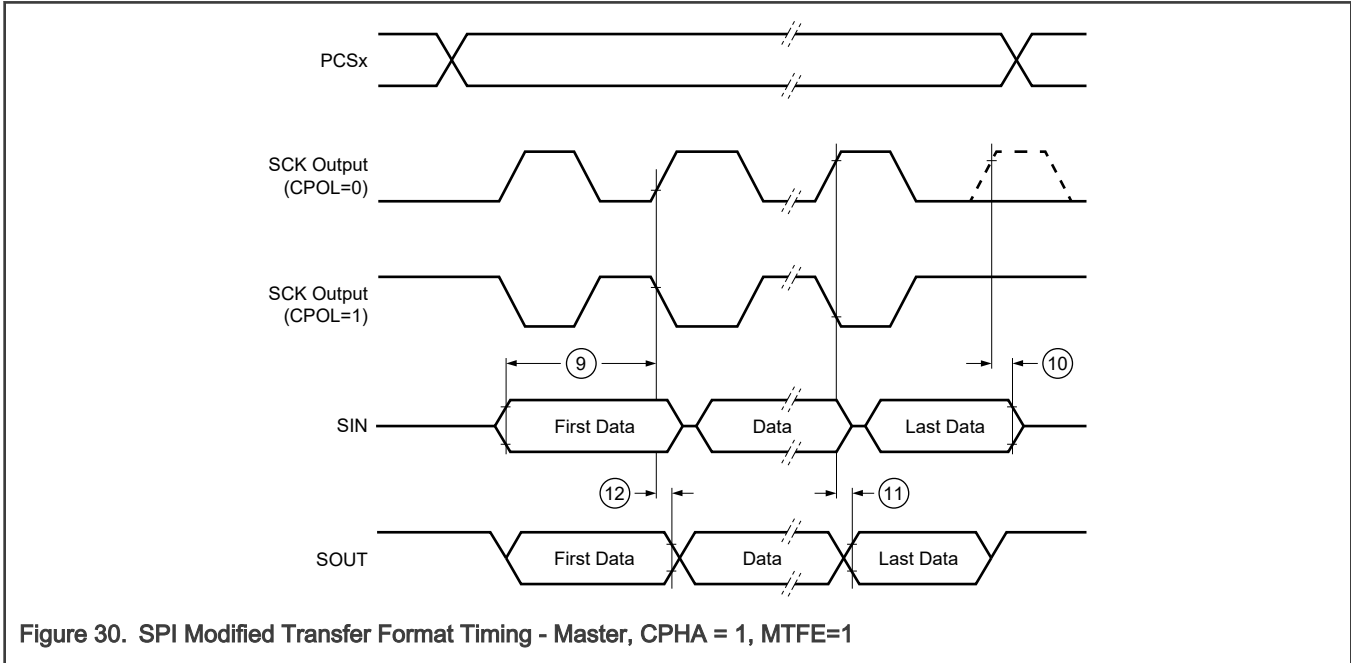
Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tHI	Input data hold time <sup>7</sup>	0	—	—	ns	Master, MTFE=1, CPHA=1, SMPL_PTR = 1	10
tHI	Input data hold time <sup>7</sup>	4	—	—	ns	Slave Receive Mode	10
tSUO	Output data valid time (after SCK edge) <sup>9</sup>	—	—	5	ns	Master, MTFE=0 max CLOAD=25pF, max pad drive setting	11
tSUO	Output data valid time (after SCK edge) <sup>9</sup>	—	—	5 + ipg_clk_d spi_perio d	ns	Master, MTFE=1, CPHA=0 max CLOAD=25pF, max pad drive setting	11
tSUO	Output data valid time (after SCK edge) <sup>9</sup>	—	—	5	ns	Master, MTFE=1, CPHA=1 max CLOAD=25pF, max pad drive setting	11
tSUO	Output data valid time (after SCK edge) <sup>6,9</sup>	—	—	16	ns	Slave Transmit Mode	11
tHO	Output data hold time <sup>9</sup>	-2	—	—	ns	Master, MTFE=0 max CLOAD=25pF, max pad drive setting	12
tHO	Output data hold time <sup>9</sup>	-2 + ipg_clk_d spi_perio d	—	—	ns	Master, MTFE=1, CPHA=0 max CLOAD=25pF, max pad drive setting	12
tHO	Output data hold time <sup>9</sup>	-2	—	—	ns	Master, MTFE=1, CPHA=1 max CLOAD=25pF, max pad drive setting	12
tHO	Output data hold time <sup>9</sup>	3	—	—	ns	Slave Transmit Mode	12

- SMPL\_PTR should be set to 1. For SPI\_CTARn[BR] - 'Baud Rate Scaler' configuration is  $\geq 3$
- The maximum SPI baud rate that is achievable in a dedicated master-slave connection depends on several parameters that are independent of the SPI module clocking capabilities (e.g. capacitive load of the signal lines, SPI slave clock-to-data delay, pad slew rate, etc.). The maximum achievable SPI baud rate needs to be evaluated in a corresponding SPI master-slave setup.
- Slave Receive Mode can operate at a maximum frequency of 60 MHz. In this mode, the DSPI can receive data on SIN, but no valid data is transmitted on SOUT.
- This value of 20 ns is with the configuration prescaler values: SPI\_CTARn[PCSSCK] - "PCS to SCK Delay Prescaler" configuration is "3" (01h) and SPI\_CTARn[CSSCK] - "PCS to SCK Delay Scaler" configuration is "2" (0000h)
- This value of 20 ns is with the configuration prescaler values: SPI\_CTARn[PASC] - "After SCK Delay Prescaler" configuration is "3" (01h) and SPI\_CTARn[ASC] - "After SCK Delay Scaler" configuration is "2" (0000h)
- For the case of both master and slave being NXP S32x devices, frequency of operation will be reduced to  $[1000 / 2 * \{tSUI\_master + tSUO\_slave + PCB\ delay\}]$  in ns.
- Input timing assumes an input signal slew rate of 2ns (20%/80%).



- 8. N is number of protocol clock cycles where the master samples SIN in MTFE mode after SCK edge.
- 9. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch), (25pF total with margin). For best signal integrity, the series resistance of the transmission line should be matched closely to the RDSON of the I/O pad output driver.

Slave mode timing values given below are applicable when device is in MTFE=0.



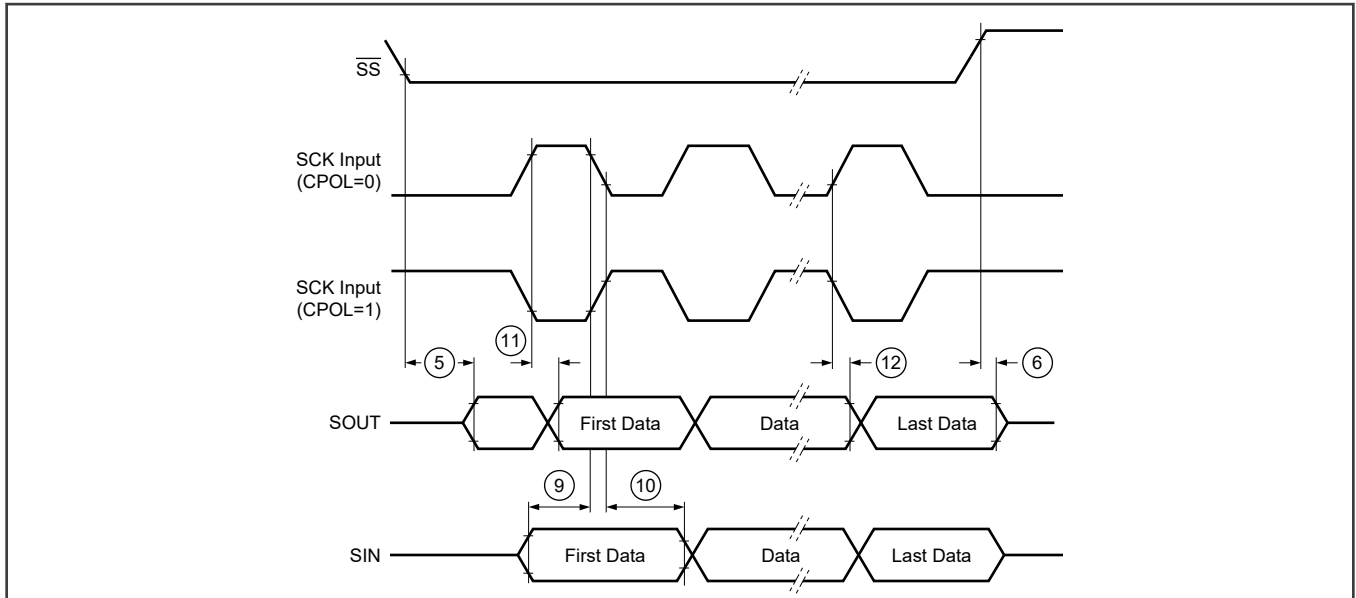


Figure 32. SPI Classic Timing - Slave CPHA = 1, MTFE=0

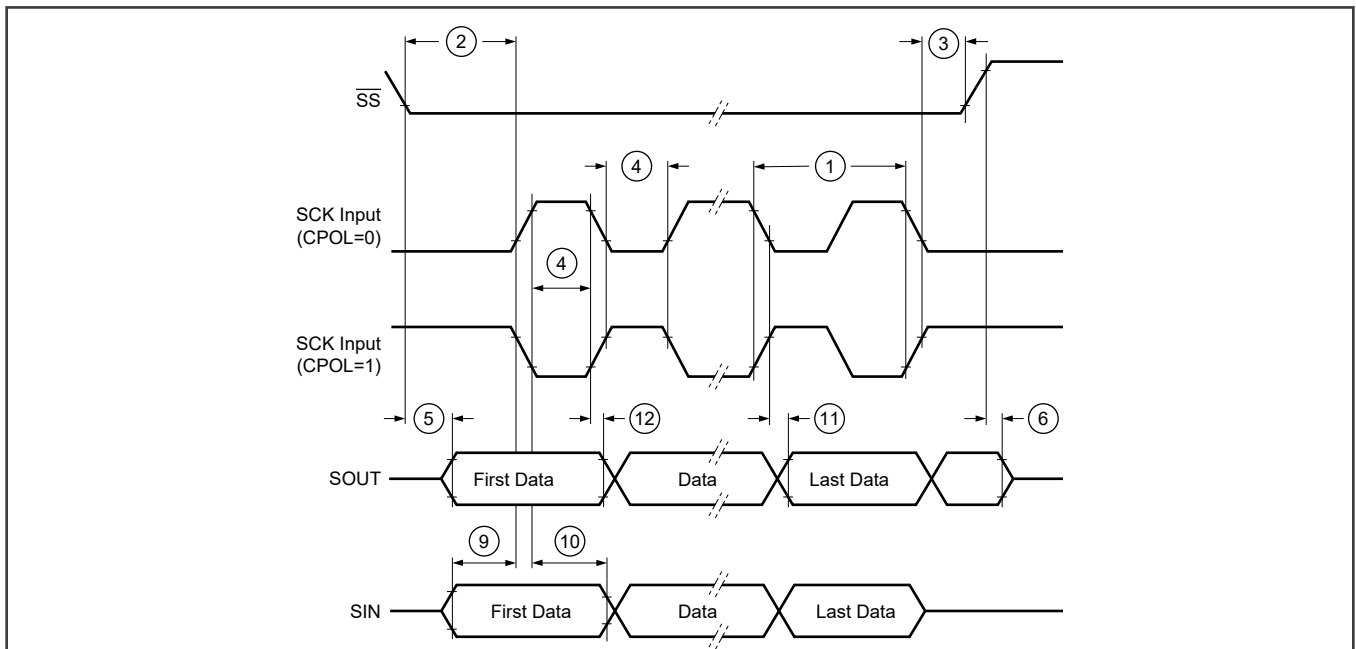


Figure 33. SPI Classic Timing - Slave CPHA = 0, MTFE=0

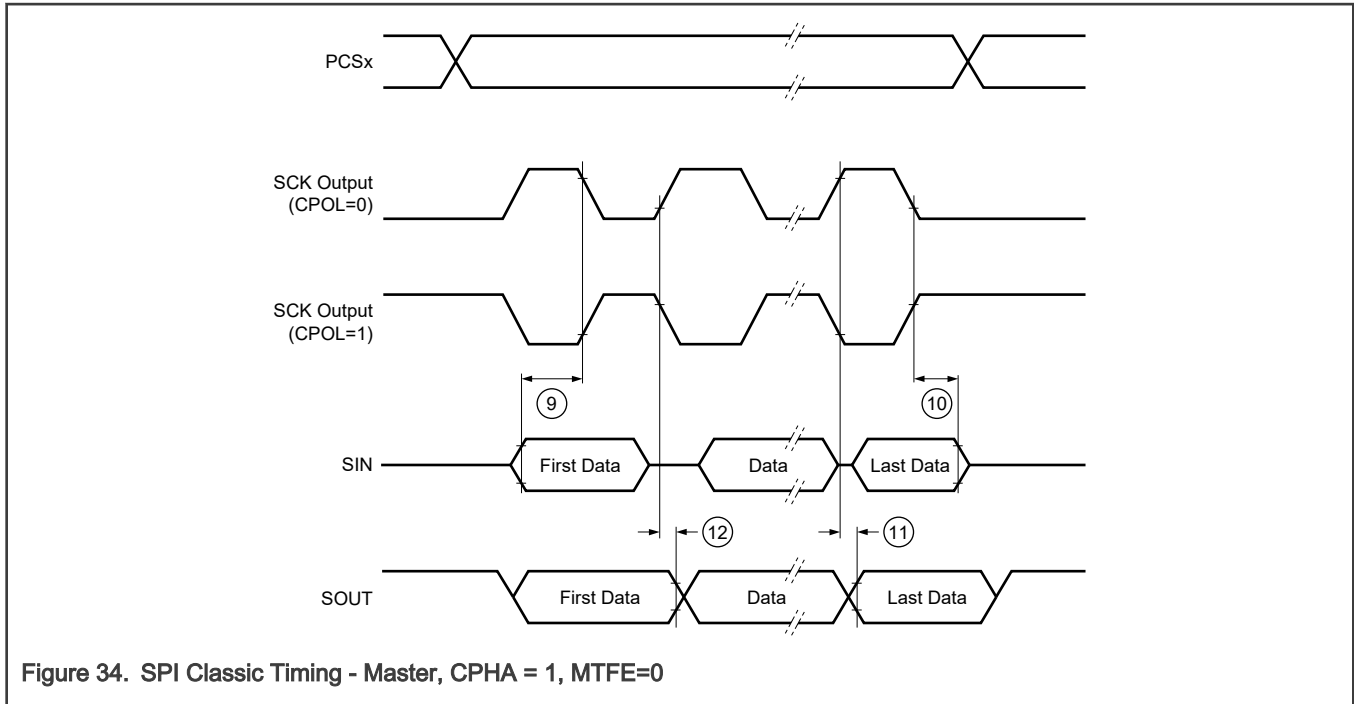


Figure 34. SPI Classic Timing - Master, CPHA = 1, MTFE=0

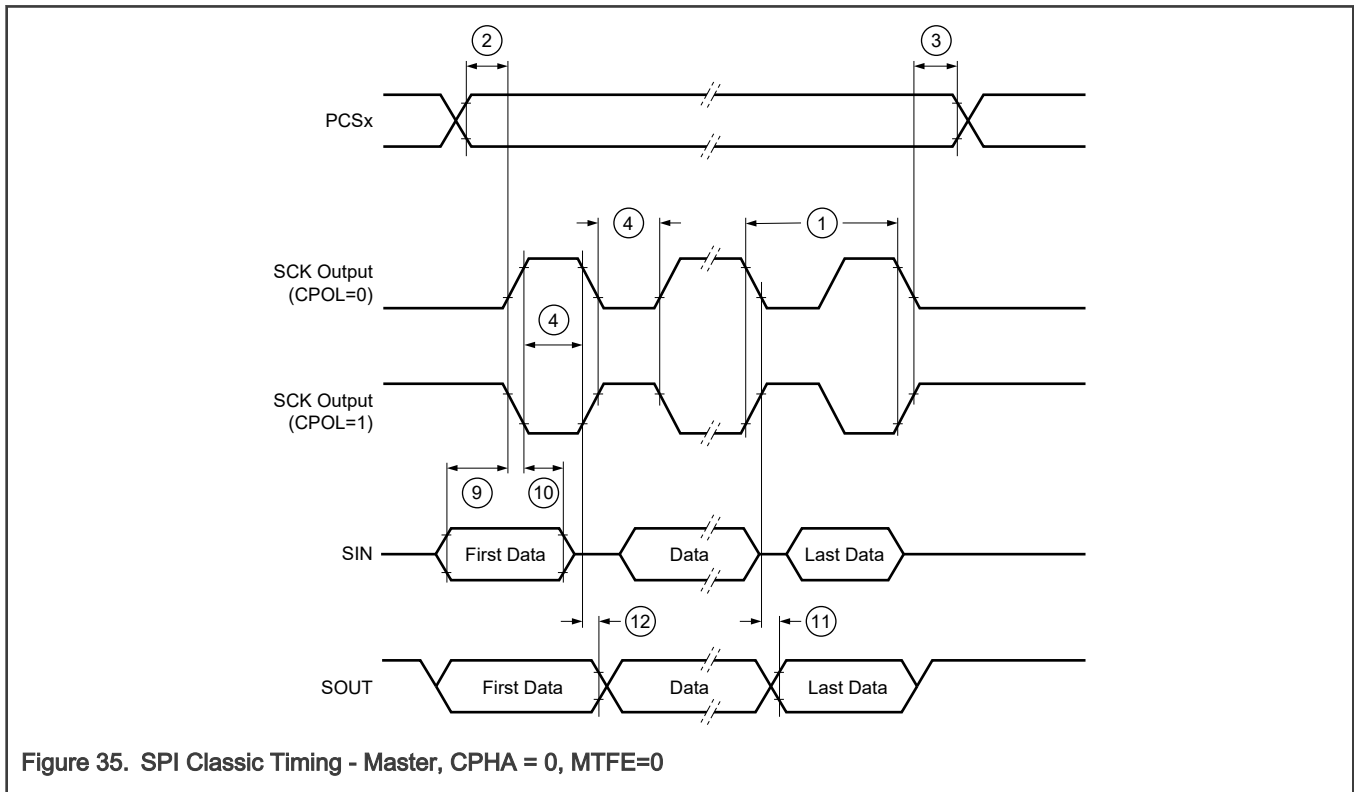


Figure 35. SPI Classic Timing - Master, CPHA = 0, MTFE=0

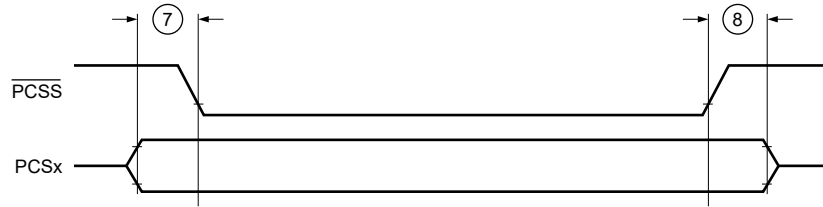


Figure 36. SPI PCS Strobe (PCSS) Timing

### 16.3.2 I2C

#### 16.3.2.1 I2C Input

Table 28. I2C Input

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
Rate	Operating Speed	—	—	100	kbps	Standard Mode defined by the I2C protocol specification	—
Rate	Operating Speed	—	—	400	kbps	Fast Mode defined by the I2C protocol specification	—
tIH_SC	Input Start condition hold time <sup>1,2</sup>	2	—	—	MODULE_CLK cycle	—	1
tCL	Input Clock low time <sup>1,2</sup>	8	—	—	MODULE_CLK cycle	—	2
tIH	Input Data hold time <sup>1,2</sup>	0	—	—	ns	SDA transitions after SCL falling edge	4
tCH	Input Clock high time <sup>1,2</sup>	4	—	—	MODULE_CLK cycle	—	6
tISU	Input Data setup time (standard mode) <sup>1,2,3</sup>	250	—	—	ns	SDA transitions before SCL rising edge	7
tISU_F	Input Data setup time (fast mode) <sup>1,2,3</sup>	100	—	—	ns	SDA transitions before SCL rising edge	7
tISU_RSC	Input Start condition setup time (repeated start condition) <sup>1,2</sup>	2	—	—	MODULE_CLK cycle	—	8
tISU_SC	Input Start condition setup time <sup>1,2</sup>	2	—	—	MODULE_CLK cycle	—	9

1. Input timing assumes an input signal slew rate of 3ns (20%/80%).
2. MODULE\_CLK from the MC\_CGM is the clock driving the I2C block.
3. MODULE\_CLK frequency should be greater than 5 MHz for standard mode and 20 MHz for fast mode.

I2C interface supports Fast Mode with a maximum data-rate of 400kbps. Higher data rates are not supported.

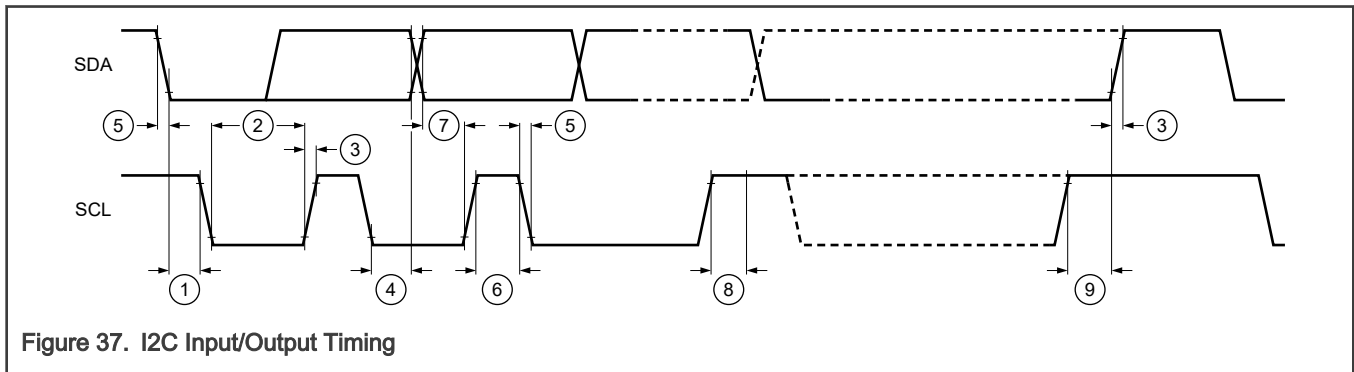


Figure 37. I2C Input/Output Timing

### 16.3.2.2 I2C Output

SRE[2:0]=110 is the required drive setting to meet the timing.

Programming IBFD (I2C bus Frequency Divider) with the maximum frequency results in the minimum output timings listed. The I2C interface is designed to scale the data transition time, moving it to the middle of the SCL low period. The actual position is affected by the prescale and division values programmed in IBFD.

Table 29. I2C Output

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tOH_SC	Output Start condition hold time <sup>1,2</sup>	6	—	—	MODULE _CLK cycle	—	1
tCL	Output Clock low time <sup>1,2</sup>	10	—	—	MODULE _CLK cycle	—	2
tRISE	SDA/SCL rise time <sup>1,2,3</sup>	—	—	300	ns	—	—
tOH	Output Data hold time <sup>1,2</sup>	7	—	—	MODULE _CLK cycle	—	4
tFALL	SDA/SCL fall time <sup>1,2,3</sup>	—	—	100	ns	—	5
tCH	Output Clock high time <sup>1,2</sup>	10	—	—	MODULE _CLK cycle	—	6
tOSU	Output Data setup time <sup>1,2</sup>	2	—	—	MODULE _CLK cycle	—	7
tOSU_RSC	Output repeated start condition setup time <sup>1,2</sup>	20	—	—	MODULE _CLK cycle	—	8
tOSU_SC	Output start condition setup time <sup>1,2</sup>	11	—	—	MODULE _CLK cycle	—	9

1. Timing valid for maximum external load  $CL = 400pF$ , at the maximum clock frequency defined by the I2C clock high and low time specifications.
2. `MODULE_CLK` from the `MC_CGM` is the clock driving the I2C block.
3. Because SCL and SDA are open-drain outputs, which the processor can only actively drive low, the time SCL or SDA takes to reach a high level depends on external signal capacitance and pullup resistor values

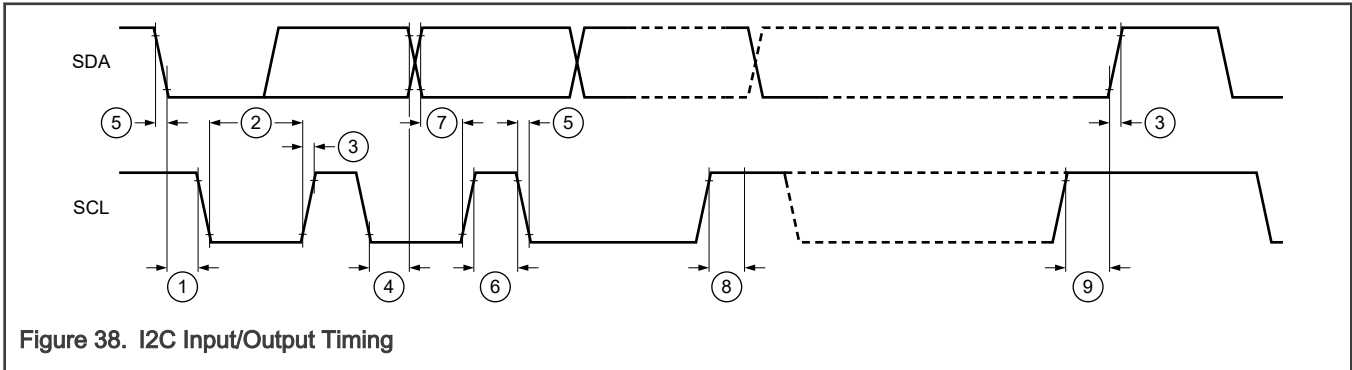


Figure 38. I2C Input/Output Timing

### 16.3.3 LIN

`SRE[2:0]=110` is the required drive setting to meet the timing.

Table 30. LIN

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
RATE	Bit Rate	—	—	2.0	Mbps	UART mode	—
RATE	Bit Rate	4.8	—	20	Kbps	LIN mode	—

### 16.3.4 LPSPI

Table 31. LPSPI

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fOP	LPSPI operating frequency <a href="#">1,2,3,4</a>	fPER_CLK / 2048	—	40	MHz	Master	—
fOP	LPSPI operating frequency <a href="#">1,4,5</a>	—	—	20	MHz	Slave	—
tSPSCK	SPSCK period <a href="#">1,2,3,4</a>	25	—	1 (fPER_CLK / 2048)	ns	Master	—
tSPSCK	SPSCK period <a href="#">1,4,5</a>	50	—	—	ns	Slave	—
tLEAD	Enable lead time (PCS to SPSCK delay) <a href="#">4,6,7</a>	tSPSCK - 3.5	—	—	ns	Master	—
tLEAD	Enable lead time (PCS to SPSCK delay) <a href="#">4,7</a>	25	—	—	ns	Slave	—

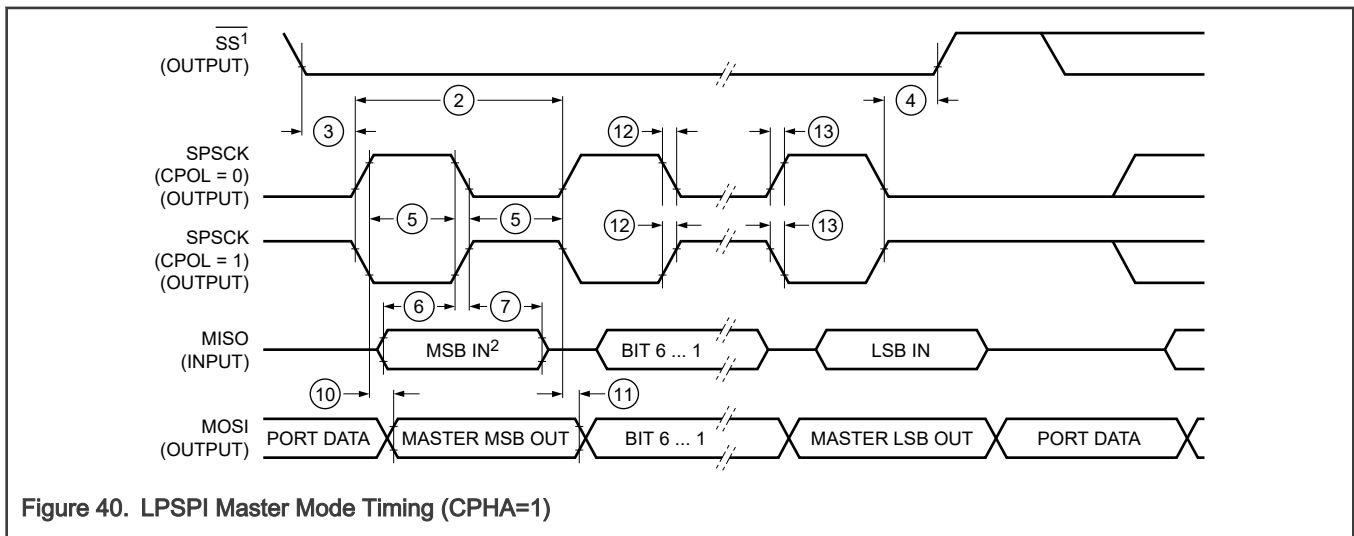
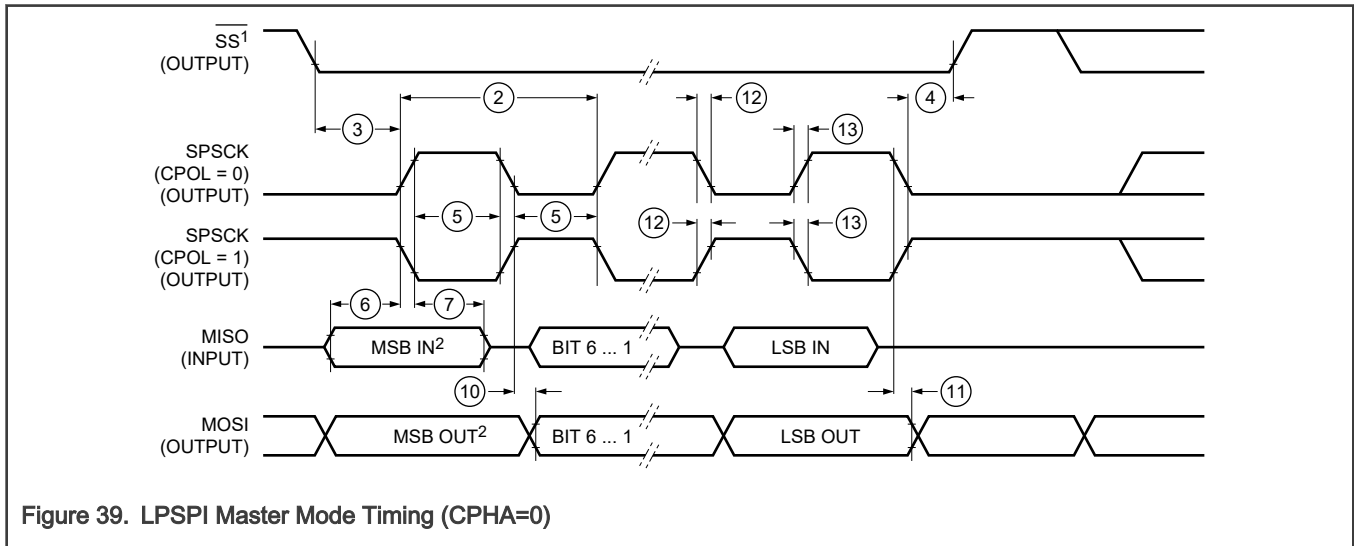
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Table 31. LPSPI (continued)

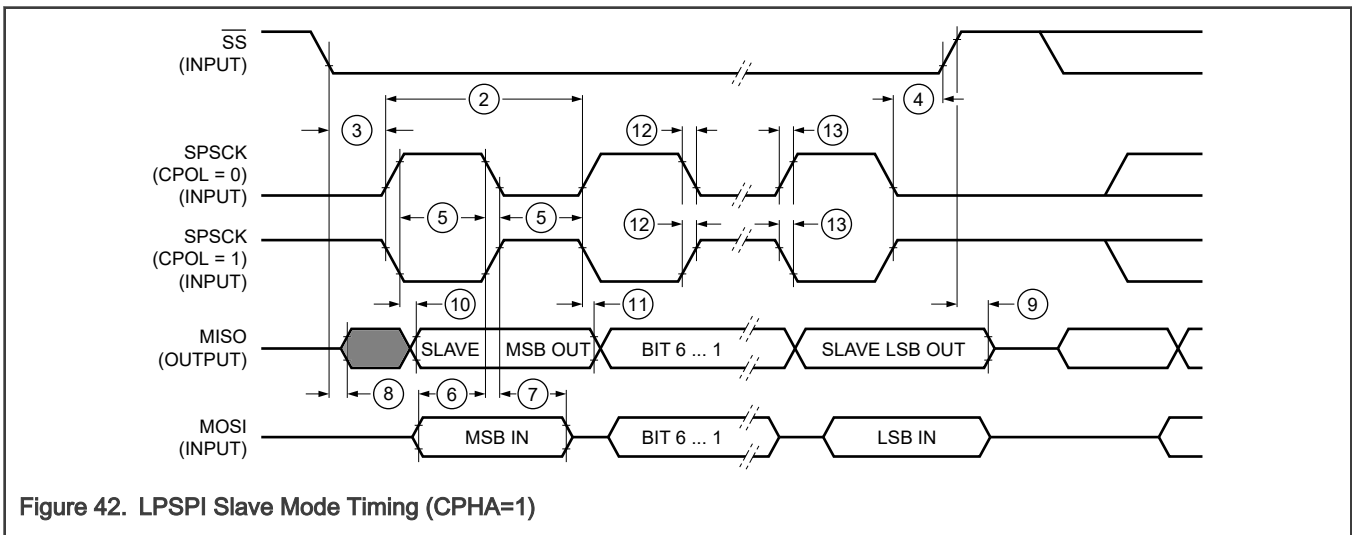
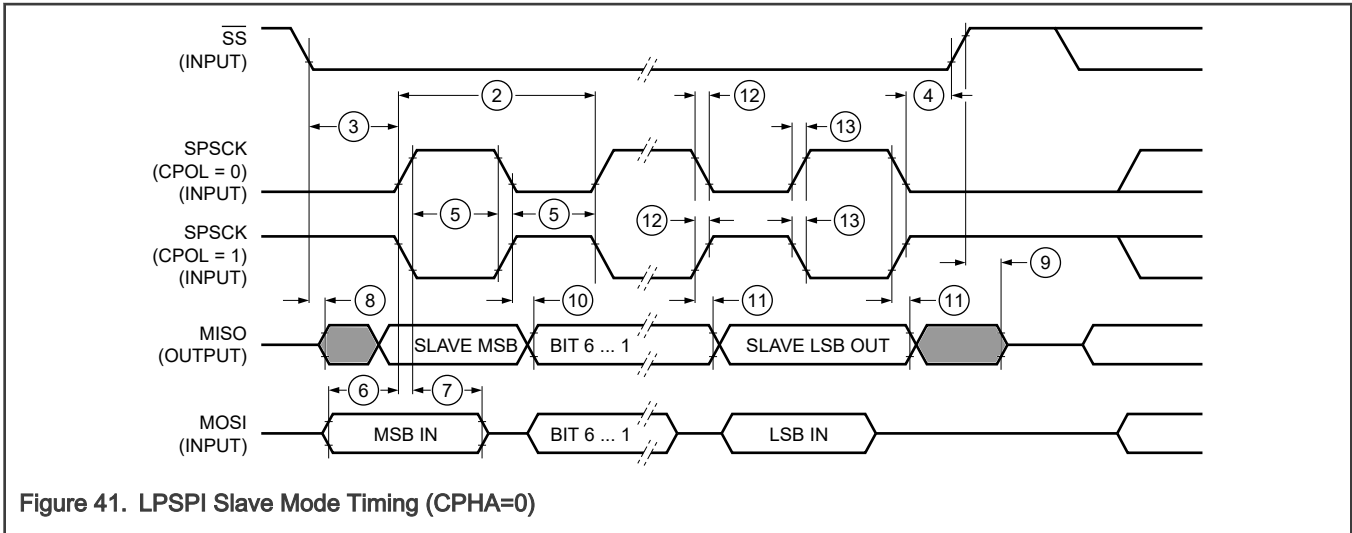
Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tLAG	Enable lag time (after SPSCCK delay) <sup>4,8,9</sup>	tSPSCCK - 2.5	—	—	ns	Master	—
tLAG	Enable lag time (after SPSCCK delay) <sup>4,9</sup>	25	—	—	ns	Slave	—
tSW	Clock (SPSCCK) high or low time (duty cycle)	(tSPSCCK / 2) - 3	—	(tSPSCCK / 2) + 3	ns	Master	—
tSW	Clock (SPSCCK) high or low time (duty cycle)	(tSPSCCK / 2) - 3	—	(tSPSCCK / 2) + 3	ns	Slave	—
tSU	Data setup time (inputs)	12	—	—	ns	Master	—
tSU	Data setup time (inputs)	4	—	—	ns	Slave	—
tHI	Data hold time (inputs)	0	—	—	ns	Master	—
tHI	Data hold time (inputs)	3	—	—	ns	Slave	—
tA	Slave access time	—	—	12.5	ns	Slave	—
tDIS	Slave MISO disable time	—	—	12.5	ns	Slave	—
tV	Data valid (after SPSCCK edge) <sup>4,10,11</sup>	—	—	6	ns	Master, SRE[2:0] = 101	—
tV	Data valid (after SPSCCK edge) <sup>4,10,11</sup>	—	—	20	ns	Slave, SRE[2:0] = 101	—
tHO	Data hold time (outputs) <sup>4,10,11</sup>	0	—	—	ns	Master, SRE[2:0] = 101	11
tHO	Data hold time (outputs) <sup>4,10,11</sup>	0	—	—	ns	Slave, SRE[2:0] = 101	11
tRI_FI	Rise / Fall time (input) <sup>12</sup>	—	—	1	ns	Master + Slave	—

1. The maximum LPSPI baud rate that is achievable in a dedicated master-slave connection depends on several parameters that are independent of the LPSPI module clocking capabilities (e.g. capacitive load of the signal lines, SPI slave clock-to-datadelay, pad slew rate, etc.). The maximum achievable LPSPI baud rate needs to be evaluated in a corresponding SPI master-slave setup.
2. The maximum master mode LPSPI clock frequency can be no more than the peripheral clock frequency divided by 2.
3. fPER\_CLK is the frequency of the device peripheral clock (PER\_CLK).
4. All timing valid to 20% and 80% levels of the LPSPI I/O voltage supply on the device.
5. The maximum slave mode LPSPI clock frequency can be no more than the peripheral clock frequency divided by 4.
6.  $tPCSSCK = (PCSSCK+1) * (2^{**}PRESCALE) * (1 / fPER\_CLK)$

7. Set the PCSSCK configuration bit as 0, for a minimum of 1 delay cycle of LPSPI baud rate clock, where PCSSCK ranges from 0 to 255.
8.  $t_{SCKPCS} = (SCKPCS+1) * (2^{**}PRESCALE) * (1 / f_{PER\_CLK})$
9. Set the SCKPCS configuration bit as 0, for a minimum of 1 delay cycle of LPSPI baud rate clock, where SCKPCS ranges from 0 to 255.
10. Output rise/fall time is determined by the output load and GPIO pad drive strength setting. See the GPIO specifications for detail.
11. Timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch), (25pF total with margin). For best signal integrity, the series resistance in the transmission line should be equal to the selected RDSON of the I/O pad output.
12. The input rise/fall time specification applies to both clock and data, and is required to guarantee related timing parameters.







### 16.3.5 CAN

See GPIO pads for CAN specifications.

### 16.3.6 FlexRay

#### 16.3.6.1 FlexRay - RxD

Table 32. FlexRay - RxD

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
C_CCRxD	Input capacitance on RxD pin	—	—	8	pF	—	—
dCCRxD01	Sum of delay from actual input to the D input of the first FF, rising edge <sup>1</sup>	—	—	10	ns	—	—

Table continues on the next page...

Table 32. FlexRay - RxD (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
dCCRxD10	Sum of delay from actual input to the D input of the first FF, falling edge <sup>1</sup>	—	—	10	ns	—	—
dCCRxAsymAccept15	Acceptance of asymmetry at receiving CC with 15pF load <sup>1</sup>	-31.5	—	44	ns	—	—
dCCRxAsymAccept25	Acceptance of asymmetry at receiving CC with 25pF load <sup>1</sup>	-30.5	—	43	ns	—	—

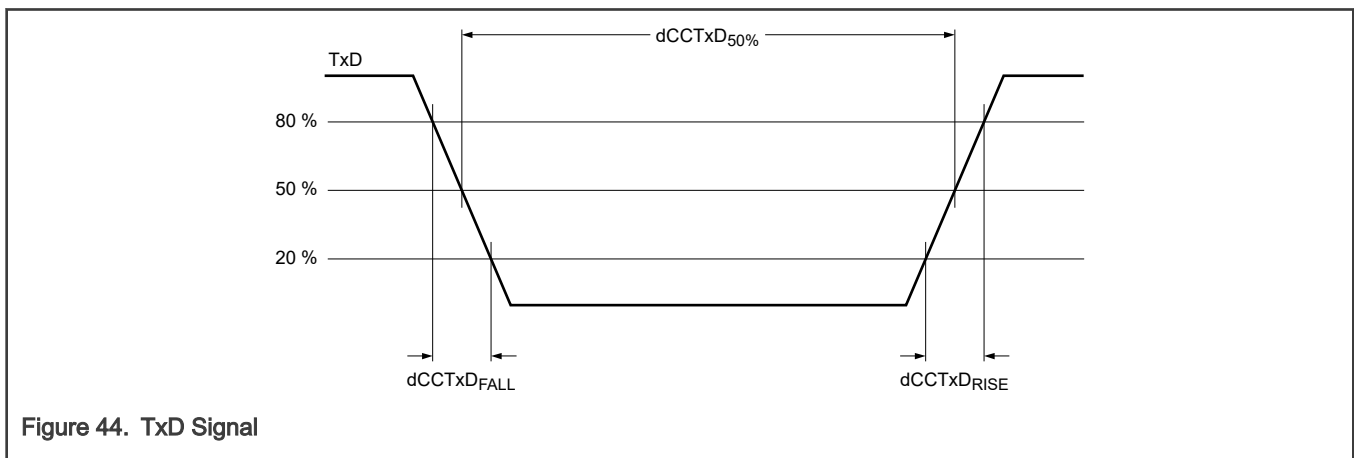
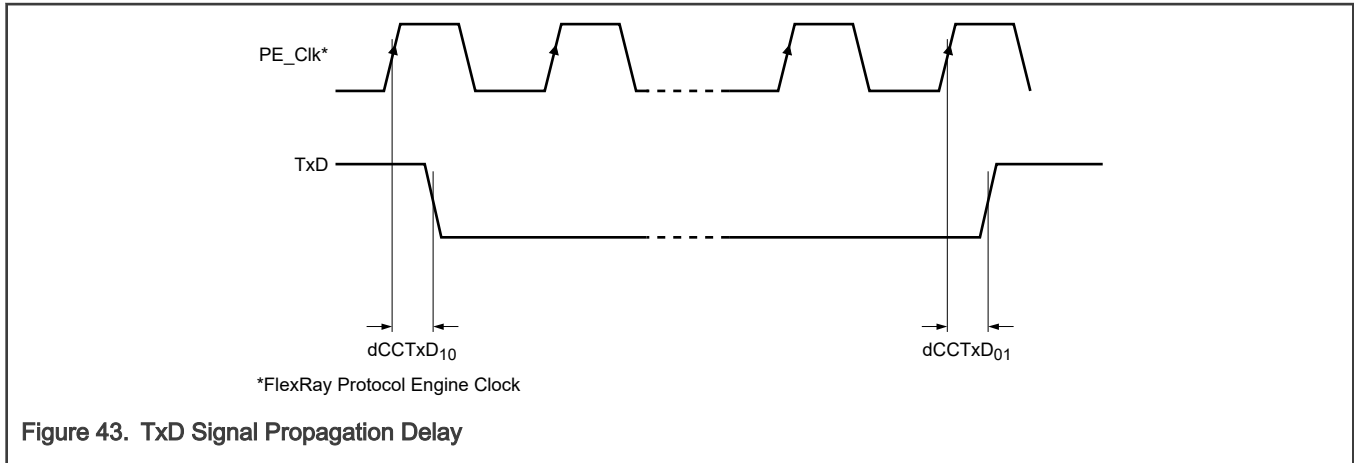
1. FlexRay RxD timing assumes an input signal slew rate of 2ns (20%/80%).

### 16.3.6.2 FlexRay - TxD

Table 33. FlexRay - TxD

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
dCCTxAsym	Asymmetry of sending CC, dCCTxD50% - N x gdBit <sup>1</sup>	-2.45	—	2.45	ns	N=1, gdBit = 100ns, TxD load = 25pF max, SRE[2:0] = 110 (3.3V GPIO)	—
dCCTxDRISE25 + dCCTxDFALL25	Sum of rise and fall time of TxD signal at the output pin <sup>1</sup>	—	—	9	ns	TxD load = 25pF max, Z = 50ohms, delay = 0.6ns, SRE[2:0] = 110 (3.3V GPIO)	—
dCCTxD01	Sum of delay between Clk to Q of the last FF and the final output buffer, rising edge <sup>1</sup>	—	—	25	ns	TxD load = 25pF max, SRE[2:0] = 110 (3.3V GPIO)	—
dCCTxD10	Sum of delay between Clk to Q of the last FF and the final output buffer, falling edge <sup>1</sup>	—	—	25	ns	TxD load = 25pF max, SRE[2:0] = 110 (3.3V GPIO)	—

1. Timing valid for maximum external load CL = 25pF, which is assumed to be a 8pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance of the transmission line should be matched closely to the RDSON of the I/O pad output driver.

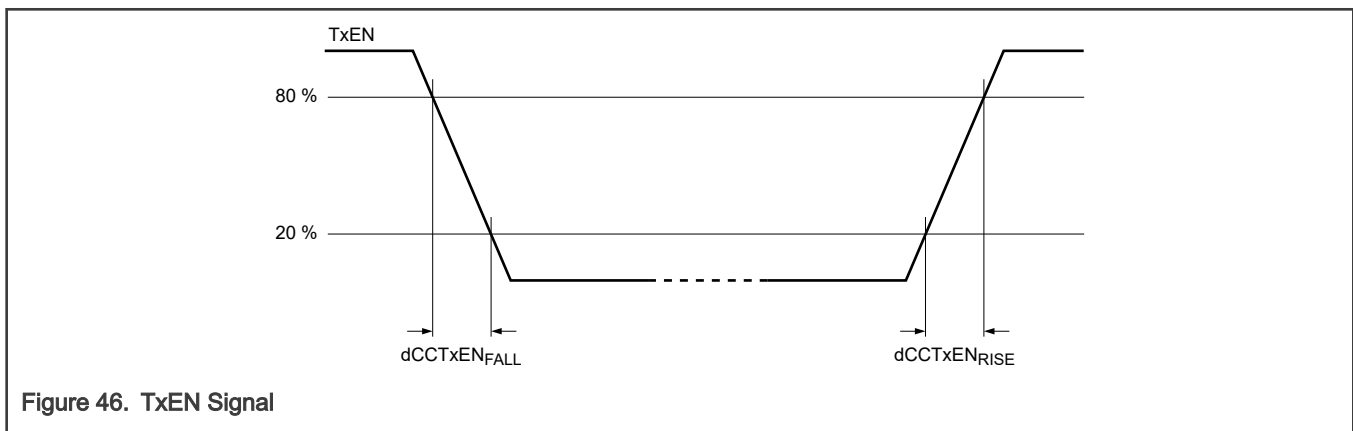
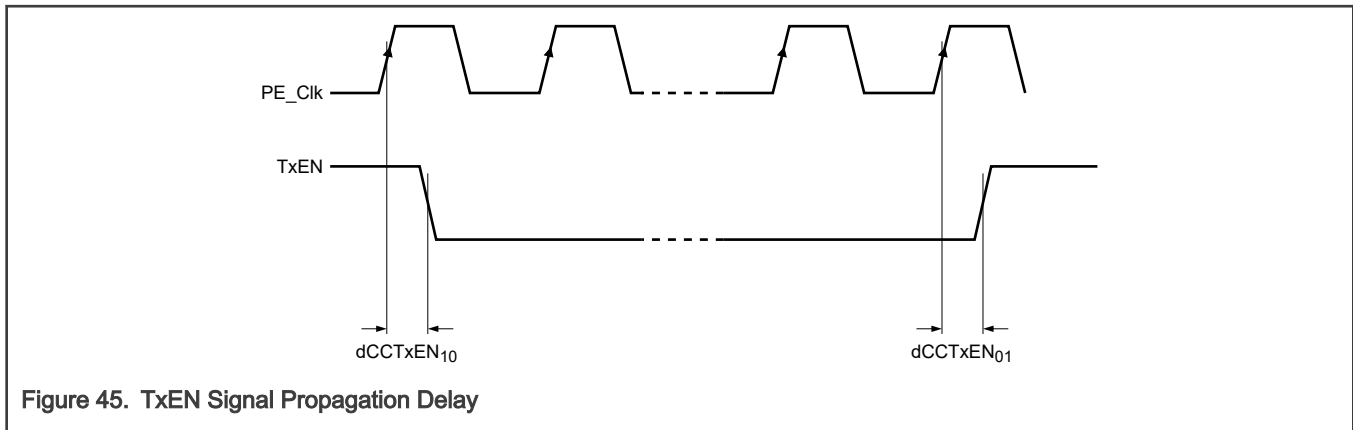


### 16.3.6.3 FlexRay - TxEN

Table 34. FlexRay - TxEN

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
dCCTxENRISE25	Rise time of TxEN signal at CC <sup>1</sup>	—	—	9	ns	TxEN load = 25pF max, SRE[2:0] = 110 (3.3V GPIO)	—
dCCTxENFALL25	Fall time of TxEN signal at CC <sup>1</sup>	—	—	9	ns	TxEN load = 25pF max, SRE[2:0] = 110 (3.3V GPIO)	—
dCCTxEN01	Sum of delay between Clk to Q of the last FF and the final output buffer, rising edge <sup>1</sup>	—	—	25	ns	TxEN load = 25pF max, SRE[2:0] = 110 (3.3V GPIO)	—
dCCTxEN10	Sum of delay between Clk to Q of the last FF and the final output buffer, falling edge <sup>1</sup>	—	—	25	ns	TxEN load = 25pF max, SRE[2:0] = 110 (3.3V GPIO)	—

- Timing valid for maximum external load  $CL = 25pF$ , which is assumed to be a  $8pF$  load at the end of a  $50\Omega$ , un-terminated 5 inch microstrip trace on standard FR4 ( $1.5pF/inch$ ), ( $25pF$  total with margin). For best signal integrity, the series resistance of the transmission line should be matched closely to the  $RDSON$  of the I/O pad output driver.



### 16.3.7 PCIe

Table 35. PCIe

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
UI	Unit Interval <sup>1</sup>	399.88	—	400.12	ps	2.5GT/s	—
UI	Unit Interval <sup>1</sup>	199.94	—	200.06	ps	5.0GT/s	—
UI	Unit Interval <sup>1</sup>	124.9625	—	125.0375	ps	8.0GT/s	—
VTX-DIFF-PP	Differential p-p Tx voltage swing <sup>1</sup>	0.8	—	1.2	Vp-p	2.5GT/s, 5.0GT/s	—
VTX-DE-RATIO-3.5dB	Tx de-emphasis level ratio <sup>1</sup>	2.5	—	4.5	dB	2.5GT/s, 5.0GT/s	—
VTX-DE-RATIO-6dB	Tx de-emphasis level ratio <sup>1</sup>	5	—	7	dB	5.0GT/s	—
TMIN-PULSE	Instantaneous lone pulse width <sup>1</sup>	0.9	—	—	UI	5.0GT/s	—

Table continues on the next page...

Table 35. PCIe (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
TTX-EYE	Transmitter Eye including all jitter sources <sup>1</sup>	0.75	—	—	UI	2.5GT/s, 5.0GT/s	—
TTX-HF-DJ-DD	Tx deterministic jitter > 1.5 MHz <sup>1</sup>	—	—	0.15	UI	5.0GT/s	—
TTX-LF-RMS	Tx RMS jitter < 1.5 MHz <sup>1</sup>	—	3	—	ps RMS	5.0GT/s	—
BWTX-PKG-PLL1	Tx PLL BW corresponding to PKGTX-PLL1 <sup>1</sup>	8	—	16	MHz	5.0GT/s	—
BWTX-PKG-PLL1	Tx PLL BW corresponding to PKGTX-PLL1 <sup>1</sup>	2	—	4	MHz	8.0GT/s	—
BWTX-PKG-PLL2	Tx PLL BW corresponding to PKGTX-PLL2 <sup>1</sup>	5	—	16	MHz	5.0GT/s	—
BWTX-PKG-PLL2	Tx PLL BW corresponding to PKGTX-PLL2 <sup>1</sup>	2	—	5	MHz	8.0GT/s	—
PKGTX-PLL1	Tx PLL peaking <sup>1</sup>	—	—	3	dB	5.0GT/s	—
PKGTX-PLL1	Tx PLL peaking <sup>1</sup>	—	—	2	dB	8.0GT/s	—
PKGTX-PLL2	Tx PLL peaking <sup>1</sup>	—	—	1	dB	5.0GT/s	—
PKGTX-PLL2	Tx PLL peaking <sup>1</sup>	—	—	1	dB	8.0GT/s	—
BWTX-PLL	Maximum Tx PLL bandwidth <sup>1</sup>	1.5	—	22	MHz	2.5GT/s	—
TTX-EYE-MEDIAN-to-MAXJITTER	Maximum time between the jitter median and max deviation from the median <sup>1</sup>	—	—	0.125	UI	2.5GT/s	—
VTX-FS-NO-EQ	Full Swing Tx voltage with no TxEq <sup>1</sup>	800	—	1300	mVPP	8.0GT/s	—
VTX-EIEOS-FS	Min Swing during EIEOS for full swing <sup>1</sup>	250	—	—	mVPP	8.0GT/s	—
TTX-UTJ	Tx uncorrelated total jitter <sup>1</sup>	—	—	31.25	ps PP @ 10e-12	8.0GT/s	—
TTX-UDJDD	Tx uncorrelated deterministic jitter <sup>1</sup>	—	—	12	ps PP	8.0GT/s	—

Table continues on the next page...

Table 35. PCIe (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
VTX-BOOST-FS	Tx boost ratio for full swing <sup>1</sup>	8	—	—	dB	8.0GT/s	—
VRX-DIFF-PP-CC	Differential Rx peak-peak voltage for common Refclk Rx architecture <sup>1</sup>	0.175	—	1.2	V	2.5GT/s	—
VRX-DIFF-PP-CC	Differential Rx peak-peak voltage for common Refclk Rx architecture <sup>1</sup>	0.12	—	1.2	V	5.0GT/s	—
TRX-EYE	Receiver eye time opening <sup>1</sup>	0.4	—	—	UI	2.5GT/s	—
TRX-TJ-CC	Max Rx inherent timing error <sup>1</sup>	—	—	0.4	UI	5.0GT/s	—
TRX-DJ-DD_CC	Max Rx deterministic timing error <sup>1</sup>	—	—	0.3	UI	5.0GT/s	—
VRX-EYE	Receive eye voltage opening <sup>1</sup>	—	120	—	mVPP diff	5.0GT/s	—
VRX-SV-8G	Eye height at TP2P <sup>1</sup>	—	25	—	mVPP	8.0GT/s, -20dB Ch	—
VRX-SV-8G	Eye height at TP2P <sup>1</sup>	—	50	—	mVPP	8.0GT/s, -12dB Ch	—
VRX-SV-8G	Eye height at TP2P <sup>1</sup>	—	200	—	mVPP	8.0GT/s, -3dB Ch	—
TRX-SV-8G	Eye width at TP2P <sup>1</sup>	0.3	—	0.35	UI	8.0GT/s	—
TRX-SV-SJ-8G	Sinusoidal Jitter at 100MHz <sup>1</sup>	—	0.1	—	UI PP	8.0GT/s	—
TRX-SV-RJ-8G	Random Jitter <sup>1</sup>	—	2	—	ps RMS	8.0GT/s	—
REXTPCIe	External pin calibration resistance	198	200	202	Ω	—	—
RJREFCLK	Reference clock random jitter (rms) <sup>1</sup>	—	—	3	ps	Integrated RJ from 12kHz to 20MHz	—
RJREFCLK	Reference clock random jitter (rms) <sup>1</sup>	—	—	2.2	ps	Integrated RJ from 2MHz to 20MHz	—
DJREFCLK	Reference clock deterministic jitter (pk-pk) <sup>1</sup>	—	—	5.7	ps	200kHz to 100MHz	—
DJREFCLK	Reference clock deterministic jitter (pk-pk) <sup>1</sup>	—	—	2.8	ps	1MHz to 20MHz	—

Table continues on the next page...

**Table 35. PCIe (continued)**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
RJ_SGMII	Reference clock random jitter (rms)	—	—	2.3	ps	Integrated RJ from 12kHz to 20MHz	—
RJ_SGMII	Reference clock random jitter (rms)	—	—	1.7	ps	Integrated RJ from 2MHz to 20MHz	—
DJ_SGMII	Reference clock deterministic jitter (pk-pk)	—	—	7.4	ps	1MHz to 100MHz	—
DJ_SGMII	Reference clock deterministic jitter (pk-pk)	—	—	3.7	ps	3MHz to 20MHz	—
FREF_OFFSET	Reference clock frequency offset	-150	—	150	ppm	—	—
DCREF_CLK	Duty cycle	40	—	60	%	—	—
VREF_CLK	Voltage level	0	—	VDD_VP_PCIE	V	—	—
IS_DIFF	Differential input swing	0.3	—	—	Vpp	—	—
SWREF_CLK	Input edge rate	0.4	—	2	V/ns	—	—
REF_CL_SKEW	Reference clock skew	—	—	200	ps	—	—

1. The PCI Express link conforms to the PCI Express Base Specification, Revision 3.1. The summary of Transmitter and Receiver specifications are copied directly from the Base Specification. Consult the Base Specification for additional details.

NXP completed PCI-SIG compliance testing with the following PHY registers modified from default settings as described below. PHY register and programming details are provided in S32SERDESSUBSYSRM. PHY TX settings optimized for NXP validation board for SUP\_ANA\_TERM\_CTRL = 4 and TX\_VBOOST\_LVL = 4. PHY PLL bandwidth updated for MPLL\_BW\_OVRD\_VAL = 218 and MPLLA\_BW\_OVRD\_VAL = 197. PHY RX equalization tuned for PCIe Gen3 long and short channel cases for RX\_EQ\_DELTA\_IQ\_OVRD\_VAL = 3.

NXP internally does PCI-SIG TX compliance testing using external reference clock source.

### 16.3.8 GMAC and PFE

#### 16.3.8.1 GMAC and PFE MII

SRE[2:0]=100 is the required drive setting to meet the timing.

**Table 36. GMAC and PFE MII**

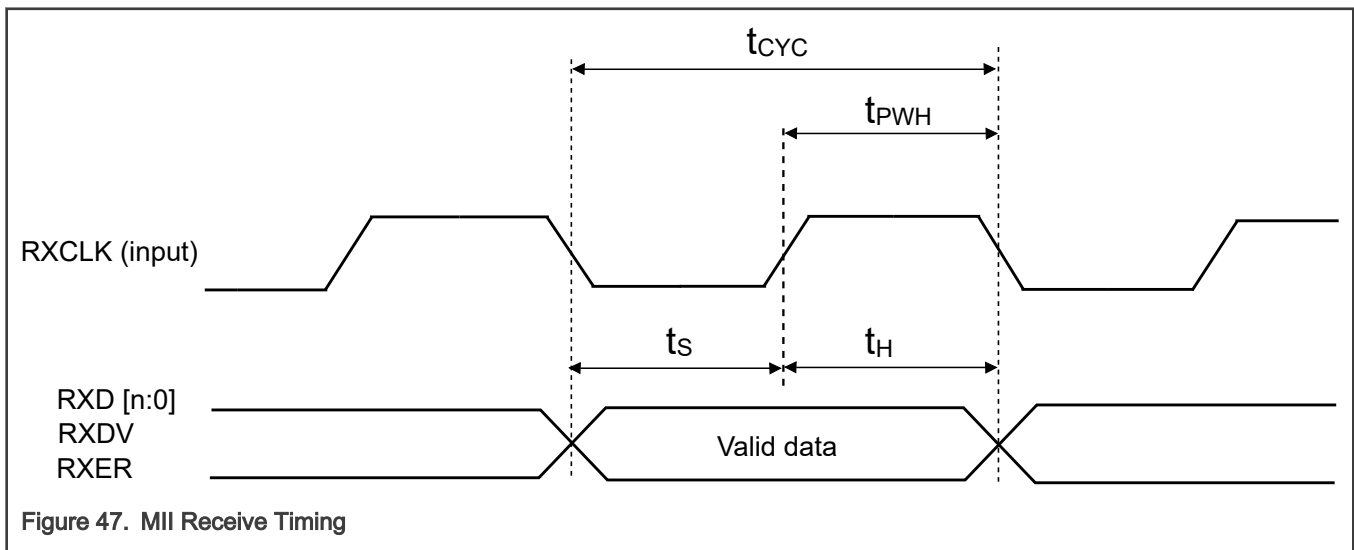
Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tCYC_RX	RX_CLK period	—	40 / 400	—	ns	10/100 Mbps	—

*Table continues on the next page...*

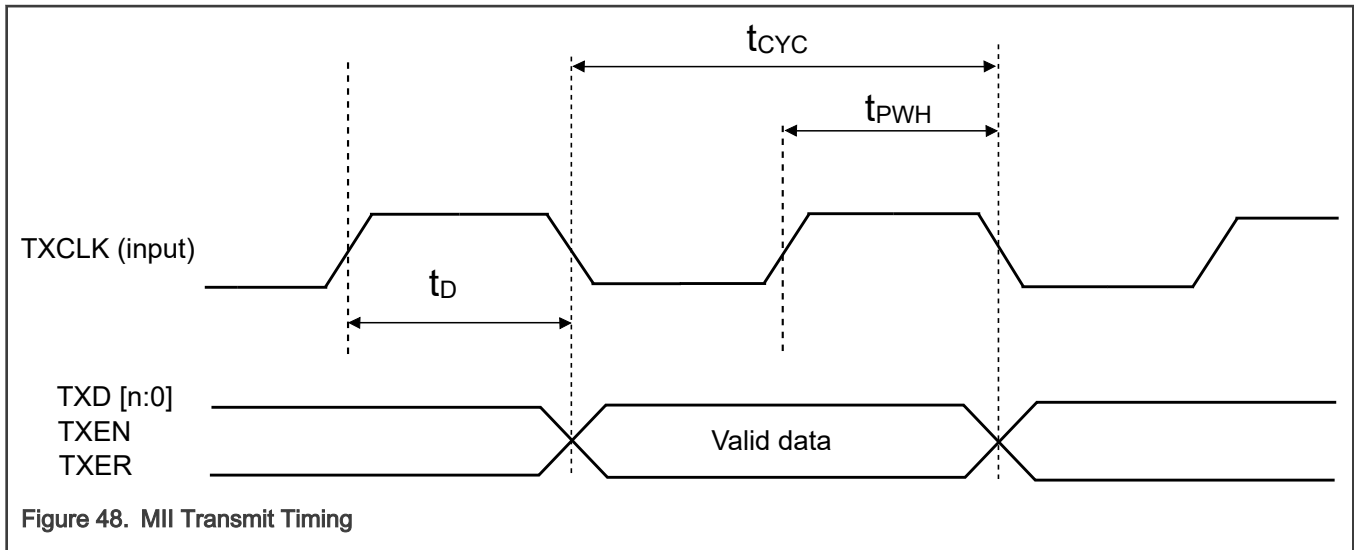
Table 36. GMAC and PFE MII (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
$\Delta t_{CYC\_RX}$	RX_CLK duty cycle (tPWH / tCYC)	45	—	55	%	—	—
tS	Input setup time to RX_CLK <sup>1</sup>	5	—	—	ns	10/100 Mbps	—
tH	Input hold time to RX_CLK <sup>1</sup>	5	—	—	ns	10/100 Mbps	—
tCYC_TX	TX_CLK period <sup>2</sup>	—	40 / 400	—	ns	10/100 Mbps	—
$\Delta t_{CYC\_TX}$	TX_CLK duty cycle (tPWH / tCYC) <sup>2</sup>	45	—	55	%	—	—
tD	Output delay from TX_CLK <sup>2</sup>	2	—	25	ns	10/100 Mbps	—

1. Input timing assumes an input signal slew rate of 3ns (20%/80%).
2. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch), (25pF total with margin). For best signal integrity, the series resistance of the transmission line should be matched closely to the RDSON of the I/O pad output driver.







### 16.3.8.2 GMAC MII 50MHz

**NOTE**

GMAC MII 50MHz spec apply to GMAC only.

Table 37. GMAC MII 50MHz

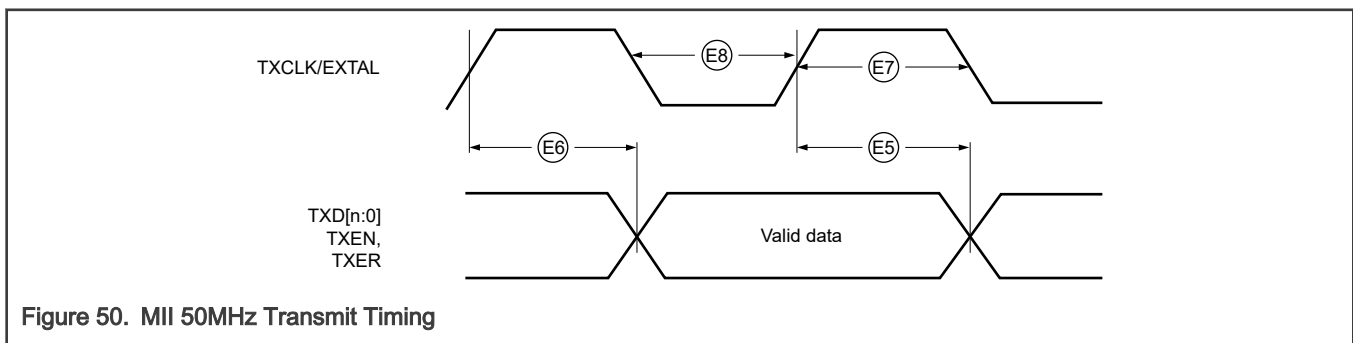
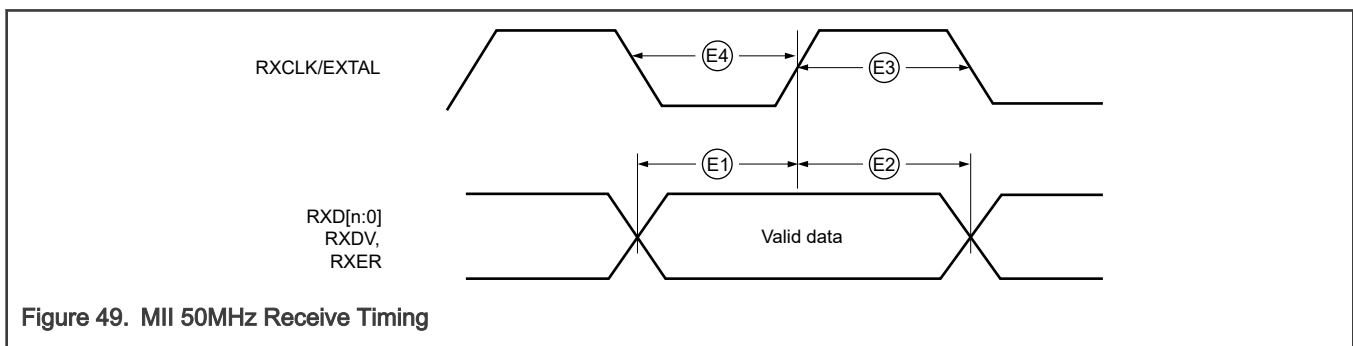
Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fRXCLK	RXCLK frequency <sup>1</sup>	—	—	50	MHz	—	—
dtRXCLK	RXCLK pulse width high <sup>1</sup>	35	—	65	% RXCLK period	—	E3
dtRXCLK	RXCLK pulse width low <sup>1</sup>	35	—	65	% RXCLK period	—	E4
tSETUP	RXD[3:0], RXDV, RXER to RXCLK setup time <sup>1</sup>	4	—	—	ns	—	—
tHOLD	RXCLK to RXD[3:0], RXDV, RXER hold time <sup>1</sup>	2	—	—	ns	—	—
fTXCLK	TXCLK frequency <sup>2</sup>	—	—	50	MHz	—	—
dtTXCLK	TXCLK pulse width high <sup>2</sup>	35	—	65	% TXCLK period	—	E7
dtTXCLK	TXCLK pulse width low <sup>2</sup>	35	—	65	% TXCLK period	—	E8

Table continues on the next page...

**Table 37. GMAC MII 50MHz (continued)**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tDATA_VALID	TXCLK to TXD[3:0], TXDV, TXER valid <sup>2</sup>	—	—	15	ns	—	E6
tDATA_INVALID	TXCLK to TXD[3:0], TXDV, TXER invalid <sup>2</sup>	2	—	—	ns	—	E5

1. Input timing assumes an input signal slew rate of 3ns (20%/80%).
2. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch, (25pF total with margin). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output driver.



### 16.3.8.3 GMAC and PFE RMII

SRE[2:0]=100 is the required drive setting to meet the timing.

**Table 38. GMAC and PFE RMII**

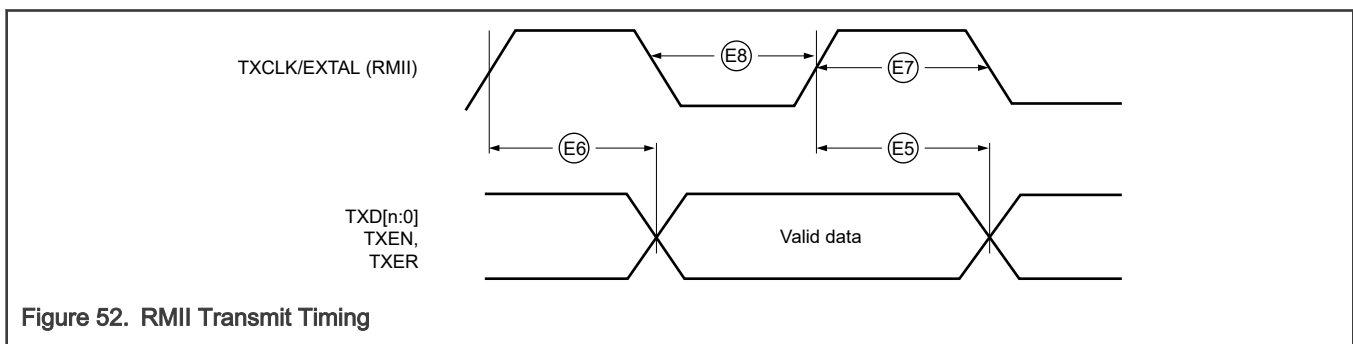
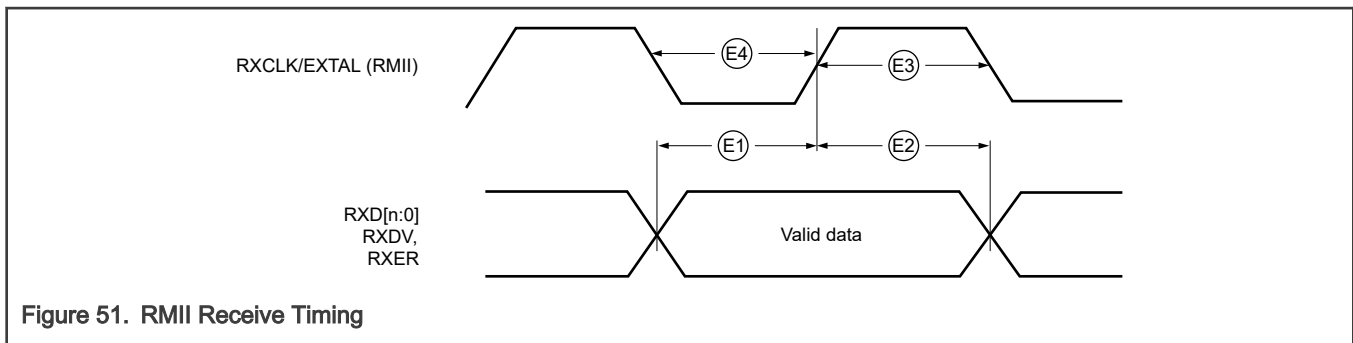
Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fRMII_CLK	RMII input clock frequency (RMII_CLK)	—	—	50	MHz	—	—
ΔtRMII_CLK	RMII_CLK duty cycle (tPWH / tCYC)	35	—	65	%	—	E3, E4, E7, E8

*Table continues on the next page...*

Table 38. GMAC and PFE RMII (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tS	RXD[1:0], CRS_DV, RXER to RMII_CLK setup time <sup>1</sup>	4	—	—	ns	—	E1
tH	RMII_CLK to RXD[1:0], CRS_DV, RXER hold time <sup>1</sup>	2	—	—	ns	—	E2
tDATA_VALID	RMII_CLK to TXD[1:0], TXEN data valid <sup>2</sup>	—	—	14	ns	CLOAD = 25pF	E6
tDATA_INVALID	RMII_CLK to TXD[1:0], TXEN data invalid <sup>2</sup>	2	—	—	ns	CLOAD = 25pF	E5

1. Input timing assumes an input signal slew rate of 3ns (20%/80%).
2. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch), (25pF total with margin). For best signal integrity, the series resistance of the transmission line should be matched closely to the RDSON of the I/O pad output driver.



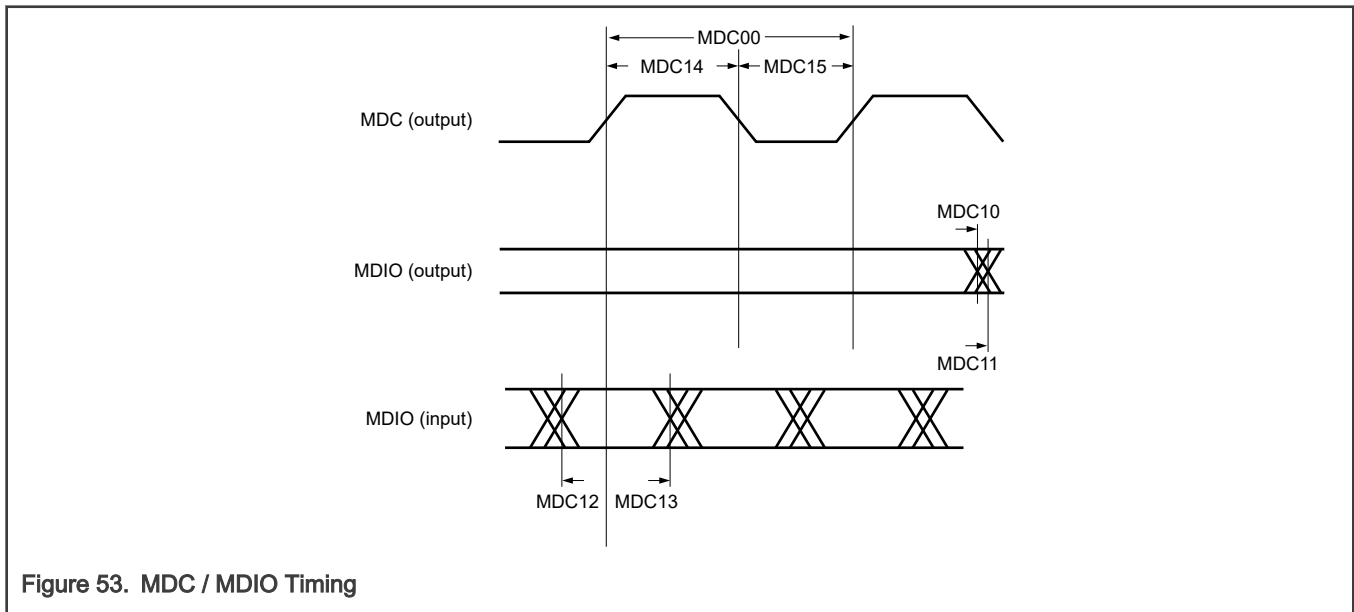
### 16.3.8.4 GMAC and PFE Management Interface

SRE[2:0]=100 is the required drive setting to meet the timing.

**Table 39. GMAC and PFE Management Interface**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fMDC	MDC clock frequency	—	—	2.5	MHz	—	MDC00
MDIO_CH	MDC pulse width high time	40	—	60	%	—	MDC14
MDIO_CL	MDC pulse width low time	40	—	60	%	—	MDC15
MDIO_DOI	MDC falling edge to MDIO output invalid (minimum propagation delay)	-0.45	—	—	ns	—	MDC10
MDIO_DOV	MDC falling edge to MDIO output valid (maximum propagation delay)	—	—	15	ns	—	MDC11
MDIO_ISU	MDIO (input) to MDC rising edge setup time <sup>1</sup>	13	—	—	ns	—	MDC12
MDIO_IH	MDIO (input) to MDC rising edge hold time	0	—	—	ns	—	MDC13

1. MDIO\_ISU spec is for GMAC, for PFE it is 17ns (min)



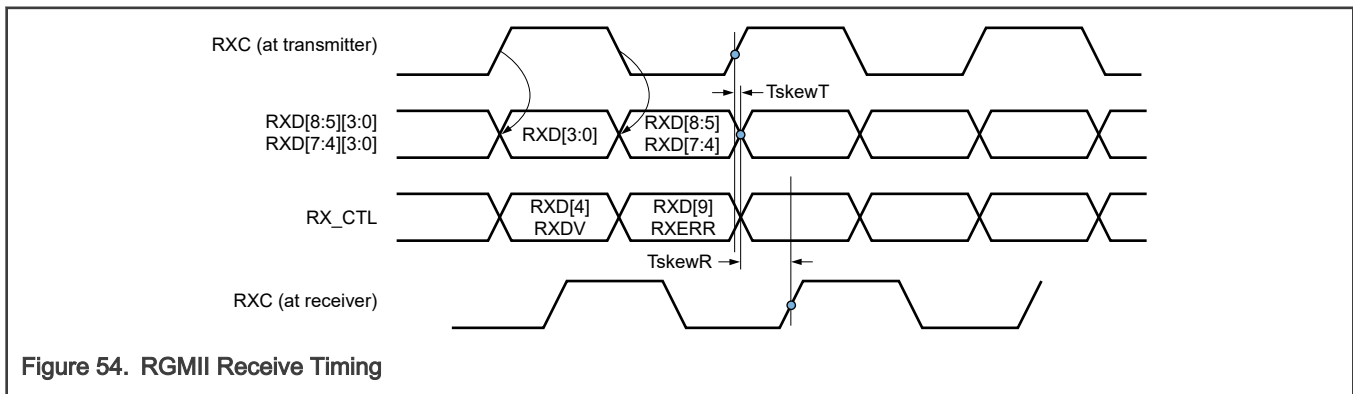
**16.3.8.5 GMAC and PFE RGMII**

SRE[2:0]=100 is the required drive setting to meet the timing.

**Table 40. GMAC and PFE RGMII**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
T <sub>cyc</sub>	Clock cycle duration <sup>1,2,3,4</sup>	7.2	—	8.8	ns	—	—
T <sub>skewT</sub>	Data to clock output skew (at transmitter) <sup>1,2,3,5</sup>	-500	—	500	ps	—	—
T <sub>skewR</sub>	Data to clock input skew (at receiver) <sup>1,2,5</sup>	1	—	2.6	ns	—	—
Duty_G	Clock duty cycle for Gigabit <sup>1,2,6</sup>	45	—	55	%	—	—
Duty_T	Clock duty cycle for 10/100T <sup>1,2,6</sup>	40	—	60	%	—	—

1. Measured as defined in EIA/JESD 8-6 1995 with a timing threshold voltage of VDDQ/2
2. RGMII timing specifications are valid for both 1.8V and 3.3V nominal I/O pad supply voltage.
3. Output timing valid for maximum external load CL = 15pF, which is assumed to be a 8pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance of the transmission line should be matched closely to the selected RDSON of the I/O pad output driver.
4. For 10 Mbps and 100 Mbps, T<sub>cyc</sub> will scale to 400 ns ±40 ns and 40 ns ±4 ns respectively.
5. For all versions prior to RGMII v2.0 specifications; This implies that PC board design will require clocks to be routed such that an additional delay of greater than 1.5 ns and less than 2 ns will be added to the associated clock signal. For 10/100, the max value is unspecified.
6. Duty cycle may be stretched/shrunk during speed changes or while transitioning to a received packet's clock domain as long as minimum duty cycle is not violated and stretching occurs for no more than three T<sub>cyc</sub> of the lowest speed transitioned between.



**Figure 54. RGMII Receive Timing**

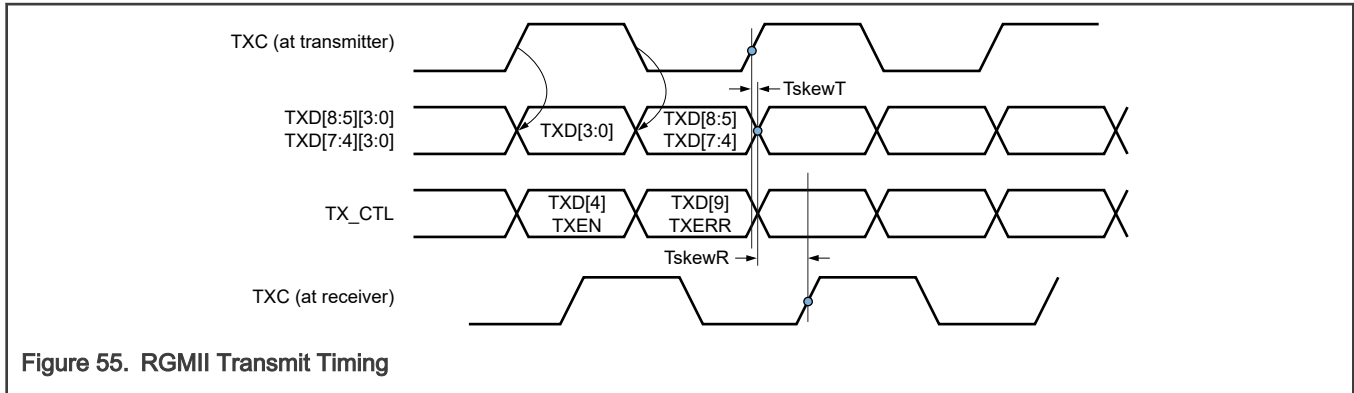


Figure 55. RGMII Transmit Timing

### 16.3.8.6 GMAC and PFE SGMII

Table 41. GMAC and PFE SGMII

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
UI	Unit Interval (mean)	799.92	800	800.08	ps	1.25 Gbps bit rate, applies to both transmitter and receiver and supports 1 Gbps data rate	—
UI	Unit Interval (mean)	319.968	320	320.032	ps	3.125 Gbps bit rate, applies to both transmitter and receiver and supports 2.5 Gbps data rate	—
trise	Transmit Vod rise time (20-80%)	—	—	100	ps	—	—
tfall	Transmit Vod fall time (20-80%)	—	—	100	ps	—	—
VOD	Transmit Output Differential Voltage	400	—	600	mV	1.25Gbps	—
VOD	Transmit Output Differential Voltage <sup>1</sup>	400	—	600	mV	3.125Gbps	—
RDOUT	Transmit Differential Output Impedance	80	100	120	Ohm	—	—
Dj	Transmit Deterministic Jitter	—	—	0.17	UI	—	—
Tj	Transmit Total Jitter	—	—	0.35	UI	—	—
RDIN	Receiver Differential Input Impedance	80	—	120	Ohm	—	—
VIN	Receiver Differential Input Voltage	200	—	1200	mV	—	—

Table continues on the next page...

Table 41. GMAC and PFE SGMII (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
LOS	Loss-of-signal threshold	75	—	200	mV	—	—
Sjt	Receiver deterministic jitter tolerance with sinusoidal noise <sup>2</sup>	—	—	0.37	UI	—	—
DRjt	Receiver combined random and deterministic jitter tolerance with sinusoidal noise <sup>2</sup>	—	—	0.55	UI	—	—
Tjt	Receiver total jitter tolerance	—	—	0.65	UI	—	—
BER	Bit Error Rate	—	—	10 <sup>-12</sup>	—	—	—

1. VOD at 3.125Gbps is only applicable for PFE\_MAC0.
2. The sinusoidal jitter in the total jitter tolerance may have any amplitude and frequency in the un-shaded region of the figure below.

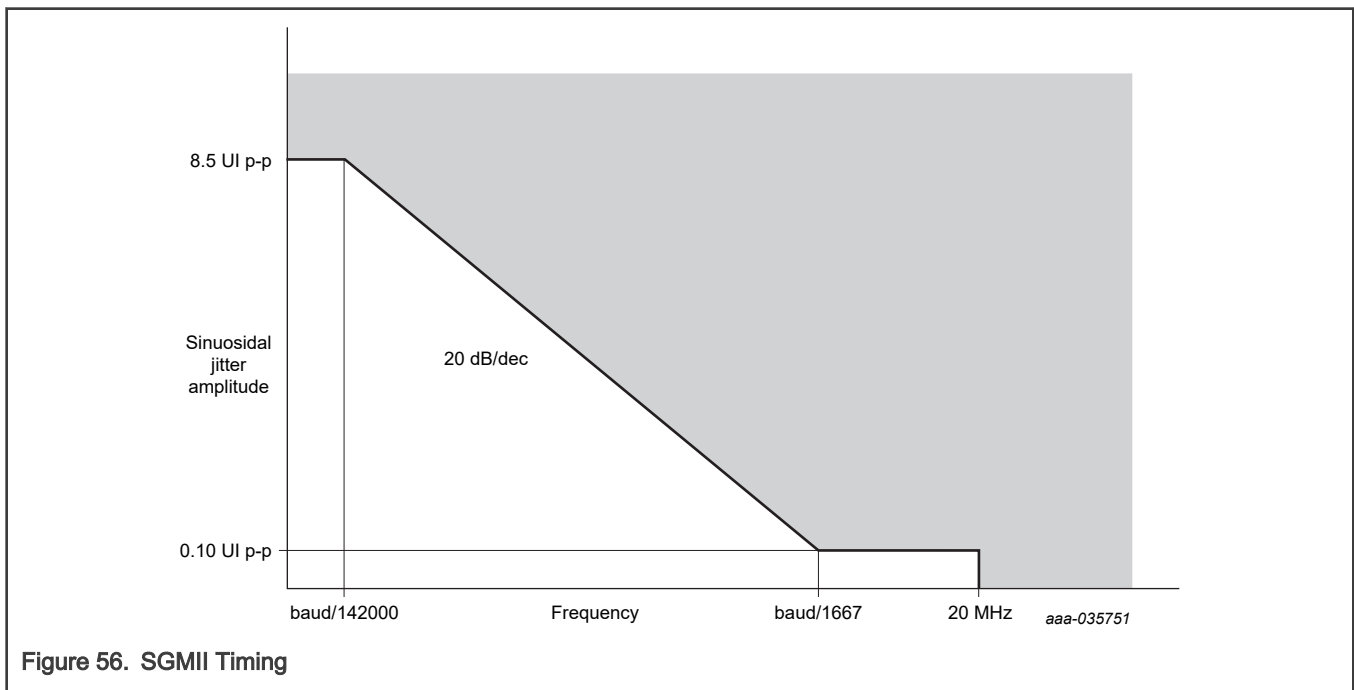


Figure 56. SGMII Timing

### 16.3.9 USB

#### 16.3.9.1 USB-ULPI

Table 42. USB-ULPI

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
TCLK	USB_CLKIN period	—	16.67	—	ns	—	U1
DFCLK	USB_CLKIN duty cycle	—	50	—	%	—	—
tISU	Input setup time (control and data) <sup>1</sup>	5	—	—	ns	—	U2
tIH	Input hold time (control and data) <sup>1</sup>	1	—	—	ns	—	U3
tOV	Output valid time (control and data) <sup>2</sup>	—	—	9.5	ns	—	U4
tOH	Output hold time (control and data) <sup>2</sup>	1	—	—	ns	—	U5

1. Input timing assumes an input signal slew rate of 3ns (20%/80%).
2. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 with 1.5pF/inch (25pF total with margin). For best signal integrity, the series resistance of the transmission line should match closely to the RDSON of the I/O pad output driver.

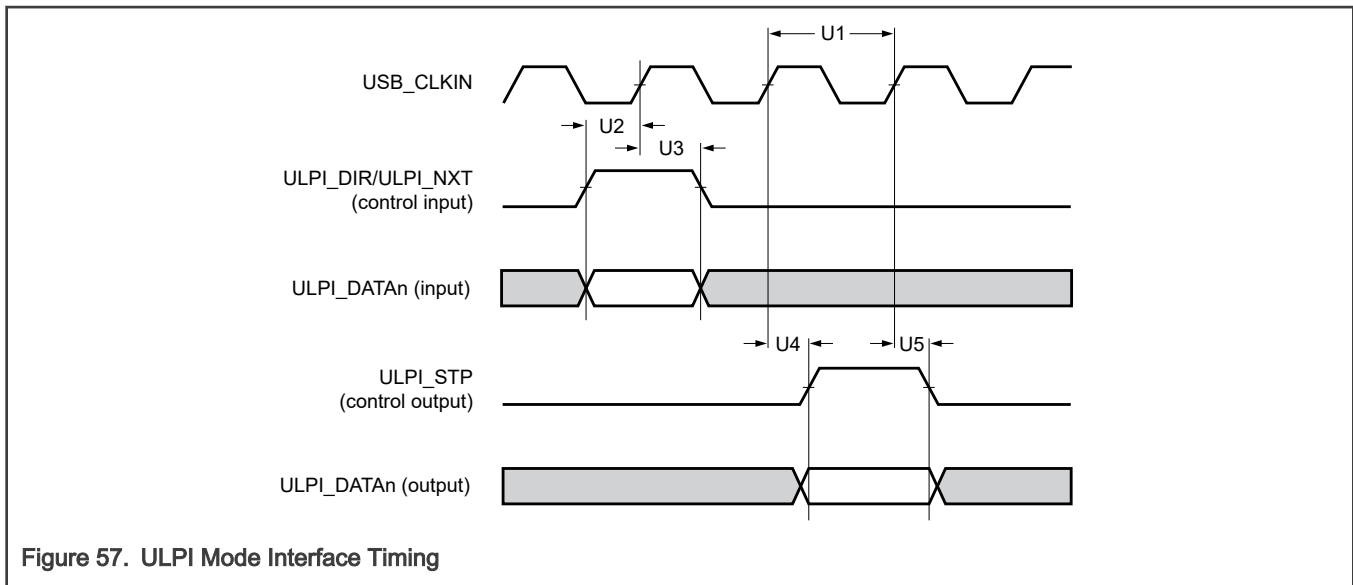


Figure 57. ULPI Mode Interface Timing

### 16.4 Memory interfaces

#### 16.4.1 QuadSPI

##### 16.4.1.1 QuadSPI

An external resistor is needed to pull up a QuadSPI chip select signal.



### 16.4.1.2 QuadSPI Quad 1.8V DDR 66MHz

The SRE[2:0]=110 is the required drive setting to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

All transitions measured at mid-supply (VDD\_IO\_QSPI/2).

**Table 43. QuadSPI Quad 1.8V DDR 66MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK	SCK clock frequency <sup>1,2</sup>	—	—	66	MHz	DLL mode enabled	—
tCL_SCK	SCK clock low time <sup>1,2</sup>	6.818	—	—	ns	—	—
tCH_SCK	SCK clock high time <sup>1,2</sup>	6.818	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>1</sup>	2.316	—	4.802	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>1,3</sup>	5.016 - n/fSCK	—	1.802 + m/fSCK	ns	—	—
tDVW	Input data valid window <sup>2</sup>	5.14	—	—	ns	—	—
tLSKEW	Skew target for Auto-learning mode <sup>4</sup>	1.89	—	—	ns	—	—

1. Output timing valid for maximum external load CL = 20pF, which is assumed to be a 10pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.
2. Input timing assumes maximum input signal transition of 1ns (20%/80%).
3. Where m=TCSS and n=TCSH-1.
4. Data valid window includes DLL Margin, and determines LEARNING skew targets which can be more pessimistic than tISU\_SCK and tIH\_SCK.

### 16.4.1.3 QuadSPI Quad 1.8V SDR 133MHz

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

**Table 44. QuadSPI Quad 1.8V SDR 133MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK	SCK clock frequency <sup>1,2,3</sup>	—	—	133	MHz	DLL Bypass mode	—
tCL_SCK	SCK low time <sup>2,3</sup>	3.383	—	—	ns	—	—
tCH_SCK	SCK high time <sup>2,3</sup>	3.383	—	—	ns	—	—

*Table continues on the next page...*

Table 44. QuadSPI Quad 1.8V SDR 133MHz (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tOD_DATA	Data output delay (w.r.t. SCK) <sup>2</sup>	-0.594	—	1.594	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>2,4</sup>	4.016 - n/ fSCK	—	4.204 + m/fSCK	ns	—	—
tISU_SCK	Input setup time (w.r.t. SCK) <sup>3</sup>	0.580	—	—	ns	—	—
tIH_SCK	Input hold time (w.r.t. SCK) <sup>3</sup>	1.000	—	—	ns	—	—

- fSCK of 133.33MHz is also acceptable.
- Output timing valid for maximum external load CL = 20pF, which is assumed to be a 10pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.
- Input timing assumes maximum input signal transition of 1ns (20%/80%).
- Where m=TCSS and n=TCSH-1.

#### 16.4.1.4 QuadSPI Octal 1.8V DDR 100MHz

The information in this section applies to Octal- and Hyperflash.

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

Table 45. QuadSPI Octal 1.8V DDR 100MHz

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK_DQS	SCK / DQS frequency <sup>1,2</sup>	—	—	100	MHz	fSCK duty cycle distortion is in the range of 45%-55%.	—
tCL_SCK	SCK low time <sup>1,2</sup>	4.500	—	—	ns	—	—
tCH_SCK	SCK high time <sup>1,2</sup>	4.500	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>1</sup>	1.016	—	3.484	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>1,3</sup>	3.016 - n/ fSCK	—	-0.016 + m/fSCK	ns	—	—
tISU_DQS	Input setup time (w.r.t. DQS) <sup>2</sup>	-0.816	—	—	ns	—	—
tIH_DQS	Input hold time (w.r.t. DQS) <sup>2</sup>	3.684	—	—	ns	—	—

- Output timing valid for maximum external load CL = 20pF, which is assumed to be a 10pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.

- Input timing assumes maximum input signal transition of 1 ns (20%/80%). DQS denotes external strobe provided by the Flash.
- Where  $m=TCSS$  and  $n=TCSH-1$ .

#### 16.4.1.5 QuadSPI Octal 1.8V DDR 133MHz

The information in this section applies to Octal- and Hyperflash.

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

**Table 46. QuadSPI Octal 1.8V DDR 133MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK_DQS	SCK / DQS frequency <sup>1,2,3</sup>	—	—	133	MHz	DLL mode enabled, fSCK duty cycle distortion is in the range of 45%-55%.	—
tCL_SCK	SCK low time <sup>1,2</sup>	3.383	—	—	ns	—	—
tCH_SCK	SCK high time <sup>1,2</sup>	3.383	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>2</sup>	0.816	—	2.567	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>2,4</sup>	$3.015 - n/fSCK$	—	$-1.33 + m/fSCK$	ns	—	—
tISU_DQS	Input setup time (w.r.t. DQS) <sup>1</sup>	-0.616	—	—	ns	—	—
tIH_DQS	Input hold time (w.r.t. DQS) <sup>1</sup>	2.767	—	—	ns	—	—

- Input timing assumes maximum input signal transition of 1 ns (20%/80%). DQS denotes external strobe provided by the Flash.
- Output timing valid for maximum external load  $CL = 20pF$ , which is assumed to be a 12pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.
- fSCK of 133.33MHz is also acceptable.
- Where  $m=TCSS$  and  $n=TCSH-1$ .

#### 16.4.1.6 QuadSPI Octal 1.8V DDR 166MHz

The information in this section applies to Octal- and Hyperflash.

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

**Table 47. QuadSPI Octal 1.8V DDR 166MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK-DQS	SCK/DQS frequency <sup>1,2</sup>	—	—	166	MHz	fSCK duty cycle distortion is in the range of 45%-55%.	—
tCL_SCK	SCK low time <sup>1,2</sup>	2.711	—	—	ns	—	—
tCH_SCK	SCK high time <sup>1,2</sup>	2.711	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>2</sup>	0.616	—	2.095	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>2,3</sup>	3.016 - n/fSCK	—	-1.805 + m/fSCK	ns	—	—
tIH_DQS	Input hold time (w.r.t. DQS) <sup>1</sup>	2.145	—	—	ns	—	—
tISU_DQS	Input setup time (w.r.t. DQS) <sup>1</sup>	-0.496	—	—	ns	—	—

1. Input timing assumes maximum input signal transition of 1 ns (20%/80%). DQS denotes external strobe provided by the Flash.
2. Output timing valid for maximum external load CL = 20pF, which is assumed to be a 12pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.
3. Where m=TCSS and n=TCSH-1.

**16.4.1.7 QuadSPI Octal 1.8V DDR 200MHz**

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

**Table 48. QuadSPI Octal 1.8V DDR 200MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK-DQS	SCK/DQS frequency <sup>1,2</sup>	—	—	200	MHz	fSCK duty cycle distortion is in the range of 45%-55%.	—
tCL_SCK	SCK low time <sup>1,2</sup>	2.25	—	—	ns	—	—
tCH_SCK	SCK high time <sup>1,2</sup>	2.25	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>2</sup>	0.616	—	1.634	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>2,3</sup>	3.016 - n/fSCK	—	-2.266 + m/fSCK	ns	—	—
tIH_DQS	Input hold time (w.r.t. DQS) <sup>1</sup>	1.684	—	—	ns	—	—

*Table continues on the next page...*

**Table 48. QuadSPI Octal 1.8V DDR 200MHz (continued)**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tISU_DQS	Input setup time (w.r.t. DQS) <sup>1</sup>	-0.466	—	—	ns	—	—

1. Input timing assumes maximum input signal transition of 1 ns (20%/80%). DQS denotes external strobe provided by the Flash.
2. Output timing valid for maximum external load CL = 20pF, which is assumed to be a 12pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.
3. Where m=TCSS and n=TCSH-1.

#### 16.4.1.8 QuadSPI Octal 1.8V SDR 100MHz

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

**Table 49. QuadSPI Octal 1.8V SDR 100MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK	SCK clock frequency <sup>1,2</sup>	—	—	100	MHz	—	—
tCL_SCK	SCK clock low time <sup>1,2</sup>	4.5	—	—	ns	—	—
tCH_SCK	SCK clock high time <sup>1,2</sup>	4.5	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>2</sup>	-2.822	—	2.822	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>2,3</sup>	3.016 - n/ fSCK	—	5.160 + m/fSCK	ns	—	—
tISU_SCK	Input setup time (w.r.t. SCK) <sup>1</sup>	3.036	—	—	ns	—	—
tIH_SCK	Input hold time (w.r.t. SCK) <sup>1</sup>	0.9	—	—	ns	—	—

1. Input timing assumes an input signal transition of 1ns (20%/80%).
2. Output timing valid for maximum external load CL = 20pF, which is assumed to be a 10pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance of the transmission line should be matched closely to the selected RDSON of the I/O pad output driver.
3. Where m=TCSS and n=TCSH-1.

#### 16.4.1.9 QuadSPI Octal 1.8V SDR 133MHz

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

**Table 50. QuadSPI Octal 1.8V SDR 133MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK	SCK clock frequency <sup>1,2,3</sup>	—	—	133	MHz	DLL Bypass mode	—
tCL_SCK	SCK clock low time <sup>1,2</sup>	3.383	—	—	ns	—	—
tCH_SCK	SCK clock high time <sup>1,2</sup>	3.383	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>2</sup>	-1.594	—	1.594	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>2,4</sup>	3.016 - n/fSCK	—	2.704 + m/fSCK	ns	—	—
tISU_SCK	Input setup time (w.r.t. SCK) <sup>1</sup>	0.580	—	—	ns	—	—
tIH_SCK	Input hold time (w.r.t. SCK) <sup>1</sup>	0.9	—	—	ns	—	—

1. Input timing assumes maximum input signal transition of 1ns (20%/80%).
2. Output timing valid for maximum external load CL = 20pF, which is assumed to be a 10pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.
3. fSCK of 133.33MHz is also acceptable.
4. Where m=TCSS and n=TCSH-1.

**16.4.1.10 QuadSPI Quad 3.3V DDR 66MHz**

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

**Table 51. QuadSPI Quad 3.3V DDR 66MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK	SCK clock frequency <sup>1,2</sup>	—	—	66	MHz	DLL mode enabled	—
tCL_SCK	SCK clock low time <sup>1,2</sup>	6.818	—	—	ns	—	—
tCH_SCK	SCK clock high time <sup>1,2</sup>	6.818	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>2</sup>	2.316	—	4.802	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>2,3</sup>	5.016 - n/fSCK	—	1.802 + m/fSCK	ns	—	—

*Table continues on the next page...*

**Table 51. QuadSPI Quad 3.3V DDR 66MHz (continued)**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tDVW	Input data valid window <sup>1</sup>	5.14	—	—	ns	—	—
tLSKEW	Skew target for Auto-learning mode <sup>4</sup>	1.89	—	—	ns	—	—

1. Input timing assumes maximum input signal transition of 1ns (20%/80%).
2. Output timing valid for maximum external load CL = 20pF, which is assumed to be a 10pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance in the transmission line should be matched closely to the selected RDSON of the I/O pad output.
3. Where m=TCSS and n=TCSH-1.
4. Data valid window includes DLL Margin, and determines LEARNING skew targets which can be more pessimistic than tISU\_SCK and tIH\_SCK..

**16.4.1.11 QuadSPI Quad 3.3V SDR 104MHz**

The SRE[2:0]=000 for Data and SRE[2:0]=000 or SRE[2:0]=110 for CLK are the required drive settings to meet the timing.

FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3.

Data transitions measured at 30%/70% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

**Table 52. QuadSPI Quad 3.3V SDR 104MHz**

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fSCK	SCK clock frequency <sup>1,2</sup>	—	—	104	MHz	—	—
tCL_SCK	SCK clock low time <sup>1,2</sup>	4.327	—	—	ns	—	—
tCH_SCK	SCK clock high time <sup>1,2</sup>	4.327	—	—	ns	—	—
tOD_DATA	Data output delay (w.r.t. SCK) <sup>2</sup>	-2.330	—	2.880	ns	—	—
tOD_CS	CS output delay (w.r.t. SCK) <sup>2,3</sup>	3.391 - n/fSCK	—	5.901 + m/fSCK	ns	—	—
tISU_SCK	Input setup time (w.r.t. SCK) <sup>1</sup>	2.152	—	—	ns	—	—
tIH_SCK	Input hold time (w.r.t. SCK) <sup>1</sup>	2.0	—	—	ns	—	—

1. Input timing assumes maximum input signal transition of 1ns (20%/80%).
2. Timing valid for maximum external load CL = 20pF, which is assumed to be a 10pF-15pF load at the end of a 50ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance of the transmission line should be matched closely to the selected RDSON of the I/O pad output driver.
3. Where m=TCSS and n=TCSH-1.

### 16.4.1.12 QuadSPI interfaces

The QuadSPI module supports 2 interfaces; QSPI A & QSPI B. These interfaces are not independent & the QSPI chapter of the reference manual should be consulted for their usage. The table below summarizes which specifications are supported on each interface.

**Table 53. QuadSPI interfaces**

Specification / Interface	3.3V Quad	1.8V Quad	1.8V Octal	1.8V Hyperflash
<b>QSPI A</b>	n/a	SDR 100/133MHz DDR 66MHz	SDR 100/133MHz DDR 100/133/166/200 MHz	DDR 100/133/166 MHz
<b>QSPI B</b>	SDR 104MHz DDR 66MHz	SDR 100/133MHz DDR 66MHz	SDR 100/133MHz DDR 100/133MHz	DDR 100/133MHz

### 16.4.1.13 QuadSPI configurations

The below table shows a subset of the QuadSPI module configurations for different speeds and data rates. The configuration values for each case are equally applicable to Quad, Octal and HyperFlash interfaces, so long as the maximum clock frequency as per [QuadSPI interfaces](#) is not exceeded.

**Table 54. QuadSPI configurations**

-	DDR-200MHz	DDR-133MHz	SDR-133MHz	SDR-104MHz	DDR-66MHz
DQS mode	External DQS Edge Aligned	External DQS Edge Aligned	Internal pad loopback	Internal pad loopback	Internal pad loopback
Sampling mode	DDR	DDR	SDR	SDR	DDR
DLL Mode	DLL Enable	DLL Enable	DLL Bypass	DLL Bypass	DLL Enable
Data Learning	No	No	No	No	Yes
IO Voltage	1.8V	1.8V	1.8V	3.3V	1.8V/3.3V
Frequency	166/200 MHz	100/133 MHz	100/133 MHz	104 MHz	66 MHz
FLSHCR[TDH]	1	1	0	0	1
FLSHCR[TCSH]	3	3	3	3	3
FLSHCR[TCSS]	3	3	3	3	3
MCR[DLPEN]	0	0	0	0	1
DLLCR[DLEN]	1	1	0	0	1
DLLCR[FREQEN]	1	0	0	0	0
DLLCR[DLL_REFCNTR]	2	2	NA	NA	2
DLLCR[DLLRES]	8	8	NA	NA	8

*Table continues on the next page...*

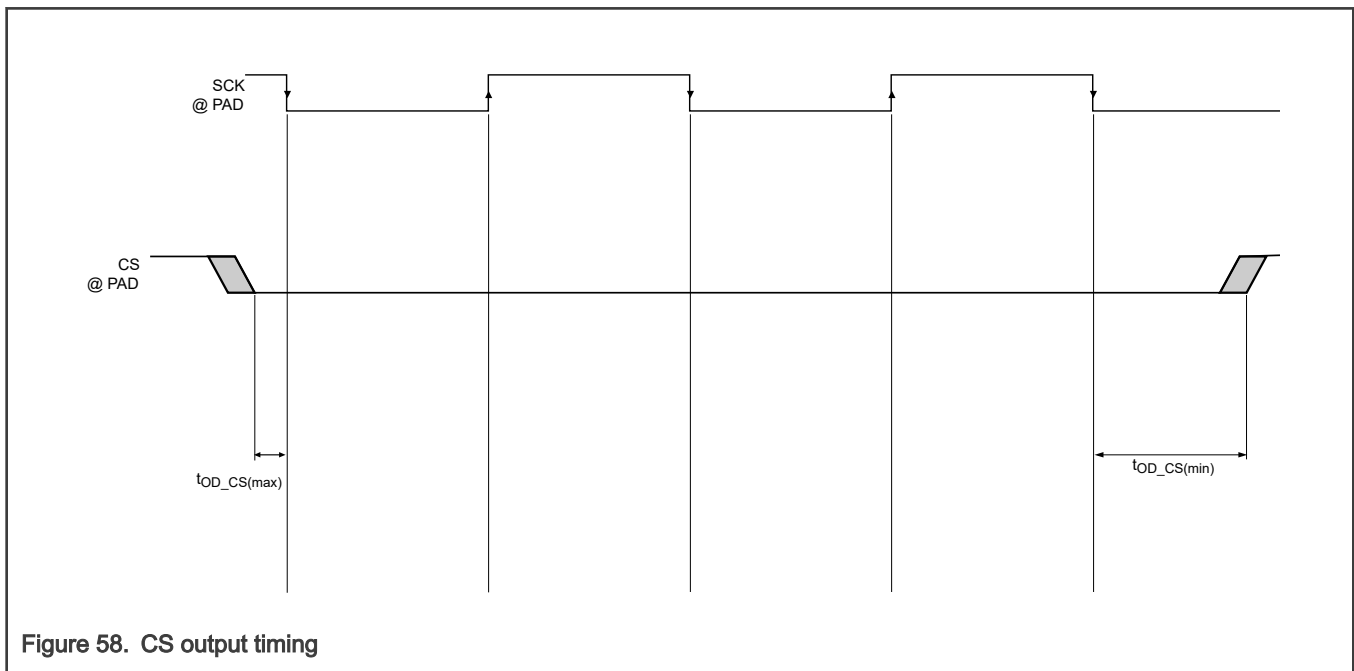


**Table 54. QuadSPI configurations (continued)**

-	DDR-200MHz	DDR-133MHz	SDR-133MHz	SDR-104MHz	DDR-66MHz
DLLCR[SLV_FINE_OFFSET]	0	0	0	0	0
DLLCR[SLV_DLY_OFFSET]	0	0	0	0	3
DLLCR[SLV_DLY_COARSE]	NA	NA	0	0	0
DLLCR[SLAVE_AUTO_UPDT]	1	1	0	0	1
DLLCR[SLV_EN]	1	1	1	1	1
DLLCR[SLV_DLL_BYPASS]	0	0	1	1	0
DLLCR[SLV_UPD]	1	1	1	1	1
SMPR[DLLFSMPF]	4	4	0	0	NA
SMPR[FSDLY]	0	0	0	0	1
SMPR[FSPHS]	NA	NA	1	1	NA

**16.4.1.14 QuadSPI timing diagrams**

The sections shows the QuadSPI timing diagrams for all modes supported by the device. All data is based on a negative edge data launch from the device.



**Figure 58. CS output timing**

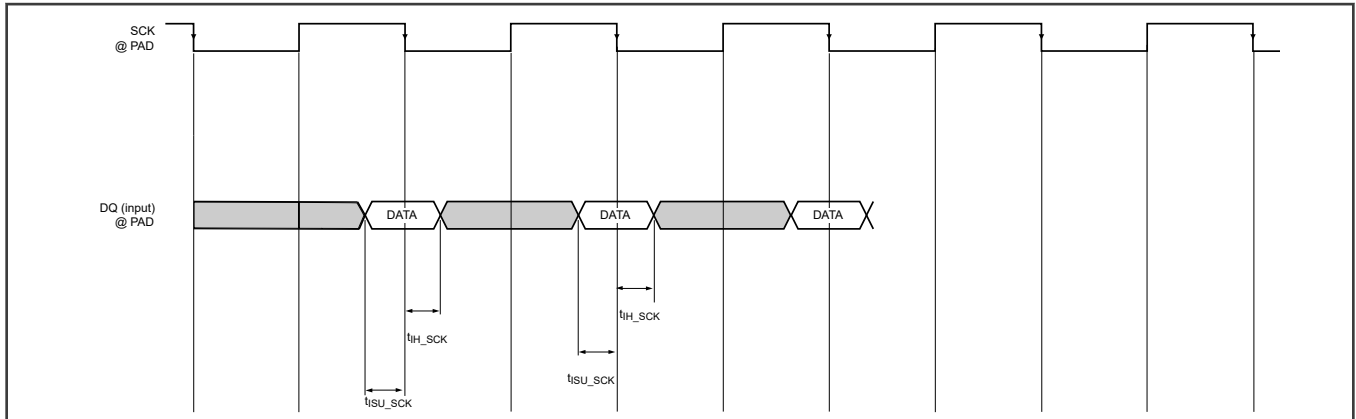


Figure 59. SDR input timing

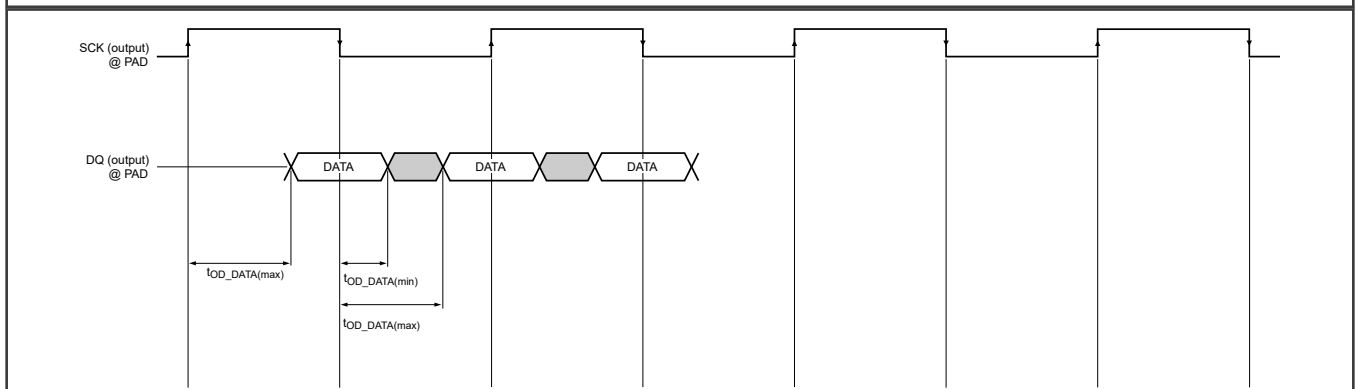


Figure 60. DDR output timing

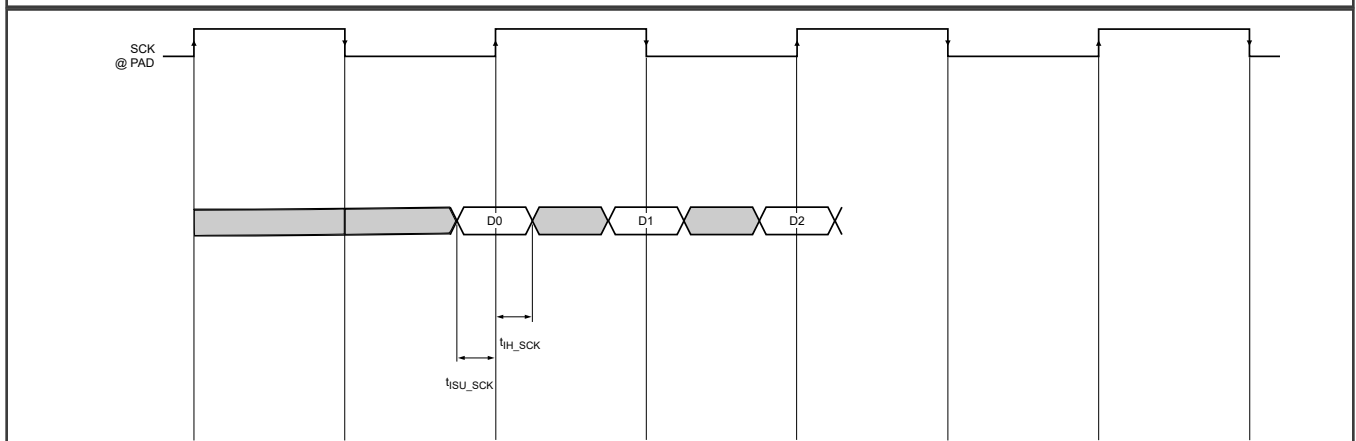


Figure 61. DDR with internal pad loopback input timing

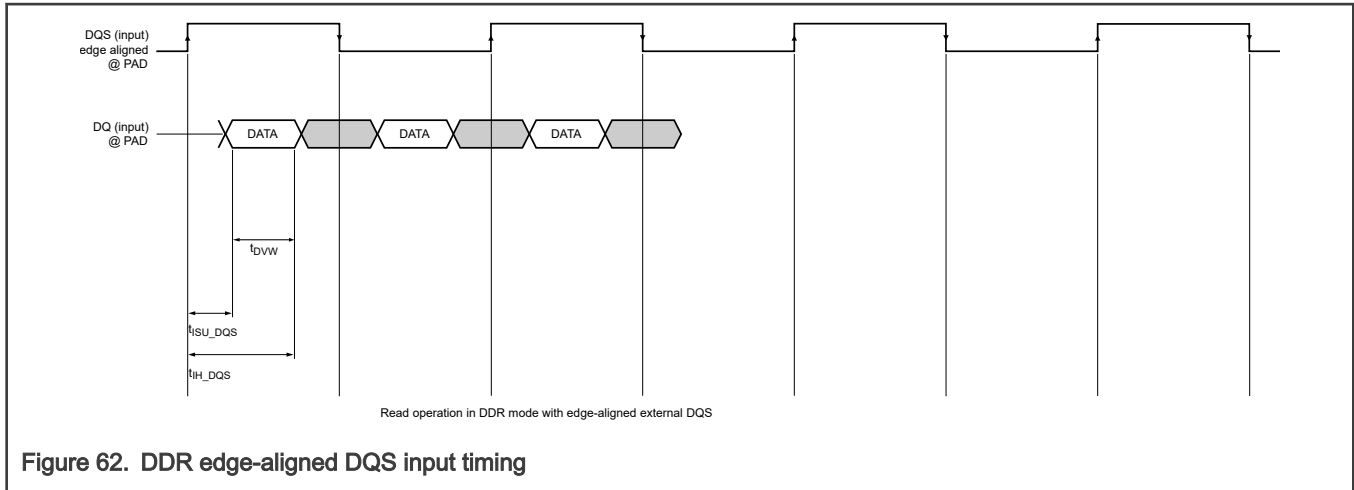


Figure 62. DDR edge-aligned DQS input timing

## 16.4.2 DDR

### 16.4.2.1 DDR

The chip supports the following memory types:

1. LPDDR4 SDRAM compliant to JEDEC209-4B LPDDR4 JEDEC standard release except row-17 support in DDR controller.
2. DDR3L SDRAM compliant to JESD79-3-1A DDR3L JEDEC standard release July, 2010.

DDR operation with the standards stated above is contingent upon the board DDR design adherence to the DDR design and layout requirements stated in the chip's Hardware Design Guide Document.

LPDDR4 routing constraints are documented in the chip's Hardware Design Guidelines Document.

### 16.4.2.2 DDR Common DC Input

The specifications given in the table below represent the common DC input conditions for all DDR interface modes. Unless otherwise specified, all input specifications (both common and DDR standard specific) are measured at the host PHY input pins. Subsequent sections list input parameters for the specific memory interface standards.

Table 55. DDR Common DC Input

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
IIZ-VREF	VREF input leakage current <sup>1</sup>	-50	—	50	uA	—	—
IIZ-BP	Input leakage current <sup>2</sup>	-50	—	50	uA	—	—
VIH-DC_BPDAT	Input high voltage threshold	VREF+0.085	—	—	V	—	—
VIL-DC_BPDAT	Input low voltage threshold	—	—	vref - 0.085	V	—	—

1. Leakage is valid for Vref over the range  $0 \leq V_{IN} \leq V_{DD\_IO\_DDR0}$ , with Vref input function enabled. All pins not under test = VDD\_IO\_DDR0.
2. Leakage current is measured when the pin is configured to a high-impedance state with all on-die termination disabled. Leakage is valid for any input except for Vref over the range:  $0 \leq V_{IN} \leq V_{DD\_IO\_DDR0}$ . All pins not under test = VSS or VDD\_IO\_DDR0.

### 16.4.2.3 DDR Common DC Output

Table 56. DDR Common DC Output

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
ROnPu	Output driver pull-up impedance: DQ, DQS outputs <sup>1</sup>	—	120,60,40	—	Ohm	—	—
ROnPd	Output driver pull-down impedance: DQ, DQS outputs <sup>1</sup>	—	120,60,40	—	Ohm	—	—
ROnPu	Output driver pull-up impedance: address, command <sup>1</sup>	—	120,60,40	—	Ohm	—	—
ROnPd	Output driver pull-down impedance: address, command <sup>1</sup>	—	120,60,40	—	Ohm	—	—
ROnPu	Output driver pull-up impedance: DDR0_RESET_B, CKE outputs <sup>2</sup>	—	18-28	—	Ohm	—	—
ROnPd	Output driver pull-down impedance: DDR0_RESET_B, CKE outputs <sup>2</sup>	—	18-28	—	Ohm	—	—

1. Calibrated at VDD\_IO\_DDR0 / 2.

2. For the DDR0\_RESET\_B pin and CKE pin, the driver is in maximum strength and impedance value is process dependent.

NOTE: Refer to IBIS model for the complete IV curve characteristics.

### 16.4.2.4 DDR3L DC Input

Table 57. DDR3L DC Input

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
Vref	Input reference voltage <sup>1,2</sup>	30.1	31.1	32.1	%VDD_I O_DDR	—	—

1. If the external Vref to the receivers is enabled, DDR0\_VREF is expected to be set to a nominal value of  $(VDD\_IO\_DDR0/2)*RxAtten$  ( $RxAtten$  for DDR3L is 0.623) through a voltage divider in order to track VDD\_IO\_DDR0 level. It can be adjusted in the system to margin the input DQ signals, although this margin does not necessarily represent the eye height since a change in Vref also changes the input receiver common mode, altering receiver performance.

2. Externally supplied Vref is not recommended. Internal Vref generation through local Vref generation at each receiver is preferred.

### 16.4.2.5 DDR3L Output Timing

Table 58. DDR3L Output Timing

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tCK(avg)	Average clock period <sup>1,2</sup>	—	1.25	—	ns	—	—
tOS(Vref)	Command and address setup time to CK (to Vref levels) <sup>1,2</sup>	350	—	—	ps	—	—
tOH(Vref)	Command and address hold time to CK (to Vref levels) <sup>1,2</sup>	350	—	—	ps	—	—
tDOeye	Output data eye <sup>1,2</sup>	0.6	—	—	UI	—	—

1. All measurements are in reference to the Vref level.
2. Measurements were done with signals terminated with a 50ohm resistor terminated to VDD\_IO\_DDR0/2, Phy output is calibrated to a drive strength of 40ohms. Slew rate AtxSlewRate was set to 0x3FF (PreDrvMode=3, PreN=F,PreP=F); TxSlewRate was set 0x3FF (PreDrvMode=3, PreN=F,PreP=F).

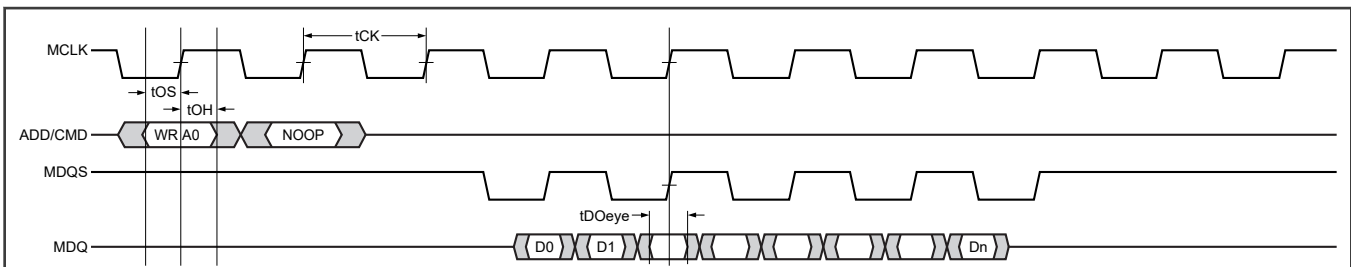


Figure 63. DDR3L Output Timing

### 16.4.2.6 LPDDR4 DC Input timing

Table 59. LPDDR4 DC Input timing

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
Vref	Internal reference voltage <sup>1,2</sup>	—	Variable	—	V	—	—

1. Because termination at the DRAMs is configurable, there is no fixed setting. The Vref value is dependent on driver impedance Ron and system effective ODT impedance Rtt.
2. Externally supplied Vref is not recommended. Internal Vref generation through local Vref generation at each receiver is preferred.

### 16.4.2.7 LPDDR4 Output Timing

Table 60. LPDDR4 Output Timing

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tCK(avg)	Average clock period <sup>1</sup>	—	0.625	—	ns	—	—
tDOeye	Output data eye <sup>1,2,3</sup>	0.55	—	—	UI	—	—
tCAOeye	CA output data eye <sup>1,4</sup>	0.62	—	—	UI	UI=625ps	—

1. Measurements were done with signals terminated with a 50ohm resistor terminated to VSS, Phy output is calibrated to a drive strength of 40ohms. Slew rate AtxSlewRate was set to 0x1FF (PreDrvMode=1, PreN=F,PreP=F); TxSlewRate was set 0x1FF (PreDrvMode=1, PreN=F, PreP=F).
2. Tx DQS to MCLK edges are trained to be aligned.
3. tDOeye is trained to be shifted min 200 ps from DQS edge (tDQS2DQ learning).
4. Addr/Cmd is centered aligned by training.

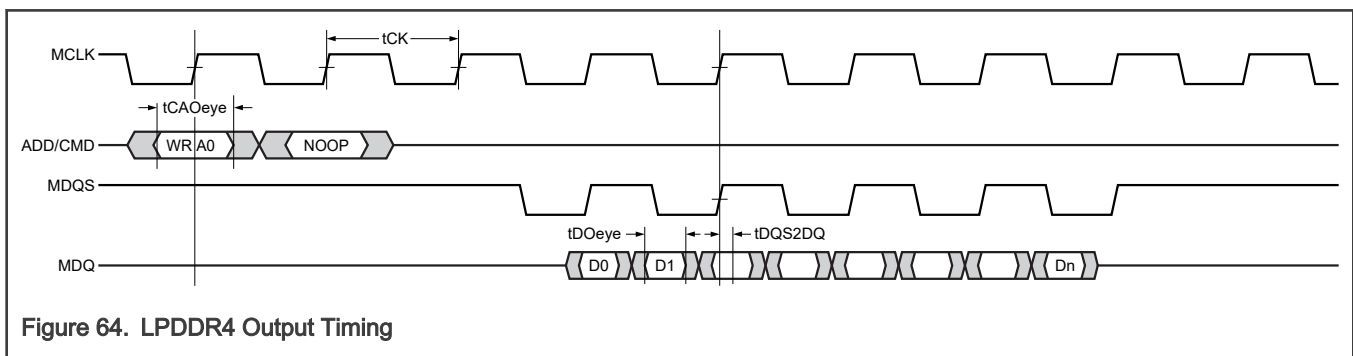


Figure 64. LPDDR4 Output Timing

### 16.4.3 uSDHC

#### 16.4.3.1 uSDHC SD3.0/eMMC5.1 DDR

The SRE[2:0]=101 is required drive setting to meet the timing.

Data transitions measured at 35%/65% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

Table 61. uSDHC SD3.0/eMMC5.1 DDR

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fpp	Clock frequency (eMMC5.1 DDR) <sup>1</sup>	—	—	52	MHz	—	SD1
fpp	Clock frequency (SD3.0 DDR) <sup>1</sup>	—	—	50	MHz	—	SD1
tWL	Clock low time	8.8	—	—	ns	—	—
tWH	Clock high time	8.8	—	—	ns	—	—
tTLH	Clock rise time <sup>1,2</sup>	—	—	0.8	ns	—	—

Table continues on the next page...

Table 61. uSDHC SD3.0/eMMC5.1 DDR (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tTHL	Clock fall time <sup>1,2</sup>	—	—	0.8	ns	—	—
tOD	SDHC output delay (output valid) <sup>1</sup>	2.7	—	5.6	ns	SDHC_CLK to SDHC_DAT	SD2
tOD	SDHC output delay (output valid) <sup>1</sup>	-5.6	—	2.6	ns	SDHC_CLK to SDHC_CMD	SD6 (See SDR-52 MHz figure)
tISU	SDHC Input setup time <sup>3</sup>	1.6	—	—	ns	SDHC_DAT to SDHC_CLK	SD3
tISU	SDHC Input setup time <sup>3</sup>	4.8	—	—	ns	SDHC_CMD to SDHC_CLK	SD7 (See SDR-52 MHz figure)
tIH	SDHC Input hold time <sup>3</sup>	1.5	—	—	ns	SDHC_CLK to SDHC_DAT	SD4
tIH	SDHC Input hold time <sup>3</sup>	1.5	—	—	ns	SDHC_CLK to SDHC_CMD	SD8 (See SDR-52 MHz figure)

1. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch), (25pF total with margin).
2. The SDHC\_CLK rise/fall time specification applies to the input clock transition required in order to meet the output delay specifications. SDHC\_CLK output transition time is dependent on output load and GPIO pad drive strength. See the GPIO pad specifications for detail.
3. Input timing assumes an input signal slew rate of 3ns (20%/80%).

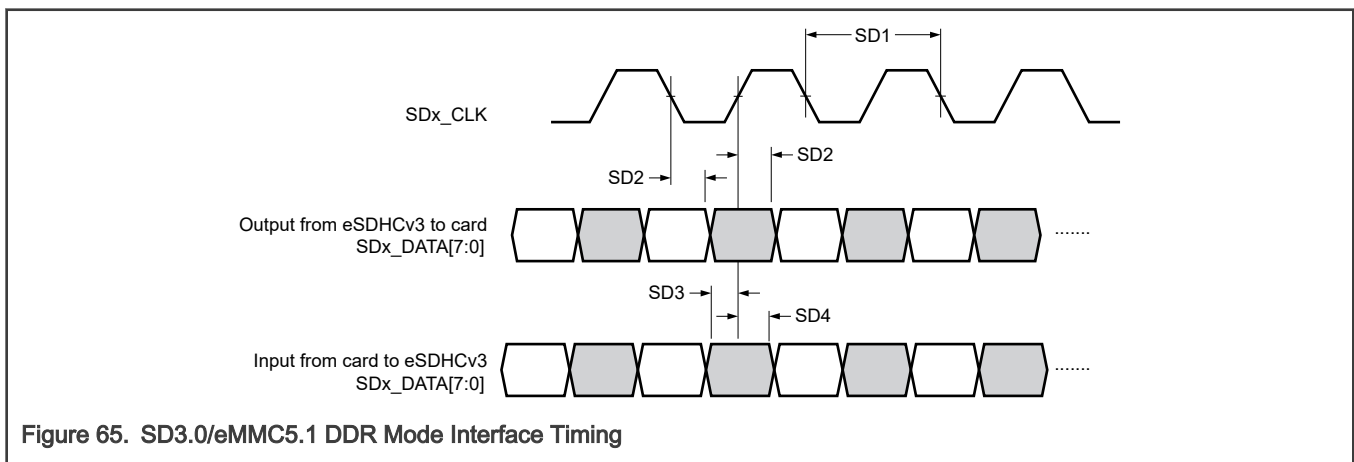


Figure 65. SD3.0/eMMC5.1 DDR Mode Interface Timing

### 16.4.3.2 uSDHC SD3.0/SDIO3.0/eMMC5.1 SDR

The SRE[2:0]=101 is required drive setting to meet the timing.

Data transitions measured at 35%/65% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

Table 62. uSDHC SD3.0/SDIO3.0/eMMC5.1 SDR

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fpp	Clock frequency (low speed) <sup>1,2</sup>	—	—	400	kHz	—	SD1
fpp	Clock frequency (SD/SDIO full speed/high speed) <sup>2,3</sup>	—	—	25/50	MHz	—	SD1
fpp	Clock frequency (eMMC full speed/high speed) <sup>2,4</sup>	—	—	20/52	MHz	—	SD1
fOD	Clock frequency (identification mode) <sup>2</sup>	100	—	400	kHz	—	SD1
tWL	Clock low time	8.8	—	—	ns	—	SD2
tWH	Clock high time	8.8	—	—	ns	—	SD3
tTLH	Clock rise time <sup>2,5</sup>	—	—	0.8	ns	—	SD4
tTHL	Clock fall time <sup>2,5</sup>	—	—	0.8	ns	—	SD5
tOD	SDHC output delay (output valid) <sup>2</sup>	-5.6	—	2.6	ns	SDHC_CLK to SDHC_CMD / SDHC_DAT	SD6
tISU	SDHC Input setup time <sup>6</sup>	4.8	—	—	ns	SDHC_CMD / SDHC_DAT to SDHC_CLK	SD7
tIH	SDHC Input hold time <sup>6</sup>	1.5	—	—	ns	SDHC_CLK to SDHC_CMD / SDHC_DAT	SD8

1. In low speed mode, card clock must be lower than 400 kHz, voltage ranges from 2.7V to 3.6V.
2. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch), (25pF total with margin).
3. 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.
4. 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.
5. The SDHC\_CLK rise/fall time specification applies to the input clock transition required in order to meet the output delay specifications. SDHC\_CLK output transition time is dependent on output load and GPIO pad drive strength. See the GPIO pad specifications for detail.
6. Input timing assumes an input signal slew rate of 3ns (20%/80%).



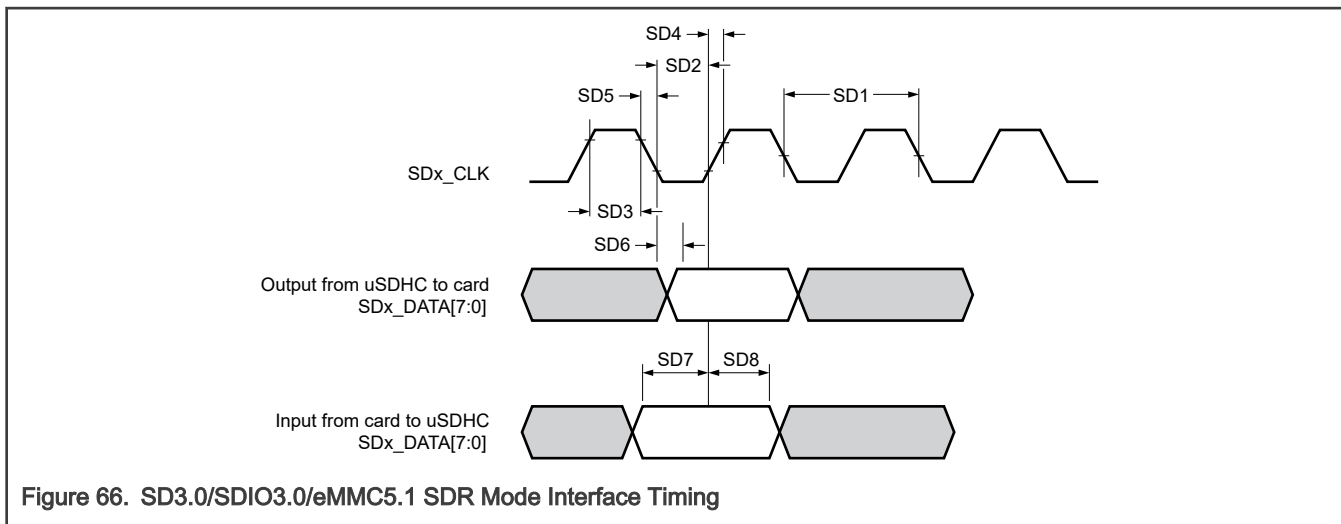


Figure 66. SD3.0/SDIO3.0/eMMC5.1 SDR Mode Interface Timing

### 16.4.3.3 uSDHC SDR-100MHz

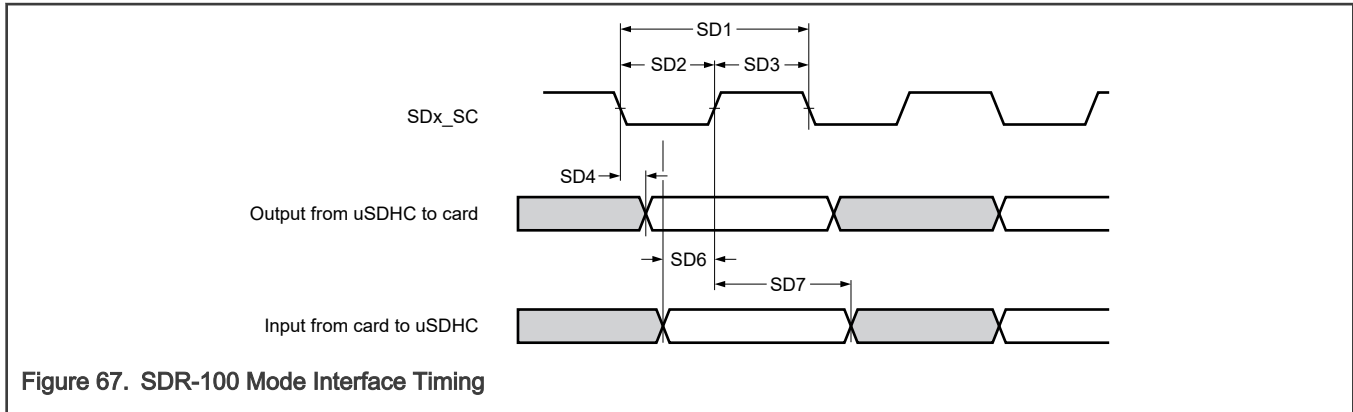
The SRE[2:0]=101 is required drive setting to meet the timing.

Data transitions measured at 35%/65% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

Table 63. uSDHC SDR-100MHz

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tCLK	Clock frequency <sup>1</sup>	—	—	100	MHz	—	SD1
tCL	Clock low time	4.5	—	—	ns	—	SD2
tCH	Clock high time	4.5	—	—	ns	—	SD3
tTLH	Clock rise time <sup>1,2</sup>	—	—	0.8	ns	—	—
tTHL	Clock fall time <sup>1,2</sup>	—	—	0.8	ns	—	—
tOD	uSDHC output delay <sup>1</sup>	-3.5	—	1.3	ns	SDHC_CLK to SDHC_CMD / SDHC_DAT	SD4
tISU	uSDHC input setup time <sup>3</sup>	1.6	—	—	ns	SDHC_CMD / SDHC_DAT to SDHC_CLK	SD6
tIH	uSDHC input hold time <sup>3</sup>	1.5	—	—	ns	SDHC_CLK to SDHC_CMD / SDHC_DAT	SD7

1. Output timing valid for maximum external load CL = 15pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance of the transmission line should be matched closely to the RDSON of the I/O pad output driver.
2. The SDHC\_CLK rise/fall time specification applies to the input clock transition required in order to meet the output delay specifications. SDHC\_CLK output transition time is dependent on output load and GPIO pad drive strength. See the GPIO pad specifications for detail.
3. Input timing assumes an input signal slew rate of 1ns (20%/80%).



### 16.4.3.4 uSDHC SDR-HS200

The SRE[2:0]=000 is required drive setting to meet the timing.

Data transitions measured at 35%/65% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

Table 64. uSDHC SDR-HS200

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tCLK	Clock frequency <sup>1</sup>	—	—	200	MHz	—	SD1
tCL	Clock low time	2.2	—	—	ns	—	SD2
tCH	Clock high time	2.2	—	—	ns	—	SD3
tTLH	Clock rise time <sup>1,2</sup>	—	—	0.8	ns	—	—
tTHL	Clock fall time <sup>1,2</sup>	—	—	0.8	ns	—	—
tOD	uSDHC output delay <sup>1</sup>	-1.2	—	0.6	ns	SDHC_CLK to SDHC_CMD / SDHC_DAT	SD4
tODW	Input data window <sup>3,4</sup>	2.6	—	—	ns	—	SD8

1. Output timing valid for maximum external load CL = 15pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 2 inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance of the transmission line should be matched closely to the RDSON of the the I/O pad output driver.
2. The SDHC\_CLK rise/fall time specification applies to the input clock transition required in order to meet the output delay specifications. SDHC\_CLK output transition time is dependent on output load and GPIO pad drive strength. See the GPIO pad specifications for detail.
3. Input timing also applicable for SDHC\_CMD also.
4. Input timing assumes an input signal slew rate of 1ns (20%/80%).

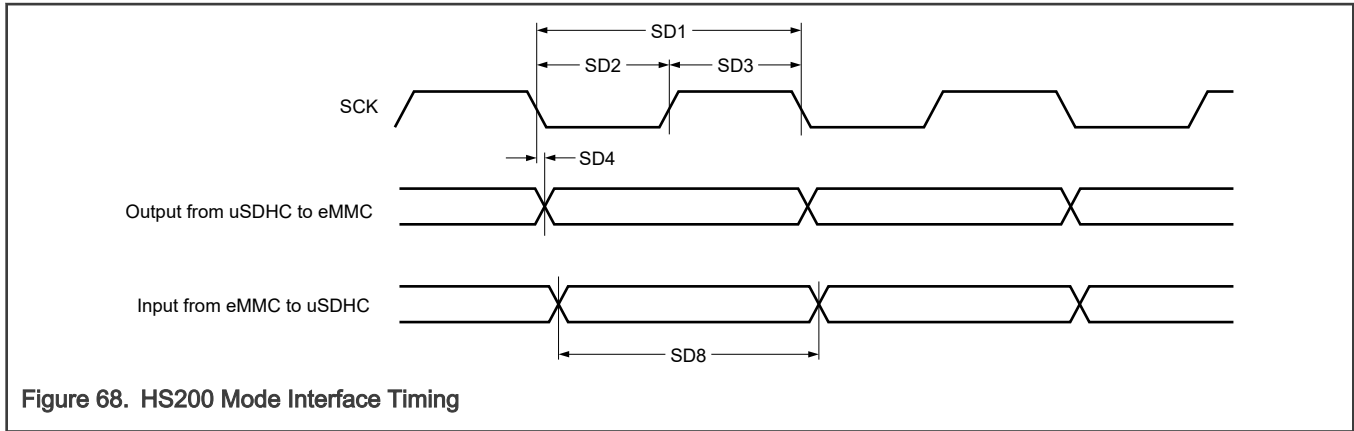


Figure 68. HS200 Mode Interface Timing

### 16.4.3.5 uSDHC DDR-HS400

The SRE[2:0]=000 for Data/CMD and SRE[2:0]=000 or SRE[2:0]=111 for CLK are the required drive settings to meet the timing.

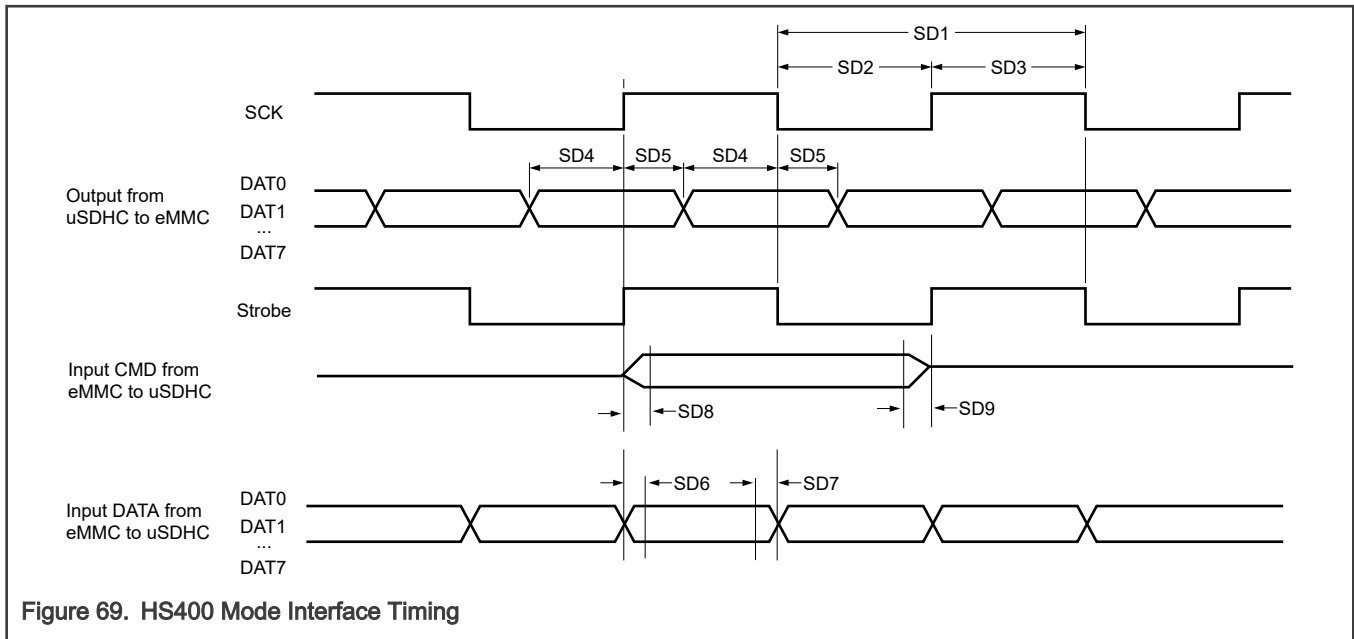
Data transitions measured at 35%/65% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid-supply.

Table 65. uSDHC DDR-HS400

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
fPP	Clock frequency <sup>1</sup>	133	—	200	MHz	—	SD1
tCL	Clock low time	2.2	—	—	ns	—	SD2
tCH	Clock high time	2.2	—	—	ns	—	SD3
tTLH	Clock rise time <sup>1,2</sup>	—	—	0.8	ns	—	—
tTHL	Clock fall time <sup>1,2</sup>	—	—	0.8	ns	—	—
tOD1	Output skew from Edge of Data to SCK <sup>1,3</sup>	0.65	—	—	ns	—	SD4
tOD2	Output skew from Edge of SCK to Data <sup>1,3</sup>	0.65	—	—	ns	—	SD5
tRQ	Input skew (data) <sup>4,5</sup>	—	—	0.45	ns	—	SD6
tRQ	Input skew (CMD) <sup>5</sup>	—	—	0.45	ns	—	SD8
tRQH	Hold skew (data) <sup>4,5</sup>	—	—	0.45	ns	—	SD7
tRQH	Hold skew (CMD) <sup>5</sup>	—	—	0.45	ns	—	SD9
tOD	uSDHC Output delay <sup>1</sup>	-1.2	—	0.6	ns	SDHC_CLK to SDHC_CMD	SD5

- Output timing valid for maximum external load CL = 15 pF, which is assumed to be a 10 pF load at the end of a 50Ohm, un-terminated, 2-inch microstrip trace on standard FR4 (1.5pF/inch). For best signal integrity, the series resistance of the transmission line should be matched closely to the RDSON of the I/O pad output driver.
- The SDHC\_CLK rise/fall time specification applies to the input clock transition required in order to meet the output delay specifications. SDHC\_CLK output transition time is dependent on output load and GPIO pad drive strength. See the GPIO pad specifications for detail.
- Board skew margin between CLK and DATA/CMD is considered as +/-50 ps in calculations

4. Spec numbers SD6 and SD7 are also applicable for the CMD input timing for HS400 mode in enhanced strobe mode. For HS400 mode without enhanced strobe, CMD input timing is the same as for HS200 mode.
5. Input timing assumes an input signal slew rate of 1ns (20%/80%).



## 16.5 Debug modules

### 16.5.1 JTAG Boundary Scan

The following table gives the JTAG specifications in boundary scan mode.

The SRE[2:0]=101 is required drive setting to meet the timing.

Table 66. JTAG Boundary Scan

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tJCYC	TCK cycle time <sup>1,2,3</sup>	100	—	—	ns	—	1
tJDC	TCK clock pulse width <sup>1,2</sup>	45	—	55	%	—	2
tTCKRISE	TCK rise/fall time <sup>1,4</sup>	—	—	3	ns	—	3
tTMSS, tTDIS	TMS, TDI data setup time <sup>1,5</sup>	5	—	—	ns	—	4
tTMSH, tTDIH	TMS, TDI data hold time <sup>1,5</sup>	5	—	—	ns	—	5
tTDOV	TCK low to TDO data valid <sup>1,6,7</sup>	—	—	17.5	ns	—	6
tTDOI	TCK low to TDO data invalid <sup>1,7</sup>	0	—	—	ns	—	7
tTDOHZ	TCK low to TDO high impedance <sup>1,7</sup>	—	—	17.5	ns	—	8

Table continues on the next page...

Table 66. JTAG Boundary Scan (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tJCMPPW	JCOMP assertion time <sup>1</sup>	100	—	—	ns	—	9
tJCMPST	JCOMP setup time to TCK high <sup>1</sup>	40	—	—	ns	—	10
tBSDV	TCK falling edge to output valid <sup>1,7,8</sup>	—	—	600	ns	—	11
tBSDVZ	TCK falling edge to output valid out of high impedance <sup>1,7</sup>	—	—	600	ns	—	12
tBSDVHZ	TCK falling edge to output high impedance <sup>1,7</sup>	—	—	600	ns	—	13
tBSDST	Boundary scan input valid to TCK rising edge <sup>1</sup>	15	—	—	ns	—	14
tBSDHT	TCK rising edge to boundary scan input invalid <sup>1</sup>	15	—	—	ns	—	15

1. These specifications apply to JTAG boundary scan mode only.
2. TCK pin must have external pull down.
3. JTAG port interface speed only. Does not apply to boundary scan timing.
4. The TCK rise/fall time specification applies to the input clock transition required in order to meet the TDO output specifications that are relative to TCK.
5. Input timing assumes an input signal slew rate of 3ns (20%/80%).
6. Timing includes TCK pad delay, clock tree delay, logic delay and TDO output pad delay.
7. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch), (25pF total with margin). For best signal integrity, the series resistance of the transmission line should be matched closely to the selected RDSON of the I/O pad output driver.
8. Applies to all pins, limited by pad slew rate. Refer to IO delay and transition specification and add 20 ns for JTAG delay.

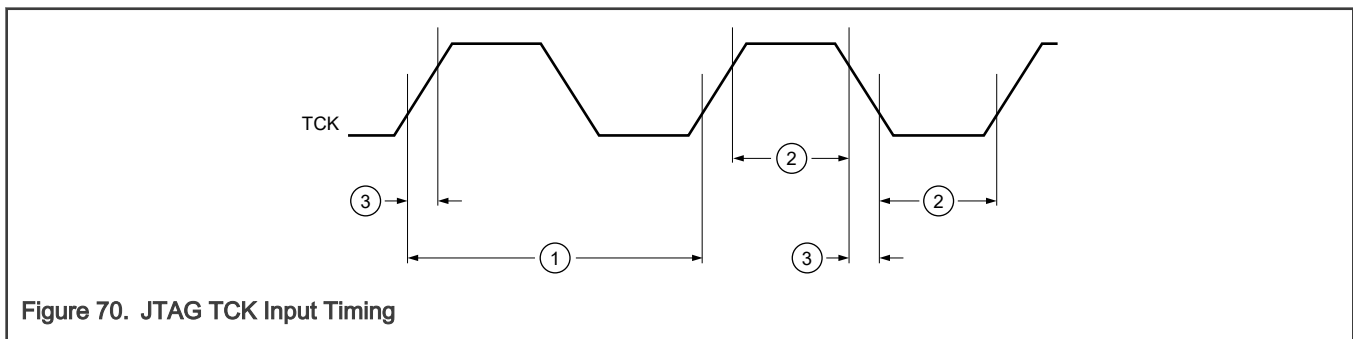


Figure 70. JTAG TCK Input Timing

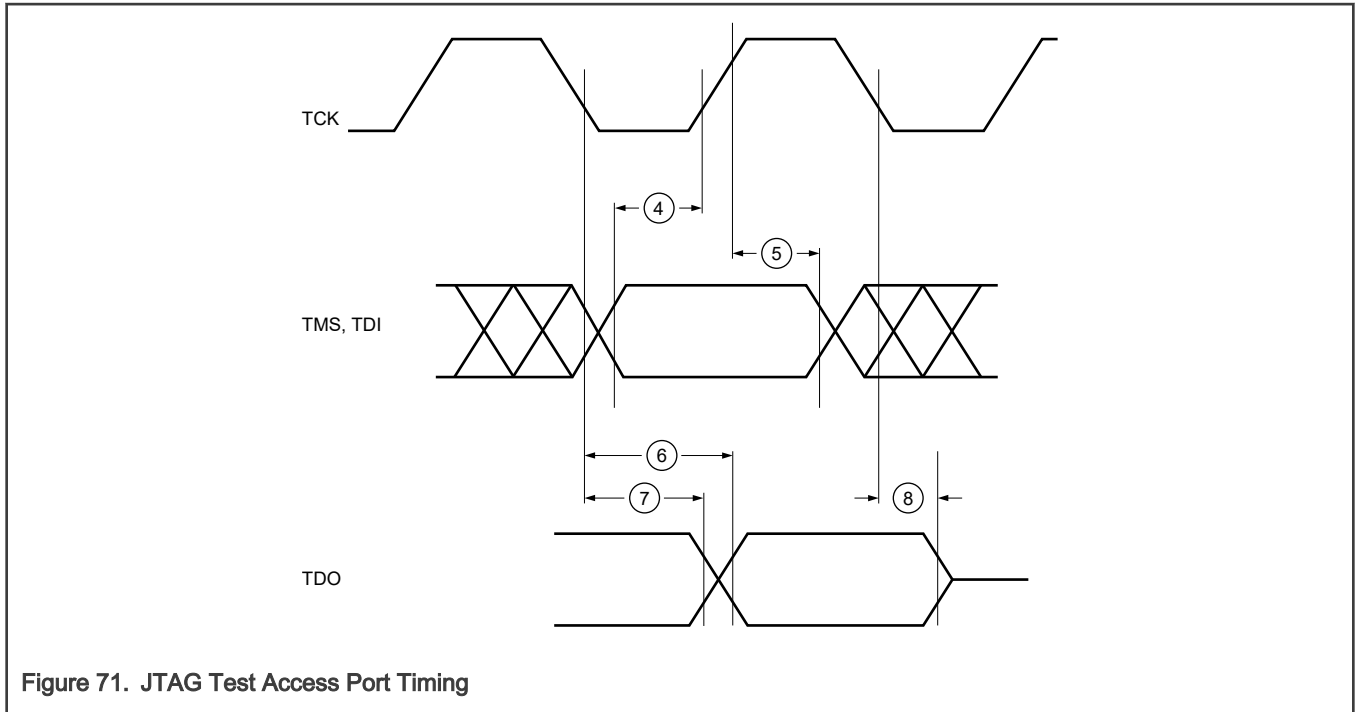


Figure 71. JTAG Test Access Port Timing

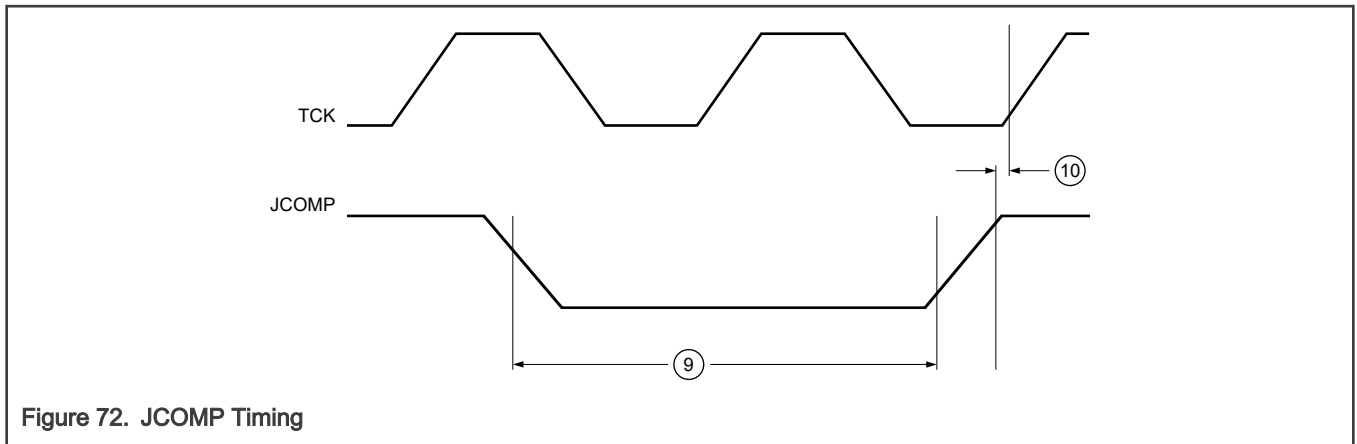


Figure 72. JCOMP Timing

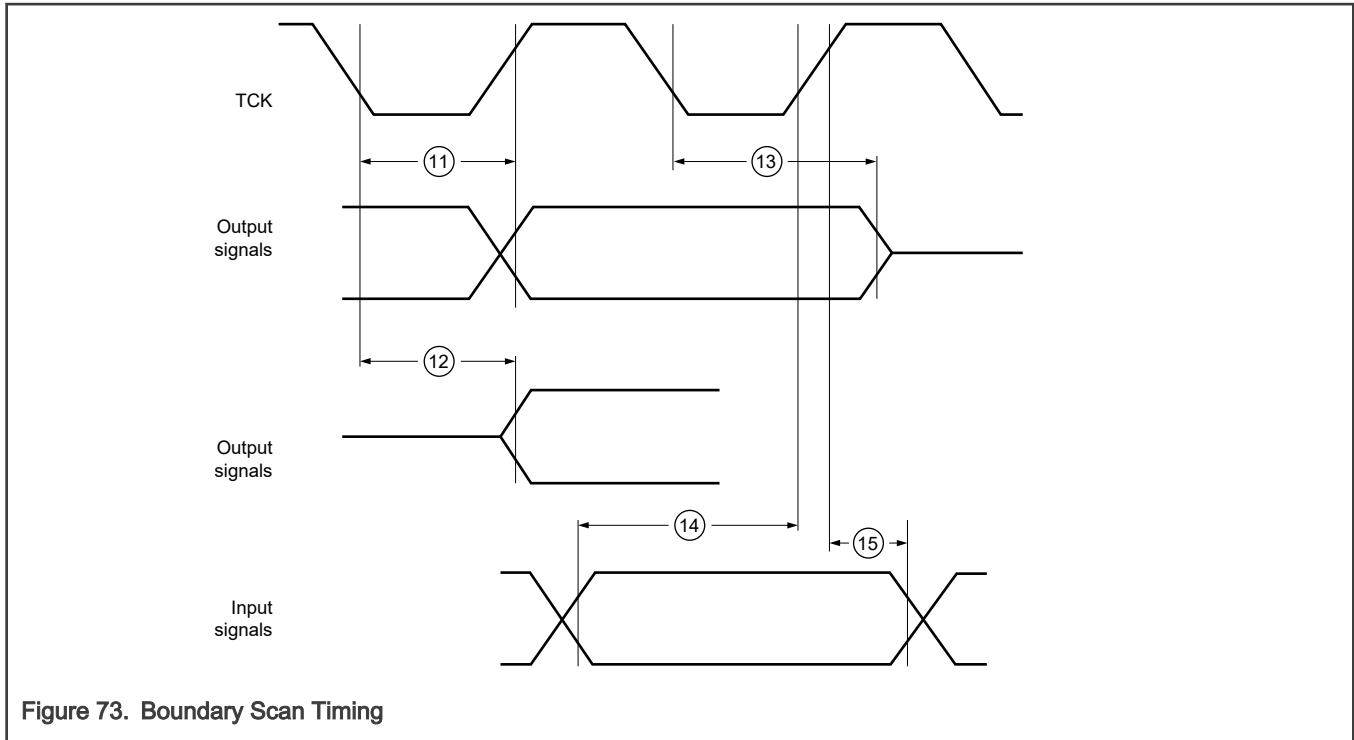


Figure 73. Boundary Scan Timing

### 16.5.2 JTAG Debug Interface Timing

The following table gives the JTAG specifications in debug interface mode.

Table 67. JTAG Debug Interface Timing

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tTCYC	Absolute minimum TCK cycle time (TDO sampled on posedge of TCK) <sup>1,2</sup>	50	—	—	ns	—	—
tTCYC	Absolute minimum TCK cycle time (TDO sampled on negedge of TCK) <sup>1,2</sup>	25	—	—	ns	—	—
tJDC	TCK clock pulse width	45	—	55	%	—	—
tNTDIS	TDI data setup time <sup>3</sup>	5	—	—	ns	—	11
tNTDIH	TDI data hold time <sup>3</sup>	5	—	—	ns	—	12
tNTMSS	TMS data setup time	5	—	—	ns	—	13
tNTMSH	TMS data hold time	5	—	—	ns	—	14

Table continues on the next page...

Table 67. JTAG Debug Interface Timing (continued)

Symbol	Description	Min	Typ	Max	Unit	Condition	Spec Number
tNTDOD	TDO propagation delay from falling edge of TCK <sup>4,5</sup>	—	—	17.5	ns	—	15
tNTDOH	TDO hold time with respect to falling edge of TCK <sup>5</sup>	1	—	—	ns	—	16
tTDOHZ	TCK low to TDO high impedance <sup>5</sup>	—	—	17.5	ns	—	—

1. Maximum frequency for TCK is limited to 6MHz during BOOTROM startup of the device, when the system clock is the trimmed 48MHz FIRC.
2. TCK pin must have external pull down.
3. Input timing assumes an input signal slew rate of 3ns (20%/80%).
4. Timing includes TCK pad delay, clock tree delay, logic delay and TDO output pad delay.
5. Output timing valid for maximum external load CL = 25pF, which is assumed to be a 10pF load at the end of a 50Ohm, un-terminated, 5 inch microstrip trace on standard FR4 (1.5pF/inch), (25pF total with margin). For best signal integrity, the series resistance of the transmission line should be matched closely to the RDSON of the I/O pad output driver.

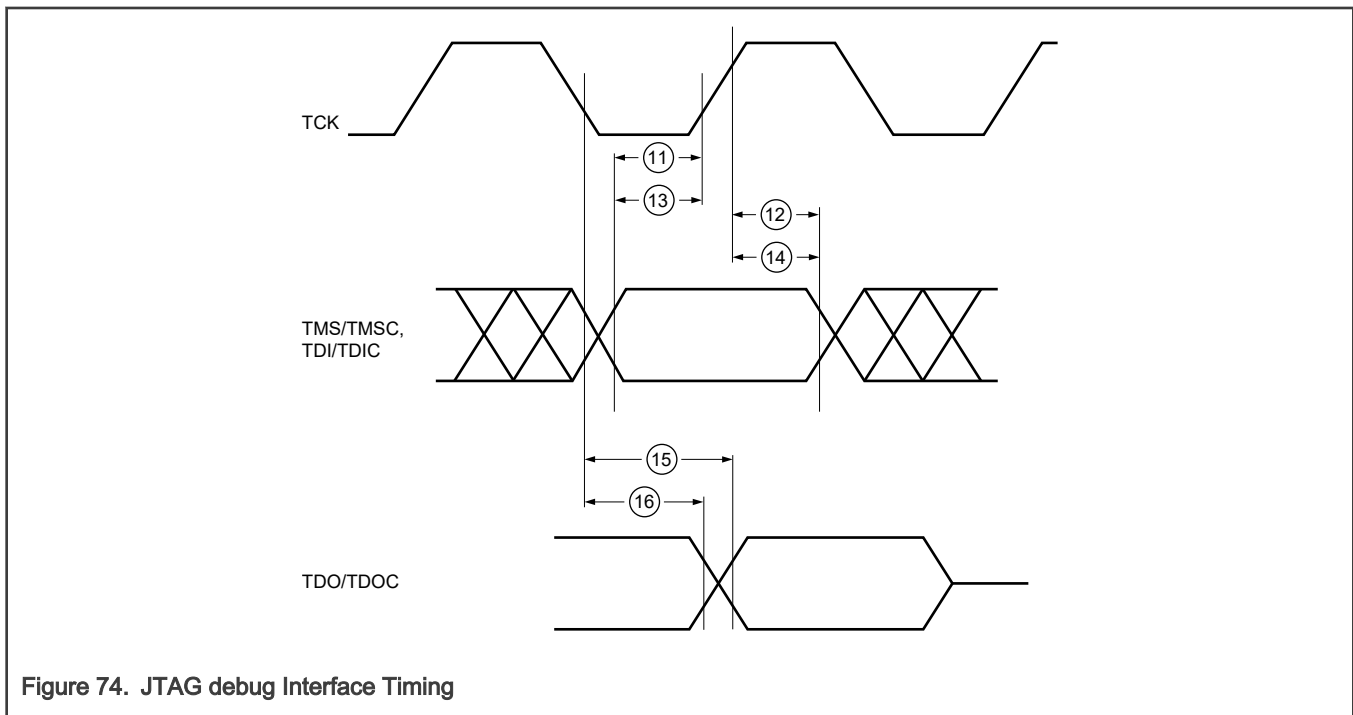


Figure 74. JTAG debug Interface Timing

## 17 Pinouts

For package pinouts and signal descriptions, refer to the Reference Manual.

## 18 Packaging

The S32G2 is offered in the following package types.



If you want the drawing for this package	Then use this document number
525-ball FCBGA	98ASA01075D

**NOTE**

To find a package drawing, go to <http://www.nxp.com> and perform a keyword search for the drawing's document number or see below figures.

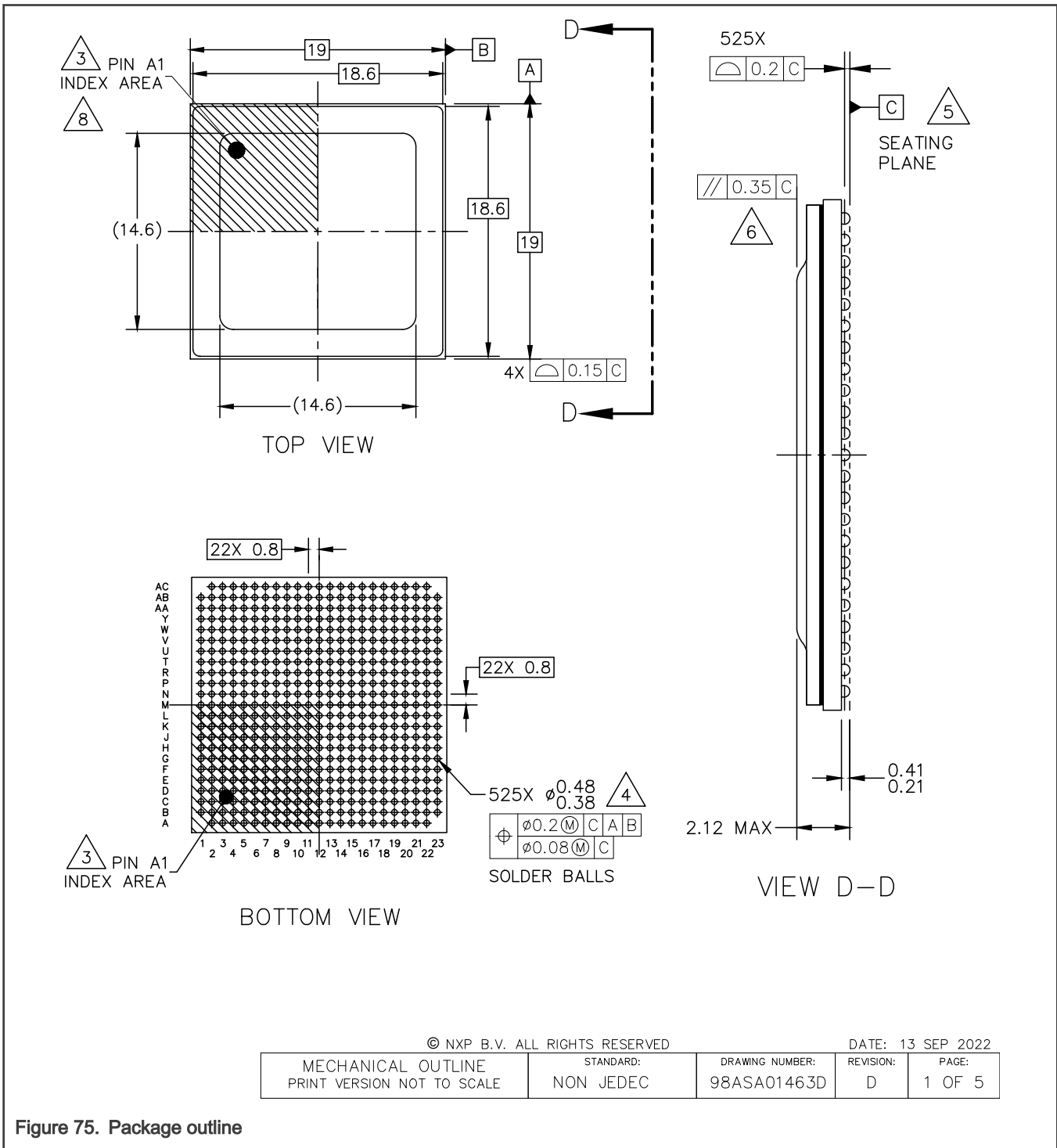
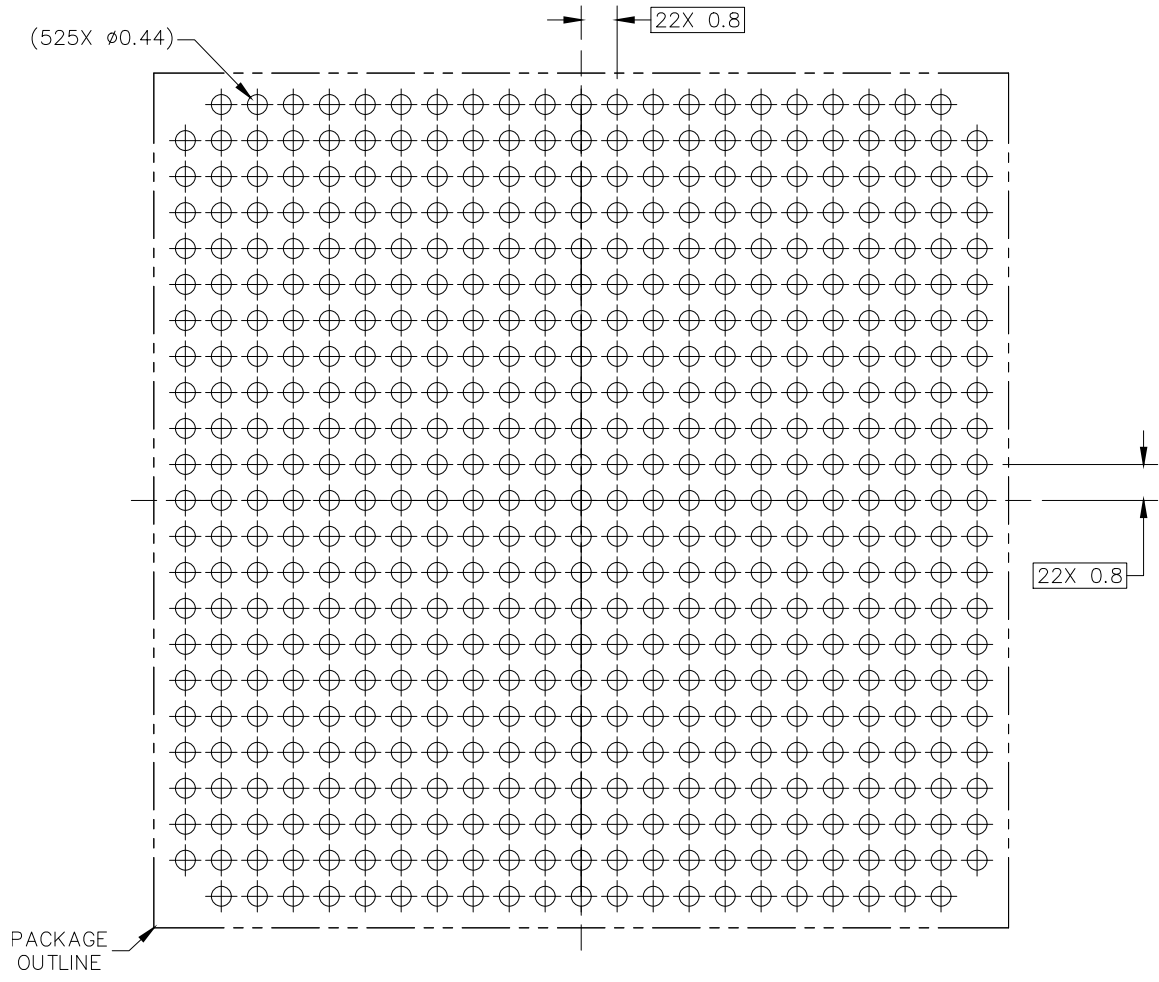


Figure 75. Package outline



PCB DESIGN GUIDELINES – SOLDER MASK OPENING PATTERN

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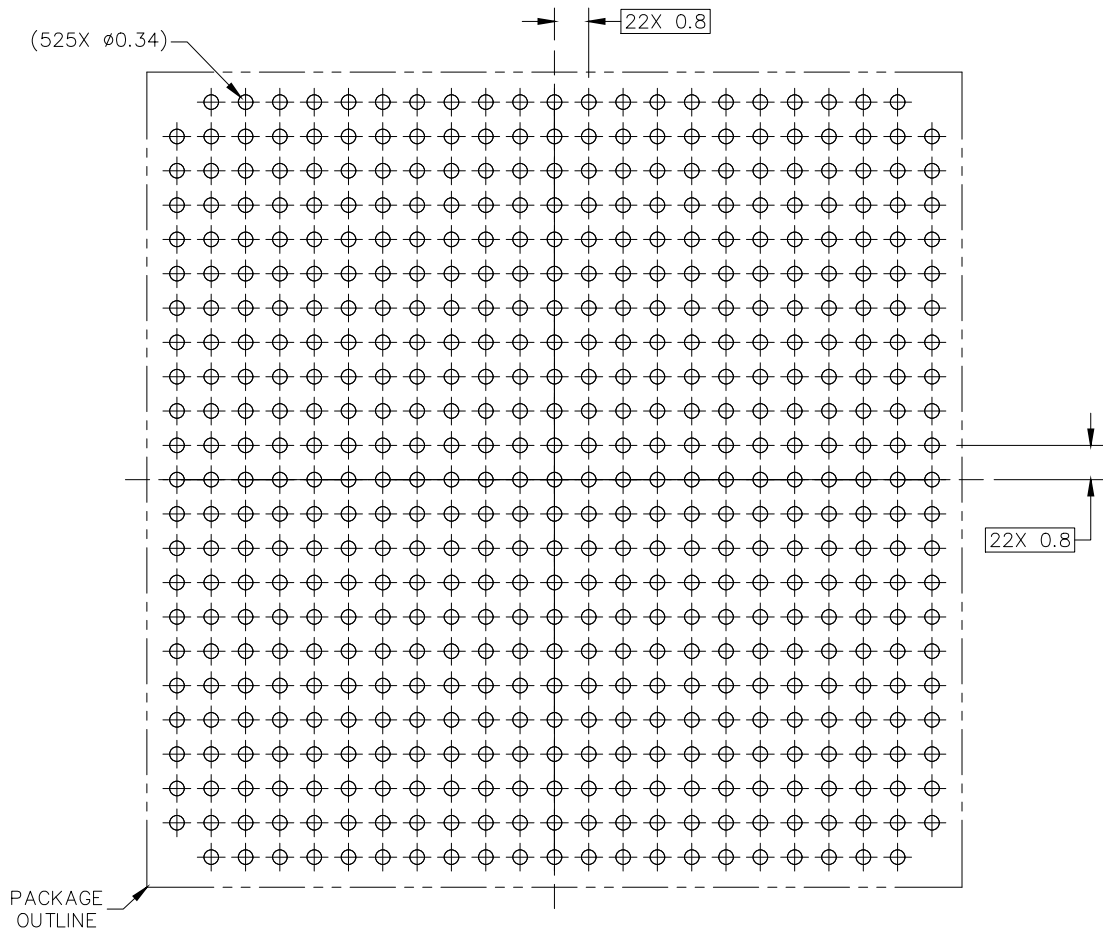
DATE: 13 SEP 2022

MECHANICAL OUTLINE PRINT VERSION NOT TO SCALE	STANDARD: NON JEDEC	DRAWING NUMBER: 98ASA01463D	REVISION: D	PAGE: 2
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Figure 76. Soldering footprint part 1 of 3

H-FC-PBGA-525 I/O  
19 X 19 X 1.97 PKG, 0.8 PITCH

SOT1655-5



PCB DESIGN GUIDELINES – I/O PADS AND SOLDERABLE AREA

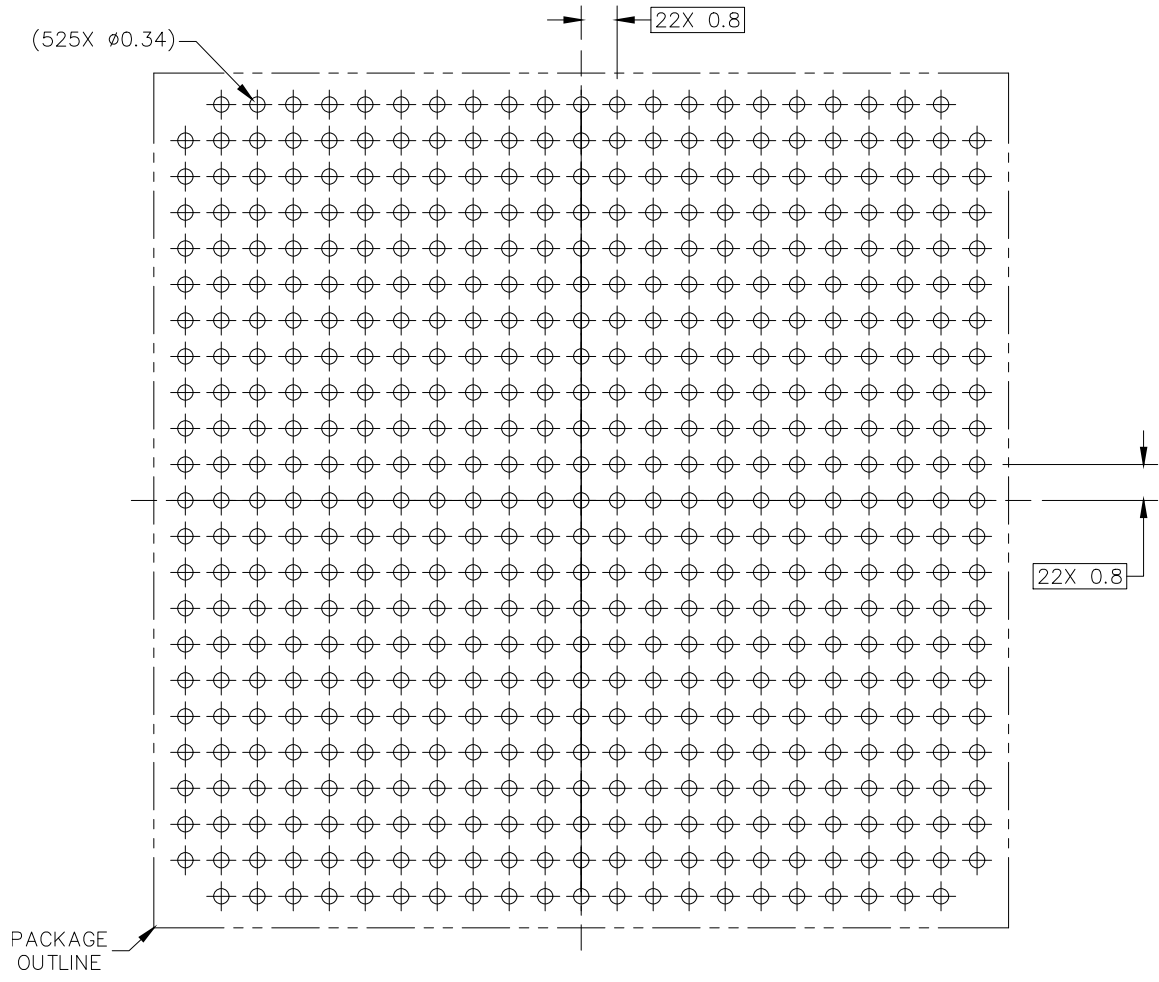
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Figure 77. Soldering footprint part 2 of 3



RECOMMENDED STENCIL THICKNESS 0.125MM

PCB DESIGN GUIDELINES – SOLDER PASTE STENCIL

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Figure 78. Soldering footprint part 3 of 3

NOTES:

1. ALL DIMENSIONS IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. PIN A1 FEATURE SHAPE, SIZE AND LOCATION MAY VARY.
4. MAXIMUM SOLDER BALL DIAMETER MEASURED PARALLEL TO DATUM C.
5. DATUM C, THE SEATING PLANE, IS DETERMINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
6. PARALLELISM MEASUREMENT SHALL EXCLUDE ANY EFFECT OF MARK ON TOP SURFACE OF PACKAGE.
7. LID OVERHANG ON SUBSTRATE NOT ALLOWED.
8. VENT AREA BETWEEN LID AND SUBSTRATE, SIZE MAY VARY.

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Figure 79. Package outline notes

## 19 Revision history

The following table lists the changes in this document.

Rev 7, September 2024
<ul style="list-style-type: none"> <li>• In section "Absolute Max Ratings" :                             <ul style="list-style-type: none"> <li>— Updated footnote "functional operation at the maxima..." to "functional operation beyond the operating condition..."</li> </ul> </li> <li>• In Operating conditions added footnote "Applies only during power up while POR_B is asserted." , "Applies to multi-voltage supplies when operating in 1.8V range." and "Applies to multi-voltage supplies when operating in 3.3V range".</li> <li>• In Clock Frequency ranges updated "max value" to 50 MHz of spec "fSDHC_CLK" with condition "SDHC_CLK-DDR/SDR 52MHz"</li> <li>• "Power-up" Table moved from Power-Up to Power-Down section.</li> <li>• In GPIO pads :                             <ul style="list-style-type: none"> <li>— Removed spec "RDSO<sub>N</sub>_33, IOH_33, TR_TF_33" with condition "SRE[2:0]=000"</li> <li>— Updated footnote "On standard FR4 with approximately 1.5pF/inch" to "3.3pF/inch".</li> </ul> </li> <li>• In SAR ADC, updated "... the external capacitance at the input pin" to "... at the input pin and reference pin..."</li> <li>• In section "DFS" removed spec "fDFS_CORE_CLK2".</li> <li>• In FXOSC, updated the condition of spec "TCST"</li> <li>• In section "PLL" :                             <ul style="list-style-type: none"> <li>— Added new footnote: "DDR PLL allows center-spread SSCG..." and "Jitter is dependent on the period of the PLL output clock, and the division ratio of the clock at the destination module".</li> </ul> </li> </ul>

*Table continues on the next page...*

**Rev 7, September 2024**

- Updated footnote to "Jitter is dependent on supply noise. Specified jitter values are valid for the FXOSC reference clock input only - not valid for FIRC reference clock input"
- Updated "System PLL" to "PLL"
- "SRE conditon" is removed from modules, and mentioned at the top of the table
- In section "I2C input" :
  - added operating speed specs with symbol "Rate"
  - added information "I2C interface supports Fast Mode with a maximum data-rate of 400kbps. Higher data rates are not supported"
- In section "I2C Output" :
  - updated the max value of "tRISE" to 300ns
  - Removed the footnote "Programming IBFD (I2C bus Frequency Divider) with the maximum frequency results in the minimum output timings listed...." and mentioned it to at the top of table.
- In section "FlexRay-RxD", removed spec "uCCLogic\_1" and "uCCLogic\_0"
- In "PCIe", updated information from "NXP completed PCI-SIG.." to "NXP internally does..."
- In LPSPI, updated "tHO" with conditon "Data hold time input" to "tHI".
- In "QuadSPI", updated information from "All transitions measured at mid-supply (VDD\_IO\_QSPI/2).." to "Data transitions measured at 30%/70% supply for the write path. Data transitions...."
- In "QuadSPI Quad 1.8V SDR 133MHz" and "QuadSPI Octal 1.8V SDR 133MHz":
  - For spec "fSCK", updated condition from DLL mode enabled to DLL Bypass Mode.
- In "QuadSPI Octal 1.8V DDR 133MHz", "QuadSPI Quad 1.8V SDR 133MHz" and "QuadSPI Octal 1.8V SDR 133MHz" :
  - Added footnote "fSCK of 133.33MHz is also acceptable"
- In section "QuadSPI Timing diagrams", updated diagrams.
- In "uSDHC" section, updated information from "All uSDHC parameters are measured at mid-supply (VDD\_IO\_SDHC/2)" to "Data transitions measured at 35%/65% supply for the write path. Data transitions measured at mid-supply for the read path. Clock transitions measured at mid..."
- In "uSDHC DDR-HS400" :
  - removed footnote "The CMD output timing for HS400 mode is the same as CMD output timing for HS200 mode.."
  - Added new specs "tOD", "trQ (input skew CMD)" and "tRQH(Hold skew CMKD)".
  - Updated min value of "tOD1" and "tOD2" to 0.65 ns.
- Updated package diagram

**Rev 6, Dec 2022**

- In "Absolute Max Ratings"
  - Added note "All specifications associated with VIN are measured at the SoC pin."
  - Added spec Max LVDS RX or TX pin injection (IINJ\_LVDS)
  - VIN specification:

**Rev 6, Dec 2022**

- updated footnote "Absolute maximum DC VIN levels for a powered...".
- Added V\_OS\_US\_10 for 1.8V and updated condition of overshoot and undershoot specifications.
- Added footnote "DC case limit. Overshoot/Undershoot beyond this range...".
- Updated figure title "SoC-pin overshoot/undershoot voltage for each GPIO pad type".
- For Overshoot/Undershoot specs updated footnote, "For AC Signals in a 3.3V supply domain, if...".
- In section "Operating Conditions"
  - Added note "All specifications associated with VIN are measured at the SoC pin."
  - Added footnoted to VIN\_18 and VIN\_33 "DC case limit. Overshoot/Undershoot beyond this range...".
  - IINJ\_D is split into powered and unpowered and related footnotes added."
- In section "Device Power and Operating Current Specifications", for PVDD\_STBY in condition corrected a typographic figure from VDD=0.8V, to VDD\_STBY = 0.8V.
- "Power sequencing" section is renamed as "Power-up" and added Power-down section.
- In section "Aurora PLL" added footnote to fPLL\_CLKIN as "40MHz is the only internal input reference..".
- In section "Reset Duration" added a paragraph as "The durations specified "Reset Duration" table and the corresponding figures...." and added below three figures:
  - Reset\_b pad detailed behavior during core supply brownout
  - Reset\_b pad detailed behavior during pad HV supply brownout
  - Reset\_b pad detailed behavior during power down
- Below figure "RESET\_B pad detailed behavior", added information as "he RESET\_B pad behavior described in the diagram and the related VRSE\_RESET\_B parameter spec also apply to the case of core VDD droop after power-up."
- In section "SIRC", PTA description changed from "SIRC Post Trim Accuracy" to "SIRC trimming resolution" and "SIRC Frequency Variation" condition updated to "Frequency variation across voltage and temperature range".
- In section "FXOSC" added sentence "In ALC disable mode the minimum crystal drive level should be greater than 500uW".
- In section "I2C" PER\_CLK changed to MODULE\_CLK.
- Added section "CAN".
- In QuadSPI sections, removed DQS and added condition as "fSCK duty cycle distortion is in the range of 45%-55%."
- In uSDHC:
  - Changed title from "uSDHC DDR-52MHz" to "uSDHC SD3.0/eMMC5.1 DDR" and from "uSDHC SDR-52MHz" to "uSDHC SD3.0/SDIO3.0/eMMC5.1 SDR" and other figure name updates.
  - In uSDHC added phrase as "All uSDHC parameters are measured at mid-supply (VDD\_IO\_SDHC/2)."
  - In "SDR-100 Mode Interface Timing" figure deleted SD5 and SD8.
  - In section "uSDHC SDR-HS200" added footnote to tODW as "Input timing also applicable for SDHC\_CMD also."
  - In "uSDHC DDR-HS400" added footnote to tRQ and tRQH as "Spec numbers SD6 and SD7 are also applicable for the CMD input timing for HS400 mode...".
  - Deleted some redundant figures.

**Rev 5, May 2022**

- In section "Feature comparison" :
  - In memory modules, for symbol "Fuses" description "8kB banks" has been updated to "2 banks at 4k Bits each".
  - Added a footnote to Fuses "The first 4k Bits is assigned exclusively to the HSE....not free for the other user purposes".
- In section "Absolute Max ratings":
  - Updated below footnotes attached to VIN:
    - Absolute maximum VIN levels for a powered device....
    - Absolute minimum VIN level for a powered device is....
  - In a footnote attached to "IINJ\_A" updated part of it as "...VREFH\_ADC/VREFL\_ADC at -40 Tj..." to "...VREFH\_ADC/VREFL\_ADC at max Tj...."
  - Added footnote to overshoot specifications as "If VDD\_IO  $\leq$  3.3V, max VIN overshoot is limited to...."
- In section "Operating Conditions":
  - For symbol, "VDD\_IO\_DDR0", typ value updated to 1.1V.
  - For symbol, " $\delta$ VDD\_IO\_DDR0", description updated from "DDR I/O supply ripple voltage" to "DDR3L I/O supply ripple voltage" and removed DDR3L from the condition.
  - Updated below footnotes attached to VIN\_18 and VIN\_33:
    - From: "Additional +0.3V are supported for DC signal." to "For AC signals, allowed max VIN  $\leq$  VDD\_IO\* for lifetime operation. If AC....".
    - From: "Absolute minimum level for VIN signal is -0.3V." to "The min DC VIN level for a powered device is -0.3V. If AC....".
  - Footnote attached to frequency specs updated to correct the modulation depth used in formula. Changed "...plus the modulation depth (max 1.5%) ..." to "...plus half the modulation depth...".
  - For VDD\_EFUSE specs, updated related footnote to add "See device hardware design guidelines document for more details."
  - Footnote attached to VRAMP\_LV is updated "On slow ramps, the RESET\_B pin may be observed to be asserted..."
- In section "Total power specifications for 0.8V and 1.8V Analog Domains" :
  - Added a sentence "All 0.8v supplies at 0.8V/1.8V" in description of all the rows as applicable to supplies.
  - Removed note "On a device with DIE\_PROCESS[1:0]....The MAX and THERMAL specs will be unchanged" and attached it as footnote to all 0.8V supplies
- In section "Device Power and Operating Current Specifications" for symbol "PVDD\_IO\_PCIEn" (Powered down state), Max value changed from 1.4 to 1.5 mW.
- In section "Device Power and Operating Current Specifications" for symbol "PVDD\_IO\_PCIEn" with condition "All circuits enabled, VDD\_IO\_PCIEn=1.8V, Gen3 8Gbps, 2 lanes. Per IP instance", added footnote "This specification can be considered a worst case maximum..."
- In section "GPIO Pads", added symbols "VOL" and "VOH" and added a footnote attached to these symbols "For current at this voltage see IOL/IOH specs respectively".
- Removed a note "VOH/VOL values should be calculated based on the provided RDSON, IOH/IOL values and IBIS models".
- In figure "1.8V/3.3V GPIO pad detailed behavior during power up", updated "weak pull-down" to "weak pull-down as per ILKG\_3318 specification".



**Rev 5, May 2022**

- Under the figure "1.8V/3.3V GPIO pad detailed behavior during power up", removed the paragraph "The weak pull-down is 100 Kohm and is separate from the usual selectable 12Kohm internal pull resistor...."
- In section "DFS", for symbol "fDFS\_PER\_CLK2" Max value updated from 960 to 628 Mhz.
- In section "PLL" :
  - Added symbol "fPLL\_DDR\_PHI0" with description "DDR PLL PHI0 Frequency" and min, max value 758 Mhz and condition DDR\_CLK (3032MT/s).
  - Footnote "PLL refers to the Core, Peripheral, Accelerator, and DDR reference PLLs on the device" moved to the top of table.
  - The formula for calculating the max frequency is updated in the related footnote "The max frequency in case of center-spread SSCG enabled for a modulation....".
  - Footnote "Spread spectrum clock modulation is only available on the Core, Accelerator and DDR reference PLLs" moved as a sentence to the top of the table.
- In PCIe specifications external reference clock pins related specs are added.
- In section "GMAC and PFE SGMII", For symbol UI the description updated to "Unit interval (mean)".
- Added sentence "All transitions measured at mid-supply (VDD\_IO\_QSPI/2)" and removed sentence "Clock measurements done with respect to VDD\_IO\_QSPI/2 level " from all QuadSPI modes.
- Removed symbol "tDVW" from the following sections :
  - "QuadSPI Quad 1.8V SDR 133MHz"
  - "QuadSPI Octal 1.8V DDR 100MHz"
  - "QuadSPI Octal 1.8V DDR 133MHz"
  - "QuadSPI Octal 1.8V DDR 166MHz"
  - "QuadSPI Octal 1.8V DDR 200MHz"
  - "QuadSPI Octal 1.8V SDR 100MHz"
  - "QuadSPI Octal 1.8V SDR 133MHz"
  - "QuadSPI Quad 3.3V SDR 104MHz"
- Added introduction sentence "The information in this section applies to Octal- and Hyperflash" in following sections :
  - QuadSPI Octal 1.8V DDR 100MHz
  - QuadSPI Octal 1.8V DDR 133MHz
  - QuadSPI Octal 1.8V DDR 166MHz
- In section "QuadSPI configurations", added introduction "The below table shows a subset of the QuadSPI module configurations for different speeds and data rate....".
- In section "DDR", updated the sentence to "LPDDR4 SDRAM compliant to JEDEC209-4B....except row-17 support in DDR controller."
- In section "DDR Common DC Output", for symbol "ROnPu" and "ROnPd", in description CLK changed to CKE outputs and footnote attached to them updated as "For the DDR0\_RESET\_B pin and CKE pin...."
- Added section "DDR3L DC Input Timing".
- Section name changed from "LPDDR4 DC Input" to "LPDDR4 DC Input Timing" and from "LPDDR4 Output" to "LPDDR4 Output Timing".
- Section "uSDHC DDR-HS400" updated thoroughly.

**Rev 5, May 2022**

- In section "JTAG Boundary Scan" "SRE[2:0]= 101" is moved to the top as a sentence.

**Rev 4, Nov 2021**

- In section "Applications", updated first paragraph "Combining ASIL D safety....".
- In section "Feature comparison" updated "SerDes subsystem with PCIe" for S32G234M to mention PCIe\_0 only and updated "SerDes subsystem lanes" to 4 configurable for PCIe or SGMII for all parts.
- In section "operating conditions" a note added " $\Delta$ VDD\* specifications are applicable to the supplies....".
- In section "Operating Conditions", clarified SVS usage in footnotes and added same footnote to VDD\_STBY as "SVS guidelines apply to all LV supplies on the device..".
- In section "Operating Conditions", Symbol "VDD\_IO\_STBY" footnote updated as "A minimum of 2.91V is supported...." and removed the condition and added it to "VDD\_IO\_B" as well.
- In section "operating conditions" for symbol "VDD\_STBY" removed a footnote "A minimum of 2.91V is supported ...".
- In section "Operating conditions", added a footnote to clarify voltage differential "The "voltage differential" refers to the difference between the lowest and highest voltages...".
- In section "operating conditions" for symbol " $\Delta$ VDD\_HV\_18\_ANA" added footnotes to clarify VDD\_EFUSE supply conditions and added another footnote to say "VREFH\_ADCn has a differential voltage of +/-100mV..".
- In section "operating conditions" removed " $\Delta$ VDD\_IO\_DDR" differential as this has a lone supply in its condition.
- In section "Clock frequency ranges", Symbol "fFTM\_1\_EXT\_CLK" changed to "fFTM\_1\_REF\_CLK".
- In section "Clock frequency ranges", Symbol "fFTM\_0\_EXT\_CLK" changed to "fFTM\_0\_REF\_CLK".
- In section "Thermal Characteristics", updated leading sentence and:
  - Updated "Junction to Lid Top Thermal Resistance", value changed from "0.1" to "1.1"
  - Added "Junction to Case Thermal Resistance"
- In section "Total power specifications for 0.8V and 1.8V Analog Domains" clarified SVS in a note "On a device with DIE\_PROCESS[1:0] = 01b...".
- In section "power sequencing" extended note "For step 4, it is acceptable for the 1.8V ..." to add "VDD\_IO\_QSPI (a 1.8V GPIO supply) has the additional option to ramp with step 3 instead of step 4."
- In section "PMIC Standby Mode Entry / Exit Protocol", updated sentence to "This implies that the PMIC\_VDD\_OK input is asserted and deasserted together with the POR\_B input during non-Standby modes. Deasserting PMIC\_VDD\_OK during non-Standby modes while not also asserting POR\_B will cause the SoC to start a power-on reset sequence."
- In section "SAR ADC", two generic footnotes are moved to top of the table.
- In section "SAR ADC", fig with title "SAR ADC Input Circuit" is updated to mention supply name as VREFH\_ADC.
- In section "DFS", formula is moved from footnote to sentence with some clarifications.
- In section "FXOSC", added support of NX3225GA crystal at 40 MHz.
- In section "FXOSC", added phrase "Duty cycle of FXOSC..."
- In section "FXOSC", updated footnote 1 and removed a non-applicable footnote from fXTAL.
- In section "FXOSC", added VCM\_SE spec and removed references to Vref.
- In section "FXOSC" removed "Please see the device reference manual for the correct setting per the crystal type" as the setting is provided in datasheet also just below it.

**Rev 4, Nov 2021**

- In section "PLL", removed  $\Delta f_{PLL\_MOD}$  spec and all specs "with center-spread enabled" in condition column. Added a footnote to specs which have "without center-spread enabled" in the condition column as "The max frequency in case of center-spread SSCG...".
- In section "PLL" added footnote to  $f_{PLL\_CORE\_VCO}$ ,  $f_{PLL\_ACCEL\_VCO}$  and  $f_{PLL\_DDR\_VCO}$  as "Same min frequency value applies for center-spread...".
- In section "SPI", for Symbol "tSUI" with condition "Master, MTFE=1, CPHA=0, SMPL\_PTR = 1" footnote added as "N is number of protocol clock cycles whe..."
- In section "FlexRay - TxD", a missing spec is added "dCCTxD10".
- In section "GMAC and PFE SGMII", for Symbol "UI" clarified data rate in condition column
- In all QuadSPI modes, moved footnote "Clock measurements done with respect to VDD\_IO\_QSPI/2 level." to top of the table.
- In section "QuadSPI Octal 1.8V DDR 166MHz", removed conflicting/wrong information about TCSS and TCSH from footnote 4.
- In section "DDR Common DC Input", deleted footnotes 3 and 4.

**Rev 3, Apr 2021**

- In section "Absolute Max Ratings", Symbol "IINJ\_A" clarified footnote "Non-disturb of ADC channels during current injection...." for -40 Tj.
- In section "Operating conditions", added a footnote to clarify voltage differential "The "voltage differential" refers to the difference between the lowest and highest voltages...".
- In section "Total power specifications for 0.8V and 1.8V Analog Domains", for S32G254A Thermal Usecase is updated to 4.22 W to correct a typography error as it was in previous versions.
- In section "Power Sequencing", figure "1.8V supply timing with respect to PMIC\_VDD\_OK during Standby Mode Exit" is updated to mention correct supply name "PMIC\_VDD\_OK".
- In section "DFS",  $f_{DFS\_CORE\_CLK3}$  is deleted as this is used for BIST.
- In section "PLL",  $f_{PLL\_PER\_PHI6}$  is deleted as this is used for BIST.
- In section "PLL", updated this note " $f_{PLL\_DDR\_PHI0}$  frequencies and data rate mentioned in this table are for LPDDR4. DDR3L frequencies and data rates are half of the LPDDR4."
- In all QuadSPI sections added phrase "FLSHCR[TCSS] and FLSHCR[TCSH] should be set to 3" and moved the information to top of the table to be consistent with "QuadSPI configurations" section.
- In section "QuadSPI interfaces"
  - Added 100 MHz to "1.8V Quad" column.
  - Added support for Hyperflash.
- In section "QuadSPI Configurations"
  - Frequency row updated to include 100 MHz
  - A reserved bit is deleted.
- In section "DDR Common DC Input", updated the description of "IIZ-BP" specification to make it applicable to all DDR pins.
- In section "DDR3L Output Timing", updated the footnote to mention slew rate.

**Rev 3, Apr 2021**

- In section "DDR3L Output Timing" and "LPDDR4 Output", updated figures to remove symbols not in the corresponding tables.

**Rev 2.1, Apr 2021**

- In section "Operating Conditions", for Symbol "VDD\_IO\_STBY" condition updated to "Min 2.91V supported in low-power standby mode".
- In section "Operating Conditions", for Symbol "VDD\_STBY" and "VDD\_IO\_STBY" footnote updated to replace 3.0V to 2.91V, "A minimum of 2.91V is supported on the VDD\_IO\_STBY supply ....".

**Rev 2, Apr 2021**

- Updated section "Applications", "block diagram", "feature comparison" and ordering information figure.
- In section "Absolute Max Ratings", Symbol "VDD\_LV\_PLL\_DDR" is deleted as this redundant.
- In section "Absolute Max Ratings", Symbol "VDD\_DDR0" updated condition.
- In section "Absolute Max Ratings", added specification "VDD\_HV\_PLL\_DDR0".
- In section "Absolute Max Ratings", specification "VXTAL" and "EXTAL" is added.
- In section "Absolute Max Ratings", specification "VAD\_INPUT" is added.
- In section "Absolute Max Ratings", for Symbol "VIN" footnotes updated.
- In section "Absolute Max Ratings", for Symbol "IINJ\_D" added a footnote "IINJ\_D specifications are per pin for an...".
- In section "Absolute Max Ratings", for Symbol "IINJ\_A" Min changed from "-2" to "-1".
- In section "Absolute Max Ratings", for Symbol "IINJ\_A" Max changed from "2" to "1".
- In section "Absolute Max Ratings", for Symbol "IINJ\_A" footnote updated "Non-disturb of adjacent ADC channels dur..." and added footnote "Allowed for a cumulative duration of 50 hours operation...".
- In section "Absolute Max Ratings", added overshoot/undershoot voltage specs and related figure.
- In section "Absolute Max Ratings", footnotes updated to change min voltage for reliability.
  - Allowed 1.92V - 2.16V for 60 seconds cumulative over lifetime....
  - Allowed 3.52V - 4.0V for 60 seconds cumulative over lifetime....
- In section "Operating Conditions", for Symbol "fSYS\_A53" footnote updated "The stated maximum operating frequency m..." top remove down spread reference.
- In section "Operating Conditions", specification "Ta" is added.
- In section "Operating Conditions", DDR4 removed and DDR3L added.
- In section "Operating Conditions", Symbol "VDD\_HV\_PLL\_DDR" is updated to "VDD\_HV\_PLL\_DDR0".
- In section "Operating Conditions", Symbol "δVDD\_HV\_PLL\_DDR" is updated to "δVDD\_HV\_PLL\_DDR0".
- In section "Operating conditions", for specification "VIN\_18" min updated to "VSS - 0.3" and max updated to "VDD\_IO\* +0.3"
- In section "Operating conditions", for specification "VIN\_33" min updated to "VSS - 0.3" and max updated to "VDD\_IO\* +0.3"
- In section "Operating Conditions", updated paragraph "The device hardware design guide summarizes..."
- In section "Operating conditions", for specification "VIN\_33" and "VIN\_18" added these two footnotes:

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- Absolute minimum level for VIN signal is -0.3V.
- Additional +0.3V are supported for DC signal.
- In section "Operating Conditions", for Symbol "VRAMP\_LV" with condition "Applies to 0.8V supplies" Max changed from "10" to "24".
- In section "Operating Conditions", Symbol "VRAMP\_HV" is splitted into two rows:
  - For 1.8V supplies and DDR I/O supplies Max changed from "10" to "24".
  - For 3.3V I/O supplies Max changed from "10" to "50"..
- In section "Operating Conditions", for Symbol "IINJ\_D" deleted footnote "GPIO electrical specifications and AC timing interface..." and added footnote "IINJ\_D specifications are per pin for an unpowered condition...".
- In section "Operating Conditions", for Symbol "IINJ\_A" Min changed from "-1mA" to "-20uA".
- In section "Operating Conditions", for Symbol "IINJ\_A" Max changed from "1mA" to "20uA".
- In section "Operating Conditions", for Symbol "IINJ\_A" updated footnote "The SAR ADC electrical specifications are..." and deleted footnote "The specified injection current is allowed...".
- In section "Clock frequency ranges", Symbol "fSDHC\_CLK" condition updated from "SDHC\_CLK - DDR HS200" to "SDHC\_CLK - SDR HS200".
- In section "Clock frequency ranges", for Symbol "fSDHC\_CLK" with condition "SDHC\_CLK - DDR HS400" Min value changed to "133".
- In section "Clock frequency ranges", for Symbol "fSDHC\_CLK" with condition "SDHC\_CLK - DDR HS400" Max changed from "400" to "200".
- In section "Thermal Characteristics" JESD51-9, 2s2p value updated to 15.5 C/W.
- In Section "Device Power and Operating Current Specifications" PVDD\_STBY typ updated to 48 and PVDD\_IO\_STBY typ updated to 120 uW. This causes total typical power consumption in standby to drop from 174uW to 168uW".
- Section "Device Power and Operating Current Specifications" is updated thourghly.
- Section "Total current specifications" is renamed as "Total power specifications for 0.8V and 1.8V Analog Domains" and the updates are:
  - Added paragraph "The following table contains ...."
  - Updated condition of 0.8V supply rails to adde VDD\_STBY
  - Updated condition of 1.8V supply rails to delete VDD\_EFUSE (Read)
  - Updated footnote "Thermal usecase: This is provided...."
  - Added footnote "Note that during Self Test execution, the power consumption...".
- Added section "Static power specifications for I/O Domains".
- In section "Power Sequencing", updated paragraph "The following sequence has been validated by NXP ....".
- In section "Power Sequencing", updated sequence to power 3.3V supplies first.
- In section "Power Sequencing", for Symbol "Vpwrdown" footnotes deleted.
- In section "Power Sequencing" added note "It is acceptable for the 1.8V supplies to not yet be within..." and added a figure "1.8V supply timing with respect to PMIC\_VDD\_OK during Standby Mode Exit".
- In section "GPIO Pads", paragraph updated "The high-impedance state level is shown based ....".
- In section "GPIO Pads", for Symbol "VIH" with condition "1.8V / 3.3V" Max value deleted.

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- In section "GPIO Pads", for Symbol "VIL" with condition "1.8V / 3.3V" Min value deleted.
- In section "GPIO Pads", for Symbol "FMAX\_18" with condition "SRE[2:0] = 101" Max changed from "100" to "133".
- In section "GPIO Pads", for Symbol "FMAX\_18" with condition "SRE[2:0] = 110" Max changed from "50" to "100".
- In section "GPIO Pads", for Symbol "FMAX\_18" with condition "SRE[2:0] = 111" Max changed from "1" to "50".
- In section "GPIO Pads", for Symbol "FMAX\_33" with condition "SRE[2:0] = 110" Max changed from "20" to "50".
- In section "GPIO Pads", fig with title "Reference Load Diagram" is updated.
- In section "GPIO Pads", fig with title "1.8V/3.3V GPIO pad detailed behavior during power up" is updated.
- In section "GPIO Pads", fig with title "1.8V and 3.3V GPIO pad detailed behavior during power up" is updated.
- In section "Aurora Pads", for Symbol "VSLEW\_AURORA" with condition "max fAURORA" Min value deleted.
- In section "Aurora Pads", for Symbol "IDD\_HV\_AUR" with condition "max fAURORA per active transmit lane" max updated from "30" to "31".
- In section "Reset and Standby related pad electrical characteristics", fig with title "RESET\_B pad detailed behavior" is updated.
- In section "PMIC Standby Mode Entry / Exit Protocol" added reference to "Power sequencing" section to look for exceptions.
- In section "SAR ADC", for Symbol "VAD\_INPUT" footnote added "The reduced limits for VAD\_INPUT in this...".
- In section "SAR ADC", Symbol "IAD\_LKG" with condition "TJ = 125C, Shared channel, channel OFF" is deleted.
- In section "SAR ADC", Symbol "IAD\_LKG" condition updated, changed "channel OFF" to "channel selection switch open"
- In section "SAR ADC", Symbol "IAD\_LKG" added footnote "The maximum and minimum leakage current...".
- In section "SAR ADC", for multiple Symbol footnote updated "This specification is taken with averagi...".
- In section "Temperature Monitoring Unit (TMU)", redundant paragraph removed "For High/Low temperature immediate threshold ....."
- In section "FXOSC", updated crystal name to add suffix "GA".
- In section "FXOSC" removed reference to "Contact NXP semiconductors...".
- In section "FXOSC" added paragraph "RGMII specifications require clock source to have tolerance of +/- 50ppm. When using this mode, the crystal selected for system clock (FXOSC) should adhere to this specification."
- In section "PLL", Symbol "fPLL\_DDR\_PHI0" min values added and a note added as "fPLL\_DDR\_PHI0 frequencies mentioned in this table....".
- In section "PLL", Symbol "fPLL\_MOD" with condition "SSCG enabled, down spread" is deleted.
- In section "PLL", Symbol "PER\_jitter" updated footnote to remove reference tom RM for jitter formula.
- In section "LPSPi", for Symbol "tLEAD" with condition "Master" Min changed from "tSPSCK - 2.5" to "tSPSCK - 3.5".
- In section "PCIe", Symbol "EQTX-COEFF-RES" with condition "8.0GT/s" is deleted.
- GMAC sections are remamed as GMAC and PFE as these are applicable to PFE aslo. Differences are noted in notes and footnotes.
- In section "GMAC and PFE RGMII", for Symbol "TskewT" footnote changed from "For all versions of RGMII prior to 2.0; ..." to "For all versions prior to RGMII v2.0 spec..."
- In section "GMAC and PFE Management Interface", for symbol "MDIO\_DOI" updated min to "-0.45".

**Rev 2, Apr 2021**

- In section "QuadSPI Octal 1.8V DDR 100MHz" updated "tCL\_SCK\_DQS" and "tCH\_SCK\_DQS" symbols.
- In section "QuadSPI Quad 1.8V SDR 133MHz" added missing specs "tCL\_SCK\_DQS" and "tCH\_SCK\_DQS".
- In all QuadSPI section:
  - Moved SRE to the top of the table in form of paragraph.
  - For Symbol "tOD\_CS" min is update as "existing data - n/fSCK" and max updated as "existing data - m/fSCK" and added related footnote "Where m=TCSS and n=TCSH-1. Both...".
  - For Symbol "tCL\_SCK" and "tCH\_SCK" added a footnote "Clock measurements done with respect to VDD\_IO\_QSPI/2 level".
  - Footnote updated to mention maximum "Input timing assumes an maximum input...".
- In section "QuadSPI configurations" updated header of the table.
- In section "DDR", removed references to DDR4 and added DDR3L standards.
- In section "DDR Common DC Input", for Symbol "IIZ-BP" Min changed from "10" to "-50".
- In section "DDR Common DC Output", for Symbol "ROnPu" from description removed "CLK outputs" from row 3 and row 4 and added them to description of row 5 and row 6.
- Deleted section "DDR Common Input", "DDR4 DC Input" and "DDR4 Output"
- Added section "DDR3L Output Timing".
- In section "LPDDR4 DC Input", deleted a figure "Equation for Vref Footnote" and related reference.
- In section "LPDDR4 Output", Symbol "tCAOeye" min updated to 0.62 and added condition as "UI=625ps".
- In all sections of "uSDHC", added SRE to the top of table.
- In section "uSDHC DDR-52MHz", added dedicated specifications for SDHC\_CMD" and updated footnotes accordingly.
- In section "uSDHC SDR-100MHz", updated tISU min 1.6ns.
- In section "uSDHC DDR-HS400", updated tISU min -0.15ns.
- In section "uSDHC DDR-HS400", for Symbol "tPP" Min changed from "200" to "133".
- In section "uSDHC DDR-HS400", figures updated.
- In section "JTAG Boundary Scan", for Symbol "tJCYC" footnote added as "TCK pin must have external pull down."
- In section "JTAG Boundary Scan", for Symbol "tJCYC" and "tJDC" footnote added as "TCK pin must have external pull down."
- In section "JTAG Debug Interface Timing", for Symbol "tJCYC" footnote added as "TCK pin must have external pull down."

**Rev 2 Draft E, Nov 2020**

- In section "Total current specifications", for S32G254A power the max is updated to 4.37 W and thermal is updated to 4.22 W.

**Rev 2 Draft D, Nov 2020**

- Added information on the first page as DDR3L is supported and DDR4 is not.
- Block diagram updated.

**Rev 2 Draft D, Nov 2020**

- Updated “feature comparison”
- Updated “Ordering information” figure.
- In “Operating conditions” for LPDDR4 I/O voltage supply updated min value to 1.06 V.
- Unsupported modes removed from “Clock frequency ranges”.
- In DC electricals added specifications for “PVDD\_IO\_AUR” and removed “IDD\_HV\_AUR\_LKG”.
- “Power sequencing” updated.
- Added a note in “Aurora pads” as “Direct 100 ohm board termination not allowed ...”
- In section “Reset and Standby related pad electrical characteristics” updated WF\_RESET\_B max value from 20 to 17 ns.
- In section “DFS” added minimum frequencies for fDFS\_CORE\_CLK1/2/2/3 and fDFS\_PER\_CLK2/5.
- In section “FIRC” for PTA spec updated footnote starting from “fVAR defines how much the output frequency...”
- In section “FXOSC” updated a footnote for CS\_XTAL that it does not include miller capacitance and removed ALC enable mode from EXTAL\_AMP spec.
- In section “PCIe” updated a note containing term “TX\_VBOOST\_LVL = 5” to “TX\_VBOOST\_LVL = 4”
- In “QuadSPI” updated SRE as:
  - b000 for 166 and 200 MHz
  - b110 for other modes.
  - Added section “QuadSPI configurations”

**Rev 2 Draft C, Sept 2020**

- Updated “should be equal to” to “should be matched closely to” in respect of transmission line resistance throughout the document.
- S32G274A is replaced with S32G2 throughout the document.
- Revised section “Overview”
- In the “Feature comparison” table:
  - Revised the PCI express (PCIe) and SERDES rows for S32G234M.
  - Number of STM updated to 8.
  - PLL updated to 5.
  - For package added phrase “525 FC-PBGA”
- In section “Absolute Max Ratings”, for Symbol “VDD\_LV\_PLL” footnote added “VDD\_LV\_PLL must be connected to VDD...”
- In section “Operating Conditions”, for Symbol “VIN\_33” and “VIN\_18” Typ value deleted.
- In section “Operating Conditions”, removed references to Fast/Typical silicon, updated with DIE\_PROCESS and updated missing values.
- In section “clock frequency ranges”, removed some unused rows.
- Revised section “Device Power and Operating Current Specifications”.
- Added section “Total current specifications”.



**Rev 2 Draft C, Sept 2020**

- From section "GPIO Pads", moved ISLEW\_POR\_B and ISLEW\_RESET\_B to a new section "Reset and Standby related pad electrical characteristics".
- In section "GPIO Pads", added paragraphs "The weak pull-down is ...." and "The ramp-up state level ..."
- In section "GPIO Pads", updated figures.
- In section "GPIO Pads",
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 110, 80% \* VDD\_IO\_\*\*" Min changed from "-27.7" to "-32"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 110, 80% \* VDD\_IO\_\*\*" Max changed from "-9.5" to "-10"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 000, 20% \* VDD\_IO\_\*\*" Min changed from "13.3" to "15"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 000, 20% \* VDD\_IO\_\*\*" Max changed from "34.0" to "40"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 101, 20% \* VDD\_IO\_\*\*" Min changed from "12.0" to "13"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 101, 20% \* VDD\_IO\_\*\*" Max changed from "31.4" to "36"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 100, 20% \* VDD\_IO\_\*\*" Min changed from "13.3" to "15"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 100, 20% \* VDD\_IO\_\*\*" Max changed from "34.0" to "40"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 000, 50% \* VDD\_IO\_\*\*" Min changed from "20.0" to "18.0"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 000, 50% \* VDD\_IO\_\*\*" Max changed from "45.0" to "43.0"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 101, 50% \* VDD\_IO\_\*\*" Min changed from "22.0" to "21.0"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 101, 50% \* VDD\_IO\_\*\*" Max changed from "51.5" to "50.0"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 000, 80% \* VDD\_IO\_\*\*" Min changed from "-33.7" to "-40"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 000, 80% \* VDD\_IO\_\*\*" Max changed from "-13" to "-14"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 100, 50% \* VDD\_IO\_\*\*" Min changed from "20.0" to "19.0"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 100, 50% \* VDD\_IO\_\*\*" Max changed from "45.0" to "44.0"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 111, 80% \* VDD\_IO\_\*\*" Min changed from "-27.7" to "-32"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 111, 80% \* VDD\_IO\_\*\*" Max changed from "-9.5" to "-10"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 110, 50% \* VDD\_IO\_\*\*" Min changed from "25.0" to "23.0"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 110, 50% \* VDD\_IO\_\*\*" Max changed from "61.5" to "61.0"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 101, 80% \* VDD\_IO\_\*\*" Min changed from "-31.0" to "-35"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 101, 80% \* VDD\_IO\_\*\*" Max changed from "-11" to "-10"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 100, 80% \* VDD\_IO\_\*\*" Min changed from "-33.7" to "-40"
  - for Symbol "IOH\_3318" with condition "SRE[2:0] = 100, 80% \* VDD\_IO\_\*\*" Max changed from "-13" to "-14"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 111, 20% \* VDD\_IO\_\*\*" Min changed from "10.0" to "11"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 111, 20% \* VDD\_IO\_\*\*" Max changed from "27.7" to "32"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 110, 20% \* VDD\_IO\_\*\*" Min changed from "10.5" to "12"
  - for Symbol "IOL\_3318" with condition "SRE[2:0] = 110, 20% \* VDD\_IO\_\*\*" Max changed from "28.6" to "33"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 111, 50% \* VDD\_IO\_\*\*" Min changed from "26.5" to "26.0"
  - for Symbol "RDSON\_3318" with condition "SRE[2:0] = 111, 50% \* VDD\_IO\_\*\*" Max changed from "61.5" to "61.0"
- Removed section "LVDS pads" as the receiver specs are already part of Aurora pads.

**Rev 2 Draft C, Sept 2020**

- In section "Aurora Pads", for Symbol "IDD\_HV\_AUR" Max changed from "28" to "30".
- In section "Aurora Pads", for Symbol "VOH\_AURORA" with condition "100 termination at receiver end" Min changed from " $VDD\_IO\_AUR/2 + 0.2$ " to " $VDD\_IO/2 + 0.2$ ".
- In section "Aurora Pads", for Symbol "VOL\_AURORA" with condition "100 termination at receiver end" Max changed from " $VDD\_IO\_AUR/2 - 0.2$ " to " $VDD\_IO/2 - 0.2$ " and a added footnote "VDD\_IO maps to corresponding supply...".
- In section "Aurora port timing", added JD spec for between 3.0Gbps to 5.0Gbp with 0.25 OUI.
- Added section "Reset and Standby related pad electrical characteristics" and its subsection "PMIC Standby Mode Entry / Exit Protocol".
- In section "SAR ADC", for Symbol "DNL" with condition "after calibration" footnote added "This specification is taken with averaging."
- In section "FIRC", PTA specification and related footnote deleted.
- In section "FXOSC", added specs for EXTAL\_AMP, LT\_Jitter.
- In section "FXOSC", paragraph updated "In crystal mode NX5032 crystal ..."
- In section "PLL", for Symbol "fPLL\_MOD" Max changed from "32" to "64".
- In section "LPSPi", fig with title "LPSPi Slave Mode Timing (CPHA=1)" and "LPSPi Slave Mode Timing (CPHA=0)" is updated.
- In Flexray section, removed references to 1.8V/3.3V GPIO and related SRE.
- In section "PCIe", for Symbol "VTX-DE-RATIO-6dB" with condition "5.0GT/s" Min changed from "5.5" to "5" and Max changed from "6.5" to "7"
- In section "PCIe", for Symbol "UI" with condition "5.0GT/s" Min changed from "199.4" to "199.94"
- In section "PCIe", for Symbol "VTX-DE-RATIO-3.5dB" with condition "2.5GT/s, 5.0GT/s" Min changed from "3" to "2.5" and Max changed from "4" to "4.5".
- In section "GMAC Management Interface" , fig with title "MDC / MDIO Timing" is changed
- In section "GMAC Management Interface", for Symbol "MDIO\_DOI" and "MDIO\_DOV" description updated to mention falling edge.
- In section "GMAC RGMII", SRE updated to b100.
- In section "QuadSPI", added paragraph as "An external resistor is needed to pull up a QuadSPI chip select signal."
- In section "DDR" added information on related JEDEC standards and other information.
- In section "DDR4 Output" and "LPDDR4 Output", for Symbol "tCK(avg)" footnote updated to mention updated slew rate "Measurements were done with signals ...."
- In section "DDR4 Output", for Symbol "tCK(avg)" value "0.625" moved from min to typ.
- In section "JTAG Boundary Scan" removed spec "TJCMPI" and figure "JCOMP Timing" is updated to reflect the spec update.

**Rev 2 Draft B, June 2020**

- In uSDHC DDR-HS400, for tPP, added min value as 200 MHz
- In SAR ADC, updated a footnote "ADC performance specifications are only guaranteed..."
- In QuadSPI, added Octal 1.8V DDR 166/200 MHz modes.
- In QuadSPI, updated 1.8V Quad SDR 133 MHz

**Rev 2 Draft B, June 2020**

- In SAR\_ADC, updated the condition of TUE as "after calibration, no current injection on an adjacent pin" to "after calibration"
- In TMU, removed a non-applicable footnote.

**Rev 2 Draft A, May 2020**

- In section "Feature comparison", changed from "Arm CoreSight JTAG (IEEE 1149.1/1149.7)" to "Arm CoreSight JTAG (IEEE 1149.1)" as cJTAG is defeatured.
- In section "Operating conditions" deleted "fCLKOUT\_LVDS".
- In section "Operating Conditions", LPDDR4 I/O voltage supply updated to 1.078 (min)
- In section "Operating Conditions", a footnote deleted "VDD\_IO\_\* I/O supplies require +/- 5% DC tolerance at 3.3V. Tolerance up to +/- 10% is allowed when including AC noise on the supply."
- In section "Operating Conditions", for Symbol "IINJ\_A" footnote updated "The specified injection current is allowed ....."
- In section "Operating Conditions", for Symbol "IINJ\_A" Min value changed to "-1"
- In section "Operating Conditions", for Symbol "IINJ\_A" Max changed from "0" to "1"
- In section "Operating Conditions", for Symbol "VDD\_VP\_PCIEEn" with condition "Fast silicon (fuse setting = b01)" footnote value changed to "Both PCIe supplies must ramp for the SerDes PHY to safely power up into its reset state. Until both supplies are ramped, the SerDes PHY will be in an undefined state."
- In section "Operating Conditions", for Symbol "VRAMP\_LV" with condition "Applies to 0.8V supplies" footnote added as "On slow ramps, the RESET\_B pin may be observed to be asserted multiple times during the supply ramping if the RESET\_B pin is not being driven low by the PMIC during this time as recommended."
- In section "Operating Conditions", for Symbol "VDD\_EFUSE" footnote changed from "VDD\_EFUSE may be grounded in order to save power when not actively programming the fuses. This supply is not required to be powered for fuse reads." to "VDD\_EFUSE must be grounded when not actively programming the fuses. This supply is not required to be powered for fuse reads."
- In section "Operating Conditions", added sentence "The "fuse setting" values/conditions in above table correspond with the DIE\_PROCESS[1:0] fuses which NXP programs during manufacturing. See Reference Manual and it's Fuse Map for further details about the purpose. Example: Value "b01" represents DIE\_PROCESS[1]=0 and DIE\_PROCESS[0]=1."
- In section "Operating Conditions", added sentence "The chip hardware design guidelines document summarizes mandatory board design rules in table "Decoupling caps values" and section "PDN impedance calculations"."
- In section "Operating Conditions", for Symbol "VDD\_LV\_PLL" with condition "Fast silicon (fuse setting = b01)" footnote changed from "The minimum operating voltage applies when SVS is enabled, FAST silicon. SVS guidelines apply to all LV supplies on the device." to "The minimum operating voltage applies when SVS is enabled, FAST silicon. SVS guidelines apply to all LV supplies on the device. Refer power management chapter of device reference manual for details on SVS."
- In section "Operating Conditions", added figure "TDISCHARGE STDBY definition"
- In section "Power Sequencing", update a note "Note that while powering up the device or exiting from Standby mode, ....."
- In section "GPIO Pads", for Symbol "VHYS\_33" with condition "Always enabled." description changed from "GPIO33 input hysteresis voltage" to "3.3V GPIO input hysteresis voltage"
- In section "GPIO Pads", added specifications for "ISLEW\_POR\_B" and "ISLEW\_RESET\_B".
- In section "GPIO Pads", added specifications for "VISE\_33", "VISE\_18" and "VISE\_3318" and corresponding figures at the end of section.

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- In section "GPIO Pads", for Symbol "FMAX\_18" with condition "SRE[2:0] = 000" footnote updated "I/O timing specifications are valid for the un-terminated 50ohm ..."
- In section "GPIO Pads", added a note "In the Standby mode exit case, the rising edge of the PMIC\_VDD\_OK ..."
- In section "GPIO Pads", for Symbol "FMAX\_33" with condition "SRE[2:0] = 110" Max changed from "10" to "20"
- In section "LVDS Pads", description of Symbol "F\_RX\_PAD\_CORE" updated.
- In section "LVDS Pads", for Symbol "VCM\_LVDS\_RX" with condition "high gain setting" changed specs to 0.6V (min) to 1 V (max).
- In section "LVDS Pads", for Symbol "VDIFF\_LVDS\_RX" with condition "high gain setting" changed specs 400mV (min).
- In section "LVDS Pads", deleted IDD\_HV\_LVDS\_RX.
- In section "Aurora Pads", for Symbol "fAURORA" with condition "100 external termination ( Not on board but inside receiver after AC coupling )" Min value changed to "0.05"
- In section "Aurora Pads", deleted ISTDBY\_AURORA.
- In section "Aurora Pads", for Symbol "VCM\_AURORA" Min changed from "775" to "0.775"
- In section "Aurora Pads", for Symbol "RTERM\_AURORA" with condition "enabled" Max changed from "125" to "130"
- In section "Aurora Pads", for Symbol "VOD\_AURORA\_DC" with condition "ipp\_obe=1 DC condition" Min changed from "900" to "800"
- In section "Aurora Pads", for Symbol "VOD\_AURORA\_DC" with condition "ipp\_obe=1 DC condition" Max deleted.
- In section "Aurora Pads", updated a footnote "Termination scheme as shown in "End Termination Circuit" applies to debug tool hardware and is not recommended to be placed on the PC."
- In section "Aurora Pads", added note "Source termination Circuit – Transmitter side 100 ohm termination is present inside the Tx pad and should not be placed on the PCB."
- In section "Aurora Pads", for Symbol "VOD\_AURORA\_DC" with condition "ipp\_obe=1 DC condition" footnote deleted.
- In section "Aurora Pads", other footnotes also updated thoroughly.
- In section "Aurora PLL", for Symbol "fPLL\_CLKIN\_PFD" footnote added as "It is Aurora PLL Input Reference Clock Frequency after pre-divider."
- In section "Aurora PLL", removed mod sign and pk-pk from description.
- In section "PMC Bandgap", for Symbol "VBG\_SCALED" with condition "Both bandgap and buffer are trimmed" description changed from "Scaled version of bandgap referencevoltage" to "Scaled version of bandgap referencevoltage measured by SAR ADC"
- In section "PMC Bandgap", for Symbol "VBG\_SCALED" with condition "Both bandgap and buffer are trimmed" footnote value updated to "ADC conversion error must be included when reading the bandgap reference voltage via the chip ADC."
- In section "PMC Bandgap", deleted specification for VBG\_REF\_T.
- In section "Reset Duration", for Symbol "POR" with condition "FIRC\_CLK, trimmed during destructive reset phase" Max changed from "600.3" to "1500"
- In section "Reset Duration", for Symbol "TFR" with condition "FIRC\_CLK, trimmed" Max changed from "333.3" to "545"
- In section "Reset Duration", for Symbol "TDR" with condition "FIRC\_CLK, trimmed during destructive reset phase" Max changed from "583.1" to "1370"
- In section "Reset Duration", added figures.

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- In section "SAR ADC", updated condition of "IAD\_LKG" to show full range specifications and deleted corresponding note.
- In section "SAR ADC", for Symbol "DNL" min updated to "-1" and max updated to "2" LSB.
- In section "SAR ADC", for Symbol "THD" condition updated as "Input signal frequency >= 50KHz."
- In section "SAR ADC", added specifications for CP1, CP2, CS, RSW1 and RAD.
- In section "SAR ADC", figure "SAR ADC Specification Characteristics" updated
- In section "SAR ADC", added note "ADC performance specifications are guaranteed when calibration uses maximum averaging i.e. when AVGEN = 1 and NRSMPPL = 3."
- In section "Temperature Monitoring Unit (TMU)", removed overlapping of TRANGE as per TERR and removed THTF\_MAX and TLTF\_MIN.
- In section "Temperature Monitoring Unit (TMU)", added note "For High/Low temperature immediate threshold value flag setting procedures, see TMHTITR[TEMP] and TMLTITR[TEMP] register fields in device reference manual."
- In section "Temperature Monitoring Unit (TMU)", deleted redundant notes.
- In section "Glitch Filter", for Symbol "TFILT" Max changed from "20" to "17"
- In section "IRQ", deleted specification for TICYC and the related footnote.
- In section "DFS", added frequencies for fDFS\_CORE\_CLK3, fDFS\_PER\_CLK2 and fDFS\_PER\_CLK5.
- In section "DFS", added PER\_jitter at odd and even mfn with different fDFS\_CLKIN and removed pk-pk from description.
- In section "DFS", revised footnote "Min jitter=Min(PER\_jitter(PLL))\*(sqrt(N))+Min(PER\_jitter(DFS)). Max jitter=Max(PER\_jitter(PLL))\*(sqrt(N))+Max(PER\_jitter(DFS)). Where N is the DFS division factor. All jitter numbers are in ps."
- In section "FXOSC", added note "See Hardware design guide for recommended circuits for each bypass mode."
- In section "FXOSC", added note "In crystal mode, 20 MHz, NX5032 crystal has 8 pF load cap and gm\_sel[3:0]=4'b0100 and NX3225 has 8pF load cap and gm\_sel[3:0]=4'b100."
- In section "FXOSC", added note "In crystal mode 24 MHz, NX5032 crystal has 8 pF load cap and gm\_sel[3:0]=4'b0101 and NX3225 has 8pF load cap and gm\_sel[3:0]=4'b0110."
- In section "FXOSC", added note "In crystal mode 40 MHz, NX5032 crystal has 8 pF load cap and gm\_sel[3:0]=4'b0101 and NX3225 has 8pF load cap and gm\_sel[3:0]=4'b1100."
- In section "FXOSC", added new specification for Leakage\_injection.
- In section "FXOSC", updated Leakage\_extal specs as -20 (min) and 20 (max) nA with condition "Bypass mode, 0.5V"
- In section "FXOSC", deleted "FXOSC Bypass Frequency"
- In section "PLL", updated thoroughly to show frequencies with/without centre spread and other updates.
- In section "SPI", changed note from "SPI timing specifications are valid only with a slave device in classic mode (MTFE=0)" to "Slave mode timing values given below are applicable when device is in MTFE=0."
- In section "SPI", updated footnotes for clarity.
- In section "I2C Output", for Symbol "tOH\_SC" footnote changed IFDR to IBFD.
- In section "LPSP1", for Symbol "tSU" with condition "Slave" Min changed from "2.5" to "4"
- In section "LPSP1", for Symbol "tLAG" with condition "Master" Min changed from "tSPSCK / 2" to "tSPSCK - 2.5"
- In section "LPSP1", for Symbol "tLAG" with condition "Slave" Min changed from "-" to "25"
- In section "LPSP1", for Symbol "tSU" with condition "Master" Min changed from "10" to "12"

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- In section "LPSPi", for Symbol "tV" with condition "Master, SRE[2:0] = 101" Max changed from "4" to "6"
- In section "LPSPi", for Symbol "tLEAD" with condition "Master" Min changed from "tSPSCK / 2" to "tSPSCK - 2.5"
- In section "LPSPi", for Symbol "tLEAD" with condition "Slave" Min changed from "-" to "25"
- In section "LPSPi", for Symbol "tLAG" with condition "Master" footnote added "tSCKPCS = (SCKPCS+1) \* (2\*\*PRESCALE) \* (1 / fPER\_CLK)"
- In section "LPSPi", for Symbol "tLEAD" with condition "Master" footnote added "tPCSSCK = (PCSSCK+1) \* (2\*\*PRESCALE) \* (1 / fPER\_CLK)"
- In section "FlexRay - TxD", for Symbol "dCCTxAsym" updated description and added min/max as -2.5/+2.5 ns.
- In section "PCIe", added a paragraph "NXP completed PCI-SIG compliance ...".
- In section "PCIe", added a paragraph "NXP completed PCI-SIG TX compliance testing ..."
- In section "PCIe", for Symbol "UI" with condition "8.0GT/s" Min changed from "125.0375" to "124.9625"
- In section "PCIe", for Symbol "UI" with condition "8.0GT/s" Max changed from "129.9625" to "125.0375"
- In section "PCIe", for Symbol "TTX-UTJ" with condition "8.0GT/s" Unit changed from "ps PP @ 10-12" to "ps PP @ 10e-12"
- In section "GMAC Management Interface", "ENET\_MSCR [HOLDTIME] should be set to 001 when Module Clock = 125 MHz. MDIO pin must have external pull up." removed
- In section "GMAC Management Interface", for Symbol "MDIO\_DOI" with condition "SRE[2:0] = 100" Min changed from "(-0.8 + (ENET\_MSCR[HOLDTIME] + 1)\*(PBRIDGE\_n\_CLK period in ns))" to "0"
- In section "GMAC Management Interface", for Symbol "MDIO\_DOV" with condition "SRE[2:0] = 100" Max changed from "(13 + (ENET\_MSCR[HOLDTIME] + 1)\*(PBRIDGE\_n\_CLK period in ns))" to "15"
- In section "GMAC RGMII", SRE updated to 110 for all specs.
- In section "GMAC SGMII", figure with title "SGMII Timing" is changed.
- In section "GMAC SGMII", Transmit Random Jitter (RJ) is deleted.
- In section "QuadSPI", deleted tISU\_SCK Auto-learning, tCK2CKmin, tCK2CKmax and deleted some redundant figures.
- In section "QuadSPI", added tLSKEW for 66MHz.
- In section "DDR Common DC Output", added "NOTE: Refer to IBIS model for the complete IV curve characteristics."
- In section "DDR Common DC Output", for Symbol "ROnPu" moved value from Max to Typ.
- In section "DDR Common Input", footnotes revised.
- In section "DDR4 Output", for Symbol "tOS(Vref)" with condition "dskew = +/- 30ps" Min changed from "225" to "210"
- In section "DDR4 Output", for Symbol "tOH(Vref)" with condition "dskew = +/- 30ps" Min changed from "225" to "210"
- In section "DDR4 DC Input", footnotes revised.
- In section "LPDDR4 Output", for Symbol "tCK(avg)" value "0.625" moved from typ to min.
- In section "LPDDR4 Output", footnote 2 updated
- In section "uSDHC DDR-52MHz", symbol tOD, SDHC\_CMD deleted from condition and added a footnote "CMD signal operates synchronously ...."
- In section "uSDHC DDR-HS400", symbol tOD, SDHC\_CMD deleted from condition and added a footnote "The CMD output timing for HS400 mode ...."
- Deleted section "Serial Wire Debug (SWD) Timing"

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- In section "JTAG Boundary Scan", for Symbol "tJCYC" footnote addedm "JTAG port interface speed only. Does not apply to boundary scan timing." to "These specifications apply to JTAG boundary scan mode only."
- In section "JTAG Boundary Scan", for Symbol "tJCMPH" description changed from "JCOMP setup time to TCK low" to "JCOMP setup time to TCK high"
- In section "JTAG Boundary Scan", added spec "TJCMPH" - JCOMP hold time to TCK low
- In section "JTAG Debug Interface Timing", for Symbol "tNTDOD" description changed from "TDO/TDOC propagation delay from falling edge of TCK" to "TDOpropagation delay from falling edge of TCK"
- In section "JTAG Debug Interface Timing", for Symbol "tNTDOD" deleted footnote "Timing includes TCK pad delay, clock tree delay, logic delay and TDO/TDOC output pad delay." to "Timing includes TCK pad delay, clock tree delay, logic delay and TDOoutput pad delay."
- In section "JTAG Debug Interface Timing", for Symbol "tTCYC" description changed from "Absolute minimum TCK cycle time (TDO/TDOC sampled on negedge of TCK)" to "Absolute minimum TCK cycle time (TDO sampled on negedge of TCK)"
- In section "JTAG Debug Interface Timing", for Symbol "tNTMSS" description changed from "TMS/TMSC data setup time" to "TMS data setup time"
- In section "JTAG Debug Interface Timing", for Symbol "tNTMSS" deleted footnote "TMSC represents the TMS bit frame of the scan packet in compact JTAG 2-wire mode."
- In section "JTAG Debug Interface Timing", for Symbol "tNTDIH" description changed from "TDI/TDIC data hold time" to "TDI data hold time"
- In section "JTAG Debug Interface Timing", for Symbol "tNTDOH" description changed from "TDO/TDOC hold time with respect to falling edge of TCK" to "TDO hold time with respect to falling edge of TCK"
- In section "JTAG Debug Interface Timing", for Symbol "tNTDIS" description changed from "TDI/TDIC data setup time" to "TDI data setup time"
- In section "JTAG Debug Interface Timing", for Symbol "tNTMSH" description changed from "TMS/TMSC data hold time" to "TMSdata hold time"
- In section "JTAG Debug Interface Timing", deleted tTCYC for cJTAG.

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