

XMC4300

Microcontroller Series for Industrial Applications

ARM® Cortex® -M4
32-bit processor core

About this Document

This datasheet is addressed to embedded hardware and software developers. It provides the reader with detailed descriptions about the ordering designations, available features, electrical and physical characteristics of the XMC4300 series devices.

The document describes the characteristics of a superset of the XMC4300 series devices. For simplicity, the various device types are referred to by the collective term XMC4300 throughout this manual.

XMC4000 Family User Documentation

The set of user documentation includes:

- **Reference Manual**
 - describes the functionality of the superset of devices.
- **Datasheets**
 - list the complete ordering designations, available features and electrical characteristics of derivative devices.
- **Errata Sheets**
 - list deviations from the specifications given in the related Reference Manual or Datasheets. Errata Sheets are provided for the superset of devices.

Attention: *Please consult all parts of the documentation set to attain consolidated knowledge about your device.*

Application related guidance is provided by **Users Guides** and **Application Notes**.

Please refer to <http://www.infineon.com/xmc4000> to get access to the latest versions of those documents.

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1 Summary of Features

1 Summary of Features

The XMC4300 devices are members of the XMC4000 Family of microcontrollers based on the ARM Cortex-M4 processor core. The XMC4000 is a family of high performance and energy efficient microcontrollers optimized for Industrial Connectivity, Industrial Control, Power Conversion, Sense & Control.

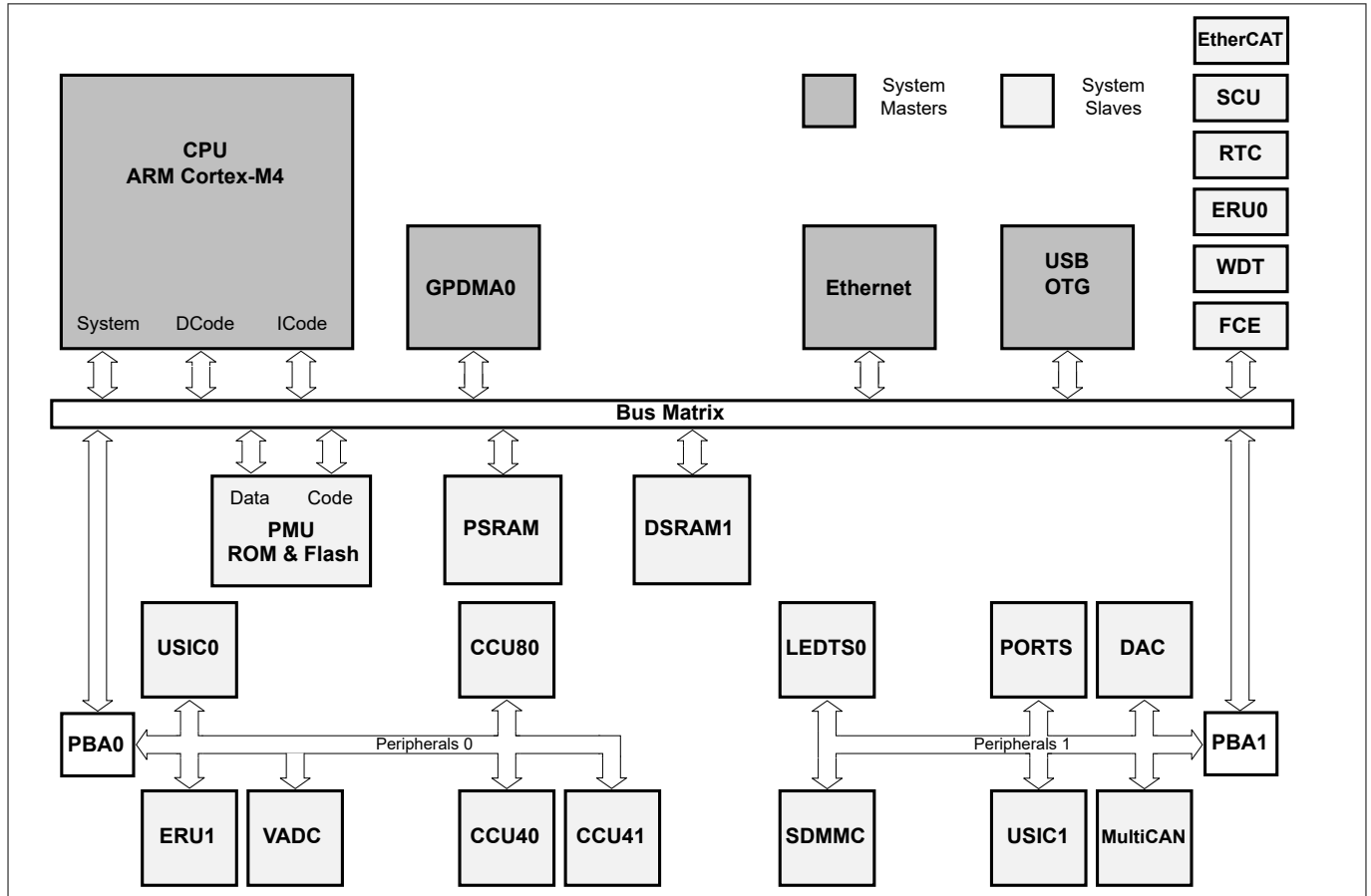


Figure 1 System Block Diagram

CPU Subsystem

- CPU Core
 - High Performance 32-bit ARM Cortex-M4 CPU
 - 16-bit and 32-bit Thumb2 instruction set
 - DSP/MAC instructions
 - System timer (SysTick) for Operating System support
- Floating Point Unit
- Memory Protection Unit
- Nested Vectored Interrupt Controller
- General Purpose DMA with up-to 8 channels
- Event Request Unit (ERU) for programmable processing of external and internal service requests
- Flexible CRC Engine (FCE) for multiple bit error detection

On-Chip Memories

- 16 KB on-chip boot ROM
- 64 KB on-chip high-speed program memory

1 Summary of Features

- 64 KB on-chip high speed data memory
- 256 KB on-chip Flash Memory with 8 KB instruction cache

Communication Peripherals

- Ethernet MAC module capable of 10/100 Mbit/s transfer rates
- EtherCATSlave interface (ECAT) capable of 100 Mbit/s transfer rates with 2 MII ports, 8 Fieldbus Memory Management Units (FMMU), 8 Sync Manager, 64 bit distributed clocks
- Universal Serial Bus, USB 2.0 host, Full-Speed OTG, with integrated PHY
- Controller Area Network interface (MultiCAN), Full-CAN/Basic-CAN with 2 nodes, 64 message objects (MO), data rate up to 1 Mbaud
- Four Universal Serial Interface Channels (USIC), providing 4 serial channels, usable as UART, double-SPI, quad-SPI, IIC, IIS and LIN interfaces
- LED and Touch-Sense Controller (LEDTS) for Human-Machine interface
- SD and Multi-Media Card interface (SDMMC) for data storage memory cards

Analog Frontend Peripherals

- Two Analog-Digital Converters (VADC) of 12-bit resolution, 8 channels each, with input out-of-range comparators
- Digital-Analog Converter (DAC) with two channels of 12-bit resolution

Industrial Control Peripherals

- One Capture/Compare Units 8 (CCU8) for motor control and power conversion
- Two Capture/Compare Units 4 (CCU4) for use as general purpose timers
- Window Watchdog Timer (WDT) for safety sensitive applications
- Die Temperature Sensor (DTS)
- Real Time Clock module with alarm support
- System Control Unit (SCU) for system configuration and control

Input/Output Lines

- Programmable port driver control module (PORTS)
- Individual bit addressability
- Tri-stated in input mode
- Push/pull or open drain output mode
- Boundary scan test support over JTAG interface

On-Chip Debug Support

- Full support for debug features: 6 breakpoints, CoreSight, trace
- Various interfaces: ARM-JTAG, SWD, single wire trace

1 Summary of Features

1.1 Ordering Information

The ordering code for an Infineon microcontroller provides an exact reference to a specific product. The code “XMC4<DDD>-<Z><PPP><T><FFFF>” identifies:

- <DDD> the derivatives function set
- <Z> the package variant
 - E: LFBGA
 - F: LQFP
 - Q: VQFN
- <PPP> package pin count
- <T> the temperature range:
 - F: -40°C to 85°C
 - K: -40°C to 125°C
- <FFFF> the Flash memory size

For ordering codes for the XMC4300 please contact your sales representative or local distributor.

This document describes several derivatives of the XMC4300 series, some descriptions may not apply to a specific product. Please see [Device Types](#).

For simplicity the term **XMC4300** is used for all derivatives throughout this document.

1.2 Device Types

These device types are available and can be ordered through Infineon’s direct and/or distribution channels.

Table 1 Synopsis of XMC4300 Device Types

Derivative ¹⁾	Package	Flash Kbytes	SRAM Kbytes
XMC4300-F100x256	PG-LQFP-100	256	128

1) x is a placeholder for the supported temperature range.

1.3 Device Type Features

The following table lists the available features per device type.

Table 2 Features of XMC4300 Device Types

Derivative ¹⁾	LEDTS Intf.	SD MMC Intf.	ETH Intf.	ECAT Slave Intf.	USB Intf.	USIC Chan.	MultiCAN Nodes, MO
XMC4300-F100x256	1	1	RMII	2 x MII	1	2 x 2	N0, N1 MO[0..63]

1) x is a placeholder for the supported temperature range.

Table 3 Features of XMC4300 Device Types

Derivative ¹⁾	ADC Chan.	DAC Chan.	CCU4 Slice	CCU8 Slice
XMC4300-F100x256	16	2	2 x 4	1 x 4

1) x is a placeholder for the supported temperature range.

1 Summary of Features

1.4 Definition of Feature Variants

The XMC4300 types are offered with several memory sizes and number of available VADC channels. [Table 4](#) describes the location of the available Flash memory, [Table 5](#) describes the location of the available SRAMs, [Table 6](#) the available VADC channels.

Table 4 Flash Memory Ranges

Total Flash Size	Cached Range	Uncached Range
256 Kbytes	0800 0000 _H – 0803 FFFF _H	0C00 0000 _H – 0C03 FFFF _H

Table 5 SRAM Memory Ranges

Total SRAM Size	Program SRAM	System Data SRAM
128 Kbytes	1FFF 0000 _H – 1FFF FFFF _H	2000 0000 _H – 2000 FFFF _H

Table 6 ADC Channels¹⁾

Package	VADC G0	VADC G1
PG-LQFP-100	CH0..CH7	CH0..CH7

1) Some pins in a package may be connected to more than one channel. For the detailed mapping see the Port I/O Function table.

1.5 Identification Registers

The identification registers allow software to identify the marking.

Table 7 XMC4300 Identification Registers

Register Name	Value	Marking
SCU_IDCHIP	0004 3001 _H	AA
JTAG IDCODE	101D F083 _H	AA

2 General Device Information

This section summarizes the logic symbols and package pin configurations with a detailed list of the functional I/O mapping.

2.1 Logic Symbols

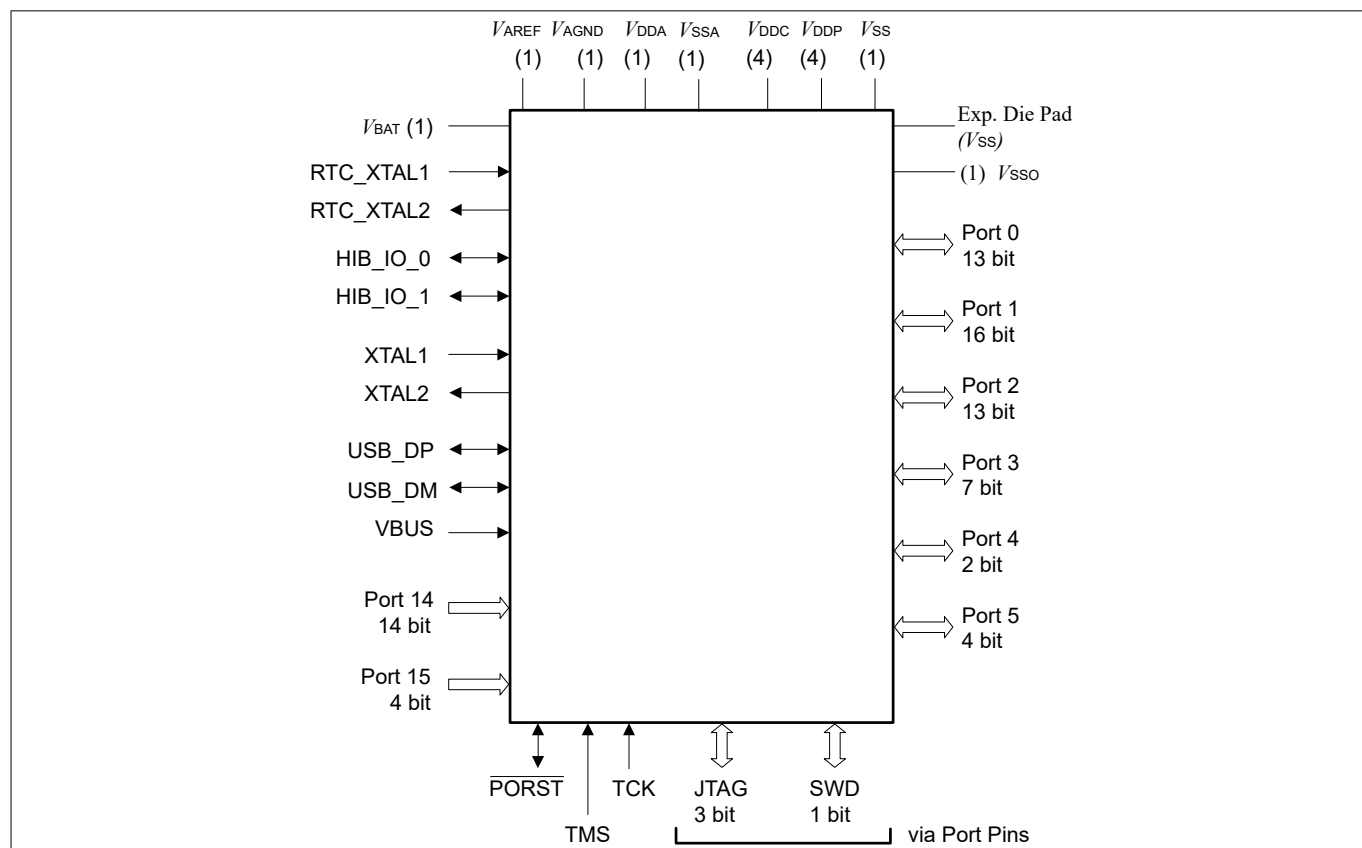


Figure 2 XMC4300 Logic Symbol PG-LQFP-100

2 General Device Information

2.2 Pin Configuration and Definition

The following figures summarize all pins, showing their locations on the four sides of the different packages.

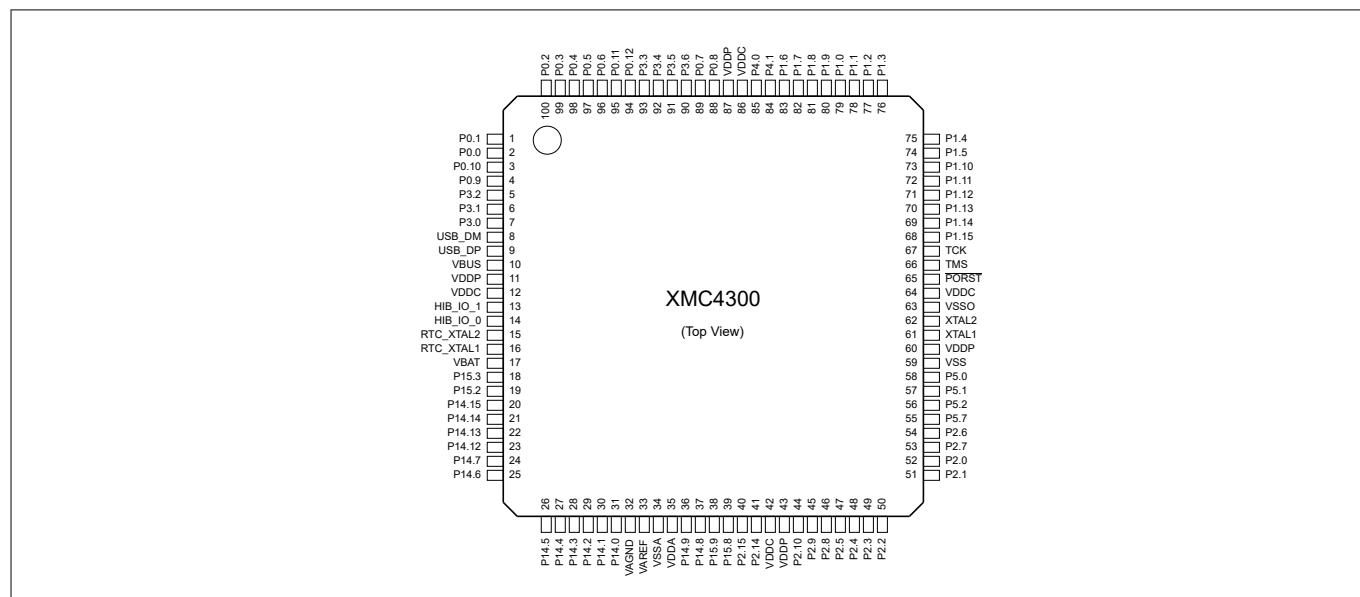


Figure 3 XMC4300 PG-LQFP-100 Pin Configuration (top view)

2.2.1 Package Pin Summary

The following general scheme is used to describe each pin:

Table 8 Package Pin Mapping Description

Function	Package A	Package B	...	Pad Type	Notes
Name	N	Ax	...	A2	

The table is sorted by the “Function” column, starting with the regular Port pins (Px.y), followed by the dedicated pins (i.e. $\overline{\text{PORST}}$) and supply pins.

The following columns, titled with the supported package variants, lists the package pin number to which the respective function is mapped in that package.

The “Pad Type” indicates the employed pad type (A1, A1+, A2, special=special pad, In=input pad, AN/ DIG_IN=analog and digital input, Power=power supply). Details about the pad properties are defined in the Electrical Parameters.

In the “Notes”, special information to the respective pin/function is given, that is deviations from the default configuration after reset. Per default the regular Port pins are configured as direct input with no internal pull device active.

Table 9 Package Pin Mapping

Function	LQFP-100	Pad Type	Notes
P0.0	2	A1+	
P0.1	1	A1+	
P0.2	100	A2	
P0.3	99	A2	

(table continues...)

2 General Device Information

Table 9 (continued) **Package Pin Mapping**

Function	LQFP-100	Pad Type	Notes
P0.4	98	A2	
P0.5	97	A2	
P0.6	96	A2	
P0.7	89	A2	After a system reset, via HWSEL this pin selects the DB.TDI function.
P0.8	88	A2	After a system reset, via HWSEL this pin selects the DB.TRST function, with a weak pull-down active.
P0.9	4	A2	
P0.10	3	A1+	
P0.11	95	A1+	
P0.12	94	A1+	
P1.0	79	A1+	
P1.1	78	A1+	
P1.2	77	A2	
P1.3	76	A2	
P1.4	75	A1+	
P1.5	74	A1+	
P1.6	83	A2	
P1.7	82	A2	
P1.8	81	A2	
P1.9	80	A2	
P1.10	73	A1+	
P1.11	72	A1+	
P1.12	71	A2	
P1.13	70	A2	
P1.14	69	A2	
P1.15	68	A2	
P2.0	52	A2	
P2.1	51	A2	After a system reset, via HWSEL this pin selects the DB.TDO function.
P2.2	50	A2	
P2.3	49	A2	
P2.4	48	A2	
P2.5	47	A2	

(table continues...)

2 General Device Information

Table 9 (continued) Package Pin Mapping

Function	LQFP-100	Pad Type	Notes
P2.6	54	A1+	
P2.7	53	A1+	
P2.8	46	A2	
P2.9	45	A2	
P2.10	44	A2	
P2.14	41	A2	
P2.15	40	A2	
P3.0	7	A2	
P3.1	6	A2	
P3.2	5	A2	
P3.3	93	A1+	
P3.4	92	A1+	
P3.5	91	A2	
P3.6	90	A2	
P4.0	85	A2	
P4.1	84	A2	
P5.0	58	A1+	
P5.1	57	A1+	
P5.2	56	A1+	
P5.7	55	A1+	
P14.0	31	AN/DIG_IN	
P14.1	30	AN/DIG_IN	
P14.2	29	AN/DIG_IN	
P14.3	28	AN/DIG_IN	
P14.4	27	AN/DIG_IN	
P14.5	26	AN/DIG_IN	
P14.6	25	AN/DIG_IN	
P14.7	24	AN/DIG_IN	
P14.8	37	AN/DAC/DIG_IN	
P14.9	36	AN/DAC/DIG_IN	
P14.12	23	AN/DIG_IN	
P14.13	22	AN/DIG_IN	
P14.14	21	AN/DIG_IN	

(table continues...)

2 General Device Information

Table 9 (continued) **Package Pin Mapping**

Function	LQFP-100	Pad Type	Notes
P14.15	20	AN/DIG_IN	
P15.2	19	AN/DIG_IN	
P15.3	18	AN/DIG_IN	
P15.8	39	AN/DIG_IN	
P15.9	38	AN/DIG_IN	
HIB_IO_0	14	A1 special	At the first power-up and with every reset of the hibernate domain this pin is configured as open-drain output and drives "0". As output the medium driver mode is active.
HIB_IO_1	13	A1 special	At the first power-up and with every reset of the hibernate domain this pin is configured as input with no pull device active. As output the medium driver mode is active.
USB_DP	9	special	
USB_DM	8	special	
TCK	67	A1	Weak pull-down active.
TMS	66	A1+	Weak pull-up active. As output the strong-soft driver mode is active.
$\overline{\text{PORST}}$	65	special	Weak pull-up permanently active, strong pull-down controlled by EVR.
XTAL1	61	clock_IN	
XTAL2	62	clock_O	
RTC_XTAL1	16	clock_IN	
RTC_XTAL2	15	clock_O	
VBAT	17	Power	When VDDP is supplied VBAT has to be supplied as well.
VBUS	10	special	
VAREF	33	AN_Ref	
VAGND	32	AN_Ref	
VDDA	35	AN_Power	
VSSA	34	AN_Power	
VDDC	12	Power	
VDDC	42	Power	
VDDC	64	Power	
VDDC	86	Power	
VDDP	11	Power	

(table continues...)

2 General Device Information

Table 9 (continued) **Package Pin Mapping**

Function	LQFP-100	Pad Type	Notes
VDDP	43	Power	
VDDP	60	Power	
VDDP	87	Power	
VSS	59	Power	
VSSO	63	Power	
VSS	Exp. Pad	Power	Exposed Die Pad The exposed die pad is connected internally to VSS. For proper operation, it is mandatory to connect the exposed pad directly to the common ground on the board. For thermal aspects, please refer to the Datasheet. Board layout examples are given in an application note.

2.2.2 Port I/O Functions

The following general scheme is used to describe each Port pin:

Table 10 **Port I/O Function Description**

Function	Outputs			Inputs		
	ALT1	ALTn	HWO0	HWIO	Input	Input
P0.0		MODA.OUT	MODB.OUT	MODB.INA	MODC.INA	
Pn.y	MODA.OUT				MODA.INA	MODC.INB

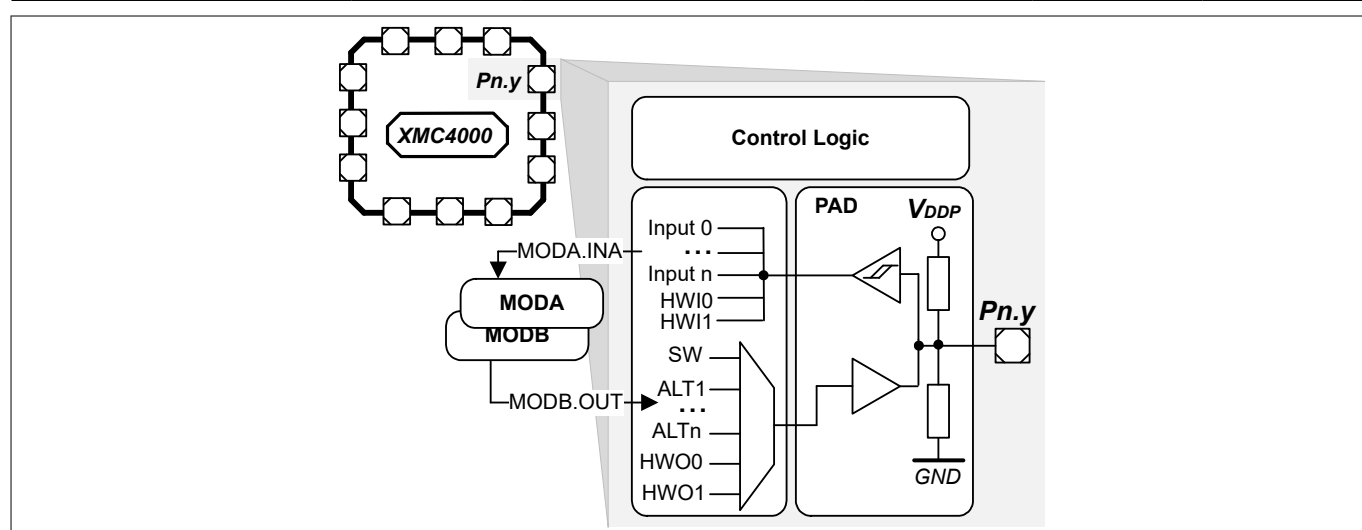


Figure 4 **Simplified Port Structure**

Pn.y is the port pin name, defining the control and data bits/registers associated with it. As GPIO, the port is under software control. Its input value is read via Pn_IN.y, Pn_OUT defines the output value.

2 General Device Information

Up to four alternate output functions (ALT1/2/3/4) can be mapped to a single port pin, selected by Pn_IOC.R.PC. The output value is directly driven by the respective module, with the pin characteristics controlled by the port registers (within the limits of the connected pad).

The port pin input can be connected to multiple peripherals. Most peripherals have an input multiplexer to select between different possible input sources.

The input path is also active while the pin is configured as output. This allows to feedback an output to on-chip resources without wasting an additional external pin.

By Pn_HWSEL it is possible to select between different hardware “masters” (HWO0/HWI0). The selected peripheral can take control of the pin(s). Hardware control overrules settings in the respective port pin registers.

2 General Device Information

2.2.2.1 Port I/O Function Table

Table 11 Port I/O Functions

Function	Output				Input						
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input
P0.0	ECAT0. PHY_RS T	CAN. N0_TXD	CCU80. OUT21	LEDTS0 .COL2			U1C1. DX0D	ETH0. CLK_R MIIB	ERU0. 0B0		ETH0. CLKRXB
P0.1	USB. DRIVEV BUS	U1C1. DOUT0	CCU80. OUT11	LEDTS0 .COL3				ETH0. CRS_DV B	ERU0. 0A0	ECAT0. P1_RX_ CLA	ETH0. RXDVB
P0.2	ECAT0. P1_TXD 2	U1C1. SELO1	CCU80. OUT01		U1C0. DOUT 3	U1C 0. HWI N3	ETH0. RXD0B		ERU0. 3B3		
P0.3	ECAT0. P1_TXD 3		CCU80. OUT20		U1C0. DOUT 2	U1C 0. HWI N2	ETH0. RXD1B			ERU1. 3B0	
P0.4	ETH0. TX_EN		CCU80. OUT10		U1C0. DOUT 1	U1C 0. HWI N1		U1C0. DX0A	ERU0. 2B3	ECAT0. P1_RXD 3A	
P0.5	ETH0. TXD0	U1C0. DOUT0	CCU80. OUT00		U1C0. DOUT 0	U1C 0. HWI N0		U1C0. DX0B		ERU1. 3A0	ECAT0. P1_RXD 2A
P0.6	ETH0. TXD1	U1C0. SELO0	CCU80. OUT30					U1C0. DX2A	ERU0. 3B2	CCU80. IN2B	ECAT0. P1_RXD 1A

(table continues...)

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output					Input									
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input	Input	Input	Input
P0.7	WDT. SERVIC E_OUT	U0C0. SELO0	ECAT0. LED_ER R			DB. TDI	U0C0. DX2B		ERU0. 2B1		CCU80. IN0A	CCU80. IN1A	CCU80. IN2A	CCU80. IN3A	
P0.8	SCU. EXTCLK	U0C0. SCLKO UT	ECAT0. LED_RU N			$\overline{\text{DB}}$. $\overline{\text{TRST}}$	U0C0. DX1B		ERU0. 2A1		CCU80. IN1B				
P0.9		U1C1. SELO0	CCU80. OUT12	LEDT50 .COL0	ETH0. MDO	ETH 0. MDIA	U1C1. DX2A	USB. ID	ERU0. 1B0				ECAT0. P1_RX_ DVA		
P0.10	ETH0. MDC	U1C1. SCLKO UT	CCU80. OUT02	LEDT50 .COL1			U1C1. DX1A		ERU0. 1A0				ECAT0. P1_TX_ CLA		
P0.11	ECAT0. P1_LIN K_ACT	U1C0. SCLKO UT	CCU80. OUT31		$\overline{\text{SDMMC}}$. $\overline{\text{RST}}$		ETH0. RXERB	U1C0. DX1A	ERU0. 3A2				ECAT0. P1_RXD 0A		
P0.12		U1C1. SELO0	CCU40. OUT3		ECAT 0. MDO	ECAT 0. MDIA		U1C1. DX2B	ERU0. 2B2						
P1.0		U0C0. SELO0	CCU40. OUT3	ERU1. PDOUT 3			U0C0. DX2A		ERU0. 3B0		CCU40. IN3A			ECAT0. P0_TX_ CLA	
P1.1		U0C0. SCLKO UT	CCU40. OUT2	ERU1. PDOUT 2		SDM MC. SDW C	U0C0. DX1A		ERU0. 3A0		CCU40. IN2A			ECAT0. P0_RX_ CLA	

(table continues...)

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output					Input						
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input
P1.2	ECAT0. P0_TXD 3		CCU40. OUT1	ERU1. PDOUT 1	U0C0. DOUT 3	U0C 0. HWI N3				ERU1. 2B0	CCU40. IN1A	
P1.3	ECAT0. P0_TX_ ENA	U0C0. MCLKO UT	CCU40. OUT0	ERU1. PDOUT 0	U0C0. DOUT 2	U0C 0. HWI N2				ERU1. 2A0	CCU40. IN0A	
P1.4	WDT. SERVIC E_OUT	CAN. N0_TXD	CCU80. OUT33		U0C0. DOUT 1	U0C 0. HWI N1	U0C0. DX0B	CAN. N1_RXD D	ERU0. 2B0		CCU41. IN0C	ECAT0. P0_RXD 0A
P1.5	CAN. N1_TXD	U0C0. DOUT0	CCU80. OUT23		U0C0. DOUT 0	U0C 0. HWI N0	U0C0. DX0A	CAN. N0_RXD A	ERU0. 2A0	ERU1. 0A0	CCU41. IN1C	ECAT0. P0_RXD 1A
P1.6	ECAT0. P0_TXD 0	U0C0. SCLKO UT			SDM MC. DATA 1_OUT T	SDM MC. DATA 1_IN						
P1.7	ECAT0. P0_TXD 1	U0C0. DOUT0		U1C1. SELO2	SDM MC. DATA 2_OUT T	SDM MC. DATA 2_IN						
(table continues...)												

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output					Input						
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input
P1.8	ECAT0. P0_TXD 2	U0C0. SELO1		U1C1. SCLKO UT	SDM MC. DATA 4_OU T	SDM MC. DATA 4_IN						
P1.9	U0C0. SCLKO UT			U1C1. DOUT0	SDM MC. DATA 5_OU T	SDM MC. DATA 5_IN					ECAT0. P0_RX_ DVA	
P1.10	ETH0. MDC	U0C0. SCLKO UT		ECAT0. LED_ER R		SDMMC. SDCD			CCU41. IN2C		ECAT0. P0_RXD 2A	
P1.11	ECAT0. LED_ST ATE_R UN	U0C0. SELO0		ECAT0. LED_RU N	ETH0. MDO	ETH O. MDIC			CCU41. IN3C		ECAT0. P0_RXD 3A	
P1.12	ETH0. TX_EN	CAN. N1_TXD		ECAT0. P0_LIN K_ACT	SDM MC. DATA 6_OU T	SDM MC. DATA 6_IN						
P1.13	ETH0. TXD0	U0C1. SELO3		ECAT0. PHY_CL K25	SDM MC. DATA 7_OU T	CAN. N1_RXD C						

(table continues...)

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output				Input									
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input	Input	Input
P1.14	ETH0. TXD1	U0C1. SELO2		ECAT0. SYNC0			U1C0. DX0E							
P1.15	SCU. EXTCLK			U1C0. DOUT0						ERU1. 1A0			ECAT0. P0_LIN KB	
P2.0	CAN. NO_TXD			LEDT S0 .COL1	ETH0. MDO	ETH 0. MDI B			ERU0. 0B3			CCU40. IN1C		
P2.1				LEDT S0 .COL0	DB.TD O/ TRAC ESWO		ETH0. CLK_R MIIA			ERU1. 0B0		CCU40. IN0C		ETH0. CLKRXA
P2.2	VADC. EMUX0 0		CCU41. OUT3	LEDT S0 .LINE0	LEDT S0. EXTE NDED 0	LEDT S0. TSIN 0A	ETH0. RXD0A	U0C1. DX0A	ERU0. 1B2			CCU41. IN3A		
P2.3	VADC. EMUX0 1	U0C1. SELO0	CCU41. OUT2	LEDT S0 .LINE1	LEDT S0. EXTE NDED 1	LEDT S0. TSIN 1A	ETH0. RXD1A	U0C1. DX2A	ERU0. 1A2			CCU41. IN2A		
(table continues...)														

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output					Input									
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input	Input	Input	Input
P2.4	VADC. EMUX0 2	U0C1. SCLKO UT	CCU41. OUT1	LEDT S0 .LINE2	LEDT S0. EXTE NDED 2	LEDT S0. TSIN 2A	ETH0. RXERA	U0C1. DX1A	ERU0. 0B2		CCU41. IN1A				
P2.5	ETH0. TX_EN	U0C1. DOUT0	CCU41. OUT0	LEDT S0 .LINE3	LEDT S0. EXTE NDED 3	LEDT S0. TSIN 3A	ETH0. RXDVA	U0C1. DX0B	ERU0. 0A2		CCU41. IN0A			ETH0. CRS_DV A	
P2.6		ERU1. PDOUT 3	CCU80. OUT13	LEDT S0 .COL3				CAN. N1_RXD A	ERU0. 1B3		CCU40. IN3C	ECAT0. P0_RX_ ERRB			
P2.7	ETH0. MDC	CAN. N1_TXD	CCU80. OUT03	LEDT S0 .COL2						ERU1. 1B0	CCU40. IN2C				
P2.8	ETH0. TXD0	ERU1. PDOUT 1	CCU80. OUT32	LEDT S0 .LINE4	LEDT S0. EXTE NDED 4	LEDT S0. TSIN 4A	DAC. TRIGGE R5				CCU40. IN0B	CCU40. IN1B	CCU40. IN2B	CCU40. IN3B	
P2.9	ETH0. TXD1	ERU1. PDOUT 2	CCU80. OUT22	LEDT S0 .LINE5	LEDT S0. EXTE NDED 5	LEDT S0. TSIN 5A	DAC. TRIGGE R4				CCU41. IN0B	CCU41. IN1B	CCU41. IN2B	CCU41. IN3B	

(table continues...)

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output						Input						
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input	Input
P2.10	VADC. EMUX1 0	ERU1. PDO 0	ECAT0. PHY_RS T	ECAT0. SYNC1									
P2.14	VADC. EMUX1 1	U1C0. DOUT0	CCU80. OUT21				U1C0. DX0D						
P2.15	VADC. EMUX1 2	ECAT0. P1_TXD 3	CCU80. OUT11	LEDTS0 .LINE6	LEDT S0. EXTEN DED6	LEDT S0. TSIN 6A	ETH0. COLA	U1C0. DX0C					
P3.0		U0C1. SCLKO UT		ECAT0. P1_TX_ ENA			U0C1. DX1B			CCU80. IN2C			
P3.1		U0C1. SELO0	ECAT0. P1_TXD 0				U0C1. DX2B		ERU0. 0B1	CCU80. IN1C			
P3.2	USB. DRIVEV BUS	CAN. N0_TXD	ECAT0. P1_TXD 1	LEDTS0 .COLA					ERU0. 0A1	CCU80. IN0C			
P3.3		U1C1. SELO1		ECAT0. MCLK	SDM MC. LED						CCU80. IN3B		
(table continues...)													

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output					Input						
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input
P3.4		U1C1. SELO2			SDM MC. BUS_ POWER					CCU80. IN0B	ECAT0. P1_LIN A	
P3.5		U1C1. SELO3		U0C1. DOUT0	SDM MC. CMD_ OUT	SDM MC. CMD _IN		ERU0. 3B1			ECAT0. P1_RX_ ERRA	
P3.6		U1C1. SELO4		U0C1. SCLKO UT	SDM MC. CLK_ OUT	SDM MC. CLK_ IN		ERU0. 3A1				
P4.0		ECAT0. PHY_CL K25		U1C0. SCLKO UT	SDM MC. DATA 0_OU T	SDM MC. DATA 0_IN	U1C1. DX1C	U0C1. DX0E				ECAT0. P0_RX_ ERRA
P4.1		U1C1. MCLKO UT		U0C1. SELO0	SDM MC. DATA 3_OU T	SDM MC. DATA 3_IN						ECAT0. P0_LIN A
P5.0				ERU1. PDOUT 0				ETH0. RXD0D	U0C0. DX0D	ECAT0. P0_RXD 0B		
(table continues...)												

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output					Input						
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input
P5.1	U0C0. DOUT0			ERU1. PDOUT 1				ETH0. RXD1D		ECAT0. P0_RXD 1B		
P5.2		ECAT0. P0_LIN K_ACT		ERU1. PDOUT 2				ETH0. CRS_DV D		ECAT0. P0_RXD 2B		ETH0. RXDVD
P5.7	ECAT0. SYNC0			LEDS0 .COLA						ECAT0. P0_RXD 3B		
P14.0							VADC. G0CH0					
P14.1							VADC. G0CH1					
P14.2							VADC. G0CH2	VADC. G1CH2				
P14.3							VADC. G0CH3	VADC. G1CH3			CAN. NO_RXD B	
P14.4							VADC. G0CH4					ECAT0. LATCH1 A
P14.5							VADC. G0CH5					ECAT0. LATCH0 A

(table continues...)

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output					Input						
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input
P14.6							VADC. G0CH6				G0ORC 6	ECAT0. P1_RX_ CLKB
P14.7							VADC. G0CH7				G0ORC 7	ECAT0. P1_RXD 0B
P14.8					DAC. OUT_ 0			VADC. G1CH0		ETH0. RXD0C		
P14.9					DAC. OUT_ 1			VADC. G1CH1		ETH0. RXD1C		
P14.12								VADC. G1CH4				ECAT0. P1_RXD 1B
P14.13								VADC. G1CH5				ECAT0. P1_RXD 2B
P14.14								VADC. G1CH6			G1ORC 6	ECAT0. P1_RXD 3B
P14.15								VADC. G1CH7			G1ORC 7	ECAT0. P1_RX_ DVB
(table continues...)												

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output						Input					
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input
P15.2											ECAT0. P1_RX_ ERRB	
P15.3											ECAT0. P1_LIN KB	
P15.8										ETH0. CLK_R MIIC	ETH0. CLKRXC	
P15.9										ETH0. CRS_DV C	ETH0. RXDVC	
HIB_IO_0	HIBOUT	WDT. SERVIC E_OUT					AKEUP A					
HIB_IO_1	HIBOUT	WDT. SERVIC E_OUT					AKEUP B					
USB_DP												
USB_DM												
TCK												

(table continues...)

2 General Device Information

Table 11 (continued) Port I/O Functions

Function	Output					Input							
	ALT1	ALT2	ALT3	ALT4	HWO 0	HWI 0	Input	Input	Input	Input	Input	Input	Input
TMS					DB.T MS/ SWDI O								
$\overline{\text{PORST}}$													
XTAL1							U0C0. DX0F	U0C1. DX0F	U1C0. DX0F	U1C1. DX0F			
XTAL2													
RTC_XTAL1									ERU0. 1B1				
RTC_XTAL2													

2 General Device Information

2.3 Power Connection Scheme

Figure 5 shows a reference power connection scheme for the XMC4300.

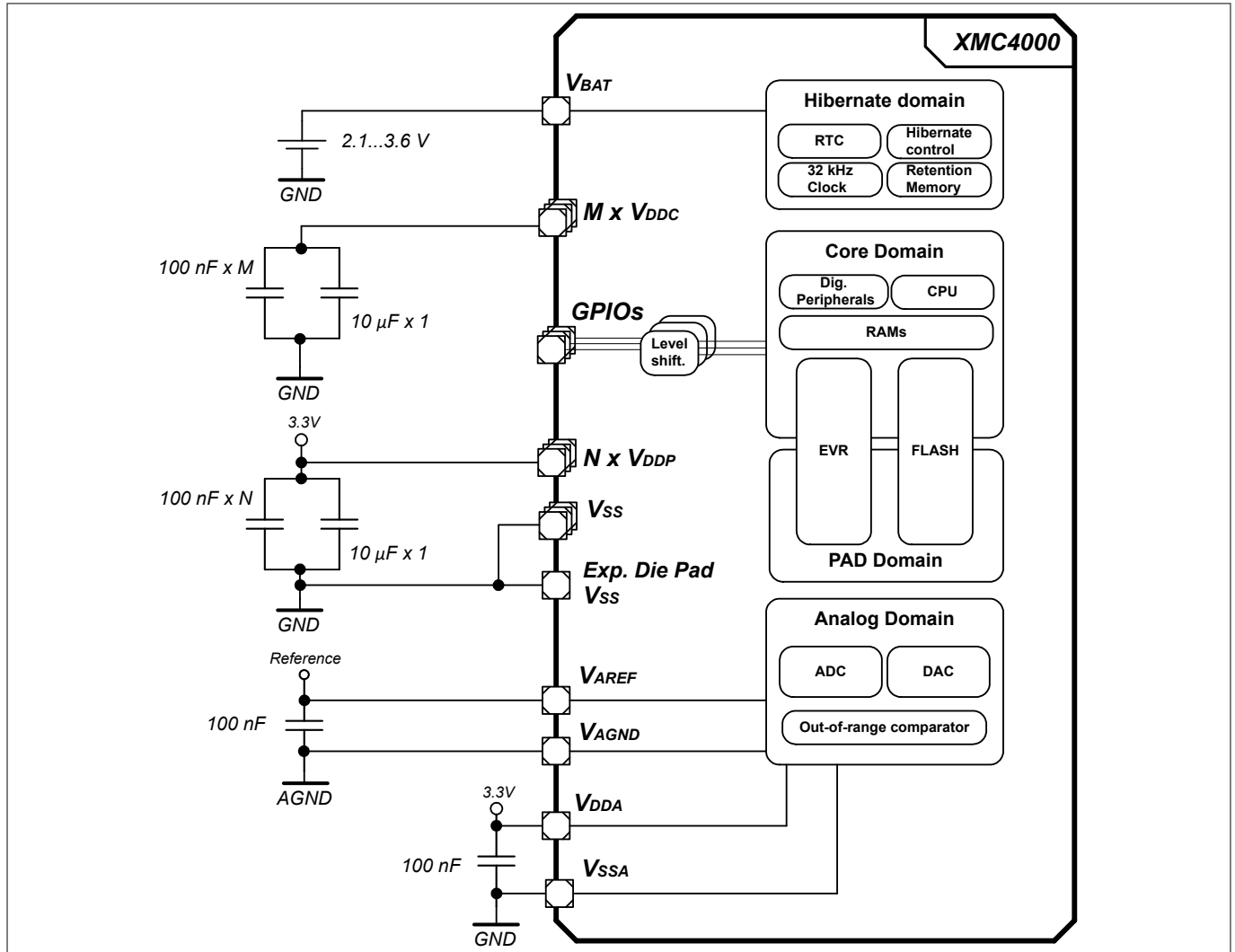


Figure 5 Power Connection Scheme

Every power supply pin needs to be connected. Different pins of the same supply need also to be externally connected. As example, all V_{DDP} pins must be connected externally to one V_{DDP} net. In this reference scheme one 100 nF capacitor is connected at each supply pin against V_{SS} . An additional 10 μ F capacitor is connected to the V_{DDP} nets and an additional 10 uF capacitor to the V_{DDP} nets.

The XMC4300 has a common ground concept, all V_{SS} , V_{SSA} and V_{SSO} pins share the same ground potential. In packages with an exposed die pad it must be connected to the common ground as well.

V_{AGND} is the low potential to the analog reference V_{AREF} . Depending on the application it can share the common ground or have a different potential. In devices with shared V_{DDA}/V_{AREF} and V_{SSA}/V_{AGND} pins the reference is tied to the supply. Some analog channels can optionally serve as "Alternate Reference"; further details on this operating mode are described in the Reference Manual.

When V_{DDP} is supplied, V_{BAT} must be supplied as well. If no other supply source (e.g. battery) is connected to V_{BAT} , the V_{BAT} pin can also be connected directly to V_{DDP} .

3 Electrical Parameters

3 Electrical Parameters

Attention: *All parameters in this chapter are preliminary target values and may change based on characterization results.*

3.1 General Parameters

3.1.1 Parameter Interpretation

The parameters listed in this section partly represent the characteristics of the XMC4300 and partly its requirements on the system. To aid interpreting the parameters easily when evaluating them for a design, they are marked with a two-letter abbreviation in column “Symbol”:

- **CC**
Such parameters indicate **C**ontroller **C**haracteristics, which are a distinctive feature of the XMC4300 and must be regarded for system design
- **SR**
Such parameters indicate **S**ystem **R**equirements, which must be provided by the application system in which the XMC4300 is designed in

3.1.2 Absolute Maximum Ratings

Stresses above the values listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Table 12 Absolute Maximum Rating Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Storage temperature	T_{ST} SR	-65	–	150	°C	–
Junction temperature	T_J SR	-40	–	150	°C	–
Voltage at 3.3 V power supply pins with respect to V_{SS}	V_{DDP} SR	–	–	4.3	V	–
Voltage on any Class A and dedicated input pin with respect to V_{SS}	V_{IN} SR	-1.0	–	$V_{DDP} + 1.0$ or max. 4.3	V	whichever is lower
Voltage on any analog input pin with respect to V_{AGND}	V_{AIN} V_{AREF} SR	-1.0	–	$V_{DDP} + 1.0$ or max. 4.3	V	whichever is lower
Input current on any pin during overload condition	I_{IN} SR	-10	–	+10	mA	

(table continues...)

3 Electrical Parameters

Table 12 (continued) **Absolute Maximum Rating Parameters**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Absolute maximum sum of all input circuit currents for one port group during overload condition ¹⁾	ΣI_{IN} SR	-25	–	+25	mA	
Absolute maximum sum of all input circuit currents during overload condition	ΣI_{IN} SR	-100	–	+100	mA	

1) The port groups are defined in [Pin Reliability in Overload](#).

Figure 6 explains the input voltage ranges of V_{IN} and V_{AIN} and its dependency to the supply level of V_{DDP} . The input voltage must not exceed 4.3 V, and it must not be more than 1.0 V above V_{DDP} . For the range up to $V_{DDP} + 1.0$ V also see the definition of the overload conditions in [Pin Reliability in Overload](#).

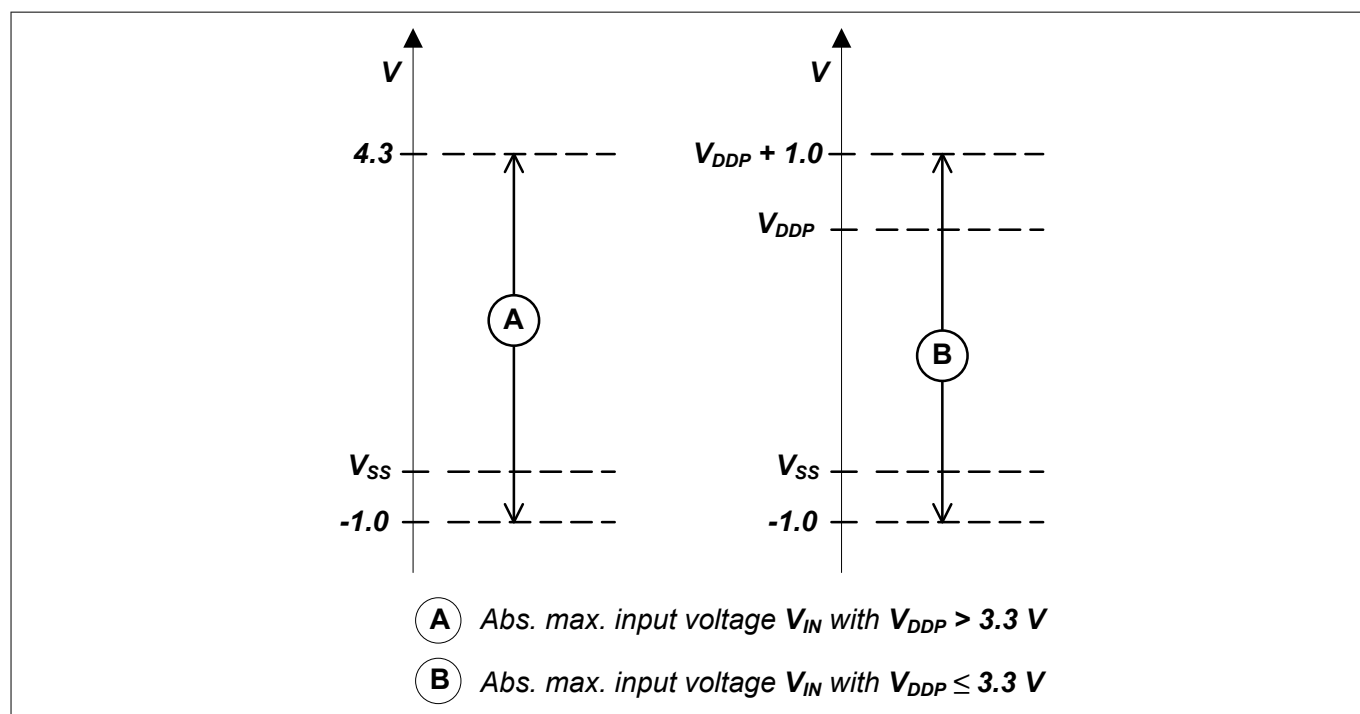


Figure 6 **Absolute Maximum Input Voltage Ranges**

3 Electrical Parameters

3.1.3 Pin Reliability in Overload

When receiving signals from higher voltage devices, low-voltage devices experience overload currents and voltages that go beyond their own IO power supplies specification.

Table 13 defines overload conditions that will not cause any negative reliability impact if all the following conditions are met:

- full operation life-time is not exceeded
- **Operating Conditions** are met for
 - pad supply levels (V_{DDP} or V_{DDA})
 - temperature

If a pin current is outside of the **Operating Conditions** but within the overload conditions, then the parameters of this pin as stated in the Operating Conditions can no longer be guaranteed. Operation is still possible in most cases but with relaxed parameters.

Note: An overload condition on one or more pins does not require a reset.

Note: A series resistor at the pin to limit the current to the maximum permitted overload current is sufficient to handle failure situations like short to battery.

Table 13 Overload Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input current on any port pin during overload condition	I_{OV} SR	-5	–	5	mA	
Absolute sum of all input circuit currents for one port group during overload condition ¹⁾	I_{OVG} SR	–	–	20	mA	$\Sigma I_{OVx} $, for all $I_{OVx} < 0$ mA
		–	–	20	mA	$\Sigma I_{OVx} $, for all $I_{OVx} > 0$ mA
Absolute sum of all input circuit currents during overload condition	I_{OVS} SR	–	–	80	mA	ΣI_{OVG}

1) The port groups are defined in Table 16.

Figure 7 shows the path of the input currents during overload via the ESD protection structures. The diodes against V_{DDP} and ground are a simplified representation of these ESD protection structures.

3 Electrical Parameters

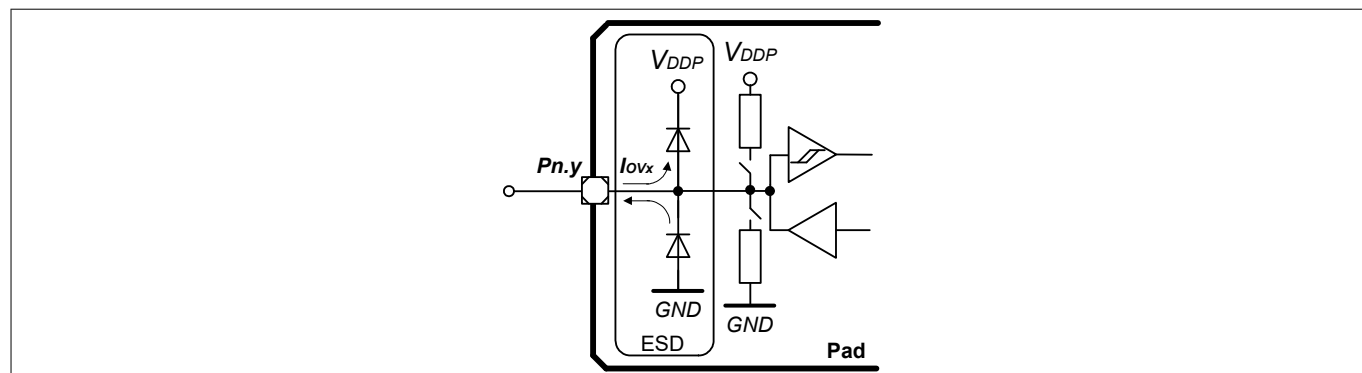


Figure 7 Input Overload Current via ESD structures

Table 14 and Table 15 list input voltages that can be reached under overload conditions. Note that the absolute maximum input voltages as defined in the [Absolute Maximum Ratings](#) must not be exceeded during overload.

Table 14 PN-Junction Characteristics for positive Overload

Pad Type	$I_{OV} = 5 \text{ mA}$, $T_J = -40^\circ\text{C}$	$I_{OV} = 5 \text{ mA}$, $T_J = 150^\circ\text{C}$
A1/A1+	$V_{IN} = V_{DDP} + 1.0 \text{ V}$	$V_{IN} = V_{DDP} + 0.75 \text{ V}$
A2	$V_{IN} = V_{DDP} + 0.7 \text{ V}$	$V_{IN} = V_{DDP} + 0.6 \text{ V}$
AN/DIG_IN	$V_{IN} = V_{DDP} + 1.0 \text{ V}$	$V_{IN} = V_{DDP} + 0.75 \text{ V}$

Table 15 PN-Junction Characteristics for negative Overload

Pad Type	$I_{OV} = 5 \text{ mA}$, $T_J = -40^\circ\text{C}$	$I_{OV} = 5 \text{ mA}$, $T_J = 150^\circ\text{C}$
A1/A1+	$V_{IN} = V_{SS} - 1.0 \text{ V}$	$V_{IN} = V_{SS} - 0.75 \text{ V}$
A2	$V_{IN} = V_{SS} - 0.7 \text{ V}$	$V_{IN} = V_{SS} - 0.6 \text{ V}$
AN/DIG_IN	$V_{IN} = V_{DDP} - 1.0 \text{ V}$	$V_{IN} = V_{DDP} - 0.75 \text{ V}$

Table 16 Port Groups for Overload and Short-Circuit Current Sum Parameters

Group	Pins
1	P0.[12:0], P3.[6:0]
2	P14.[15:0], P15.[9:2]
3	P2.[15:0], P5.[7:0]
4	P1.[15:0], P4.[1:0]

3 Electrical Parameters

3.1.4 Pad Driver and Pad Classes Summary

This section gives an overview on the different pad driver classes and their basic characteristics.

Table 17 Pad Driver and Pad Classes Overview

Class	Power Supply	Type	Sub-Class	Speed Grade	Load	Termination
A	3.3 V	LVTTL I/O,	A1 (e.g. GPIO)	6 MHz	100 pF	No
			A1+ (e.g. serial I/Os)	25 MHz	50 pF	Series termination recommended
			A2 (e.g. ext. Bus)	80 MHz	15 pF	Series termination recommended

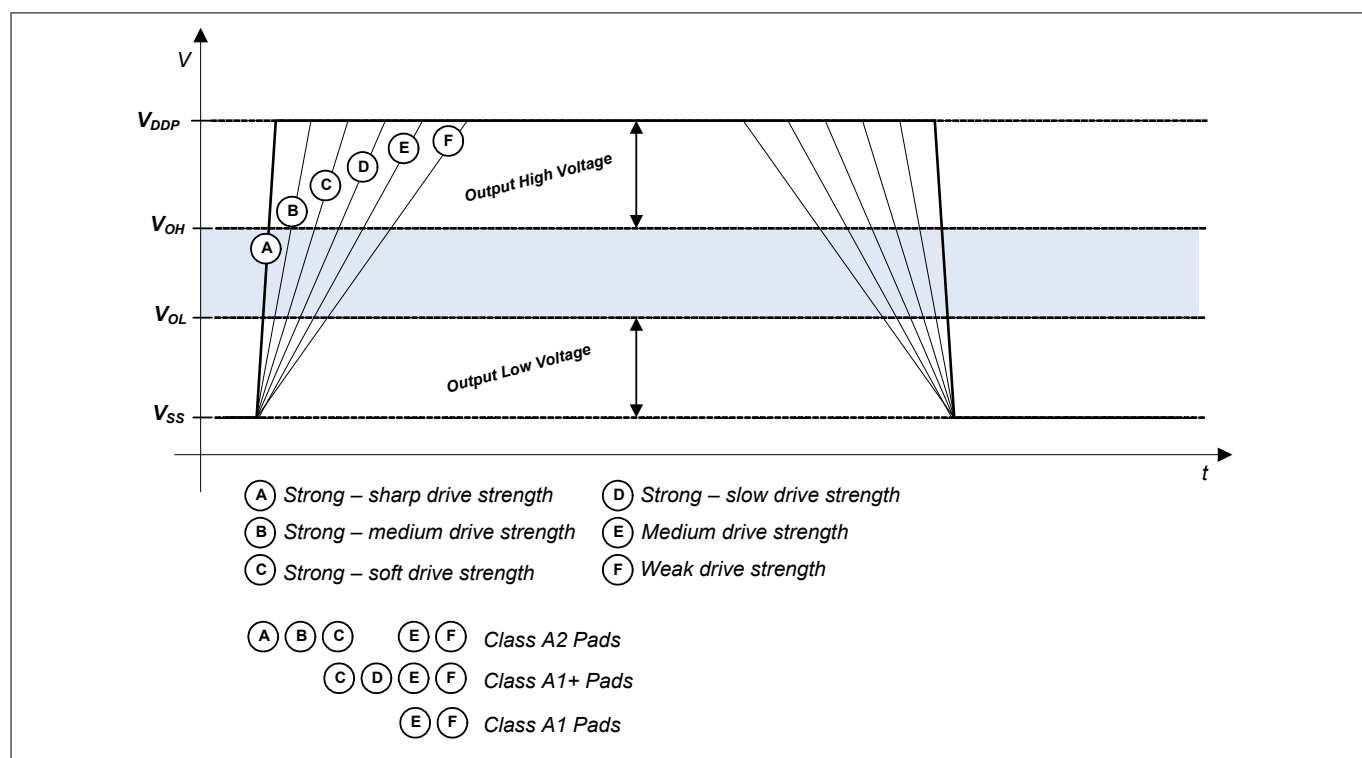


Figure 8 Output Slopes with different Pad Driver Modes

Figure 8 is a qualitative display of the resulting output slope performance with different output driver modes. The detailed input and output characteristics are listed in [Input/Output Pins](#).

3 Electrical Parameters

3.1.5 Operating Conditions

The following operating conditions must not be exceeded in order to ensure correct operation and reliability of the XMC4300. All parameters specified in the following sections refer to these operating conditions, unless noted otherwise.

Table 18 **Operating Conditions Parameters**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Ambient Temperature	T_A SR	-40	–	85	°C	Temp. Range F
		-40	–	125	°C	Temp. Range K
Digital supply voltage	V_{DDP} SR	3.13 ¹⁾	3.3	3.63 ²⁾	V	
Core Supply Voltage	V_{DDC} CC	- ¹⁾	1.3	–	V	Generated internally
Digital ground voltage	V_{SS} SR	0	–	–	V	
ADC analog supply voltage	V_{DDA} SR	3.0	3.3	3.6 ²⁾	V	
Analog ground voltage for V_{DDA}	V_{SSA} SR	-0.1	0	0.1	V	
Battery Supply Voltage for Hibernate Domain	V_{BAT} SR	1.95 ³⁾	–	3.63	V	When V_{DDP} is supplied V_{BAT} has to be supplied as well.
System Frequency	f_{SYS} SR	–	–	144	MHz	
Short circuit current of digital outputs	I_{SC} SR	-5	–	5	mA	
Absolute sum of short circuit currents per pin group ⁴⁾	ΣI_{SC_PG} SR	–	–	20	mA	
Absolute sum of short circuit currents of the device	ΣI_{SC_D} SR	–	–	100	mA	

1) See also the Supply Monitoring thresholds, [Power-Up and Supply Monitoring](#).

2) Voltage overshoot to 4.0 V is permissible at Power-Up and $\overline{PORST}$ low, provided the pulse duration is less than 100 μ s and the cumulated sum of the pulses does not exceed 1 h over lifetime.

3) To start the hibernate domain it is required that $V_{BAT} \geq 2.1$ V, for a reliable start of the oscillation of RTC_XTAL in crystal mode it is required that $V_{BAT} \geq 3.0$ V.

4) The port groups are defined in [Table 16](#).

3 Electrical Parameters

3.2 DC Parameters

3.2.1 Input/Output Pins

The digital input stage of the shared analog/digital input pins is identical to the input stage of the standard digital input/output pins.

The Pull-up on the $\overline{\text{PORST}}$ pin is identical to the Pull-up on the standard digital input/output pins.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 19 Standard Pad Parameters

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Pin capacitance (digital inputs/outputs)	C_{IO} CC	–	10	pF	
Pull-down current	$ I_{PDL} $ SR	150	–	μA	¹⁾ $V_{IN} \geq 0.6 \times V_{DDP}$
		–	10	μA	²⁾ $V_{IN} \leq 0.36 \times V_{DDP}$
Pull-up current	$ I_{PUH} $ SR	–	10	μA	²⁾ $V_{IN} \geq 0.6 \times V_{DDP}$
		100	–	μA	¹⁾ $V_{IN} \leq 0.36 \times V_{DDP}$
Input Hysteresis for pads of all A classes ³⁾	H_YSA CC	$0.1 \times V_{DDP}$	–	V	
$\overline{\text{PORST}}$ spike filter always blocked pulse duration	t_{SF1} CC	–	10	ns	
$\overline{\text{PORST}}$ spike filter pass-through pulse duration	t_{SF2} CC	100	–	ns	
$\overline{\text{PORST}}$ pull-down current	$ I_{PPD} $ CC	13	–	mA	$V_{IN} = 1.0 \text{ V}$

- 1) Current required to override the pull device with the opposite logic level (“force current”). With active pull device, at load currents between force and keep current the input state is undefined.
- 2) Load current at which the pull device still maintains the valid logic level (“keep current”). With active pull device, at load currents between force and keep current the input state is undefined.
- 3) Hysteresis is implemented to avoid metastable states and switching due to internal ground bounce. It can not be guaranteed that it suppresses switching due to external system noise.

3 Electrical Parameters

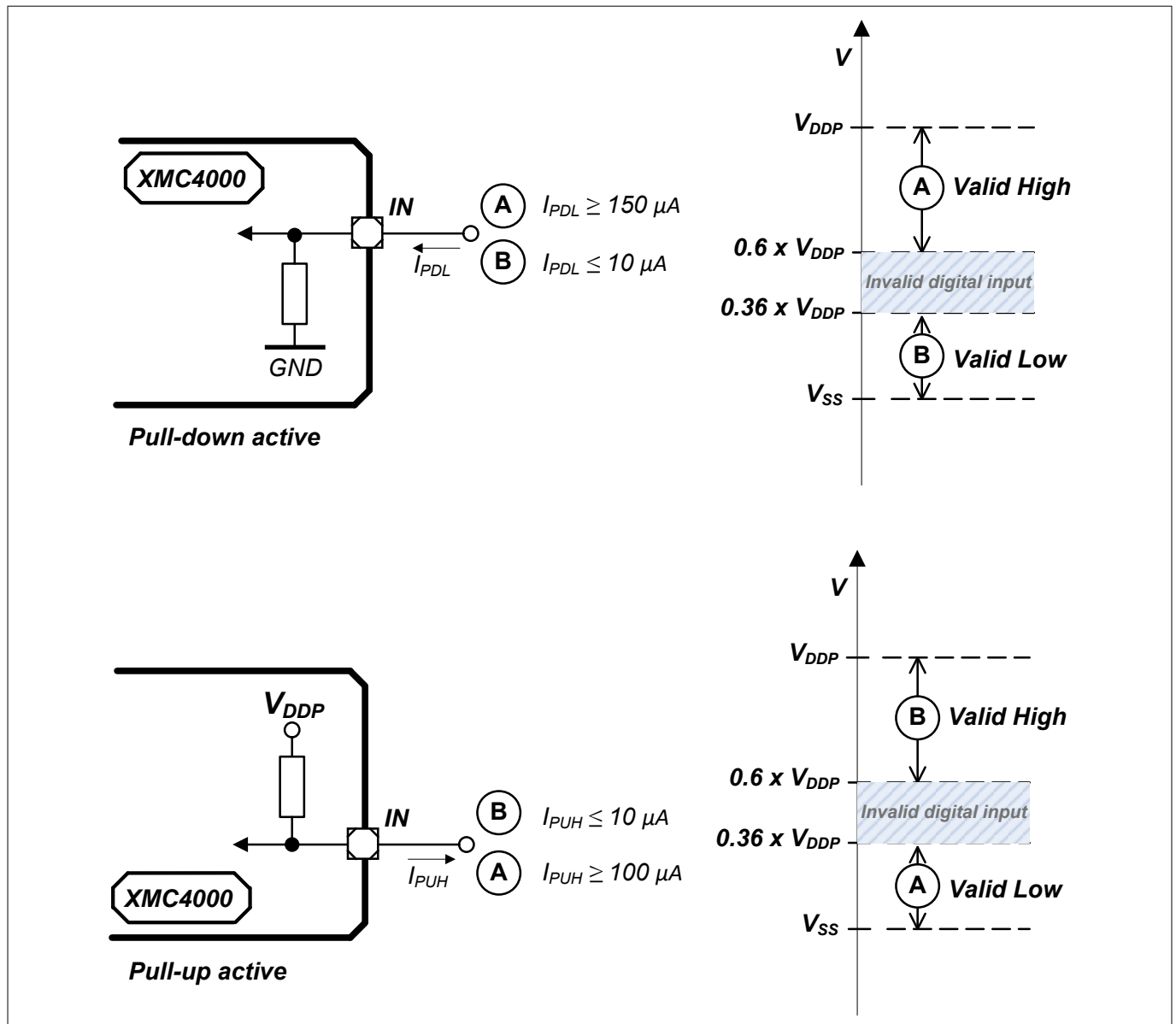


Figure 9 Pull Device Input Characteristics

Figure 9 visualizes the input characteristics with an active internal pull device:

- in the cases “A” the internal pull device is overridden by a strong external driver;
- in the cases “B” the internal pull device defines the input logical state against a weak external load

Table 20 Standard Pads Class_A1

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Input leakage current	$I_{OZA1\ CC}$	-500	500	nA	$0\text{ V} \leq V_{IN} \leq V_{DDP}$
Input high voltage	$V_{IHA1\ SR}$	$0.6 \times V_{DDP}$	$V_{DDP} + 0.3$	V	max. 3.6 V
Input low voltage	$V_{ILA1\ SR}$	-0.3	$0.36 \times V_{DDP}$	V	

(table continues...)

3 Electrical Parameters

Table 20 (continued) **Standard Pads Class_A1**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Output high voltage, POD ¹⁾ = weak	V _{OHA1} CC	V _{DDP} - 0.4	–	V	I _{OH} ≥ -400 μA
		2.4	–	V	I _{OH} ≥ -500 μA
Output high voltage, POD ¹⁾ = medium		V _{DDP} - 0.4	–	V	I _{OH} ≥ -1.4 mA
		2.4	–	V	I _{OH} ≥ -2 mA
Output low voltage	V _{OLA1} CC	–	0.4	V	I _{OL} ≤ 500 μA; POD ¹⁾ = weak
		–	0.4	V	I _{OL} ≤ 2 mA; POD ¹⁾ = medium
Fall time	t _{FA1} CC	–	150	ns	C _L = 20 pF; POD ¹⁾ = weak
		–	50	ns	C _L = 50 pF; POD ¹⁾ = medium
Rise time	t _{RA1} CC	–	150	ns	C _L = 20 pF; POD ¹⁾ = weak
		–	50	ns	C _L = 50 pF; POD ¹⁾ = medium

1) POD = Pin Out Driver

Table 21 **Standard Pads Class_A1+**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Input leakage current	I_{OZA1+} CC	-1	1	μA	$0\text{ V} \leq V_{IN} \leq V_{DDP}$
Input high voltage	V_{IHA1+} SR	$0.6 \times V_{DDP}$	$V_{DDP} + 0.3$	V	max. 3.6 V
Input low voltage	V_{ILA1+} SR	-0.3	$0.36 \times V_{DDP}$	V	
Output high voltage, POD ¹⁾ = weak	V_{OHA1+} CC	$V_{DDP} - 0.4$	–	V	$I_{OH} \geq -400\text{ }\mu\text{A}$
		2.4	–	V	$I_{OH} \geq -500\text{ }\mu\text{A}$
Output high voltage, POD ¹⁾ = medium		$V_{DDP} - 0.4$	–	V	$I_{OH} \geq -1.4\text{ mA}$
		2.4	–	V	$I_{OH} \geq -2\text{ mA}$
Output high voltage, POD ¹⁾ = strong		$V_{DDP} - 0.4$	–	V	$I_{OH} \geq -1.4\text{ mA}$
		2.4	–	V	$I_{OH} \geq -2\text{ mA}$

(table continues...)

3 Electrical Parameters

Table 21 (continued) **Standard Pads Class_A1+**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Output low voltage	V_{OLA1+} CC	–	0.4	V	$I_{OL} \leq 500 \mu A$; POD ¹⁾ = weak
		–	0.4	V	$I_{OL} \leq 2 \text{ mA}$; POD ¹⁾ = medium
		–	0.4	V	$I_{OL} \leq 2 \text{ mA}$; POD ¹⁾ = strong
Fall time	t_{FA1+} CC	–	150	ns	$C_L = 20 \text{ pF}$; POD ¹⁾ = weak
		–	50	ns	$C_L = 50 \text{ pF}$; POD ¹⁾ = medium
		–	28	ns	$C_L = 50 \text{ pF}$; POD ¹⁾ = strong; edge = slow
		–	16	ns	$C_L = 50 \text{ pF}$; POD ¹⁾ = strong; edge = soft;
Rise time	t_{RA1+} CC	–	150	ns	$C_L = 20 \text{ pF}$; POD ¹⁾ = weak
		–	50	ns	$C_L = 50 \text{ pF}$; POD ¹⁾ = medium
		–	28	ns	$C_L = 50 \text{ pF}$; POD ¹⁾ = strong; edge = slow
		–	16	ns	$C_L = 50 \text{ pF}$; POD ¹⁾ = strong; edge = soft

1) POD = Pin Out Driver

Table 22 **Standard Pads Class_A2**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Input Leakage current	I_{OZA2} CC	-6	6	μA	$0 \text{ V} \leq V_{IN} < 0.5 \cdot V_{DDP} - 1 \text{ V}$; $0.5 \cdot V_{DDP} + 1 \text{ V} < V_{IN} \leq V_{DDP}$
		-3	3	μA	$0.5 \cdot V_{DDP} - 1 \text{ V} < V_{IN} < 0.5 \cdot V_{DDP} + 1 \text{ V}$
Input high voltage	V_{IHA2} SR	$0.6 \times V_{DDP}$	$V_{DDP} + 0.3$	V	max. 3.6 V

(table continues...)

3 Electrical Parameters

Table 22 (continued) **Standard Pads Class_A2**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Input low voltage	V_{ILA2} SR	-0.3	$0.36 \times V_{DDP}$	V	
Output high voltage, POD = weak	V_{OHA2} CC	$V_{DDP} - 0.4$	–	V	$I_{OH} \geq -400 \mu A$
		2.4	–	V	$I_{OH} \geq -500 \mu A$
Output high voltage, POD = medium		$V_{DDP} - 0.4$	–	V	$I_{OH} \geq -1.4 \text{ mA}$
		2.4	–	V	$I_{OH} \geq -2 \text{ mA}$
Output high voltage, POD = strong		$V_{DDP} - 0.4$	–	V	$I_{OH} \geq -1.4 \text{ mA}$
		2.4	–	V	$I_{OH} \geq -2 \text{ mA}$
Output low voltage, POD = weak	V_{OLA2} CC	–	0.4	V	$I_{OL} \leq 500 \mu A$
Output low voltage, POD = medium		–	0.4	V	$I_{OL} \leq 2 \text{ mA}$
Output low voltage, POD = strong		–	0.4	V	$I_{OL} \leq 2 \text{ mA}$
Fall time	t_{FA2} CC	–	150	ns	$C_L = 20 \text{ pF}$; POD = weak
		–	50	ns	$C_L = 50 \text{ pF}$; POD = medium
		–	3.7	ns	$C_L = 50 \text{ pF}$; POD = strong; edge = sharp
		–	7	ns	$C_L = 50 \text{ pF}$; POD = strong; edge = medium
		–	16	ns	$C_L = 50 \text{ pF}$; POD = strong; edge = soft
Rise time	t_{RA2} CC	–	150	ns	$C_L = 20 \text{ pF}$; POD = weak
		–	50	ns	$C_L = 50 \text{ pF}$; POD = medium
		–	3.7	ns	$C_L = 50 \text{ pF}$; POD = strong; edge = sharp

(table continues...)

3 Electrical Parameters

Table 22 (continued) **Standard Pads Class_A2**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
		–	7.0	ns	$C_L = 50 \text{ pF}$; POD = strong; edge = medium
		–	16	ns	$C_L = 50 \text{ pF}$; POD = strong; edge = soft

Table 23 **HIB_IO Class_A1 special Pads**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Input leakage current	$I_{OZHIB \text{ CC}}$	-500	500	nA	$0 \text{ V} \leq V_{IN} \leq V_{BAT}$
Input high voltage	$V_{IHIB \text{ SR}}$	$0.6 \times V_{BAT}$	$V_{BAT} + 0.3$	V	max. 3.6 V
Input low voltage	$V_{ILIB \text{ SR}}$	-0.3	$0.36 \times V_{BAT}$	V	
Input Hysteresis for HIB_IO pins ¹⁾	$HYSHIB \text{ CC}$	$0.1 \times V_{BAT}$	–	V	$V_{BAT} \geq 3.13 \text{ V}$
		$0.06 \times V_{BAT}$	–	V	$V_{BAT} < 3.13 \text{ V}$
Output high voltage, POD ¹⁾ = medium	$V_{OHHIB \text{ CC}}$	$V_{BAT} - 0.4$	–	V	$I_{OH} \geq -1.4 \text{ mA}$
Output low voltage	$V_{OLHIB \text{ CC}}$	–	0.4	V	$I_{OL} \leq 2 \text{ mA}$
Fall time	$t_{FHIB \text{ CC}}$	–	50	ns	$V_{BAT} \geq 3.13 \text{ V}$ $C_L = 50 \text{ pF}$
		–	100	ns	$V_{BAT} < 3.13 \text{ V}$ $C_L = 50 \text{ pF}$
Rise time	$t_{RHIB \text{ CC}}$	–	50	ns	$V_{BAT} \geq 3.13 \text{ V}$ $C_L = 50 \text{ pF}$
		–	100	ns	$V_{BAT} < 3.13 \text{ V}$ $C_L = 50 \text{ pF}$

1) Hysteresis is implemented to avoid metastable states and switching due to internal ground bounce. It can not be guaranteed that it suppresses switching due to external system noise.

3 Electrical Parameters

3.2.2 Analog to Digital Converters (VADC)

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 24 VADC Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Analog reference voltage ¹⁾	V_{AREF} SR	$V_{AGND} + 1$	–	$V_{DDA} + 0.05$ ²⁾	V	
Analog reference ground ¹⁾	V_{AGND} SR	$V_{SSM} - 0.05$	–	$V_{AREF} - 1$	V	
Analog reference voltage range ^{1) 3)}	$V_{AREF} - V_{AGND}$ SR	1	–	$V_{DDA} + 0.1$	V	
Analog input voltage	V_{AIN} SR	V_{AGND}	–	V_{DDA}	V	
Input leakage at analog inputs ⁴⁾	I_{OZ1} CC	-100	–	200	nA	$0.03 \times V_{DDA} < V_{AIN} < 0.97 \times V_{DDA}$
		-500	–	100	nA	$0 \text{ V} \leq V_{AIN} \leq 0.03 \times V_{DDA}$
		-100	–	500	nA	$0.97 \times V_{DDA} \leq V_{AIN} \leq V_{DDA}$
Input leakage current at V_{AREF}	I_{OZ2} CC	-1	–	1	μA	$0 \text{ V} \leq V_{AREF} \leq V_{DDA}$
Input leakage current at V_{AGND}	I_{OZ3} CC	-1	–	1	μA	$0 \text{ V} \leq V_{AGND} \leq V_{DDA}$
Internal ADC clock	f_{ADCI} CC	2	–	36	MHz	$V_{DDA} = 3.3 \text{ V}$
Switched capacitance at the analog voltage inputs ⁵⁾	C_{AINSW} CC	–	4	6.5	pF	
Total capacitance of an analog input	C_{AINTOT} CC	–	12	20	pF	
Switched capacitance at the positive reference voltage input ^{1) 6)}	C_{AREFSW} CC	–	15	30	pF	
Total capacitance of the voltage reference inputs ¹⁾	$C_{AREFTOT}$ CC	–	20	40	pF	
Total Unadjusted Error	TUE CC	-4	–	4	LSB	12-bit resolution; $V_{DDA} = 3.3 \text{ V}$; $V_{AREF} = V_{DDA}$ ⁷⁾
Differential Non-Linearity Error ⁸⁾	EA_{DNL} CC	-3	–	3	LSB	
Gain Error ⁸⁾	EA_{GAIN} CC	-4	–	4	LSB	
Integral Non-Linearity ⁸⁾	EA_{INLCC}	-3	–	3	LSB	
Offset Error ⁸⁾	EA_{OFF} CC	-4	–	4	LSB	
RMS Noise ⁹⁾	E_{NRMS} CC	–	1	$2^{10) 11)}$	LSB	
Worst case ADC V_{DDA} power supply current per active converter	I_{DDAA} CC	–	1.5	2	mA	during conversion $V_{DDP} = 3.6 \text{ V}$, $T_J = 150^\circ\text{C}$

(table continues...)

3 Electrical Parameters

Table 24 (continued) VADC Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Charge consumption on V_{AREF} per conversion ¹⁾	Q_{CONV} CC	–	30	–	pC	$0\text{ V} \leq V_{AREF} \leq V_{DDA}$ ¹²⁾
ON resistance of the analog input path	R_{AIN} CC	–	600	1200	Ohm	
ON resistance for the ADC test (pull down for AIN7)	R_{AIN7T} CC	180	550	900	Ohm	
Resistance of the reference voltage input path	R_{AREF} CC	–	700	1700	Ohm	

- 1) Applies to AINx, when used as alternate reference input.
- 2) A running conversion may become imprecise in case the normal conditions are violated (voltage overshoot).
- 3) If the analog reference voltage is below V_{DDA} , then the ADC converter errors increase. If the reference voltage is reduced by the factor k ($k < 1$), TUE, DNL, INL, Gain, and Offset errors increase also by the factor $1/k$.
- 4) The leakage current definition is a continuous function, as shown in figure ADCx Analog Inputs Leakage. The numerical values defined determine the characteristic points of the given continuous linear approximation - they do not define step function (see Figure 12).
- 5) The sampling capacity of the conversion C-network is pre-charged to $V_{AREF}/2$ before the sampling moment. Because of the parasitic elements, the voltage measured at AINx can deviate from $V_{AREF}/2$.
- 6) This represents an equivalent switched capacitance. This capacitance is not switched to the reference voltage at once. Instead, smaller capacitances are successively switched to the reference voltage.
- 7) For 10-bit conversions, the errors are reduced to $1/4$; for 8-bit conversions, the errors are reduced to $1/16$. Never less than ± 1 LSB.
- 8) The sum of DNL/INL/GAIN/OFF errors does not exceed the related total unadjusted error TUE.
- 9) This parameter is valid for soldered devices and requires careful analog board design.
- 10) Resulting worst case combined error is arithmetic combination of TUE and EN_{RMS} .
- 11) Value is defined for one sigma Gauss distribution.
- 12) The resulting current for a conversion can be calculated with $I_{AREF} = Q_{CONV} / t_c$. The fastest 12-bit post-calibrated conversion of $t_c = 459\text{ ns}$ results in a typical average current of $I_{AREF} = 65.4\text{ }\mu\text{A}$.

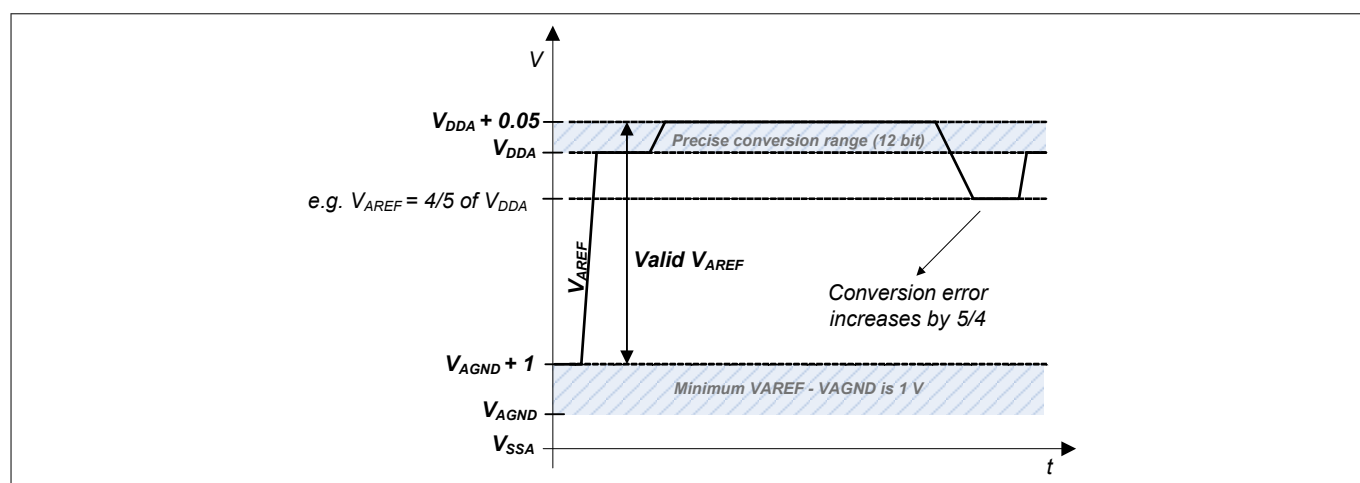


Figure 10 VADC Reference Voltage Range

The power-up calibration of the VADC requires a maximum number of $4352 f_{ADC}$ cycles.

3 Electrical Parameters

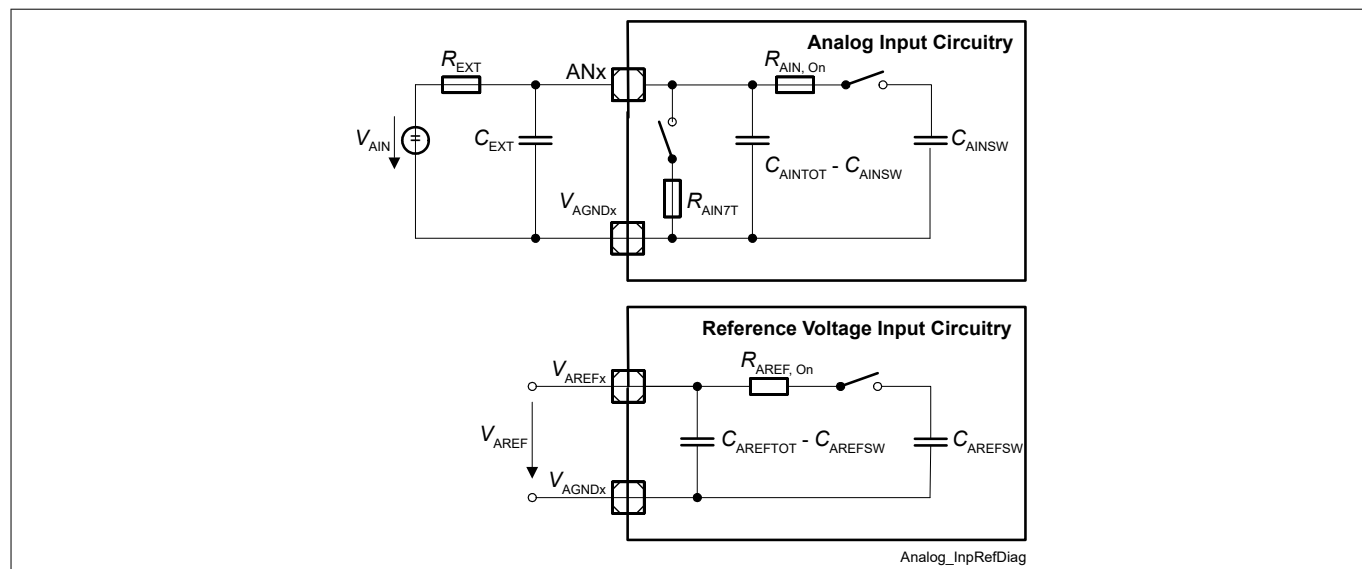


Figure 11 VADC Input Circuits

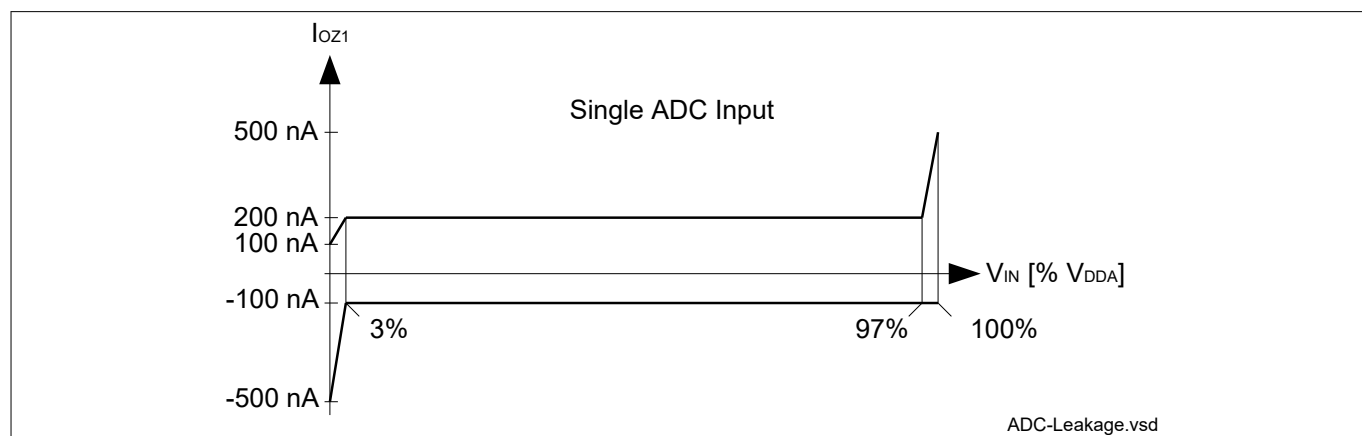


Figure 12 VADC Analog Input Leakage Current

Conversion Time

Table 25 Conversion Time (Operating Conditions apply)

Parameter	Symbol	Values	Unit	Note
Conversion time	t_C CC	$2 \times T_{ADC} + (2 + N + STC + PC + DM) \times T_{ADCI}$	μs	N = 8, 10, 12 for N-bit conversion $T_{ADC} = 1/f_{PERIPH}$ $T_{ADCI} = 1/f_{ADCI}$

- STC defines additional clock cycles to extend the sample time
- PC adds two cycles if post-calibration is enabled
- DM adds one cycle for an extended conversion time of the MSB

3 Electrical Parameters

Conversion Time Examples

System assumptions:

$f_{ADC} = 144 \text{ MHz}$ that is $t_{ADC} = 6.9 \text{ ns}$, $DIVA = 3$, $f_{ADCI} = 36 \text{ MHz}$ that is $t_{ADCI} = 27.8 \text{ ns}$

According to the given formulas the following minimum conversion times can be achieved ($STC = 0$, $DM = 0$):

12-bit post-calibrated conversion ($PC = 2$):

$$t_{CN12C} = (2 + 12 + 2) \times t_{ADCI} + 2 \times t_{ADC} = 16 \times 27.8 \text{ ns} + 2 \times 6.9 \text{ ns} = 459 \text{ ns}$$

12-bit uncalibrated conversion:

$$t_{CN12} = (2 + 12) \times t_{ADCI} + 2 \times t_{ADC} = 14 \times 27.8 \text{ ns} + 2 \times 6.9 \text{ ns} = 403 \text{ ns}$$

10-bit uncalibrated conversion:

$$t_{CN10} = (2 + 10) \times t_{ADCI} + 2 \times t_{ADC} = 12 \times 27.8 \text{ ns} + 2 \times 6.9 \text{ ns} = 348 \text{ ns}$$

8-bit uncalibrated:

$$t_{CN8} = (2 + 8) \times t_{ADCI} + 2 \times t_{ADC} = 10 \times 27.8 \text{ ns} + 2 \times 6.9 \text{ ns} = 292 \text{ ns}$$

3.2.3 Digital to Analog Converters (DAC)

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 26 DAC Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
RMS supply current	$I_{DD \text{ CC}}$	–	2.5	4	mA	per active DAC channel, without load currents of DAC outputs
Resolution	$RES \text{ CC}$	–	12	–	Bit	
Update rate	$f_{URATE_A \text{ CC}}$	–		2	Msample/s	data rate, where DAC can follow 64 LSB code jumps to ± 1 LSB accuracy
Update rate	$f_{URATE_F \text{ CC}}$	–		5	Msample/s	data rate, where DAC can follow 64 LSB code jumps to ± 4 LSB accuracy
Settling time	$t_{SETTLE \text{ CC}}$	–	1	2	μs	at full scale jump, output voltage reaches target value ± 20 LSB
Slew rate	$SR \text{ CC}$	2	5	–	V/ μs	

(table continues...)

3 Electrical Parameters

Table 26 (continued) DAC Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Minimum output voltage	$V_{OUT_MIN\ CC}$	–	0.3	–	V	code value unsigned: 000 _H ; signed: 800 _H
Maximum output voltage	$V_{OUT_MAX\ CC}$	–	2.5	–	V	code value unsigned: FFF _H ; signed: 7FF _H
Integral non-linearity	$INL\ CC$	-5.5	±2.5	5.5	LSB	$R_L \geq 5\ k\Omega$, $C_L \leq 50\ pF$
Differential non-linearity	$DNL\ CC$	-2	±1	2	LSB	$R_L \geq 5\ k\Omega$, $C_L \leq 50\ pF$
Offset error	$ED_{OFF\ CC}$		±20		mV	
Gain error	$ED_{G_IN\ CC}$	-6.5	-1.5	3	%	
Startup time	$t_{STARTUP\ CC}$	–	15	30	µs	time from output enabling till code valid ±16 LSB
3dB Bandwidth of Output Buffer	$f_{C1\ CC}$	2.5	5	–	MHz	verified by design
Output sourcing current	$I_{OUT_SOURCE\ CC}$	–	-30	–	mA	
Output sinking current	$I_{OUT_SINK\ CC}$	–	0.6	–	mA	
Output resistance	$R_{OUT\ CC}$	–	50	–	Ohm	
Load resistance	$R_L\ SR$	5	–	–	kOhm	
Load capacitance	$C_L\ SR$	–	–	50	pF	
Signal-to-Noise Ratio	$SNR\ CC$	–	70	–	dB	examination bandwidth < 25 kHz
Total Harmonic Distortion	$THD\ CC$	–	70	–	dB	examination bandwidth < 25 kHz

(table continues...)

3 Electrical Parameters

Table 26 (continued) DAC Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Power Supply Rejection Ratio	<i>PSRR CC</i>	–	56	–	dB	to V_{DDA} verified by design

Conversion Calculation

Unsigned:

$$DACxDATA = 4095 \times (V_{OUT} - V_{OUT_MIN}) / (V_{OUT_MAX} - V_{OUT_MIN})$$

Signed:

$$DACxDATA = 4095 \times (V_{OUT} - V_{OUT_MIN}) / (V_{OUT_MAX} - V_{OUT_MIN}) - 2048$$

3 Electrical Parameters

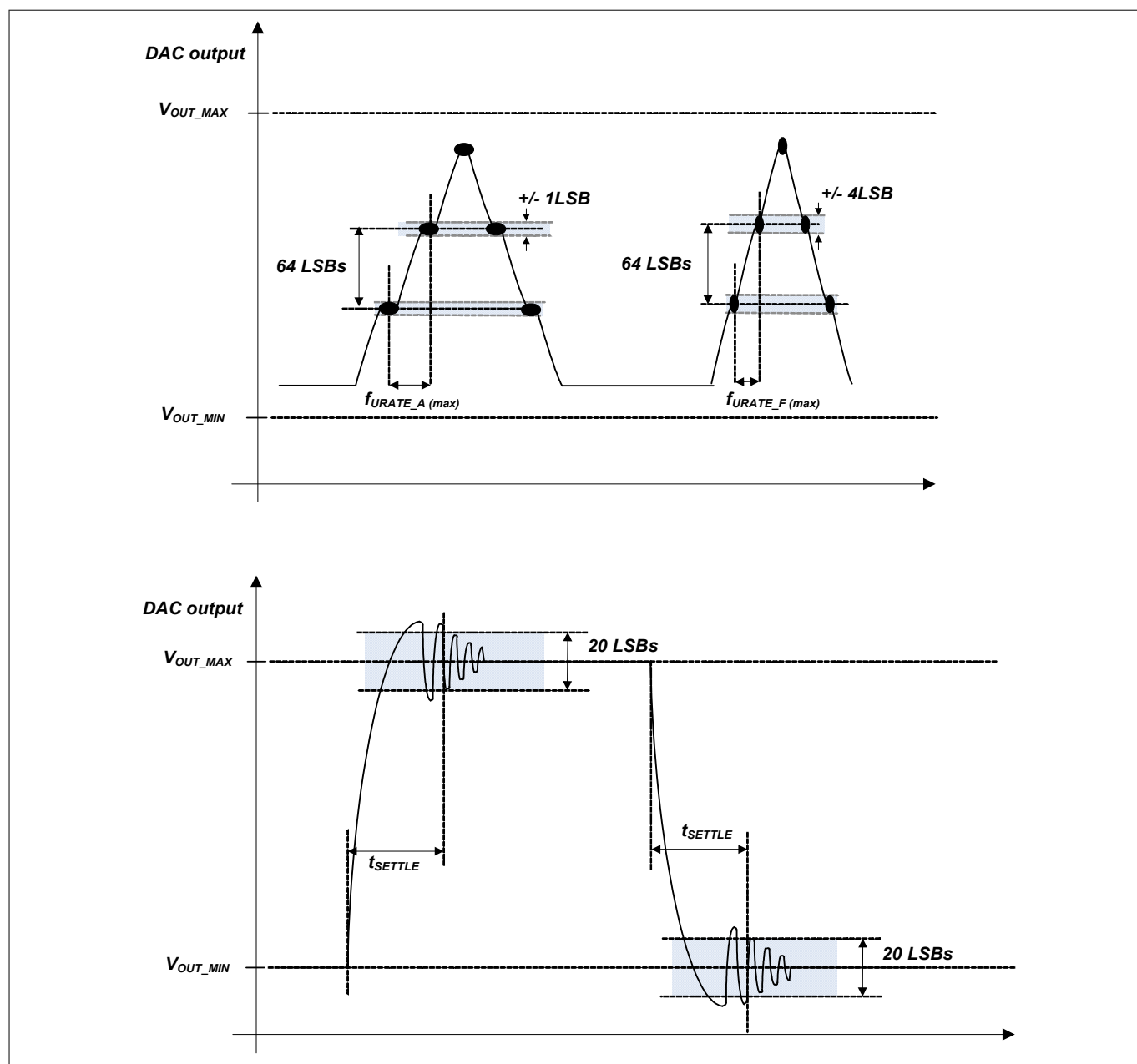


Figure 13 **DAC Conversion Examples**

3 Electrical Parameters

3.2.4 Out-of-Range Comparator (ORC)

The Out-of-Range Comparator (ORC) triggers on analog input voltages (V_{AIN}) above the analog reference¹⁾ (V_{AREF}) on selected input pins (GxORCy) and generates a service request trigger (GxORCOUTy).

Note: These parameters are not subject to production test, but verified by design and/or characterization.

The parameters in Table 27 apply for the maximum reference voltage $V_{AREF} = V_{DDA} + 50$ mV.

Table 27 ORC Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
DC Switching Level	V_{ODC} CC	100	125	210	mV	$V_{AIN} \geq V_{AREF} + V_{ODC}$
Hysteresis	V_{OHYS} CC	50	–	V_{ODC}	mV	
Detection Delay of a persistent Overvoltage	t_{ODD} CC	50	–	450	ns	$V_{AIN} \geq V_{AREF} + 210$ mV
		45	–	105	ns	$V_{AIN} \geq V_{AREF} + 400$ mV
Always detected Overvoltage Pulse	t_{OPDD} CC	440	–	–	ns	$V_{AIN} \geq V_{AREF} + 210$ mV
		90	–	–	ns	$V_{AIN} \geq V_{AREF} + 400$ mV
Never detected Overvoltage Pulse	t_{OPDN} CC	–	–	45	ns	$V_{AIN} \geq V_{AREF} + 210$ mV
		–	–	30	ns	$V_{AIN} \geq V_{AREF} + 400$ mV
Release Delay	t_{ORD} CC	65	–	105	ns	$V_{AIN} \leq V_{AREF}$
Enable Delay	t_{OED} CC	–	100	200	ns	

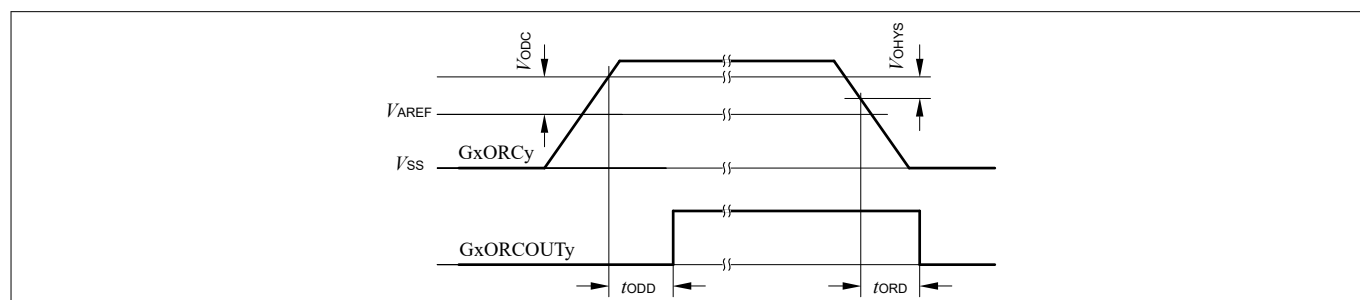


Figure 14 GxORCOUTy Trigger Generation

¹ Always the standard VADC reference, alternate references do not apply to the ORC.

3 Electrical Parameters

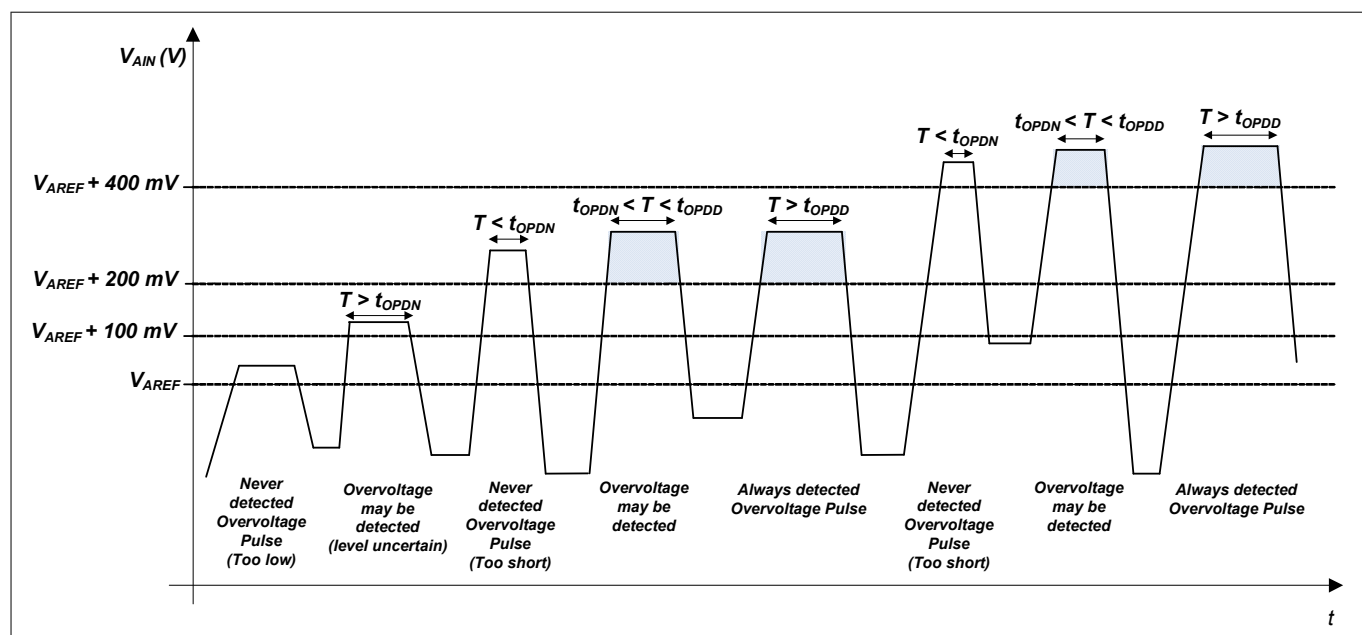


Figure 15 ORC Detection Ranges

3.2.5 Die Temperature Sensor

The Die Temperature Sensor (DTS) measures the junction temperature T_J .

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 28 Die Temperature Sensor Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Temperature sensor range	T_{SR} SR	-40	–	150	°C	
Linearity Error (to the below defined formula)	ΔT_{LE} CC	–	±1	–	°C	per $\Delta T_J \leq 30^\circ\text{C}$
Offset Error	ΔT_{OE} CC	–	±6	–	°C	$\Delta T_{OE} = T_J - T_{DTS}$ $V_{DDP} \leq 3.3 \text{ V}^{1)}$
Measurement time	t_M CC	–	–	100	µs	
Start-up time after reset inactive	t_{TSST} SR	–	–	10	µs	

1) At $V_{DDP_max} = 3.63 \text{ V}$ the typical offset error increases by an additional $\Delta T_{OE} = \pm 1^\circ\text{C}$.

3 Electrical Parameters

The following formula calculates the temperature measured by the DTS in [°C] from the RESULT bit field of the DTSSTAT register.

$$\text{Temperature } T_{\text{DTS}} = (\text{RESULT} - 605) / 2.05 \text{ [°C]}$$

This formula and the values defined in Table 28 apply with the following calibration values:

- DTSCON.BGTRIM = 8_H
- DTSCON.REFTRIM = 4_H

3.2.6 USB OTG Interface DC Characteristics

The Universal Serial Bus (USB) Interface is compliant to the USB Rev. 2.0 Specification and the OTG Specification Rev. 1.3. High-Speed Mode is not supported.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 29 USB OTG VBUS and ID Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
VBUS input voltage range	$V_{\text{IN CC}}$	0.0	–	5.25	V	
A-device VBUS valid threshold	$V_{\text{B1 CC}}$	4.4	–	–	V	
A-device session valid threshold	$V_{\text{B2 CC}}$	0.8	–	2.0	V	
B-device session valid threshold	$V_{\text{B3 CC}}$	0.8	–	4.0	V	
B-device session end threshold	$V_{\text{B4 CC}}$	0.2	–	0.8	V	
VBUS input resistance to ground	$R_{\text{VBUS_IN CC}}$	40	–	100	kOhm	
B-device VBUS pull-up resistor	$R_{\text{VBUS_PU CC}}$	281	–	–	Ohm	Pull-up voltage = 3.0 V
B-device VBUS pull-down resistor	$R_{\text{VBUS_PD CC}}$	656	–	–	Ohm	
USB.ID pull-up resistor	$R_{\text{UID_PU CC}}$	14	–	25	kOhm	
VBUS input current	$I_{\text{VBUS_IN CC}}$	–	–	150	μA	0 V ≤ V_{IN} ≤ 5.25 V: T_{AVG} = 1 ms

Table 30 USB OTG Data Line (USB_DP, USB_DM) Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input low voltage	$V_{\text{IL SR}}$	–	–	0.8	V	
Input high voltage (driven)	$V_{\text{IH SR}}$	2.0	–	–	V	
Input high voltage (floating) ¹⁾	$V_{\text{IHZ SR}}$	2.7	–	3.6	V	
Differential input sensitivity	$V_{\text{DIS CC}}$	0.2	–	–	V	

(table continues...)

3 Electrical Parameters

Table 30 (continued) **USB OTG Data Line (USB_DP, USB_DM) Parameters (Operating Conditions apply)**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Differential common mode range	V_{CM} CC	0.8	–	2.5	V	
Output low voltage	V_{OL} CC	0.0	–	0.3	V	1.5 kOhm pull-up to 3.6 V
Output high voltage	V_{OH} CC	2.8	–	3.6	V	15 kOhm pull-down to 0 V
DP pull-up resistor (idle bus)	R_{PUI} CC	900	–	1575	Ohm	
DP pull-up resistor (upstream port receiving)	R_{PUA} CC	1425	–	3090	Ohm	
DP, DM pull-down resistor	R_{PD} CC	14.25	–	24.8	kOhm	
Input impedance DP, DM	Z_{INP} CC	300	–	–	kOhm	$0\text{ V} \leq V_{IN} \leq V_{DDP}$
Driver output resistance DP, DM	Z_{DRV} CC	28	–	44	Ohm	

1) Measured at A-connector with $1.5\text{ kOhm} \pm 5\%$ to $3.3\text{ V} \pm 0.3\text{ V}$ connected to USB_DP or USB_DM and at B-connector with $15\text{ kOhm} \pm 5\%$ to ground connected to USB_DP and USB_DM.

3.2.7 Oscillator Pins

Note: *It is strongly recommended to measure the oscillation allowance (negative resistance) in the final target system (layout) to determine the optimal parameters for the oscillator operation. Please refer to the limits specified by the crystal or ceramic resonator supplier.*

Note: *These parameters are not subject to production test, but verified by design and/or characterization.*

The oscillator pins can be operated with an external crystal (see [Figure 16](#)) or in direct input mode (see [Figure 17](#)).

3 Electrical Parameters

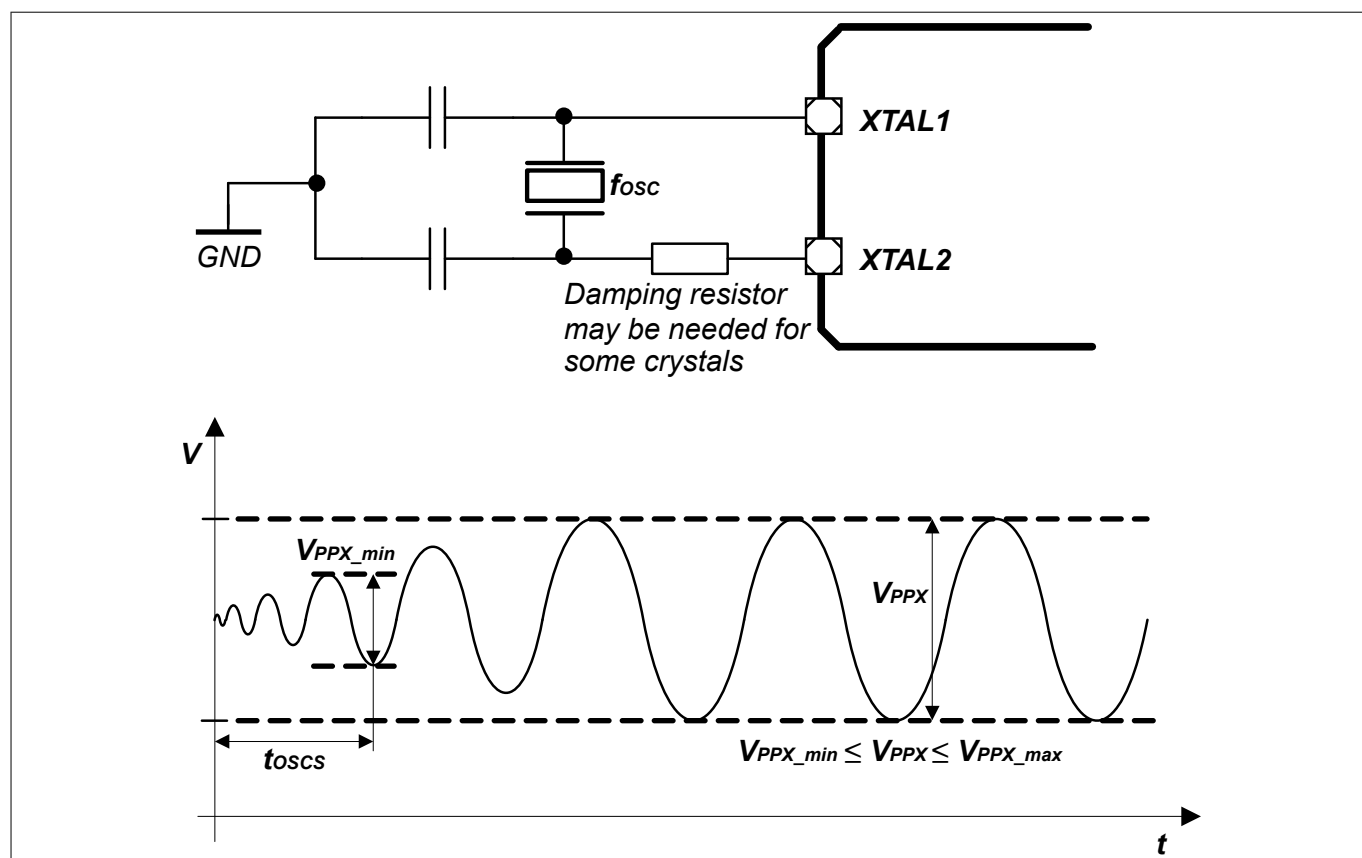


Figure 16 **Oscillator in Crystal Mode**

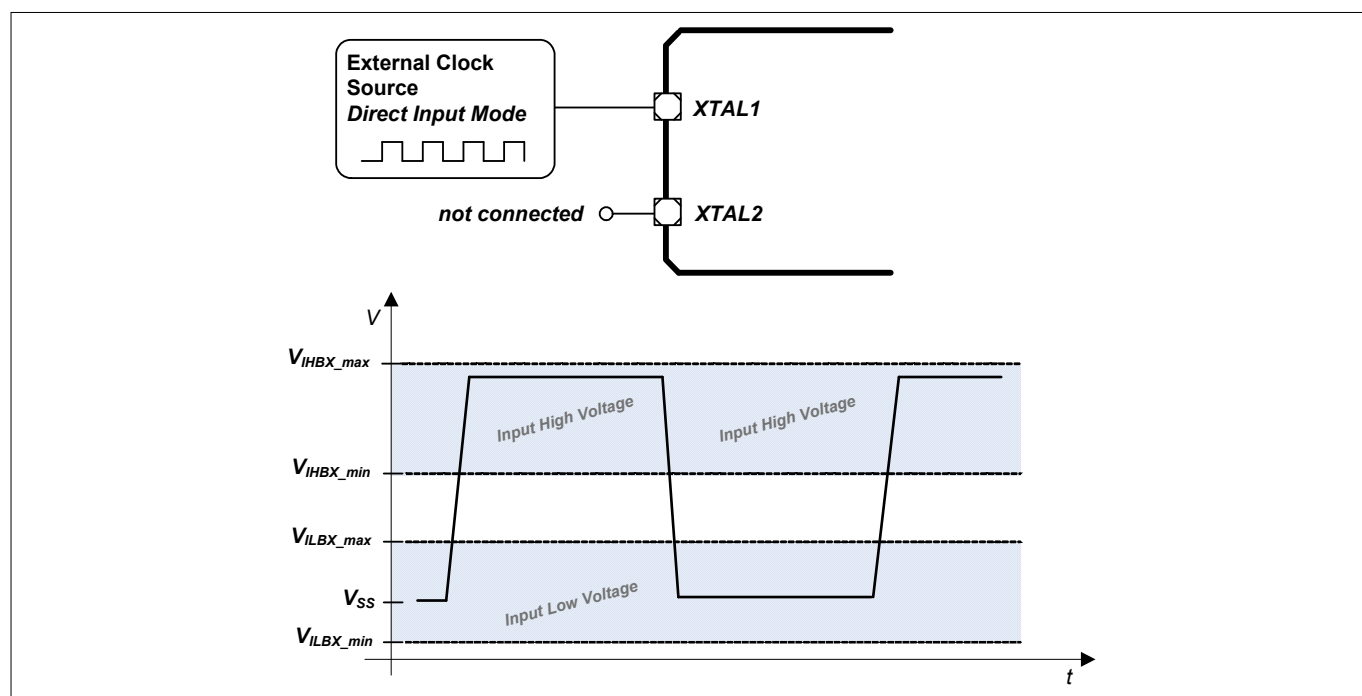


Figure 17 **Oscillator in Direct Input Mode**

3 Electrical Parameters

Table 31 OSC_XTAL Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input frequency	f_{OSC} SR	4	–	40	MHz	Direct Input Mode selected
		4	–	25	MHz	External Crystal Mode selected
Oscillator start-up time ^{1) 2)}	t_{OSCS} CC	–	–	10	ms	
Input voltage at XTAL1	V_{IX} SR	-0.5	–	$V_{DDP} + 0.5$	V	
Input amplitude (peak-to-peak) at XTAL1 ^{2) 3)}	V_{PPX} SR	$0.4 \times V_{DDP}$	–	$V_{DDP} + 1.0$	V	
Input high voltage at XTAL1 ⁴⁾	V_{IHBX} SR	1.0	–	$V_{DDP} + 0.5$	V	
Input low voltage at XTAL1 ⁴⁾	V_{ILBX} SR	-0.5	–	0.4	V	
Input leakage current at XTAL1	I_{ILX1} CC	-100	–	100	nA	Oscillator power down $0 V \leq V_{IX} \leq V_{DDP}$

- 1) t_{OSCS} is defined from the moment the oscillator is enabled with SCU_OSCHPCTRL.MODE until the oscillations reach an amplitude at XTAL1 of $0.4 \times V_{DDP}$.
- 2) The external oscillator circuitry must be optimized by the customer and checked for negative resistance and amplitude as recommended and specified by crystal suppliers.
- 3) If the shaper unit is enabled and not bypassed.
- 4) If the shaper unit is bypassed, dedicated DC-thresholds have to be met.

Table 32 RTC_XTAL Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input frequency	f_{OSC} SR	–	32.768	–	kHz	
Oscillator start-up time ^{1) 2) 3)}	t_{OSCS} CC	–	–	5	s	
Input voltage at RTC_XTAL1	V_{IX} SR	-0.3	–	$V_{BAT} + 0.3$	V	
Input amplitude (peak-to-peak) at RTC_XTAL1 ^{2) 4)}	V_{PPX} SR	0.4	–	–	V	
Input high voltage at RTC_XTAL1 ⁵⁾	V_{IHBX} SR	$0.6 \times V_{BAT}$	–	$V_{BAT} + 0.3$	V	
Input low voltage at RTC_XTAL1 ⁵⁾	V_{ILBX} SR	-0.3	–	$0.36 \times V_{BAT}$	V	
Input Hysteresis for RTC_XTAL1 ^{5) 6)}	V_{HYSX} CC	$0.1 \times V_{BAT}$		–	V	$3.0 V \leq V_{BAT} < 3.6 V$
		$0.03 \times V_{BAT}$		–	V	$V_{BAT} < 3.0 V$

(table continues...)

3 Electrical Parameters

Table 32 (continued) **RTC_XTAL Parameters**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Input leakage current at RTC_XTAL1	$I_{ILX1\ CC}$	-100	–	100	nA	Oscillator power down $0\text{ V} \leq V_{IX} \leq V_{BAT}$

- 1) t_{OSCS} is defined from the moment the oscillator is enabled by the user with SCU_OSCULCTRL.MODE until the oscillations reach an amplitude at RTC_XTAL1 of 400 mV.
- 2) The external oscillator circuitry must be optimized by the customer and checked for negative resistance and amplitude as recommended and specified by crystal suppliers.
- 3) For a reliable start of the oscillation in crystal mode it is required that $V_{BAT} \geq 3.0\text{ V}$. A running oscillation is maintained across the full V_{BAT} voltage range.
- 4) If the shaper unit is enabled and not bypassed.
- 5) If the shaper unit is bypassed, dedicated DC-thresholds have to be met.
- 6) Hysteresis is implemented to avoid metastable states and switching due to internal ground bounce. It can not be guaranteed that it suppresses switching due to external system noise.

3.2.8 Power Supply Current

The total power supply current defined below consists of a leakage and a switching component.

Application relevant values are typically lower than those given in the following tables, and depend on the customer's system operating conditions (e.g. thermal connection or used application configurations).

Note: These parameters are not subject to production test, but verified by design and/or characterization.

If not stated otherwise, the operating conditions for the parameters in the following table are:

$$V_{DDP} = 3.3\text{ V}, T_A = 25^\circ\text{C}$$

Table 33 **Power Supply Parameters**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Active supply current ^{1) 2)} Peripherals enabled Frequency: $f_{CPU} / f_{PERIPH} / f_{CCU}$ in MHz	$I_{DDPA\ CC}$	–	135	–	mA	144/144/144
		–	125	–		144/72/72
		–	97	–		72/72/144
		–	80	–		24/24/24
		–	68	–		1/1/1
Active supply current Code execution from RAM Flash in Sleep mode	$I_{DDPA\ CC}$	–	108	–	mA	144/144/144
		–	98	–		144/72/72
Active supply current ³⁾ Peripherals disabled Frequency: $f_{CPU} / f_{PERIPH} / f_{CCU}$ in MHz	$I_{DDPA\ CC}$	–	86	–	mA	144/144/144
		–	85	–		144/72/72
		–	70	–		72/72/144
		–	55	–		24/24/24
		–	50	–		1/1/1

(table continues...)

3 Electrical Parameters

Table 33 (continued) Power Supply Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Sleep supply current ⁴⁾ Peripherals enabled Frequency: $f_{CPU} / f_{PERIPH} / f_{CCU}$ in MHz	$I_{DDPS\ CC}$	–	127	–	mA	144/144/144
		–	115	–		144/72/72
		–	93	–		72/72/144
		–	57	–		24/24/24
		–	47	–		1/1/1
$f_{CPU} / f_{PERIPH} / f_{CCU}$ in kHz		–	48	–		100/100/100
Sleep supply current ⁵⁾ Peripherals disabled Frequency: $f_{CPU} / f_{PERIPH} / f_{CCU}$ in MHz	$I_{DDPS\ CC}$	–	77	–	mA	144/144/144
		–	76	–		144/72/72
		–	65	–		72/72/144
		–	53	–		24/24/24
		–	46	–		1/1/1
$f_{CPU} / f_{PERIPH} / f_{CCU}$ in kHz		–	47	–		100/100/100
Deep Sleep supply current ⁶⁾ Flash in Sleep mode Frequency: $f_{CPU} / f_{PERIPH} / f_{CCU}$ in MHz	$I_{DDPD\ CC}$	–	11	–	mA	24/24/24
		–	7.0	–		4/4/4
		–	6.6	–		1/1/1
		–	7.6	–		100/100/100 ⁷⁾
Hibernate supply current RTC on ⁸⁾	$I_{DDPH\ CC}$	–	8.7	–	μA	$V_{BAT} = 3.3\ V$
		–	6.5	–		$V_{BAT} = 2.4\ V$
		–	5.7	–		$V_{BAT} = 2.0\ V$
Hibernate supply current RTC off ⁹⁾	$I_{DDPH\ CC}$	–	8.0	–	μA	$V_{BAT} = 3.3\ V$
		–	6.0	–		$V_{BAT} = 2.4\ V$
		–	5.0	–		$V_{BAT} = 2.0\ V$
Hibernate off ¹⁰⁾	$I_{DDPH\ CC}$	–	4.4	–	μA	$V_{BAT} = 3.3\ V$
		–	3.5	–		$V_{BAT} = 2.4\ V$
		–	3.1	–		$V_{BAT} = 2.0\ V$
Worst case active supply current ¹¹⁾	$I_{DDPA\ CC}$	–	–	250 ²⁾	mA	$V_{DDP} = 3.6\ V$, $T_J = 150^\circ C$
V_{DDA} power supply current	$I_{DDA\ CC}$	–	–	– ¹²⁾	mA	
I_{DDP} current at $\overline{PORST}$ Low	$I_{DDP_PORST\ CC}$	–	5	10	mA	$V_{DDP} = 3.3\ V$, $T_J = 25^\circ C$
		–	13	55	mA	$V_{DDP} = 3.6\ V$, $T_J = 150^\circ C$

(table continues...)

3 Electrical Parameters

Table 33 (continued) Power Supply Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Power Dissipation	$P_{DISS\ CC}$	–	–	1.4	W	$V_{DDP} = 3.6\text{ V}$, $T_J = 150^\circ\text{C}$
Wake-up time from Sleep to Active mode	$t_{SSA\ CC}$	–	6	–	cycles	
Wake-up time from Deep Sleep to Active mode		–	–	–	ms	Defined by the wake-up of the Flash module, see “Flash Memory Parameters”
Wake-up time from Hibernate mode		–	–	–	ms	Wake-up via power-on reset event, see “Power-Up and Supply Monitoring”

- 1) CPU executing code from Flash, all peripherals idle.
- 2) I_{DDP} decreases typically by approximately 5 mA when f_{SYS} decreases by 10 MHz, at constant T_J .
- 3) CPU executing code from Flash.
- 4) CPU in sleep, all peripherals idle, Flash in Active mode.
- 5) CPU in sleep, Flash in Active mode.
- 6) CPU in sleep, peripherals disabled, after wake-up code execution from RAM.
- 7) To wake-up the Flash from its Sleep mode, $f_{CPU} \geq 1\text{ MHz}$ is required.
- 8) OSC_ULP operating with external crystal on RTC_XTAL.
- 9) OSC_ULP off, Hibernate domain operating with OSC_SI clock.
- 10) V_{BAT} supplied, but Hibernate domain not started; for example state after factory assembly.
- 11) Test Power Loop: $f_{SYS} = 144\text{ MHz}$, CPU executing benchmark code from Flash, all CCUs in 100 kHz timer mode, all ADC groups in continuous conversion mode, USICs as SPI in internal loop-back mode, CAN in 500 kHz internal loop-back mode, interrupt triggered DMA block transfers to parity protected RAMs and FCE, DTS measurements and FPU calculations.
The power consumption of each customer application will most probably be lower than this value, but must be evaluated separately.
- 12) Sum of currents of all active converters (ADC and DAC).

Peripheral Idle Currents

Default test conditions:

- f_{sys} and derived clocks at 144 MHz
- $V_{DDP} = 3.3\text{ V}$, $T_a = 25^\circ\text{C}$
- all peripherals are held in reset (see the PRSTAT registers in the Reset Control Unit of the SCU)
- the peripheral clocks are disabled (see CGATSTAT registers in the Clock Control Unit of the SCU)
- no I/O activity

The given values are a result of differential measurements with asserted and deasserted peripheral reset as well as disabled and enabled clock of the peripheral under test.

The tested peripheral is left in the state after the peripheral reset is deasserted, no further initialisation or configuration is done. For example no timer is running in the CCUs, no communication active in the USICs, etc.

3 Electrical Parameters

Table 34 **Peripheral Idle Currents**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
PORTS FCE WDT	$I_{\text{PER CC}}$	–	≤ 0.3	–	mA	
MultiCAN ERU LEDTSCU0 ETH CCU4x ¹⁾ , CCU8x ¹⁾		–	≤ 1.0	–		
DAC (digital) ²⁾		–	1.3	–		
USICx SDMMC		–	3.0	–		
VADC (digital) ²⁾		–	4.5	–		
DMA0, USB, EtherCAT		–	6.0	–		

- 1) Enabling the f_{CCU} clock for the CCU4x/CCU8x modules adds approximately $I_{\text{PER}} = 4.8$ mA, disregarding which and how many of those peripherals are enabled.
- 2) The current consumption of the analog components are given in the dedicated Datasheet sections of the respective peripheral.

3 Electrical Parameters

3.2.9 Flash Memory Parameters

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 35 Flash Memory Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Erase Time per 256 Kbyte Sector	$t_{\text{ERP CC}}$	–	5	5.5	s	
Erase Time per 64 Kbyte Sector	$t_{\text{ERP CC}}$	–	1.2	1.4	s	
Erase Time per 16 Kbyte Logical Sector	$t_{\text{ERP CC}}$	–	0.3	0.4	s	
Program time per page ¹⁾	$t_{\text{PRP CC}}$	–	5.5	11	ms	
Erase suspend delay	$t_{\text{FL_ErSusp CC}}$	–	–	15	ms	
Wait time after margin change	$t_{\text{FL_MarginDel CC}}$	10	–	–	μs	
Wake-up time	$t_{\text{WU CC}}$	–	–	270	μs	
Read access time	$t_{\text{a CC}}$	22	–	–	ns	For operation with $1/f_{\text{CPU}} < t_{\text{a}}$ wait states must be configured ²⁾
Data Retention Time, Physical Sector ^{3) 4)}	$t_{\text{RET CC}}$	20	–	–	years	Max. 1000 erase/program cycles
Data Retention Time, Logical Sector ^{3) 4)}	$t_{\text{RETL CC}}$	20	–	–	years	Max. 100 erase/program cycles
Data Retention Time, User Configuration Block (UCB) ^{3) 4)}	$t_{\text{RTU CC}}$	20	–	–	years	Max. 4 erase/program cycles per UCB
Endurance on 64 Kbyte Physical Sector PS4	$N_{\text{EPS4 CC}}$	10000	–	–	cycles	Cycling distributed over life time ⁵⁾

- 1) In case the Program Verify feature detects weak bits, these bits will be programmed once more. The reprogramming takes an additional time of 5.5 ms.
- 2) The following formula applies to the wait state configuration: $\text{FCON.WSPFLASH} \times (1/f_{\text{CPU}}) \geq t_{\text{a}}$.
- 3) Storage and inactive time included.
- 4) Values given are valid for an average weighted junction temperature of $T_{\text{J}} = 110^{\circ}\text{C}$.
- 5) Only valid with robust EEPROM emulation algorithm, equally cycling the logical sectors. For more details see the Reference Manual.

3 Electrical Parameters

3.3 AC Parameters

3.3.1 Testing Waveforms

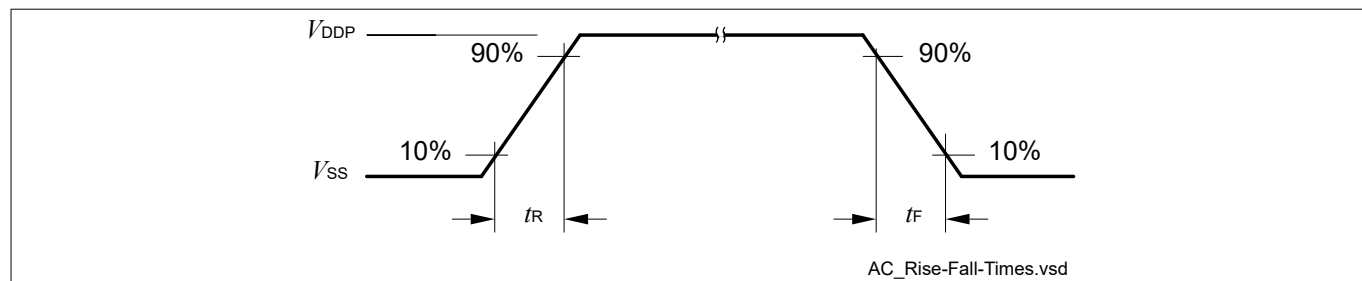


Figure 18 Rise/Fall Time Parameters

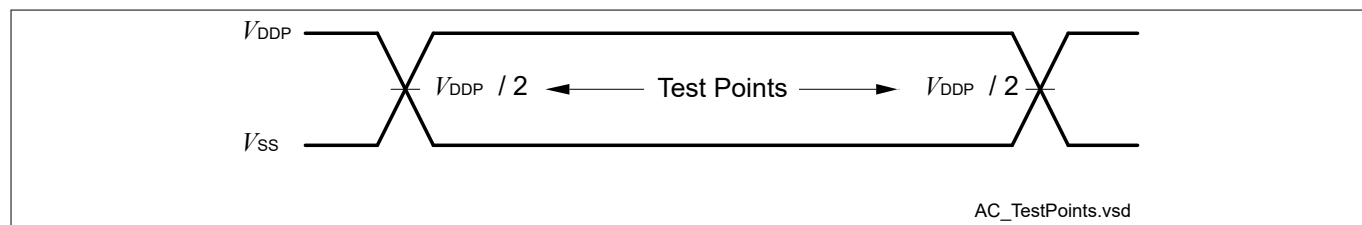


Figure 19 Testing Waveform, Output Delay

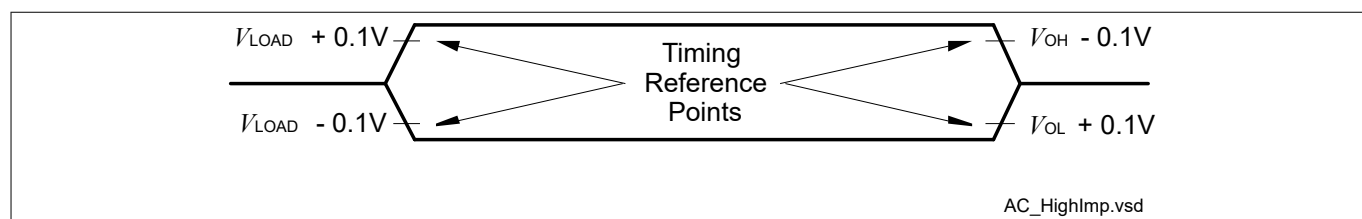


Figure 20 Testing Waveform, Output High Impedance

3 Electrical Parameters

3.3.2 Power-Up and Supply Monitoring

$\overline{\text{PORST}}$ is always asserted when V_{DDP} and/or V_{DDC} violate the respective thresholds.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

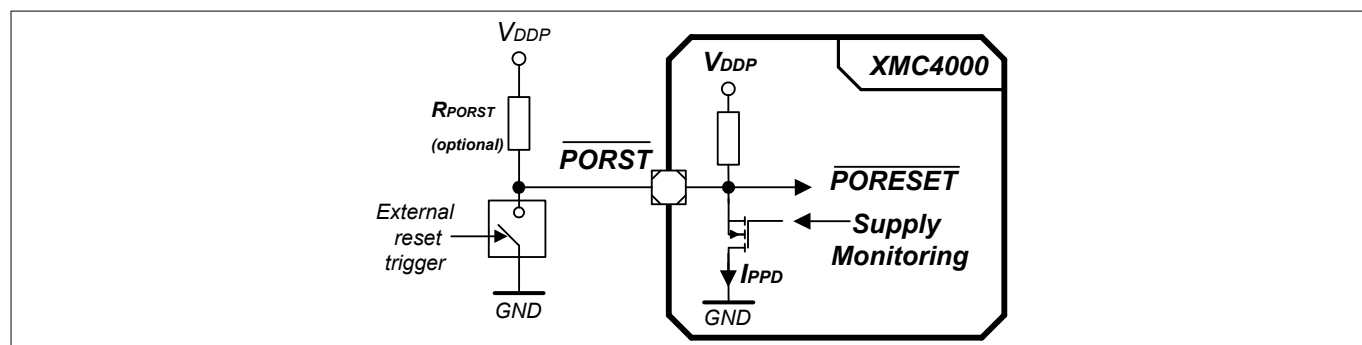


Figure 21 $\overline{\text{PORST}}$ Circuit

Table 36 Supply Monitoring Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Digital supply voltage reset threshold	$V_{\text{POR CC}}$	2.79 ¹⁾	–	3.05 ²⁾	V	³⁾
Core supply voltage reset threshold	$V_{\text{PV CC}}$	–	–	1.17	V	
V_{DDP} voltage to ensure defined pad states	$V_{\text{DDPPA CC}}$	–	1.0	–	V	
$\overline{\text{PORST}}$ rise time	$t_{\text{PR SR}}$	–	–	2	μs	⁴⁾
Startup time from power-on reset with code execution from Flash	$t_{\text{SSW CC}}$	–	2.5	3.5	ms	Time to the first user code instruction
V_{DDC} ramp up time	$t_{\text{VCR CC}}$	–	550	–	μs	Ramp up after power-on or after a reset triggered by a violation of V_{POR} or V_{PV}

1) Minimum threshold for reset assertion.

2) Maximum threshold for reset deassertion.

3) The V_{DDP} monitoring has a typical hysteresis of $V_{\text{PORHYS}} = 180 \text{ mV}$.

4) If t_{PR} is not met, low spikes on $\overline{\text{PORST}}$ may be seen during start up (e.g. reset pulses generated by the supply monitoring due to a slow ramping V_{DDP}).

3 Electrical Parameters

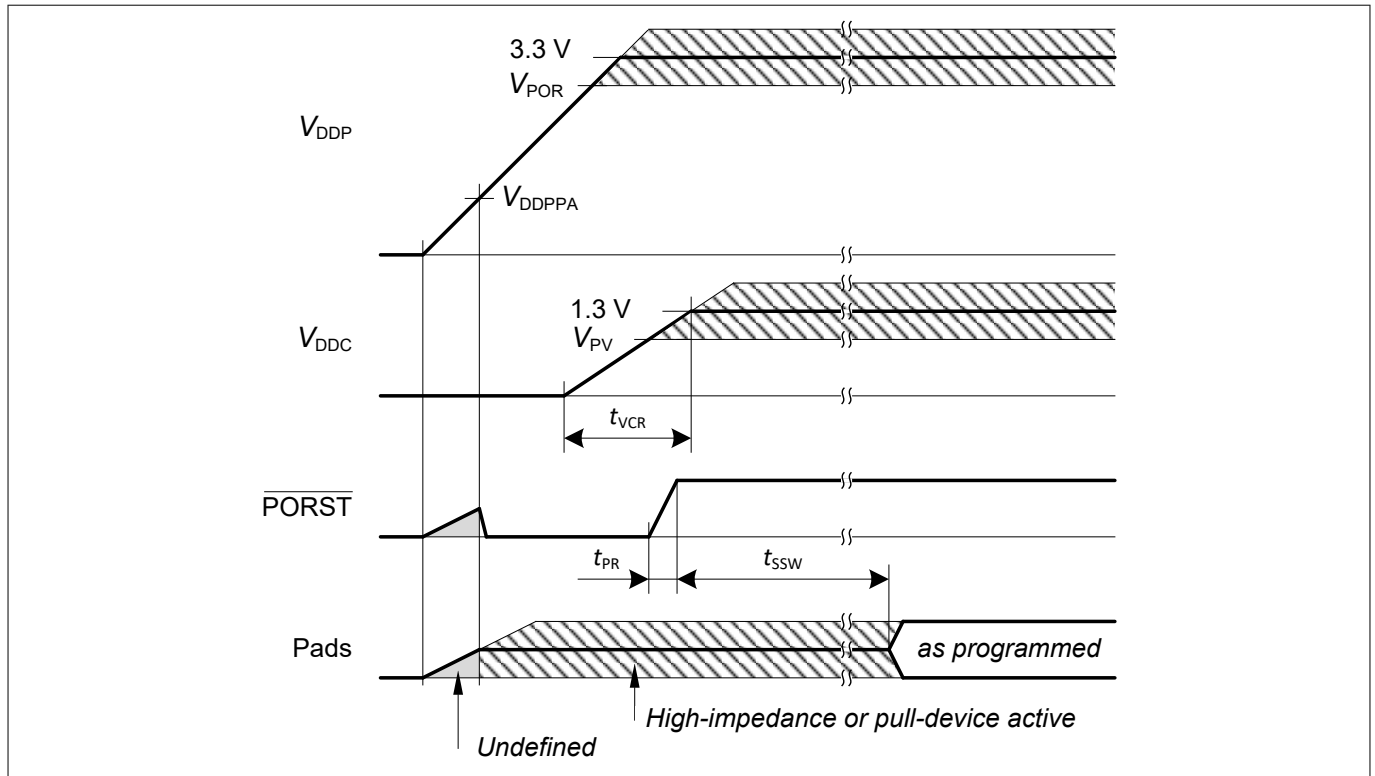


Figure 22 Power-Up Behavior

3.3.3 Power Sequencing

While starting up and shutting down as well as when switching power modes of the system it is important to limit the current load steps. A typical cause for such load steps is changing the CPU frequency f_{CPU} . Load steps exceeding the below defined values may cause a power on reset triggered by the supply monitor.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 37 Power Sequencing Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Positive Load Step Current	ΔI_{PLS} SR	–	–	50	mA	Load increase on V_{DDP} $\Delta t \leq 10$ ns
Negative Load Step Current	ΔI_{NLS} SR	–	–	150	mA	Load decrease on V_{DDP} $\Delta t \leq 10$ ns
V_{DDC} Voltage Over-/Undershoot from Load Step	ΔV_{LS} CC	–	–	± 100	mV	For maximum positive or negative load step
Positive Load Step Settling Time	t_{PLSS} SR	50	–	–	μ s	
Negative Load Step Settling Time	t_{NLSS} SR	100	–	–	μ s	
External Buffer Capacitor on V_{DDC}	C_{EXT} SR	–	10	–	μ F	In addition $C = 100$ nF capacitor on each V_{DDC} pin

3 Electrical Parameters

Positive Load Step Examples

System assumptions:

$f_{CPU} = f_{SYS}$, target frequency $f_{CPU} = 144$ MHz, main PLL $f_{VCO} = 288$ MHz, stepping done by K2 divider, t_{PLSS} between individual steps:

24 MHz - 48 MHz - 72 MHz - 96 MHz - 144 MHz (K2 steps 12 - 6 - 4 - 3 - 2)

24 MHz - 48 MHz - 96 MHz - 144 MHz (K2 steps 12 - 6 - 3 - 2)

24 MHz - 72 MHz - 144 MHz (K2 steps 12 - 4 - 2)

3.3.4 Phase Locked Loop (PLL) Characteristics

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Main and USB PLL

Table 38 PLL Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Accumulated Jitter	D_P CC	–	–	±5	ns	accumulated over 300 cycles $f_{SYS} = 144$ MHz
Duty Cycle ¹⁾	D_{DC} CC	46	50	54	%	Low pulse to total period, assuming an ideal input clock source
PLL base frequency	$f_{PLLBASE}$ CC	30	–	140	MHz	
VCO input frequency	f_{REF} CC	4	–	16	MHz	
VCO frequency range	f_{VCO} CC	260	–	520	MHz	
PLL lock-in time	t_L CC	–	–	400	μs	

1) 50% for even K2 divider values, $50 \pm (10/K2)$ for odd K2 divider values.

3 Electrical Parameters

3.3.5 Internal Clock Source Characteristics

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Fast Internal Clock Source

Table 39 Fast Internal Clock Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Nominal frequency	$f_{\text{OFINC CC}}$	–	36.5	–	MHz	not calibrated
		–	24	–	MHz	calibrated
Accuracy	$\Delta f_{\text{OFI CC}}$	-0.5	–	0.5	%	automatic calibration ^{1) 2)}
		-15	–	15	%	factory calibration, $V_{\text{DDP}} = 3.3 \text{ V}$
		-25	–	25	%	no calibration, $V_{\text{DDP}} = 3.3 \text{ V}$
		-7	–	7	%	Variation over voltage range ³⁾ $3.13 \text{ V} \leq V_{\text{DDP}} \leq 3.63 \text{ V}$
Start-up time	$t_{\text{OFIS CC}}$	–	50	–	μs	

1) Error in addition to the accuracy of the reference clock.

2) Automatic calibration compensates variations of the temperature and in the V_{DDP} supply voltage.

3) Deviations from the nominal V_{DDP} voltage induce an additional error to the uncalibrated and/or factory calibrated oscillator frequency.

Slow Internal Clock Source

Table 40 Slow Internal Clock Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Nominal frequency	$f_{\text{OSI CC}}$	–	32.768	–	kHz	
Accuracy	$\Delta f_{\text{OSI CC}}$	-4	–	4	%	$V_{\text{BAT}} = \text{const.}$ $0^\circ\text{C} \leq T_{\text{A}} \leq 85^\circ\text{C}$
		-5	–	5	%	$V_{\text{BAT}} = \text{const.}$ $T_{\text{A}} < 0^\circ\text{C}$ or $T_{\text{A}} > 85^\circ\text{C}$
		-5	–	5	%	$2.4 \text{ V} \leq V_{\text{BAT}},$ $T_{\text{A}} = 25^\circ\text{C}$
		-10	–	10	%	$1.95 \text{ V} \leq V_{\text{BAT}} < 2.4 \text{ V},$ $T_{\text{A}} = 25^\circ\text{C}$
Start-up time	$t_{\text{OSIS CC}}$	–	50	–	μs	

3 Electrical Parameters

3.3.6 JTAG Interface Timing

The following parameters are applicable for communication through the JTAG debug interface. The JTAG module is fully compliant with IEEE1149.1-2000.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Note: Operating conditions apply.

Table 41 JTAG Interface Timing Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
TCK clock period	t_1 SR	25	–	–	ns	
TCK high time	t_2 SR	10	–	–	ns	
TCK low time	t_3 SR	10	–	–	ns	
TCK clock rise time	t_4 SR	–	–	4	ns	
TCK clock fall time	t_5 SR	–	–	4	ns	
TDI/TMS setup to TCK rising edge	t_6 SR	6	–	–	ns	
TDI/TMS hold after TCK rising edge	t_7 SR	6	–	–	ns	
TDO valid after TCK falling edge ¹⁾ (propagation delay)	t_8 CC	–	–	13	ns	$C_L = 50$ pF
		3	–	–	ns	$C_L = 20$ pF
TDO hold after TCK falling edge ¹⁾	t_{18} CC	2	–	–	ns	
TDO high impd. to valid from TCK falling edge ^{1) 2)}	t_9 CC	–	–	14	ns	$C_L = 50$ pF
TDO valid to high impd. from TCK falling edge ¹⁾	t_{10} CC	–	–	13.5	ns	$C_L = 50$ pF

1) The falling edge on TCK is used to generate the TDO timing.

2) The setup time for TDO is given implicitly by the TCK cycle time.

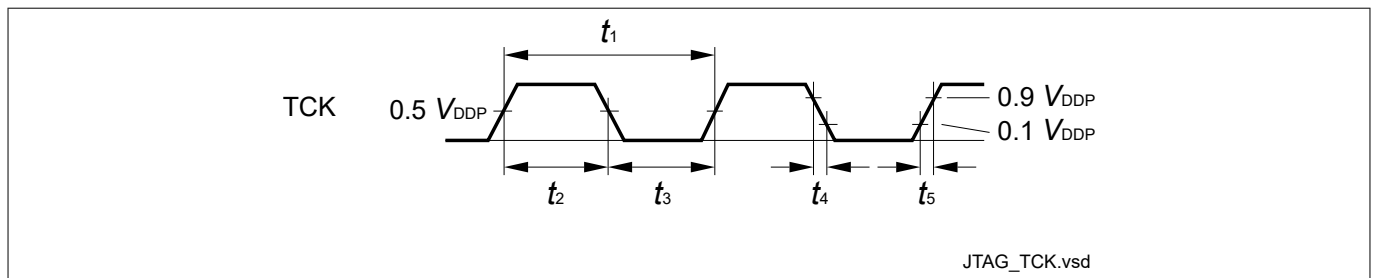


Figure 23 Test Clock Timing (TCK)

3 Electrical Parameters

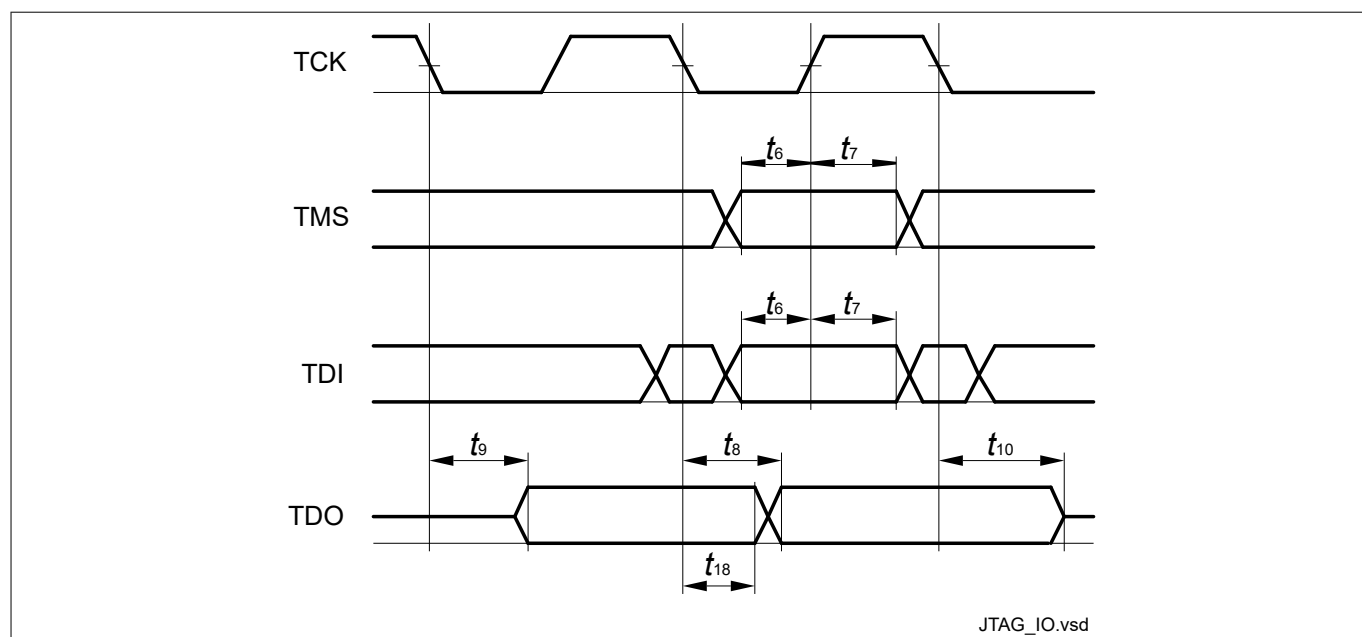


Figure 24 JTAG Timing

3.3.7 Serial Wire Debug Port (SW-DP) Timing

The following parameters are applicable for communication through the SW-DP interface.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Note: Operating conditions apply.

Table 42 SWD Interface Timing Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
SWDCLK clock period	t_{SC} SR	25	–	–	ns	$C_L = 30$ pF
		40	–	–	ns	$C_L = 50$ pF
SWDCLK high time	t_1 SR	10	–	500000	ns	
SWDCLK low time	t_2 SR	10	–	500000	ns	
SWDIO input setup to SWDCLK rising edge	t_3 SR	6	–	–	ns	
SWDIO input hold after SWDCLK rising edge	t_4 SR	6	–	–	ns	
SWDIO output valid time after SWDCLK rising edge	t_5 CC	–	–	17	ns	$C_L = 50$ pF
		–	–	13	ns	$C_L = 30$ pF
SWDIO output hold time from SWDCLK rising edge	t_6 CC	3	–	–	ns	

3 Electrical Parameters

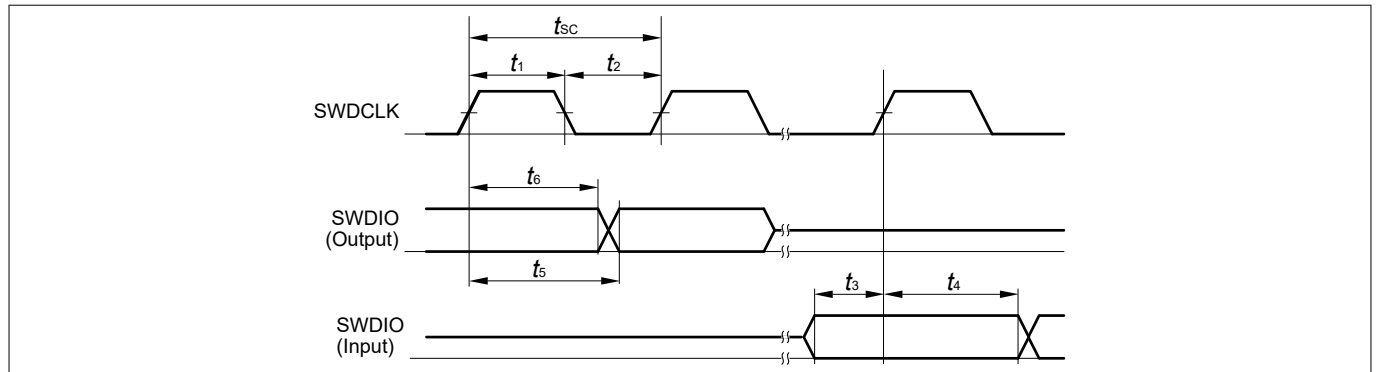


Figure 25 SWD Timing

3.3.8 Peripheral Timing

3.3.8.1 Synchronous Serial Interface (USIC SSC) Timing

The following parameters are applicable for a USIC channel operated in SSC mode.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 43 USIC SSC Master Mode Timing

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
SCLKOUT master clock period	$t_{CLK\ CC}$	33.3	–	–	ns	
Slave select output SELO active to first SCLKOUT transmit edge	$t_1\ CC$	$t_{PB} - 6.5^{1)}$	–	–	ns	
Slave select output SELO inactive after last SCLKOUT receive edge	$t_2\ CC$	$t_{PB} - 8.5^{1)}$	–	–	ns	
Data output DOUT[3:0] valid time	$t_3\ CC$	-6	–	8	ns	
Receive data input DX0/DX[5:3] setup time to SCLKOUT receive edge	$t_4\ SR$	23	–	–	ns	
Data input DX0/DX[5:3] hold time from SCLKOUT receive edge	$t_5\ SR$	1	–	–	ns	

1) $t_{PB} = 1/f_{PB}$

3 Electrical Parameters

Table 44 USIC SSC Slave Mode Timing

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
DX1 slave clock period	t_{CLK} SR	66.6	–	–	ns	
Select input DX2 setup to first clock input DX1 transmit edge ¹⁾	t_{10} SR	3	–	–	ns	
Select input DX2 hold after last clock input DX1 receive edge ¹⁾	t_{11} SR	4	–	–	ns	
Receive data input DX0/DX[5:3] setup time to shift clock receive edge ¹⁾	t_{12} SR	6	–	–	ns	
Data input DX0/DX[5:3] hold time from clock input DX1 receive edge ¹⁾	t_{13} SR	4	–	–	ns	
Data output DOUT[3:0] valid time	t_{14} CC	0	–	24	ns	

1) This input timing is valid for asynchronous input signal handling of slave select input, shift clock input, and receive data input (bits DXnCR.DSEN = 0).

3 Electrical Parameters

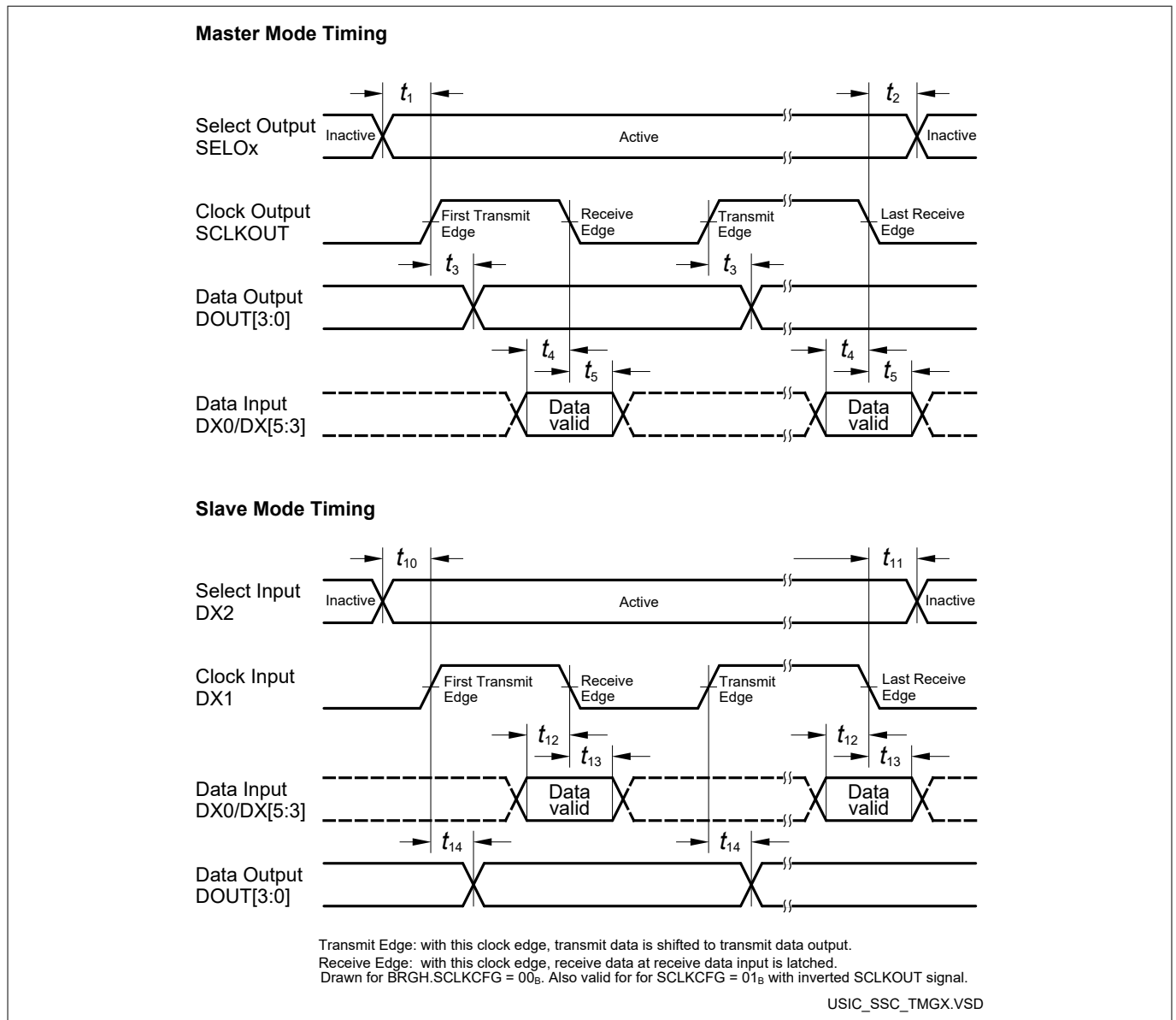


Figure 26 USIC - SSC Master/Slave Mode Timing

Note: This timing diagram shows a standard configuration, for which the slave select signal is low-active, and the serial clock signal is not shifted and not inverted.

3 Electrical Parameters

3.3.8.2 Inter-IC (IIC) Interface Timing

The following parameters are applicable for a USIC channel operated in IIC mode.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 45 USIC IIC Standard Mode Timing¹⁾

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Fall time of both SDA and SCL	t_1 CC/SR	–	–	300	ns	
Rise time of both SDA and SCL	t_2 CC/SR	–	–	1000	ns	
Data hold time	t_3 CC/SR	0	–	–	μs	
Data set-up time	t_4 CC/SR	250	–	–	ns	
LOW period of SCL clock	t_5 CC/SR	4.7	–	–	μs	
HIGH period of SCL clock	t_6 CC/SR	4.0	–	–	μs	
Hold time for (repeated) START condition	t_7 CC/SR	4.0	–	–	μs	
Set-up time for repeated START condition	t_8 CC/SR	4.7	–	–	μs	
Set-up time for STOP condition	t_9 CC/SR	4.0	–	–	μs	
Bus free time between a STOP and START condition	t_{10} CC/SR	4.7	–	–	μs	
Capacitive load for each bus line	C_b SR	–	–	400	pF	

1) Due to the wired-AND configuration of an IIC bus system, the port drivers of the SCL and SDA signal lines need to operate in open-drain mode. The high level on these lines must be held by an external pull-up device, approximately 10 kOhm for operation at 100 kbit/s, approximately 2 kOhm for operation at 400 kbit/s.

Table 46 USIC IIC Fast Mode Timing¹⁾

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Fall time of both SDA and SCL	t_1 CC/SR	20 + $0.1 \cdot C_b$ ²⁾	–	300	ns	
Rise time of both SDA and SCL	t_2 CC/SR	20 + $0.1 \cdot C_b$ ²⁾	–	300	ns	
Data hold time	t_3 CC/SR	0	–	–	μs	
Data set-up time	t_4 CC/SR	100	–	–	ns	
LOW period of SCL clock	t_5 CC/SR	1.3	–	–	μs	
HIGH period of SCL clock	t_6 CC/SR	0.6	–	–	μs	
Hold time for (repeated) START condition	t_7 CC/SR	0.6	–	–	μs	

(table continues...)

3 Electrical Parameters

Table 46 (continued) **USIC IIC Fast Mode Timing¹⁾**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Set-up time for repeated START condition	t_8 CC/SR	0.6	–	–	μs	
Set-up time for STOP condition	t_9 CC/SR	0.6	–	–	μs	
Bus free time between a STOP and START condition	t_{10} CC/SR	1.3	–	–	μs	
Capacitive load for each bus line	C_b SR	–	–	400	pF	

- 1) Due to the wired-AND configuration of an IIC bus system, the port drivers of the SCL and SDA signal lines need to operate in open-drain mode. The high level on these lines must be held by an external pull-up device, approximately 10 kOhm for operation at 100 kbit/s, approximately 2 kOhm for operation at 400 kbit/s.
- 2) C_b refers to the total capacitance of one bus line in pF.

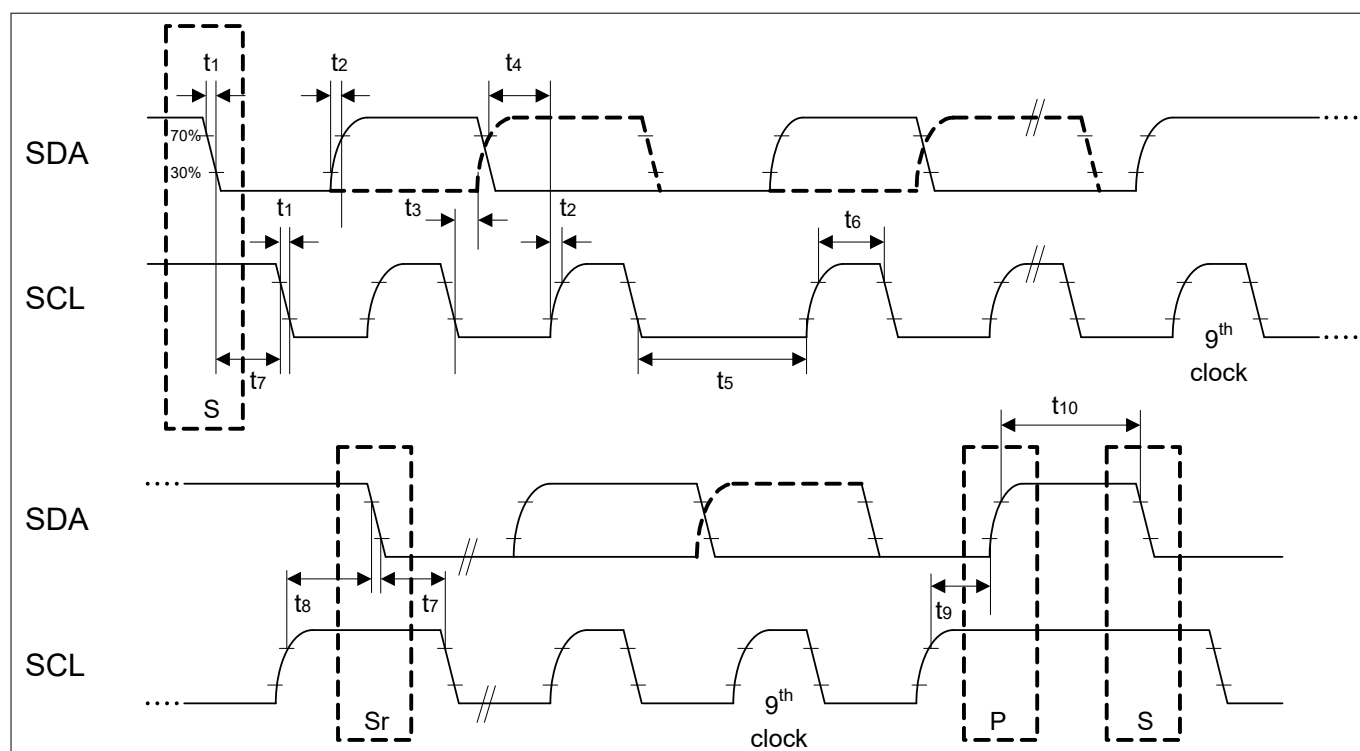


Figure 27 USIC IIC Stand and Fast Mode Timing

3 Electrical Parameters

3.3.8.3 Inter-IC Sound (IIS) Interface Timing

The following parameters are applicable for a USIC channel operated in IIS mode.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 47 USIC IIS Master Transmitter Timing

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Clock period	t_1 CC	33.3	–	–	ns	
Clock high time	t_2 CC	$0.35 \times t_{1min}$	–	–	ns	
Clock low time	t_3 CC	$0.35 \times t_{1min}$	–	–	ns	
Hold time	t_4 CC	0	–	–	ns	
Clock rise time	t_5 CC	–	–	$0.15 \times t_{1min}$	ns	

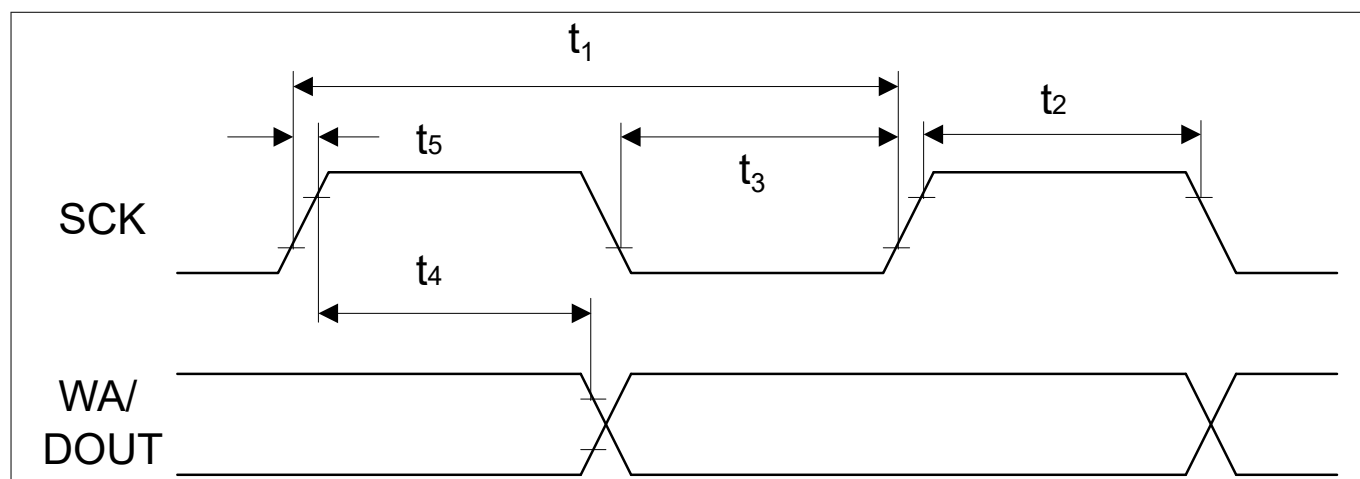


Figure 28 USIC IIS Master Transmitter Timing

Table 48 USIC IIS Slave Receiver Timing

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Clock period	t_6 SR	66.6	–	–	ns	
Clock high time	t_7 SR	$0.35 \times t_{6min}$	–	–	ns	
Clock low time	t_8 SR	$0.35 \times t_{6min}$	–	–	ns	
Set-up time	t_9 SR	$0.2 \times t_{6min}$	–	–	ns	
Hold time	t_{10} SR	0	–	–	ns	

3 Electrical Parameters

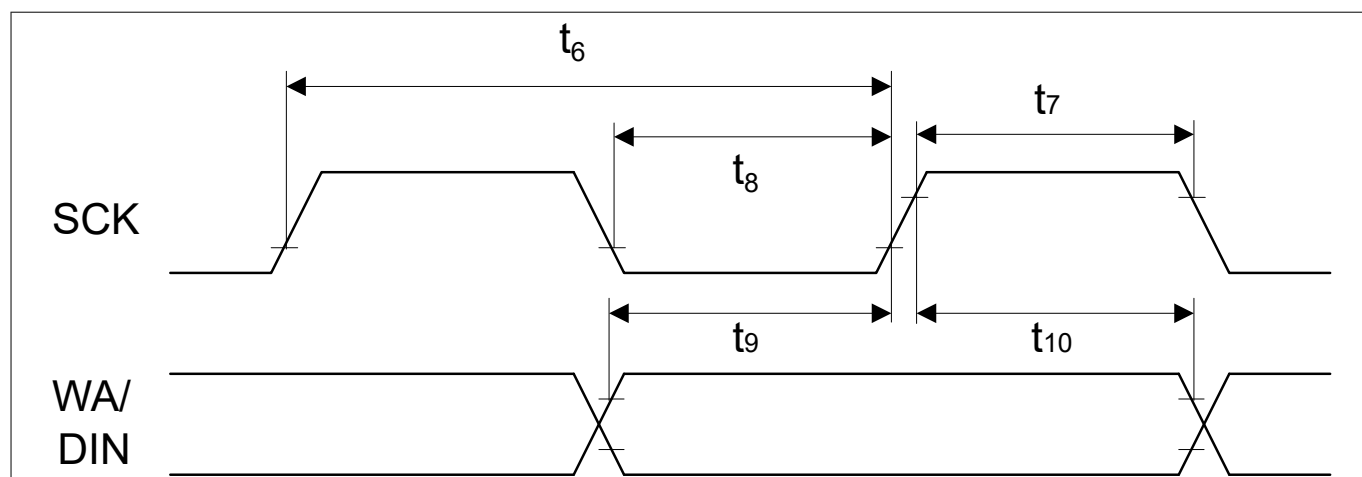


Figure 29 USIC IIS Slave Receiver Timing

3.3.8.4 SDMMC Interface Timing

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Note: Operating Conditions apply, total external capacitive load $C_L = 40 \text{ pF}$.

AC Timing Specifications (Full-Speed Mode)

Table 49 SDMMC Timing for Full-Speed Mode

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Clock frequency in full speed transfer mode ($1/t_{pp}$)	$f_{pp} \text{ CC}$	0	24	MHz	
Clock cycle in full speed transfer mode	$t_{pp} \text{ CC}$	40	–	ns	
Clock low time	$t_{WL} \text{ CC}$	10	–	ns	
Clock high time	$t_{WH} \text{ CC}$	10	–	ns	
Clock rise time	$t_{TLH} \text{ CC}$	–	10	ns	
Clock fall time	$t_{THL} \text{ CC}$	–	10	ns	
Inputs setup to clock rising edge	$t_{ISU_F} \text{ SR}$	2	–	ns	
Inputs hold after clock rising edge	$t_{IH_F} \text{ SR}$	2	–	ns	
Outputs valid time in full speed mode	$t_{ODLY_F} \text{ CC}$	–	10	ns	
Outputs hold time in full speed mode	$t_{OH_F} \text{ CC}$	0	–	ns	

3 Electrical Parameters

Table 50 **SD Card Bus Timing for Full-Speed Mode¹⁾**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
SD card input setup time	t_{ISU}	5	–	ns	
SD card input hold time	t_{IH}	5	–	ns	
SD card output valid time	t_{ODLY}	–	14	ns	
SD card output hold time	t_{OH}	0	–	ns	

1) Reference card timing values for calculation examples. Not subject to production test and not characterized.

Full-Speed Output Path (Write)

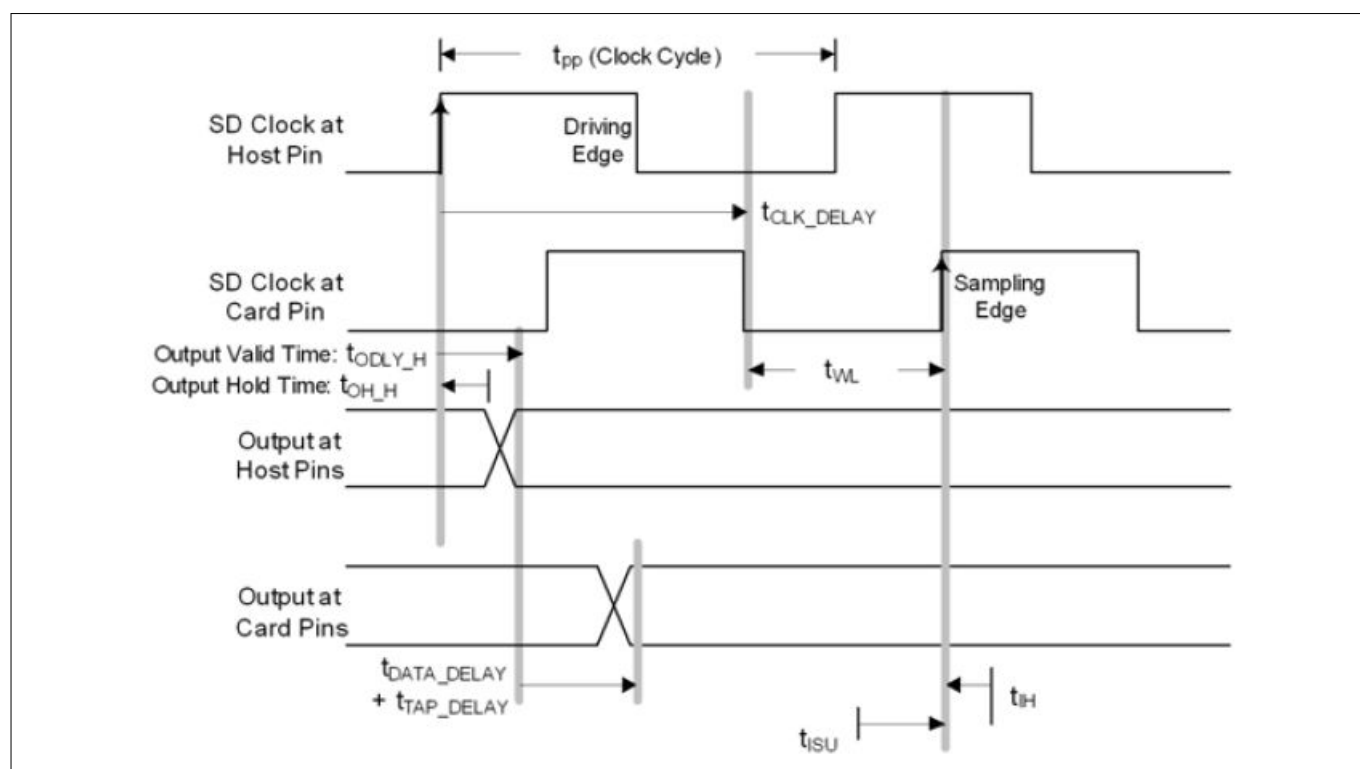


Figure 30 **Full-Speed Output Path**

Full-Speed Write Meeting Setup (Maximum Delay)

The following equations show how to calculate the allowed skew range between the SD_CLK and SD_DAT/CMD signals on the PCB.

No clock delay:

$$t_{ODLY_F} + t_{DATA_DELAY} + t_{TAP_DELAY} + t_{ISU} < t_{WL} \quad (1)$$

With clock delay:

$$t_{ODLY_F} + t_{DATA_DELAY} + t_{TAP_DELAY} + t_{ISU} < t_{WL} + t_{CLK_DELAY} \quad (2)$$

3 Electrical Parameters

$$\begin{aligned}
 t_{\text{DATA_DELAY}} + t_{\text{TAP_DELAY}} + t_{\text{WL}} &< t_{\text{PP}} + t_{\text{CLK_DELAY}} - t_{\text{ISU}} - t_{\text{ODLY_F}} \\
 t_{\text{DATA_DELAY}} + t_{\text{TAP_DELAY}} + 20 &< 40 + t_{\text{CLK_DELAY}} - 5 - 10 \\
 t_{\text{DATA_DELAY}} &< 5 + t_{\text{CLK_DELAY}} - t_{\text{TAP_DELAY}}
 \end{aligned}
 \tag{3}$$

The data can be delayed versus clock up to 5 ns in ideal case of $t_{\text{WL}} = 20$ ns.

Full-Speed Write Meeting Hold (Minimum Delay)

The following equations show how to calculate the allowed skew range between the SD_CLK and SD_DAT/CMD signals on the PCB.

$$\begin{aligned}
 t_{\text{CLK_DELAY}} &< t_{\text{WL}} + t_{\text{OH_F}} + t_{\text{DATA_DELAY}} + t_{\text{TAP_DELAY}} - t_{\text{IH}} \\
 t_{\text{CLK_DELAY}} &< 20 + t_{\text{DATA_DELAY}} + t_{\text{TAP_DELAY}} - 5 \\
 t_{\text{DATA_DELAY}} &< 15 + t_{\text{CLK_DELAY}} + t_{\text{TAP_DELAY}}
 \end{aligned}
 \tag{4}$$

The clock can be delayed versus data up to 18.2 ns (external delay line) in ideal case of $t_{\text{WL}} = 20$ ns, with maximum $t_{\text{TAP_DELAY}} = 3.2$ ns programmed.

Full-Speed Input Path (Read)

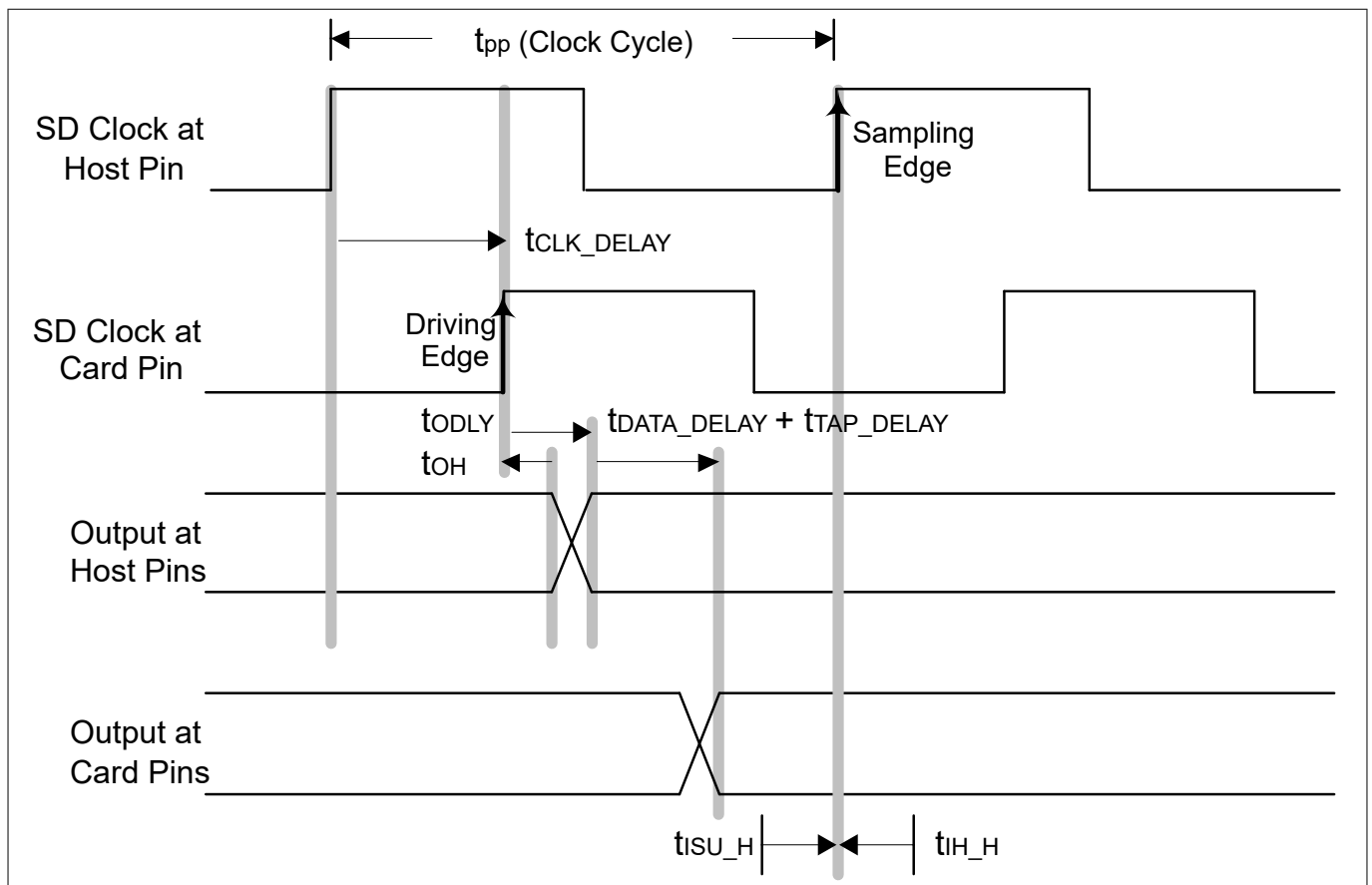


Figure 31 Full-Speed Input Path

Full-Speed Read Meeting Setup (Maximum Delay)

The following equations show how to calculate the allowed combined propagation delay range of the SD_CLK and SD_DAT/CMD signals on the PCB.

3 Electrical Parameters

$$\begin{aligned}
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} + t_{\text{TAP_DELAY}} + t_{\text{ODLY}} + t_{\text{ISU_F}} &< 0.5 \times t_{\text{pp}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &< 0.5 \times t_{\text{pp}} - t_{\text{ODLY}} - t_{\text{ISU_F}} - t_{\text{TAP_DELAY}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &< 20 - 14 - 2 - t_{\text{TAP_DELAY}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &< 4 - t_{\text{TAP_DELAY}}
 \end{aligned}
 \tag{5}$$

The data + clock delay can be up to 4 ns for a 40 ns clock cycle.

Full-Speed Read Meeting Hold (Minimum Delay)

The following equations show how to calculate the allowed combined propagation delay range of the SD_CLK and SD_DAT/CMD signals on the PCB.

$$\begin{aligned}
 t_{\text{CLK_DELAY}} + t_{\text{OH}} + t_{\text{DATA_DELAY}} + t_{\text{TAP_DELAY}} &> t_{\text{IH_F}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &> t_{\text{IH_F}} - t_{\text{OH}} - t_{\text{TAP_DELAY}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &> 2 - t_{\text{TAP_DELAY}}
 \end{aligned}
 \tag{6}$$

The data + clock delay must be greater than 2 ns if $t_{\text{TAP_DELAY}}$ is not used.

If the $t_{\text{TAP_DELAY}}$ is programmed to at least 2 ns, the data + clock delay must be greater than 0 ns (or less). This is always fulfilled.

AC Timing Specifications (High-Speed Mode)

Table 51 SDMMC Timing for High-Speed Mode

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
Clock frequency in high speed transfer mode ($1/t_{\text{pp}}$)	$f_{\text{pp CC}}$	0	48	MHz	
Clock cycle in high speed transfer mode	$t_{\text{pp CC}}$	20	–	ns	
Clock low time	$t_{\text{WL CC}}$	7	–	ns	
Clock high time	$t_{\text{WH CC}}$	7	–	ns	
Clock rise time	$t_{\text{TLH CC}}$	–	3	ns	
Clock fall time	$t_{\text{THL CC}}$	–	3	ns	
Inputs setup to clock rising edge	$t_{\text{ISU_H SR}}$	2	–	ns	
Inputs hold after clock rising edge	$t_{\text{IH_H SR}}$	2	–	ns	
Outputs valid time in high speed mode	$t_{\text{ODLY_H CC}}$	–	14	ns	
Outputs hold time in high speed mode	$t_{\text{OH_H CC}}$	2	–	ns	

Table 52 SD Card Bus Timing for High-Speed Mode¹⁾

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
SD card input setup time	t_{ISU}	6	–	ns	

(table continues...)

3 Electrical Parameters

Table 52 (continued) **SD Card Bus Timing for High-Speed Mode¹⁾**

Parameter	Symbol	Values		Unit	Note/Test Condition
		Min.	Max.		
SD card input hold time	t_{IH}	2	–	ns	
SD card output valid time	t_{ODLY}	–	14	ns	
SD card output hold time	t_{OH}	2.5	–	ns	

1) Reference card timing values for calculation examples. Not subject to production test and not characterized.

High-Speed Output Path (Write)

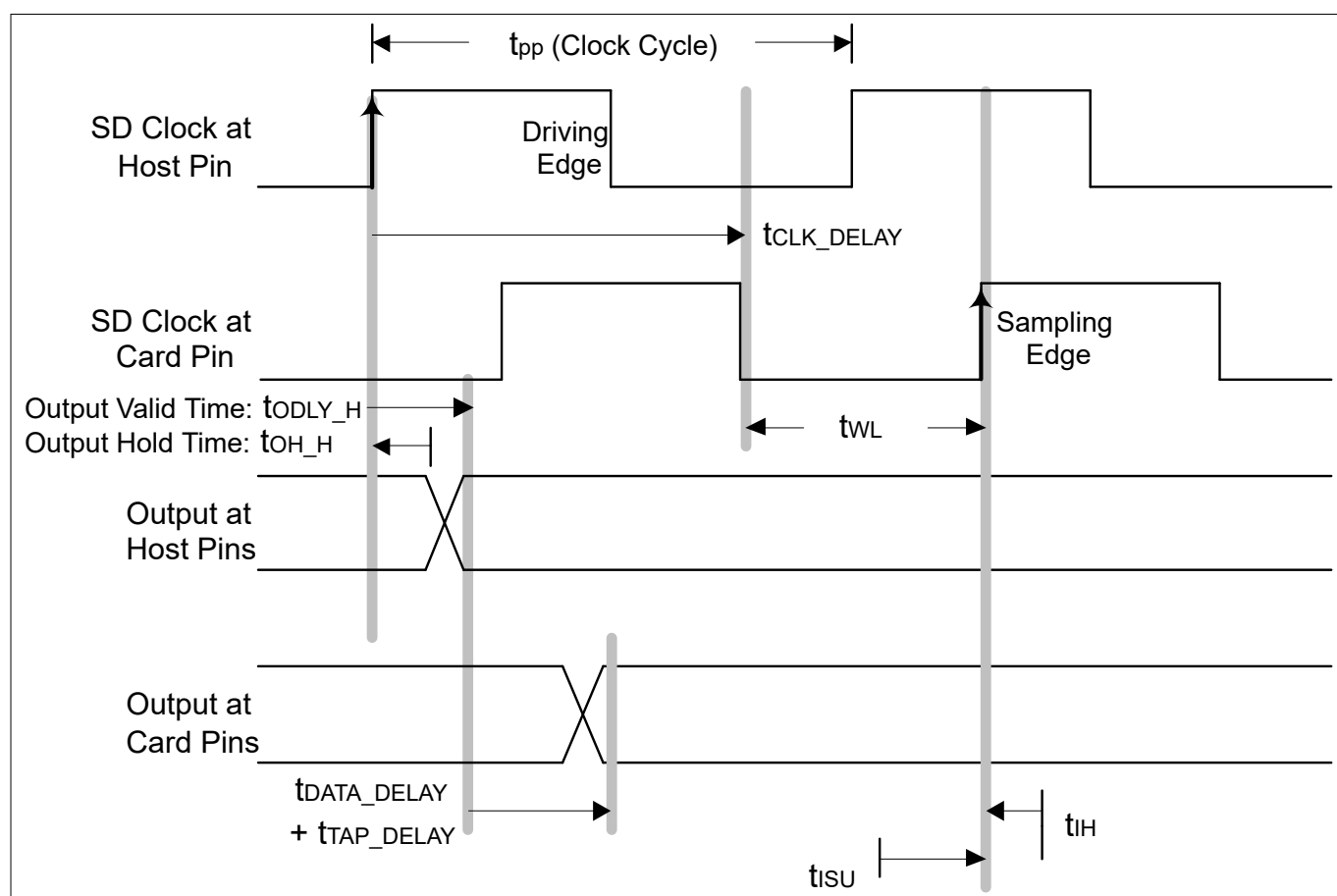


Figure 32 High-Speed Output Path

High-Speed Write Meeting Setup (Maximum Delay)

The following equations show how to calculate the allowed skew range between the SD_CLK and SD_DAT/CMD signals on the PCB.

No clock delay:

$$t_{ODLY_H} + t_{DATA_DELAY} + t_{TAP_DELAY} + t_{ISU} < t_{WL} \quad (7)$$

With clock delay:

3 Electrical Parameters

$$t_{ODLY_H} + t_{DATA_DELAY} + t_{TAP_DELAY} + t_{ISU} < t_{WL} + t_{CLK_DELAY} \quad (8)$$

$$\begin{aligned} t_{DATA_DELAY} + t_{TAP_DELAY} - t_{CLK_DELAY} &< t_{WL} - t_{ISU} - t_{ODLY_H} \\ t_{DATA_DELAY} - t_{CLK_DELAY} &< t_{WL} - t_{ISU} - t_{ODLY_H} - t_{TAP_DELAY} \\ t_{DATA_DELAY} - t_{CLK_DELAY} &< 10 - 6 - 14 - t_{TAP_DELAY} \\ t_{DATA_DELAY} - t_{CLK_DELAY} &< -10 - t_{TAP_DELAY} \end{aligned} \quad (9)$$

The data delay is less than the clock delay by at least 10 ns in the ideal case where $t_{WL} = 10$ ns.

High-Speed Write Meeting Hold (Minimum Delay)

The following equations show how to calculate the allowed skew range between the SD_CLK and SD_DAT/CMD signals on the PCB.

$$\begin{aligned} t_{CLK_DELAY} &< t_{WL} + t_{OH_H} + t_{DATA_DELAY} + t_{TAP_DELAY} - t_{IH} \\ t_{CLK_DELAY} - t_{DATA_DELAY} &< t_{WL} + t_{OH_H} + t_{TAP_DELAY} - t_{IH} \\ t_{CLK_DELAY} - t_{DATA_DELAY} &< 10 + 2 + t_{TAP_DELAY} - 2 \\ t_{CLK_DELAY} - t_{DATA_DELAY} &< 10 + t_{TAP_DELAY} \end{aligned} \quad (10)$$

The clock can be delayed versus data up to 13.2 ns (external delay line) in ideal case of $t_{WL} = 10$ ns, with maximum $t_{TAP_DELAY} = 3.2$ ns programmed.

High-Speed Input Path (Read)

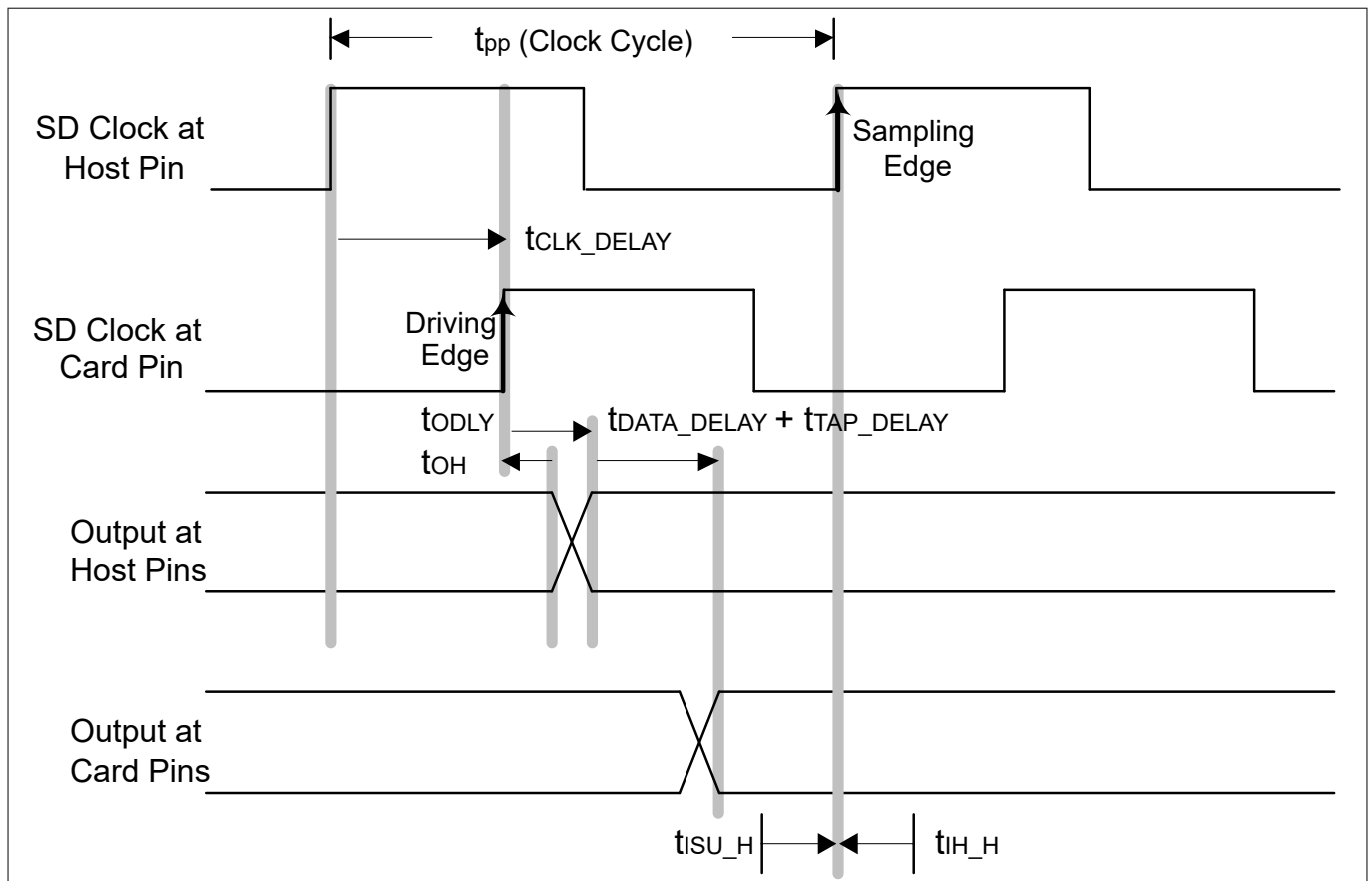


Figure 33 High-Speed Input Path

3 Electrical Parameters

High-Speed Read Meeting Setup (Maximum Delay)

The following equations show how to calculate the allowed combined propagation delay range of the SD_CLK and SD_DAT/CMD signals on the PCB.

$$\begin{aligned}
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} + t_{\text{TAP_DELAY}} + t_{\text{ODLY}} + t_{\text{ISU_H}} &< t_{\text{pp}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &< t_{\text{pp}} - t_{\text{ODLY}} - t_{\text{ISU_H}} - t_{\text{TAP_DELAY}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &< 20 - 14 - 2 - t_{\text{TAP_DELAY}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &< 4 - t_{\text{TAP_DELAY}}
 \end{aligned}
 \tag{11}$$

The data + clock delay can be up to 4 ns for a 20 ns clock cycle.

High-Speed Read Meeting Hold (Minimum Delay)

The following equations show how to calculate the allowed combined propagation delay range of the SD_CLK and SD_DAT/CMD signals on the PCB.

$$\begin{aligned}
 t_{\text{CLK_DELAY}} + t_{\text{OH}} + t_{\text{DATA_DELAY}} + t_{\text{TAP_DELAY}} &> t_{\text{IH_H}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &> t_{\text{IH_H}} - t_{\text{OH}} - t_{\text{TAP_DELAY}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &> 2 - 2.5 - t_{\text{TAP_DELAY}} \\
 t_{\text{CLK_DELAY}} + t_{\text{DATA_DELAY}} &> -0.5 - t_{\text{TAP_DELAY}}
 \end{aligned}
 \tag{12}$$

The data + clock delay must be greater than -0.5 ns for a 20 ns clock cycle. This is always fulfilled.

3.3.9 USB Interface Characteristics

The Universal Serial Bus (USB) Interface is compliant to the USB Rev. 2.0 Specification and the OTG Specification Rev. 1.3. High-Speed Mode is not supported.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

Table 53 USB Timing Parameters (operating conditions apply)

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Rise time	t_R CC	4	–	20	ns	$C_L = 50$ pF
Fall time	t_F CC	4	–	20	ns	$C_L = 50$ pF
Rise/Fall time matching	t_R/t_F CC	90	–	111.11	%	$C_L = 50$ pF
Crossover voltage	V_{CRS} CC	1.3	–	2.0	V	$C_L = 50$ pF

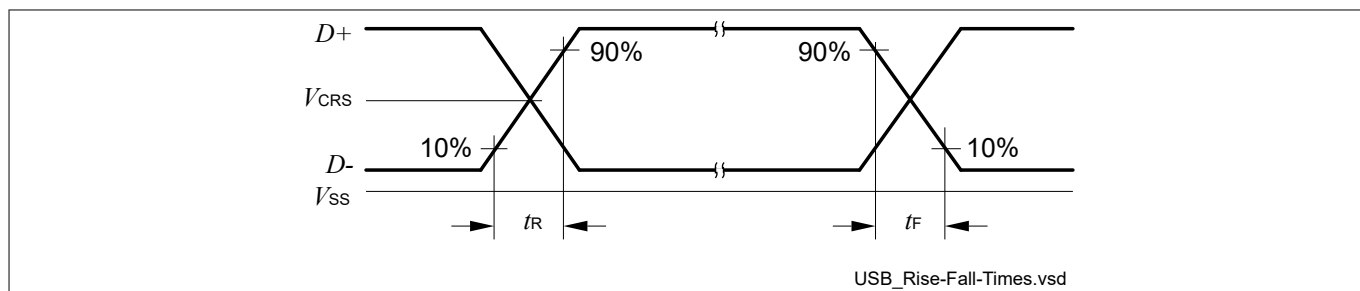


Figure 34 USB Signal Timing

3 Electrical Parameters

3.3.10 Ethernet Interface (ETH) Characteristics

For proper operation of the Ethernet Interface it is required that $f_{\text{SYS}} \geq 100 \text{ MHz}$.

Note: These parameters are not subject to production test, but verified by design and/or characterization.

3.3.10.1 ETH Measurement Reference Points

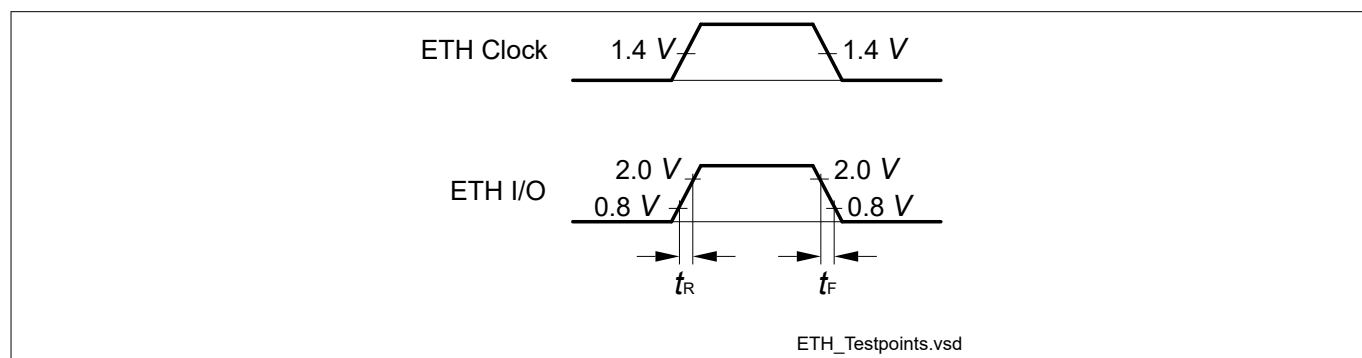


Figure 35 ETH Measurement Reference Points

3.3.10.2 ETH Management Signal Parameters (ETH_MDC, ETH_MDIO)

Table 54 ETH Management Signal Timing Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
ETH_MDC period	$t_1 \text{ CC}$	400	–	–	ns	$C_L = 25 \text{ pF}$
ETH_MDC high time	$t_2 \text{ CC}$	160	–	–	ns	
ETH_MDC low time	$t_3 \text{ CC}$	160	–	–	ns	
ETH_MDIO setup time (output)	$t_4 \text{ CC}$	10	–	–	ns	
ETH_MDIO hold time (output)	$t_5 \text{ CC}$	10	–	–	ns	
ETH_MDIO data valid (input)	$t_6 \text{ SR}$	0	–	300	ns	

3 Electrical Parameters

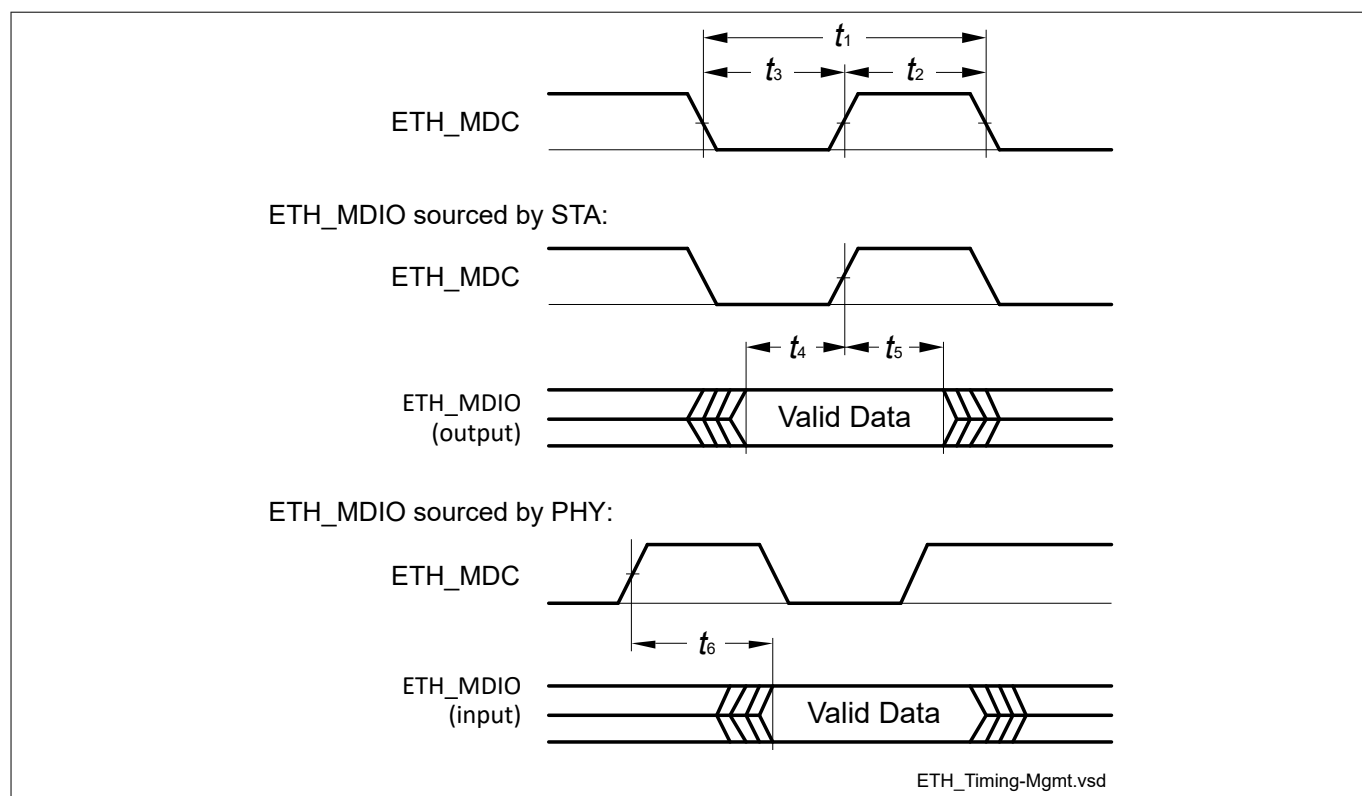


Figure 36 **ETH Management Signal Timing**

3 Electrical Parameters

3.3.10.3 ETH RMII Parameters

In the following, the parameters of the RMII (Reduced Media Independent Interface) are described.

Table 55 ETH RMII Signal Timing Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
ETH_RMII_REF_CL clock period	t_{13} SR	20	–	–	ns	$C_L = 25$ pF; 50 ppm
ETH_RMII_REF_CL clock high time	t_{14} SR	7	–	13	ns	$C_L = 25$ pF
ETH_RMII_REF_CL clock low time	t_{15} SR	7	–	13	ns	
ETH_RMII_RXD[1:0], ETH_RMII_CRS setup time	t_{16} SR	4	–	–	ns	
ETH_RMII_RXD[1:0], ETH_RMII_CRS hold time	t_{17} SR	2	–	–	ns	
ETH_RMII_TXD[1:0], ETH_RMII_TXEN data valid	t_{18} CC	4	–	15	ns	

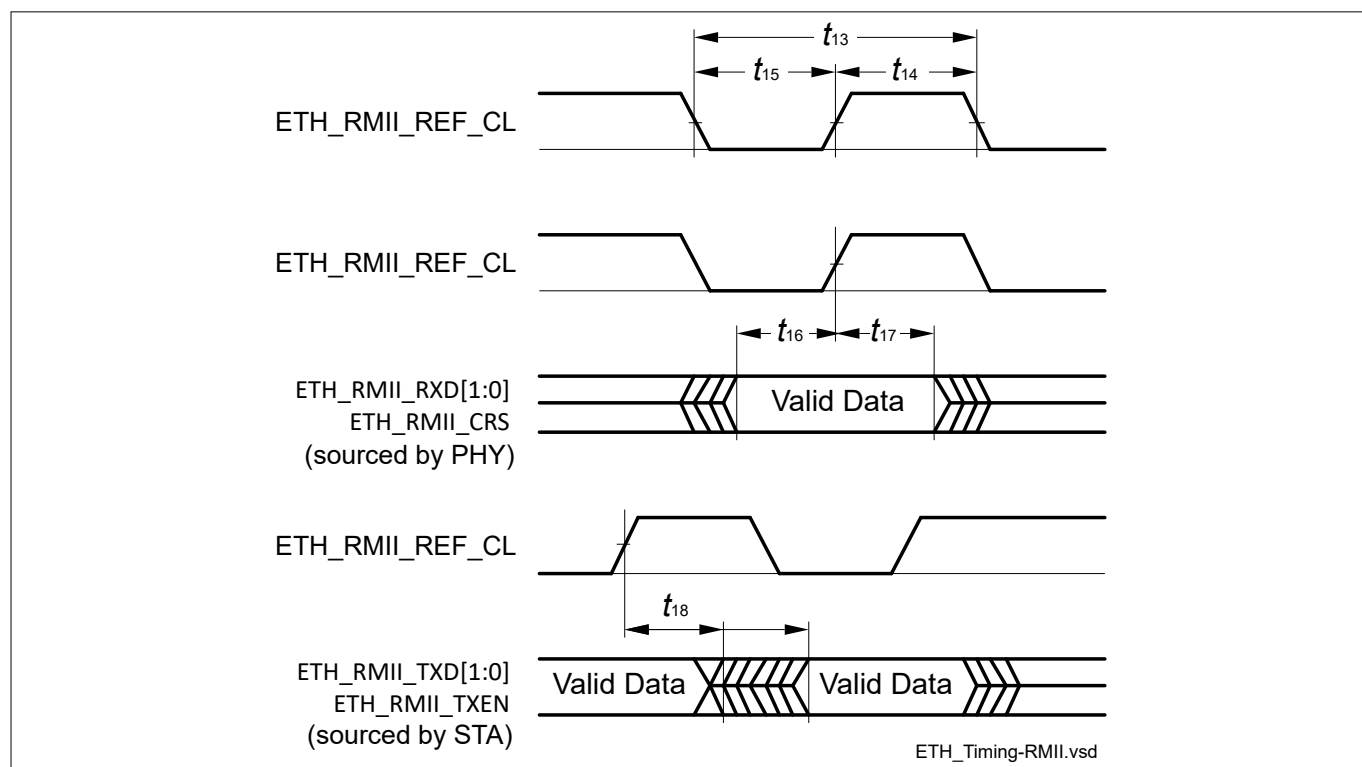


Figure 37 ETH RMII Signal Timing

3 Electrical Parameters

3.3.11 EtherCAT (ECAT) Characteristics

3.3.11.1 ECAT Measurement Reference Points

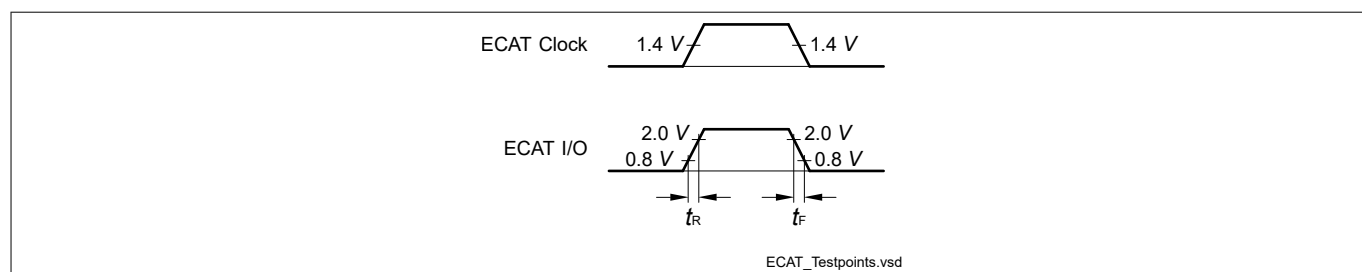


Figure 38 Measurement Reference Points

3.3.11.2 ETH Management Signal Parameters (MCLK, MDIO)

Table 56 ECAT Management Signal Timing Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
ECAT_MCLK period	$t_{\text{MCLK CC}}$	–	400	–	ns	IEEE802.3 requirement (2.5 MHz) $C_L = 25 \text{ pF}$
ECAT_MCLK high time	$t_{\text{MCLK}_h \text{ CC}}$	160	–	–	ns	
ECAT_MCLK low time	$t_{\text{MCLK}_l \text{ CC}}$	160	–	–	ns	
ECAT_MDIO setup time (output)	$t_{\text{D_setup CC}}$	10	–	–	ns	
ECAT_MDIO hold time (output)	$t_{\text{D_hold CC}}$	10	–	–	ns	
ECAT_MDIO data valid (input)	$t_{\text{D_valid SR}}$	0	–	300	ns	

3 Electrical Parameters

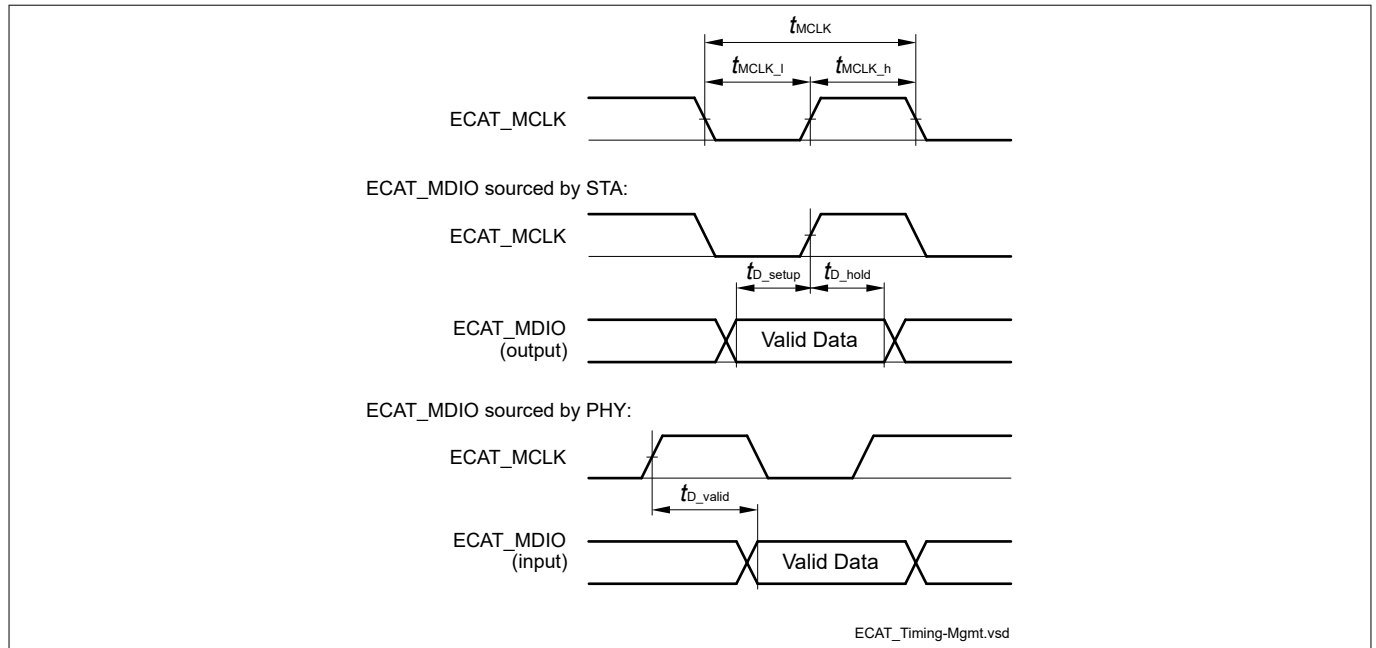


Figure 39 ECAT Management Signal Timing

3.3.11.3 MII Timing TX Characteristics

Table 57 ETH MII TX Signal Timing Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
PHY_CLK25, TX_CLK period	t_{TX_CLK} SR	–	40	–	ns	
Delay between PHY clock source PHY_CLK25 and TX_CLK output of the PHY	t_{PHY_delay} SR	–	–	–	ns	PHY dependent
PHY setup requirement: TXEN/TXD[3:0] with respect to TX_CLK	t_{TX_setup} SR	15	–	0	ns	PHY dependent IEEE802.3 limit is 15 ns
PHY hold requirement: TXEN/TXD[3:0] with respect to TX_CLK	t_{TX_hold} CC	0	–	25	ns	PHY dependent IEEE802.3 limit is 0 ns

Note: ECAT0_CONPx.TX_SHIFT can be adjusted by displaying TX_CLK of a PHY and TXEN/TXD[3:0] on an oscilloscope. TXEN/TXD[3:0] is allowed to change between 0 ns and 25 ns after a rising edge of TX_CLK (according to IEEE802.3 – check your PHY's documentation). Configure TX_SHIFT so that TXEN/TXD[3:0] change near the middle of this range. It is sufficient to check just one of the TXEN/TXD[3:0] signals, because they are nearly generated at the same time.

3 Electrical Parameters

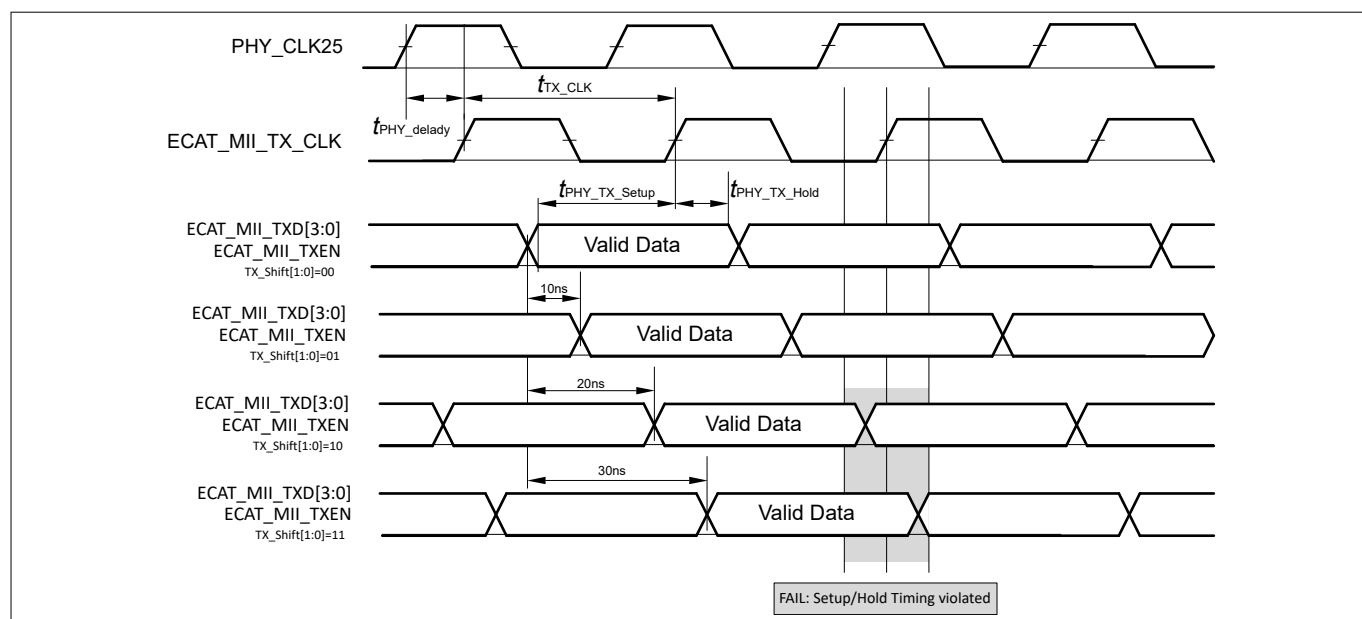


Figure 40 MII TX Characteristics

3.3.11.4 MII Timing RX Characteristics

Table 58 ETH MII RX Signal Timing Parameters

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
RX_CLK period	t_{RX_CLK} SR	–	40	–	ns	$C_L = 25$ pF, IEEE802.3 requirement
RX_DV/RX_DV/RXD[3:0] valid before rising edge of RX_CLK	t_{RX_setup} SR	10	–	–	ns	
RX_DV/RX_DV/RXD[3:0] valid after rising edge of RX_CLK	t_{RX_hold} SR	10	–	–	ns	

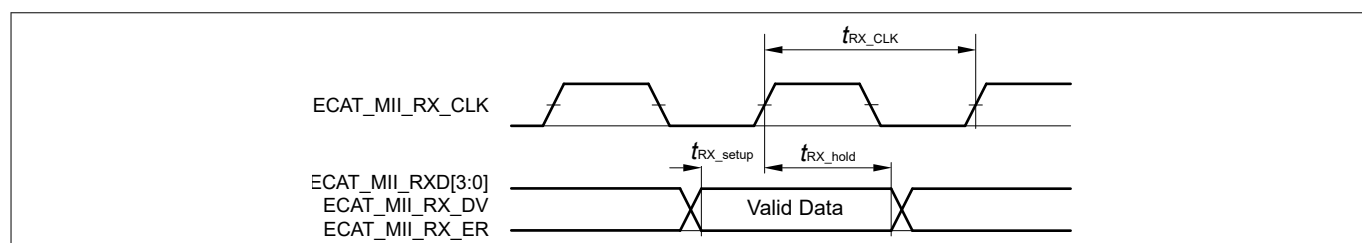


Figure 41 MII RX characteristics

3 Electrical Parameters

3.3.11.5 Sync/Latch Timings

Table 59 Sync/Latch Timings

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
SYNC0/1	$t_{DC_SYNC_Jitter}$ SR	–	–	$11 + m^{1)}$	ns	
LATCH0/1	t_{DC_LATCH} SR	$12 + n^{2)}$	–	–	ns	

1) additional delay form logic and pad, number is added after characterization

2) additional shaping delay, number is added after characterization

Note: SYNC0/1 pulse length are initially loaded by EEPROM content ADR 0x0002. The actual used value can be read back from Register DC_PULSE_LEN.

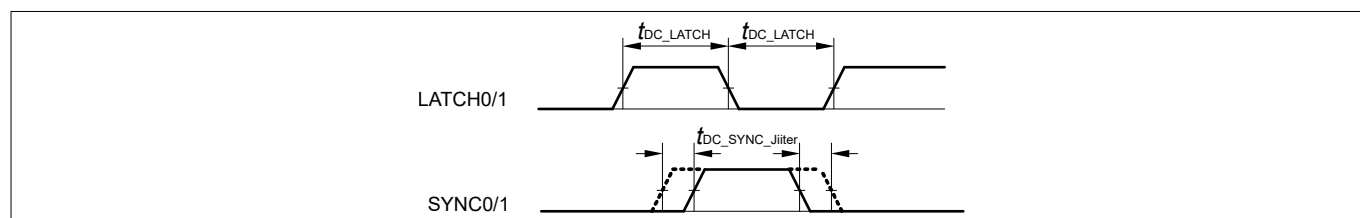


Figure 42 Sync/Latch Timings

4 Package and Reliability

4 Package and Reliability

The XMC4300 is a member of the XMC4000 Family of microcontrollers. It is also compatible to a certain extent with members of similar families or subfamilies.

Each package is optimized for the device it houses. Therefore, there may be slight differences between packages of the same pin-count but for different device types. In particular, the size of the Exposed Die Pad may vary.

If different device types are considered or planned for an application, it must be ensured that the board layout fits all packages under consideration.

4.1 Package Parameters

Table 60 provides the thermal characteristics of the packages used in XMC4300.

Table 60 Thermal Characteristics of the Packages

Parameter	Symbol	Limit Values		Unit	Package Types
		Min.	Max.		
Exposed Die Pad dimensions including U-Groove	Ex × Ey CC	–	7.0 × 7.0	mm	PG-LQFP-100-25
Exposed Die Pad dimensions excluding U-Groove	Ax × Ay CC	–	6.2 × 6.2	mm	PG-LQFP-100-25
Exposed Die Pad dimensions	–	–	7.0 × 7.0	mm	PG-LQFP-100-29
Thermal resistance Junction-Ambient $T_J \leq 150^\circ\text{C}$	$R_{\Theta JA}$ CC	–	22.5	K/W	PG-LQFP-100-25 ¹⁾ PG-LQFP-100-29 ¹⁾

1) Device mounted on a 4-layer JEDEC board (JESD 51-7) with thermal vias; exposed pad soldered.

Note: For electrical reasons, it is required to connect the exposed pad to the board ground V_{SS} , independent of EMC and thermal requirements.

4.1.1 Thermal Considerations

When operating the XMC4300 in a system, the total heat generated in the chip must be dissipated to the ambient environment to prevent overheating and the resulting thermal damage.

The maximum heat that can be dissipated depends on the package and its integration into the target board. The “Thermal resistance $R_{\Theta JA}$ ” quantifies these parameters. The power dissipation must be limited so that the average junction temperature does not exceed 150°C .

The difference between junction temperature and ambient temperature is determined by

$$\Delta T = (P_{\text{INT}} + P_{\text{IOSTAT}} + P_{\text{IODYN}}) \times R_{\Theta JA}$$

The internal power consumption is defined as

$$P_{\text{INT}} = V_{\text{DDP}} \times I_{\text{DDP}} \text{ (switching current and leakage current).}$$

The static external power consumption caused by the output drivers is defined as

$$P_{\text{IOSTAT}} = \Sigma((V_{\text{DDP}} - V_{\text{OH}}) \times I_{\text{OH}}) + \Sigma(V_{\text{OL}} \times I_{\text{OL}})$$

The dynamic external power consumption caused by the output drivers (P_{IODYN}) depends on the capacitive load connected to the respective pins and their switching frequencies.

If the total power dissipation for a given system configuration exceeds the defined limit, countermeasures must be taken to ensure proper system operation:

4 Package and Reliability

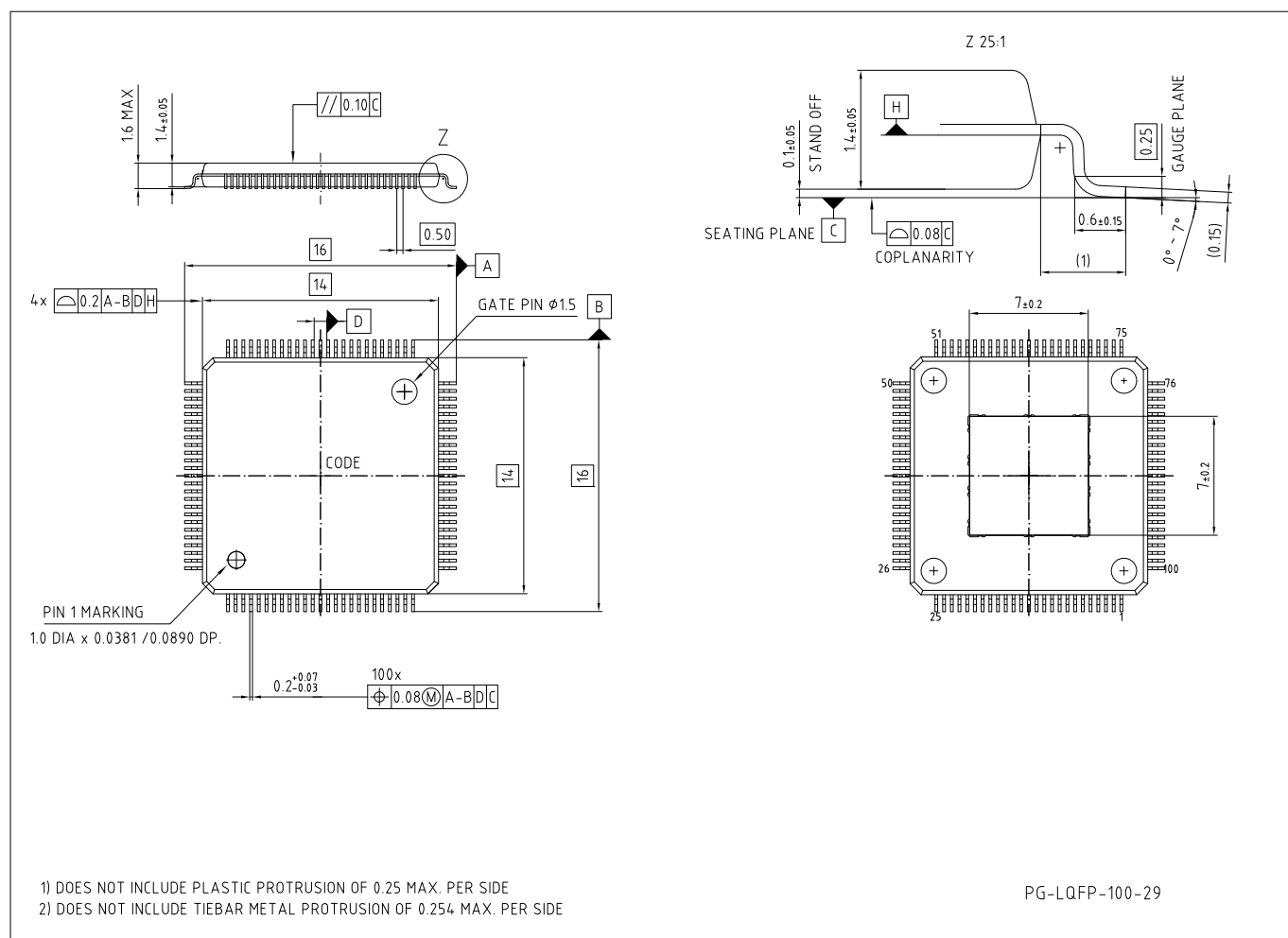


Figure 44 PG-LQFP-100-29 (Plastic Green Low Profile Quad Flat Package)

All dimensions in mm.

You can find complete information about Infineon packages, packing and marking in our Infineon Internet Page "Packages": <http://www.infineon.com/packages>

5 Quality Declarations

5 Quality Declarations

The qualification of the XMC4300 is executed according to the JEDEC standard JESD471.

Note: For automotive applications refer to the Infineon automotive microcontrollers.

Table 61 **Quality Parameters**

Parameter	Symbol	Values			Unit	Note/Test Condition
		Min.	Typ.	Max.		
Operation lifetime	t_{OP} CC	20	–	–	a	$T_J \leq 109^\circ\text{C}$, device permanent on
ESD susceptibility according to Human Body Model (HBM)	V_{HBM} SR	–	–	3000	V	EIA/JESD22-A114-B
ESD susceptibility according to Charged Device Model (CDM)	V_{CDM} SR	–	–	1000	V	Conforming to JESD22-C101-C
Moisture sensitivity level	MSL CC	–	–	3	–	JEDEC J-STD-020D
Soldering temperature	T_{SDR} SR	–	–	260	$^\circ\text{C}$	Profile according to JEDEC J-STD-020D

Revision history

Revision history

Document revision	Date	Description of changes
V1.2	2023-04-01	Summary of Features : Updated number of breakpoints from 8 to 6. Table 60 : Added PG-LQFP-100-29 details. Figure 44 : Added package diagram: PG-LQFP-100-29.
V1.3	2024-11-25	Template update; no content update

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