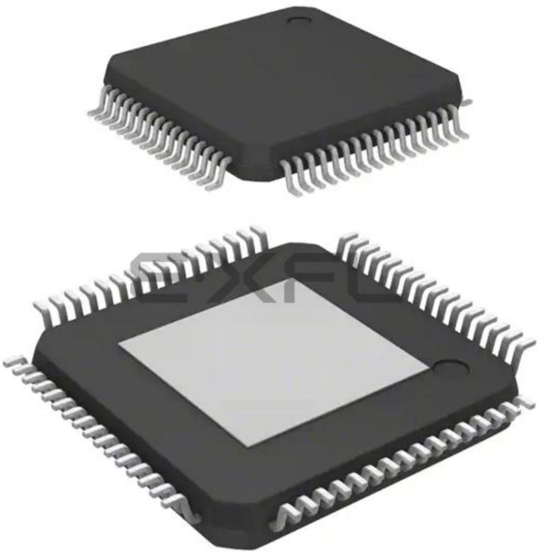

What is "Embedded - Microcontrollers"?

"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M4
Core Size	32-Bit Single-Core
Speed	120MHz
Connectivity	CANbus, Ethernet, I²C, LINbus, SPI, UART, USB
Peripherals	DMA, I²S, LED, POR, PWM, WDT
Number of I/O	31
Program Memory Size	256KB (256K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	80K x 8
Voltage - Supply (Vcc/Vdd)	3.13V ~ 3.63V
Data Converters	A/D 14x12b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	64-LQFP Exposed Pad
Supplier Device Package	PG-LQFP-64-19
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/xmc4400f64k256baxqma1

Table of Contents

On-Chip Memories

- 16 KB on-chip boot ROM
- 16 KB on-chip high-speed program memory
- 32 KB on-chip high speed data memory
- 32 KB on-chip high-speed communication memory
- 512 KB on-chip Flash Memory with 4 KB instruction cache

Communication Peripherals

- Ethernet MAC module capable of 10/100 Mbit/s transfer rates
- Universal Serial Bus, USB 2.0 host, Full-Speed OTG, with integrated PHY
- Controller Area Network interface (MultiCAN), Full-CAN/Basic-CAN with two nodes, 64 message objects (MO), data rate up to 1MBit/s
- Four Universal Serial Interface Channels (USIC), providing four serial channels, usable as UART, double-SPI, quad-SPI, IIC, IIS and LIN interfaces
- LED and Touch-Sense Controller (LEDTS) for Human-Machine interface

Analog Frontend Peripherals

- Four Analog-Digital Converters (VADC) of 12-bit resolution, 8 channels each, with input out-of-range comparators
- Delta Sigma Demodulator with four channels, digital input stage for A/D signal conversion
- Digital-Analog Converter (DAC) with two channels of 12-bit resolution

Industrial Control Peripherals

- Two Capture/Compare Units 8 (CCU8) for motor control and power conversion
- Four Capture/Compare Units 4 (CCU4) for use as general purpose timers
- Four High Resoultion PWM (HRPWM) channels
- Two Position Interfaces (POSIF) for servo motor positioning
- 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

1.3 Package Variants

Different markings of the XMC4400 use different package variants. Details of those packages are given in the **Package Parameters** section of the Data Sheet.

Table 2 XMC4400 Package Variants

Package Variant	Marking	Package
XMC4400-F100	EES-AA, ES-AA, ES-AB, AB	PG-LQFP-100-11
XMC4400-F64		PG-LQFP-64-19
XMC4400-F100	BA	PG-LQFP-100-25
XMC4400-F64		PG-TQFP-64-19

1.4 Device Type Features

The following table lists the available features per device type.

Table 3 Features of XMC4400 Device Types

Derivative[1)]	LEDTS Intf.	ETH Intf.	USB Intf.	USIC Chan.	MultiCAN Nodes, MO
XMC4400-F100x512	1	RMII	1	2 x 2	N0, N1 MO[0..63]
XMC4400-F64x512	1	RMII	1	2 x 2	N0, N1 MO[0..63]
XMC4400-F100x256	1	RMII	1	2 x 2	N0, N1 MO[0..63]
XMC4400-F64x256	1	RMII	1	2 x 2	N0, N1 MO[0..63]
XMC4402-F100x256	1	–	1	2 x 2	N0, N1 MO[0..63]
XMC4402-F64x256	1	–	1	2 x 2	N0, N1 MO[0..63]

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

2.2.2 Port I/O Functions

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

Table 11 Port I/O Function Description

Function	Outputs			Inputs		
	ALT1	**ALTn**	**HWO0**	**HWI0**	**Input**	**Input**
P0.0		MODA.OUT	MODB.OUT	MODB.INA	MODC.INA	
Pn.y	MODA.OUT				MODA.INA	MODC.INB

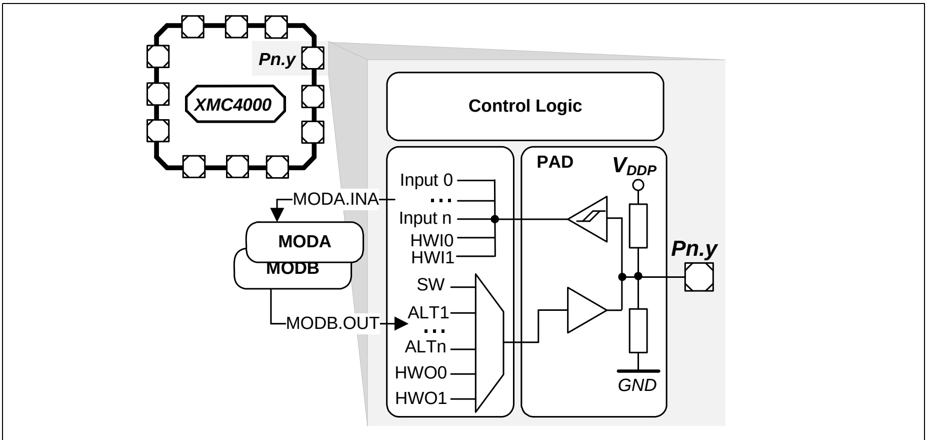

Figure 6 Simplified Port Structure

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.

Up to four alternate output functions (ALT1/2/3/4) can be mapped to a single port pin, selected by Pn_IOCR.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.

2.2.2.1 Port I/O Function Table

Table 12 Port I/O Functions

Function	Output					Input								
	ALT1	ALT2	ALT3	ALT4	HWO0	HWI0	Input	Input	Input	Input	Input	Input	Input	Input
P0.0		CAN.N0_TXD	CCU80.OUT21	LEDTS0.COL2			U1C1.DX0D	ETH0.CLK_RMIIB	ERU0.0B0			HRPWM0.C1INB		ETH0.CLKRXB
P0.1	USB.DRIVEVBUS	U1C1.DOUT0	CCU80.OUT11	LEDTS0.COL3				ETH0.CRS_DVB	ERU0.0A0			HRPWM0.C2INB		ETH0.RXDVB
P0.2		U1C1.SELO1	CCU80.OUT01	HRPWM0.HROUT01	U1C0.DOUT3	U1C0.HWIN3	ETH0.RXD0B		ERU0.3B3					
P0.3			CCU80.OUT20	HRPWM0.HROUT20	U1C0.DOUT2	U1C0.HWIN2	ETH0.RXD1B			ERU1.3B0				
P0.4	ETH0.TX_EN		CCU80.OUT10	HRPWM0.HROUT21	U1C0.DOUT1	U1C0.HWIN1		U1C0.DX0A	ERU0.2B3					
P0.5	ETH0.TXD0	U1C0.DOUT0	CCU80.OUT00	HRPWM0.HROUT00	U1C0.DOUT0	U1C0.HWIN0		U1C0.DX0B		ERU1.3A0				
P0.6	ETH0.TXD1	U1C0.SELO0	CCU80.OUT30	HRPWM0.HROUT30				U1C0.DX2A	ERU0.3B2		CCU80.IN2B			
P0.7	WWDT.SERVICE_OUT	U0C0.SELO0		HRPWM0.HROUT11		DB.TDI	U0C0.DX2B	DSD.DIN1A	ERU0.2B1		CCU80.IN0A	CCU80.IN1A	CCU80.IN2A	CCU80.IN3A
P0.8	SCU.EXTCLK	U0C0.SCLKOUT		HRPWM0.HROUT10		DB.$\overline{\text{TRST}}$	U0C0.DX1B	DSD.DIN0A	ERU0.2A1		CCU80.IN1B			
P0.9	HRPWM0.HROUT31	U1C1.SELO0	CCU80.OUT12	LEDTS0.COL0	ETH0.MDO	ETH0.MDIA	U1C1.DX2A	USB.ID	ERU0.1B0					
P0.10	ETH0.MDC	U1C1.SCLKOUT	CCU80.OUT02	LEDTS0.COL1			U1C1.DX1A		ERU0.1A0					
P0.11		U1C0.SCLKOUT	CCU80.OUT31				ETH0.RXERB	U1C0.DX1A	ERU0.3A2					
P0.12		U1C1.SELO0	CCU40.OUT3					U1C1.DX2B	ERU0.2B2					
P1.0	DSD.CGPWMN	U0C0.SELO0	CCU40.OUT3	ERU1.PDOUT3			U0C0.DX2A		ERU0.3B0		CCU40.IN3A	HRPWM0.C0INA		
P1.1	DSD.CGPWMP	U0C0.SCLKOUT	CCU40.OUT2	ERU1.PDOUT2			U0C0.DX1A	POSIF0.IN2A	ERU0.3A0		CCU40.IN2A	HRPWM0.C1INA		
P1.2			CCU40.OUT1	ERU1.PDOUT1	U0C0.DOUT3	U0C0.HWIN3		POSIF0.IN1A		ERU1.2B0	CCU40.IN1A	HRPWM0.C2INA		
P1.3		U0C0.MCLKOUT	CCU40.OUT0	ERU1.PDOUT0	U0C0.DOUT2	U0C0.HWIN2		POSIF0.IN0A		ERU1.2A0	CCU40.IN0A	HRPWM0.C0INB		
P1.4	WWDT.SERVICE_OUT	CAN.N0_TXD	CCU80.OUT33	CCU81.OUT20	U0C0.DOUT1	U0C0.HWIN1	U0C0.DX0B	CAN.N1_RXDD	ERU0.2B0		CCU41.IN0C	HRPWM0.BL0A		
P1.5	CAN.N1_TXD	U0C0.DOUT0	CCU80.OUT23	CCU81.OUT10	U0C0.DOUT0	U0C0.HWIN0	U0C0.DX0A	CAN.N0_RXDA	ERU0.2A0	ERU1.0A0	CCU41.IN1C	DSD.DIN2B		
P1.6		U0C0.SCLKOUT					DSD.DIN2A							

Table 12 Port I/O Functions (cont'd)

Function	Output					Input								
	ALT1	**ALT2**	**ALT3**	**ALT4**	**HWO0**	**HWI0**	**Input**	**Input**	**Input**	**Input**	**Input**	**Input**	**Input**	**Input**
P1.7		U0C0. DOUT0	DSD. MCLK2	U1C1. SELO2				DSD. MCLK2A			DSD. MCLK0C			
P1.8		U0C0. SELO1	DSD. MCLK1	U1C1. SCLKOUT				DSD. MCLK1A			DSD. MCLK0D	DSD. MCLK2D	DSD. MCLK3D	
P1.9	U0C0. SCLKOUT		DSD. MCLK0	U1C1. DOUT0				DSD. MCLK0A			DSD. MCLK1C	DSD. MCLK2C	DSD. MCLK3C	
P1.10	ETH0. MDC	U0C0. SCLKOUT	CCU81. OUT21								CCU41. IN2C			
P1.11		U0C0. SELO0	CCU81. OUT11		ETH0. MDO	ETH0. MDIC					CCU41. IN3C			
P1.12	ETH0. TX_EN	CAN. N1_TXD	CCU81. OUT01											
P1.13	ETH0. TXD0	U0C1. SELO3	CCU81. OUT20				CAN. N1_RXDC							
P1.14	ETH0. TXD1	U0C1. SELO2	CCU81. OUT10											
P1.15	SCU. EXTCLK	DSD. MCLK2	CCU81. OUT00	U1C0. DOUT0	DB. ETM_TRACED ATA3			DSD. MCLK2B		ERU1. 1A0				
P2.0	CAN. N0_TXD	CCU81. OUT21	DSD. CGPWMN	LEDTS0. COL1	ETH0. MDO	ETH0. MDIB			ERU0. 0B3		CCU40. IN1C			
P2.1		CCU81. OUT11	DSD. CGPWMP	LEDTS0. COL0	DB.TDO/ TRACESWO		ETH0. CLK_RMIIA			ERU1. 0B0	CCU40. IN0C			ETH0. CLKRXA
P2.2	VADC. EMUX00	CCU81. OUT01	CCU41. OUT3	LEDTS0. LINE0	LEDTS0. EXTENDED0	LEDTS0. TSIN0A	ETH0. RXD0A	U0C1. DX0A	ERU0. 1B2		CCU41. IN3A			
P2.3	VADC. EMUX01	U0C1. SELO0	CCU41. OUT2	LEDTS0. LINE1	LEDTS0. EXTENDED1	LEDTS0. TSIN1A	ETH0. RXD1A	U0C1. DX2A	ERU0. 1A2	POSIF1. IN2A	CCU41. IN2A			
P2.4	VADC. EMUX02	U0C1. SCLKOUT	CCU41. OUT1	LEDTS0. LINE2	LEDTS0. EXTENDED2	LEDTS0. TSIN2A	ETH0. RXERA	U0C1. DX1A	ERU0. 0B2	POSIF1. IN1A	CCU41. IN1A	HRPWM0. BL1A		
P2.5	ETH0. TX_EN	U0C1. DOUT0	CCU41. OUT0	LEDTS0. LINE3	LEDTS0. EXTENDED3	LEDTS0. TSIN3A	ETH0. RXDVA	U0C1. DX0B	ERU0. 0A2	POSIF1. IN0A	CCU41. IN0A	HRPWM0. BL2A		ETH0. CRS_DVA
P2.6			CCU80. OUT13	LEDTS0. COL3			DSD. DIN1B	CAN. N1_RXDA	ERU0. 1B3		CCU40. IN3C			
P2.7	ETH0. MDC	CAN. N1_TXD	CCU80. OUT03	LEDTS0. COL2			DSD. DIN0B			ERU1. 1B0	CCU40. IN2C			
P2.8	ETH0. TXD0		CCU80. OUT32	LEDTS0. LINE4	LEDTS0. EXTENDED4	LEDTS0. TSIN4A	DAC. TRIGGER5				CCU40. IN0B	CCU40. IN1B	CCU40. IN2B	CCU40. IN3B
P2.9	ETH0. TXD1		CCU80. OUT22	LEDTS0. LINE5	LEDTS0. EXTENDED5	LEDTS0. TSIN5A	DAC. TRIGGER4				CCU41. IN0B	CCU41. IN1B	CCU41. IN2B	CCU41. IN3B
P2.10	VADC. EMUX10													
P2.14	VADC. EMUX11	U1C0. DOUT0	CCU80. OUT21		DB. ETM_TRACEC LK			U1C0. DX0D			CCU43. IN0B	CCU43. IN1B	CCU43. IN2B	CCU43. IN3B
P2.15	VADC. EMUX12		CCU80. OUT11	LEDTS0. LINE6	LEDTS0. EXTENDED6	LEDTS0. TSIN6A	ETH0. COLA	U1C0. DX0C			CCU42. IN0B	CCU42. IN1B	CCU42. IN2B	CCU42. IN3B

Table 12 Port I/O Functions (cont'd)

Function	Output					Input									
	ALT1	**ALT2**	**ALT3**	**ALT4**	**HWO0**	**HWI0**	**Input**	**Input**	**Input**	**Input**	**Input**	**Input**	**Input**	**Input**	
P14.9					DAC. OUT_1			VADC. G1CH1		VADC. G3CH3	ETH0. RXD1C				
P14.12								VADC. G1CH4							
P14.13								VADC. G1CH5							
P14.14								VADC. G1CH6					G1ORC6		
P14.15								VADC. G1CH7					G1ORC7		
P15.2									VADC. G2CH2						
P15.3									VADC. G2CH3						
P15.8										VADC. G3CH0	ETH0. CLK_RMIIC			ETH0. CLKRXC	
P15.9										VADC. G3CH1	ETH0. CRS_DVC			ETH0. RXDVC	
USB_DP															
USB_DM															
HIB_IO_0	HIBOUT	WWDT. SERVICE_OUT					WAKEUPA								
HIB_IO_1	HIBOUT	WWDT. SERVICE_OUT					WAKEUPB								
TCK						DB.TCK/ SWCLK									
TMS					DB.TMS/ SWDIO										
$\overline{\text{PORST}}$															
XTAL1							U0C0. DX0F	U0C1. DX0F	U1C0. DX0F	U1C1. DX0F					
XTAL2															
RTC_XTAL1									ERU0. 1B1						
RTC_XTAL2															

2.3 Power Connection Scheme

Figure 7. shows a reference power connection scheme for the XMC4400.

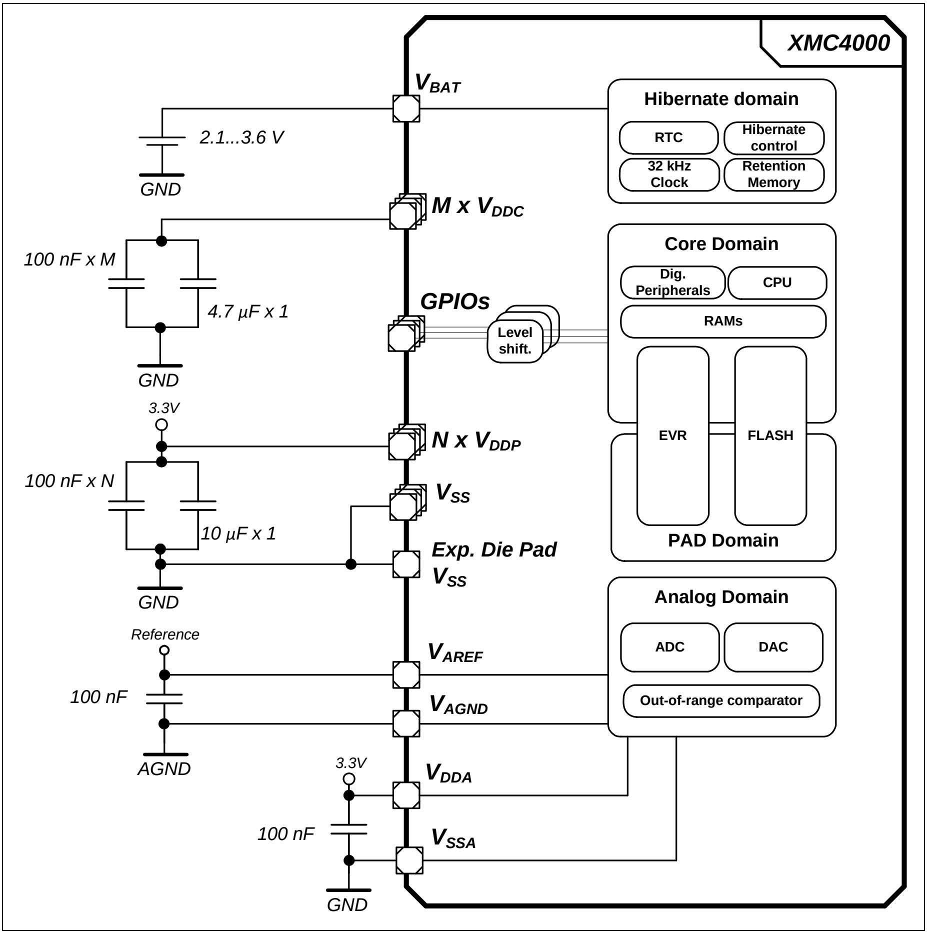

Figure 7 Power Connection Scheme

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 µF capacitor is connected to the V_{DDP} nets and an additional 4.7uF capacitor to the V_{DDC} nets.

Figure 8 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 **Section 3.1.3**.

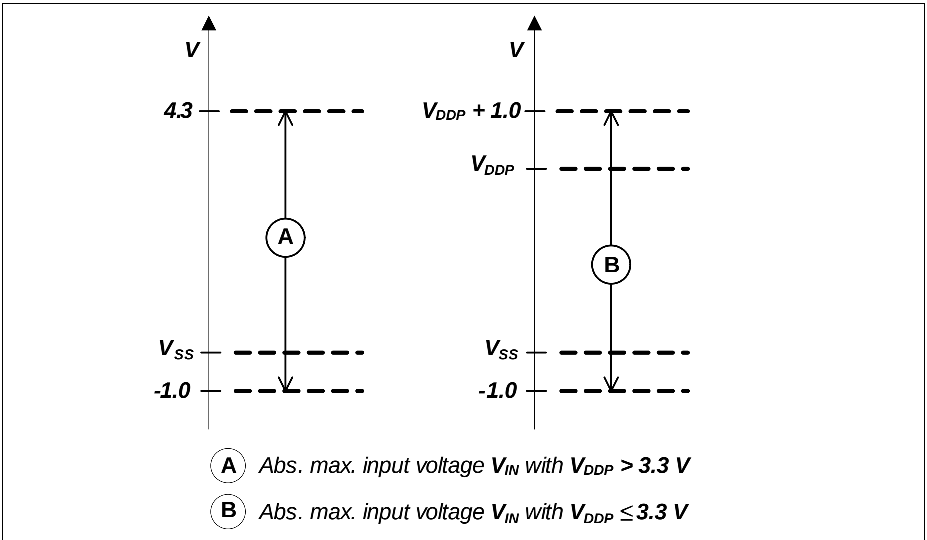

Figure 8 Absolute Maximum Input Voltage Ranges

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 14 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 parameters, then the parameters functionality 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.

Table 21 Standard Pads Class_A1

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.		Max.		
Input leakage current	I_{OZA1} CC	-500		500	nA	$0\ V \le V_{IN} \le V_{DDP}$
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	$I_{OH} \ge$ -400 μA
		2.4		–	V	$I_{OH} \ge$ -500 μA
Output high voltage, POD[1] = medium		V_{DDP} - 0.4		–	V	$I_{OH} \ge$ -1.4 mA
		2.4		–	V	$I_{OH} \ge$ -2 mA
Output low voltage	V_{OLA1} CC	–		0.4	V	$I_{OL} \le$ 500 μA; POD[1] = weak
		–		0.4	V	$I_{OL} \le$ 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 22 Standard Pads Class_A1+

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.		Max.		
Input leakage current	I_{OZA1+} CC	-1		1	μA	$0\ V \le V_{IN} \le V_{DDP}$
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 22 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	$I_{OH} \geq$ -400 μA
		2.4		–	V	$I_{OH} \geq$ -500 μA
Output high voltage, POD[1] = medium		V_{DDP} - 0.4		–	V	$I_{OH} \geq$ -1.4 mA
		2.4		–	V	$I_{OH} \geq$ -2 mA
Output high voltage, POD[1] = strong		V_{DDP} - 0.4		–	V	$I_{OH} \geq$ -1.4 mA
		2.4		–	V	$I_{OH} \geq$ -2 mA
Output low voltage	V_{OLA1+} CC	–		0.4	V	$I_{OL} \leq$ 500 μA; POD[1] = weak
		–		0.4	V	$I_{OL} \leq$ 2 mA; POD[1] = medium
		–		0.4	V	$I_{OL} \leq$ 2 mA; POD[1] = strong
Fall time	t_{FA1+} CC	–		150	ns	C_L = 20 pF; POD[1] = weak
		–		50	ns	C_L = 50 pF; POD[1] = medium
		–		28	ns	C_L = 50 pF; POD[1] = strong; edge = slow
		–		16	ns	C_L = 50 pF; POD[1] = strong; edge = soft;
Rise time	t_{RA1+} CC	–		150	ns	C_L = 20 pF; POD[1] = weak
		–		50	ns	C_L = 50 pF; POD[1] = medium
		–		28	ns	C_L = 50 pF; POD[1] = strong; edge = slow
		–		16	ns	C_L = 50 pF; POD[1] = strong; edge = soft

1) POD = Pin Out Driver

Table 23 Standard Pads Class_A2

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.		Max.		
Input Leakage current	I_{OZA2} CC	-6		6	µA	0 V ≤ V_{IN} < 0.5*V_{DDP} - 1 V; 0.5*V_{DDP} + 1 V <V_{IN} ≤ V_{DDP}
		-3		3	µA	0.5*V_{DDP} - 1 V < V_{IN} < 0.5*V_{DDP} + 1 V
Input high voltage	V_{IHA2} SR	0.6 × V_{DDP}		V_{DDP} + 0.3	V	max. 3.6 V
Input low voltage	V_{ILA2} SR	-0.3		0.36 × V_{DDP}	V	
Output high voltage, POD = weak	V_{OHA2} CC	V_{DDP} - 0.4		–	V	I_{OH} ≥ -400 µA
		2.4		–	V	I_{OH} ≥ -500 µA
Output high voltage, POD = medium		V_{DDP} - 0.4		–	V	I_{OH} ≥ -1.4 mA
		2.4		–	V	I_{OH} ≥ -2 mA
Output high voltage, POD = strong		V_{DDP} - 0.4		–	V	I_{OH} ≥ -1.4 mA
		2.4		–	V	I_{OH} ≥ -2 mA
Output low voltage, POD = weak	V_{OLA2} CC	–		0.4	V	I_{OL} ≤ 500 µA
Output low voltage, POD = medium		–		0.4	V	I_{OL} ≤ 2 mA
Output low voltage, POD = strong		–		0.4	V	I_{OL} ≤ 2 mA

3.2.2 Analog to Digital Converters (ADCx)

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

Table 25 ADC Parameters (Operating Conditions apply)

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Analog reference voltage[5]	V_{AREF} SR	V_{AGND} + 1	–	V_{DDA} + 0.05[1]	V	
Analog reference ground[5]	V_{AGND} SR	V_{SSM} - 0.05	–	V_{AREF} - 1	V	
Analog reference voltage range[2)5]	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[3]	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 VAREF	I_{OZ2} CC	-1	–	1	µA	$0\text{ V} \leq V_{AREF} \leq V_{DDA}$
Input leakage current at VAGND	I_{OZ3} CC	-1	–	1	µA	$0\text{ V} \leq V_{AGND} \leq V_{DDA}$
Internal ADC clock	f_{ADCI} CC	2	–	30	MHz	V_{DDA} = 3.3 V
Switched capacitance at the analog voltage inputs[4]	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[5)6]	C_{AREFSW} CC	–	15	30	pF	
Total capacitance of the voltage reference inputs[5]	$C_{AREFTOT}$ CC	–	20	40	pF	

3.2.4 Out-of-Range Comparator (ORC)

The Out-of-Range Comparator (ORC) triggers on analog input voltages (V_{AIN}) above the analog reference[1)] (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 28** apply for the maximum reference voltage $V_{AREF} = V_{DDA}$ + 50 mV.

Table 28 ORC Parameters (Operating Conditions apply)

Parameter	Symbol		Values			Unit	Note / Test Condition
			Min.	Typ.	Max.		
DC Switching Level	V_{ODC}	CC	100	125	200	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	55	–	450	ns	$V_{AIN} \geq V_{AREF}$ + 200 mV
			45	–	105	ns	$V_{AIN} \geq V_{AREF}$ + 400 mV
Always detected Overvoltage Pulse	t_{OPDD}	CC	440	–	–	ns	$V_{AIN} \geq V_{AREF}$ + 200 mV
			90	–	–	ns	$V_{AIN} \geq V_{AREF}$ + 400 mV
Never detected Overvoltage Pulse	t_{OPDN}	CC	–	–	49	ns	$V_{AIN} \geq V_{AREF}$ + 200 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	

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

Table 38 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 × V_{BAT}	–	V_{BAT} + 0.3	V	
Input low voltage at RTC_XTAL1[5)]	V_{ILBX} SR	-0.3	–	0.36 × V_{BAT}	V	
Input Hysteresis for RTC_XTAL1[5)6)]	V_{HYSX} CC	0.1 × V_{BAT}		–	V	3.0 V ≤ V_{BAT} < 3.6 V
		0.03 × V_{BAT}		–	V	V_{BAT} < 3.0 V
Input leakage current at RTC_XTAL1	I_{ILX1} CC	-100	–	100	nA	Oscillator power down 0 V ≤ V_{IX} ≤ 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} ≥ 3.0 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.

3.2.10 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 V, T_A = 25 °C

Table 39 Power Supply Parameters

Parameter	Symbol		Values			Unit	Note / Test Condition
			Min.	Typ.	Max.		
Active supply current[1] Peripherals enabled Frequency: f_{CPU} / f_{PERIPH} / f_{CCU} in MHz	I_{DDPA}	CC	–	113	–	mA	120 / 120 / 120
			–	102	–		120 / 60 / 60
			–	82	–		60 / 60 / 120
			–	61	–		24 / 24 / 24
			–	51	–		1 / 1 / 1
Active supply current Code execution from RAM Flash in Sleep mode Frequency: f_{CPU} / f_{PERIPH} / f_{CCU} in MHz	I_{DDPA}	CC	–	53	–	mA	120 / 120 / 120
			–	50	–		120 / 60 / 60
Active supply current[2] Peripherals disabled Frequency: f_{CPU} / f_{PERIPH} in MHz	I_{DDPA}	CC	–	80	–	mA	120 / 120 / 120
			–	80	–		120 / 60 / 60
			–	65	–		60 / 60 / 120
			–	55	–		24 / 24 / 24
			–	50	–		1 / 1 / 1

Table 39 Power Supply Parameters

Parameter	Symbol		Values			Unit	Note / Test Condition
			Min.	Typ.	Max.		
Power Dissipation	P_{DISS}	CC	–	–	1	W	V_{DDP} = 3.6 V, T_J = 150 °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 **Section 3.2.11**
Wake-up time from Hibernate mode			–	–	–	ms	Wake-up via power-on reset event, see **Section 3.3.2**

1) CPU executing code from Flash, all peripherals idle.
2) CPU executing code from Flash. Ethernet, USB and CCU clock off.
3) CPU in sleep, all peripherals idle, Flash in Active mode.
4) CPU in sleep, Flash in Active mode.
5) CPU in sleep, peripherals disabled, after wake-up code execution from RAM.
6) To wake-up the Flash from its Sleep mode, $f_{CPU} \geq 1$ MHz is required.
7) OSC_ULP operating with external crystal on RTC_XTAL
8) OSC_ULP off, Hibernate domain operating with OSC_SI clock
9) Test Power Loop: f_{SYS} = 120 MHz, CPU executing benchmark code from Flash, all CCUs in 100kHz timer mode, all ADC groups in continuous conversion mode, USICs as SPI in internal loop-back mode, CAN in 500kHz 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.
10) I_{DDP} decreases typically by 5 mA when f_{SYS} decreases by 10 MHz, at constant T_J
11) Sum of currents of all active converters (ADC and DAC)

3.3 AC Parameters

3.3.1 Testing Waveforms

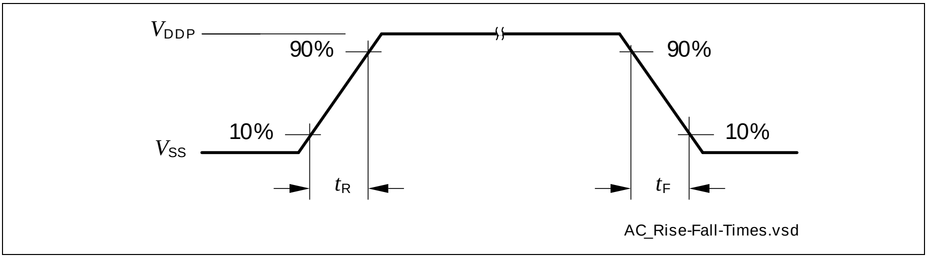

Figure 23 Rise/Fall Time Parameters

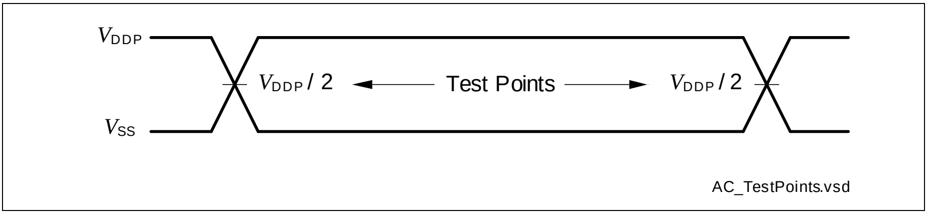

Figure 24 Testing Waveform, Output Delay

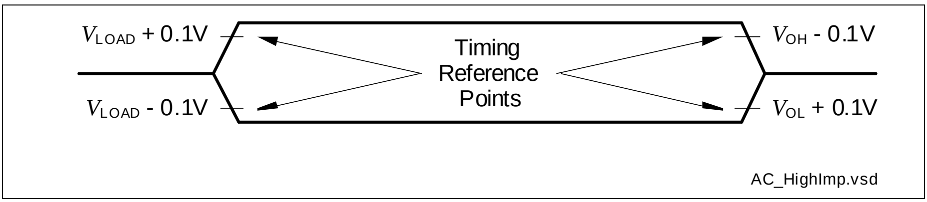

Figure 25 Testing Waveform, Output High Impedance

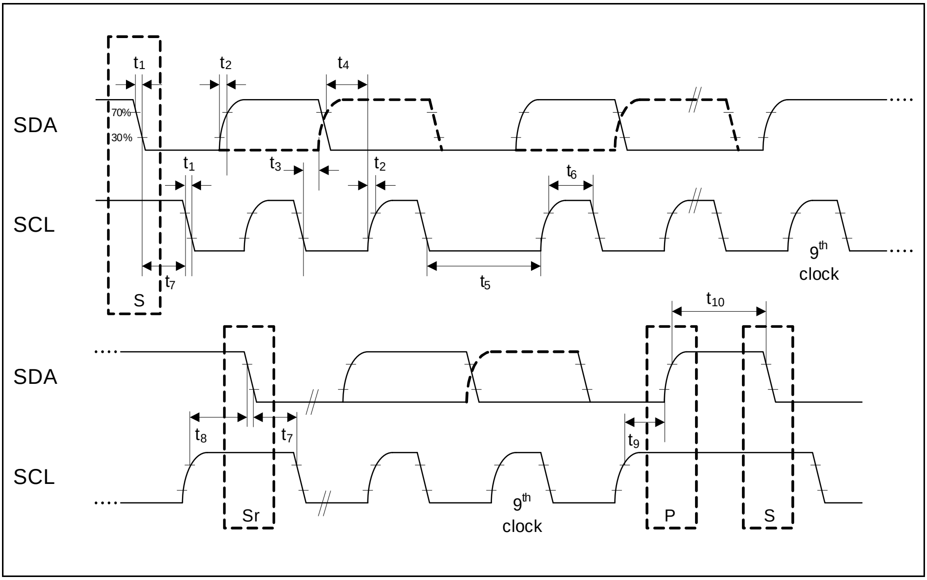

Figure 35 USIC IIC Stand and Fast Mode Timing

3.3.9.4 Inter-IC Sound (IIS) Interface Timing

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

Note: Operating Conditions apply.

Table 55 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	t_2 CC	0.35 x t_{1min}	–	–	ns	
Clock Low	t_3 CC	0.35 x t_{1min}	–	–	ns	
Hold time	t_4 CC	0	–	–	ns	
Clock rise time	t_5 CC	–	–	0.15 x t_{1min}	ns	

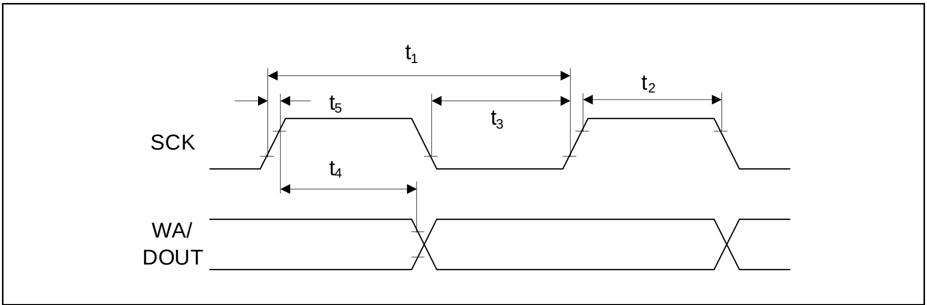

Figure 36 USIC IIS Master Transmitter Timing

Table 56 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	t_7 SR	0.35 x t_{6min}	–	–	ns	
Clock Low	t_8 SR	0.35 x t_{6min}	–	–	ns	
Set-up time	t_9 SR	0.2 x t_{6min}	–	–	ns	
Hold time	t_{10} SR	0	–	–	ns	

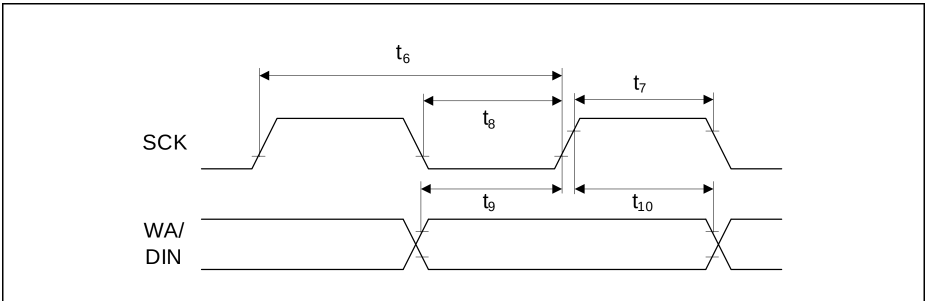

Figure 37 USIC IIS Slave Receiver Timing