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"[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	Obsolete
Core Processor	C166SV2
Core Size	16/32-Bit
Speed	80MHz
Connectivity	CANbus, EBI/EMI, I ² C, LINbus, SPI, SSC, UART/USART, USI
Peripherals	I ² S, POR, PWM, WDT
Number of I/O	118
Program Memory Size	448KB (448K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	64K x 8
Voltage - Supply (Vcc/Vdd)	3V ~ 5.5V
Data Converters	A/D 24x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	144-LQFP Exposed Pad
Supplier Device Package	PG-LQFP-144-4
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/xc2387a56f80labkfuma1

Edition 2014-06

**Published by
Infineon Technologies AG
81726 Munich, Germany**

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Summary of Features

- Two Synchronizable A/D Converters with a total of up to 24 channels, 10-bit resolution, conversion time below 1 μ s, optional data preprocessing (data reduction, range check), broken wire detection
- Up to 6 serial interface channels to be used as UART, LIN, high-speed synchronous channel (SPI), IIC bus interface (10-bit addressing, 400 kbit/s), IIS interface
- On-chip MultiCAN interface (Rev. 2.0B active) with up to 64 message objects (Full CAN/Basic CAN) on up to 3 CAN nodes and gateway functionality
- On-chip system timer and on-chip real time clock
- Up to 12 Mbytes external address space for code and data
 - Programmable external bus characteristics for different address ranges
 - Multiplexed or demultiplexed external address/data buses
 - Selectable address bus width
 - 16-bit or 8-bit data bus width
 - Four programmable chip-select signals
 - Hold- and hold-acknowledge bus arbitration support
- Single power supply from 3.0 V to 5.5 V
- Programmable watchdog timer and oscillator watchdog
- Up to 119 general purpose I/O lines
- On-chip bootstrap loaders
- Supported by a full range of development tools including C compilers, macro-assembler packages, emulators, evaluation boards, HLL debuggers, simulators, logic analyzer disassemblers, programming boards
- On-chip debug support via Device Access Port (DAP) or JTAG interface
- 144-pin Green LQFP package, 0.5 mm (19.7 mil) pitch

Ordering Information

The ordering code for an Infineon microcontroller provides an exact reference to a specific product. This ordering code identifies:

- the function set of the corresponding product type
- the temperature range:
 - SAF-...: -40°C to 85°C
 - SAH-...: -40°C to 110°C
 - SAK-...: -40°C to 125°C
- the package and the type of delivery.

For ordering codes for the XC238xA please contact your sales representative or local distributor.

This document describes several derivatives of the XC238xA group:

Basic Device Types are readily available and

Special Device Types are only available on request.

As this document refers to all of these derivatives, some descriptions may not apply to a specific product, in particular to the special device types.

For simplicity the term **XC238xA** is used for all derivatives throughout this document.

1.1 Basic Device Types

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

Table 1 Synopsis of XC238xA Basic Device Types

Derivative ¹⁾	Flash Memory ²⁾	PSRAM DSRAM ³⁾	Capt./Comp. Modules	ADC ⁴⁾ Chan.	Interfaces ⁴⁾
XC2387A-104FxxLR	832 Kbytes	32 Kbytes 16 Kbytes	CC2 CCU60/1/2/3	16 + 8	3 CAN Nodes, 6 Serial Chan.

1) xx is a placeholder for the available speed grade (in MHz).

2) Specific information about the on-chip Flash memory in [Table 3](#).

3) All derivatives additionally provide 8 Kbytes SBRAM and 2 Kbytes DPRAM.

4) Specific information about the available channels in [Table 5](#).

Analog input channels are listed for each Analog/Digital Converter module separately (ADC0 + ADC1).

1.3 Definition of Feature Variants

The XC238xA types are offered with several Flash memory sizes. [Table 3](#) describes the location of the available memory areas for each Flash memory size.

Table 3 Flash Memory Allocation

Total Flash Size	Flash Area A ¹⁾	Flash Area B	Flash Area C
832 Kbytes	C0'0000 _H ... C0'FFFF _H	C1'0000 _H ... CC'FFFF _H	n.a.
576 Kbytes	C0'0000 _H ... C0'FFFF _H	C1'0000 _H ... C7'FFFF _H	CC'0000 _H ... CC'FFFF _H
448 Kbytes	C0'0000 _H ... C0'FFFF _H	C1'0000 _H ... C5'FFFF _H	CC'0000 _H ... CC'FFFF _H

1) The uppermost 4-Kbyte sector of the first Flash segment is reserved for internal use (C0'F000_H to C0'FFFF_H).

Table 4 Flash Memory Module Allocation (in Kbytes)

Total Flash Size	Flash 0 ¹⁾	Flash 1	Flash 2	Flash 3
832 Kbytes	256	256	256	64
576 Kbytes	256	256	---	64
448 Kbytes	256	128	---	64

1) The uppermost 4-Kbyte sector of the first Flash segment is reserved for internal use (C0'F000_H to C0'FFFF_H).

The XC238xA types are offered with different interface options. [Table 5](#) lists the available channels for each option.

Table 5 Interface Channel Association

Total Number	Available Channels
16 ADC0 channels	CH0 ... CH15
8 ADC1 channels	CH0 ... CH7 (overlay: CH8 ... CH11)
3 CAN nodes	CAN0, CAN1, CAN2 64 message objects
2 CAN nodes	CAN0, CAN1 64 message objects
6 serial channels	U0C0, U0C1, U1C0, U1C1, U2C0, U2C1
4 serial channels	U0C0, U0C1, U1C0, U1C1

Table 6 Pin Definitions and Functions (cont'd)

Pin	Symbol	Ctrl.	Type	Function
39	P5.4	I	In/A	Bit 4 of Port 5, General Purpose Input
	ADC0_CH4	I	In/A	Analog Input Channel 4 for ADC0
	CCU63_T12 HRB	I	In/A	External Run Control Input for T12 of CCU63
	T3EUDA	I	In/A	GPT12E Timer T3 External Up/Down Control Input
	TMS_A	I	In/A	JTAG Test Mode Selection Input
40	P5.5	I	In/A	Bit 5 of Port 5, General Purpose Input
	ADC0_CH5	I	In/A	Analog Input Channel 5 for ADC0
	CCU60_T12 HRB	I	In/A	External Run Control Input for T12 of CCU60
41	P5.6	I	In/A	Bit 6 of Port 5, General Purpose Input
	ADC0_CH6	I	In/A	Analog Input Channel 6 for ADC0
42	P5.7	I	In/A	Bit 7 of Port 5, General Purpose Input
	ADC0_CH7	I	In/A	Analog Input Channel 7 for ADC0
43	P5.8	I	In/A	Bit 8 of Port 5, General Purpose Input
	ADC0_CH8	I	In/A	Analog Input Channel 8 for ADC0
	ADC1_CH8	I	In/A	Analog Input Channel 8 for ADC1
	CCU6x_T12H RC	I	In/A	External Run Control Input for T12 of CCU60/1/2/3
	CCU6x_T13H RC	I	In/A	External Run Control Input for T13 of CCU60/1/2/3
	U2C0_DX0F	I	In/A	USIC2 Channel 0 Shift Data Input
44	P5.9	I	In/A	Bit 9 of Port 5, General Purpose Input
	ADC0_CH9	I	In/A	Analog Input Channel 9 for ADC0
	ADC1_CH9	I	In/A	Analog Input Channel 9 for ADC1
	CC2_T7IN	I	In/A	CAPCOM2 Timer T7 Count Input

Table 6 Pin Definitions and Functions (cont'd)

Pin	Symbol	Ctrl.	Type	Function
60	P4.0	O0 / I	St/B	Bit 0 of Port 4, General Purpose Input/Output
	CC2_CC24	O3 / I	St/B	CAPCOM2 CC24IO Capture Inp./ Compare Out.
	CS0	OH	St/B	External Bus Interface Chip Select 0 Output
61	P2.3	O0 / I	St/B	Bit 3 of Port 2, General Purpose Input/Output
	U0C0_DOUT	O1	St/B	USIC0 Channel 0 Shift Data Output
	CCU63_COU T63	O2	St/B	CCU63 Channel 3 Output
	CC2_CC16	O3 / I	St/B	CAPCOM2 CC16IO Capture Inp./ Compare Out.
	A16	OH	St/B	External Bus Interface Address Line 16
	ESR2_0	I	St/B	ESR2 Trigger Input 0
	U0C0_DX0E	I	St/B	USIC0 Channel 0 Shift Data Input
	U0C1_DX0D	I	St/B	USIC0 Channel 1 Shift Data Input
	RxDC0A	I	St/B	CAN Node 0 Receive Data Input
62	P11.2	O0 / I	St/B	Bit 2 of Port 11, General Purpose Input/Output
	CCU61_CC6 1	O1	St/B	CCU61 Channel 1 Output
	CCU63_CCP OS2A	I	St/B	CCU63 Position Input 2
	CCU61_CC6 1INB	I	St/B	CCU61 Channel 1 Input
63	P4.1	O0 / I	St/B	Bit 1 of Port 4, General Purpose Input/Output
	TxDC2	O2	St/B	CAN Node 2 Transmit Data Output
	CC2_CC25	O3 / I	St/B	CAPCOM2 CC25IO Capture Inp./ Compare Out.
	CS1	OH	St/B	External Bus Interface Chip Select 1 Output
	CCU62_CCP OS0B	I	St/B	CCU62 Position Input 0
	T4EUDB	I	St/B	GPT12E Timer T4 External Up/Down Control Input
	ESR1_8	I	St/B	ESR1 Trigger Input 8

Table 6 Pin Definitions and Functions (cont'd)

Pin	Symbol	Ctrl.	Type	Function
95	P10.3	O0 / I	St/B	Bit 3 of Port 10, General Purpose Input/Output
	CCU60_COU T60	O2	St/B	CCU60 Channel 0 Output
	AD3	OH / IH	St/B	External Bus Interface Address/Data Line 3
	U0C0_DX2A	I	St/B	USIC0 Channel 0 Shift Control Input
	U0C1_DX2A	I	St/B	USIC0 Channel 1 Shift Control Input
96	P0.5	O0 / I	St/B	Bit 5 of Port 0, General Purpose Input/Output
	U1C1_SCLK OUT	O1	St/B	USIC1 Channel 1 Shift Clock Output
	U1C0_SELO 2	O2	St/B	USIC1 Channel 0 Select/Control 2 Output
	CCU61_COU T62	O3	St/B	CCU61 Channel 2 Output
	A5	OH	St/B	External Bus Interface Address Line 5
	U1C1_DX1A	I	St/B	USIC1 Channel 1 Shift Clock Input
	U1C0_DX1C	I	St/B	USIC1 Channel 0 Shift Clock Input
97	P3.3	O0 / I	St/B	Bit 3 of Port 3, General Purpose Input/Output
	U2C0_SELO 0	O1	St/B	USIC2 Channel 0 Select/Control 0 Output
	U2C1_SELO 1	O2	St/B	USIC2 Channel 1 Select/Control 1 Output
	U2C0_DX2A	I	St/B	USIC2 Channel 0 Shift Control Input
98	P10.4	O0 / I	St/B	Bit 4 of Port 10, General Purpose Input/Output
	U0C0_SELO 3	O1	St/B	USIC0 Channel 0 Select/Control 3 Output
	CCU60_COU T61	O2	St/B	CCU60 Channel 1 Output
	AD4	OH / IH	St/B	External Bus Interface Address/Data Line 4
	U0C0_DX2B	I	St/B	USIC0 Channel 0 Shift Control Input
	U0C1_DX2B	I	St/B	USIC0 Channel 1 Shift Control Input
	ESR1_9	I	St/B	ESR1 Trigger Input 9

General Device Information

Table 6 Pin Definitions and Functions (cont'd)

Pin	Symbol	Ctrl.	Type	Function
117	P10.10	O0 / I	St/B	Bit 10 of Port 10, General Purpose Input/Output
	U0C0_SELO0	O1	St/B	USIC0 Channel 0 Select/Control 0 Output
	CCU60_COUT63	O2	St/B	CCU60 Channel 3 Output
	AD10	OH / IH	St/B	External Bus Interface Address/Data Line 10
	U0C0_DX2C	I	St/B	USIC0 Channel 0 Shift Control Input
	U0C1_DX1A	I	St/B	USIC0 Channel 1 Shift Clock Input
	TDI_B	IH	St/B	JTAG Test Data Input If JTAG pos. B is selected during start-up, an internal pull-up device will hold this pin high when nothing is driving it.
118	P10.11	O0 / I	St/B	Bit 11 of Port 10, General Purpose Input/Output
	U1C0_SCLKOUT	O1	St/B	USIC1 Channel 0 Shift Clock Output
	BRKOUT	O2	St/B	OCDS Break Signal Output
	AD11	OH / IH	St/B	External Bus Interface Address/Data Line 11
	U1C0_DX1D	I	St/B	USIC1 Channel 0 Shift Clock Input
	RxDC2B	I	St/B	CAN Node 2 Receive Data Input
	TMS_B	IH	St/B	JTAG Test Mode Selection Input If JTAG pos. B is selected during start-up, an internal pull-up device will hold this pin high when nothing is driving it.
119	P9.2	O0 / I	St/B	Bit 2 of Port 9, General Purpose Input/Output
	CCU63_CC62	O1	St/B	CCU63 Channel 2 Output
	CCU63_CC62INA	I	St/B	CCU63 Channel 2 Input
	CAPINB	I	St/B	GPT12E Register CAPREL Capture Input

Table 6 Pin Definitions and Functions (cont'd)

Pin	Symbol	Ctrl.	Type	Function
134	P9.7	O0 / I	St/B	Bit 7 of Port 9, General Purpose Input/Output
	CCU62_COU T60	O1	St/B	CCU62 Channel 0 Output
	CCU62_COU T63	O2	St/B	CCU62 Channel 3 Output
	CCU63_CTR APB	I	St/B	CCU63 Emergency Trap Input
	U2C0_DX1D	I	St/B	USIC2 Channel 0 Shift Clock Input
	CCU60_CCP OS0B	I	St/B	CCU60 Position Input 0
135	P1.7	O0 / I	St/B	Bit 7 of Port 1, General Purpose Input/Output
	CCU62_CC6 0	O1	St/B	CCU62 Channel 0 Output
	U1C1_MCLK OUT	O2	St/B	USIC1 Channel 1 Master Clock Output
	U2C0_SCLK OUT	O3	St/B	USIC2 Channel 0 Shift Clock Output
	A15	OH	St/B	External Bus Interface Address Line 15
	U2C0_DX1C	I	St/B	USIC2 Channel 0 Shift Clock Input
	CCU62_CC6 0INA	I	St/B	CCU62 Channel 0 Input
136	XTAL2	O	Sp/M	Crystal Oscillator Amplifier Output
137	XTAL1	I	Sp/M	Crystal Oscillator Amplifier Input To clock the device from an external source, drive XTAL1, while leaving XTAL2 unconnected. Voltages on XTAL1 must comply to the core supply voltage V_{DDIM} .
	ESR2_9	I	St/B	ESR2 Trigger Input 9

3.3 Central Processing Unit (CPU)

The core of the CPU consists of a 5-stage execution pipeline with a 2-stage instruction-fetch pipeline, a 16-bit arithmetic and logic unit (ALU), a 32-bit/40-bit multiply and accumulate unit (MAC), a register-file providing three register banks, and dedicated SFRs. The ALU features a multiply-and-divide unit, a bit-mask generator, and a barrel shifter.

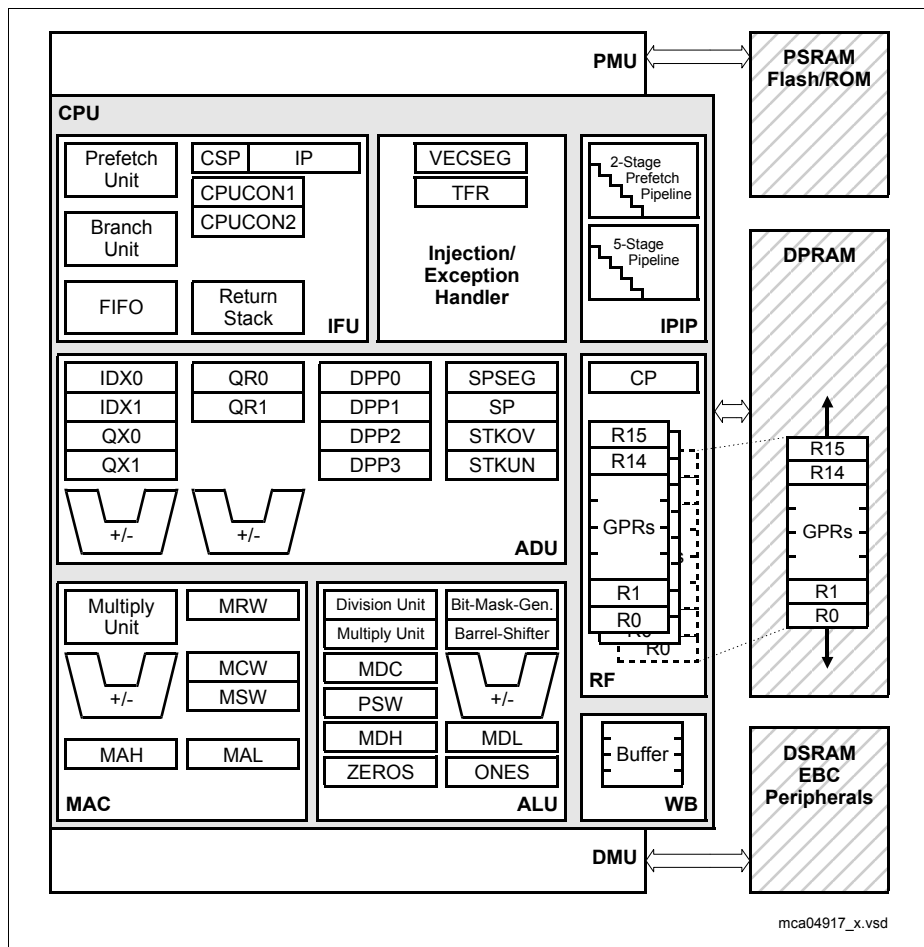


Figure 5 CPU Block Diagram

Functional Description

With this hardware most XC238xA instructions are executed in a single machine cycle of 12.5 ns with an 80-MHz CPU clock. For example, shift and rotate instructions are always processed during one machine cycle, no matter how many bits are shifted. Also, multiplication and most MAC instructions execute in one cycle. All multiple-cycle instructions have been optimized so that they can be executed very fast; for example, a 32-/16-bit division is started within 4 cycles while the remaining cycles are executed in the background. Another pipeline optimization, the branch target prediction, eliminates the execution time of branch instructions if the prediction was correct.

The CPU has a register context consisting of up to three register banks with 16 word-wide GPRs each at its disposal. One of these register banks is physically allocated within the on-chip DPRAM area. A Context Pointer (CP) register determines the base address of the active register bank accessed by the CPU at any time. The number of these register bank copies is only restricted by the available internal RAM space. For easy parameter passing, a register bank may overlap others.

A system stack of up to 32 Kwords is provided for storage of temporary data. The system stack can be allocated to any location within the address space (preferably in the on-chip RAM area); it is accessed by the CPU with the stack pointer (SP) register. Two separate SFRs, STKOV and STKUN, are implicitly compared with the stack pointer value during each stack access to detect stack overflow or underflow.

The high performance of the CPU hardware implementation can be best utilized by the programmer with the highly efficient XC238xA instruction set. This includes the following instruction classes:

- Standard Arithmetic Instructions
- DSP-Oriented Arithmetic Instructions
- Logical Instructions
- Boolean Bit Manipulation Instructions
- Compare and Loop Control Instructions
- Shift and Rotate Instructions
- Prioritize Instruction
- Data Movement Instructions
- System Stack Instructions
- Jump and Call Instructions
- Return Instructions
- System Control Instructions
- Miscellaneous Instructions

The basic instruction length is either 2 or 4 bytes. Possible operand types are bits, bytes and words. A variety of direct, indirect or immediate addressing modes are provided to specify the required operands.

3.4 Memory Protection Unit (MPU)

The XC238xA's Memory Protection Unit (MPU) protects user-specified memory areas from unauthorized read, write, or instruction fetch accesses. The MPU can protect the whole address space including the peripheral area. This completes established mechanisms such as the register security mechanism or stack overrun/underrun detection.

Four Protection Levels support flexible system programming where operating system, low level drivers, and applications run on separate levels. Each protection level permits different access restrictions for instructions and/or data.

Every access is checked (if the MPU is enabled) and an access violating the permission rules will be marked as invalid and leads to a protection trap.

A set of protection registers for each protection level specifies the address ranges and the access permissions. Applications requiring more than 4 protection levels can dynamically re-program the protection registers.

3.5 Memory Checker Module (MCHK)

The XC238xA's Memory Checker Module calculates a checksum (fractional polynomial division) on a block of data, often called Cyclic Redundancy Code (CRC). It is based on a 32-bit linear feedback shift register and may, therefore, also be used to generate pseudo-random numbers.

The Memory Checker Module is a 16-bit parallel input signature compression circuitry which enables error detection within a block of data stored in memory, registers, or communicated e.g. via serial communication lines. It reduces the probability of error masking due to repeated error patterns by calculating the signature of blocks of data.

The polynomial used for operation is configurable, so most of the commonly used polynomials may be used. Also, the block size for generating a CRC result is configurable via a local counter. An interrupt may be generated if testing the current data block reveals an error.

An autonomous CRC compare circuitry is included to enable redundant error detection, e.g. to enable higher safety integrity levels.

The Memory Checker Module provides enhanced fault detection (beyond parity or ECC) for data and instructions in volatile and non volatile memories. This is especially important for the safety and reliability of embedded systems.

Functional Description

to a dedicated vector table location). The occurrence of a hardware trap is also indicated by a single bit in the trap flag register (TFR). Unless another higher-priority trap service is in progress, a hardware trap will interrupt any ongoing program execution. In turn, hardware trap services can normally not be interrupted by standard or PEC interrupts.

Depending on the package option up to 3 External Service Request (ESR) pins are provided. The ESR unit processes their input values and allows to implement user controlled trap functions (System Requests SR0 and SR1). In this way reset, wakeup and power control can be efficiently realized.

Software interrupts are supported by the 'TRAP' instruction in combination with an individual trap (interrupt) number. Alternatively to emulate an interrupt by software a program can trigger interrupt requests by writing the Interrupt Request (IR) bit of an interrupt control register.

3.7 On-Chip Debug Support (OCDS)

The On-Chip Debug Support system built into the XC238xA provides a broad range of debug and emulation features. User software running on the XC238xA can be debugged within the target system environment.

The OCDS is controlled by an external debugging device via the debug interface. This either consists of the 2-pin Device Access Port (DAP) or of the JTAG port conforming to IEEE-1149. The debug interface can be completed with an optional break interface.

The debugger controls the OCDS with a set of dedicated registers accessible via the debug interface (DAP or JTAG). In addition the OCDS system can be controlled by the CPU, e.g. by a monitor program. An injection interface allows the execution of OCDS-generated instructions by the CPU.

Multiple breakpoints can be triggered by on-chip hardware, by software, or by an external trigger input. Single stepping is supported, as is the injection of arbitrary instructions and read/write access to the complete internal address space. A breakpoint trigger can be answered with a CPU halt, a monitor call, a data transfer, or/and the activation of an external signal.

Tracing data can be obtained via the debug interface, or via the external bus interface for increased performance.

Tracing of program execution is supported by the XC2000 Family emulation device.

The DAP interface uses two interface signals, the JTAG interface uses four interface signals, to communicate with external circuitry. The debug interface can be amended with two optional break lines.

Functional Description

With its maximum resolution of 2 system clock cycles, the **GPT2 module** provides precise event control and time measurement. It includes two timers (T5, T6) and a capture/reload register (CAPREL). Both timers can be clocked with an input clock which is derived from the CPU clock via a programmable prescaler or with external signals. The counting direction (up/down) for each timer can be programmed by software or altered dynamically with an external signal on a port pin (TxEUD). Concatenation of the timers is supported with the output toggle latch (T6OTL) of timer T6, which changes its state on each timer overflow/underflow.

The state of this latch may be used to clock timer T5, and/or it may be output on pin T6OUT. The overflows/underflows of timer T6 can also be used to clock the CAPCOM2 timers and to initiate a reload from the CAPREL register.

The CAPREL register can capture the contents of timer T5 based on an external signal transition on the corresponding port pin (CAPIN); timer T5 may optionally be cleared after the capture procedure. This allows the XC238xA to measure absolute time differences or to perform pulse multiplication without software overhead.

The capture trigger (timer T5 to CAPREL) can also be generated upon transitions of GPT1 timer T3 inputs T3IN and/or T3EUD. This is especially advantageous when T3 operates in Incremental Interface Mode.

3.13 Universal Serial Interface Channel Modules (USIC)

The XC238xA features the USIC modules USIC0, USIC1, USIC2. Each module provides two serial communication channels.

The Universal Serial Interface Channel (USIC) module is based on a generic data shift and data storage structure which is identical for all supported serial communication protocols. Each channel supports complete full-duplex operation with a basic data buffer structure (one transmit buffer and two receive buffer stages). In addition, the data handling software can use FIFOs.

The protocol part (generation of shift clock/data/control signals) is independent of the general part and is handled by protocol-specific preprocessors (PPPs).

The USIC's input/output lines are connected to pins by a pin routing unit. The inputs and outputs of each USIC channel can be assigned to different interface pins, providing great flexibility to the application software. All assignments can be made during runtime.

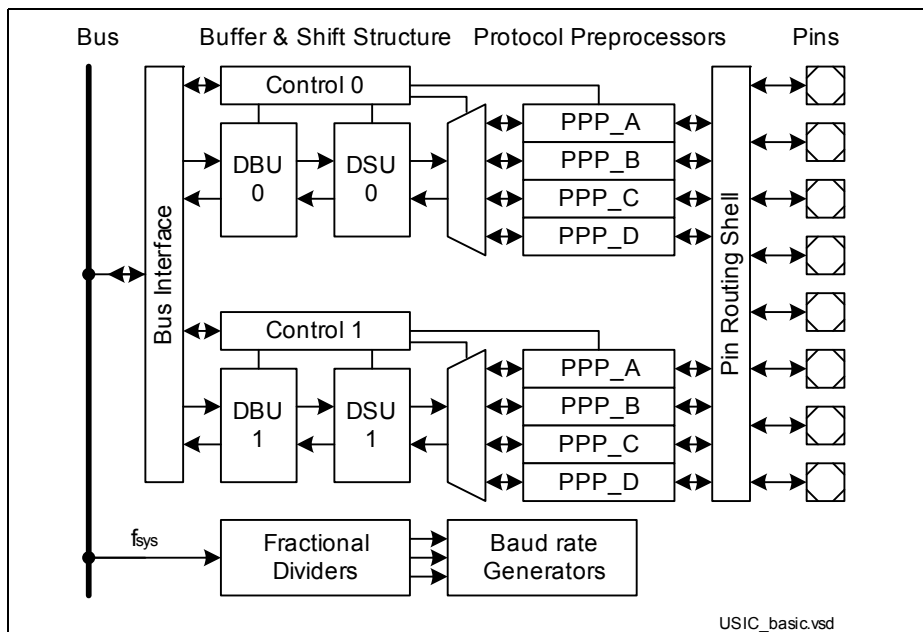


Figure 11 General Structure of a USIC Module

The regular structure of the USIC module brings the following advantages:

- Higher flexibility through configuration with same look-and-feel for data management
- Reduced complexity for low-level drivers serving different protocols
- Wide range of protocols with improved performances (baud rate, buffer handling)

4.3 Analog/Digital Converter Parameters

These parameters describe the conditions for optimum ADC performance.

Note: Operating Conditions apply.

Table 18 ADC Parameters

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Switched capacitance at an analog input	C_{AINSW} CC	–	4	5	pF	not subject to production test ¹⁾
Total capacitance at an analog input	C_{AINT} CC	–	10	12	pF	not subject to production test ¹⁾
Switched capacitance at the reference input	C_{AREFSW} CC	–	7	9	pF	not subject to production test ¹⁾
Total capacitance at the reference input	C_{AREFT} CC	–	13	15	pF	not subject to production test ¹⁾
Differential Non-Linearity Error	$ EA_{DNL} $ CC	–	0.8	1.0	LSB	not subject to production test
Gain Error	$ EA_{GAIN} $ CC	–	0.4	0.8	LSB	not subject to production test
Integral Non-Linearity	$ EA_{INL} $ CC	–	0.8	1.2	LSB	not subject to production test
Offset Error	$ EA_{OFF} $ CC	–	0.5	0.8	LSB	not subject to production test
Analog clock frequency	f_{ADCI} SR	0.5	–	20	MHz	Upper voltage range
		0.5	–	16.5	MHz	Lower voltage range
Input resistance of the selected analog channel	R_{AIN} CC	–	–	2	kOhm	not subject to production test ¹⁾
Input resistance of the reference input	R_{AREF} CC	–	–	2	kOhm	not subject to production test ¹⁾

Electrical Parameters

Sample time and conversion time of the XC238xA's A/D converters are programmable. The timing above can be calculated using [Table 19](#).

The limit values for f_{ADCI} must not be exceeded when selecting the prescaler value.

Table 19 A/D Converter Computation Table

GLOBCTR.5-0 (DIVA)	A/D Converter Analog Clock f_{ADCI}	INPCRx.7-0 (STC)	Sample Time¹⁾ t_s
000000 _B	f_{SYS}	00 _H	$t_{\text{ADCI}} \times 2$
000001 _B	$f_{\text{SYS}} / 2$	01 _H	$t_{\text{ADCI}} \times 3$
000010 _B	$f_{\text{SYS}} / 3$	02 _H	$t_{\text{ADCI}} \times 4$
:	$f_{\text{SYS}} / (\text{DIVA}+1)$:	$t_{\text{ADCI}} \times (\text{STC}+2)$
111110 _B	$f_{\text{SYS}} / 63$	FE _H	$t_{\text{ADCI}} \times 256$
111111 _B	$f_{\text{SYS}} / 64$	FF _H	$t_{\text{ADCI}} \times 257$

1) The selected sample time is doubled if broken wire detection is active (due to the presampling phase).

Converter Timing Example A:

Assumptions: $f_{\text{SYS}} = 80 \text{ MHz}$ (i.e. $t_{\text{SYS}} = 12.5 \text{ ns}$), DIVA = 03_H, STC = 00_H

Analog clock $f_{\text{ADCI}} = f_{\text{SYS}} / 4 = 20 \text{ MHz}$, i.e. $t_{\text{ADCI}} = 50 \text{ ns}$

Sample time $t_s = t_{\text{ADCI}} \times 2 = 100 \text{ ns}$

Conversion 10-bit:

$$t_{\text{C10}} = 13 \times t_{\text{ADCI}} + 2 \times t_{\text{SYS}} = 13 \times 50 \text{ ns} + 2 \times 12.5 \text{ ns} = 0.675 \mu\text{s}$$

Conversion 8-bit:

$$t_{\text{C8}} = 11 \times t_{\text{ADCI}} + 2 \times t_{\text{SYS}} = 11 \times 50 \text{ ns} + 2 \times 12.5 \text{ ns} = 0.575 \mu\text{s}$$

Converter Timing Example B:

Assumptions: $f_{\text{SYS}} = 40 \text{ MHz}$ (i.e. $t_{\text{SYS}} = 25 \text{ ns}$), DIVA = 02_H, STC = 03_H

Analog clock $f_{\text{ADCI}} = f_{\text{SYS}} / 3 = 13.3 \text{ MHz}$, i.e. $t_{\text{ADCI}} = 75 \text{ ns}$

Sample time $t_s = t_{\text{ADCI}} \times 5 = 375 \text{ ns}$

Conversion 10-bit:

$$t_{\text{C10}} = 16 \times t_{\text{ADCI}} + 2 \times t_{\text{SYS}} = 16 \times 75 \text{ ns} + 2 \times 25 \text{ ns} = 1.25 \mu\text{s}$$

Conversion 8-bit:

$$t_{\text{C8}} = 14 \times t_{\text{ADCI}} + 2 \times t_{\text{SYS}} = 14 \times 75 \text{ ns} + 2 \times 25 \text{ ns} = 1.10 \mu\text{s}$$

Electrical Parameters

Table 23 Flash Parameters (cont'd)

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
Number of erase cycles	N_{Er} SR	—	—	15 000	cycles	$t_{RET} \geq 5$ years; Valid for up to 64 user-selected sectors (data storage)
		—	—	1 000	cycles	$t_{RET} \geq 20$ years

- 1) All Flash module(s) can be erased/programmed while code is executed and/or data is read from only one Flash module or from PSRAM. The Flash module that delivers code/data can, of course, not be erased/programmed.
- 2) Flash module 3 can be erased/programmed while code is executed and/or data is read from any other Flash module.
- 3) Value of IMB_IMBCTRL.WSFLASH.
- 4) Programming and erase times depend on the internal Flash clock source. The control state machine needs a few system clock cycles. This increases the stated durations noticeably only at extremely low system clock frequencies.

Access to the XC238xA Flash modules is controlled by the IMB. Built-in prefetch mechanisms optimize the performance for sequential access.

Flash access waitstates only affect non-sequential access. Due to prefetch mechanisms, the performance for sequential access (depending on the software structure) is only partially influenced by waitstates.

4.6.2 Definition of Internal Timing

The internal operation of the XC238xA is controlled by the internal system clock f_{SYS} .

Because the system clock signal f_{SYS} can be generated from a number of internal and external sources using different mechanisms, the duration of the system clock periods (TCSs) and their variation (as well as the derived external timing) depend on the mechanism used to generate f_{SYS} . This must be considered when calculating the timing for the XC238xA.

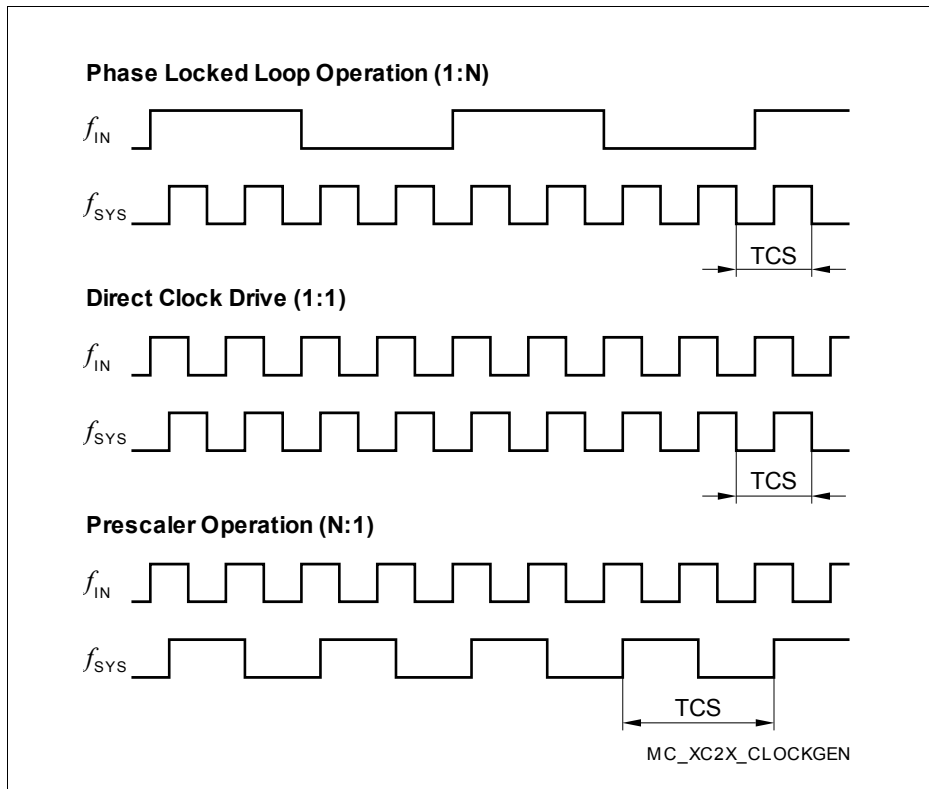


Figure 19 Generation Mechanisms for the System Clock

Note: The example of PLL operation shown in [Figure 19](#) uses a PLL factor of 1:4; the example of prescaler operation uses a divider factor of 2:1.

The specification of the external timing (AC Characteristics) depends on the period of the system clock (TCS).

Table 39 DAP Interface Timing for Lower Voltage Range

Parameter	Symbol	Values			Unit	Note / Test Condition
		Min.	Typ.	Max.		
DAP0 clock period	t_{11} SR	25 ¹⁾	—	—	ns	
DAP0 high time	t_{12} SR	8	—	—	ns	
DAP0 low time	t_{13} SR	8	—	—	ns	
DAP0 clock rise time	t_{14} SR	—	—	4	ns	
DAP0 clock fall time	t_{15} SR	—	—	4	ns	
DAP1 setup to DAP0 rising edge	t_{16} SR	6	—	—	ns	pad_type= standard
DAP1 hold after DAP0 rising edge	t_{17} SR	6	—	—	ns	pad_type= standard
DAP1 valid per DAP0 clock period ²⁾	t_{19} CC	12	17	—	ns	pad_type= standard

1) The debug interface cannot operate faster than the overall system, therefore $t_{11} \geq t_{SYS}$.

2) The Host has to find a suitable sampling point by analyzing the sync telegram response.

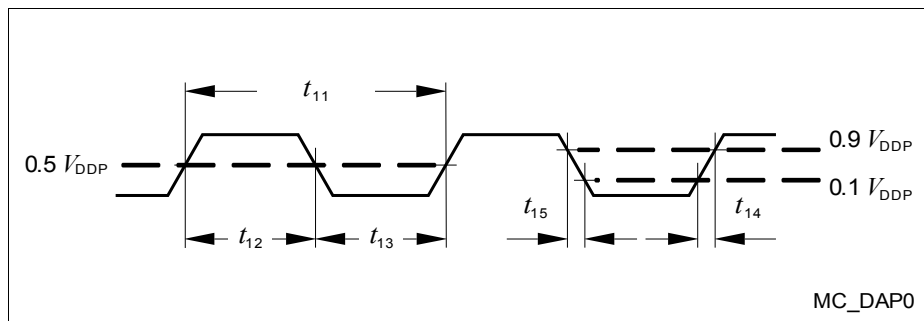


Figure 29 Test Clock Timing (DAP0)