Infineon Technologies - XC167CI32F40FBBAKXQMA1 Datasheet

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Last Time Buy
Core Processor	C166SV2
Core Size	16-Bit
Speed	40MHz
Connectivity	CANbus, EBI/EMI, I²C, SPI, UART/USART
Peripherals	PWM, WDT
Number of I/O	103
Program Memory Size	256KB (256K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	12K x 8
Voltage - Supply (Vcc/Vdd)	2.35V ~ 2.7V
Data Converters	A/D 16x8/10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	-
Package / Case	-
Supplier Device Package	-
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/xc167ci32f40fbbakxqma1

XC167CI-32F

16-Bit Single-Chip Microcontroller with C166SV2 Core

Microcontrollers

Never stop thinking

2 General Device Information

2.1 Introduction

The XC167 derivatives are high-performance members of the Infineon XC166 Family of full featured single-chip CMOS microcontrollers. These devices extend the functionality and performance of the C166 Family in terms of instructions (MAC unit), peripherals, and speed. They combine high CPU performance (up to 40 million instructions per second) with high peripheral functionality and enhanced IO-capabilities. They also provide clock generation via PLL and various on-chip memory modules such as program Flash, program RAM, and data RAM.

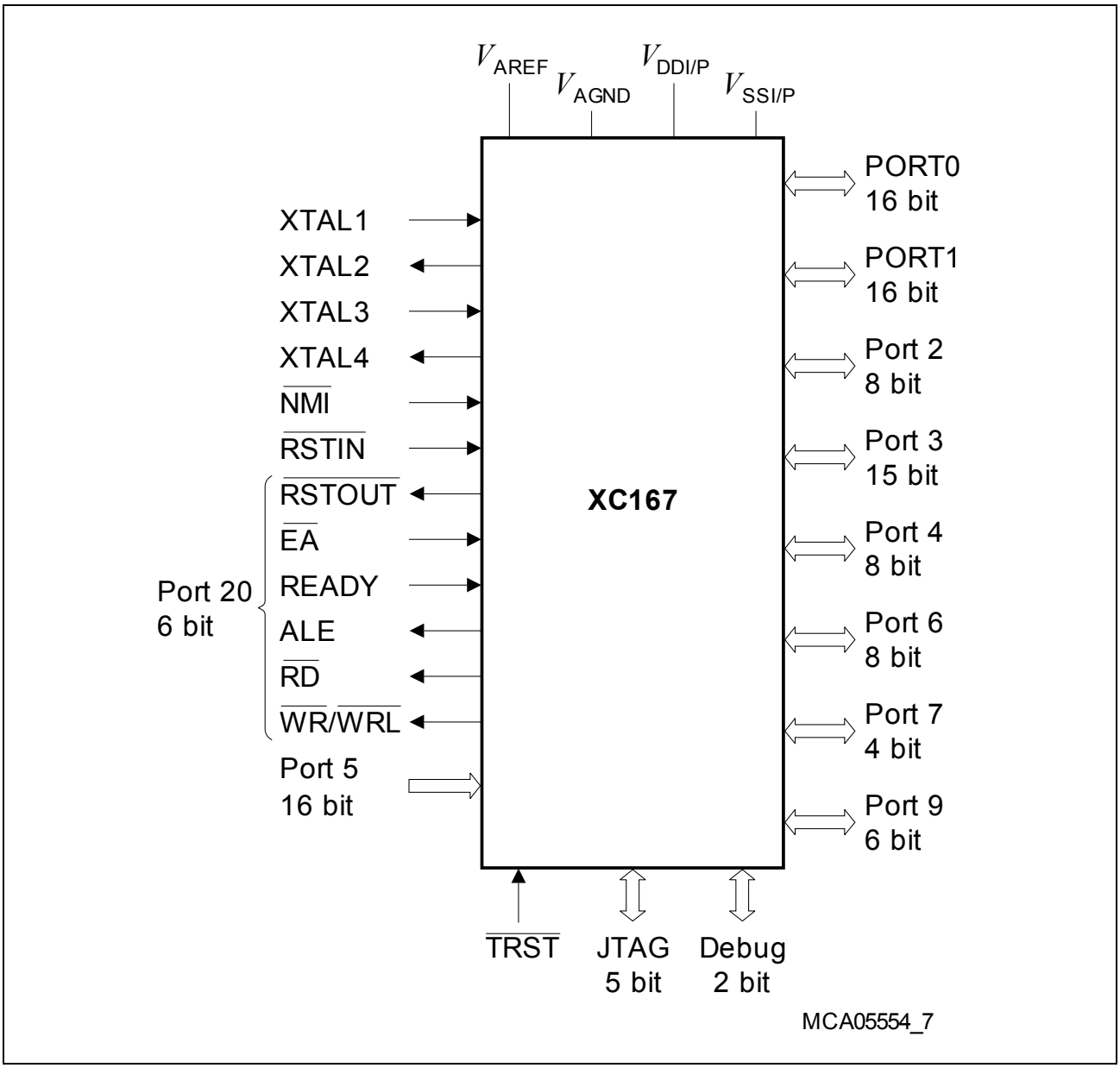

Figure 1 Logic Symbol

2.2 Pin Configuration and Definition

The pins of the XC167 are described in detail in **Table 2**, including all their alternate functions. **Figure 2** summarizes all pins in a condensed way, showing their location on the 4 sides of the package. E*) and C*) mark pins to be used as alternate external interrupt inputs, C*) marks pins that can have CAN interface lines assigned to them.

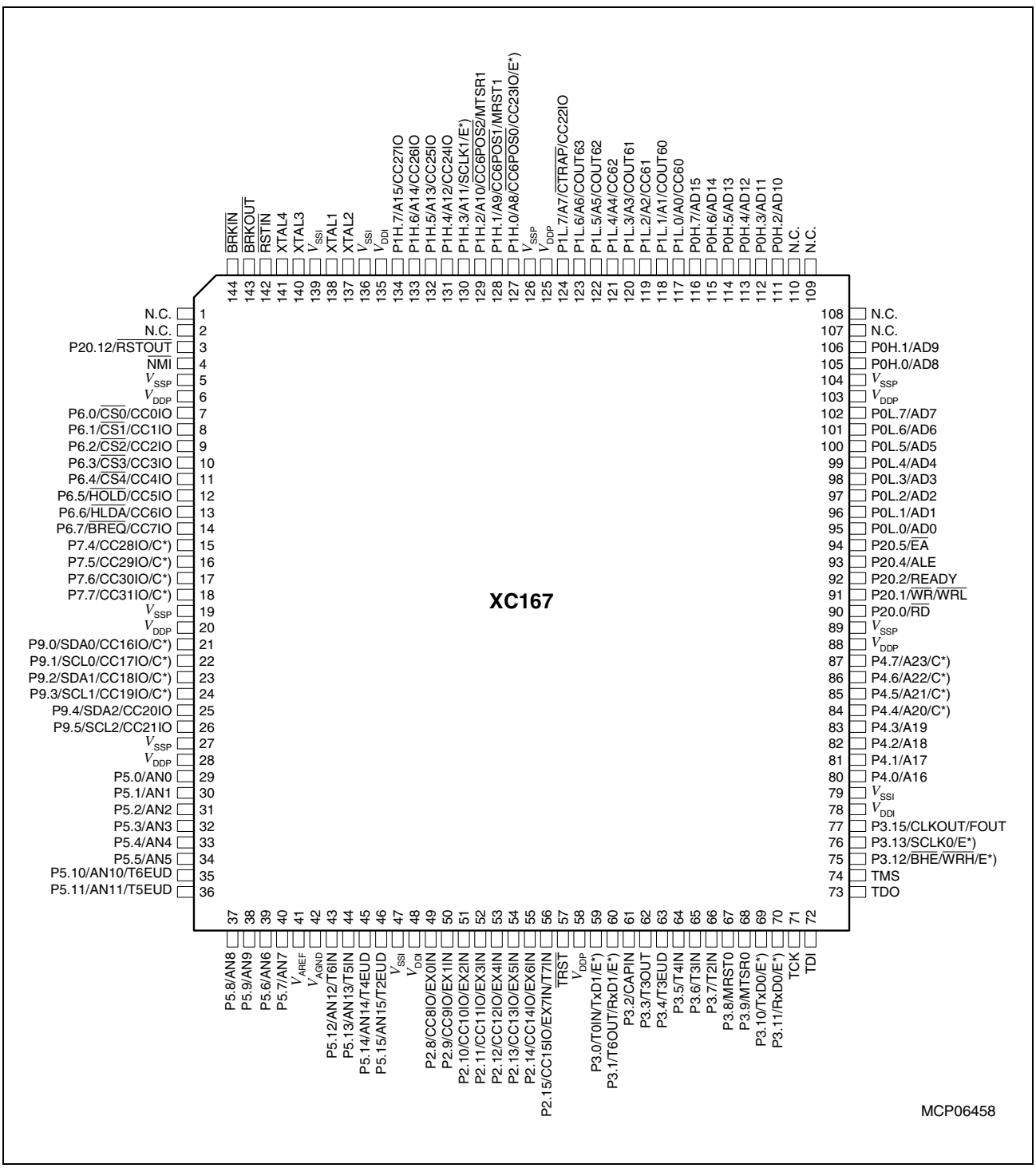

Figure 2 Pin Configuration (top view)

Table 2 Pin Definitions and Functions (cont'd)

Sym-bol	Pin Num.	Input Outp.	Function
P4		IO	Port 4 is an 8-bit bidirectional I/O port. Each pin can be programmed for input (output driver in high-impedance state) or output (configurable as push/pull or open drain driver). The input threshold of Port 4 is selectable (standard or special). Port 4 can be used to output the segment address lines, the optional chip select lines, and for serial interface lines:[1)]
P4.0	80	O	A16 Least Significant Segment Address Line
P4.1	81	O	A17 Segment Address Line
P4.2	82	O	A18 Segment Address Line
P4.3	83	O	A19 Segment Address Line
P4.4	84	O	A20 Segment Address Line,
		I	CAN2_RxD CAN Node 2 Receive Data Input,
		I	EX5IN Fast External Interrupt 5 Input (alternate pin B)
P4.5	85	O	A21 Segment Address Line,
		I	CAN1_RxD CAN Node 1 Receive Data Input,
		I	EX4IN Fast External Interrupt 4 Input (alternate pin B)
P4.6	86	O	A22 Segment Address Line,
		O	CAN1_TxD CAN Node 1 Transmit Data Output,
		I	EX5IN Fast External Interrupt 5 Input (alternate pin A)
P4.7	87	O	A23 Most Significant Segment Address Line,
		I	CAN1_RxD CAN Node 1 Receive Data Input,
		O	CAN2_TxD CAN Node 2 Transmit Data Output,
		I	EX4IN Fast External Interrupt 4 Input (alternate pin A)

Table 2 Pin Definitions and Functions (cont'd)

Sym-bol	Pin Num.	Input Outp.	Function	
P20		IO	Port 20 is a 6-bit bidirectional I/O port. Each pin can be programmed for input (output driver in high-impedance state) or output. The input threshold of Port 20 is selectable (standard or special). The following Port 20 pins also serve for alternate functions:	
P20.0	90	O	$\overline{RD}$	External Memory Read Strobe, activated for every external instruction or data read access.
P20.1	91	O	$\overline{WR}$/$\overline{WRL}$	External Memory Write Strobe. In $\overline{WR}$-mode this pin is activated for every external data write access. In $\overline{WRL}$-mode this pin is activated for low byte data write accesses on a 16-bit bus, and for every data write access on an 8-bit bus.
P20.2	92	I	READY	READY Input. When the READY function is enabled, memory cycle time waitstates can be forced via this pin during an external access.
P20.4	93	O	ALE	Address Latch Enable Output. Can be used for latching the address into external memory or an address latch in the multiplexed bus modes.
P20.5	94	I	$\overline{EA}$	External Access Enable pin. **A low-level** at this pin during and after Reset forces the XC167 to latch the configuration from PORT0 and pin $\overline{RD}$, and to begin instruction execution out of external memory. **A high-level** forces the XC167 to latch the configuration from pins $\overline{RD}$, ALE, and $\overline{WR}$, and to begin instruction execution out of the internal program memory. "ROMless" versions must have this pin tied to '0'.
P20.12	3	O	$\overline{RSTOUT}$	Internal Reset Indication Output. **Is activated** asynchronously with an external hardware reset. It may also be activated (selectable) synchronously with an internal software or watchdog reset. **Is deactivated** upon the execution of the EINIT instruction, optionally at the end of reset, or at any time (before EINIT) via user software.
			Note: Port 20 pins may input configuration values (see $\overline{EA}$).	

3.3 Central Processing Unit (CPU)

The main 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.

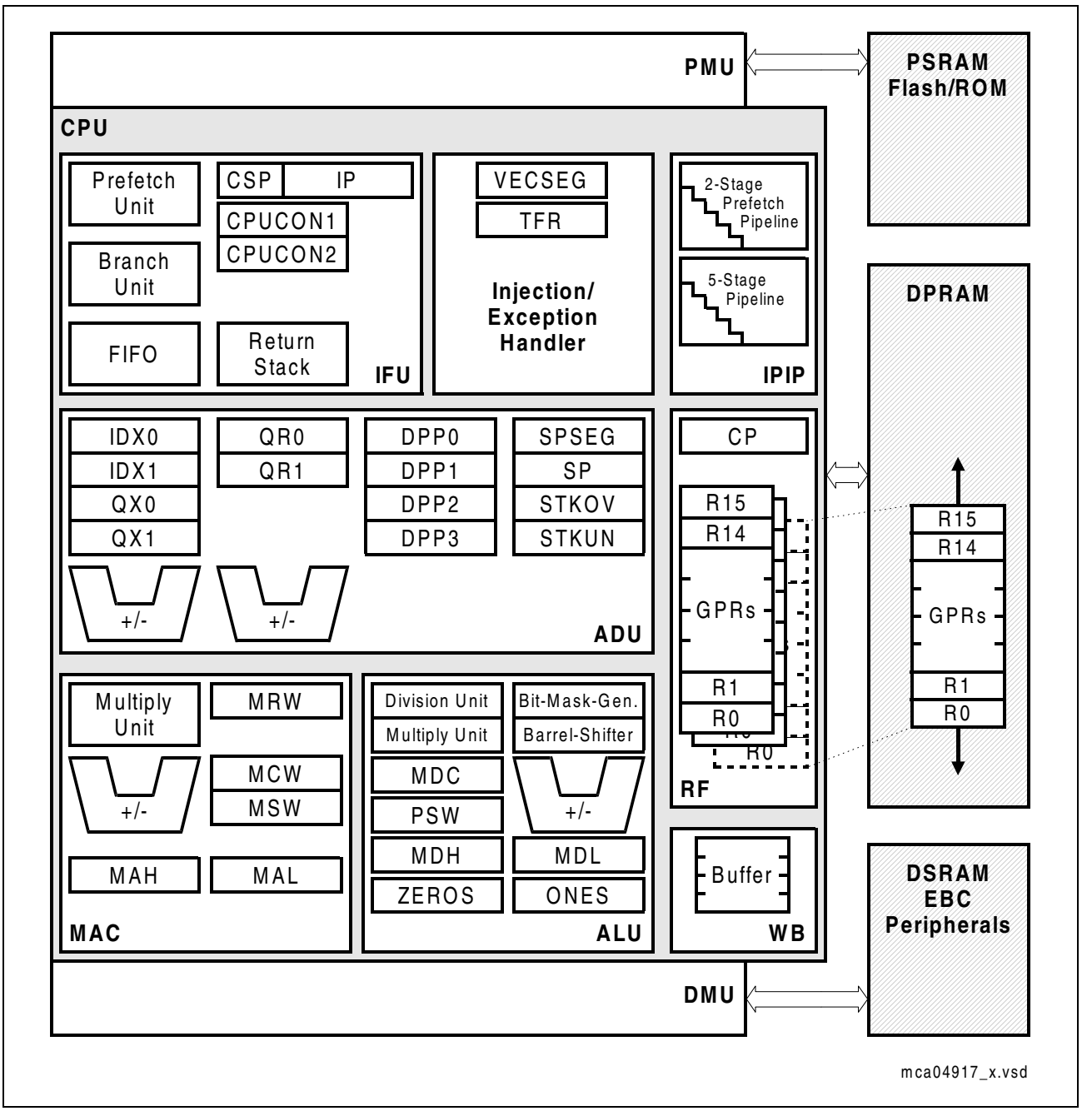

Figure 4 CPU Block Diagram

Based on these hardware provisions, most of the XC167's instructions can be executed in just one machine cycle which requires 25 ns at 40 MHz CPU clock. For example, shift

3.5 On-Chip Debug Support (OCDS)

The On-Chip Debug Support system provides a broad range of debug and emulation features built into the XC167. The user software running on the XC167 can thus be debugged within the target system environment.

The OCDS is controlled by an external debugging device via the debug interface, consisting of the IEEE-1149-conforming JTAG port and a break interface. The debugger controls the OCDS via a set of dedicated registers accessible via the JTAG interface. Additionally, 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 well as 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 JTAG interface or via the external bus interface for increased performance.

The debug interface uses a set of 6 interface signals (4 JTAG lines, 2 break lines) to communicate with external circuitry. These interface signals use dedicated pins.

Complete system emulation is supported by the New Emulation Technology (NET) interface.

3.6 Capture/Compare Units (CAPCOM1/2)

The CAPCOM units support generation and control of timing sequences on up to 32 channels with a maximum resolution of 1 system clock cycle (8 cycles in staggered mode). The CAPCOM units are typically used to handle high speed I/O tasks such as pulse and waveform generation, pulse width modulation (PMW), Digital to Analog (D/A) conversion, software timing, or time recording relative to external events.

Four 16-bit timers (T0/T1, T7/T8) with reload registers provide two independent time bases for each capture/compare register array.

The input clock for the timers is programmable to several prescaled values of the internal system clock, or may be derived from an overflow/underflow of timer T6 in module GPT2. This provides a wide range of variation for the timer period and resolution and allows precise adjustments to the application specific requirements. In addition, external count inputs for CAPCOM timers T0 and T7 allow event scheduling for the capture/compare registers relative to external events.

Both of the two capture/compare register arrays contain 16 dual purpose capture/compare registers, each of which may be individually allocated to either CAPCOM timer T0 or T1 (T7 or T8, respectively), and programmed for capture or compare function.
All registers of each module have each one port pin associated with it which serves as an input pin for triggering the capture function, or as an output pin to indicate the occurrence of a compare event.

Table 6 Compare Modes (CAPCOM1/2)

Compare Modes	Function
Mode 0	Interrupt-only compare mode; several compare interrupts per timer period are possible
Mode 1	Pin toggles on each compare match; several compare events per timer period are possible
Mode 2	Interrupt-only compare mode; only one compare interrupt per timer period is generated
Mode 3	Pin set ‘1’ on match; pin reset ‘0’ on compare timer overflow; only one compare event per timer period is generated
Double Register Mode	Two registers operate on one pin; pin toggles on each compare match; several compare events per timer period are possible
Single Event Mode	Generates single edges or pulses; can be used with any compare mode

When a capture/compare register has been selected for capture mode, the current contents of the allocated timer will be latched (‘captured’) into the capture/compare register in response to an external event at the port pin which is associated with this register. In addition, a specific interrupt request for this capture/compare register is generated. Either a positive, a negative, or both a positive and a negative external signal transition at the pin can be selected as the triggering event.

The contents of all registers which have been selected for one of the five compare modes are continuously compared with the contents of the allocated timers.

When a match occurs between the timer value and the value in a capture/compare register, specific actions will be taken based on the selected compare mode.

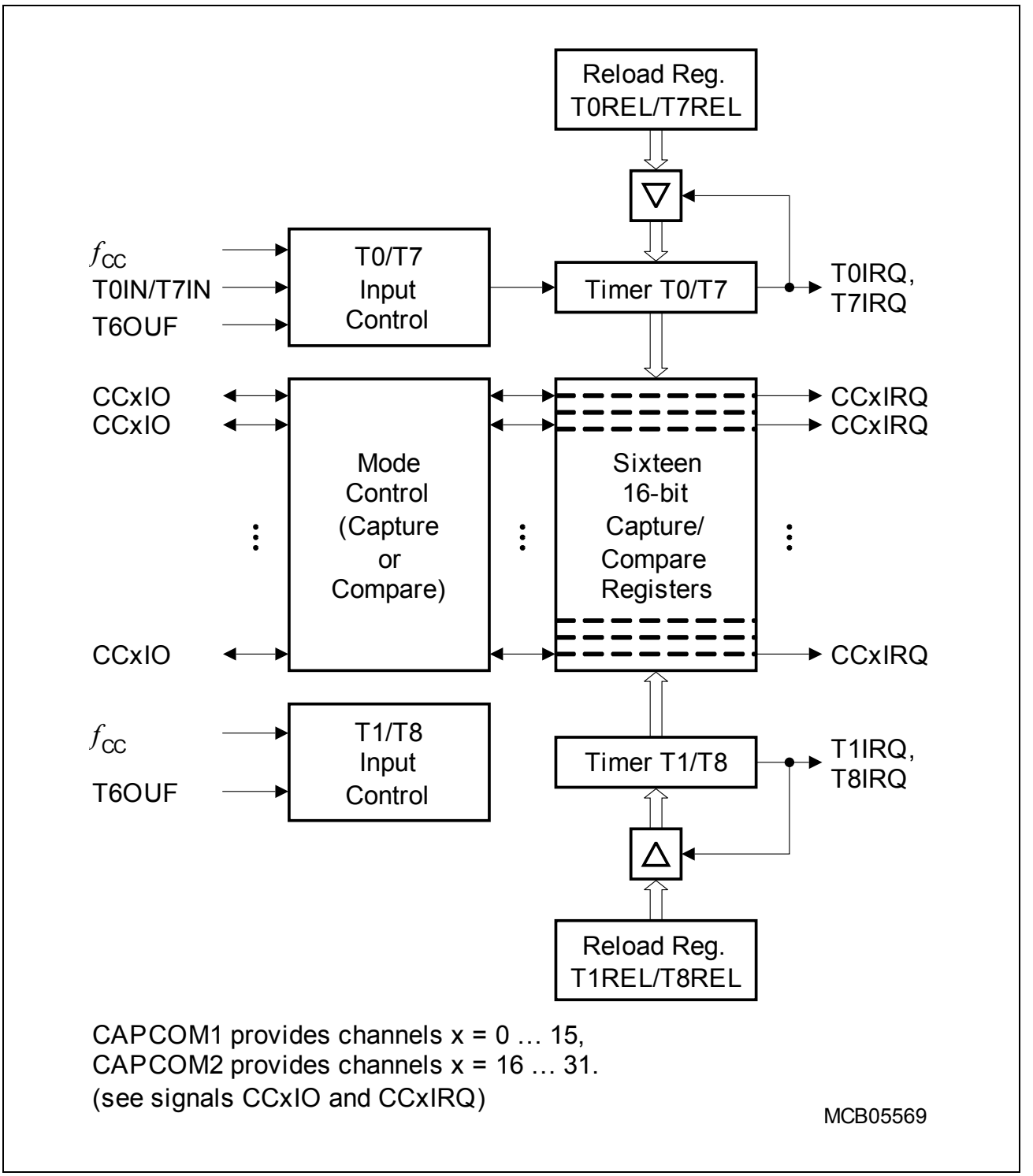

Figure 5 CAPCOM1/2 Unit Block Diagram

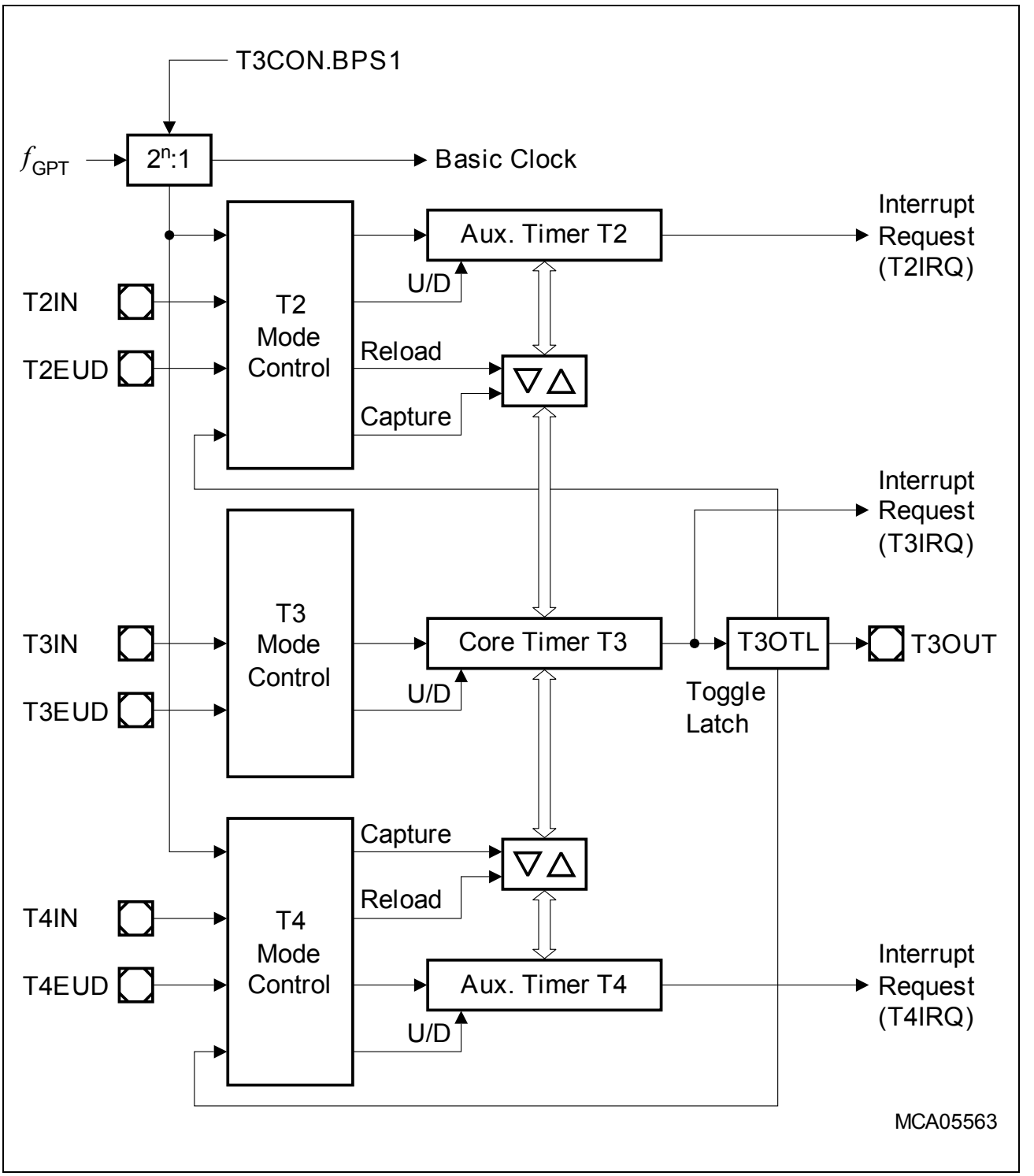

Figure 7 Block Diagram of GPT1

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

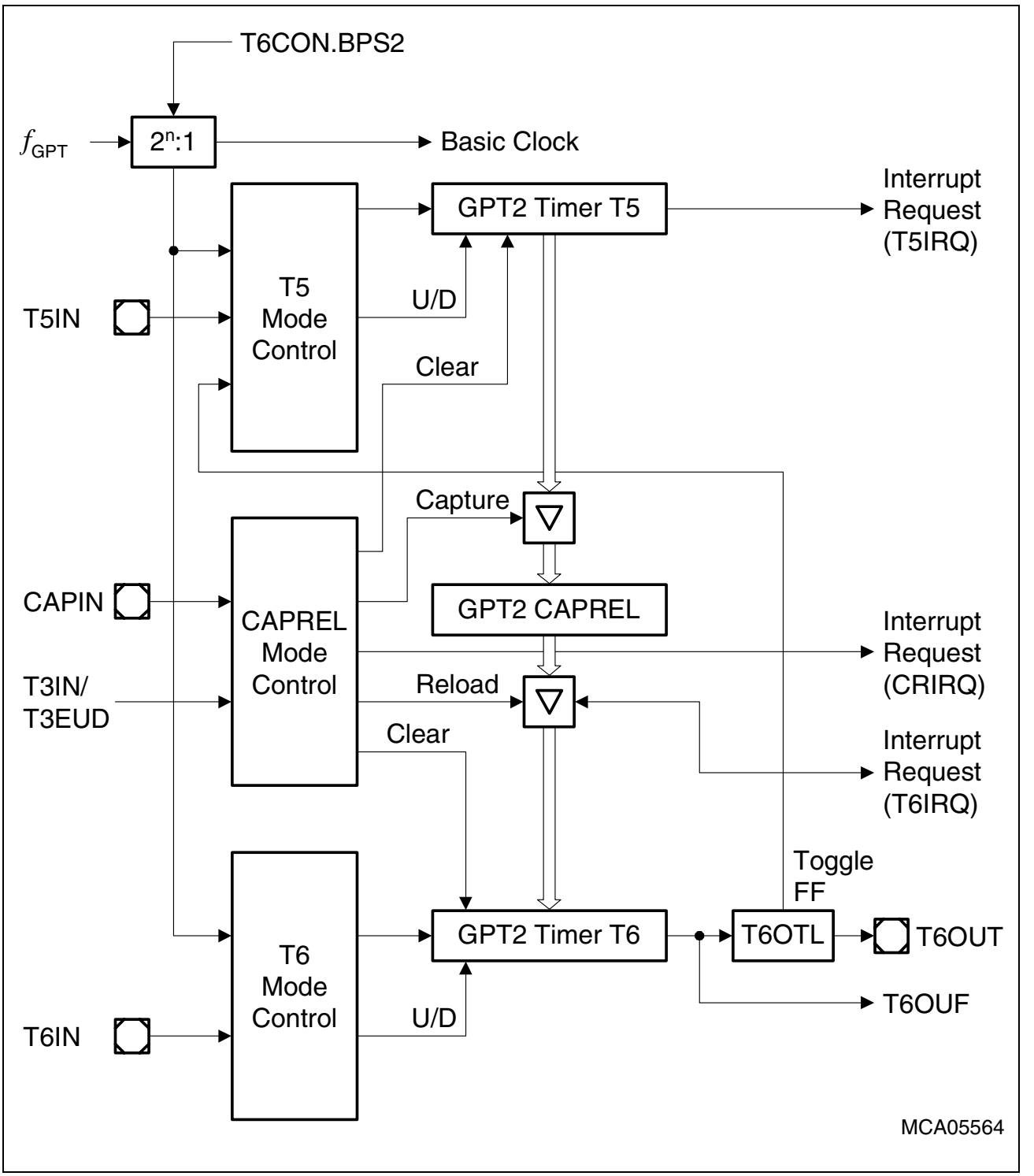

Figure 8 Block Diagram of GPT2

3.12 High Speed Synchronous Serial Channels (SSC0/SSC1)

The High Speed Synchronous Serial Channels SSC0/SSC1 support full-duplex and half-duplex synchronous communication. It may be configured so it interfaces with serially linked peripheral components, full SPI functionality is supported.

A dedicated baud rate generator allows to set up all standard baud rates without oscillator tuning. For transmission, reception and error handling three separate interrupt vectors are provided.

The SSC transmits or receives characters of 2 … 16 bits length synchronously to a shift clock which can be generated by the SSC (master mode) or by an external master (slave mode). The SSC can start shifting with the LSB or with the MSB and allows the selection of shifting and latching clock edges as well as the clock polarity.

A number of optional hardware error detection capabilities has been included to increase the reliability of data transfers. Transmit error and receive error supervise the correct handling of the data buffer. Phase error and baudrate error detect incorrect serial data.

Summary of Features

- Master or Slave mode operation
- Full-duplex or Half-duplex transfers
- Baudrate generation from 20 Mbit/s to 305.18 bit/s (@ 40 MHz)
- Flexible data format
  - Programmable number of data bits: 2 to 16 bits
  - Programmable shift direction: LSB-first or MSB-first
  - Programmable clock polarity: idle low or idle high
  - Programmable clock/data phase: data shift with leading or trailing clock edge
- Loop back option available for testing purposes
- Interrupt generation on transmitter buffer empty condition, receive buffer full condition, error condition (receive, phase, baudrate, transmit error)
- Three pin interface with flexible SSC pin configuration

3.18 Power Management

The XC167 provides several means to control the power it consumes either at a given time or averaged over a certain timespan. Three mechanisms can be used (partly in parallel):

- **Power Saving Modes** switch the XC167 into a special operating mode (control via instructions).
  Idle Mode stops the CPU while the peripherals can continue to operate.
  Sleep Mode and Power Down Mode stop all clock signals and all operation (RTC may optionally continue running). Sleep Mode can be terminated by external interrupt signals.
- **Clock Generation Management** controls the distribution and the frequency of internal and external clock signals. While the clock signals for currently inactive parts of logic are disabled automatically, the user can reduce the XC167's CPU clock frequency which drastically reduces the consumed power.
  External circuitry can be controlled via the programmable frequency output FOUT.
- **Peripheral Management** permits temporary disabling of peripheral modules (control via register SYSCON3). Each peripheral can separately be disabled/enabled.

The on-chip RTC supports intermittent operation of the XC167 by generating cyclic wake-up signals. This offers full performance to quickly react on action requests while the intermittent sleep phases greatly reduce the average power consumption of the system.

Table 8 Instruction Set Summary (cont'd)

Mnemonic	Description	Bytes
ROL/ROR	Rotate left/right direct word GPR	2
ASHR	Arithmetic (sign bit) shift right direct word GPR	2
MOV(B)	Move word (byte) data	2 / 4
MOVBS/Z	Move byte operand to word op. with sign/zero extension	2 / 4
JMPA/I/R	Jump absolute/indirect/relative if condition is met	4
JMPS	Jump absolute to a code segment	4
JB(C)	Jump relative if direct bit is set (and clear bit)	4
JNB(S)	Jump relative if direct bit is not set (and set bit)	4
CALLA/I/R	Call absolute/indirect/relative subroutine if condition is met	4
CALLS	Call absolute subroutine in any code segment	4
PCALL	Push direct word register onto system stack and call absolute subroutine	4
TRAP	Call interrupt service routine via immediate trap number	2
PUSH/POP	Push/pop direct word register onto/from system stack	2
SCXT	Push direct word register onto system stack and update register with word operand	4
RET(P)	Return from intra-segment subroutine (and pop direct word register from system stack)	2
RETS	Return from inter-segment subroutine	2
RETI	Return from interrupt service subroutine	2
SBRK	Software Break	2
SRST	Software Reset	4
IDLE	Enter Idle Mode	4
PWRDN	Enter Power Down Mode (supposes $\overline{\text{NMI}}$-pin being low)	4
SRVWDT	Service Watchdog Timer	4
DISWDT/ENWDT	Disable/Enable Watchdog Timer	4
EINIT	End-of-Initialization Register Lock	4
ATOMIC	Begin ATOMIC sequence	2
EXTR	Begin EXTended Register sequence	2
EXTP(R)	Begin EXTended Page (and Register) sequence	2 / 4
EXTS(R)	Begin EXTended Segment (and Register) sequence	2 / 4

4.3 Analog/Digital Converter Parameters

Table 14 A/D Converter Characteristics (Operating Conditions apply)

Parameter	Symbol		Limit Values		Unit	Test Condition
			Min.	Max.		
Analog reference supply	V_{AREF}	SR	4.5	V_{DDP} + 0.1	V	1)
Analog reference ground	V_{AGND}	SR	V_{SS} - 0.1	V_{SS} + 0.1	V	–
Analog input voltage range	V_{AIN}	SR	V_{AGND}	V_{AREF}	V	2)
Basic clock frequency	f_{BC}		0.5	20	MHz	3)
Conversion time for 10-bit result[4]	t_{C10P}	CC	$52 \times t_{BC} + t_S + 6 \times t_{SYS}$		–	Post-calibr. on
	t_{C10}	CC	$40 \times t_{BC} + t_S + 6 \times t_{SYS}$		–	Post-calibr. off
Conversion time for 8-bit result[4]	t_{C8P}	CC	$44 \times t_{BC} + t_S + 6 \times t_{SYS}$		–	Post-calibr. on
	t_{C8}	CC	$32 \times t_{BC} + t_S + 6 \times t_{SYS}$		–	Post-calibr. off
Calibration time after reset	t_{CAL}	CC	484	11,696	t_{BC}	5)
Total unadjusted error	TUE	CC	–	±2	LSB	1)
Total capacitance of an analog input	C_{AINT}	CC	–	15	pF	6)
Switched capacitance of an analog input	C_{AINS}	CC	–	10	pF	6)
Resistance of the analog input path	R_{AIN}	CC	–	2	kΩ	6)
Total capacitance of the reference input	C_{AREFT}	CC	–	20	pF	6)
Switched capacitance of the reference input	C_{AREFS}	CC	–	15	pF	6)
Resistance of the reference input path	R_{AREF}	CC	–	1	kΩ	6)

1) TUE is tested at $V_{AREF} = V_{DDP} + 0.1$ V, $V_{AGND} = 0$ V. It is verified by design for all other voltages within the defined voltage range.
If the analog reference supply voltage drops below 4.5 V (i.e. $V_{AREF} \geq 4.0$ V) or exceeds the power supply voltage by up to 0.2 V (i.e. $V_{AREF} = V_{DDP} + 0.2$ V) the maximum TUE is increased to ±3 LSB. This range is not subject to production test.
The specified TUE is guaranteed only, if the absolute sum of input overload currents on Port 5 pins (see I_{OV} specification) does not exceed 10 mA, and if V_{AREF} and V_{AGND} remain stable during the respective period of time. During the reset calibration sequence the maximum TUE may be ±4 LSB.

2) V_{AIN} may exceed V_{AGND} or V_{AREF} up to the absolute maximum ratings. However, the conversion result in these cases will be $X000_H$ or $X3FF_H$, respectively.

4.4.3 External Clock Drive XTAL1

Table 19 External Clock Drive Characteristics (Operating Conditions apply)

Parameter	Symbol		Limit Values		Unit
			Min.	Max.	
Oscillator period	t_{OSC}	SR	25	250[1)]	ns
High time[2)]	t_1	SR	6	–	ns
Low time[2)]	t_2	SR	6	–	ns
Rise time[2)]	t_3	SR	–	8	ns
Fall time[2)]	t_4	SR	–	8	ns

1) The maximum limit is only relevant for PLL operation to ensure the minimum input frequency for the PLL.

2) The clock input signal must reach the defined levels V_{ILC} and V_{IHC}.

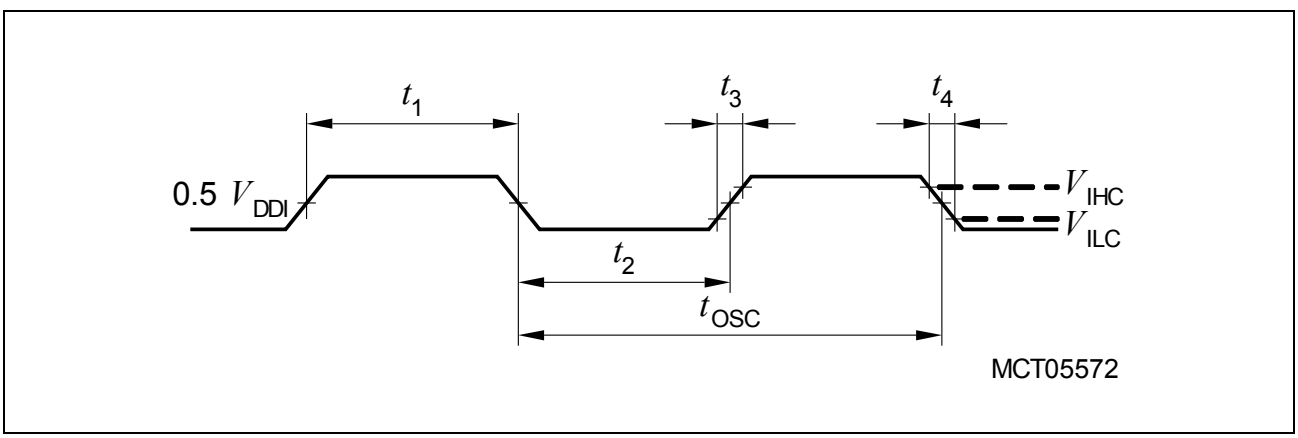

Figure 17 External Clock Drive XTAL1

Note: If the on-chip oscillator is used together with a crystal or a ceramic resonator, the oscillator frequency is limited to a range of 4 MHz to 16 MHz.
It is strongly recommended to measure the oscillation allowance (negative resistance) in the final target system (layout) to determine the optimum parameters for the oscillator operation. Please refer to the limits specified by the crystal supplier.
When driven by an external clock signal it will accept the specified frequency range. Operation at lower input frequencies is possible but is verified by design only (not subject to production test).

Table 22 External Bus Cycle Timing (Operating Conditions apply)

Parameter	Symbol		Limits		Unit
			Min.	Max.	
Output valid delay for: RD, WR(L/H)	tc_{10}	CC	1	15	ns
Output valid delay for: A23 … A16, BHE, ALE	tc_{11}	CC	-1	8	ns
Output valid delay for: A15 … A0 (on PORT1)	tc_{12}	CC	3	18	ns
Output valid delay for: A15 … A0 (on PORT0)	tc_{13}	CC	3	18	ns
Output valid delay for: CS	tc_{14}	CC	3	16	ns
Output valid delay for: D15 … D0 (write data, MUX-mode)	tc_{15}	CC	3	19	ns
Output valid delay for: D15 … D0 (write data, DEMUX-mode)	tc_{16}	CC	2	16	ns
Output hold time for: RD, WR(L/H)	tc_{20}	CC	-3	4	ns
Output hold time for: A23 … A16, BHE, ALE	tc_{21}	CC	0	11	ns
Output hold time for: A15 … A0 (on PORT0)	tc_{23}	CC	1	13	ns
Output hold time for: CS	tc_{24}	CC	-2	4	ns
Output hold time for: D15 … D0 (write data)	tc_{25}	CC	1	13	ns
Input setup time for: READY, D15 … D0 (read data)	tc_{30}	SR	29	–	ns
Input hold time READY, D15 … D0 (read data)[1)]	tc_{31}	SR	-5	–	ns

1) Read data are latched with the same (internal) clock edge that triggers the address change and the rising edge of RD. Therefore address changes before the end of RD have no impact on (demultiplexed) read cycles. Read data can be removed after the rising edge of RD.

Note: The shaded parameters have been verified by characterization. They are not subject to production test.

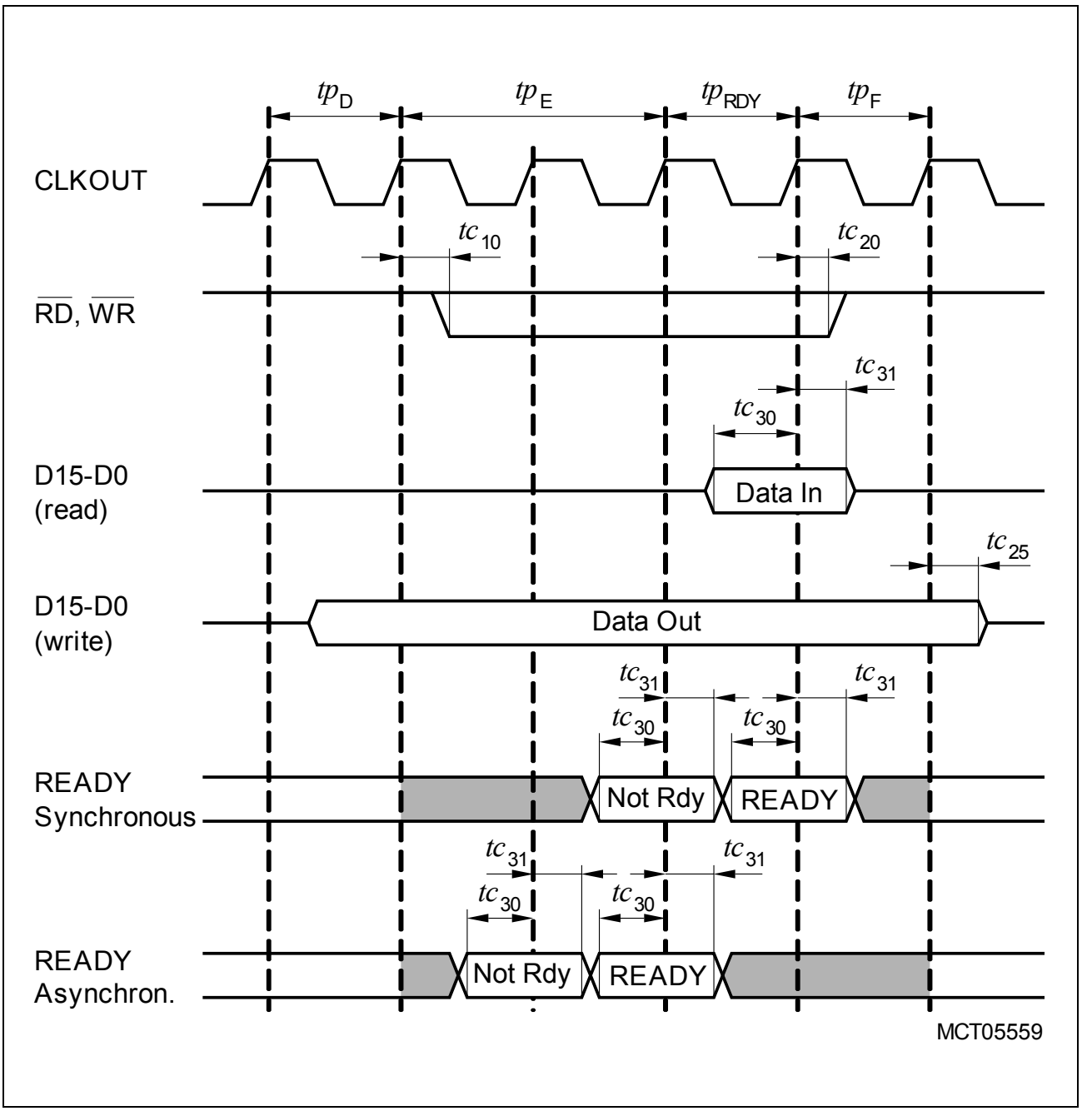

Figure 23 READY Timing

Note: If the READY input is sampled inactive at the indicated sampling point (“Not Rdy”) a READY-controlled waitstate is inserted (tp_{RDY}), sampling the READY input active at the indicated sampling point (“Ready”) terminates the currently running bus cycle.
Note the different sampling points for synchronous and asynchronous READY.
This example uses one mandatory waitstate (see tp_E) before the READY input is evaluated.

5 Package and Reliability

5.1 Packaging

Table 24 Package Parameters

Parameter	Symbol	Limit Values		Unit	Notes
		Min.	Max.		
Green Package PG-TQFP-144-7					
Thermal resistance junction to case	$R_{\Theta JC}$	–	8	K/W	–
Thermal resistance junction to leads	$R_{\Theta JL}$	–	40	K/W	–
Standard Package P-TQFP-144-19					
Thermal resistance junction to case	$R_{\Theta JC}$	–	6	K/W	–
Thermal resistance junction to leads	$R_{\Theta JL}$	–	18	K/W	–

Package Outlines

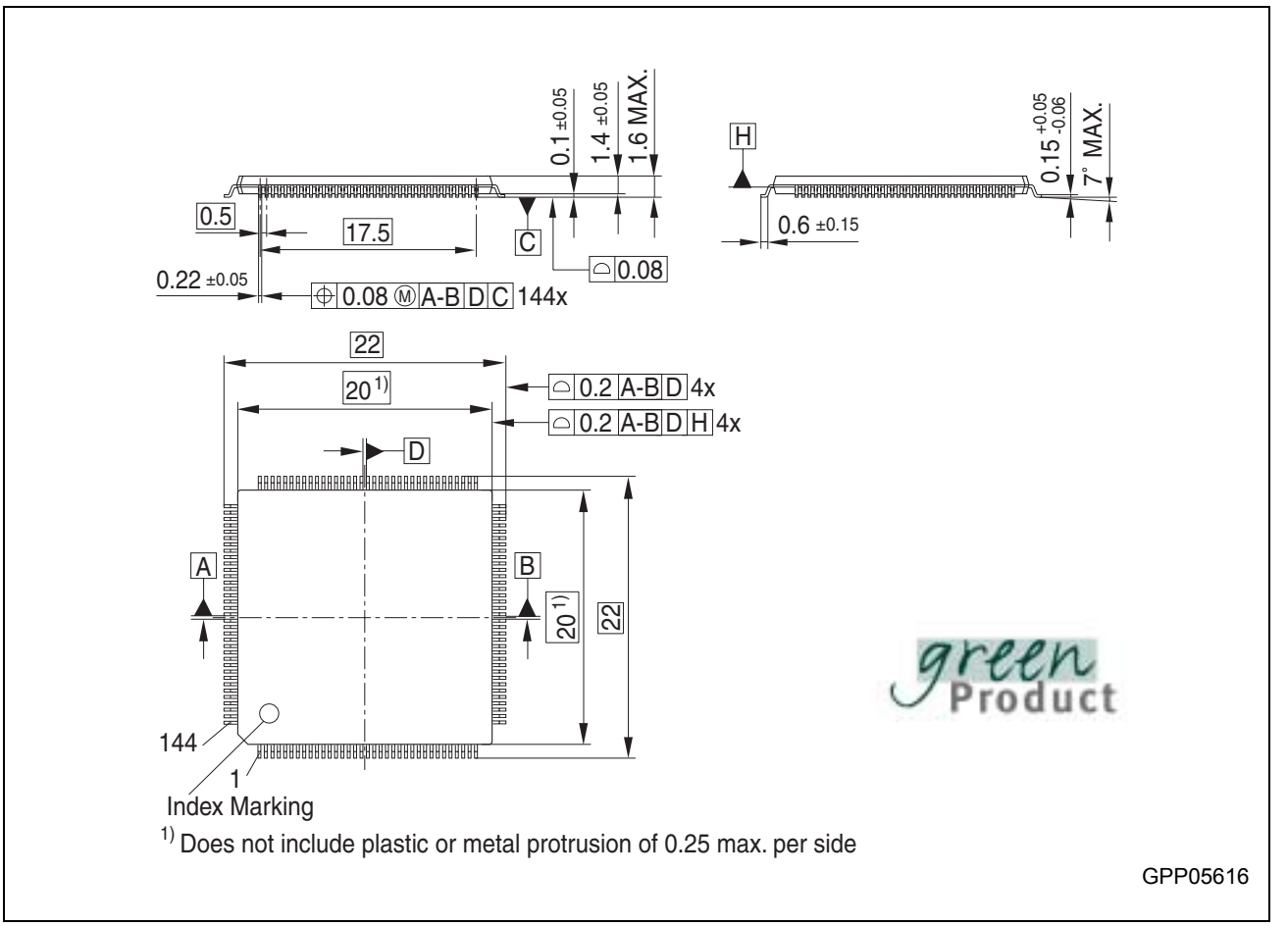

Figure 26 PG-TQFP-144-7 (Plastic Green Thin Quad Flat Package)