Infineon Technologies - XC167CI16F40FBBFXQMA1 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	128KB (128K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	8K 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	Surface Mount
Package / Case	144-LQFP
Supplier Device Package	PG-TQFP-144-7
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/xc167ci16f40fbbfxqma1

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Table 1 XC167 Derivative Synopsis

Derivative[1)]	Temp. Range	Program Memory	On-Chip RAM	Interfaces
SAK-XC167CI-16F40F, SAK-XC167CI-16F20F	-40 °C to 125 °C	128 Kbytes Flash	2 Kbytes DPRAM, 4 Kbytes DSRAM, 2 Kbytes PSRAM	ASC0, ASC1, SSC0, SSC1, CAN0, CAN1, IIC
SAF-XC167CI-16F40F, SAF-XC167CI-16F20F	-40 °C to 85 °C	128 Kbytes Flash	2 Kbytes DPRAM, 4 Kbytes DSRAM, 2 Kbytes PSRAM	ASC0, ASC1, SSC0, SSC1, CAN0, CAN1, IIC

1) This Data Sheet is valid for devices starting with and including design step BB.

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.

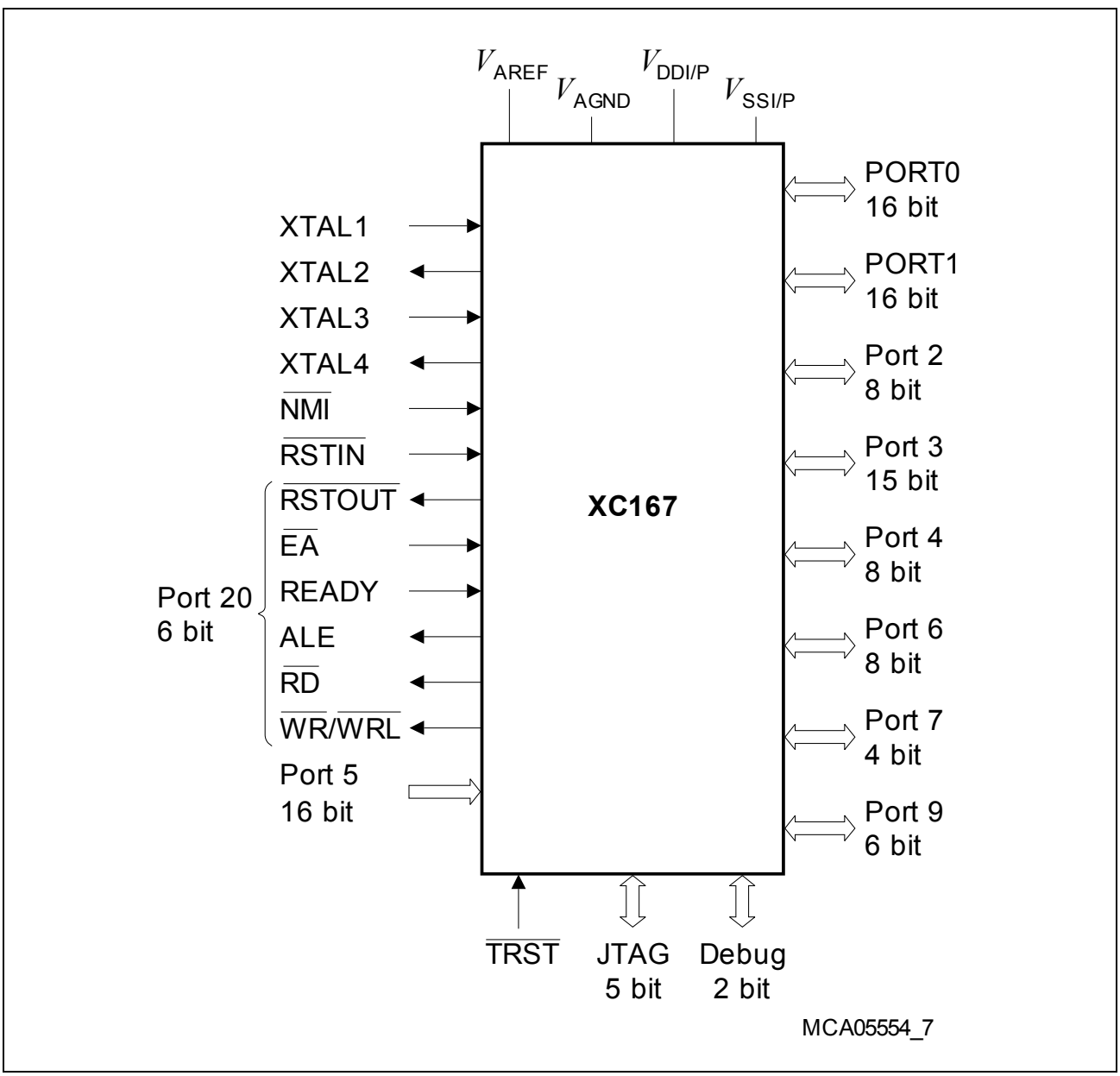

Figure 1 Logic Symbol

Table 2 Pin Definitions and Functions (cont'd)

Sym-bol	Pin Num.	Input Outp.	Function
P9		IO	Port 9 is a 6-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 9 is selectable (standard or special). The following Port 9 pins also serve for alternate functions:[1)]
P9.0	21	I/O	CC16IO CAPCOM2: CC16 Capture Inp./Compare Outp.,
		I	CAN2_RxD CAN Node 2 Receive Data Input,
		I/O	SDA0 IIC Bus Data Line 0
P9.1	22	I/O	CC17IO CAPCOM2: CC17 Capture Inp./Compare Outp.,
		O	CAN2_TxD CAN Node 2 Transmit Data Output,
		I/O	SCL0 IIC Bus Clock Line 0
P9.2	23	I/O	CC18IO CAPCOM2: CC18 Capture Inp./Compare Outp.,
		I	CAN1_RxD CAN Node 1 Receive Data Input,
		I/O	SDA1 IIC Bus Data Line 1
P9.3	24	I/O	CC19IO CAPCOM2: CC19 Capture Inp./Compare Outp.,
		O	CAN1_TxD CAN Node 1 Transmit Data Output,
		I/O	SCL1 IIC Bus Clock Line 1
P9.4	25	I/O	CC20IO CAPCOM2: CC20 Capture Inp./Compare Outp.,
		I/O	SDA2 IIC Bus Data Line 2
P9.5	26	I/O	CC21IO CAPCOM2: CC21 Capture Inp./Compare Outp.,
		I/O	SCL2 IIC Bus Clock Line 2

Table 2 Pin Definitions and Functions (cont'd)

Sym-bol	Pin Num.	Input Outp.	Function
P2		IO	Port 2 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 2 is selectable (standard or special). The following Port 2 pins also serve for alternate functions:
P2.8	49	I/O I	CC8IO CAPCOM1: CC8 Capture Inp./Compare Output, EX0IN Fast External Interrupt 0 Input (default pin)
P2.9	50	I/O I	CC9IO CAPCOM1: CC9 Capture Inp./Compare Output, EX1IN Fast External Interrupt 1 Input (default pin)
P2.10	51	I/O I	CC10IO CAPCOM1: CC10 Capture Inp./Compare Outp., EX2IN Fast External Interrupt 2 Input (default pin)
P2.11	52	I/O I	CC11IO CAPCOM1: CC11 Capture Inp./Compare Outp., EX3IN Fast External Interrupt 3 Input (default pin)
P2.12	53	I/O I	CC12IO CAPCOM1: CC12 Capture Inp./Compare Outp., EX4IN Fast External Interrupt 4 Input (default pin)
P2.13	54	I/O I	CC13IO CAPCOM1: CC13 Capture Inp./Compare Outp., EX5IN Fast External Interrupt 5 Input (default pin)
P2.14	55	I/O I	CC14IO CAPCOM1: CC14 Capture Inp./Compare Outp., EX6IN Fast External Interrupt 6 Input (default pin)
P2.15	56	I/O I I	CC15IO CAPCOM1: CC15 Capture Inp./Compare Outp., EX7IN Fast External Interrupt 7 Input (default pin), T7IN CAPCOM2: Timer T7 Count Input
$\overline{\text{TRST}}$	57	I	$\overline{\text{Test}}$-System Reset Input. For normal system operation, pin $\overline{\text{TRST}}$ should be held low. A high level at this pin at the rising edge of $\overline{\text{RSTIN}}$ activates the XC164CM's debug system. In this case, pin $\overline{\text{TRST}}$ must be driven low once to reset the debug system.

Table 2 Pin Definitions and Functions (cont'd)

Sym-bol	Pin Num.	Input Outp.	Function	
P3		IO	Port 3 is a 15-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 3 is selectable (standard or special). The following Port 3 pins also serve for alternate functions:	
P3.0	59	I	T0IN	CAPCOM1 Timer T0 Count Input,
		O	TxD1	ASC1 Clock/Data Output (Async./Sync),
		I	EX1IN	Fast External Interrupt 1 Input (alternate pin B)
P3.1	60	O	T6OUT	GPT2 Timer T6 Toggle Latch Output,
		I/O	RxD1	ASC1 Data Input (Async.) or Inp./Outp. (Sync.),
		I	EX1IN	Fast External Interrupt 1 Input (alternate pin A)
P3.2	61	I	CAPIN	GPT2 Register CAPREL Capture Input
P3.3	62	O	T3OUT	GPT1 Timer T3 Toggle Latch Output
P3.4	63	I	T3EUD	GPT1 Timer T3 External Up/Down Control Input
P3.5	64	I	T4IN	GPT1 Timer T4 Count/Gate/Reload/Capture Inp
P3.6	65	I	T3IN	GPT1 Timer T3 Count/Gate Input
P3.7	66	I	T2IN	GPT1 Timer T2 Count/Gate/Reload/Capture Inp
P3.8	67	I/O	MRST0	SSC0 Master-Receive/Slave-Transmit In/Out.
P3.9	68	I/O	MTSR0	SSC0 Master-Transmit/Slave-Receive Out/In.
P3.10	69	O	TxD0	ASC0 Clock/Data Output (Async./Sync.),
		I	EX2IN	Fast External Interrupt 2 Input (alternate pin B)
P3.11	70	I/O	RxD0	ASC0 Data Input (Async.) or Inp./Outp. (Sync.),
		I	EX2IN	Fast External Interrupt 2 Input (alternate pin A)
P3.12	75	O	$\overline{\text{BHE}}$	External Memory High Byte Enable Signal,
		O	$\overline{\text{WRH}}$	External Memory High Byte Write Strobe,
		I	EX3IN	Fast External Interrupt 3 Input (alternate pin B)
P3.13	76	I/O	SCLK0	SSC0 Master Clock Output/Slave Clock Input.,
		I	EX3IN	Fast External Interrupt 3 Input (alternate pin A)
P3.15	77	O	CLKOUT	Master Clock Output,
		O	FOUT	Programmable Frequency Output
TCK	71	I	Debug System: JTAG Clock Input	
TDI	72	I	Debug System: JTAG Data In	
TDO	73	O	Debug System: JTAG Data Out	
TMS	74	I	Debug System: JTAG Test Mode Selection	

Table 2 Pin Definitions and Functions (cont'd)

Sym-bol	Pin Num.	Input Outp.	Function	
PORT1		IO	PORT1 consists of the two 8-bit bidirectional I/O ports P1L and P1H. Each pin can be programmed for input (output driver in high-impedance state) or output. PORT1 is used as the 16-bit address bus (A) in demultiplexed bus modes (also after switching from a demultiplexed to a multiplexed bus mode). The following PORT1 pins also serve for alt. functions:	
P1L.0	117	I/O	CC60	CAPCOM6: Input / Output of Channel 0
P1L.1	118	O	COUT60	CAPCOM6: Output of Channel 0
P1L.2	119	I/O	CC61	CAPCOM6: Input / Output of Channel 1
P1L.3	120	O	COUT61	CAPCOM6: Output of Channel 1
P1L.4	121	I/O	CC62	CAPCOM6: Input / Output of Channel 2
P1L.5	122	O	COUT62	CAPCOM6: Output of Channel 2
P1L.6	123	O	$\overline{\text{COUT63}}$	Output of 10-bit Compare Channel
P1L.7	124	I	$\overline{\text{CTRAP}}$	$\overline{\text{CAPCOM2}}$: CC22 Capture Inp./Compare Outp. $\overline{\text{CTRAP}}$ is an input pin with an internal pull-up resistor. A low level on this pin switches the CAPCOM6 compare outputs to the logic level defined by software (if enabled).
		I/O	$\overline{\text{CC22IO}}$	CAPCOM2: CC22 Capture Inp./Compare Outp.
P1H.0	127	I	$\overline{\text{CC6POS0}}$	CAPCOM6: Position 0 Input,
		I	EX0IN	Fast External Interrupt 0 Input (alternate pin B),
		I/O	$\overline{\text{CC23IO}}$	CAPCOM2: CC23 Capture Inp./Compare Outp.
P1H.1	128	I	$\overline{\text{CC6POS1}}$	CAPCOM6: Position 1 Input,
		I/O	$\overline{\text{MRST1}}$	SSC1 Master-Receive/Slave-Transmit In/Out.
P1H.2	129	I	$\overline{\text{CC6POS2}}$	CAPCOM6: Position 2 Input,
		I/O	MTSR1	SSC1 Master-Transmit/Slave-Receive Out/Inp.
P1H.3	130	I/O	SCLK1	SSC1 Master Clock Output / Slave Clock Input,
		I	EX0IN	Fast External Interrupt 0 Input (alternate pin A)
P1H.4	131	I/O	CC24IO	CAPCOM2: CC24 Capture Inp./Compare Outp.
P1H.5	132	I/O	CC25IO	CAPCOM2: CC25 Capture Inp./Compare Outp.
P1H.6	133	I/O	CC26IO	CAPCOM2: CC26 Capture Inp./Compare Outp.
P1H.7	134	I/O	CC27IO	CAPCOM2: CC27 Capture Inp./Compare Outp.

Table 2 Pin Definitions and Functions (cont'd)

Sym-bol	Pin Num.	Input Outp.	Function
V_{AREF}	41	–	Reference voltage for the A/D converter.
V_{AGND}	42	–	Reference ground for the A/D converter.
V_{DDI}	48, 78, 135	–	Digital Core Supply Voltage (On-Chip Modules): +2.5 V during normal operation and idle mode. Please refer to the **Operating Conditions**.
V_{DDP}	6, 20, 28, 58, 88, 103, 125	–	Digital Pad Supply Voltage (Pin Output Drivers): +5 V during normal operation and idle mode. Please refer to the **Operating Conditions**.
V_{SSI}	47, 79, 136, 139	–	**Digital Ground** Connect decoupling capacitors to adjacent V_{DD}/V_{SS} pin pairs as close as possible to the pins. All V_{SS} pins must be connected to the ground-line or ground-plane.
V_{SSP}	5, 19, 27, 89, 104, 126	–	

1) The CAN interface lines are assigned to ports P4, P7, and P9 under software control.

The EBC also controls accesses to resources connected to the on-chip LXBus. The LXBus is an internal representation of the external bus and allows accessing integrated peripherals and modules in the same way as external components.

The TwinCAN module is connected and accessed via the LXBus.

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.

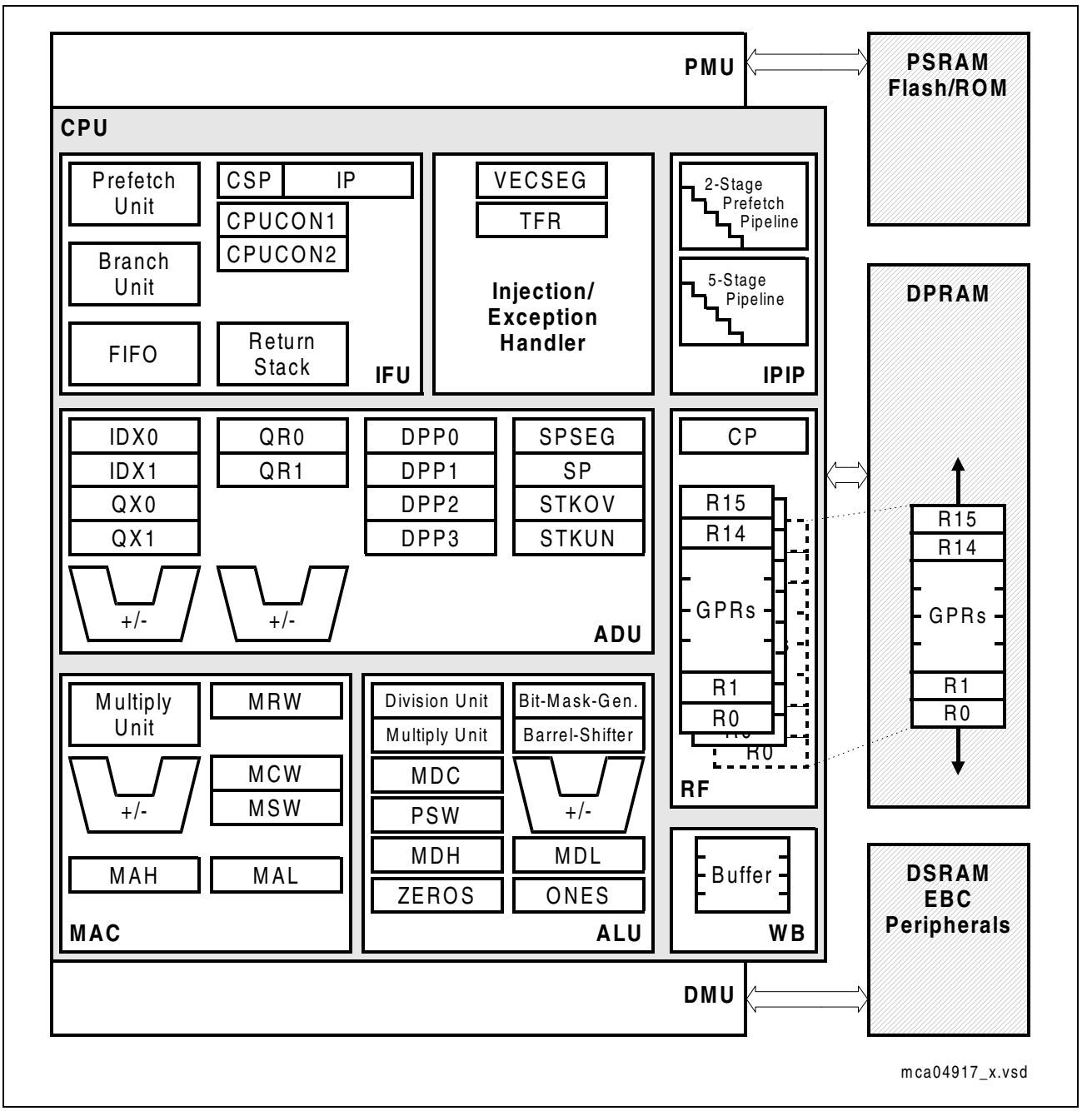

Figure 4 CPU Block Diagram

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

The XC167 also provides an excellent mechanism to identify and to process exceptions or error conditions that arise during run-time, so-called ‘Hardware Traps’. Hardware traps cause immediate non-maskable system reaction which is similar to a standard interrupt service (branching to a dedicated vector table location). The occurrence of a hardware trap is additionally signified by an individual bit in the trap flag register (TFR). Except when another higher prioritized trap service is in progress, a hardware trap will interrupt any actual program execution. In turn, hardware trap services can normally not be interrupted by standard or PEC interrupts.

Table 5 shows all of the possible exceptions or error conditions that can arise during run-time:

Table 5 Hardware Trap Summary

Exception Condition	Trap Flag	Trap Vector	Vector Location[1)]	Trap Number	Trap Priority
Reset Functions: • Hardware Reset • Software Reset • Watchdog Timer Overflow	–	 RESET RESET RESET	 xx’0000$_H$ xx’0000$_H$ xx’0000$_H$	 00$_H$ 00$_H$ 00$_H$	 III III III
Class A Hardware Traps: • Non-Maskable Interrupt • Stack Overflow • Stack Underflow • Software Break	 NMI STKOF STKUF SOFTBRK	 NMITRAP STOTRAP STUTRAP SBRKTRAP	 xx’0008$_H$ xx’0010$_H$ xx’0018$_H$ xx’0020$_H$	 02$_H$ 04$_H$ 06$_H$ 08$_H$	 II II II II
Class B Hardware Traps: • Undefined Opcode • PMI Access Error • Protected Instruction Fault • Illegal Word Operand Access	 UNDOPC PACER PRTFLT ILLOPA	 BTRAP BTRAP BTRAP BTRAP	 xx’0028$_H$ xx’0028$_H$ xx’0028$_H$ xx’0028$_H$	 0A$_H$ 0A$_H$ 0A$_H$ 0A$_H$	 I I I I
Reserved	–	–	[2C$_H$ - 3C$_H$]	[0B$_H$ - 0F$_H$]	–
Software Traps • TRAP Instruction	–	–	Any [xx’0000$_H$ - xx’01FC$_H$] in steps of 4$_H$	Any [00$_H$ - 7F$_H$]	Current CPU Priority

1) Register VECSEG defines the segment where the vector table is located to.

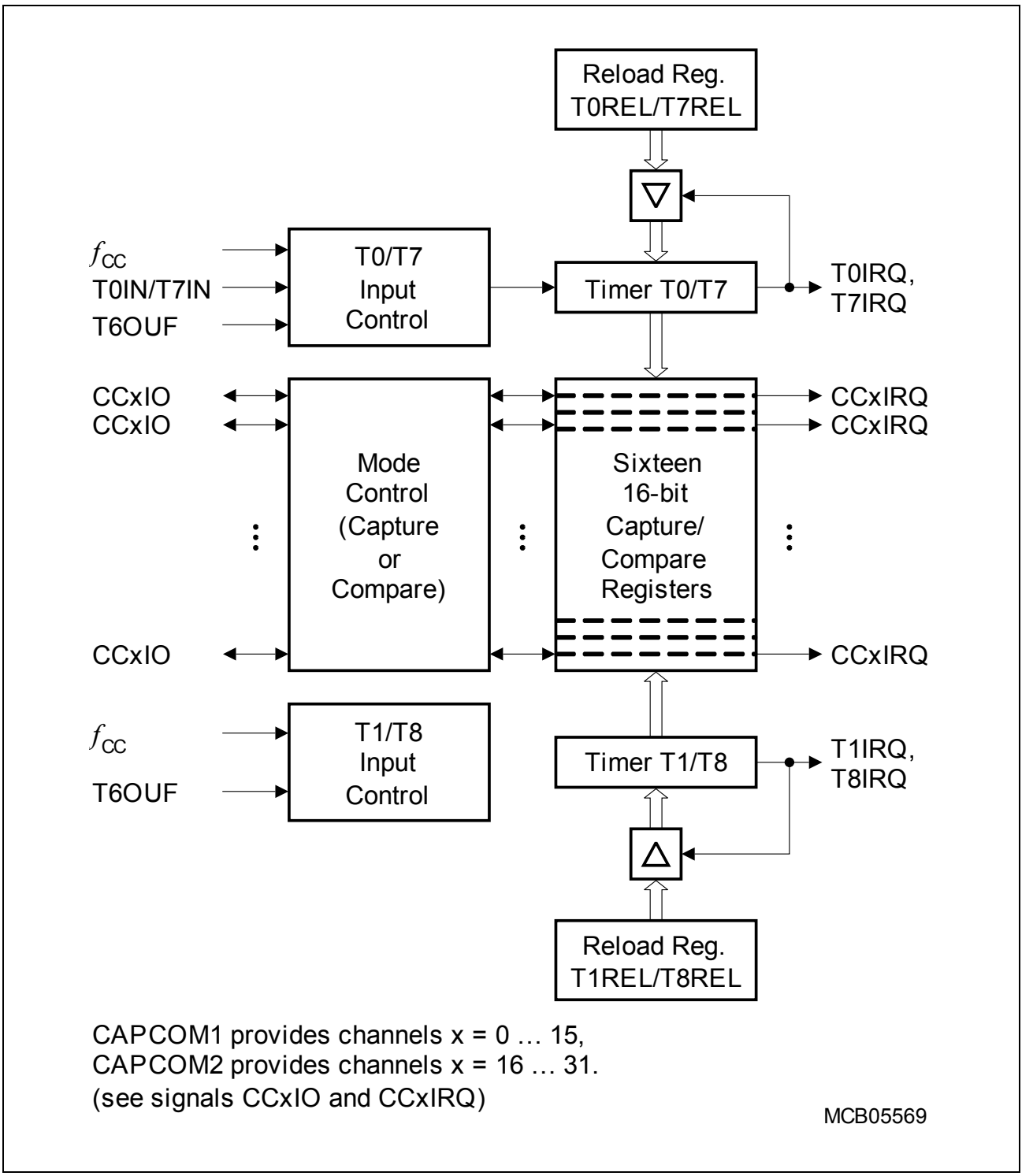

Figure 5 CAPCOM1/2 Unit Block Diagram

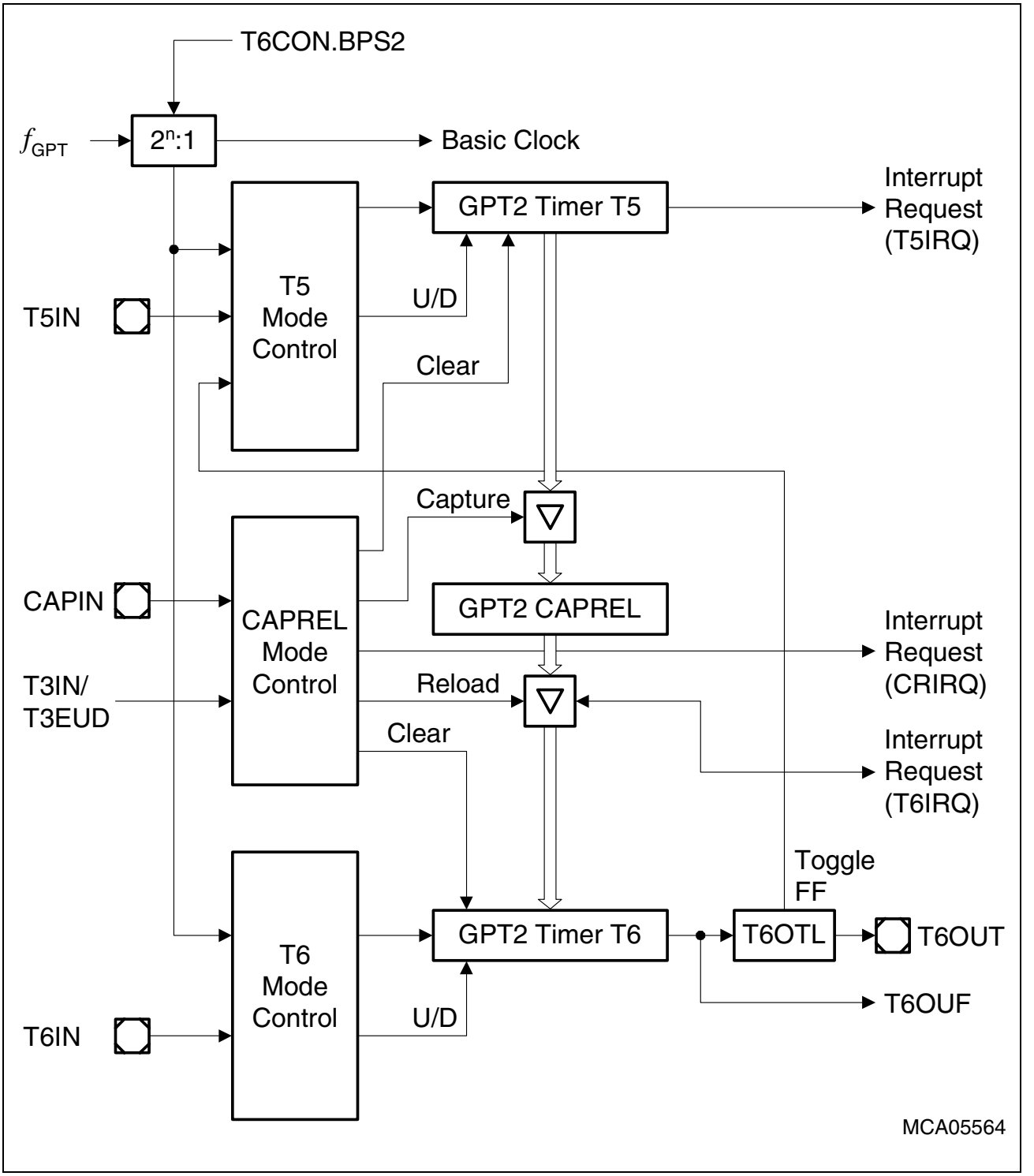

Figure 8 Block Diagram of GPT2

3.13 TwinCAN Module

The integrated TwinCAN module handles the completely autonomous transmission and reception of CAN frames in accordance with the CAN specification V2.0 part B (active), i.e. the on-chip TwinCAN module can receive and transmit standard frames with 11-bit identifiers as well as extended frames with 29-bit identifiers.

Two Full-CAN nodes share the TwinCAN module's resources to optimize the CAN bus traffic handling and to minimize the CPU load. The module provides up to 32 message objects, which can be assigned to one of the CAN nodes and can be combined to FIFO-structures. Each object provides separate masks for acceptance filtering.

The flexible combination of Full-CAN functionality and FIFO architecture reduces the efforts to fulfill the real-time requirements of complex embedded control applications. Improved CAN bus monitoring functionality as well as the number of message objects permit precise and comfortable CAN bus traffic handling.

Gateway functionality allows automatic data exchange between two separate CAN bus systems, which reduces CPU load and improves the real time behavior of the entire system.

The bit timing for both CAN nodes is derived from the master clock and is programmable up to a data rate of 1 Mbit/s. Each CAN node uses two pins of Port 4, Port 7, or Port 9 to interface to an external bus transceiver. The interface pins are assigned via software.

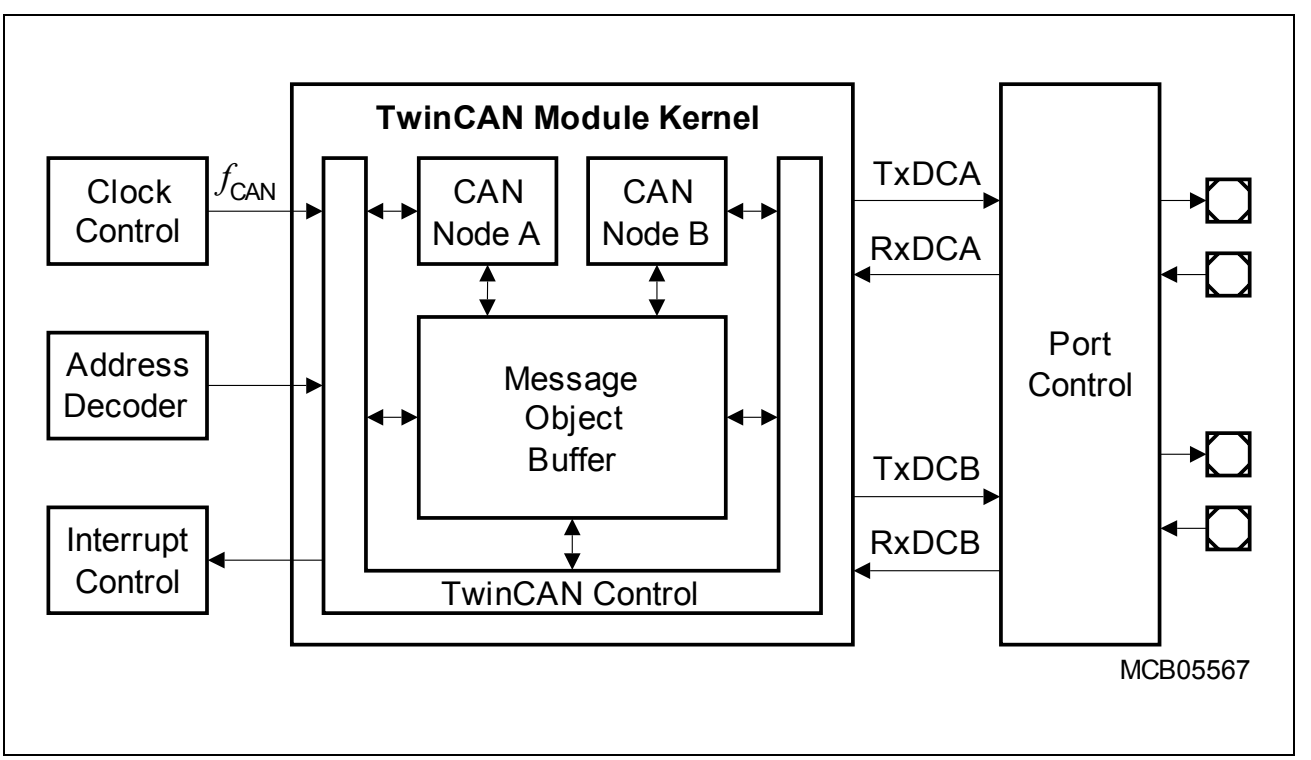

Figure 10 TwinCAN Module Block Diagram

3.15 Watchdog Timer

The Watchdog Timer represents one of the fail-safe mechanisms which have been implemented to prevent the controller from malfunctioning for longer periods of time.

The Watchdog Timer is always enabled after a reset of the chip, and can be disabled until the EINIT instruction has been executed (compatible mode), or it can be disabled and enabled at any time by executing instructions DISWDT and ENWDT (enhanced mode). Thus, the chip's start-up procedure is always monitored. The software has to be designed to restart the Watchdog Timer before it overflows. If, due to hardware or software related failures, the software fails to do so, the Watchdog Timer overflows and generates an internal hardware reset and pulls the $\overline{\text{RSTOUT}}$ pin low in order to allow external hardware components to be reset.

The Watchdog Timer is a 16-bit timer, clocked with the system clock divided by 2/4/128/256. The high byte of the Watchdog Timer register can be set to a prespecified reload value (stored in WDTREL) in order to allow further variation of the monitored time interval. Each time it is serviced by the application software, the high byte of the Watchdog Timer is reloaded and the low byte is cleared. Thus, time intervals between 13 µs and 419 ms can be monitored (@ 40 MHz).
The default Watchdog Timer interval after reset is 3.28 ms (@ 40 MHz).

3.19 Instruction Set Summary

Table 8 lists the instructions of the XC167 in a condensed way.
The various addressing modes that can be used with a specific instruction, the operation of the instructions, parameters for conditional execution of instructions, and the opcodes for each instruction can be found in the **"Instruction Set Manual"**.

This document also provides a detailed description of each instruction.

Table 8 Instruction Set Summary

Mnemonic	Description	Bytes
ADD(B)	Add word (byte) operands	2 / 4
ADDC(B)	Add word (byte) operands with Carry	2 / 4
SUB(B)	Subtract word (byte) operands	2 / 4
SUBC(B)	Subtract word (byte) operands with Carry	2 / 4
MUL(U)	(Un)Signed multiply direct GPR by direct GPR (16- × 16-bit)	2
DIV(U)	(Un)Signed divide register MDL by direct GPR (16-/16-bit)	2
DIVL(U)	(Un)Signed long divide reg. MD by direct GPR (32-/16-bit)	2
CPL(B)	Complement direct word (byte) GPR	2
NEG(B)	Negate direct word (byte) GPR	2
AND(B)	Bitwise AND, (word/byte operands)	2 / 4
OR(B)	Bitwise OR, (word/byte operands)	2 / 4
XOR(B)	Bitwise exclusive OR, (word/byte operands)	2 / 4
BCLR/BSET	Clear/Set direct bit	2
BMOV(N)	Move (negated) direct bit to direct bit	4
BAND/BOR/BXOR	AND/OR/XOR direct bit with direct bit	4
BCMP	Compare direct bit to direct bit	4
BFLDH/BFLDL	Bitwise modify masked high/low byte of bit-addressable direct word memory with immediate data	4
CMP(B)	Compare word (byte) operands	2 / 4
CMPD1/2	Compare word data to GPR and decrement GPR by 1/2	2 / 4
CMPI1/2	Compare word data to GPR and increment GPR by 1/2	2 / 4
PRIOR	Determine number of shift cycles to normalize direct word GPR and store result in direct word GPR	2
SHL/SHR	Shift left/right direct word GPR	2

Table 16 VCO Bands for PLL Operation[1)]

PLLCON.PLLVB	VCO Frequency Range	Base Frequency Range
00	100 … 150 MHz	20 … 80 MHz
01	150 … 200 MHz	40 … 130 MHz
10	200 … 250 MHz	60 … 180 MHz
11	Reserved	

1) Not subject to production test - verified by design/characterization.

4.4.5 External Bus Timing

Table 20 CLKOUT Reference Signal

Parameter	Symbol		Limits		Unit
			Min.	Max.	
CLKOUT cycle time	tc_5	CC	40/30/25[1]		ns
CLKOUT high time	tc_6	CC	8	–	ns
CLKOUT low time	tc_7	CC	6	–	ns
CLKOUT rise time	tc_8	CC	–	4	ns
CLKOUT fall time	tc_9	CC	–	4	ns

1) The CLKOUT cycle time is influenced by the PLL jitter (given values apply to f_{CPU} = 25/33/40 MHz). For longer periods the relative deviation decreases (see PLL deviation formula).

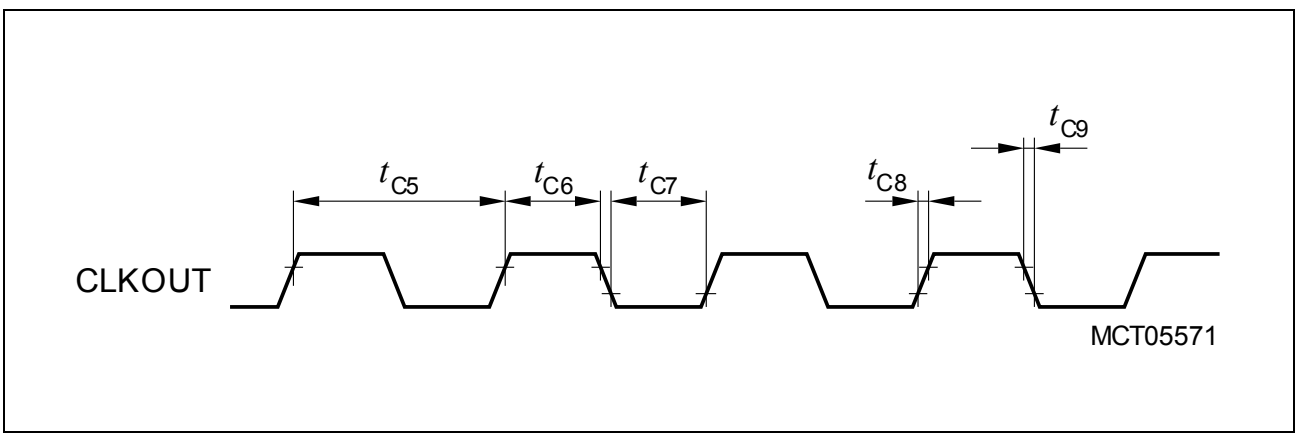

Figure 20 CLKOUT Signal Timing

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	13	ns
Output valid delay for: BHE, ALE	tc_{11}	CC	-1	7	ns
Output valid delay for: A23 … A16, A15 … A0 (on PORT1)	tc_{12}	CC	1	16	ns
Output valid delay for: A15 … A0 (on PORT0)	tc_{13}	CC	3	16	ns
Output valid delay for: CS	tc_{14}	CC	1	14	ns
Output valid delay for: D15 … D0 (write data, MUX-mode)	tc_{15}	CC	3	17	ns
Output valid delay for: D15 … D0 (write data, DEMUX-mode)	tc_{16}	CC	3	17	ns
Output hold time for: RD, WR(L/H)	tc_{20}	CC	-3	3	ns
Output hold time for: BHE, ALE	tc_{21}	CC	0	8	ns
Output hold time for: A23 … A16, A15 … A0 (on PORT0)	tc_{23}	CC	1	13	ns
Output hold time for: CS	tc_{24}	CC	-3	3	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	24	–	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.

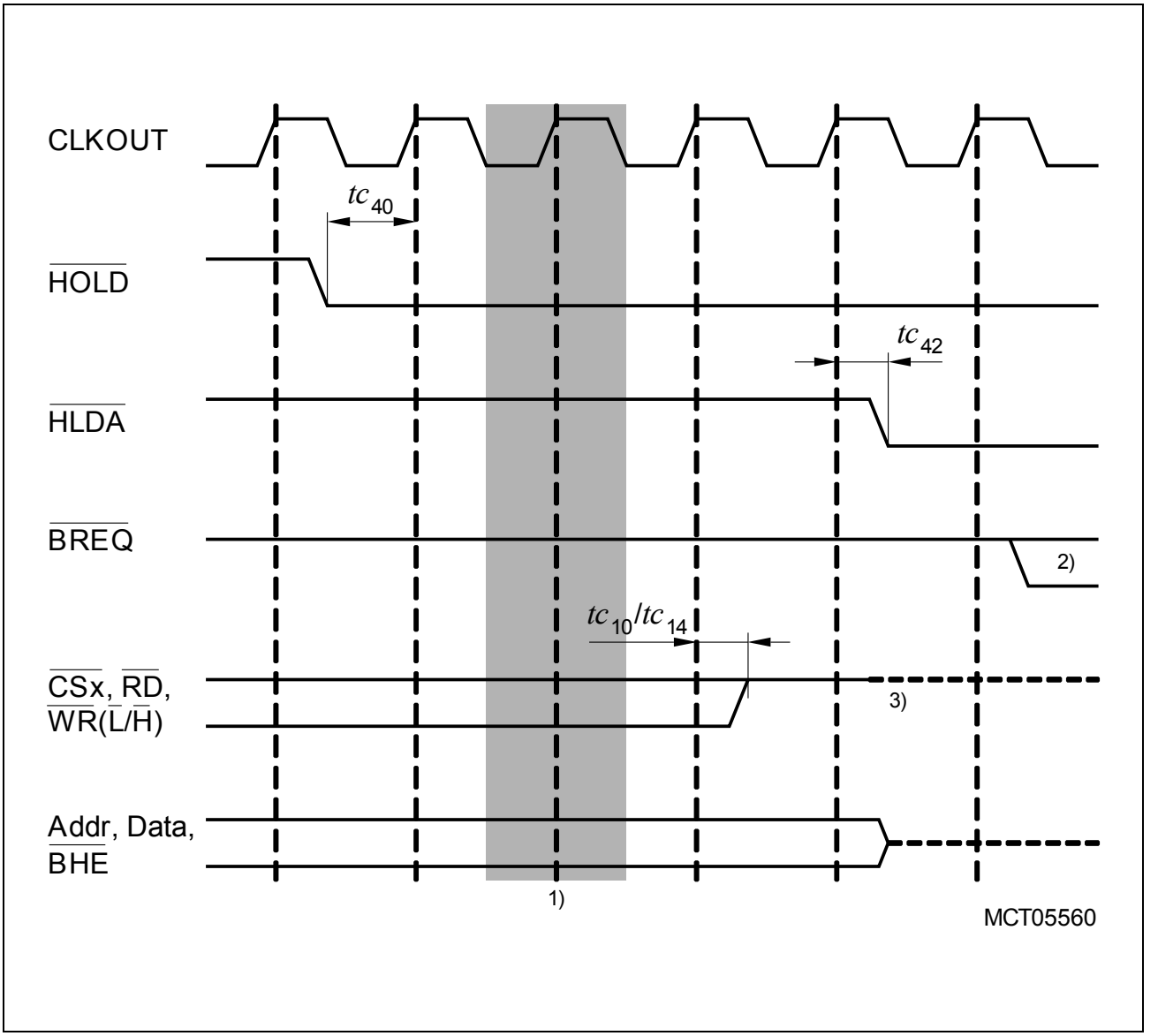

Figure 24 External Bus Arbitration, Releasing the Bus

Notes

1. *The XC167 will complete the currently running bus cycle before granting bus access.*
2. *This is the first possibility for BREQ to get active.*
3. *The control outputs will be resistive high (pull-up) after being driven inactive (ALE will be low).*