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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	C166
Core Size	16-Bit
Speed	20MHz
Connectivity	EBI/EMI, I²C, SPI, UART/USART
Peripherals	POR, PWM, WDT
Number of I/O	76
Program Memory Size	-
Program Memory Type	ROMless
EEPROM Size	-
RAM Size	3K x 8
Voltage - Supply (Vcc/Vdd)	4.5V ~ 5.5V
Data Converters	A/D 4x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	100-BQFP
Supplier Device Package	PG-MQFP-100-2
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/c161pilmcafxuma1

C161PI Revision History:	1999-07 Preliminary	
Previous Versions:	1998-05 1998-01 1997-12	(C161RI / Preliminary) (C161RI / Advance Information) (C161RI / Advance Information)

Page	Subjects
---	3 V specification introduced
4, 5, 7	Signal FOUT added
14	XRAM description added
15	Unlatched $\overline{CS}$ description added
23	Block Diagram corrected
24	Description of divider chain improved
25, 51, 52	ADC description updated to 10-bit
36, 37	Revised description of Absolute Max. Ratings and Operating Conditions
39, 44	Power supply values improved
45 - 50	Revised description for clock generation including PLL
54 ff.	Standard 25-MHz timing

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The C161PI is the successor of the C161RI. Therefore this data sheet also replaces the C161RI data sheet (see also revision history).

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St.-Martin-Strasse 53
D-81541 München

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Table 1 Pin Definitions and Functions

Symbol	Pin Num. TQFP	Pin Num. MQFP	Input Outp.	Function
P5			I	Port 5 is a 6-bit input-only port with Schmitt-Trigger characteristics. The pins of Port 5 also serve as (up to 4) analog input channels for the A/D converter, or they serve as timer inputs:
P5.0	97	99	I	AN0
P5.1	98	100	I	AN1
P5.2	99	1	I	AN2
P5.3	100	2	I	AN3
P5.14	1	3	I	T4EUD GPT1 Timer T4 Ext. Up/Down Ctrl. Input
P5.15	2	4	I	T2EUD GPT1 Timer T5 Ext. Up/Down Ctrl. Input
XTAL1	4	6	I	XTAL1: Input to the oscillator amplifier and input to the internal clock generator
XTAL2	5	7	O	XTAL2: Output of the oscillator amplifier circuit. To clock the device from an external source, drive XTAL1, while leaving XTAL2 unconnected. Minimum and maximum high/low and rise/fall times specified in the AC Characteristics must be observed.

Table 1 Pin Definitions and Functions (continued)

Symbol	Pin Num. TQFP	Pin Num. MQFP	Input Outp.	Function	
P3			IO	Port 3 is a 15-bit bidirectional I/O port. It is bit-wise programmable for input or output via direction bits. For a pin configured as input, the output driver is put into high-impedance state. Port 3 outputs can be configured as push/pull or open drain drivers. The input threshold of Port 3 is selectable (TTL or special). The following Port 3 pins also serve for alternate functions:	
P3.0	7	9	I/O	SCL0	I2C Bus Clock Line 0
P3.1	8	10	I/O	SDA0	I2C Bus Data Line 0
P3.2	9	11	I	CAPIN	GPT2 Register CAPREL Capture Input
P3.3	10	12	O	T3OUT	GPT1 Timer T3 Toggle Latch Output
P3.4	11	13	I	T3EUD	GPT1 Timer T3 External Up/Down Ctrl.Inp
P3.5	12	14	I	T4IN	GPT1 Timer T4 Count/Gate/Reload/ Capture Input
P3.6	13	15	I	T3IN	GPT1 Timer T3 Count/Gate Input
P3.7	14	16	I	T2IN	GPT1 Timer T2 Count/Gate/Reload/ Capture Input
P3.8	15	17	I/O	MRST	SSC Master-Rec. / Slave-Trans. Inp/Outp.
P3.9	16	18	I/O	MTSR	SSC Master-Trans. / Slave-Rec. Outp/Inp.
P3.10	17	19	O	T×D0	ASC0 Clock/Data Output (Async./Sync.)
P3.11	18	20	I/O	R×D0	ASC0 Data Input (Async.) or I/O (Sync.)
P3.12	19	21	O	$\overline{\text{BHE}}$	External Memory High Byte Enable Signal,
			O	$\overline{\text{WRH}}$	External Memory High Byte Write Strobe
P3.13	20	22	I/O	SCLK	SSC Master Clock Outp. / Slave Clock Inp.
P3.15	21	23	O	CLKOUT	System Clock Output (=CPU Clock)
			O	FOUT	Programmable Frequency Output
				Note: Pins P3.0 and P3.1 are open drain outputs only.	

Table 1 Pin Definitions and Functions (continued)

Symbol	Pin Num. TQFP	Pin Num. MQFP	Input Outp.	Function
P6			IO	Port 6 is an 8-bit bidirectional I/O port. It is bit-wise programmable for input or output via direction bits. For a pin configured as input, the output driver is put into high-impedance state. Port 6 outputs can be configured as push/pull or open drain drivers. The Port 6 pins also serve for alternate functions:
P6.0	79	81	O	$\overline{CS0}$ Chip Select 0 Output
P6.1	80	82	O	$\overline{CS1}$ Chip Select 1 Output
P6.2	81	83	O	$\overline{CS2}$ Chip Select 2 Output
P6.3	82	84	O	$\overline{CS3}$ Chip Select 3 Output
P6.4	83	85	O	CS4 Chip Select 4 Output
P6.5	84	86	I/O	SDA1 I^2C Bus Data Line 1
P6.6	85	87	I/O	SCL1 I^2C Bus Clock Line 1
P6.7	86	88	I/O	SDA2 I^2C Bus Data Line 2
				Note: Pins P6.7-5 are open drain outputs only.
P2			IO	Port 2 is an 8-bit bidirectional I/O port. It is bit-wise programmable for input or output via direction bits. For a pin configured as input, the output driver is put into high-impedance state. Port 2 outputs can be configured as push/pull or open drain drivers. The input threshold of Port 2 is selectable (TTL or special). The Port 2 pins also serve for alternate functions:
P2.8	87	89	I	EX0IN Fast External Interrupt 0 Input
P2.9	88	90	I	EX1IN Fast External Interrupt 1 Input
P2.10	89	91	I	EX2IN Fast External Interrupt 2 Input
P2.11	90	92	I	EX3IN Fast External Interrupt 3 Input
P2.12	91	93	I	EX4IN Fast External Interrupt 4 Input
P2.13	92	94	I	EX5IN Fast External Interrupt 5 Input
P2.14	93	95	I	EX6IN Fast External Interrupt 6 Input
P2.15	94	96	I	EX7IN Fast External Interrupt 7 Input
V_{AREF}	95	97	-	Reference voltage for the A/D converter.
V_{AGND}	96	98	-	Reference ground for the A/D converter.

General Purpose Timer (GPT) Unit

The GPT unit represents a very flexible multifunctional timer/counter structure which may be used for many different time related tasks such as event timing and counting, pulse width and duty cycle measurements, pulse generation, or pulse multiplication.

The GPT unit incorporates five 16-bit timers which are organized in two separate modules, GPT1 and GPT2. Each timer in each module may operate independently in a number of different modes, or may be concatenated with another timer of the same module.

Each of the three timers T2, T3, T4 of **module GPT1** can be configured individually for one of four basic modes of operation, which are Timer, Gated Timer, Counter, and Incremental Interface Mode. In Timer Mode, the input clock for a timer is derived from the CPU clock, divided by a programmable prescaler, while Counter Mode allows a timer to be clocked in reference to external events.
Pulse width or duty cycle measurement is supported in Gated Timer Mode, where the operation of a timer is controlled by the ‘gate’ level on an external input pin. For these purposes, each timer has one associated port pin (TxIN) which serves as gate or clock input. The maximum resolution of the timers in module GPT1 is 16 TCL.

The count direction (up/down) for each timer is programmable by software or may additionally be altered dynamically by an external signal on a port pin (TxEUD) to facilitate eg. position tracking.

In Incremental Interface Mode the GPT1 timers (T2, T3, T4) can be directly connected to the incremental position sensor signals A and B via their respective inputs TxIN and TxEUD. Direction and count signals are internally derived from these two input signals, so the contents of the respective timer Tx corresponds to the sensor position. The third position sensor signal TOP0 can be connected to an interrupt input.

Timer T3 has an output toggle latch (T3OTL) which changes its state on each timer over-flow/underflow. The state of this latch may be output on a port pin (T3OUT) eg. for time out monitoring of external hardware components, or may be used internally to clock timers T2 and T4 for measuring long time periods with high resolution.

In addition to their basic operating modes, timers T2 and T4 may be configured as reload or capture registers for timer T3. When used as capture or reload registers, timers T2 and T4 are stopped. The contents of timer T3 are captured into T2 or T4 in response to a signal at their associated input pins (TxIN). Timer T3 is reloaded with the contents of T2 or T4 triggered either by an external signal or by a selectable state transition of its toggle latch T3OTL. When both T2 and T4 are configured to alternately reload T3 on opposite state transitions of T3OTL with the low and high times of a PWM signal, this signal can be constantly generated without software intervention.

The state of this latch may be used to clock timer T5. The overflows/underflows of timer T6 can additionally be used to cause a reload from the CAPREL register. The CAPREL register may capture the contents of timer T5 based on an external signal transition on the corresponding port pin (CAPIN), and timer T5 may optionally be cleared after the capture procedure. This allows absolute time differences to be measured or pulse multiplication to be performed without software overhead.

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

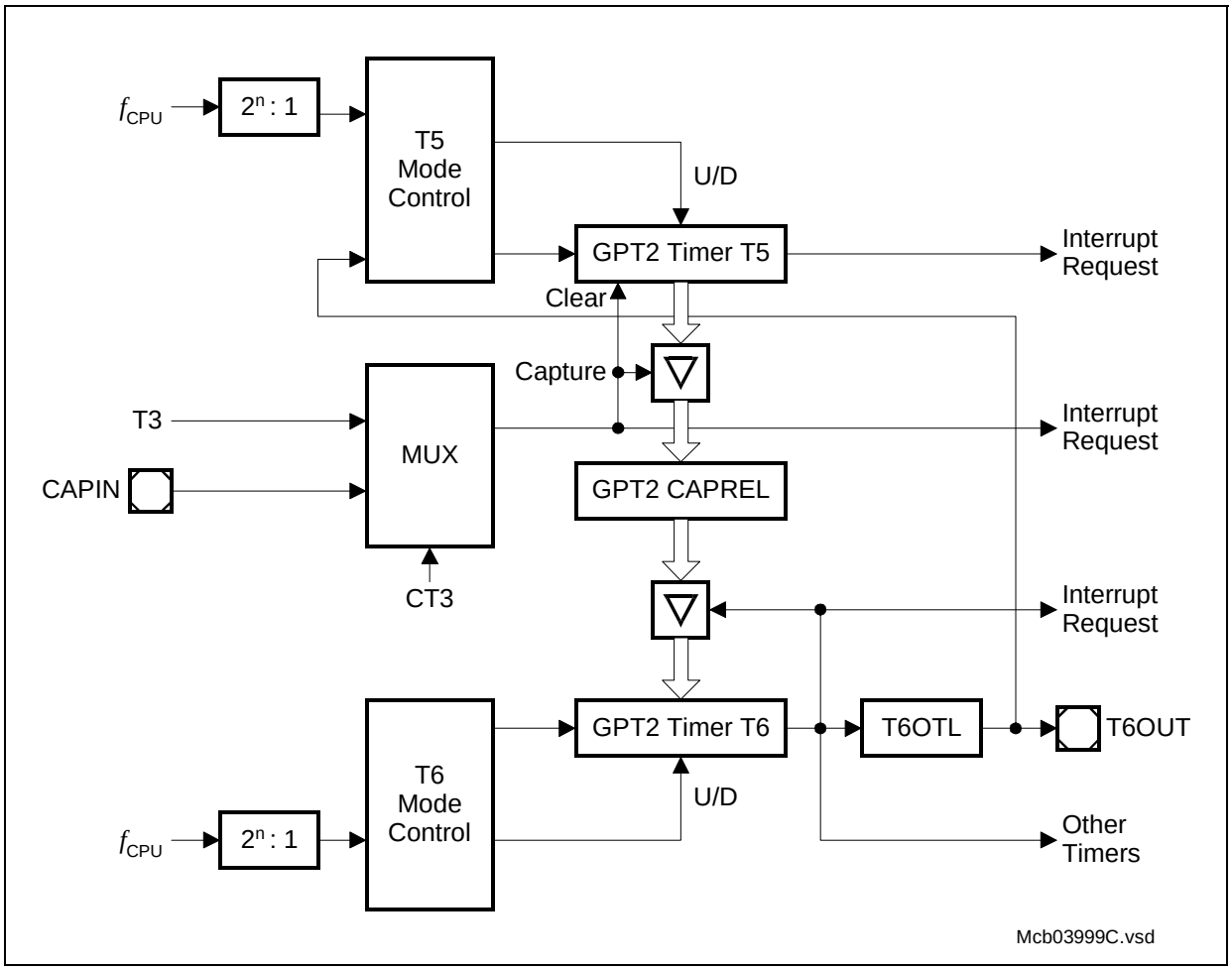

Figure 7 Block Diagram of GPT2

Instruction Set Summary

The table below lists the instructions of the C161PI 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 **“C166 Family Instruction Set Manual”**.

This document also provides a detailled description of each instruction.

Table 4 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 XOR, (word/byte operands)	2 / 4
BCLR	Clear direct bit	2
BSET	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/L	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
ROL / ROR	Rotate left/right direct word GPR	2
ASHR	Arithmetic (sign bit) shift right direct word GPR	2

Table 5 C161PI Registers, Ordered by Name (continued)

Name		Physical Address		8-Bit Addr.	Description	Reset Value
IDPROG		$F078_H$	**E**	$3C_H$	Identifier	0000_H
ISNC	**b**	$F1DE_H$	**E**	EF_H	Interrupt Subnode Control Register	0000_H
MDC	**b**	$FF0E_H$		87_H	CPU Multiply Divide Control Register	0000_H
MDH		$FE0C_H$		06_H	CPU Multiply Divide Reg. – High Word	0000_H
MDL		$FE0E_H$		07_H	CPU Multiply Divide Reg. – Low Word	0000_H
ODP2	**b**	$F1C2_H$	**E**	$E1_H$	Port 2 Open Drain Control Register	0000_H
ODP3	**b**	$F1C6_H$	**E**	$E3_H$	Port 3 Open Drain Control Register	0000_H
ODP6	**b**	$F1CE_H$	**E**	$E7_H$	Port 6 Open Drain Control Register	00_H
ONES	**b**	$FF1E_H$		$8F_H$	Constant Value 1’s Register (read only)	$FFFF_H$
P0L	**b**	$FF00_H$		80_H	Port 0 Low Reg. (Lower half of PORT0)	00_H
P0H	**b**	$FF02_H$		81_H	Port 0 High Reg. (Upper half of PORT0)	00_H
P1L	**b**	$FF04_H$		82_H	Port 1 Low Reg. (Lower half of PORT1)	00_H
P1H	**b**	$FF06_H$		83_H	Port 1 High Reg. (Upper half of PORT1)	00_H
P2	**b**	$FFC0_H$		$E0_H$	Port 2 Register	0000_H
P3	**b**	$FFC4_H$		$E2_H$	Port 3 Register	0000_H
P4	**b**	$FFC8_H$		$E4_H$	Port 4 Register (7 bits)	00_H
P5	**b**	$FFA2_H$		$D1_H$	Port 5 Register (read only)	$XXXX_H$
P5DIDIS	**b**	$FFA4_H$		$D2_H$	Port 5 Digital Input Disable Register	0000_H
P6	**b**	$FFCC_H$		$E6_H$	Port 6 Register (8 bits)	00_H
PECC0		$FEC0_H$		60_H	PEC Channel 0 Control Register	0000_H
PECC1		$FEC2_H$		61_H	PEC Channel 1 Control Register	0000_H
PECC2		$FEC4_H$		62_H	PEC Channel 2 Control Register	0000_H
PECC3		$FEC6_H$		63_H	PEC Channel 3 Control Register	0000_H
PECC4		$FEC8_H$		64_H	PEC Channel 4 Control Register	0000_H
PECC5		$FECA_H$		65_H	PEC Channel 5 Control Register	0000_H
PECC6		$FECC_H$		66_H	PEC Channel 6 Control Register	0000_H
PECC7		$FECE_H$		67_H	PEC Channel 7 Control Register	0000_H
PSW	**b**	$FF10_H$		88_H	CPU Program Status Word	0000_H
PDCR		$F0AA_H$	**E**	55_H	Pin Driver Control Register	0000_H
RP0H	**b**	$F108_H$	**E**	84_H	System Startup Config. Reg. (Rd. only)	XX_H

Parameter Interpretation

The parameters listed in the following partly represent the characteristics of the C161PI and partly its demands on the system. To aid in interpreting the parameters right, when evaluating them for a design, they are marked in column “Symbol”:

CC (**C**ontroller **C**haracteristics):
The logic of the C161PI will provide signals with the respective timing characteristics.

SR (**S**ystem **R**equirement):
The external system must provide signals with the respective timing characteristics to the C161PI.

DC Characteristics (Standard Supply Voltage Range)

(Operating Conditions apply)

Parameter	Symbol	Limit Values		Unit	Test Condition
		min.	max.		
Input low voltage XTAL1, P3.0, P3.1, P6.5, P6.6, P6.7	V_{IL1} SR	– 0.5	0.3 V_{DD}	V	–
Input low voltage (TTL)	V_{IL} SR	– 0.5	0.2 V_{DD} – 0.1	V	–
Input low voltage (Special Threshold)	V_{ILS} SR	– 0.5	2.0	V	–
Input high voltage $\overline{\text{RSTIN}}$	V_{IH1} SR	0.6 V_{DD}	V_{DD} + 0.5	V	–
Input high voltage XTAL1, P3.0, P3.1, P6.5, P6.6, P6.7	V_{IH2} SR	0.7 V_{DD}	V_{DD} + 0.5	V	–
Input high voltage (TTL)	V_{IH} SR	0.2 V_{DD} + 0.9	V_{DD} + 0.5	V	–
Input high voltage (Special Threshold)	V_{IHS} SR	0.8 V_{DD} - 0.2	V_{DD} + 0.5	V	–
Input Hysteresis (Special Threshold)	HYS	400	–	mV	–
Output low voltage (PORT0, PORT1, Port 4, ALE, $\overline{\text{RD}}$, $\overline{\text{WR}}$, $\overline{\text{BHE}}$, CLKOUT, $\overline{\text{RSTOUT}}$)	V_{OL} CC	–	0.45	V	I_{OL} = 2.4 mA
Output low voltage (P3.0, P3.1, P6.5, P6.6, P6.7)	V_{OL2} CC	–	0.4	V	I_{OL2} = 3 mA

DC Characteristics (Standard Supply Voltage Range) (continued)
(Operating Conditions apply)

Parameter	Symbol	Limit Values		Unit	Test Condition
		min.	max.		
Power-down mode supply current (5V) with RTC running	I_{PDR5} 8)	–	200 + 25*f_{OSC}	µA	$V_{DD} = V_{DDmax}$ f_{OSC} in [MHz] 9)
Power-down mode supply current (5V) with RTC disabled	I_{PDO5}	–	50	µA	$V_{DD} = V_{DDmax}$ 9)

1) This specification is not valid for outputs which are switched to open drain mode. In this case the respective output will float and the voltage results from the external circuitry.

2) These parameters describe the $\overline{\text{RSTIN}}$ pullup, which equals a resistance of ca. 50 to 250 KΩ.

3) The maximum current may be drawn while the respective signal line remains inactive.

4) The minimum current must be drawn in order to drive the respective signal line active.

5) This specification is only valid during Reset, or during Hold- or Adapt-mode. During Hold mode Port 6 pins are only affected, if they are used (configured) for $\overline{\text{CS}}$ output and the open drain function is not enabled.

6) Not 100% tested, guaranteed by design characterization.

7) The supply current is a function of the operating frequency. This dependency is illustrated in the figure below. These parameters are tested at V_{DDmax} and maximum CPU clock with all outputs disconnected and all inputs at V_{IL} or V_{IH}.
The oscillator also contributes to the total supply current. The given values refer to the worst case, ie. I_{PDRmax}. For lower oscillator frequencies the respective supply current can be reduced accordingly.

8) This parameter is determined mainly by the current consumed by the oscillator. This current, however, is influenced by the external oscillator circuitry (crystal, capacitors). The values given refer to a typical circuitry and may change in case of a not optimized external oscillator circuitry.

9) This parameter is tested including leakage currents. All inputs (including pins configured as inputs) at 0 V to 0.1 V or at V_{DD} – 0.1 V to V_{DD}, V_{REF} = 0 V, all outputs (including pins configured as outputs) disconnected.

AC Characteristics
Definition of Internal Timing

The internal operation of the C161PI is controlled by the internal CPU clock f_{CPU}. Both edges of the CPU clock can trigger internal (e.g. pipeline) or external (e.g. bus cycles) operations.

The specification of the external timing (AC Characteristics) therefore depends on the time between two consecutive edges of the CPU clock, called “TCL” (see figure below).

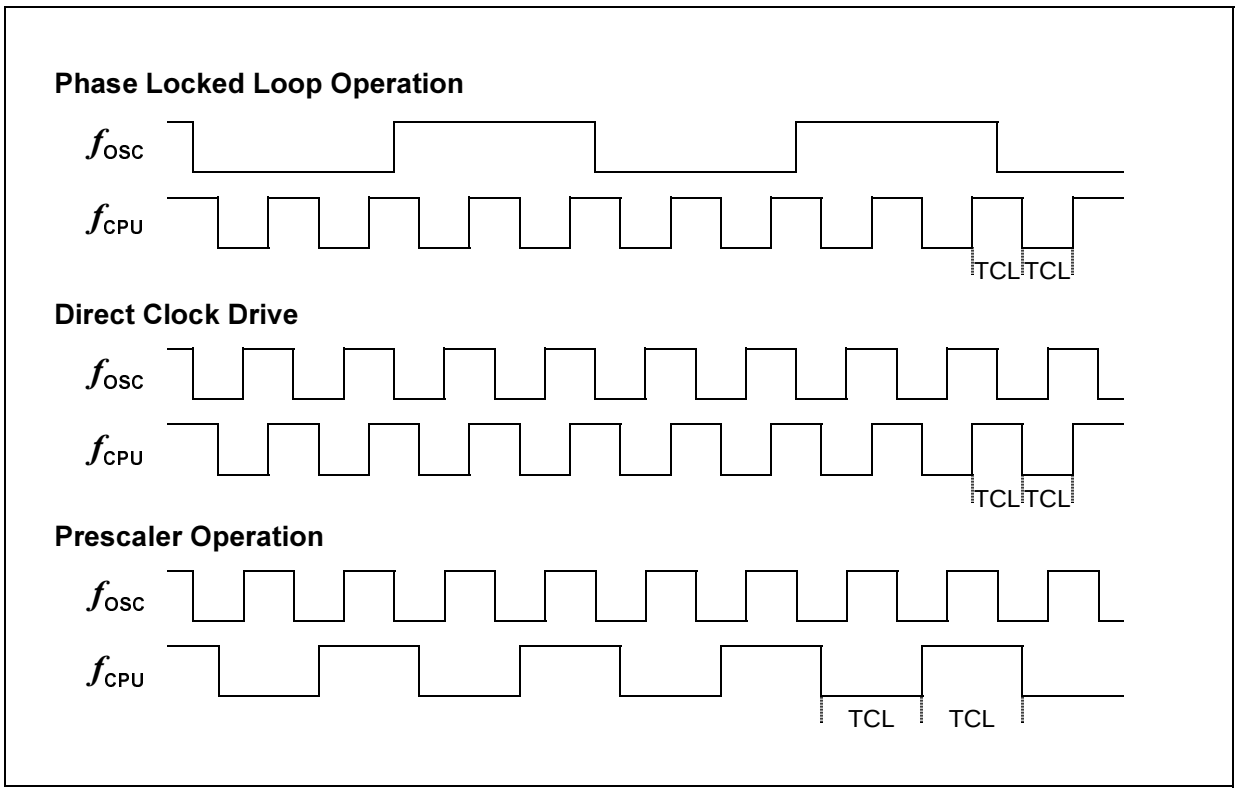

Figure 11 Generation Mechanisms for the CPU Clock

The CPU clock signal f_{CPU} can be generated from the oscillator clock signal f_{OSC} via different mechanisms. The duration of TCLs and their variation (and also the derived external timing) depends on the used mechanism to generate f_{CPU}. This influence must be regarded when calculating the timings for the C161PI.

Note: The example for PLL operation shown in the fig. above refers to a PLL factor of 4.

The used mechanism to generate the CPU clock is selected during reset via the logic levels on pins P0.15-13 (P0H.7-5).

The table below associates the combinations of these three bits with the respective clock generation mode.

Table 8 C161PI Clock Generation Modes

P0.15-13 (P0H.7-5)	CPU Frequency $f_{CPU} = f_{OSC} * F$	External Clock Input Range [1]	Notes
1 1 1	$f_{OSC} * 4$	2.5 to 6.25 MHz	Default configuration
1 1 0	$f_{OSC} * 3$	3.33 to 8.33 MHz	
1 0 1	$f_{OSC} * 2$	5 to 12.5 MHz	
1 0 0	$f_{OSC} * 5$	2 to 5 MHz	
0 1 1	$f_{OSC} * 1$	1 to 25 MHz	Direct drive [2]
0 1 0	$f_{OSC} * 1.5$	6.66 to 16.6 MHz	
0 0 1	$f_{OSC} / 2$	2 to 50 MHz	CPU clock via prescaler
0 0 0	$f_{OSC} * 2.5$	4 to 10 MHz	

1) The external clock input range refers to a CPU clock range of 10...25 MHz.

2) The maximum frequency depends on the duty cycle of the external clock signal.

Prescaler Operation

When pins P0.15-13 (P0H.7-5) equal 001_B during reset the CPU clock is derived from the internal oscillator (input clock signal) by a 2:1 prescaler.
The frequency of f_{CPU} is half the frequency of f_{OSC} and the high and low time of f_{CPU} (i.e. the duration of an individual TCL) is defined by the period of the input clock f_{OSC}.

The timings listed in the AC Characteristics that refer to TCLs therefore can be calculated using the period of f_{OSC} for any TCL.

Phase Locked Loop

For all combinations of pins P0.15-13 (P0H.7-5) except for 001_B and 011_B the on-chip phase locked loop is enabled and provides the CPU clock (see table above). The PLL multiplies the input frequency by the factor **F** which is selected via the combination of pins P0.15-13 (i.e. $f_{CPU} = f_{OSC} * \mathbf{F}$). With every **F**'th transition of f_{OSC} the PLL circuit synchronizes the CPU clock to the input clock. This synchronization is done smoothly, i.e. the CPU clock frequency does not change abruptly.

Due to this adaptation to the input clock the frequency of f_{CPU} is constantly adjusted so it is locked to f_{OSC}. The slight variation causes a jitter of f_{CPU} which also effects the duration of individual TCLs.

AC Characteristics

Multiplexed Bus (Reduced Supply Voltage Range)

(Operating Conditions apply)

ALE cycle time = 6 TCL + 2t_A + t_C + t_F (150 ns at 20 MHz CPU clock without waitstates)

Parameter	Symbol		Max. CPU Clock = 20 MHz		Variable CPU Clock 1 / 2TCL = 1 to 20 MHz		Unit
			min.	max.	min.	max.	
ALE high time	t_5	CC	11 + t_A	–	TCL - 14 + t_A	–	ns
Address setup to ALE	t_6	CC	5 + t_A	–	TCL - 20 + t_A	–	ns
Address hold after ALE	t_7	CC	15 + t_A	–	TCL - 10 + t_A	–	ns
ALE falling edge to $\overline{RD}$, $\overline{WR}$ (with RW-delay)	t_8	CC	15 + t_A	–	TCL - 10 + t_A	–	ns
ALE falling edge to $\overline{RD}$, $\overline{WR}$ (no RW-delay)	t_9	CC	-10 + t_A	–	-10 + t_A	–	ns
Address float after $\overline{RD}$, $\overline{WR}$ (with RW-delay)	t_{10}	CC	–	6	–	6	ns
Address float after $\overline{RD}$, $\overline{WR}$ (no RW-delay)	t_{11}	CC	–	31	–	TCL + 6	ns
$\overline{RD}$, $\overline{WR}$ low time (with RW-delay)	t_{12}	CC	34 + t_C	–	2TCL - 16 + t_C	–	ns
$\overline{RD}$, $\overline{WR}$ low time (no RW-delay)	t_{13}	CC	59 + t_C	–	3TCL - 16 + t_C	–	ns
$\overline{RD}$ to valid data in (with RW-delay)	t_{14}	SR	–	22 + t_C	–	2TCL - 28 + t_C	ns
$\overline{RD}$ to valid data in (no RW-delay)	t_{15}	SR	–	47 + t_C	–	3TCL - 28 + t_C	ns
ALE low to valid data in	t_{16}	SR	–	49 + t_A + t_C	–	3TCL - 30 + t_A + t_C	ns
Address to valid data in	t_{17}	SR	–	57 + 2t_A + t_C	–	4TCL - 43 + 2t_A + t_C	ns
Data hold after $\overline{RD}$ rising edge	t_{18}	SR	0	–	0	–	ns
Data float after $\overline{RD}$	t_{19}	SR	–	36 + t_F	–	2TCL - 14 + t_F	ns

Multiplexed Bus (Reduced Supply Voltage Range) (continued)
(Operating Conditions apply)
ALE cycle time = 6 TCL + $2t_A$ + t_C + t_F (150 ns at 20 MHz CPU clock without waitstates)

Parameter	Symbol		Max. CPU Clock = 20 MHz		Variable CPU Clock 1 / 2TCL = 1 to 20 MHz		Unit
			min.	max.	min.	max.	
Data hold after $\overline{\text{RdCS}}$	t_{51}	SR	0	–	0	–	ns
Data float after $\overline{\text{RdCS}}$	t_{52}	SR	–	30 + t_F	–	2TCL - 20 + t_F	ns
Address hold after $\overline{\text{RdCS}}$, $\overline{\text{WrCS}}$	t_{54}	CC	30 + t_F	–	2TCL - 20 + t_F	–	ns
Data hold after $\overline{\text{WrCS}}$	t_{56}	CC	30 + t_F	–	2TCL - 20 + t_F	–	ns

1) These parameters refer to the latched chip select signals ($\overline{\text{CSxL}}$). The early chip select signals ($\overline{\text{CSxE}}$) are specified together with the address and signal $\overline{\text{BHE}}$ (see figures below).

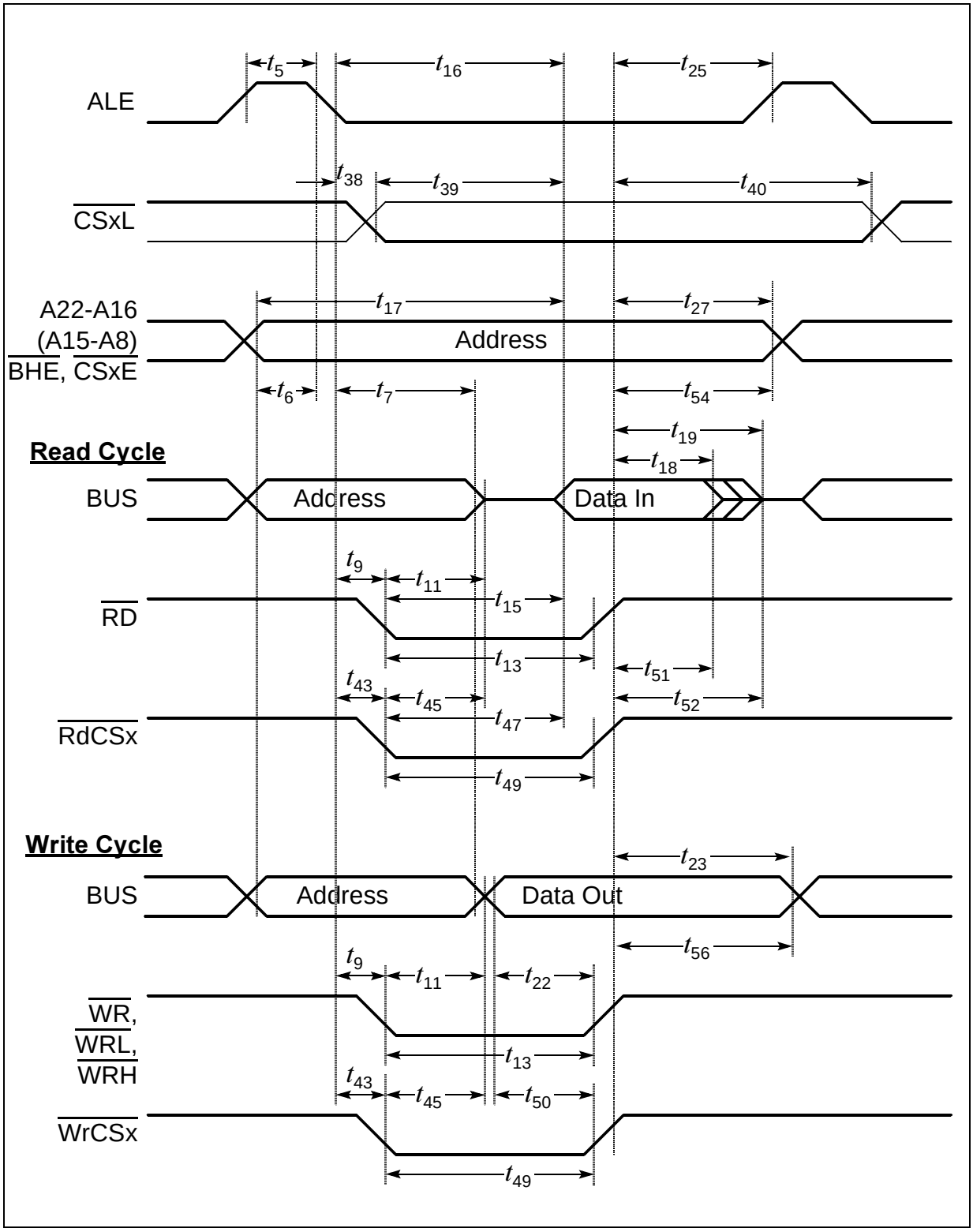

Figure 18 External Memory Cycle: Multiplexed Bus, No Read/Write Delay, Normal ALE

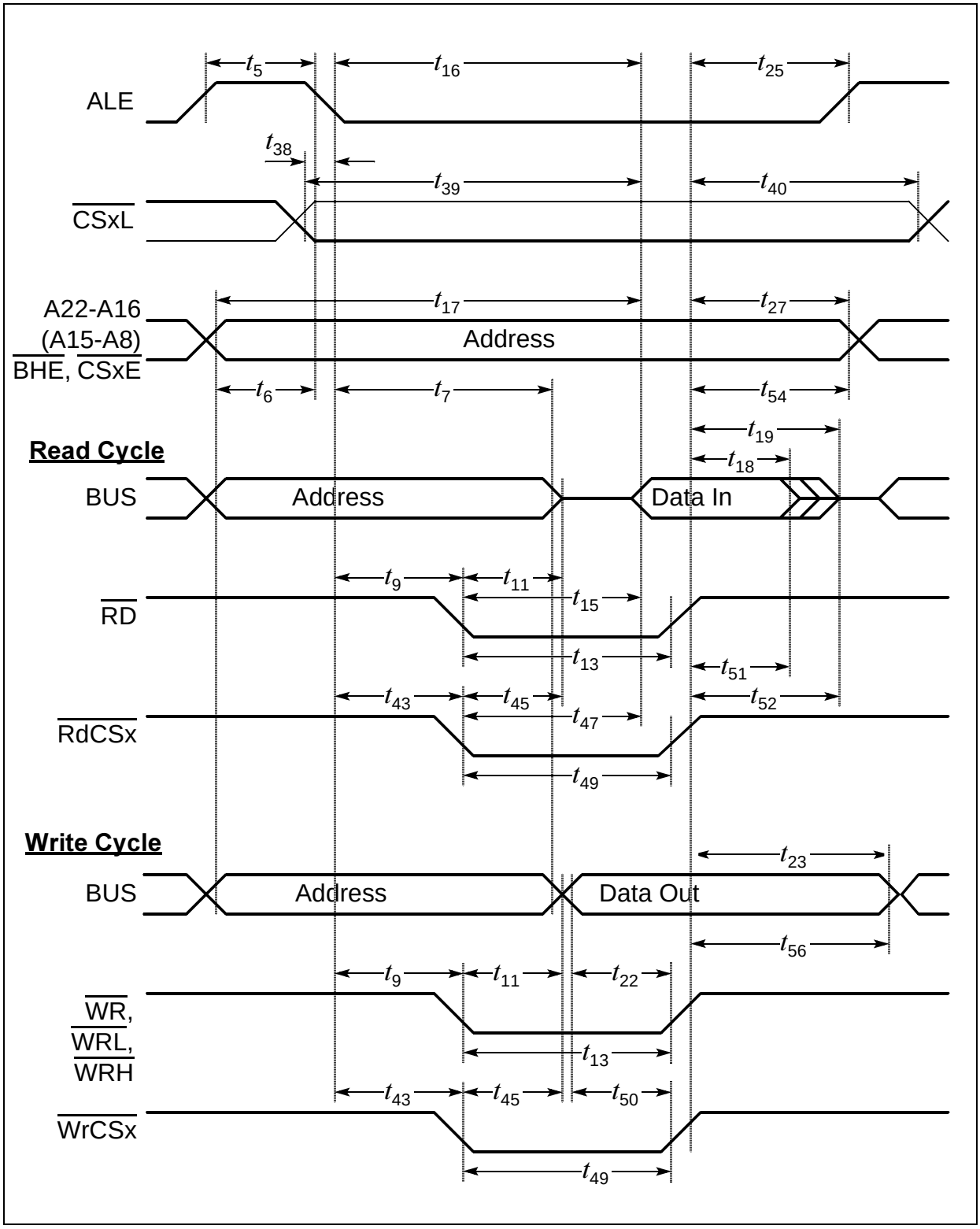

Figure 19 External Memory Cycle:
Multiplexed Bus, No Read/Write Delay, Extended ALE

Demultiplexed Bus (Reduced Supply Voltage Range) (continued)
(Operating Conditions apply)
ALE cycle time = 4 TCL + 2t_A + t_C + t_F (100 ns at 20 MHz CPU clock without waitstates)

Parameter	Symbol		Max. CPU Clock = 20 MHz		Variable CPU Clock 1 / 2TCL = 1 to 20 MHz		Unit
			min.	max.	min.	max.	
Data hold after $\overline{WR}$	t_{24}	CC	15 + t_F	–	TCL - 10 + t_F	–	ns
$\overline{ALE}$ rising edge after $\overline{RD}$, $\overline{WR}$	t_{26}	CC	-12 + t_F	–	-12 + t_F	–	ns
Address hold after $\overline{WR}$ [2]	t_{28}	CC	0 + t_F	–	0 + t_F	–	ns
$\overline{ALE}$ falling edge to $\overline{CS}$ [3]	t_{38}	CC	-8 - t_A	10 - t_A	-8 - t_A	10 - t_A	ns
$\overline{CS}$ low to Valid Data In [3]	t_{39}	SR	–	47 + t_C + 2t_A	–	3TCL - 28 + t_C + 2t_A	ns
$\overline{CS}$ hold after $\overline{RD}$, $\overline{WR}$ [3]	t_{41}	CC	9 + t_F	–	TCL - 16 + t_F	–	ns
$\overline{ALE}$ falling edge to $\overline{RdCS}$, $\overline{WrCS}$ (with RW-delay)	t_{42}	CC	19 + t_A	–	TCL - 6 + t_A	–	ns
$\overline{ALE}$ falling edge to $\overline{RdCS}$, $\overline{WrCS}$ (no RW-delay)	t_{43}	CC	-6 + t_A	–	-6 + t_A	–	ns
$\overline{RdCS}$ to Valid Data In (with RW-delay)	t_{46}	SR	–	20 + t_C	–	2TCL - 30 + t_C	ns
$\overline{RdCS}$ to Valid Data In (no RW-delay)	t_{47}	SR	–	45 + t_C	–	3TCL - 30 + t_C	ns
$\overline{RdCS}$, $\overline{WrCS}$ Low Time (with RW-delay)	t_{48}	CC	38 + t_C	–	2TCL - 12 + t_C	–	ns
$\overline{RdCS}$, $\overline{WrCS}$ Low Time (no RW-delay)	t_{49}	CC	63 + t_C	–	3TCL - 12 + t_C	–	ns
Data valid to $\overline{WrCS}$	t_{50}	CC	28 + t_C	–	2TCL - 22 + t_C	–	ns
Data hold after $\overline{RdCS}$	t_{51}	SR	0	–	0	–	ns
Data float after $\overline{RdCS}$ (with RW-delay) [1]	t_{53}	SR	–	30 + t_F	–	2TCL - 20 + 2t_A + t_F [1]	ns
Data float after $\overline{RdCS}$ (no RW-delay) [1]	t_{68}	SR	–	5 + t_F	–	TCL - 20 + 2t_A + t_F [1]	ns

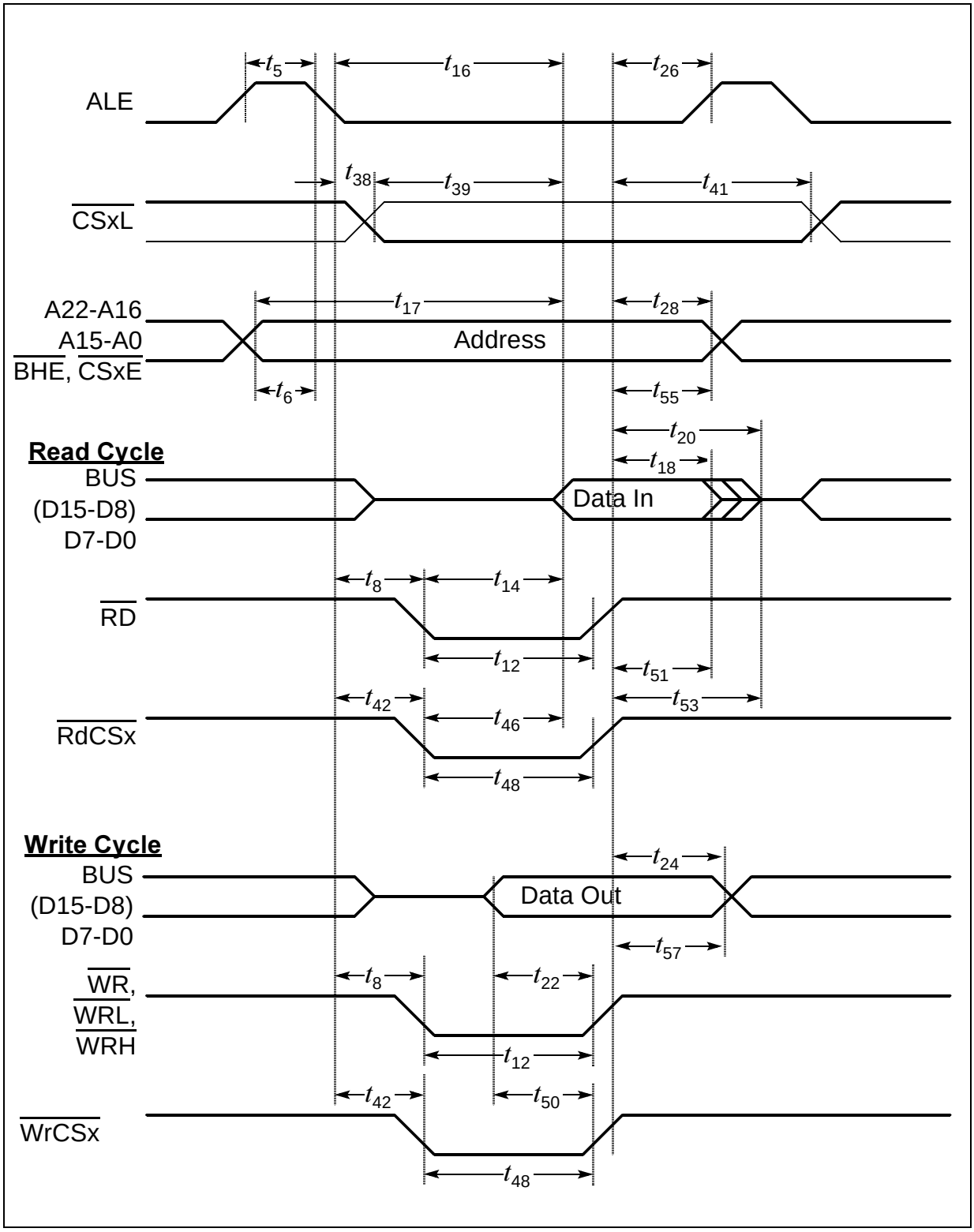

Figure 20 External Memory Cycle: Demultiplexed Bus, With Read/Write Delay, Normal ALE

AC Characteristics

CLKOUT and $\overline{\text{READY}}$ (Standard Supply Voltage Range)

(Operating Conditions apply)

Parameter	Symbol		Max. CPU Clock = 25 MHz		Variable CPU Clock 1 / 2TCL = 1 to 25 MHz		Unit
			min.	max.	min.	max.	
CLKOUT cycle time	t_{29}	CC	40	40	2TCL	2TCL	ns
CLKOUT high time	t_{30}	CC	14	–	TCL – 6	–	ns
CLKOUT low time	t_{31}	CC	10	–	TCL – 10	–	ns
CLKOUT rise time	t_{32}	CC	–	4	–	4	ns
CLKOUT fall time	t_{33}	CC	–	4	–	4	ns
CLKOUT rising edge to ALE falling edge	t_{34}	CC	0 + t_A	10 + t_A	0 + t_A	10 + t_A	ns
Synchronous $\overline{\text{READY}}$ setup time to CLKOUT	t_{35}	SR	14	–	14	–	ns
Synchronous $\overline{\text{READY}}$ hold time after CLKOUT	t_{36}	SR	4	–	4	–	ns
Asynchronous $\overline{\text{READY}}$ low time	t_{37}	SR	54	–	2TCL + t_{58}	–	ns
Asynchronous $\overline{\text{READY}}$ setup time [1]	t_{58}	SR	14	–	14	–	ns
Asynchronous $\overline{\text{READY}}$ hold time [1]	t_{59}	SR	4	–	4	–	ns
Async. $\overline{\text{READY}}$ hold time after $\overline{\text{RD}}$, $\overline{\text{WR}}$ high (Demultiplexed Bus) [2]	t_{60}	SR	0	0 + 2t_A + t_C + t_F [2]	0	TCL - 20 + 2t_A + t_C + t_F [2]	ns

1) These timings are given for test purposes only, in order to assure recognition at a specific clock edge.

2) Demultiplexed bus is the worst case. For multiplexed bus 2TCL are to be added to the maximum values. This adds even more time for deactivating $\overline{\text{READY}}$.
The 2t_A and t_C refer to the next following bus cycle, t_F refers to the current bus cycle.
The maximum limit for t_{60} must be fulfilled if the next following bus cycle is $\overline{\text{READY}}$ controlled.

Package Outlines (continued)

Plastic Package, P-TQFP-100-1 (SMD)
(Plastic Thin Metric Quad Flat Package)

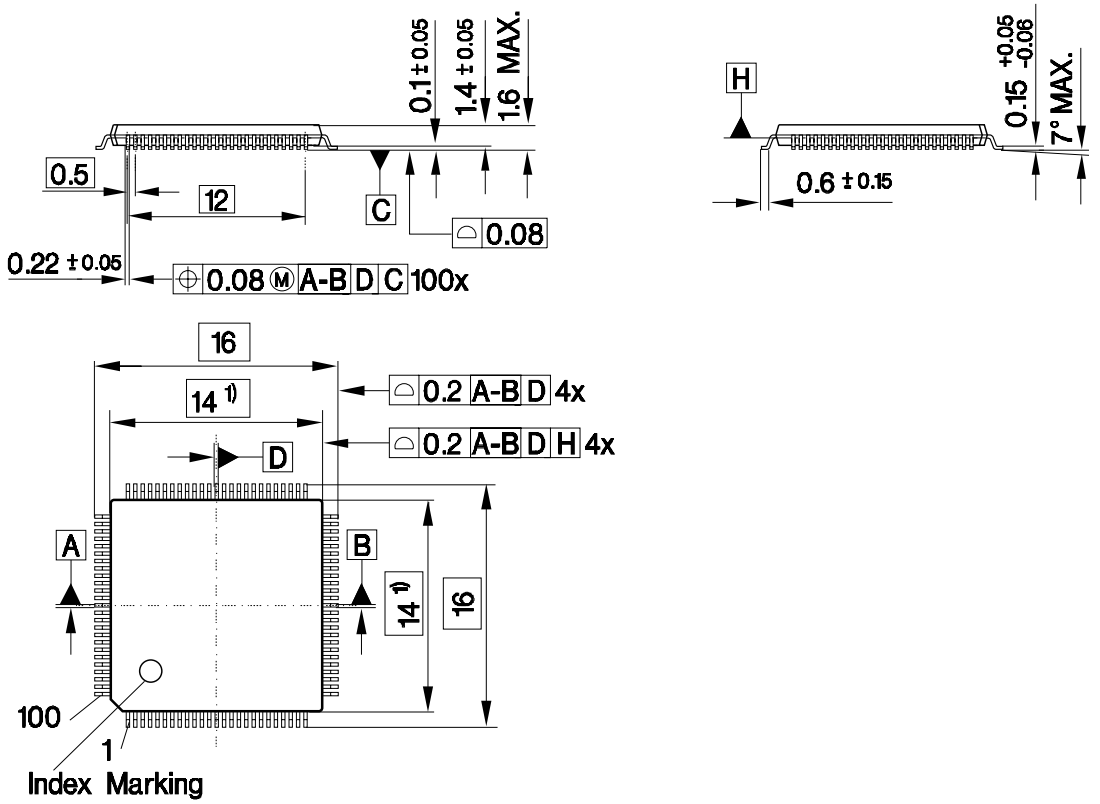

Figure 26

Sorts of Packing

Package outlines for tubes, trays, etc. are contained in our Data Book “Package Information”

SMD = Surface Mounted Device

Dimensions in mm