DATA SHEET

83CE654

CMOS single-chip 8-bit microcontroller with Electromagnetic Compatibility improvements

Preliminary specification

1996 Aug 15

IC20 Data Handbook

Philips
Semiconductors

PHILIPS

CMOS single-chip 8-bit microcontroller with Electromagnetic Compatibility improvements

83CE654

DESCRIPTION

The 83CE654 Single-Chip 8-Bit Microcontroller is manufactured in an advanced CMOS process and is a derivative of the 80C51 microcontroller family. The 83CE654 has the same instruction set as the 80C51. The 83CE654 has 16k bytes mask programmable ROM and 256 bytes RAM.

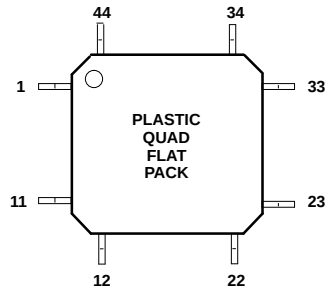
This device provides architectural enhancements that make it applicable in a variety of applications for general control systems. The 83CE654 contains a non-volatile 16k × 8 read-only program memory, a volatile 256 × 8 read/write data memory, four 8-bit I/O ports, two 16-bit timer/event counters (identical to the timers of the 80C51), a multi-source, two-priority-level, nested interrupt structure, an I^2C interface, UART and on-chip oscillator and timing circuits. For systems that require extra capability, the 83CE654 can be expanded using standard TTL compatible memories and logic.

The device also functions as an arithmetic processor having facilities for both binary and BCD arithmetic plus bit-handling capabilities. The instruction set consists of over 100 instructions: 49 one-byte, 45 two-byte and 17 three-byte. With a 16MHz crystal, 58% of the instructions are executed in 0.75µs and 40% in 1.5µs. Multiply and divide instructions require 3µs.

FEATURES

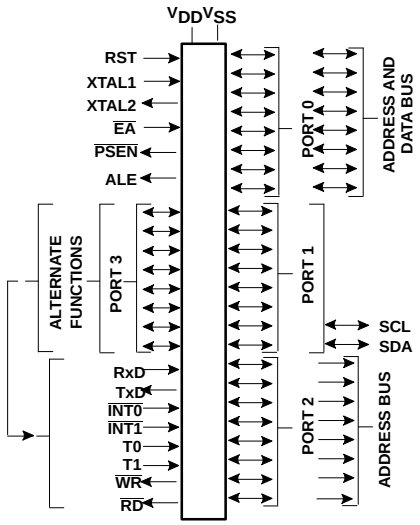
- 80C51 central processing unit
- 16k × 8 ROM expandable externally to 64k bytes
- 256 × 8 RAM, expandable externally to 64k bytes
- Two standard 16-bit timer/counters
- Four 8-bit I/O ports
- I^2C-bus serial I/O port with byte oriented master and slave functions
- Full-duplex UART facilities
- ROM code protection
- XTAL frequency range: 1.2MHz to 16MHz
- Software enable/disable of ALE output pulse
- Electromagnetic compatibility (EMC) improvements
- Operating ambient temperature range:
  - P83CE654 FBB T_{amb} 0°C to +70°C
  - P83CE654 FFB T_{amb} –40°C to +85°C

PIN CONFIGURATION



Pin	Function	Pin	Function
1	P1.5	23	P2.5/A13
2	P1.6/SCL	24	P2.6/A14
3	P1.7/SDA	25	P2.7/A15
4	RST	26	$\overline{PSEN}$
5	P3.0/RxD	27	ALE
6	V_{SS4}	28	V_{SS2}
7	P3.1/TxD	29	$\overline{EA}$
8	P3.2/$\overline{INT0}$	30	P0.7/AD7
9	P3.3/$\overline{INT1}$	31	P0.6/AD6
10	P3.4/T0	32	P0.5/AD5
11	P3.5/T1	33	P0.4/AD4
12	P3.6/$\overline{WR}$	34	P0.3/AD3
13	P3.7/$\overline{RD}$	35	P0.2/AD2
14	XTAL2	36	P0.1/AD1
15	XTAL1	37	P0.0/AD0
16	V_{SS1}	38	V_{DD2}
17	V_{DD1}	39	V_{SS3}
18	P2.0/A8	40	P1.0
19	P2.1/A9	41	P1.1
20	P2.2/A10	42	P1.2
21	P2.3/A11	43	P1.3
22	P2.4/A12	44	P1.4

LOGIC SYMBOL



ORDERING INFORMATION

ROM	TEMPERATURE RANGE °C AND PACKAGE	FREQUENCY MHz	DRAWING NUMBER
P83CE654FBB	0 to +70, Plastic Quad Flat Pack	1.2 to 16	SOT307-2[1]
P83CE654FFB	–40 to +85, Plastic Quad Flat Pack	1.2 to 16	SOT307-2[1]

NOTE:
1. SOT311 replaced by SOT307-2.

ELECTROMAGNETIC COMPATIBILITY (EMC) IMPROVEMENTS

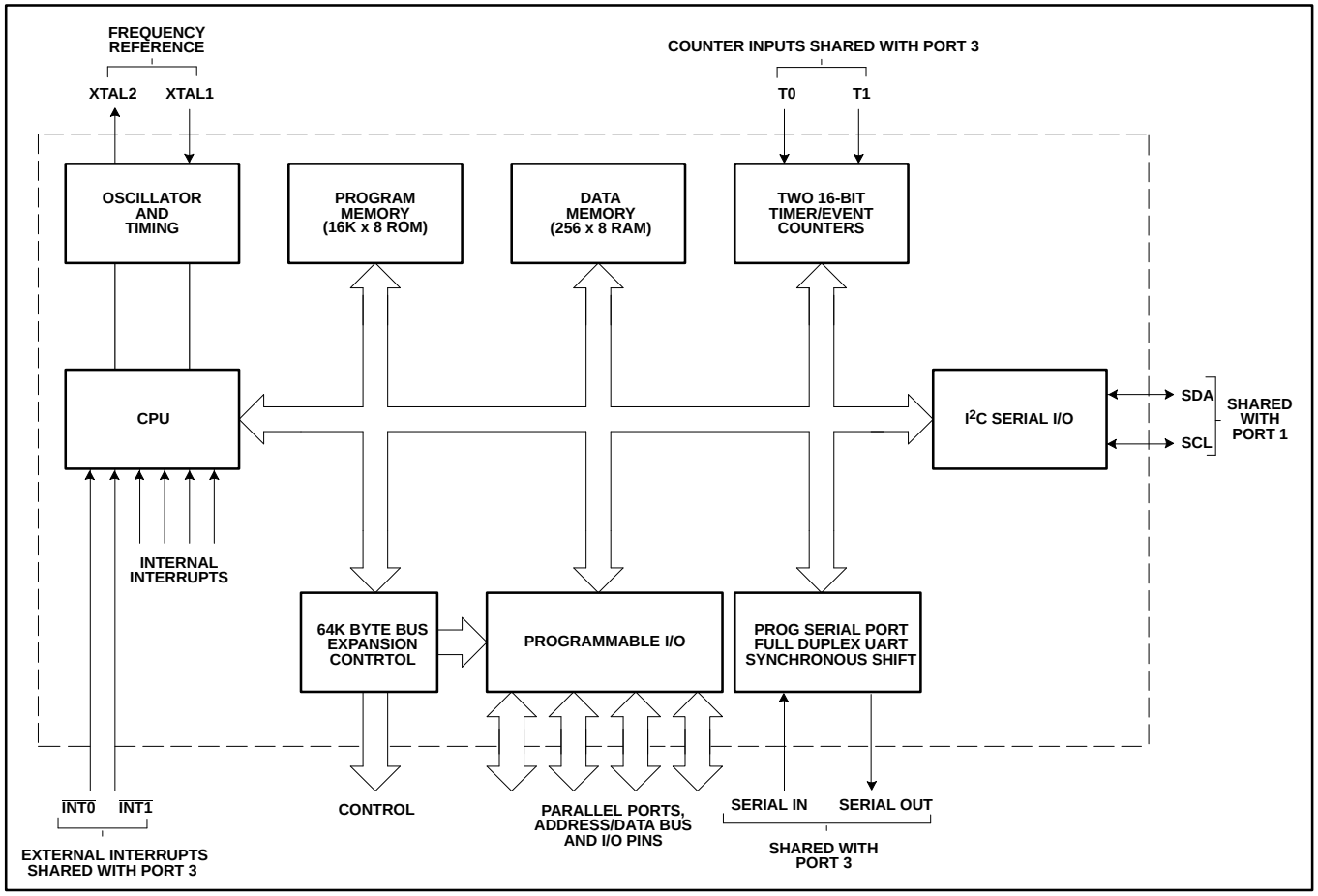
Primary attention is paid on the reduction of electromagnetic emission of the microcontroller P83CE654.

The following features effect in reducing the electromagnetic emission and additionally improve the electromagnetic susceptibility:

- Two supply voltage pins (V_{DD1}, V_{DD2}) and four ground pins (V_{SS1} to V_{SS4})
- Separate V_{DD} pins for the internal logic and the port buffers
- Internal decoupling capacitance improves the EMC radiation behavior and the EMC immunity
- External capacitors are to be located as close as possible between pins V_{DD2} and V_{SS3} as well as V_{DD1} and V_{SS1}; ceramic chip capacitors are recommended (100nF).
- The ALE output signal (pulses at a frequency of $f_{OSC}/6$) can be disabled under software control (bit 5 in the SFR PCON: “RFI”); if disabled, no ALE pulse will occur.

ALE pin will be pulled down internally, switching an external address latch to a quiet state. The MOVX instruction will still toggle ALE as a normal MOVX. ALE will retain its normal high value during Idle mode and a low value during Power-down mode while in the “RFI” reduction mode. Additionally during internal access ($\overline{EA}$ = 1) ALE will toggle normally when the address exceeds the internal program memory size. During external access ($\overline{EA}$ = 0) ALE will always toggle normally, whether the flag “RFI” is set or not.

BLOCK DIAGRAM



PIN DESCRIPTIONS

MNEMONIC	PIN NUMBER	TYPE	NAME AND FUNCTION
V_{SS1}, V_{SS2}, V_{SS3}, V_{SS4}	16, 28, 39, 6	I	**Ground:** 0V reference. All pins must be connected.
V_{DD1}, V_{DD2}	17, 38	I	**Power Supply:** This is the power supply voltage for normal, idle, and power-down operation. Both pins must be connected.
P0.0–0.7	37–30	I/O	**Port 0:** Port 0 is an open-drain, bidirectional I/O port. Port 0 pins that have 1s written to them float and can be used as high-impedance inputs. Port 0 is also the multiplexed low-order address and data bus during accesses to external program and data memory. In this application, it uses strong internal pull-ups when emitting 1s. Port 0 can sink/source 8 LSTTL inputs.
P1.0–P1.7	40–44, 1–3	I/O	**Port 1:** Port 1 is an 8-bit bidirectional I/O port with internal pull-ups, except P1.6 and P1.7 which are open drain. Port 1 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 1 pins that are externally pulled low will source current because of the internal pull-ups. (See DC Electrical Characteristics: I_{IL}). Port 1 also receives the low-order address byte during program memory verification. Alternate functions include:
P1.6	2	I/O	**SCL:** I^2C-bus serial port clock line.
P1.7	3	I/O	**SDA:** I^2C-bus serial port data line.
P2.0–P2.7	18–25	I/O	**Port 2:** Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. Port 2 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 2 pins that are externally being pulled low will source current because of the internal pull-ups. (See DC Electrical Characteristics: I_{IL}). Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @DPTR). In this application, it uses strong internal pull-ups when emitting 1s. During accesses to external data memory that use 8-bit addresses (MOV @Ri), port 2 emits the contents of the P2 special function register.
P3.0–P3.7	5, 7–13	I/O	**Port 3:** Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. Port 3 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 3 pins that are externally being pulled low will source current because of the pull-ups. (See DC Electrical Characteristics: I_{IL}). Port 3 also serves the special features of the 80C51 family, as listed below:
	5	I	**RxD (P3.0):** Serial input port
	7	O	**TxD (P3.1):** Serial output port
	8	I	**$\overline{INT0}$ (P3.2):** External interrupt 0 or gate control input for timer/event counter 0
	9	I	**$\overline{INT1}$ (P3.3):** External interrupt 1 or gate control input for timer/event counter 1
	10	I	**T0 (P3.4):** Timer 0 external input
	11	I	**T1 (P3.5):** Timer 1 external input
	12	O	**$\overline{WR}$ (P3.6):** External data memory write strobe
	13	O	**$\overline{RD}$ (P3.7):** External data memory read strobe
RST	4	I	**Reset:** A high on this pin for two machine cycles while the oscillator is running, resets the device. An internal pull-down resistor to V_{SS} permits a power-on reset using only an external capacitor to V_{DD}.
ALE	27	I/O	**Address Latch Enable:** Output pulse for latching the low byte of the address during an access to external memory. In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency, and can be used for external timing or clocking. Note that one ALE pulse is skipped during each access to external data memory. ALE can sink/source 8 LSTTL inputs. It can drive CMOS inputs without an external pull-up. To prohibit the toggling of ALE pin (RFI noise reduction) the bit RFI in the PCON Register (PCON.5) must be set by software. This bit is cleared on RESET and can be cleared by software. When set, ALE pin will be pulled down internally, switching an external address latch to a quiet state. The MOVX instruction will still toggle ALE as a normal MOVX. ALE will retain its normal high value during Idle mode and a low value during Power-down mode while in the "RFI" mode. Additionally during internal access ($\overline{EA}$ = 1) ALE will toggle normally when the address exceeds the internal program memory size. During external access ($\overline{EA}$ = 0) ALE will always toggle normally, whether the flag "RFI" is set or not.
$\overline{PSEN}$	26	O	**Program Store Enable:** The read strobe to external program memory. When the 83CE654 is executing code from the external program memory, $\overline{PSEN}$ is activated twice each machine cycle, except that two $\overline{PSEN}$ activations are skipped during each access to external data memory. $\overline{PSEN}$ is not activated during fetches from internal program memory. $\overline{PSEN}$ can sink/source 8 LSTTL inputs.
$\overline{EA}$	29	I	**External Access Enable:** when, during RESET, $\overline{EA}$ is held at a TTL HIGH level the CPU executes out of the internal program ROM, provided the program counter is less than 16384. When $\overline{EA}$ is held at a TTL LOW level during RESET, the CPU executes out of external program memory via Port 0 and Port 2. $\overline{EA}$ is not allowed to float.
XTAL1	15	I	**Crystal 1:** Input to the inverting oscillator amplifier and input to the internal clock generator circuits.
XTAL2	14	O	**Crystal 2:** Output from the inverting oscillator amplifier.

NOTE:
To avoid "latch-up" effect at power-on, the voltage on any pin at any time must not be higher or lower than V_{DD} + 0.5V or V_{SS} – 0.5V, respectively.

Table 1. 83CE654 Special Function Registers

SYMBOL	DESCRIPTION	DIRECT ADDRESS	BIT ADDRESS, SYMBOL, OR ALTERNATIVE PORT FUNCTION MSB							LSB	RESET VALUE
ACC*	Accumulator	E0H	E7	E6	E5	E4	E3	E2	E1	E0	00H
B*	B register	F0H	F7	F6	F5	F4	F3	F2	F1	F0	00H
DPTR:	Data pointer (2 bytes)										
DPH	Data pointer high	83H									00H
DPL	Data pointer low	82H									00H
			AF	AE	AD	AC	AB	AA	A9	A8	
IE*#	Interrupt enable	A8H	EA		ES1	ES0	ET1	EX1	ET0	EX0	0x000000B
			BF	BE	BD	BC	BB	BA	B9	B8	
IP*#	Interrupt priority	B8H	–		PS1	PS0	PT1	PX1	PT0	PX0	xx000000B
			87	86	85	84	83	82	81	80	
P0*	Port 0	80H	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0	FFH
			97	96	95	94	93	92	91	90	
P1*#	Port 1	90H	SDA	SCL							FFH
			A7	A6	A5	A4	A3	A2	A1	A0	
P2*	Port 2	A0H	A15	A14	A13	A12	A11	A10	A9	A8	FFH
			B7	B6	B5	B4	B3	B2	B1	B0	
P3*	Port 3	B0H	$\overline{RD}$	$\overline{WR}$	T1	T0	$\overline{INT1}$	$\overline{INT0}$	TXD	RXD	FFH
PCON#	Power control	87H	SMOD	–	RFI	–	GF1	GF0	PD	IDL	0xxx0000B
			9F	9E	9D	9C	9B	9A	99	98	
S0CON*#	Serial 0 port control	98H	SM0	SM1	SM2	REN	TB8	RB8	TI	RI	00H
S0BUF#	Serial 0 data buffer	99H									xxxxxxxxB
			D7	D6	D5	D4	D3	D2	D1	D0	
PSW*	Program status word	D0H	CY	AC	F0	RS1	RS0	OV	F1	P	00H
S1DAT#	Serial 1 data	DAH									00H
SP	Stack pointer	81H									07H
S1ADR#	Serial 1 address	DBH	——————————— SLAVE ADDRESS ———————————							GC	00H
S1STA#	Serial 1 status	D9H	SC4	SC3	SC2	SC1	SC0	0	0	0	F8H
			DF	DE	DD	DC	DB	DA	D9	D8	
S1CON*#	Serial 1 control	D8H	CR2	ENS1	STA	STO	SI	AA	CR1	CR0	00000000B
			8F	8E	8D	8C	8B	8A	89	88	
TCON*	Timer control	88H	TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0	00H
TH1	Timer high 1	8DH									00H
TH0	Timer high 0	8CH									00H
TL1	Timer low 1	8BH									00H
TL0	Timer low 0	8AH									00H
TMOD	Timer mode	89H	GATE	C/$\overline{T}$	M1	M0	GATE	C/$\overline{T}$	M1	M0	00H

* SFRs are bit addressable.
\# SFRs are modified from or added to the 80C51 SFRs.

ROM CODE PROTECTION

The 83CE654 has an additional security feature. ROM code protection may be selected by setting a mask-programmable security bit (i.e., user dependent). This feature may be requested during ROM code submission. When selected, the ROM code is protected and cannot be read out at any time by any test mode or by any instruction in the external program memory space.

The MOVC instructions are the only instructions that have access to program code in the internal or external program memory. The $\overline{EA}$ input is latched during RESET and is "don't care" after RESET (also if the security bit is not set). This implementation prevents reading internal program code by switching from external program memory to internal program memory during a MOVC instruction or any other instruction that uses immediate data.

Table 2 lists the access to the internal and external program memory by the MOVC instructions when the security bit has been set to a logical "1":

OSCILLATOR CHARACTERISTICS

XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier. The pins can be configured for use as an on-chip oscillator, as shown in the Logic Symbol, page 2.

To drive the device from an external clock source, XTAL1 should be driven while XTAL2 is left unconnected. There are no requirements on the duty cycle of the external clock signal, because the input to the internal clock circuitry is through a divide-by-two flip-flop. However, minimum and maximum high and low times specified in the data sheet must be observed.

Reset

A reset is accomplished by holding the RST pin high for at least two machine cycles (24 oscillator periods), while the oscillator is running. To insure a good power-on reset, the RST pin must be high long enough to allow the oscillator time to start up (normally a few milliseconds) plus two machine cycles. At power-on, the voltage on V_{DD} and RST must come up at the same time for a proper start-up.

Power-on Reset (See Figure 1.)

When V_{DD} is turned on, and provided its rise-time does not exceed 10ms, an automatic reset can be obtained by connecting the RST pin to V_{DD} via a 2.2µF capacitor. When the power is switched on, the voltage on the RST pin is equal to V_{DD} minus the capacitor voltage, and decreases from V_{DD} as the capacitor charges through the internal resistor (R_{RST}) to ground. The larger the capacitor, the more slowly V_{RST} decreases. V_{RST} must remain above the lower threshold of the Schmitt trigger long enough to effect a complete reset. The time required is the oscillator start-up time, plus 2 machine cycles.

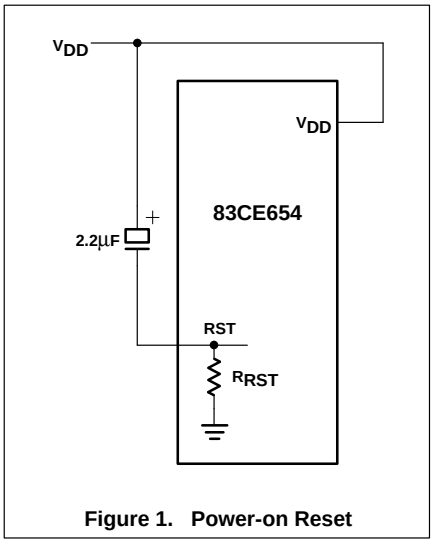


Figure 1. Power-on Reset

Idle Mode

In the idle mode, the CPU puts itself to sleep while all of the on-chip peripherals stay active. The instruction to invoke the idle mode is the last instruction executed in the normal operating mode before the idle mode is activated. The CPU contents, the on-chip RAM, and all of the special function registers remain intact during this mode. The idle mode can be terminated either by any enabled interrupt (at which time the process is picked up at the interrupt service routine and continued), or by a hardware reset which starts the processor in the same manner as a power-on reset.

Power-Down Mode

In the power-down mode, the oscillator is stopped and the instruction to invoke power-down is the last instruction executed. Only the contents of the on-chip RAM are preserved. A hardware reset is the only way to terminate the power-down mode. the control bits for the reduced power modes are in the special function register PCON. Table 3 shows the state of the I/O ports during low current operating modes.

Power Control Register PCON

These special modes are activated by software via the Special Function Register PCON. Its hardware address is 87H. PCON is not bit addressable. The reset value of PCON is (0x0x0000).

	7	6	5	4	3	2	1	0
PCON (87H)	SMOD	–	RFI	–	GF1	GF0	PD	IDL

Bit	Symbol	Function
PCON.7	SMOD	Double Baud rate bit. When set to logic 1 the baud rate is doubled when Timer 1 is used to generate baud rate, and the Serial Port is used in modes 1, 2 or 3.
PCON.6	–	(reserved for future use*)
PCON.5	RFI	When set to logic 1 the toggling of ALE pin is prohibited. This bit is cleared on RESET.
PCON.4	–	(reserved for future use*)
PCON.3	GF1	General purpose flag bit.
PCON.2	GF0	General purpose flag bit.
PCON.1	PD	Power-down bit. Setting this bit activates Power-down mode.
PCON.0	IDL	Idle mode bit. Setting this bit activates the Idle mode. If 1s are written to PD and IDL at the same time, PD takes precedence.

NOTE:

* User software should not write 1s to reserved bits. These bits may be used in future 80C51 family products to invoke new features. In that case, the reset or inactive value of the new bit will be 0, and its active value will be 1. The value read from a reserved bit is indeterminate.

I^2C Serial Communication—SIO1

The I^2C serial port is identical to the I^2C serial port on the 8XC552. The operation of this subsystem is described in detail in the 8XC552 section of this manual.

Note that in both the 83CE654 and the 8XC552 the I^2C pins are alternate functions to port pins P1.6 and P1.7. Because of this, P1.6 and P1.7 on these parts do not have a pull-up structure as found on the 80C51. Therefore P1.6 and P1.7 have open drain outputs on the 83CE654.

Table 2.

	ACCESS TO INTERNAL PROGRAM MEMORY	ACCESS TO EXTERNAL PROGRAM MEMORY
MOVC in internal program memory	YES	YES
MOVC in external program memory	NO	YES

NOTE:
If the security bit has been set to a logical 0, there are no restrictions for the MOVC instructions.

Table 3. External Pin Status During Idle and Power-Down Mode

MODE	PROGRAM MEMORY	ALE	$\overline{PSEN}$	PORT 0	PORT 1	PORT 2	PORT 3
Idle	Internal	1	1	Data	Data	Data	Data
Idle	External	1	1	Float	Data	Address	Data
Power-down	Internal	0	0	Data	Data	Data	Data
Power-down	External	0	0	Float	Data	Data	Data

Serial Control Register (S1CON) – See Table 4

S1CON (D8H)	CR2	ENS1	STA	STO	SI	AA	CR1	CR0

Bits CR0, CR1 and CR2 determine the serial clock frequency that is generated in the master mode of operation.

Table 4. Serial Clock Rates

CR2	CR1	CR0	BIT FREQUENCY (kHz) AT f_{OSC}			
			6MHz	12MHz	16MHz	f_{OSC} DIVIDED BY
0	0	0	23	47	63	256
0	0	1	27	54	71	224
0	1	0	31	63	83	192
0	1	1	37	75	100	160
1	0	0	6.25	12.5	17	960
1	0	1	50	100	133[1]	120
1	1	0	100	200[1]	267[1]	60
1	1	1	0.24 < 62.5 0 < 255	0.49 < 62.5 0 < 254	0.65 < 55.6 0 < 253	96 × (256 – (reload value Timer 1)) reload value range Timer 1 (in mode 2)

NOTES:
1. These frequencies exceed the upper limit of 100kHz of the I^2C-bus specification and cannot be used in an I^2C-bus application.

ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Voltage on V_{DD} to V_{SS}	–0.5 to +6.5	V
Voltage on any pin to V_{SS}	–0.5 to V_{DD}+0.5	V
Storage temperature range	–65 to +150	°C
Power dissipation (based on package heat transfer limitations, not device power consumption)[1]	1	W
Operating ambient temperature range		
FBB	0 to +70	°C
FFB	–40 to +85	°C

NOTE:

1. Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. this is a stress rating only and functional operation of the device at these or any conditions other than those described in the AC and DC Electrical Characteristics section of this specification is not implied. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.

DEVICE SPECIFICATIONS

TYPE	SUPPLY VOLTAGE (V)		FREQUENCY (MHz)		TEMPERATURE RANGE (°C)
	MIN.	MAX.	MIN.	MAX.	
P83CE654FBB	4.5	5.5	1.2	16	0 to +70
P83CE654FFB	4.5	5.5	1.2	16	–40 to +85

DC ELECTRICAL CHARACTERISTICS

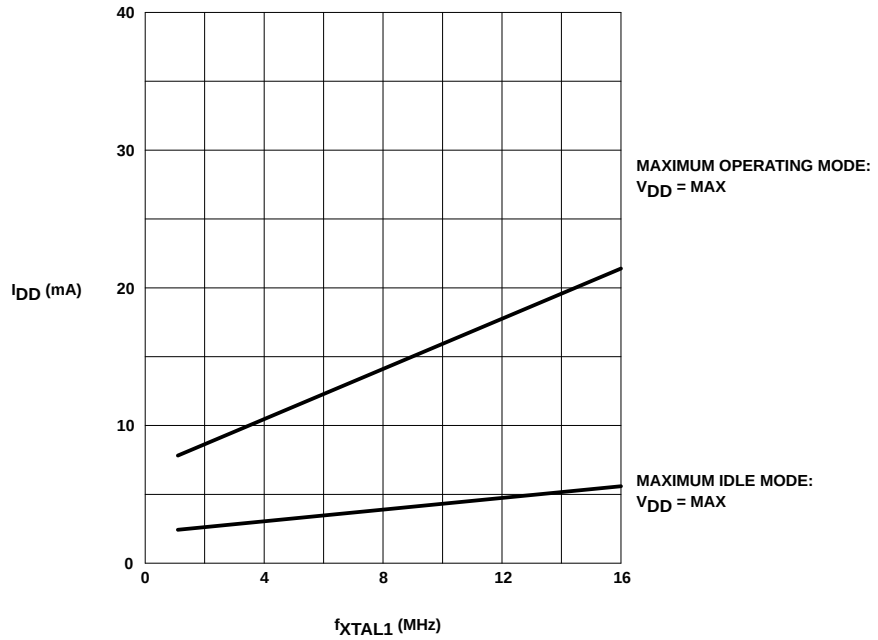
V_{DD} = 5V (±10%), V_{SS} = 0V, T_{amb} = 0°C to +70°C or –40°C to +85°C

SYMBOL	PARAMETER	PART TYPE	TEST CONDITIONS	LIMITS MIN.	LIMITS MAX.	UNIT
V_{IL}	Input low voltage, except $\overline{EA}$, P1.6/SCL, P1.7/SDA	0 to +70°C –40 to +85°C		–0.5 –0.5	$0.2V_{DD}$–0.1 $0.2V_{DD}$–0.15	V V
V_{IL1}	Input low voltage to $\overline{EA}$	0 to +70°C –40 to +85°C		–0.5 –0.5	$0.2V_{DD}$–0.3 $0.2V_{DD}$–0.35	V V
V_{IL2}	Input low voltage to P1.6/SCL, P1.7/SDA[6]			–0.5	$0.3V_{DD}$	V
V_{IH}	Input high voltage, except XTAL1, RST, P1.6/SCL, P1.7/SDA	0 to +70°C –40 to +85°C		$0.2V_{DD}$+0.9 $0.2V_{DD}$+1.0	V_{DD}+0.5 V_{DD}+0.5	V V
V_{IH1}	Input high voltage, XTAL1, RST	0 to +70°C –40 to +85°C		$0.7V_{DD}$ $0.7V_{DD}$+0.1	V_{DD}+0.5 V_{DD}+0.5	V V
V_{IH2}	Input high voltage, P1.6/SCL, P1.7/SDA[6]			$0.7V_{DD}$	6.0	V
V_{OL}	Output low voltage, ports 1, 2, 3, except P1.6/SCL, P1.7/SDA[4], ALE, $\overline{PSEN}$		I_{OL} = 1.6mA[7]		0.45	V
V_{OL1}	Output low voltage, port 0, ALE, $\overline{PSEN}$[4]		I_{OL} = 3.2mA[7]		0.45	V
V_{OL2}	Output low voltage, P1.6/SCL, P1.7/SDA[4]		I_{OL} = 3.0mA[7]		0.4	V
V_{OH}	Output high voltage, ports 1, 2, 3, except P1.6, P1.7, ALE, $\overline{PSEN}$		I_{OH} = –60µA; V_{DD} = 5V (± 10%) I_{OH} = –25µA I_{OH} = –10µA	2.4 $0.75V_{DD}$ $0.9V_{DD}$		V V V
V_{OH1}	Output high voltage; port 0 in external bus mode[5]		I_{OH} = –800µA; V_{DD} = 5V (± 10%) I_{OH} = –300µA I_{OH} = –80µA	2.4 $0.75V_{DD}$ $0.9V_{DD}$		V V V
I_{IL}	Logical 0 input current, ports 1, 2, 3, except P1.6/SCL, P1.7/SDA	0 to +70°C –40 to +85°C	V_i = 0.45V V_i = 0.45V		–50 –75	µA µA
I_{TL}	Logical 1-to-0 transition current, ports 1, 2, 3, except P1.6/SCL, P1.7/SDA	0 to +70°C –40 to +85°C	V_i = 2.0V V_i = 2.0V		–650 –750	µA µA
I_{LI1}	Input leakage current, port 0, $\overline{EA}$		0.45V < V_i < V_{DD}		±10	µA
I_{LI2}	Input leakage current, P1.6/SCL, P1.7/SDA		0V < V_i < 5.5V 0V < V_{DD} < 5.5V		±10	µA
I_{DD}	Power supply current: Active mode @ 16MHz[1, 8] Idle mode @ 16MHz[2, 8] Power down mode[3]		 V_{DD} = 5.5V V_{DD} = 5V ± 10% @2V < V_{PD} < V_{DDMAX}		 22 6 50	 mA mA µA
R_{RST}	Internal reset pull-down resistor			50	150	kΩ
C_{IO}	Pin capacitance of I/O buffer		Freq.=1MHz; T_{amb} = 25°C		10	pF

NOTES: See Next Page.

NOTES FOR DC ELECTRICAL CHARACTERISTICS:

1. The operating supply current is measured with all output pins disconnected; XTAL1 driven with $t_r = t_f = 5ns$; $V_{IL} = V_{SS} + 0.5V$; $V_{IH} = V_{DD} - 0.5V$; XTAL2 not connected; $\overline{EA}$ = RST = Port 0 = P1.6 = P1.7 = V_{DD}.
2. The idle mode supply current is measured with all output pins disconnected; XTAL1 driven with $t_r = t_f = 5ns$; $V_{IL} = V_{SS} + 0.5V$; $V_{IH} = V_{DD} - 0.5V$; XTAL2 not connected; Port 0 = P1.6 = P1.7 = V_{DD}; $\overline{EA}$ = RST = V_{SS}.
3. The power-down current is measured with all output pins disconnected; XTAL2 not connected; Port 0 = P1.6 = P1.7 = V_{DD}; $\overline{EA}$ = XTAL1 = RST = V_{SS}.
4. Capacitive loading on ports 0 and 2 may cause spurious noise to be superimposed on the V_{OL}s of ALE and ports 1 and 3. The noise is due to external bus capacitance discharging into the port 0 and port 2 pins when these pins make 1-to-0 transitions during bus operations. In the worst cases (capacitive loading > 100pF), the noise pulse on the ALE pin may exceed 0.8V. In such cases, it may be desirable to qualify ALE with a Schmitt Trigger, or use an address latch with a Schmitt Trigger STROBE input.
5. Capacitive loading on ports 0 and 2 may cause the V_{OH} on ALE and $\overline{PSEN}$ to momentarily fall below the $0.9V_{DD}$ specification when the address bits are stabilizing.
6. The input threshold voltage of P1.6 and P1.7 (SIO1) meets the I^2C specification, so an input voltage below $0.3V_{DD}$ will be recognized as a logic 0 while an input voltage above $0.7V_{DD}$ will be recognized as a logic 1.
7. Under steady state (non-transient) conditions, I_{OL} must be externally limited as follows: Maximum I_{OL} = 10mA per port pin; Maximum I_{OL} = 26mA total for Port 0; Maximum I_{OL} = 15mA total for Ports 1, 2, and 3; Maximum I_{OL} = 71mA total for all output pins. If I_{OL} exceeds the test conditions, V_{OL} may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test conditions.
8. I_{DDMAX} for the 80/83CE654 at the other frequencies can be derived from Figure 2, where FREQ is the external oscillator frequency in MHz. I_{DDMAX} is given in mA.



VALID ONLY WITHIN FREQUENCY SPECIFICATIONS OF DEVICE UNDER TEST.

Figure 2. I_{DD} vs. Frequency

AC ELECTRICAL CHARACTERISTICS[1, 2]

SYMBOL	FIGURE	PARAMETER	16MHz CLOCK		VARIABLE CLOCK		UNIT
			MIN	MAX	MIN	MAX	
$1/t_{CLCL}$	3	Oscillator frequency			1.2	16	MHz
t_{LHLL}	3	ALE pulse width	85		$2t_{CLCL}-40$		ns
t_{AVLL}	3	Address valid to ALE low	8		$t_{CLCL}-55$		ns
t_{LLAX}	3	Address hold after ALE low	28		$t_{CLCL}-35$		ns
t_{LLIV}	3	ALE low to valid instruction in		150		$4t_{CLCL}-100$	ns
t_{LLPL}	3	ALE low to $\overline{PSEN}$ low	23		$t_{CLCL}-40$		ns
t_{PLPH}	3	$\overline{PSEN}$ pulse width	143		$3t_{CLCL}-45$		ns
t_{PLIV}	3	$\overline{PSEN}$ low to valid instruction in		83		$3t_{CLCL}-105$	ns
t_{PXIX}	3	Input instruction hold after $\overline{PSEN}$	0		0		ns
t_{PXIZ}	3	Input instruction float after $\overline{PSEN}$		38		$t_{CLCL}-25$	ns
t_{AVIV}	3	Address to valid instruction in		208		$5t_{CLCL}-105$	ns
t_{PLAZ}	3	$\overline{PSEN}$ low to address float		10		10	ns
Data Memory							
t_{AVLL}	4, 5	Address valid to ALE low	8		$t_{CLCL}-55$		ns
t_{RLRH}	4, 5	$\overline{RD}$ pulse width	275		$6t_{CLCL}-100$		ns
t_{WLWH}	4, 5	$\overline{WR}$ pulse width	275		$6t_{CLCL}-100$		ns
t_{RLDV}	4, 5	$\overline{RD}$ low to valid data in		148		$5t_{CLCL}-165$	ns
t_{RHDX}	4, 5	Data hold after $\overline{RD}$	0		0		ns
t_{RHDZ}	4, 5	Data float after $\overline{RD}$		55		$2t_{CLCL}-70$	ns
t_{LLDV}	4, 5	ALE low to valid data in		350		$8t_{CLCL}-150$	ns
t_{AVDV}	4, 5	Address to valid data in		398		$9t_{CLCL}-165$	ns
t_{LLWL}	4, 5	ALE low to $\overline{RD}$ or $\overline{WR}$ low	138	238	$3t_{CLCL}-50$	$3t_{CLCL}+50$	ns
t_{AVWL}	4, 5	Address valid to $\overline{WR}$ low or $\overline{RD}$ low	120		$4t_{CLCL}-130$		ns
t_{QVWX}	4, 5	Data valid to $\overline{WR}$ transition	3		$t_{CLCL}-60$		ns
t_{DW}	4, 5	Data setup time before $\overline{WR}$	288		$7t_{CLCL}-150$		ns
t_{WHQX}	4, 5	Data hold after $\overline{WR}$	13		$t_{CLCL}-50$		ns
t_{RLAZ}	4, 5	$\overline{RD}$ low to address float		0		0	ns
t_{WHLH}	4, 5	$\overline{RD}$ or $\overline{WR}$ high to ALE high	23	103	$t_{CLCL}-40$	$t_{CLCL}+40$	ns
Shift Register[3]							
t_{XLXL}	6	Serial port clock cycle time	0.75		$12t_{CLCL}$		µs
t_{QVXH}	6	Output data setup to clock rising edge	492		$10t_{CLCL}-133$		ns
t_{XHQX}	6	Output data hold after clock rising edge	80		$2t_{CLCL}-117$		ns
t_{XHDX}	6	Input data hold after clock rising edge	0		0		ns
t_{XHDV}	6	Clock rising edge to input data valid		492		$10t_{CLCL}-133$	ns
External Clock							
t_{CHCX}	7	High time	20		20	$t_{CLCL} - t_{LOW}$	ns
t_{CLCX}	7	Low time	20		20	$t_{CLCL} - t_{HIGH}$	ns
t_{CLCH}	7	Rise time		20		20	ns
t_{CHCL}	7	Fall time		20		20	ns

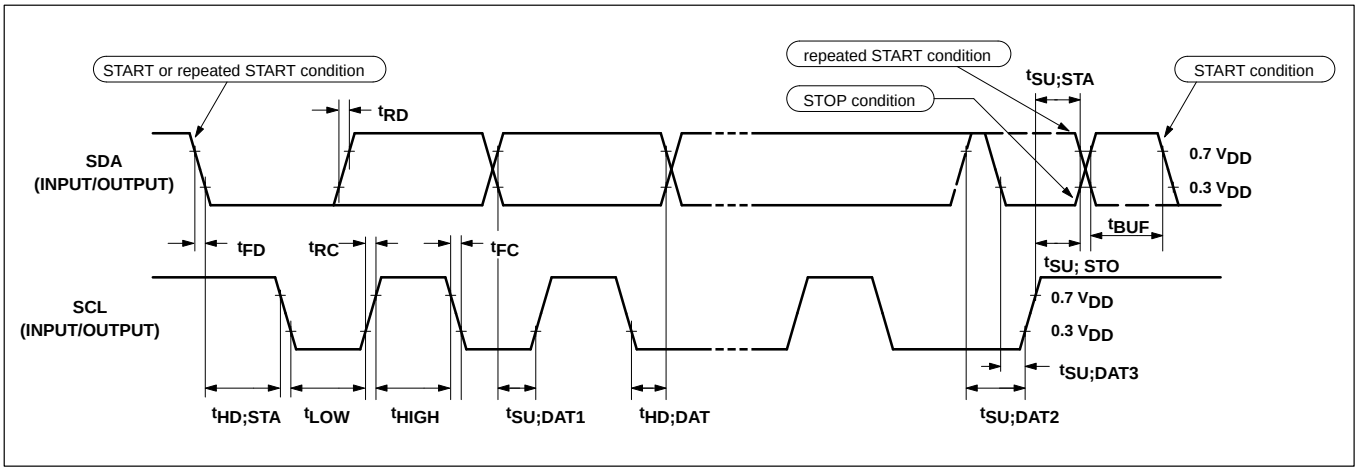
NOTES:
1. Parameters are valid over operating temperature range unless otherwise specified.
2. Load capacitance for port 0, ALE, and $\overline{PSEN}$ = 100pF, load capacitance for all other outputs = 80pF.
3. Test condition: T_{amb} = 0°C to +70C; V_{DD} = 5V + 10%; V_{SS} = 0V; load capacitance = 80pF.

AC ELECTRICAL CHARACTERISTICS – I²C INTERFACE

SYMBOL	PARAMETER	INPUT	OUTPUT
SCL TIMING CHARACTERISTICS			
$t_{HD;STA}$	START condition hold time	≥ 14 t_{CLCL}	> 4.0µs[1]
t_{LOW}	SCL LOW time	≥ 16 t_{CLCL}	> 4.7µs[1]
t_{HIGH}	SCL HIGH time	≥ 14 t_{CLCL}	> 4.0µs[1]
t_{RC}	SCL rise time	≤ 1µs	– [2]
t_{FC}	SCL fall time	≤ 0.3µs	< 0.3µs[3]
SDA TIMING CHARACTERISTICS			
$t_{SU;DAT1}$	Data set-up time	≥ 250ns	> 20 t_{CLCL} – t_{RD}
$t_{SU;DAT2}$	SDA set-up time (before rep. START cond.)	≥ 250ns	> 1µs[1]
$t_{SU;DAT3}$	SDA set-up time (before STOP cond.)	≥ 250ns	> 8 t_{CLCL}
$t_{HD;DAT}$	Data hold time	≥ 0ns	> 8 t_{CLCL} – t_{FC}
$t_{SU;STA}$	Repeated START set-up time	≥ 14 t_{CLCL}	> 4.7µs[1]
$t_{SU;STO}$	STOP condition set-up time	≥ 14 t_{CLCL}	> 4.0µs[1]
t_{BUF}	Bus free time	≥ 14 t_{CLCL}	> 4.7µs[1]
t_{RD}	SDA rise time	≤ 1µs	– [2]
t_{FD}	SDA fall time	≤ 0.3µs	< 0.3µs[3]

NOTES:
1. At 100 kbit/s. At other bit rates this value is inversely proportional to the bit-rate of 100 kbit/s.
2. Determined by the external bus-line capacitance and the external bus-line pull-resistor, this must be < 1µs.
3. Spikes on the SDA and SCL lines with a duration of less than 3 t_{CLCL} will be filtered out. Maximum capacitance on bus-lines SDA and SCL = 400pF.
4. $t_{CLCL} = 1/f_{OSC}$ = one oscillator clock period at pin XTAL1. For 62ns < t_{CLCL} < 285ns (16MHz > f_{OSC} > 3.5MHz) the SIO1 interface meets the I²C-bus specification for bit-rates up to 100 kbit/s.

TIMING SIO1 (I²C) INTERFACE



Oscillator Circuitry

The capacitors connected to the crystal should be: C1 = C2 = 20pF.

EXPLANATION OF THE AC SYMBOLS

Each timing symbol has five characters. The first character is always 't' (= time). The other characters, depending on their positions, indicate the name of a signal or the logical status of that signal. The designations are:

A – Address
C – Clock
D – Input data
H – Logic level high
I – Instruction (program memory contents)
L – Logic level low, or ALE
P – $\overline{PSEN}$
Q – Output data
R – $\overline{RD}$ signal
t – Time
V – Valid
W – $\overline{WR}$ signal
X – No longer a valid logic level
Z – Float

Examples: t_{AVLL} = Time for address valid to ALE low.
t_{LLPL} = Time for ALE low to $\overline{PSEN}$ low.

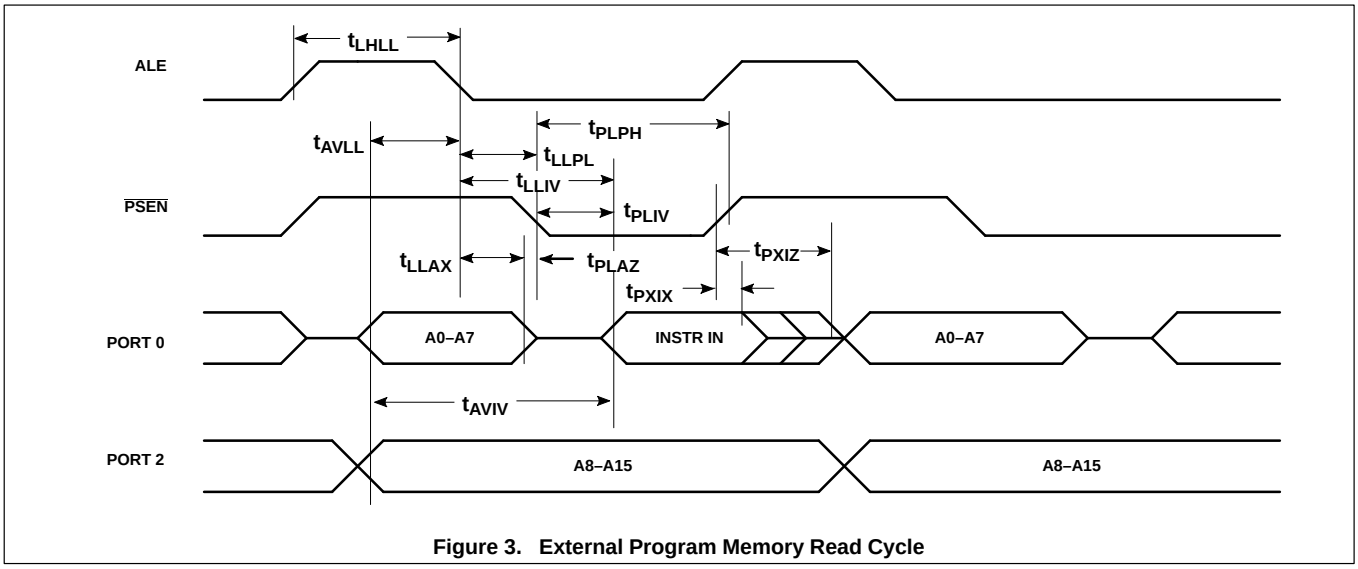


Figure 3. External Program Memory Read Cycle

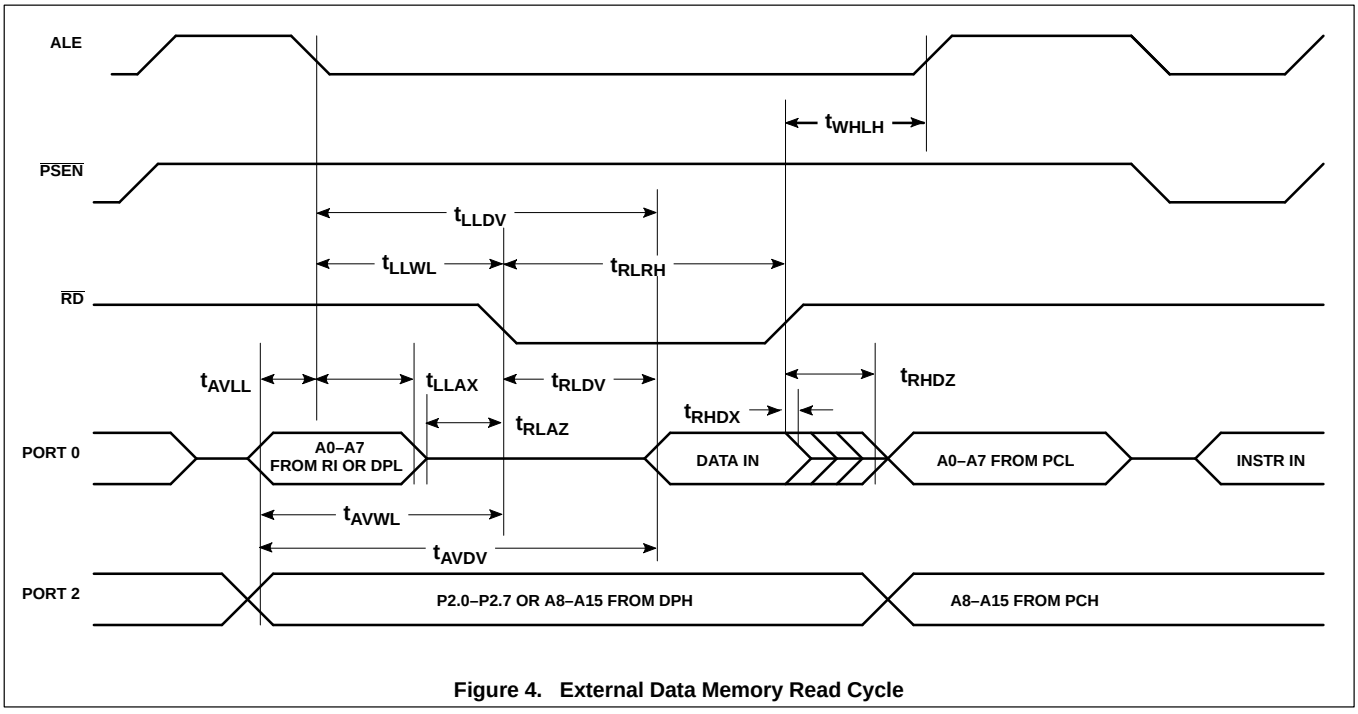


Figure 4. External Data Memory Read Cycle

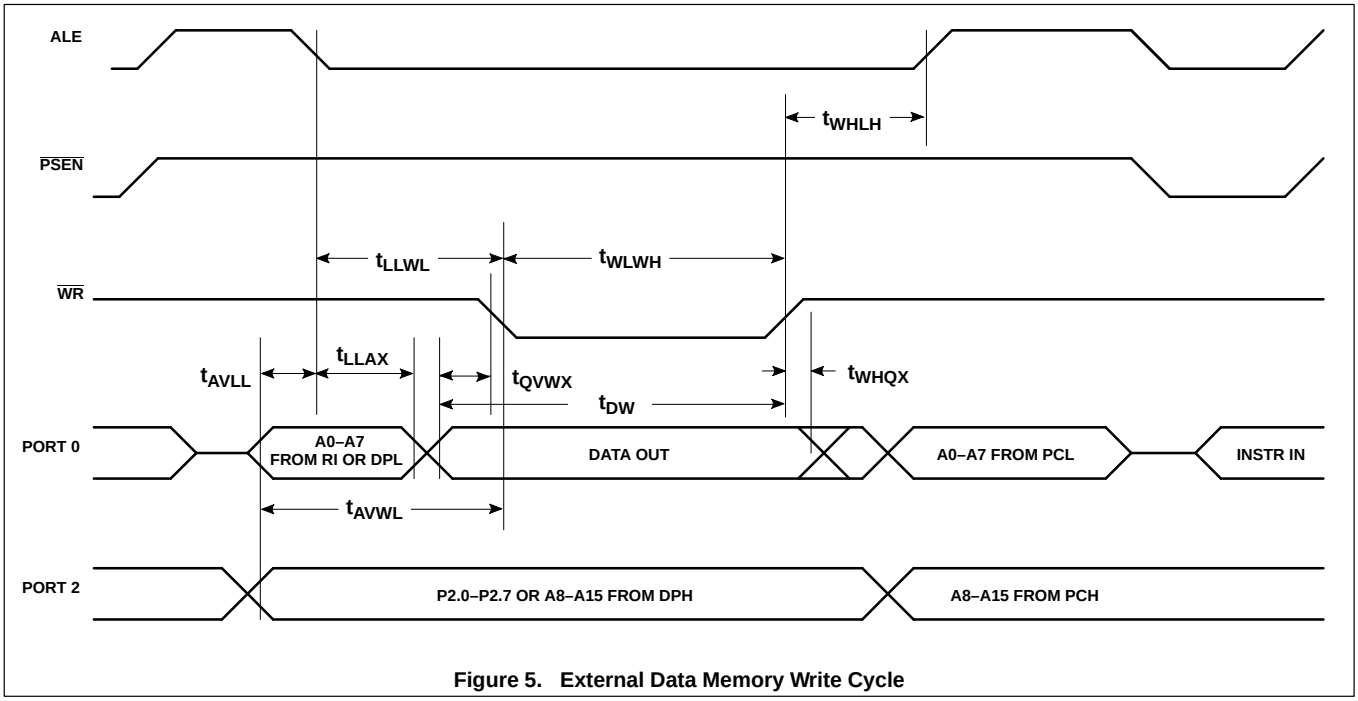


Figure 5. External Data Memory Write Cycle

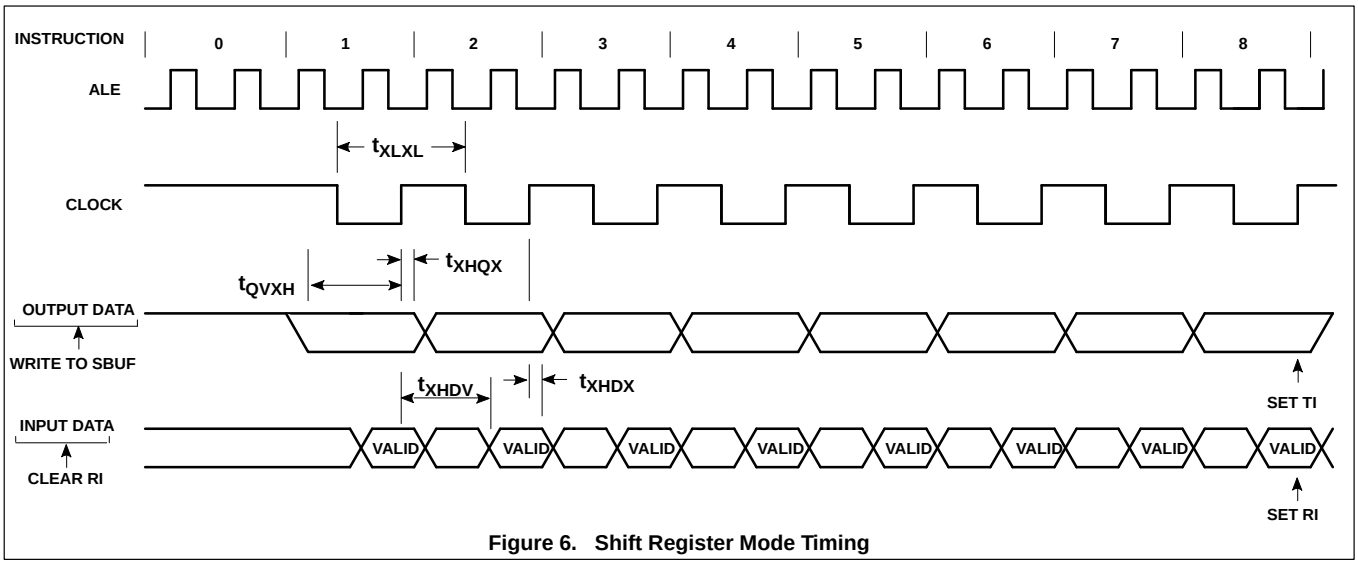


Figure 6. Shift Register Mode Timing

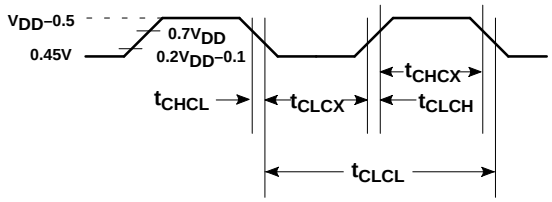
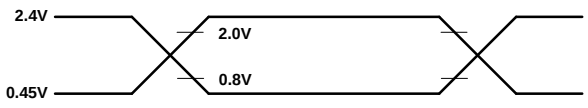
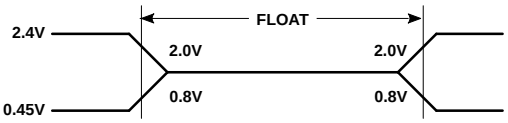


Figure 7. External Clock Drive



NOTE:
AC INPUTS DURING TESTING ARE DRIVEN AT 2.4V FOR A LOGIC '1' AND 0.45V FOR A LOGIC '0'. TIMING MEASUREMENTS ARE MADE AT 2.0V FOR A LOGIC '1' AND 0.8V FOR A LOGIC '0'.

Figure 8. AC Testing Input/Output



NOTE:
THE FLOAT STATE IS DEFINED AS THE POINT AT WHICH A PORT 0 PIN SINKS 3.2MA OR SOURCES 400µS AT THE VOLTAGE TEST LEVELS.

Figure 9. Float Waveform

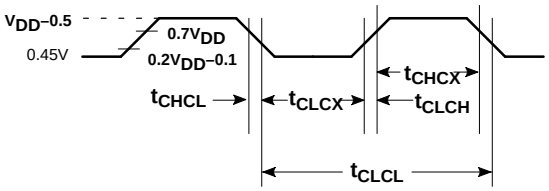
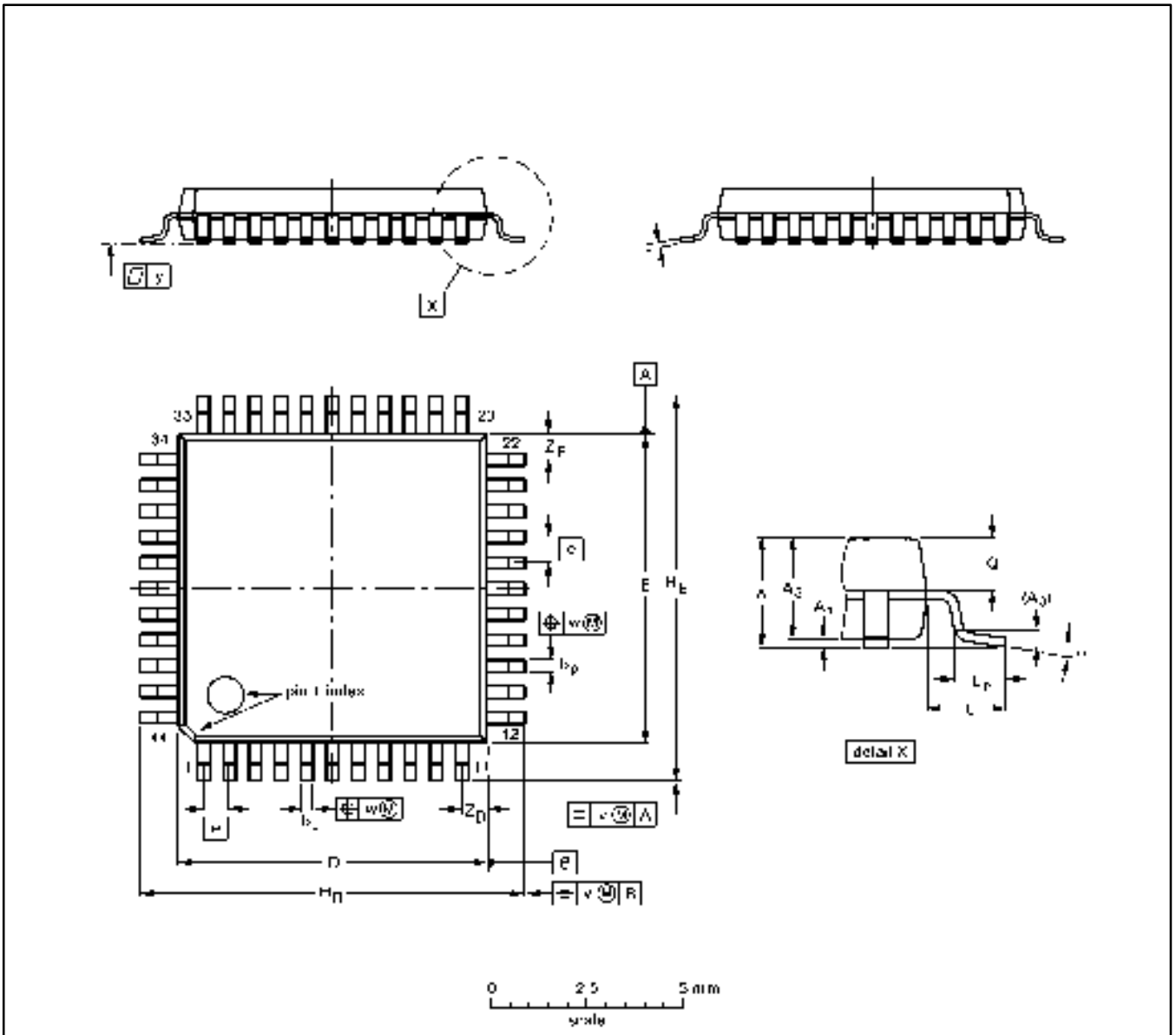


Figure 10. Clock Signal Waveform for I_{DD} Tests in Active and Idle Modes
$t_{CLCH} = t_{CHCL} = 5ns$

Purchase of Philips I²C components conveys a license under the Philips' I²C patent to use the components in the I²C system provided the system conforms to the I²C specifications defined by Philips. This specification can be ordered using the code 9398 393 40011.

QFP44: plastic quad flat package; 44 leads (lead length 1.3 mm); body 10 x 10 x 1.75 mm SOT307-2



DIMENSIONS (mm are the original dimensions)

UNIT	A max	A_1	A_2	A_3	b_p	c	D[1]	E[1]	e	H_D	H_E	L	L_p	Q	v	w	y	Z_D[1]	Z_E[1]	θ
mm	2.10	0.25 0.05	1.85 1.65	0.25	0.40 0.20	0.25 0.14	10.1 9.9	10.1 9.9	0.8	12.9 12.5	12.9 12.3	1.3	0.95 0.55	0.85 0.75	0.15	0.13	0.1	1.2 0.9	1.2 0.9	10° 0°

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included

OUTLINE VERSION	REFERENCES			EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ		
SOT307-2					92-11-17 95-02-04

CMOS single-chip 8-bit microcontroller with Electromagnetic Compatibility improvements

83CE654

DEFINITIONS

Data Sheet Identification	Product Status	Definition
Objective Specification	**Formative or in Design**	This data sheet contains the design target or goal specifications for product development. Specifications may change in any manner without notice.
Preliminary Specification	**Preproduction Product**	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Product Specification	**Full Production**	This data sheet contains Final Specifications. Philips Semiconductors reserves the right to make changes at any time without notice, in order to improve design and supply the best possible product.

Philips Semiconductors
811 East Arques Avenue
P.O. Box 3409
Sunnyvale, California 94088–3409
Telephone 800-234-7381

Let's make things better.

Philips Semiconductors

PHILIPS