DATA SHEET

87C654
CMOS single-chip 8-bit microcontroller

Product specification

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IC20 Data Handbook

Philips
Semiconductors

PHILIPS

# CMOS single-chip 8-bit microcontroller 87C654

DESCRIPTION

The 87C654 Single-Chip 8-Bit Microcontroller is manufactured in an advanced CMOS process and is a derivative of the 80C51 microcontroller family. The 87C654 has the same instruction set as the 80C51. Two versions of the derivative exist:

83C654—16k bytes mask programmable ROM

87C654—EPROM version

This device provides architectural enhancements that make it applicable in a variety of applications for general control systems. The 87C654 contains a non-volatile $16k \times 8$ EPROM, 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 I2C interface, UART and on-chip oscillator and timing circuits. For systems that require extra capability, the 87C654 can be expanded using standard TTL compatible memories and logic.
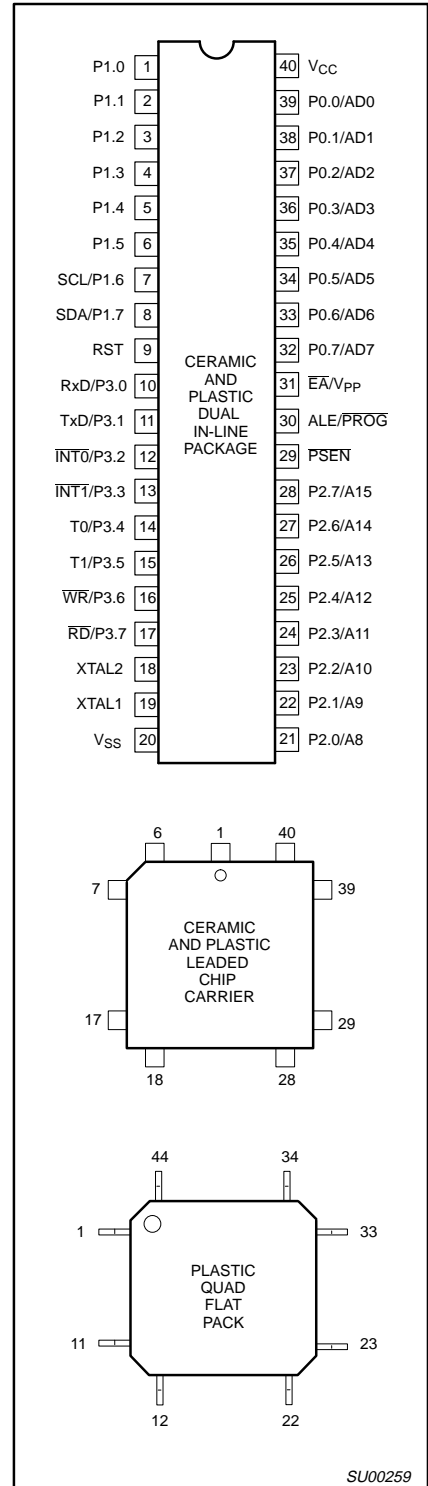
The device also functions as an arithmetic processor having facilities for both binary and BCD arithmetic plus bit-handling capabilities. The instruction set consists of over 100 instructions: 49 one-byte, 45 two-byte and 17 three-byte. With a 16MHz crystal, 58% of the instructions are executed in 0.75µs and 40% in 1.5µs. Multiply and divide instructions require 3µs.
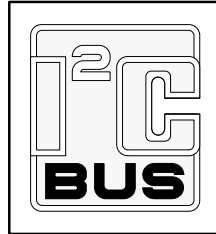
FEATURES

- 80C51 central processing unit
- $16k \times 8$ EPROM 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
- I2C-bus serial I/O port with byte oriented master and slave functions
- Full-duplex UART facilities
- Power control modes
  - Idle mode
  - Power-down mode
- Five package styles
- Extended temperature range
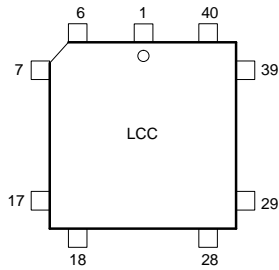- OTP package available
- Two speed ranges
  - 16MHz
  - 20MHz

PIN CONFIGURATIONS

CERAMIC AND PLASTIC DUAL IN-LINE PACKAGE

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

CERAMIC AND PLASTIC LEADED CHIP CARRIER

PLASTIC QUAD FLAT PACK

SU00259

CERAMIC AND PLASTIC LEADED CHIP CARRIER PIN FUNCTIONS

Pin	Function	Pin	Function
1	NC*	23	NC8
2	P1.0	24	P2.0/A8
3	P1.1	25	P2.1/A9
4	P1.2	26	P2.2/A10
5	P1.3	27	P2.3/A11
6	P1.4	28	P2.4/A12
7	P1.5	29	P2.5/A13
8	P1.6/SCL	30	P2.6/A14
9	P1.7/SDA	31	P2.7/A15
10	RST	32	$\overline{PSEN}$
11	P3.0/RxD	33	ALE/$\overline{PROG}$
12	NC8	34	NC8
13	P3.1/TxD	35	$\overline{EA}$/V_{PP}
14	P3.2/$\overline{INT0}$	36	P0.7/AD7
15	P3.3/$\overline{INT1}$	37	P0.6/AD6
16	P3.4/T0	38	P0.5/AD5
17	P3.5/T1	39	P0.4/AD4
18	P3.6/$\overline{WR}$	40	P0.3/AD3
19	P3.7/$\overline{RD}$	41	P0.2/AD2
20	XTAL2	42	P0.1/AD1
21	XTAL1	43	P0.0/AD0
22	V_{SS}	44	V_{CC}

* DO NOT CONNECT   SU00260

PLASTIC QUAD FLAT PACK PIN FUNCTIONS
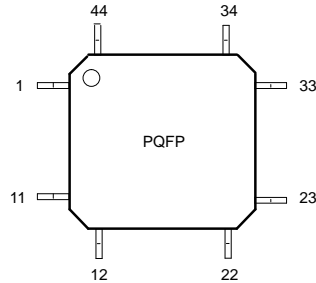
Pin	Function	Pin	Function
1	P1.5	23	P2.5/A13
2	P1.6/SCL	24	P2.6/A14
3	P1.7/SDA	25	P2.7/A15
4	RST	26	$\overline{PSEN}$
5	P3.0/RxD	27	ALE/$\overline{PROG}$
6	NC*	28	NC*
7	P3.1/TxD	29	$\overline{EA}$/V_{PP}
8	P3.2/$\overline{INT0}$	30	P0.7/AD7
9	P3.3/$\overline{INT1}$	31	P0.6/AD6
10	P3.4/T0	32	P0.5/AD5
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_{SS}	38	V_{CC}
17	NC*	39	NC*
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	P.13
22	P2.4/A12	44	P1.4

* DO NOT CONNECT   SU00261

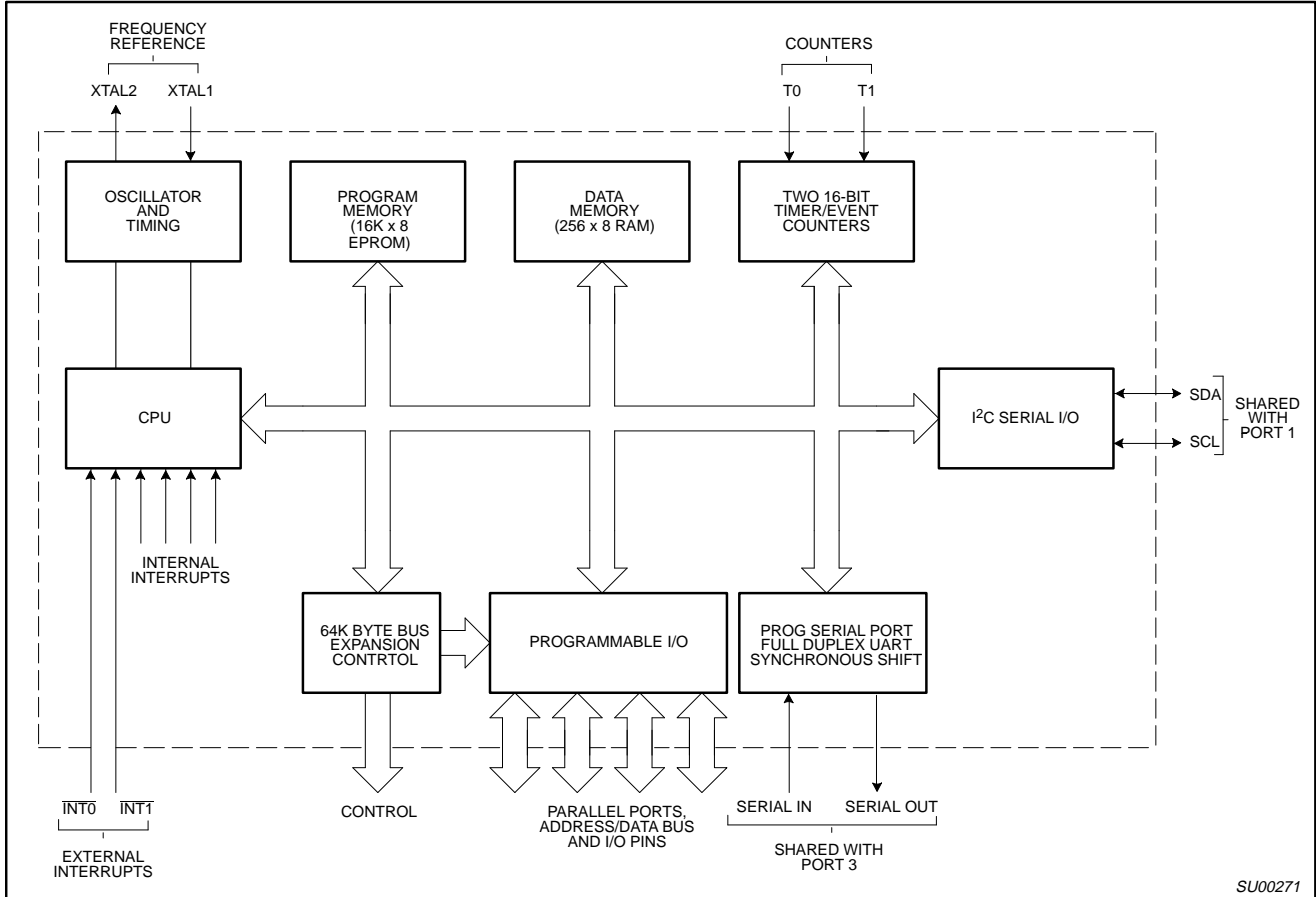## LOGIC SYMBOL

SU00262

CMOS single-chip 8-bit microcontroller

87C654

ORDERING INFORMATION

PHILIPS PART ORDER NUMBER PART MARKING		PHILIPS NORTH AMERICA PART ORDER NUMBER			TEMPERATURE RANGE °C	
ROMless	ROM	ROMless	ROM	Drawing Number	AND PACKAGE	FREQ MHz
P80C652FBP	P83C654FBP/xxx	S80C652FBPN	S83C654FBPN	SOT129-1	0 to +70, Plastic Dual In-line Package	16
					0 to +70, Ceramic Dual In-line Package w/Window	16
P80C652FBA	P83C654FBA/xxx	S80C652FBAA	S83C654FBAA	SOT187-2	0 to +70, Plastic Leaded Chip Carrier	16
P80C652FBB	P83C654FBB/xxx	S80C652FBBB	S83C654FBBB	SOT307-2[4]	0 to +70, Plastic Quad Flat Pack	16
P80C652FFP	P83C654FFP/xxx	S80C652FFPN	S83C654FFPN	SOT129-1	−40 to +85, Plastic Dual In-line Package	16
P80C652FFA	P83C654FFA/xxx	S80C652FFAA	S83C654FFAA	SOT187-2	−40 to +85, Plastic Leaded Chip Carrier	16
P80C652FFB	P83C654FFB/xxx	S80C652FFBB	S83C654FFBB	SOT307-2[4]	−40 to +85, Plastic Quad Flat Pack	16
P80C652FHP	P83C654FHP/xxx	S80C652FHPN	S83C654FHPN	SOT129-1	−40 to +125, Plastic Dual In-line Package	16
P80C652FHA	P83C654FHA/xxx	S80C652FHAA	S83C654FHAA	SOT187-2	−40 to +125, Plastic Leaded Chip Carrier	16
P80C652FHB	P83C654FHB/xxx	S80C652FHBB	S83C654FHBB	SOT307-2[4]	−40 to +125, Plastic Quad Flat Pack	16
P80C652IBP	P83C654IBP/xxx	S80C652IBPN	S83C654IBPN	SOT129-1	0 to +70, Plastic Dual In-line Package	24
P80C652IBA	P83C654IBA/xxx	S80C652IBAA	S83C654IBAA	SOT187-2	0 to +70, Plastic Leaded Chip Carrier	24
P80C652IBB	P83C654IBB/xxx	S80C652IBBB	S83C654IBBB	SOT307-2[4]	0 to +70, Plastic Quad Flat Pack	24
P80C652IFP	P83C654IFP/xxx	S80C652IFPN	S83C654IFPN	SOT129-1	−40 to +85, Plastic Dual In-line Package	24
P80C652IFA	P83C654IFA/xxx	S80C652IFAA	S83C654IFAA	SOT187-2	−40 to +85, Plastic Leaded Chip Carrier	24
P80C652IFB	P83C654IFB/xxx	S80C652IFBB	S83C654IFBB	SOT307-2[4]	−40 to +85, Plastic Quad Flat Pack	24

NOTES:
1. For full specification, see the 87C652 data sheet.
2. 87C654 frequency range is 3.5MHz – 16MHz or 3.5MHz – 24MHz.
3. xxx denotes the ROM code number.
4. SOT311 replaced by SOT307-2.

EPROM	Drawing Number	TEMPERATURE RANGE °C AND PACKAGE	FREQ MHz
S87C654-4N40	SOT129-1	0 to +70, Plastic Dual In-line Package	16
S87C654-4F40	0590B	0 to +70, Ceramic Dual In-line Package w/Window	16
S87C654-4A44	SOT187-2	0 to +70, Plastic Leaded Chip Carrier	16
S87C654-4K44	1472A	0 to +70, Ceramic Leaded Chip Carrier w/Window	16
S87C654–4B44	SOT307-2	0 to +70, Plastic Quad Flat Pack	16
S87C654-5N40	SOT129-1	−40 to +85, Plastic Dual In-line Package	16
S87C654-5F40	0590B	−40 to +85, Ceramic Dual In-line Package w/Window	16
S87C654-5A44	SOT187-2	−40 to +85, Plastic Leaded Chip Carrier	16
S87C654-5B44	SOT307-2	−40 to +85, Plastic Quad Flat Pack	16
S87C654–7N40	SOT129-1	0 to +70, Plastic Dual In-line Package	20
S87C654–7F40	0590B	0 to +70, Ceramic Dual In-line Package w/Window	20
S87C654–7A44	SOT187-2	0 to +70, Plastic Leaded Chip Carrier	20
S87C654–7K44	1472A	0 to +70, Ceramic Leaded Chip Carrier w/Window	20
S87C654–8N40	SOT129-1	−40 to +85, Plastic Dual In-line Package	20
S87C654–8F40	0590B	−40 to +85, Ceramic Dual In-line Package w/Window	20
S87C654–8A44	SOT187-2	−40 to +85, Plastic Leaded Chip Carrier	20

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BLOCK DIAGRAM

SU00271

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PIN DESCRIPTIONS

MNEMONIC	PIN NUMBER			TYPE	NAME AND FUNCTION
	DIP	LCC	QFP		
V_{SS}	20	22	16	I	**Ground:** 0V reference.
V_{CC}	40	44	38	I	**Power Supply:** This is the power supply voltage for normal, idle, and power-down operation.
P0.0–0.7	39–32	43–36	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 also outputs the code bytes during program verification in the 87C654. External pull-ups are required during program verification.
P1.0–P1.7	1–8	2–9	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	7	8	2	I/O	**SCL:** I^{2}C-bus serial port clock line.
P1.7	8	9	3	I/O	**SDA:** I^{2}C-bus serial port data line.
P2.0–P2.7	21–28	24–31	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	10–17	11, 13–19	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:
	10	11	5	I	**RxD (P3.0):** Serial input port
	11	13	7	O	**TxD (P3.1):** Serial output port
	12	14	8	I	$\overline{INT0}$ **(P3.2):** External interrupt
	13	15	9	I	$\overline{INT1}$ **(P3.3):** External interrupt
	14	16	10	I	**T0 (P3.4):** Timer 0 external input
	15	17	11	I	**T1 (P3.5):** Timer 1 external input
	16	18	12	O	$\overline{WR}$ **(P3.6):** External data memory write strobe
	17	19	13	O	$\overline{RD}$ **(P3.7):** External data memory read strobe
RST	9	10	4	I	**Reset:** A high on this pin for two machine cycles while the oscillator is running, resets the device. An internal diffused resistor to V_{SS} permits a power-on reset using only an external capacitor to V_{CC}.
ALE/$\overline{PROG}$	30	33	27	I/O	**Address Latch Enable/Program Pulse:** 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. This pin is also the program pulse input ($\overline{PROG}$) during EPROM programming.
$\overline{PSEN}$	29	32	26	O	**Program Store Enable:** The read strobe to external program memory. When the 87C654 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.
$\overline{EA}$/V_{PP}	31	35	29	I	**External Access Enable/Programming Supply Voltage:** $\overline{EA}$ must be externally held low to enable the device to fetch code from external program memory locations 0000H and 3FFFH. If $\overline{EA}$ is held high, the device executes from internal program memory unless the program counter contains an address greater than 3FFFH. This pin also receives the 12.75V programming supply voltage (V_{PP}) during EPROM programming.
XTAL1	19	21	15	I	**Crystal 1:** Input to the inverting oscillator amplifier and input to the internal clock generator circuits.
XTAL2	18	20	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 than V_{CC} + 0.5V or V_{SS} – 0.5V, respectively.

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Table 1.   8XC652/654 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	–	–	–	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.

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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.

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_{CC} and RST must come up at the same time for a proper start-up.

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 2 shows the state of the I/O ports during low current operating modes.

I^{2}C SERIAL COMMUNICATION—SIO1

The I^{2}C serial port is identical to the I^{2}C 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 8XC652/4 and the 8XC552 the I^{2}C 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 8XC652/4.

Table 2. 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 3

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 3. Serial Clock Rates

CR2	CR1	CR0	BIT FREQUENCY (kHz) AT f_{OSC}				f_{OSC} DIVIDED BY
			6MHz	12MHz	16MHz	20MHz	
0	0	0	23	47	62.5	78	256
0	0	1	27	54	71	89[1]	224
0	1	0	31.25	62.5	83.3	104[1]	192
0	1	1	37	75	100	125[1]	160
1	0	0	6.25	12.5	17	21	960
1	0	1	50	100	133[1]	166[1]	120
1	1	0	100	200[1]	267[1]	334[1]	60
1	1	1	0.25 < 62.5 0 to 255	0.5 < 62.5 0 to 254	0.65 < 55.6 0 to 253	0.81 < 69.4 0 to 253	96 × (256 – (reload value Timer 1)) (Reload value range: 0 – 254 in mode 2)

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

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ABSOLUTE MAXIMUM RATINGS[1, 2, 3]

PARAMETER	RATING	UNIT
Storage temperature range	−65 to +150	°C
Voltage on $\overline{EA}$/V_{PP} to V_{SS}	−0.5 to + 13	V
Voltage on any other pin to V_{SS}	−0.5 to + 6.5	V
Input, output current on any single pin	±5	mA
Power dissipation (based on package heat transfer limitations, not device power consumption)	1	W

NOTES:
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.
2. This product includes circuitry specifically designed for the protection of its internal devices from the damaging effects of excessive static charge. Nonetheless, it is suggested that conventional precautions be taken to avoid applying greater than the rated maxima.
3. Parameters are valid over operating temperature range unless otherwise specified. All voltages are with respect to V_{SS} unless otherwise noted.

DEVICE SPECIFICATIONS

TYPE	SUPPLY VOLTAGE (V)		FREQUENCY (MHz)		TEMPERATURE RANGE
	MIN.	MAX.	MIN.	MAX.	(°C)
S87C654–4	4.5	5.5	3.5	16	0 to +70
S87C654–5	4.5	5.5	3.5	16	−40 to +85
S87C654–7	4.5	5.5	3.5	20	0 to +70
S87C654–8	4.5	5.5	3.5	20	−40 to +85

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DC ELECTRICAL CHARACTERISTICS

$V_{SS} = 0V$

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	$0.2V_{CC}-0.1$ $0.2V_{CC}-0.15$	V V
V_{IL1}	Input low voltage to $\overline{EA}$	0 to +70°C −40 to +85°C		−0.5 −0.5	$0.2V_{CC}-0.3$ $0.2V_{CC}-0.35$	V V
V_{IL2}	Input low voltage to P1.6/SCL, P1.7/SDA[1]			−0.5	$0.3V_{CC}$	V
V_{IH}	Input high voltage, except XTAL1, RST, P1.6/SCL, P1.7/SDA	0 to +70°C −40 to +85°C		$0.2V_{CC}+0.9$ $0.2V_{CC}+1.0$	$V_{CC}+0.5$ $V_{CC}+0.5$	V V
V_{IH1}	Input high voltage, XTAL1, RST	0 to +70°C −40 to +85°C		$0.7V_{CC}$ $0.7V_{CC}+0.1$	$V_{CC}+0.5$ $V_{CC}+0.5$	V V
V_{IH2}	Input high voltage, P1.6/SCL, P1.7/SDA[1]			$0.7V_{CC}$	6.0	V
V_{OL}	Output low voltage, ports 1, 2, 3, except P1.6/SCL, P1.7/SDA		$I_{OL} = 1.6mA$[2,3]		0.45	V
V_{OL1}	Output low voltage, port 0, ALE, $\overline{PSEN}$		$I_{OL} = 3.2mA$[2,3]		0.45	V
V_{OL2}	Output low voltage, P1.6/SCL, P1.7/SDA		$I_{OL} = 3.0mA$		0.4	V
V_{OH}	Output high voltage, ports 1, 2, 3	0 to +70°C −40 to +85°C	$I_{OH} = -60\mu A$ $I_{OH} = -25\mu A$	2.4 $0.75V_{CC}$		V V
V_{OH1}	Output high voltage; port 0 in external bus mode, ALE, $\overline{PSEN}$, RST[4]	0 to +70°C −40 to +85°C	$I_{OH} = -400\mu A$ $I_{OH} = -150\mu A$	2.4 $0.75V_{CC}$		V V
I_{IL}	Logical 0 input current, ports 1, 2, 3, 4, except P1.6/SCL, P1.7/SDA	0 to +70°C −40 to +85°C	$V_{IN} = 0.45V$		−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	See note 5		−650 −750	μA μA
I_{L1}	Input leakage current, port 0		$0.45V < V_I < V_{CC}$		±10	μA
I_{L2}	Input leakage current, P1.6/SCL, P1.7/SDA		$0V < V_I < 6.0V$ $0V < V_{CC} < 6.0V$		±10	μA μA
I_{CC}	Power supply current: Active mode @ 16MHz[7] Idle mode @ 16MHz[8] Power down mode[9,10] Power down mode[9,10]	 0 to +70°C −40 to +85°C	See note 6 $V_{CC}=6.0V$		 25 6 50 135	 mA mA μA μA
R_{RST}	Internal reset pull-down resistor			50	150	kΩ
C_{IO}	Pin capacitance		Freq.=1MHz		10	pF

NOTES: See Next Page.

NOTES FOR DC ELECTRICAL CHARACTERISTICS:

1. The input threshold voltage of P1.6 and P1.7 (SIO1) meets the I^2C specification, so an input voltage below $0.3V_{CC}$ will be recognized as a logic 0 while an input voltage above $0.7V_{CC}$ will be recognized as a logic 1.
2. 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. I_{OL} can exceed these conditions provided that no single output sinks more than 5mA and no more than two outputs exceed the test conditions.
3. 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.
4. Capacitive loading on ports 0 and 2 may cause the V_{OH} on ALE and $\overline{PSEN}$ to momentarily fall below the $0.9V_{CC}$ specification when the address bits are stabilizing.
5. Pins of ports 1 , 2, and 3 source a transition current when they are being externally driven from 1 to 0. The transition current reaches its maximum value when V_{IN} is approximately 2V.
6. See Figures 9 through 11 for I_{CC} test conditions.
7. The operating supply current is measured with all output pins disconnected; XTAL1 driven with t_r = t_f = 10ns; V_{IL} = V_{SS} + 0.5V; V_{IH} = V_{CC} −0.5V; XTAL2 not connected; $\overline{EA}$ = RST = Port 0 = P1.6 = P1.7 = V_{CC}; f_{CLK} = 16MHz. See Figure 9.
8. The idle mode supply current is measured with all output pins disconnected; XTAL1 driven with t_r = t_f = 10ns; V_{IL} = V_{SS} + 0.5V; V_{IH} = V_{CC} −0.5V; XTAL2 not connected; Port 0 = P1.6 = P1.7 = V_{CC}; $\overline{EA}$ = RST = V_{SS}; f_{CLK} = 16MHz. See Figure 10.
9. The power-down current is measured with all output pins disconnected; XTAL2 not connected; Port 0 = P1.6 = P1.7 = V_{CC}; $\overline{EA}$ = RST = V_{SS}. See Figure 11.
10. $2V \leq V_{PD} \leq V_{CC}$max.

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AC ELECTRICAL CHARACTERISTICS[1, 2]

SYMBOL	FIGURE	PARAMETER	16MHz CLOCK		VARIABLE CLOCK		UNIT
			MIN	MAX	MIN	MAX	
$1/t_{CLCL}$	2	Oscillator frequency **Speed Versions** 87C654 −4, −5			3.5	16	MHz
t_{LHLL}	2	ALE pulse width	85		$2t_{CLCL}-40$		ns
t_{AVLL}	2	Address valid to ALE low	8		$t_{CLCL}-55$		ns
t_{LLAX}	2	Address hold after ALE low	28		$t_{CLCL}-35$		ns
t_{LLIV}	2	ALE low to valid instruction in		150		$4t_{CLCL}-100$	ns
t_{LLPL}	2	ALE low to $\overline{PSEN}$ low	23		$t_{CLCL}-40$		ns
t_{PLPH}	2	$\overline{PSEN}$ pulse width	143		$3t_{CLCL}-45$		ns
t_{PLIV}	2	$\overline{PSEN}$ low to valid instruction in		83		$3t_{CLCL}-105$	ns
t_{PXIX}	2	Input instruction hold after $\overline{PSEN}$	0		0		ns
t_{PXIZ}	2	Input instruction float after $\overline{PSEN}$		38		$t_{CLCL}-25$	ns
t_{AVIV}	2	Address to valid instruction in		208		$5t_{CLCL}-105$	ns
t_{PLAZ}	2	$\overline{PSEN}$ low to address float		10		10	ns
Data Memory							
t_{AVLL}	3, 4	Address valid to ALE low	28		$t_{CLCL}-35$		ns
t_{RLRH}	3, 4	$\overline{RD}$ pulse width	275		$6t_{CLCL}-100$		ns
t_{WLWH}	3, 4	$\overline{WR}$ pulse width	275		$6t_{CLCL}-100$		ns
t_{RLDV}	3, 4	$\overline{RD}$ low to valid data in		148		$5t_{CLCL}-165$	ns
t_{RHDX}	3, 4	Data hold after $\overline{RD}$	0		0		ns
t_{RHDZ}	3, 4	Data float after $\overline{RD}$		55		$2t_{CLCL}-70$	ns
t_{LLDV}	3, 4	ALE low to valid data in		350		$8t_{CLCL}-150$	ns
t_{AVDV}	3, 4	Address to valid data in		398		$9t_{CLCL}-165$	ns
t_{LLWL}	3, 4	ALE low to $\overline{RD}$ or $\overline{WR}$ low	138	238	$3t_{CLCL}-50$	$3t_{CLCL}+50$	ns
t_{AVWL}	3, 4	Address valid to $\overline{WR}$ low or $\overline{RD}$ low	120		$4t_{CLCL}-130$		ns
t_{QVWX}	3, 4	Data valid to $\overline{WR}$ transition	3		$t_{CLCL}-60$		ns
t_{DW}	3, 4	Data setup time before $\overline{WR}$	288		$7t_{CLCL}-150$		ns
t_{WHQX}	3, 4	Data hold after $\overline{WR}$	13		$t_{CLCL}-50$		ns
t_{RLAZ}	3, 4	$\overline{RD}$ low to address float		0		0	ns
t_{WHLH}	3, 4	$\overline{RD}$ or $\overline{WR}$ high to ALE high	23	103	$t_{CLCL}-40$	$t_{CLCL}+40$	ns
Shift Register							
t_{XLXL}	5	Serial port clock cycle time[3]	0.75		$12t_{CLCL}$		μs
t_{QVXH}	5	Output data setup to clock rising edge[3]	492		$10t_{CLCL}-133$		ns
t_{XHQX}	5	Output data hold after clock rising edge[3]	80		$2t_{CLCL}-117$		ns
t_{XHDX}	5	Input data hold after clock rising edge[3]	0		0		ns
t_{XHDV}	5	Clock rising edge to input data valid[3]		492		$10t_{CLCL}-133$	ns
External Clock							
t_{CHCX}	6	High time[3]	20		20	$t_{CLCL} - t_{LOW}$	ns
t_{CLCX}	6	Low time[3]	20		20	$t_{CLCL} - t_{HIGH}$	ns
t_{CLCH}	6	Rise time[3]		20		20	ns
t_{CHCL}	6	Fall time[3]		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. These values are characterized but not 100% production tested.
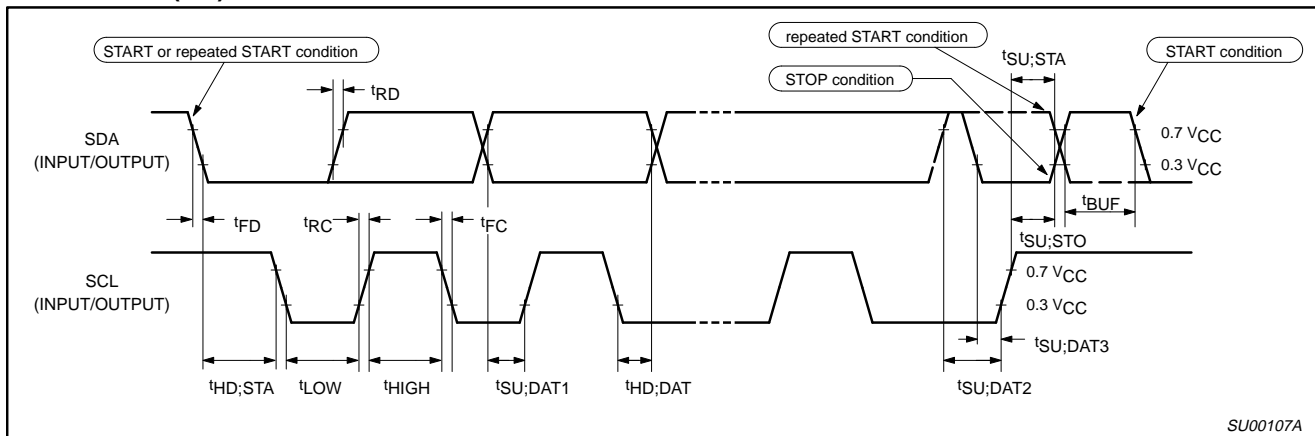
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AC ELECTRICAL CHARACTERISTICS[1, 2]

SYMBOL	FIGURE	PARAMETER	20MHz CLOCK		VARIABLE CLOCK		UNIT
			MIN	MAX	MIN	MAX	
$1/t_{CLCL}$	2	Oscillator frequency: **Speed Versions** **87C654** **−7, −8**			3.5	20	MHz
t_{LHLL}	2	ALE pulse width	60		$2t_{CLCL}{-}40$		ns
t_{AVLL}	2	Address valid to ALE low	25		$t_{CLCL}{-}25$		ns
t_{LLAX}	2	Address hold after ALE low	25		$t_{CLCL}{-}25$		ns
t_{LLIV}	2	ALE low to valid instruction in		135		$4t_{CLCL}{-}65$	ns
t_{LLPL}	2	ALE low to $\overline{PSEN}$ low	25		$t_{CLCL}{-}25$		ns
t_{PLPH}	2	$\overline{PSEN}$ pulse width	105		$3t_{CLCL}{-}45$		ns
t_{PLIV}	2	$\overline{PSEN}$ low to valid instruction in		90		$3t_{CLCL}{-}60$	ns
t_{PXIX}	2	Input instruction hold after $\overline{PSEN}$	0		0		ns
t_{PXIZ}	2	Input instruction float after $\overline{PSEN}$		25		$t_{CLCL}{-}25$	ns
t_{AVIV}	2	Address to valid instruction in		170		$5t_{CLCL}{-}80$	ns
t_{PLAZ}	2	$\overline{PSEN}$ low to address float		10		10	ns
Data Memory							
t_{AVLL}	3, 4	Address valid to ALE low	25		$t_{CLCL}{-}25$		ns
t_{RLRH}	3, 4	$\overline{RD}$ pulse width	200		$6t_{CLCL}{-}100$		ns
t_{WLWH}	3, 4	$\overline{WR}$ pulse width	200		$6t_{CLCL}{-}100$		ns
t_{RLDV}	3, 4	$\overline{RD}$ low to valid data in		160		$5t_{CLCL}{-}90$	ns
t_{RHDX}	3, 4	Data hold after $\overline{RD}$	0		0		ns
t_{RHDZ}	3, 4	Data float after $\overline{RD}$		72		$2t_{CLCL}{-}28$	ns
t_{LLDV}	3, 4	ALE low to valid data in		250		$8t_{CLCL}{-}150$	ns
t_{AVDV}	3, 4	Address to valid data in		285		$9t_{CLCL}{-}165$	ns
t_{LLWL}	3, 4	ALE low to $\overline{RD}$ or $\overline{WR}$ low	100	200	$3t_{CLCL}{-}50$	$3t_{CLCL}{+}50$	ns
t_{AVWL}	3, 4	Address valid to $\overline{WR}$ low or $\overline{RD}$ low	125		$4t_{CLCL}{-}75$		ns
t_{QVWX}	3, 4	Data valid to $\overline{WR}$ transition	20		$t_{CLCL}{-}30$		ns
t_{DW}	3, 4	Data setup time before $\overline{WR}$	220		$7t_{CLCL}{-}130$		ns
t_{WHQX}	3, 4	Data hold after $\overline{WR}$	25		$t_{CLCL}{-}25$		ns
t_{RLAZ}	3, 4	$\overline{RD}$ low to address float		0		0	ns
t_{WHLH}	3, 4	$\overline{RD}$ or $\overline{WR}$ high to ALE high	25	75	$t_{CLCL}{-}25$	$t_{CLCL}{+}25$	ns
Shift Register							
t_{XLXL}	5	Serial port clock cycle time[3]	0.6		$12t_{CLCL}$		μs
t_{QVXH}	5	Output data setup to clock rising edge[3]	367		$10t_{CLCL}{-}133$		ns
t_{XHQX}	5	Output data hold after clock rising edge[3]	40		$2t_{CLCL}{-}60$		ns
t_{XHDX}	5	Input data hold after clock rising edge[3]	0		0		ns
t_{XHDV}	5	Clock rising edge to input data valid[3]		367		$10t_{CLCL}{-}133$	ns
External Clock							
t_{CHCX}	6	High time[3]	17		17	$t_{CLCL} - t_{LOW}$	ns
t_{CLCX}	6	Low time[3]	17		17	$t_{CLCL} - t_{HIGH}$	ns
t_{CLCH}	6	Rise time[3]		20		20	ns
t_{CHCL}	6	Fall time[3]		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. These values are characterized but not 100% production tested.

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AC ELECTRICAL CHARACTERISTICS – I²C INTERFACE

SYMBOL	PARAMETER	INPUT	OUTPUT
SCL TIMING CHARACTERISTICS			
t_{HD}; STA	START condition hold time	$\geq 14\ t_{CLCL}$	> 4.0µs[1]
t_{LOW}	SCL LOW time	$\geq 16\ t_{CLCL}$	> 4.7µs[1]
t_{HIGH}	SCL HIGH time	$\geq 14\ t_{CLCL}$	> 4.0µs[1]
t_{RC}	SCL rise time	$\leq 1µs$	– [2]
t_{FC}	SCL fall time	$\leq 0.3µs$	< 0.3µs[3]
SDA TIMING CHARACTERISTICS			
t_{SU}; DAT1	Data set-up time	$\geq 250ns$	> 20 t_{CLCL} – t_{RD}
t_{SU}; DAT2	SDA set-up time (before rep. START cond.)	$\geq 250ns$	> 1µs[1]
t_{SU}; DAT3	SDA set-up time (before STOP cond.)	$\geq 250ns$	> 8 t_{CLCL}
t_{HD}; DAT	Data hold time	$\geq 0ns$	> 8 t_{CLCL} – t_{FC}
t_{SU}; STA	Repeated START set-up time	$\geq 14\ t_{CLCL}$	> 4.7µs[1]
t_{SU}; STO	STOP condition set-up time	$\geq 14\ t_{CLCL}$	> 4.0µs[1]
t_{BUF}	Bus free time	$\geq 14\ t_{CLCL}$	> 4.7µs[1]
t_{RD}	SDA rise time	$\leq 1µs$	– [2]
t_{FD}	SDA fall time	$\leq 0.3µs$	< 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 SI01 interface meets the I²C-bus specification for bit-rates up to 100 kbit/s.

TIMING SIO1 (I²C) INTERFACE

SU00107A

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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.
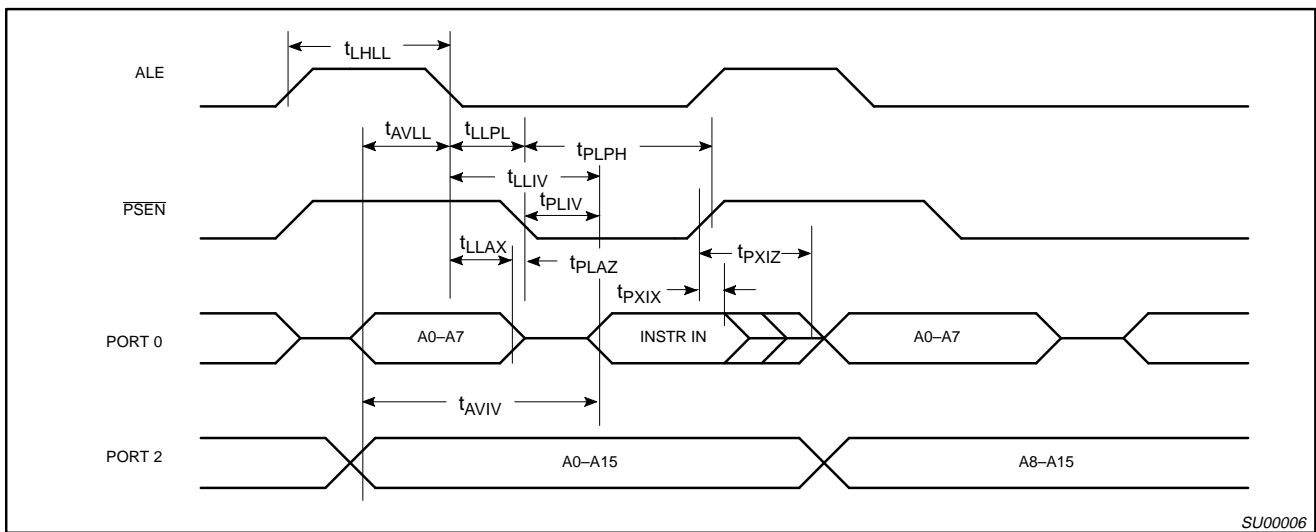
Figure 1. External Program Memory Read Cycle
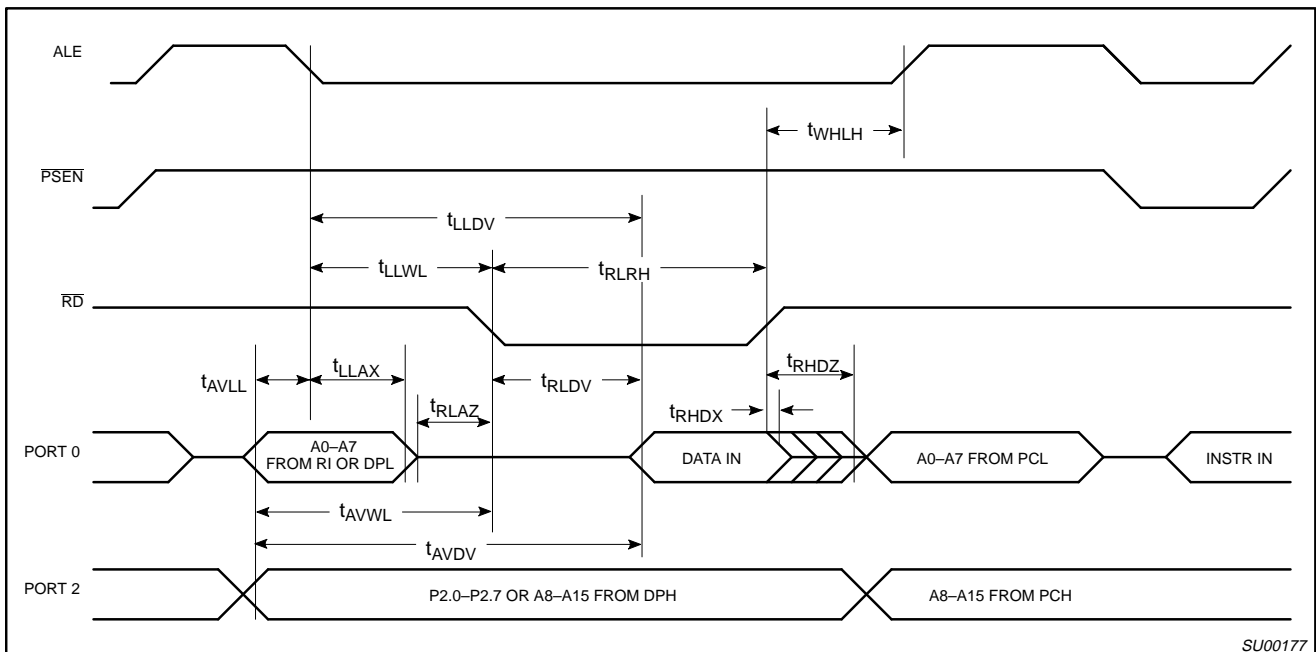
Figure 2. External Data Memory Read Cycle

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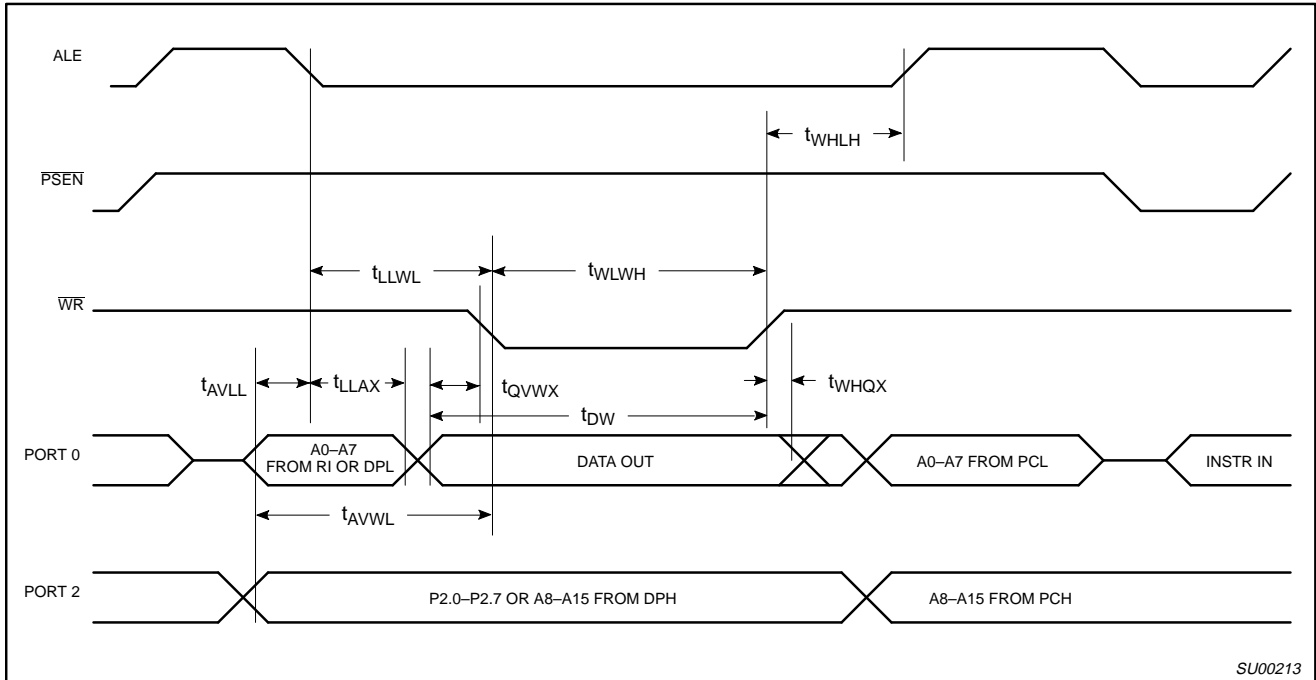
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Figure 3. External Data Memory Write Cycle
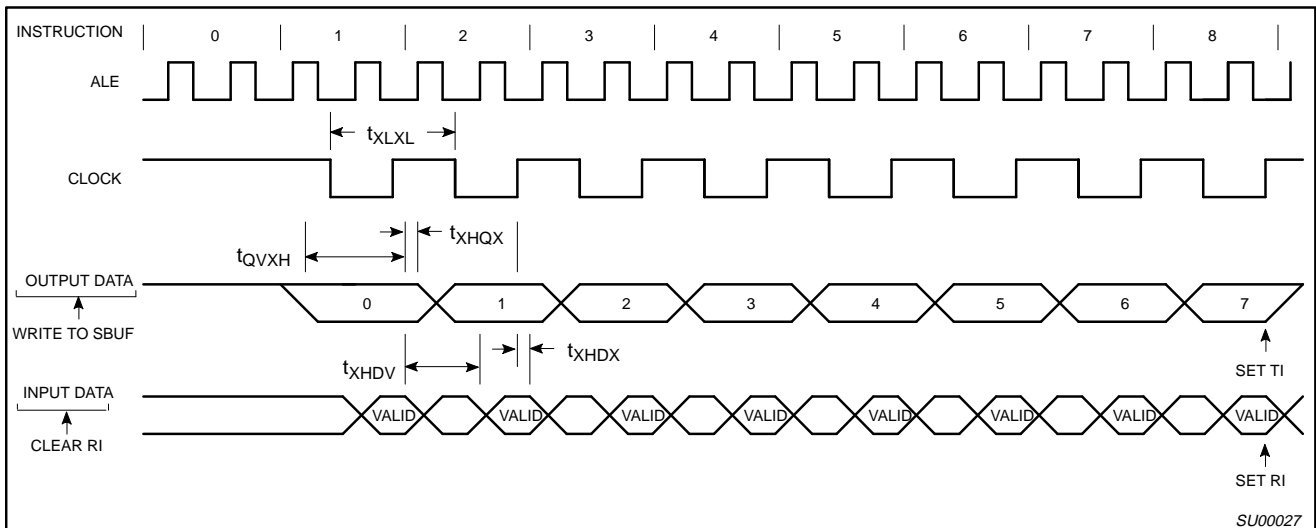
Figure 4. Shift Register Mode Timing
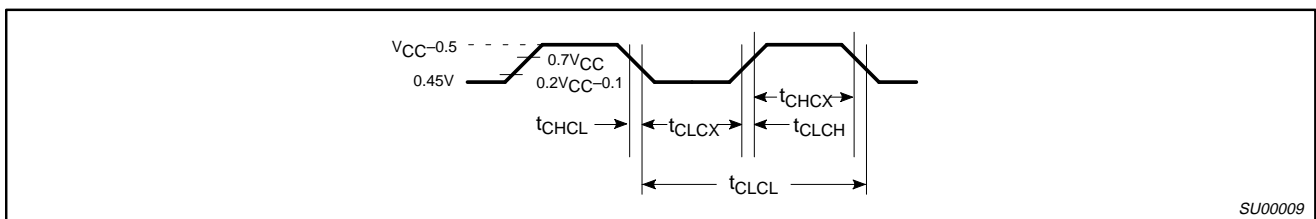
Figure 5. External Clock Drive

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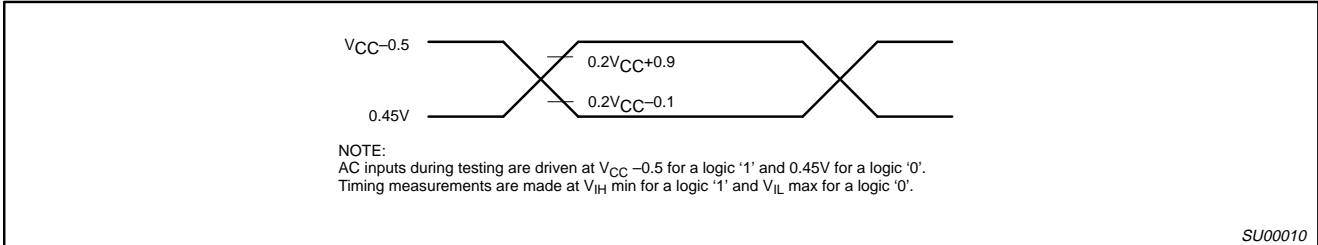
Figure 6. AC Testing Input/Output
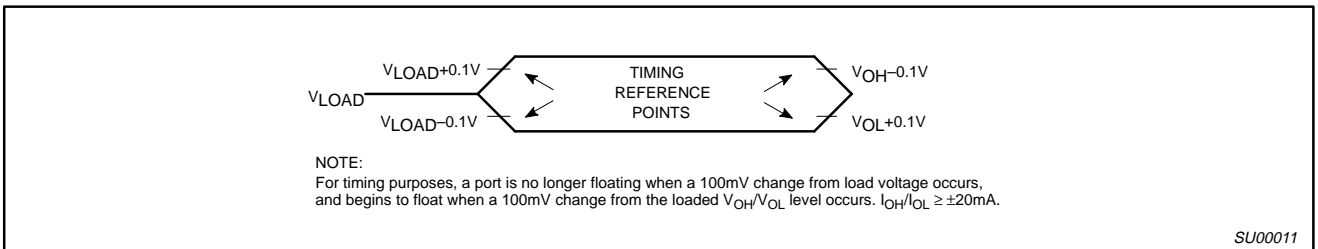
Figure 7. Float Waveform
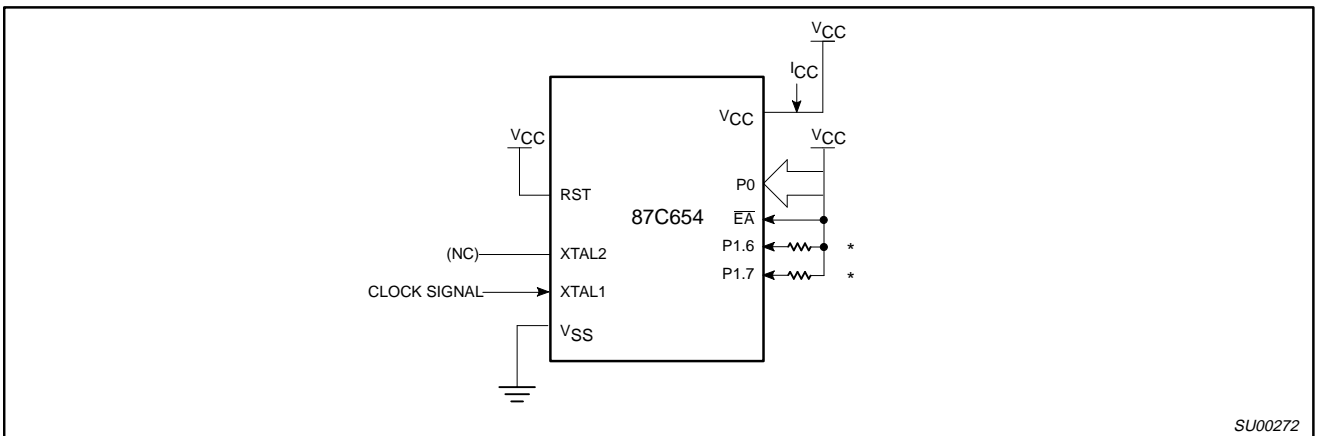
Figure 8. I_{CC} Test Condition, Active Mode
All other pins are disconnected

NOTE:
* Ports 1.6 and 1.7 should be connected to V_{CC} through resistors of sufficiently high value such that the sink current into these pins does not exceed the I_{OL1} specification.

Figure 9. I$_{CC}$ Test Condition, Idle Mode
All other pins are disconnected
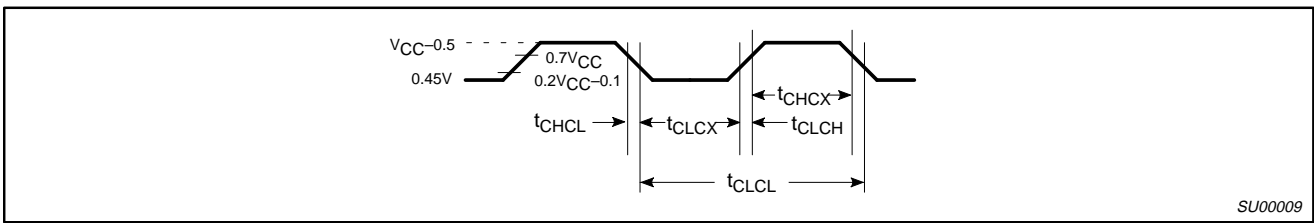
Figure 10. Clock Signal Waveform for I$_{CC}$ Tests in Active and Idle Modes
t$_{CLCH}$ = t$_{CHCL}$ = 10ns
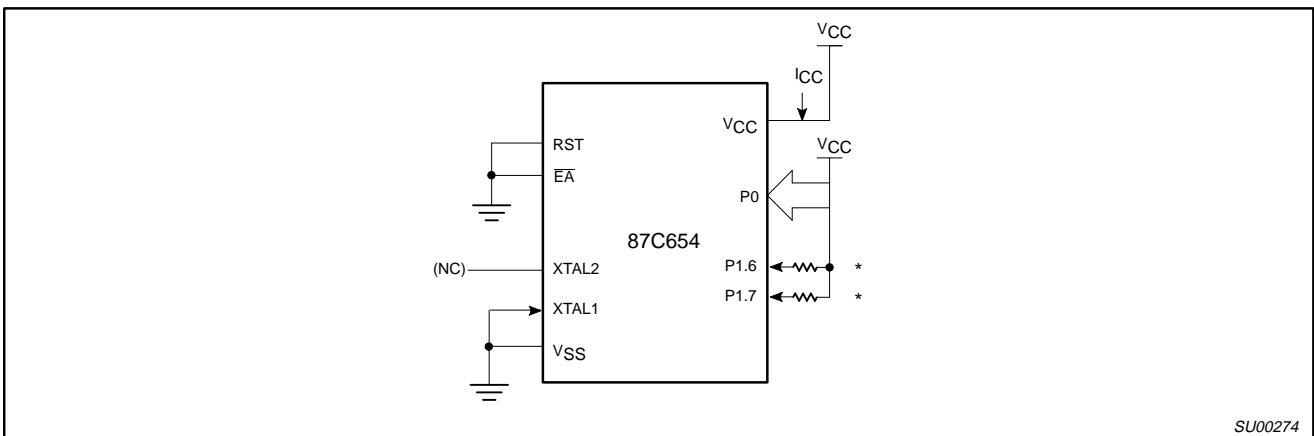
Figure 11. I$_{CC}$ Test Condition, Power Down Mode
All other pins are disconnected. V$_{CC}$ = 2V to 5.5V

NOTE:
*   Ports 1.6 and 1.7 should be connected to V$_{CC}$ through resistors of sufficiently high value such that the sink current into these pins does not exceed the I$_{OL1}$ specification.

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EPROM CHARACTERISTICS

The 87C654 is programmed by using a modified Quick-Pulse Programming™ algorithm. It differs from older methods in the value used for V_{PP} (programming supply voltage) and in the width and number of the ALE/$\overline{PROG}$ pulses.

The 87C654 contains two signature bytes that can be read and used by an EPROM programming system to identify the device. The signature bytes identify the device as an 87C654 manufactured by Philips Components.

Table 4 shows the logic levels for reading the signature byte, and for programming the program memory, the encryption table, and the lock bits. The circuit configuration and waveforms for quick-pulse programming are shown in Figures 12 and 13. Figure 14 shows the circuit configuration for normal program memory verification.

Quick-Pulse Programming

The setup for microcontroller quick-pulse programming is shown in Figure 12. Note that the 87C654 is running with a 4 to 6MHz oscillator. The reason the oscillator needs to be running is that the device is executing internal address and program data transfers.

The address of the EPROM location to be programmed is applied to ports 1 and 2, as shown in Figure 12. The code byte to be programmed into that location is applied to port 0. RST, $\overline{PSEN}$ and pins of ports 2 and 3 specified in Table 4 are held at the 'Program Code Data' levels indicated in Table 4. The ALE/$\overline{PROG}$ is pulsed low 25 times as shown in Figure 13.

To program the encryption table, repeat the 25 pulse programming sequence for addresses 0 through 1FH, using the 'Pgm Encryption Table' levels. Do not forget that after the encryption table is programmed, verification cycles will produce only encrypted data.

To program the lock bits, repeat the 25 pulse programming sequence using the 'Pgm Lock Bit' levels. After one lock bit is programmed, further programming of the code memory and encryption table is disabled. However, the other lock bit can still be programmed.

Note that the $\overline{EA}$/V_{PP} pin must not be allowed to go above the maximum specified V_{PP} level for any amount of time. Even a narrow glitch above that voltage can cause permanent damage to the device. The V_{PP} source should be well regulated and free of glitches and overshoot.

Program Verification

If lock bit 2 has not been programmed, the on-chip program memory can be read out for program verification. The address of the program memory locations to be read is applied to ports 1 and 2 as shown in Figure 14. The other pins are held at the 'Verify Code Data' levels indicated in Table 4. The contents of the address location will be emitted on port 0. External pull-ups are required on port 0 for this operation.

If the encryption table has been programmed, the data presented at port 0 will be the exclusive NOR of the program byte with one of the encryption bytes. The user will have to know the encryption table contents in order to correctly decode the verification data. The encryption table itself cannot be read out.

Reading the Signature Bytes

The signature bytes are read by the same procedure as a normal verification of locations 030H and 031H, except that P3.6 and P3.7 need to be pulled to a logic low. The values are:

(030H) = 15H indicates manufactured by Philips

(031H) = 99H indicates 87C654

Program/Verify Algorithms

Any algorithm in agreement with the conditions listed in Table 4, and which satisfies the timing specifications, is suitable.

Erasure Characteristics

Erasure of the EPROM begins to occur when the chip is exposed to light with wavelengths shorter than approximately 4,000 angstroms. Since sunlight and fluorescent lighting have wavelengths in this range, exposure to these light sources over an extended time (about 1 week in sunlight, or 3 years in room level fluorescent lighting) could cause inadvertent erasure. **For this and secondary effects, it is recommended that an opaque label be placed over the window.** For elevated temperature or environments where solvents are being used, apply Kapton tape Fluorglas part number 2345–5, or equivalent.

The recommended erasure procedure is exposure to ultraviolet light (at 2537 angstroms) to an integrated dose of at least 15W-sec/cm^2. Exposing the EPROM to an ultraviolet lamp of 12,000µW/cm^2 rating for 20 to 39 minutes, at a distance of about 1 inch, should be sufficient. Erasure leaves the array in an all 1s state.

Table 4. EPROM Programming Modes

MODE	RST	$\overline{PSEN}$	ALE/$\overline{PROG}$	$\overline{EA}$/V_{PP}	P2.7	P2.6	P3.7	P3.6
Read signature	1	0	1	1	0	0	0	0
Program code data	1	0	0*	V_{PP}	1	0	1	1
Verify code data	1	0	1	1	0	0	1	1
Pgm encryption table	1	0	0*	V_{PP}	1	0	1	0
Pgm lock bit 1	1	0	0*	V_{PP}	1	1	1	1
Pgm lock bit 2	1	0	0*	V_{PP}	1	1	0	0

NOTES:
1. '0' = Valid low for that pin, '1' = valid high for that pin.
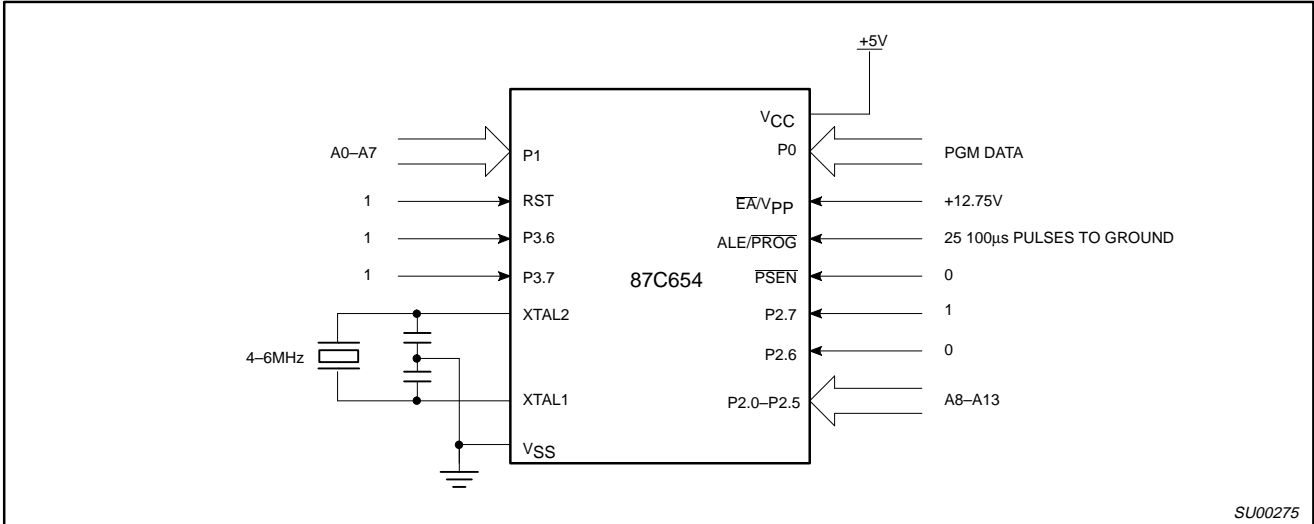2. V_{PP} = 12.75V ±0.25V.
3. V_{CC} = 5V±10% during programming and verification.
* ALE/$\overline{PROG}$ receives 25 programming pulses while V_{PP} is held at 12.75V. Each programming pulse is low for 100µs (±10µs) and high for a minimum of 10µs.
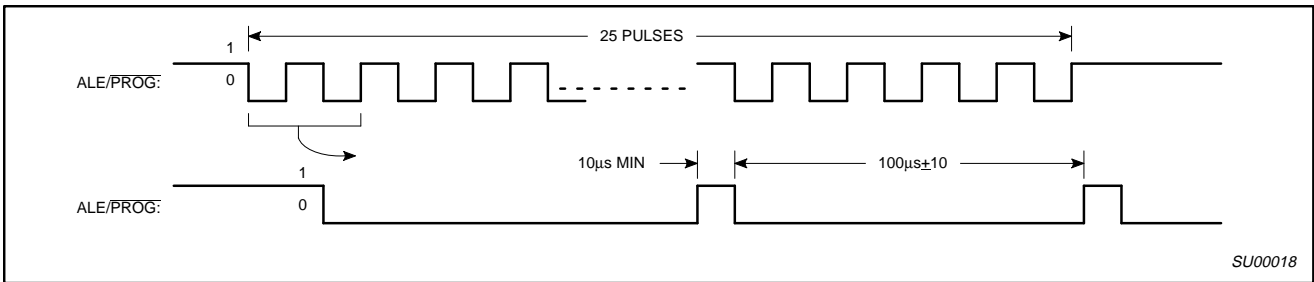

™Trademark phrase of Intel Corporation.
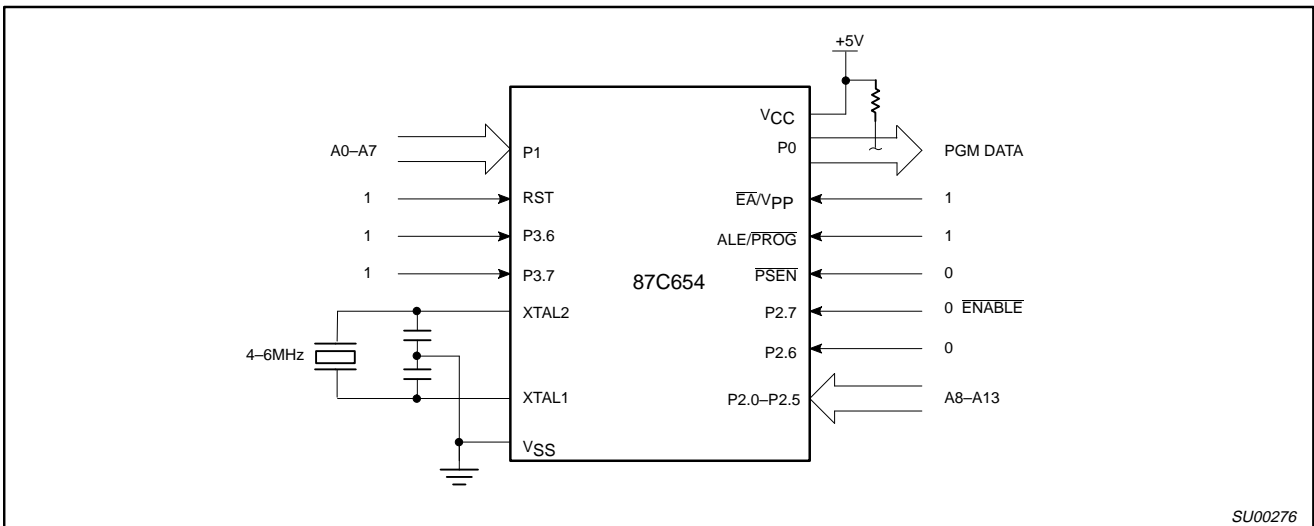
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Figure 12. Programming Configuration

**Figure 13. $\overline{PROG}$ Waveform**

Figure 14. Program Verification

EPROM PROGRAMMING AND VERIFICATION CHARACTERISTICS

T_{amb} = 21°C to +27°C, V_{CC} = 5V±10%, V_{SS} = 0V (See Figure 15)

SYMBOL	PARAMETER	MIN	MAX	UNIT
V_{PP}	Programming supply voltage	12.5	13.0	V
I_{PP}	Programming supply current		50	mA
$1/t_{CLCL}$	Oscillator frequency	4	6	MHz
t_{AVGL}	Address setup to $\overline{PROG}$ low	$48t_{CLCL}$		
t_{GHAX}	Address hold after $\overline{PROG}$	$48t_{CLCL}$		
t_{DVGL}	Data setup to $\overline{PROG}$ low	$48t_{CLCL}$		
t_{GHDX}	Data hold after $\overline{PROG}$	$48t_{CLCL}$		
t_{EHSH}	P2.7 ($\overline{ENABLE}$) high to V_{PP}	$48t_{CLCL}$		
t_{SHGL}	V_{PP} setup to $\overline{PROG}$ low	10		μs
t_{GHSL}	V_{PP} hold after $\overline{PROG}$	10		μs
t_{GLGH}	$\overline{PROG}$ width	90	110	μs
t_{AVQV}	Address to data valid		$48t_{CLCL}$	
t_{ELQZ}	$\overline{ENABLE}$ low to data valid		$48t_{CLCL}$	
t_{EHQZ}	Data float after $\overline{ENABLE}$	0	$48t_{CLCL}$	
t_{GHGL}	$\overline{PROG}$ high to $\overline{PROG}$ low	10		μs
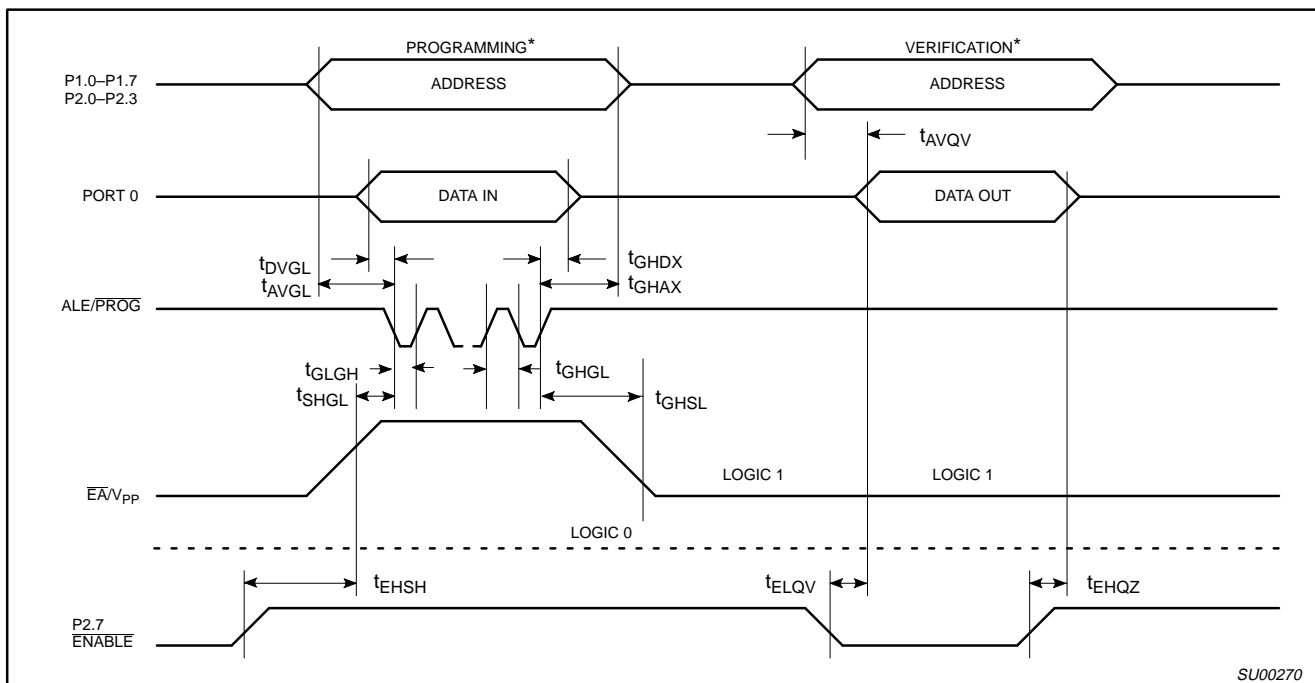
* FOR PROGRAMMING VERIFICATION SEE FIGURE 12.
FOR VERIFICATION CONDITIONS SEE FIGURE 14.

Figure 15. EPROM Programming and Verification
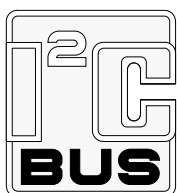
Purchase of Philips I²C components conveys a license under the Philips' I²C patent to use the components in the I²C system provided the system conforms to the I²C specifications defined by Philips. This specification can be ordered using the code 9398 393 40011.

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DIP40:   plastic dual in-line package; 40 leads (600 mil)   **SOT129-1**

0   5   10 mm
scale
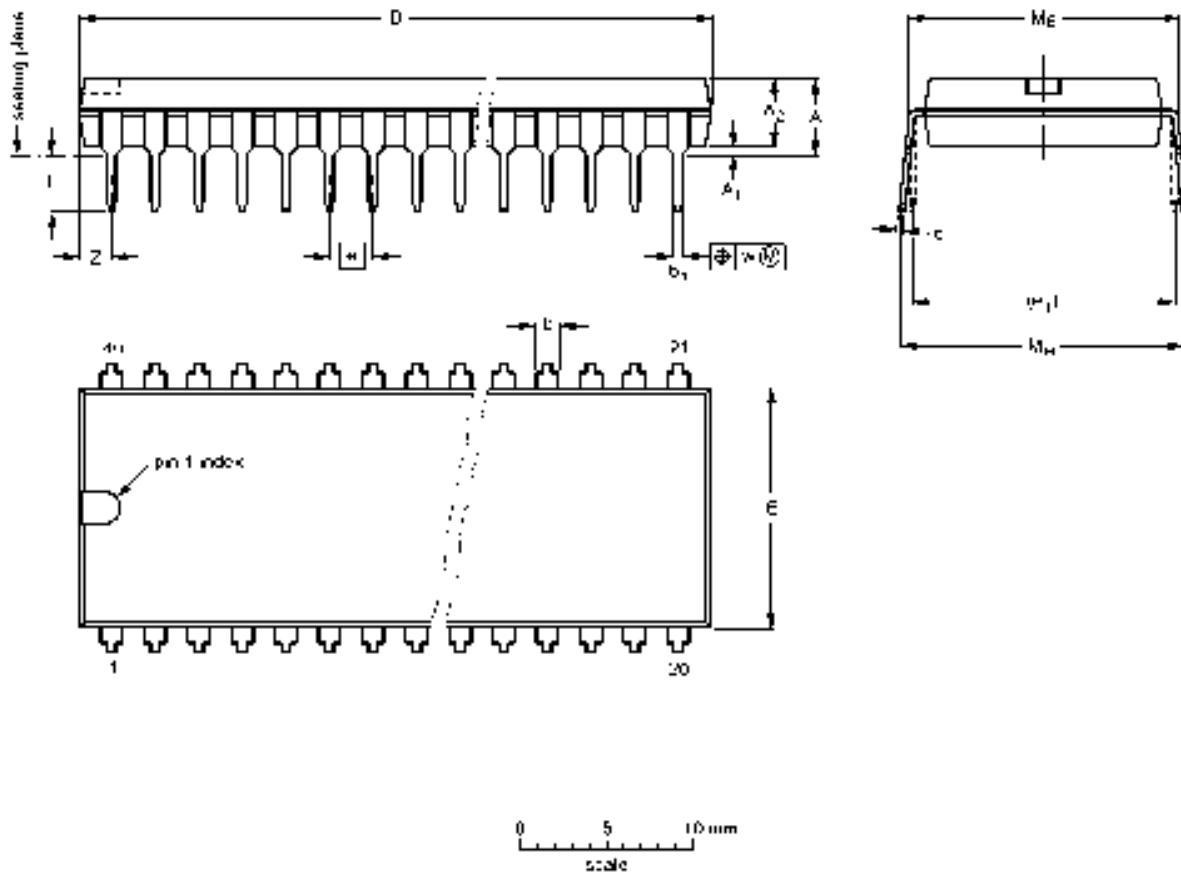
DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A₁ min.	A₂ max.	b	b₁	c	D[1]	E[1]	e	e₁	L	M_E	M_H	w	z[1] max.
mm	4.7	0.51	4.0	1.70 1.14	0.53 0.38	0.36 0.23	52.50 51.50	14.1 13.7	2.54	15.24	3.60 3.05	15.80 15.24	17.42 15.90	0.254	2.25
inches	0.19	0.020	0.16	0.067 0.045	0.021 0.015	0.014 0.009	2.067 2.029	0.56 0.54	0.10	0.60	0.14 0.12	0.62 0.60	0.69 0.63	0.01	0.089

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			
SOT129-1	051G08	MO-015AJ				92-11-17 95-01-14

PLCC44:   plastic leaded chip carrier; 44 leads   **SOT187-2**
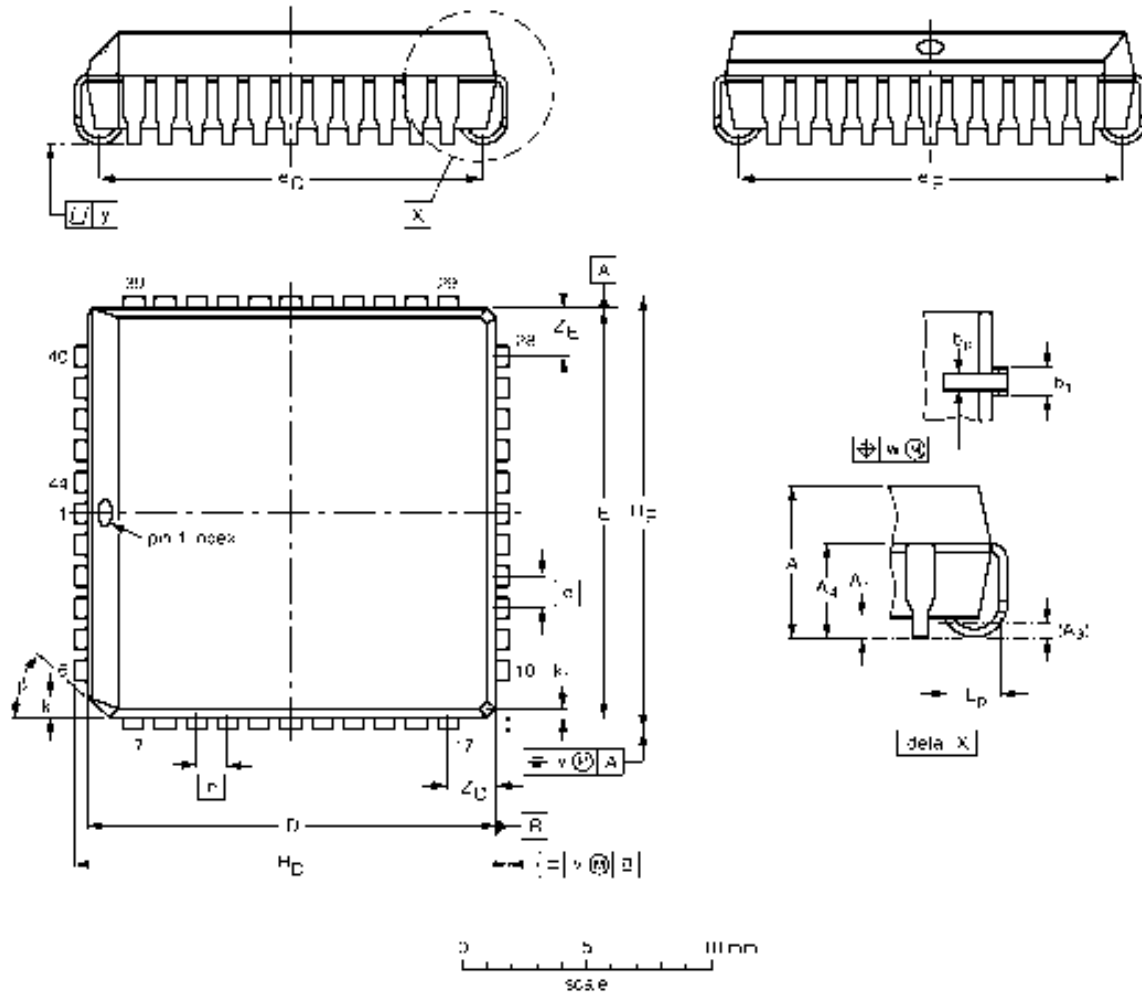
DIMENSIONS (millimetre dimensions are derived from the original inch dimensions)

UNIT	A	A₁ min.	A₃	A₄ max.	bₚ	b₁	D⁽¹⁾	E⁽¹⁾	e	eᴅ	eₑ	Hᴅ	Hₑ	k	k₁ max.	Lₚ	v	w	y	Zᴅ⁽¹⁾ max.	Zₑ⁽¹⁾ max.	β
mm	4.57 4.19	0.51	0.25	3.05	0.53 0.33	0.81 0.66	16.66 16.51	16.66 16.51	1.27	16.00 14.99	16.00 14.99	17.65 17.40	17.65 17.40	1.22 1.07	0.51	1.44 1.02	0.18	0.18	0.10	2.16	2.16	45°
inches	0.180 0.165	0.020	0.01	0.12	0.021 0.013	0.032 0.026	0.656 0.650	0.656 0.650	0.05	0.630 0.590	0.630 0.590	0.695 0.685	0.695 0.685	0.048 0.042	0.020	0.057 0.040	0.007	0.007	0.004	0.085	0.085	

Note

1. Plastic or metal protrusions of 0.01 inches maximum per side are not included.

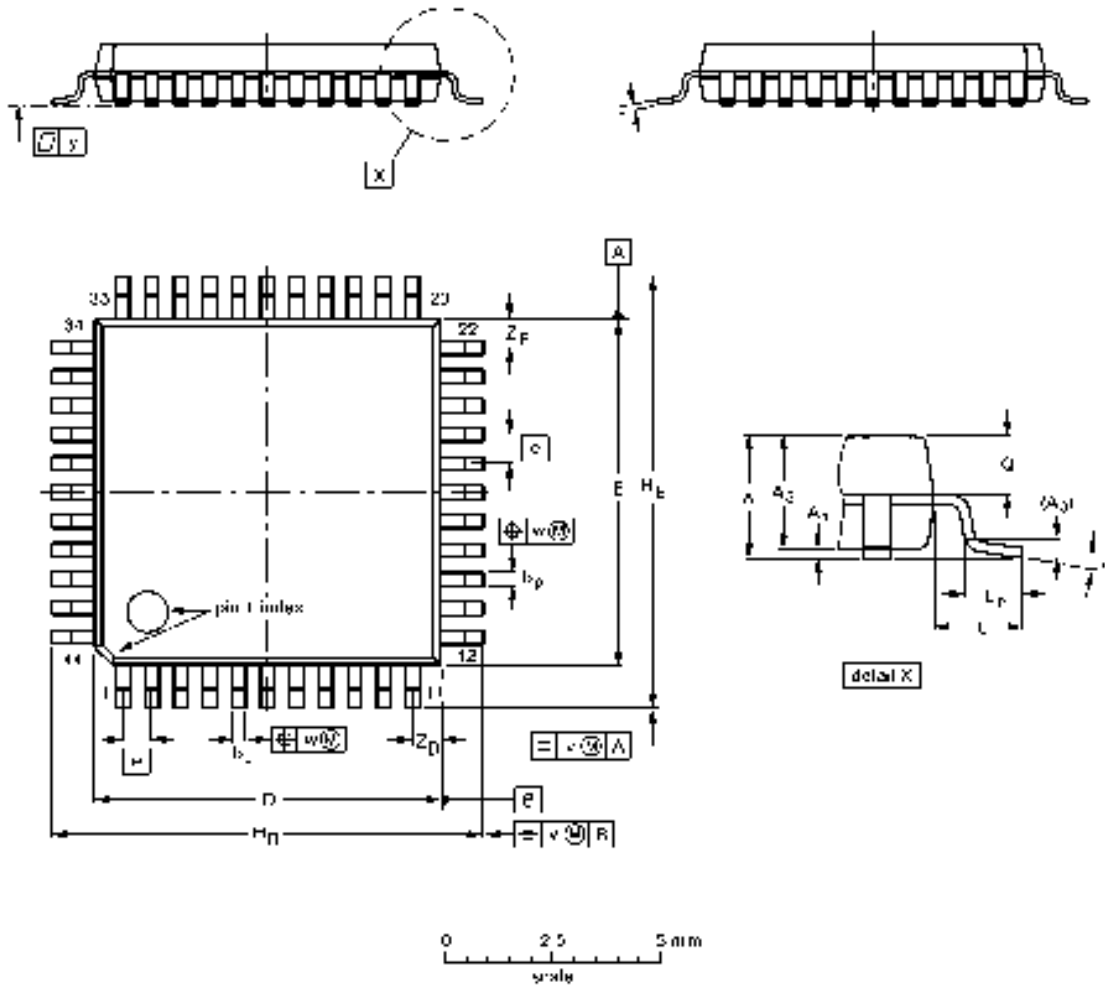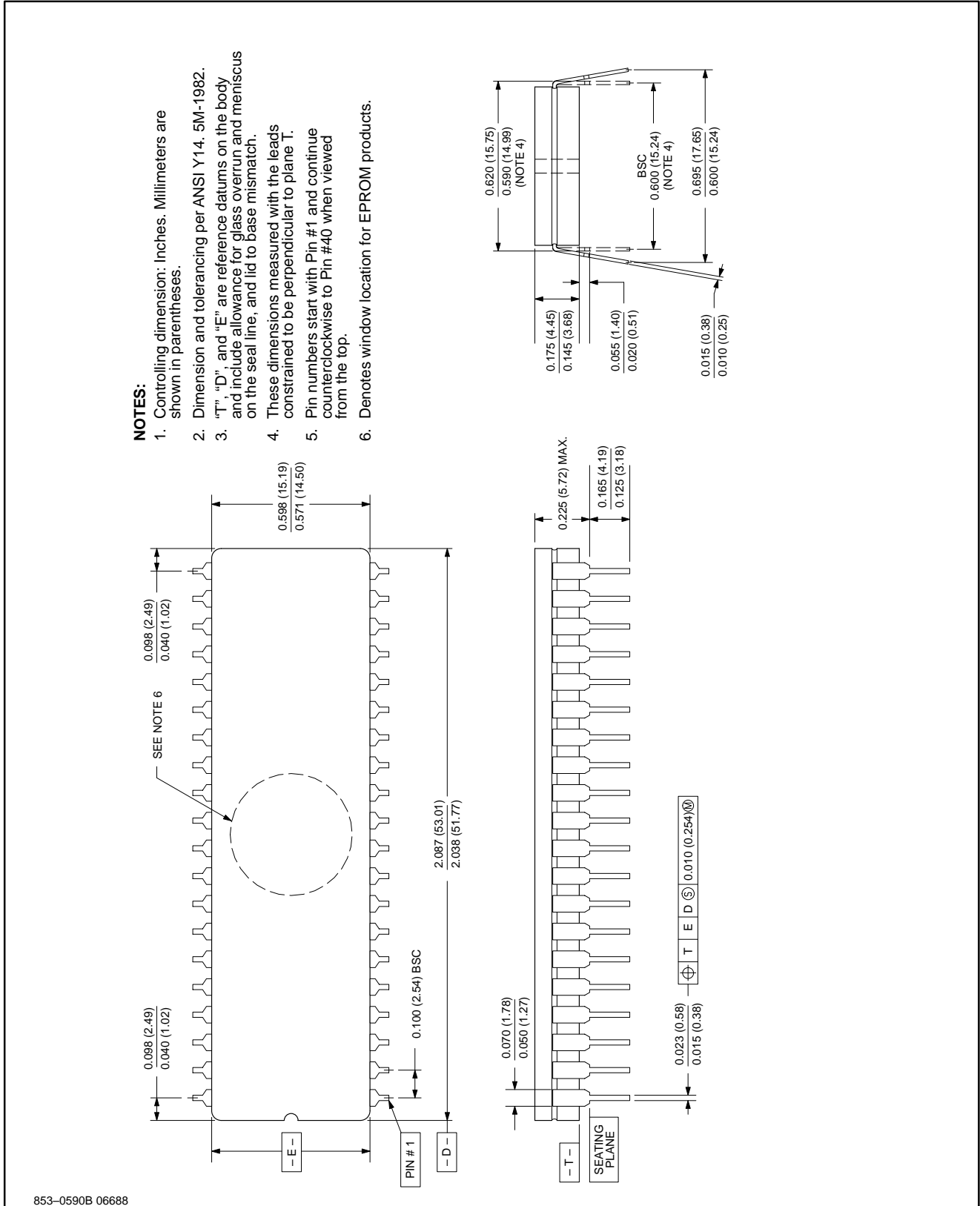| OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT187-2	112E10	MO-047AC				92-11-17 95-02-25

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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	1.80 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	1.0	0.95 0.55	0.85 0.75	0.15	0.15	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

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0590B   40-PIN (600 mils wide) CERAMIC DUAL IN-LINE (F) PACKAGE (WITH WINDOW (FA) PACKAGE)

NOTES:

1. Controlling dimension: Inches. Millimeters are shown in parentheses.

2. Dimension and tolerancing per ANSI Y14. 5M-1982.

3. "T", "D", and "E" are reference datums on the body and include allowance for glass overrun and meniscus on the seal line, and lid to base mismatch.

4. These dimensions measured with the leads constrained to be perpendicular to plane T.

5. Pin numbers start with Pin #1 and continue counterclockwise to Pin #40 when viewed from the top.

6. Denotes window location for EPROM products.

853–0590B 06688

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1472A   44-PIN CERQUAD J-BEND (K) PACKAGE

NOTES:

1. All dimensions and tolerances to conform to ANSI Y14.5–1982.
2. UV window is optional.
3. Dimensions do not include glass protrusion. Glass protrusion to be 0.005 inches maximum on each side.
4. Controlling dimension millimeters.
5. All dimensions and tolerances include lead trim offset and lead plating finish.
6. Backside solder relief is optional and dimensions are for reference only.

DETAIL B
mm/(inch)

DETAIL A
TYP. ALL SIDES
mm/(inch)

853-1472A 05854

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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.

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