DATA SHEET

80C31/80C51

CMOS SINGLE-CHIP 8 BIT MICROCONTROLLER

- **80C31/80C51 : 0 TO 12 MHz**
  80C31/80C51-1 : 0 TO 16 MHz
  80C31-S/80C51-S : 0 TO 20 MHz

80C31/80C51-L : 0 TO 6 MHz WITH 2.7 V < Vcc < 6 V
80C51F : 80C51 WITH PROTECTED ROM

FEATURES

- **POWER CONTROL MODES**
- **128 x 8 BIT RAM**
- **4 K BYTES OF ROM (80C51)**
- **32 PROGRAMMABLE I/O LINES**
- **TWO 16 BIT TIMER/COUNTER**
- **64 K PROGRAM MEMORY SPACE**
- **FULLY STATIC DESIGN**
- **BOOLEAN PROCESSOR**
- **5 INTERRUPT SOURCES**
- **PROGRAMMABLE SERIAL PORT**
- **64 K DATA MEMORY SPACE**
- **TEMPERATURE RANGE : COMMERCIAL, INDUSTRIAL, AUTOMOTIVE AND MILITARY**

INTRODUCTION

MHS's 80C31 and 80C51 are high performance CMOS versions of the 8031/8051 NMOS single chip 8 bit µC and are manufactured using a self-aligned silicon gate CMOS process (SAJI VI).

The fully static design of the MHS 80C31/80C51 allows to reduce system power consumption by bringing the clock frequency down to any value, even DC, without loss of data.

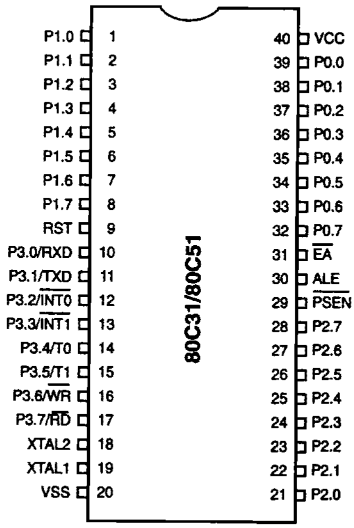
The 80C51 retains all the features of the 8051 : 4 K bytes of ROM ; 128 bytes of RAM ; 32 I/O lines ; two 16 bit timers ; a 5-source, 2-level interrupt structure ; a full duplex serial port ; and on-chip oscillator and clock circuits.

In addition, the 80C51 has two software-selectable modes of reduced activity for further reduction in power consumption. In the Idle Mode the CPU is frozen while the RAM, the timers, the serial port, and the interrupt system continue to function. In the Power Down Mode the RAM is saved and all other functions are inoperative.

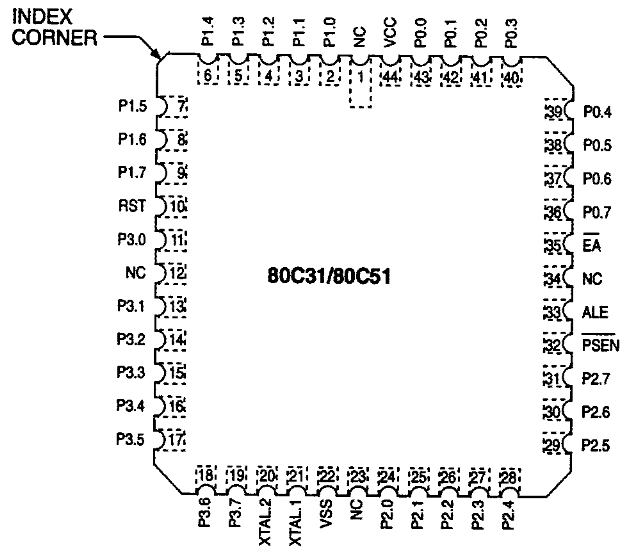
The 80C31 is identical to the 80C51 except that it has no on-chip ROM.

INTERFACE

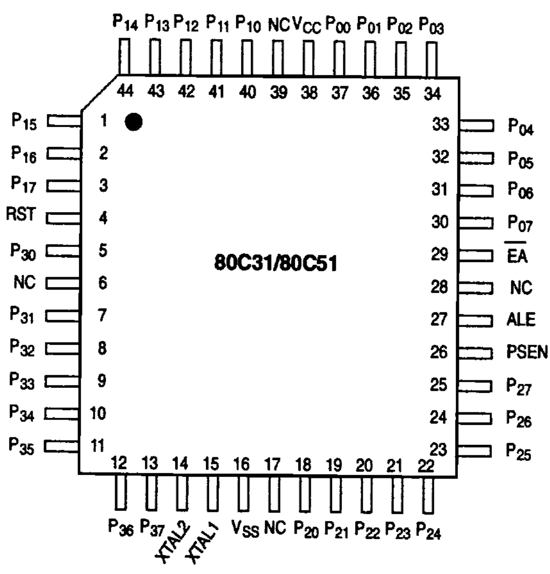
PIN CONFIGURATION



DIL



LCC



Flat Pack

Diagrams are for reference only. Package sizes are not to scale.

Figure 1.

PIN DESCRIPTION

Vss

Circuit ground potential

Vcc

Supply voltage during normal, Idle, and Power Down operation.

Port 0

Port 0 is an 8 bit open drain bi-directional I/O port. Port 0 pins that have 1's written to them float, and in that state 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 pullups when emitting 1's. Port 0 also outputs the code bytes during program verification in the 80C51. External pullups are required during program verification. Port 0 can sink eight LS TTL inputs.

Port 1

Port 1 is an 8 bit bi-directional I/O port with internal pullups. Port 1 pins that have 1's written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (IIL, on the data sheet) because of the internal pullups.

Port 1 also receives the low-order address byte during program verification. In the 80C51, Port 1 can sink/source three LS TTL inputs. It can drive CMOS inputs without external pullups.

Port 2

Port 2 is an 8 bit bi-directional I/O port with internal pullups. Port 2 pins that have 1's written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL, on the data sheet) because of the internal pullups. 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 pullups when emitting 1's. During accesses to external Data Memory that use 8 bit addresses (MOVX @Ri), Port 2 emits the contents of the P2 Special Function Register.

It also receives the high-order address bits and control signals during program verification in the 80C51. Port 2 can sink/source three LS TTL inputs. It can drive CMOS inputs without external pullups.

Port 3

Port 3 is an 8 bit bi-directional I/O port with internal pullups. Port 3 pins that have 1's written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (IIL, on the data sheet) because of the pullups. It also serves the function of various special features of the MHS 51 Family, as listed below.

Port Pin	Alternate Function
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{\text{INT0}}$ (external interrupt 0)
P3.3	$\overline{\text{INT1}}$ (external interrupt 1)
P3.4	T0 (Timer 0 external input)
P3.5	T1 (Timer 1 external input)
P3.6	$\overline{\text{WR}}$ (external Data Memory write strobe)
P3.7	$\overline{\text{RD}}$ (external Data Memory read strobe)

Port 3 can sink/source three LS TTL inputs. It can drive CMOS inputs without external pullups.

RST

A high level on this for two machine cycles while the oscillator is running resets the device. An internal pull-down resistor permits Power-On reset using only a capacitor connected to Vcc.

ALE

Address Latch Enable output for latching the low byte of the address during accesses to external memory. ALE is activated as though for this purpose at a constant rate of 1/6 the oscillator frequency except during an external data memory access at which time on ALE pulse is skipped. ALE can sink/source 8 LS TTL inputs. It can drive CMOS inputs without an external pullup.

$\overline{\text{PSEN}}$

Program Store Enable output is the read strobe to external Program Memory. PSEN is activated twice each machine cycle during fetches from external Program Memory. (However, when executing out of external Program Memory, two activations of PSEN are skipped during each access to external Data Memory). PSEN is not activated during fetches from internal Program Memory. PSEN can sink/source 8 LS TTL inputs. It can drive CMOS inputs without an external pullup.

$\overline{\text{EA}}$

When EA is held high, the CPU executed out of internal Program Memory (unless the Program Counter exceeds 0FFFH). When EA is held low, the CPU executes only out of external Program Memory. EA must not be floated.

XTAL1

Input to the inverting amplifier that forms the oscillator. Receives the external oscillator signal when an external oscillator is used.

XTAL2

Output of the inverting amplifier that forms the oscillator, and input to the internal clock generator. This pin should be floated when an external oscillator is used.

FUNCTIONAL DESCRIPTION

BLOCK DIAGRAM

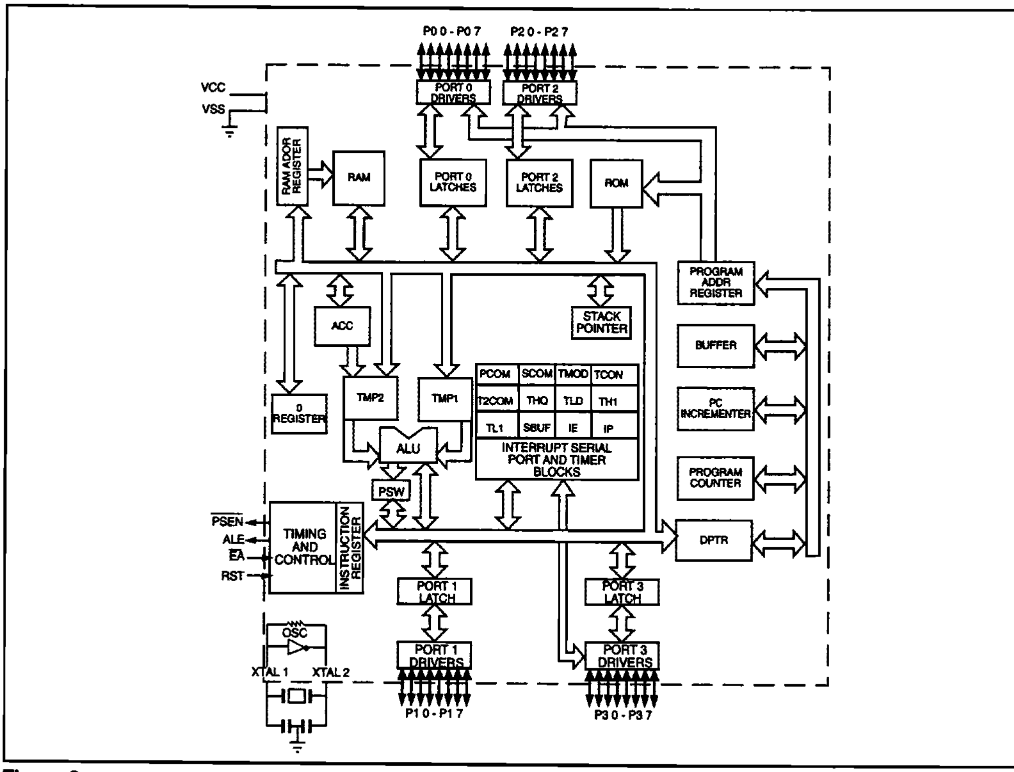


Figure 2.

IDLE AND POWER DOWN OPERATION

Figure 3 shows the internal Idle and Power Down clock configuration. As illustrated, Power Down operation stops the oscillator. Idle mode operation allows the interrupt, serial port, and timer blocks to continue to function while the clock to the CPU is gated off.

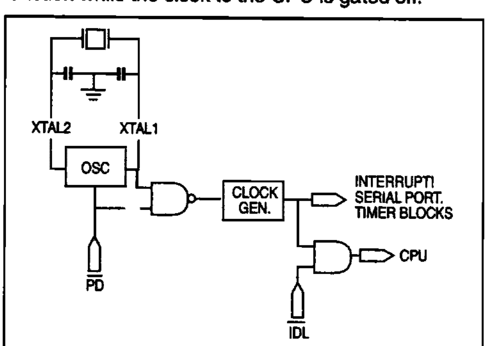


Figure 3 : Idle and Power Down Hardware.

PCON : Power Control Register

(MSB) (LSB)

SMOD	–	–	–	GF1	GF0	PD	IDL

Symbol	Position	Name and Function
SMOD	PCON.7	Double Baud rate bit. When set to a 1, the baud rate is doubled when the serial port is being used in either modes 1, 2 or 3.
–	PCON.6	(Reserved)
–	PCON.5	(Reserved)
–	PCON.4	(Reserved)
GF1	PCON.3	General-purpose flag bit.
GF0	PCON.2	General-purpose flag bit.
PD	PCON.1	Power Down bit. Setting this bit activates power down operation.
IDL	PCON.0	Idle mode bit. Setting this bit activates idle mode operation.

These special modes are activated by software via the Special Function Register, its hardware address is 87H. PCON is not bit addressable.

If 1's are written to PD and IDL at the same time. PD takes precedence. The reset value of PCON is (0XXX0000).

IDLE MODE

The instruction that sets PCON.0 is the last instruction executed before the Idle mode is activated. Once in the Idle mode the CPU status is preserved in its entirety : the Stack Pointer, Program Counter, Program Status Word, Accumulator, RAM, and all other register maintain their data during Idle. Table 1 describes the status of the external pins during Idle mode.

There are two ways to terminate the Idle mode. Activation of any enabled interrupt will cause PCON.0 to be cleared by hardware, terminating Idle mode. The interrupt is serviced, and following RETI, the next instruction to be executed will be the one following the instruction that wrote 1 to PCON.0.

The flag bits GF0 and GF1 may be used to determine whether the interrupt was received during normal execution or during the Idle mode. For example, the instruction that writes to PCON.0 can also set or clear one or both flag bits. When Idle mode is terminated by an enabled interrupt, the service routine can examine the status of the flag bits.

The second way of terminating the Idle is with a hardware reset. Since the oscillator is still running, the hardware reset needs to be active for only 2 machine cycles (24 oscillator periods) to complete the reset operation.

POWER DOWN MODE

The instruction that sets PCON.1 is the last executed prior to entering power down. Once in power down, the oscillator is stopped. The contents of the onchip RAM and the Special Function Register is saved during power down mode. A hardware reset is the only way of exiting the power down mode. The hardware reset initiates the Special Function Register (see *Table 1*).

In the Power Down mode, V_{CC} may be lowered to minimize circuit power consumption. Care must be taken to ensure the voltage is not reduced until the power down mode is entered, and that the voltage is restored before the hardware reset is applied which frees the oscillator. Reset should not be released until the oscillator has restarted and stabilized.

Table 1 describes the status of the external pins while in the power down mode. It should be noted that if the power down mode is activated while in external program memory, the port data that is held in the Special Function Register P2 is restored to Port 2. If the data is a 1, the port pin is held high during the power down mode by the strong pullup, T1, shown in *Figure 4*.

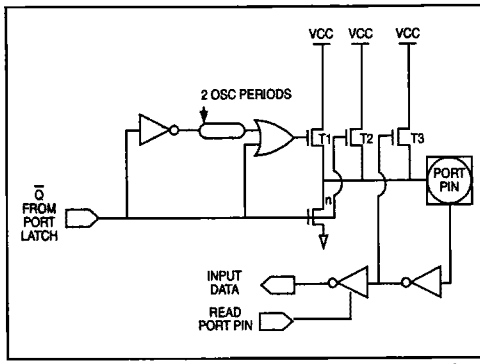


Figure 4 : I/O Buffers in the 80C51 (Ports 1, 2, 3).

STOP CLOCK MODE

Due to static design, the MHS 80C31/C51 clock speed can be reduced until 0 MHz without any data loss in memory or registers. This mode allows step by step utilization, and permits to reduce system power consumption by bringing the clock frequency down to any value. At 0 MHz, the power consumption is the same as in the Power Down Mode.

I/O PORTS

The I/O port drive of the 80C51 is similar to the 8051. The I/O buffers for Ports 1, 2 and 3 are implemented as shown in figure 4.

When the port latch contains a 0, all pFETS in *figure 4* are off while the nFET is turned on. When the port latch makes a 0-to-1 transition, the nFET turns off. The strong pullup pFET, T1, turns on for two oscillator periods, pulling the output high very rapidly. As the output line is drawn high, pFET T3 turns on through the inverter to supply the I_{OH} source current. This inverter and T3 form a latch which holds the 1 and is supported by T2.

When Port 2 is used as an address port, for access to external program of data memory, any address bit that contains a 1 will have his strong pullup turned on for the entire duration of the external memory access.

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MODE	PROGRAM MEMORY	ALE	PSEN	PORT0	PORT1	PORT2	PORT3
Idle	Internal	1	1	Port Data	Port Data	Port Data	Port Data
Idle	External	1	1	Floating	Port Data	Address	Port Data
Power Down	Internal	0	0	Port Data	Port Data	Port Data	Port Data
Power Down	External	0	0	Floating	Port Data	Port Data	Port Data

Table 1 : Status of the external pins during Idle and Power Down modes.

When an I/O pin on Ports 1, 2 or 3 is used as an input, the user should be aware that the external circuit must sink current during the logical 1-to-0 transition. The maximum sink current is specified as ITL under the D.C. Specifications. When the input goes below approximately 2 V, T3 turns off to save ICC current. Note, when returning to a logical 1, T2 is the only internal pullup that is on. This will result in a slow rise time if the user's circuit does not force the input line high.

OSCILLATOR CHARACTERISTICS

XTAL1 and XTAL2 are the input and output respectively, of an inverting amplifier which is configured for use as an on-chip oscillator, as shown in figure 5. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL1 should be driven while XTAL2 is left unconnected as shown in *figure 6*. There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum high and low times specified on the Data Sheet must be observed.

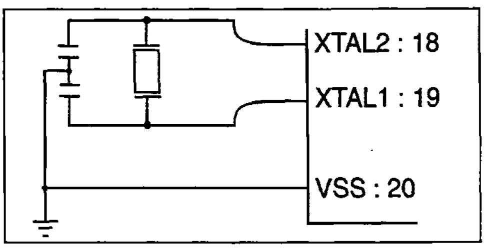


Figure 5 : Crystal Oscillator.

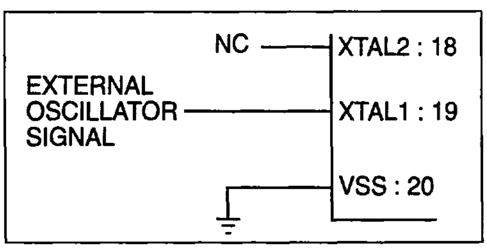


Figure 6 : External Drive Configuration.

80C51 WITH PROTECTED ROM

MHS provides a new member in the 80C51 Family named "80C51F" which permits full protection of the internal ROM contents.

With a non protected 80C51, it is very easy to read out the contents of the internal 4 K bytes of ROM.

Three methods exist, two of them are special test modes and the last one is by means of MOVC instructions.

- **Test mode "VER" :** Using this special test mode, the internal ROM contents are output on port P0 ; the address being applied on ports P2 (AD15...AD8) and P1 (AD7...AD0).
- **Test mode "TMB" :** With this second test mode, the contents of the 80C51 internal bus is presented on port P1 during the PH2 clock phases.
- **Using MOVC instructions :** If EA = 0, and following a reset, the 80C51 fetches its instructions from external program memory. It is then possible to write a small program whose purpose is to dump the internal ROM contents by means of MOVC A, @A + DPTR and MOVC A, @A + PC instructions.

80C51F with program protection features

This version adds ROM protection features in some strategic points of the 80C51F in order to eliminate the possibility of reading the ROM contents (once the protection has been programmed) by one if the three forementioned methods (VER and TMB test modes, or MOVC instructions).

Nevertheless the customer must note the following :

- Once the protection has been programmed, the 80C51F program always starts at address 0 in the internal ROM.
- The application program must be self contained in the internal 4 K of ROM, otherwise it would be possible to trap the program counter address in the external PROM/EPROM (beyond 4 K) and then to dump the internal ROM contents by means of a patch using MOVC instructions.

Thus, if an extra EPROM is necessary, it is advised to ensure that it will contain only constants or tables.

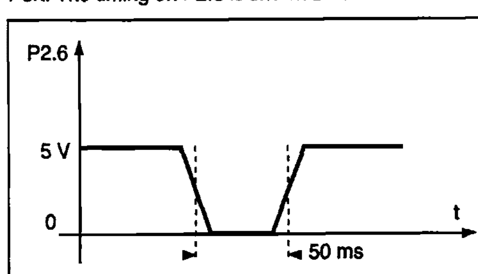
Test of the on-chip program memory

- **Before protection is activated :** The 80C51F can be tested as any normal 80C51 (using test equipment or any other methods).
- **After protection is activated :** It is then no longer possible to dump the internal ROM contents.

How to program the protection mechanism

- To burn correctly the fuse a specific configuration of inputs must be settled as below :
  - RST = ALE = 1
  - P2.7 = 1

Furthermore PSEN signal must be tied at + 9 V ± 5 % level voltage and a pulse must be applied on P2.6 input Port. The timing on P2.6 is shown below :



Time Rise and Fall Rise ≤ 100 µs.

- The electrical schematic shows a typical application to deliver P2.6 signal.

ELECTRICAL CHARACTERISTICS

ABSOLUTE MAXIMUM RATINGS*

Ambiant Temperature Under Bias :
- C = commercial ....0°C to 70°C
- I = industrial ....– 40°C to +85°C

Storage Temperature.......................– 65°C to + 150°C
Voltage on V_{CC} to V_{SS}..........................– 0.5 V to + 7 V
Voltage on Any Pin to V_{SS}........ – 0.5 V to V_{CC} + 0.5 V
Power Dissipation ....1 W**

** This value is based on the maximum allowable die temperature and the thermal resistance of the package

* Notice

Stresses at or 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 other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

DC CHARACTERISTICS

T_A = 0 to + 70°C ; Vcc = 5 V ± 20 % ; Vss = 0 V ; F = 0 to 16 MHz.
Vcc = 5 V ± 10 % ; Vss = 0 V ; F = 16 to 20 MHz
T_A = – 40 to 85°C ; Vcc = 5 V ± 10 % ; Vss = 0 V ; F = 0 to 16 MHz.

SYMBOL	PARAMETER	MIN	MAX	UNIT	TEST CONDITIONS
VIL	Input Low Voltage	– 0.5 V	0.2 VCC – 0.1	V	
VIH	Input High Voltage (Except XTAL and RST)	0.2 VCC + 0.9	VCC + 0.5	V	
VIH1	Input High Voltage (RST and XTAL1)	0.7 VCC	VCC + 0.5	V	
VOL	Output Low Voltage (Ports 1, 2, and 3)		0.3 0.45 1.0	V V V	IOL = 100 µA IOL = 1.6 mA (note 3) IOL = 3.5 mA
VOL1	Output Low Voltage (Port 0, ALE, $\overline{PSEN}$)		0.3 0.45 1.0	V V V	IOL = 200 µA IOL = 3.2 mA (note 3) IOL = 7.0 mA
VOH	Output High Voltage Ports 1, 2, 3	Vcc – 0.3		V	IOH = – 10 µA
		Vcc – 0.7		V	IOH = – 30 µA
		Vcc – 1.5		V	IOH = – 60 µA VCC = 5 V ± 10 %
VOH1	Output High Voltage (Port 0, ALE, PSEN)	Vcc – 0.3		V	IOH = – 200 µA
		Vcc – 0.7		V	IOH = – 3.2 mA
		Vcc – 1,5		V	IOH = – 7.0 mA VCC = 5 V ± 10 %
IIL	Logical 0 Input Current (Ports 1, 2, 3)		C – 50 I – 60	µA	Vin = 0.45 V
ILI	Input Leakage Current (Port 0, EA)		± 10	µA	0.45 < Vin < VCC
ITL	Logical 1 to 0 Transition Current (Ports 1, 2, 3)		– 650	µA	Vin = 2.0 V
IPD	Power Down Current		50	µA	VCC = 2.0 V to 6 V (note 2)
RRST	RST Pulldown Resistor	50	150	kΩ	
CIO	Capacitance of I/O Buffer		10	pF	f_c = 1 MHz, T_A = 25°C
ICC	Power Supply Current Active Mode 12 MHz 16 MHz 20 MHz Idle Mode 12 MHz 16 MHz 20 MHz		 20 26 32 5 6 8	 mA mA mA mA mA mA	(notes 1, 2)

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ABSOLUTE MAXIMUM RATINGS*

Ambiant Temperature Under Bias :
A = Automotive ....– 40°C to + 125°C
Storage Temperature.......................– 65°C to + 150°C
Voltage on Any Pin to V_{SS} ...... – 0.5 V to VCC + 0.5 V
Voltage on V_{CC} to V_{SS} ....– 0.5 V to 6.5 V
Power Dissipation ....1 W

*** Notice**

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DC CHARACTERISTICS

T_A = – 40° to 125°C ; V_{CC} = 5 V ± 10 % ; V_{SS} = 0 V ; F = 0 to 12 MHz

SYMBOL	PARAMETER	MIN	MAX	UNIT	TEST CONDITIONS
VIL	Input Low Voltage	– 0.5 V	0.2 VCC – 0.1	V	
VIH	Input High Voltage (Except XTAL1, RST)	0.2 VCC + 0.9	VCC + 0.5	V	
VIH1	Input High Voltage (XTAL1, RST)	0.7 VCC	VCC + 0.5	V	
VOL	Output Low Voltage (Ports 1, 2, and 3)		0.3 0.45 1.0	V V V	IOL = 100 µA IOL = 1.6 mA (note 3) IOL = 3.5 mA
VOL1	Output Low Voltage (Port 0, ALE, $\overline{\text{PSEN}}$)		0.3 0.45 1.0	V	IOL = 200 µA IOL = 3.2 mA (note 3) IOL = 7.0 mA
VOH	Output High Voltage (Ports 1, 2, 3)	Vcc – 0.3		V	IOH = – 10 µA
		Vcc – 0.7		V	IOH = – 30 µA
		Vcc – 1.5		V	IOH = – 60 µA
VOH1	Output High Voltage (Port 0 in External Bus Mode, ALE, PSEN)	Vcc – 0.3		V	IOH = – 200 µA
		Vcc – 0.7		V	IOH = – 3.2 mA
		Vcc – 1,5		V	IOH = – 7.0 mA
IIL	Logical 0 Input Current Ports 1, 2, 3		– 75	µA	Vin = 0.45 V
ITL	Logical 1 to 0 Transition Current (Ports 1, 2, 3)		– 750	µA	Vin = 2.0 V
ILI	Input Leakage Current (Port 0, $\overline{\text{EA}}$)		± 10	µA	0.45 < Vin < VCC
RRST	RST Pulldown Resistor	50	150	kΩ	
CIO	Pin Capacitance		10	pF	Test Freq = 1 MHz, T_A = 25°C
IPD	Power Down Current		75	µA	VCC = 2 V to 5.5 V (note 2)
ICC	Power supply current Active mode 12 MHz Idle mode 12 MHz		 21 7	 mA mA	 VCC = 5.5 V (notes 1, 2) VCC = 5.5 V (notes 1, 2)

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ABSOLUTE MAXIMUM RATINGS*

Ambiant Temperature Under Bias :
M =Military .... – 55°C to + 125°C
Storage Temperature .... – 65°C to + 150°C
Voltage on Any Pin to V_{SS} ....– 0.5 V to VCC + 0.5 V
Voltage on V_{CC} to V_{SS} .... – 0.5 V to 6.5 V
Power Dissipation .... 1 W

*** Notice**

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 other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended period may affect device reliability.

DC CHARACTERISTICS

T_A = – 55° to 125°C ; VSS = 0 V ; VCC = 5 V ± 10 % ; F = 0 to 12 MHz

SYMBOL	PARAMETER	MIN	MAX	UNIT	TEST CONDITIONS
VIL	Input Low Voltage	– 0.5 V	0.2 VCC – 0.1	V	
VIH	Input High Voltage (Except XTAL1, RST)	0.2 VCC + 0.9	VCC + 0.5	V	
VIH1	Input High Voltage (XTAL1, RST)	0.7 VCC	VCC + 0.5	V	
VOL	Output Low Voltage (Ports 1, 2, 3)		0.45	V	IOL = 1.6 mA (note 3)
VOL1	Output Low Voltage (Port 0, ALE, $\overline{PSEN}$)		0.45	V	IOL = 3.2 mA (note 3)
VOH	Output High Voltage (Ports 1, 2, 3)	2.4		V	IOH = – 60 µA VCC = 5 V ± 10 %
		0.75 VCC		V	IOH = – 25 µA
		0.9 VCC		V	IOH = – 10 µA
VOH1	Output High Voltage (Port 0 in External Bus Mode, ALE, PEN)	2.4		V	IOH = – 800 µA VCC = 5 V ± 10 %
		0.75 VCC		V	IOH = – 300 µA
		0.9 VCC		V	IOH = – 80 µA
IIL	Logical 0 Input Current Ports 1, 2, 3		– 75	µA	Vin = 0.45 V
ITL	Logical 1 to 0 Transition Current (Ports 1, 2, 3)		– 750	µA	Vin = 2 V
ILI	Input Leakage Current (Port 0, $\overline{EA}$)		± 10	µA	0.45 < Vin < VCC
RRST	RST Pulldown Resistor	50	150	kΩ	
CIO	Pin Capacitance		10	pF	Test Freq = 1 MHz, T_A = 25°C
IPD	Power Down Current		75	µA	VCC = 2 V to 5.5 V (note 2)
ICC	Power supply current Active mode 12 MHz Idle mode 12 MHz		 21 7	 mA mA	 VCC = 5.5 V (notes 1, 2) VCC = 5.5 V (notes 1, 2)

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ABSOLUTE MAXIMUM RATINGS*

Ambiant Temperature Under Bias :
C = commercial .... 0°C to 70°C
I = industrial .... – 40°C to +85°C
Storage Temperature .... – 65°C to + 150°C
Voltage on V_{CC} to V_{SS} .... – 0.5 V to + 7 V
Voltage on Any Pin to V_{SS} .... – 0.5 V to V_{CC} + 0.5 V
Power Dissipation .... 1 W**

** This value is based on the maximum allowable die temperature and the thermal resistance of the package

*** Notice**

Stresses at or 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 other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

DC CHARACTERISTICS

T_A = – 40° to 85°C ; V_{CC} = 2.7 V to 6 V ; VSS = 0 V ; F = 0 to 6 MHz

SYMBOL	PARAMETER	MIN	MAX	UNIT	TEST CONDITIONS
VIL	Input Low Voltage	– 0.5 V	0.2 V_{CC} – 0.1	V	
VIH	Input High Voltage (Except XTALs and RST)	0.2 V_{CC} + 0.9	V_{CC} + 0.5	V	
VIH1	Input High Voltage to RST for Reset	0.7 V_{CC}	V_{CC} + 0.5	V	
VIH2	Input High Voltage to XTAL1	0.7 V_{CC}	V_{CC} + 0.5	V	
VPD	Power Down Voltage to V_{CC} in PD Mode	2.0	6.0	V	
VOL	Output Low Voltage (Ports 1, 2, and 3)		0.45		IOL = 800 µA (note 3)
VOL1	Output Low Voltage (Port 0, ALE, $\overline{PSEN}$)		0.45	V	IOL = 1.6 mA (note 3)
VOH	Output High Voltage Ports 1, 2, 3	0.9 V_{CC}		V	IOH = – 10 µA
VOH1	Output High Voltage (Port 0 in External Bus Mode), ALE, $\overline{PEN}$	0.9 V_{CC}		V	IOH = – 80 µA
IIL	Logical 0 Input Current Ports 1, 2, 3		C: – 50 I: – 60	µA	Vin = 0.45 V
ILI	Input Leakage Current		± 10	µA	0.45 < Vin < VCC
ITL	Logical 1 to 0 Transition Current (Ports 1, 2, 3)		– 650	µA	Vin = 2.0 V
IPD	Power Down Current		50	µA	V_{CC} = 2.0 V to 6 V (note 2)
RRST	RST Pulldown Resistor	50	150	kΩ	
CIO	Capacitance of I/O Buffer		10	pF	f_c = 1 MHz, T_A = 25°C

MAXIMUM I_{CC} (mA)

	OPERATING (NOTE 3)			IDLE (NOTE 4)		
FREQ. VCC	2.7 V	5 V	6 V	2.7 V	5 V	6 V
1 MHz	0.8 mA	1.5 mA	1.8 mA	400 µA	800 µA	1 mA
6 MHz	4 mA	8 mA	10 mA	1.2 mA	3.5 mA	3.8 mA

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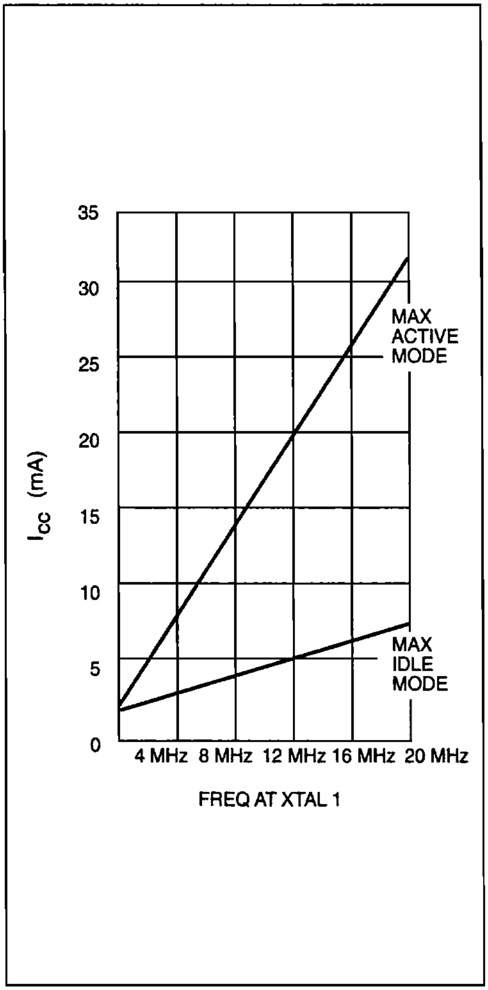

Figure 1 : ICC vs. Frequency. Valid only within frequency specifications of the device under test.

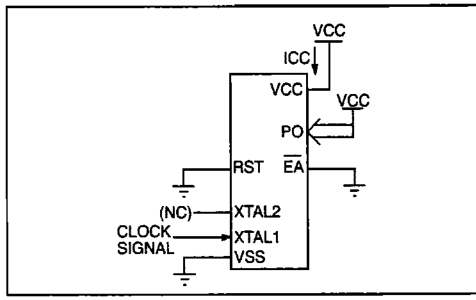

Figure 12 : ICC Test Condition, Idle Mode. All other pins are disconnected.

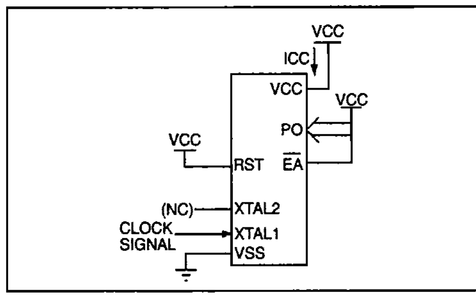

Figure 13 : ICC Test Condition, Active Mode. All other pins are disconnected.

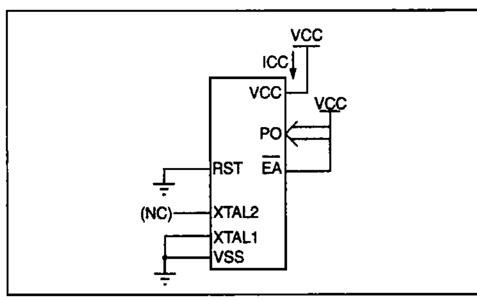

Figure 15 : ICC Test Condition, Power Down Mode. All other pins are disconnected.

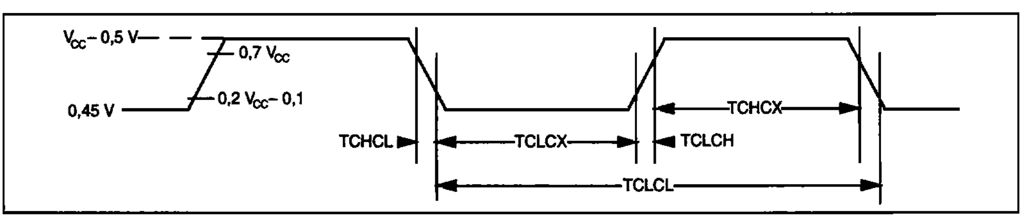

Figure 14 : Clock Signal Waveform for ICC Tests in Active and Idle Modes. TCLCH = TCHCL = 5 ns.

Note 1 : ICC max is given by :

Active Mode : ICCMAX = 1.47 x FREQ + 2.35

Idle Mode : ICCMAX = 0.33 x FREQ + 1.05

where FREQ is the external oscillator frequency in MHz. ICCMAX is given in mA. See figures 1 through 5 for ICC test conditions.

Note 2: ICC is measured with all output pins disconnected ; XTAL1 driven with TCLCH, TCHCL = 5 ns, VIL = VSS + .5 V, VIH = VCC – .5 V ; XTAL2 N.C. ; EA = RST = Port 0 = VCC. ICC would be slightly higher if a crystal oscillator used.

Idle ICC is measured with all output pins disconnected ; XTAL1 driven with TCLCH, TCHCL = 5 ns, VIL = VSS + .5 V, VIH = VCC – .5 V ; XTAL2 N.C ; Port 0 = VCC ; EA = RST = VSS.

Power Down ICC is measured with all output pins disconnected ; EA = PORT 0 = VCC ; XTAL2 N.C. ; RST = VSS.

Note 3 : Capacitance loading on Ports 0 and 2 may cause spurious noise pulses to be superimposed on the V_{OLS} 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 100 pF), the noise pulse on the ALE line may exceed 0.45 V may exceed 0,45 V with maxi VOL peak 0.6 V. A Schmitt Trigger use is not necessary.

EXPLANATION OF THE AC SYMBOL

Each timing symbol has 5 characters. The first character is always a "T" (stands for time). The other characters, depending on their positions, stand for the name of a signal or the logical status of that signal. The following is a list of all the characters and what they stand for.

Example :

TAVLL = Time for Address Valid to ALE low.

TLLPL = Time for ALE low to $\overline{\text{PSEN}}$ low.

A : Address.	Q : Output data.
C : Clock.	R : READ signal.
D : Input data.	T : Time.
H : Logic level HIGH.	V : Valid.
I : Instruction (program memory contents).	W : WRITE signal.
L : Logic level LOW, or ALE.	X : No longer a valid logic level.
P : PSEN.	Z : Float.

AC PARAMETERS

T_A = 0 to + 70 °C ; VSS = 0 V ; VCC = 5 V ± 20 % ; 0 to 16 MHz
T_A = 0 to + 70 °C ; VSS = 0 V ; VCC = 5 V ± 10 % ; 16 to 20 MHz
T_A = – 40 to + 85 °C ; VSS = 0 V ; VCC = 5 V ± 10 % ; 0 to 16 MHz
T_A = – 55 to + 125 °C ; VSS = 0 V ; VCC = 5 V ± 10 % ; 0 to 12 MHz
(Load Capacitance for PORT0, ALE and PSEN = 100 pf ; Load Capacitance for all other outputs = 80 pf.)

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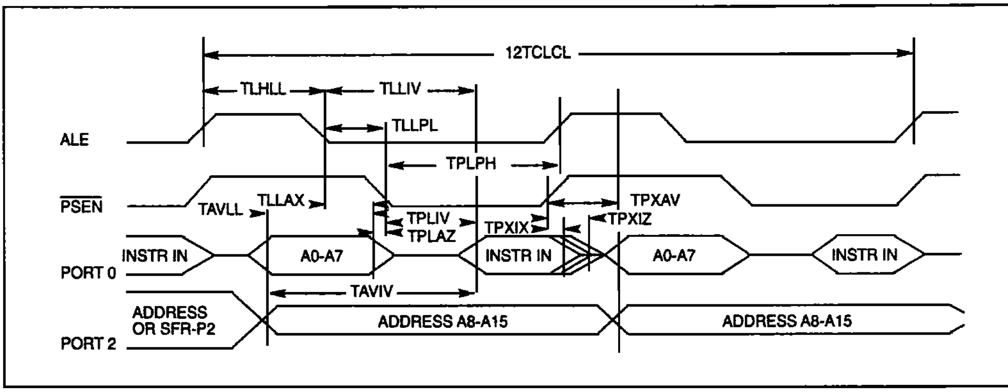
EXTERNAL PROGRAM MEMORY CHARACTERISTICS

SYMBOL	PARAMETER	0 TO 12 MHz		16 MHz		20 MHz	
		MIN	MAX	MIN	MAX	MIN	MAX
TLHLL	ALE pulse width	2TCLCL-40		110		70	
TAVLL	Address Valid to ALE	TCLCL-40		30		25	
TLLAX	Address Hold After ALE	TCLCL-30		35		25	
TLLIV	ALE to Valid Instr In		4TCLCL-100		185		140
TLLPL	ALE to PSEN	TCLCL-30		45		30	
TPLPH	PSEN Pulse Width	3TCLCL-45		165		130	
TPLIV	PSEN to Valid Instr IN		3TCLCL-105		125		80
TPXIX	Input Instr Hold After PSEN	0		0		0	
TPXIZ	Input Instr Float After PSEN		TCLCL-25		22		10
TPXAV	PSEN to Address Valid	TCLCL-8		55		45	
TAVIV	Address to Valid Instr In		5TCLCL-105		230		180
TPLAZ	PSEN Low to Address Float		10		10		10

EXTERNAL PROGRAM MEMORY READ CYCLE



EXTERNAL DATA MEMORY CHARACTERISTICS

SYMBOL	PARAMETER	0 TO 12 MHz		16 MHz		20 MHz	
		MIN	MAX	MIN	MAX	MIN	MAX
TRLRH	RD Pulse Width	6TCLCL-100		340		260	
TWLWH	WR Pulse Width	6TCLCL-100		340		260	
TRLDV	RD to Valid Data In		5TCLCL-165		240		180
TRHDX	Data Hold After RD	0		0		0	
TRHDZ	Data Float After RD		2TCLCL-60		90		70
TLLDV	ALE to Valid Data In		8TCLCL-150		435		360
TAVDV	Address to Valid Data In		9TCLCL-165		480		400
TLLWL	ALE to WR or RD	3TCLCL-50	3TCLCL+50	150	250	125	185
TAVWL	Address to WR or RD	4TCLCL-130		180		170	
TQVWX	Data Valid to WR Transition	TCLCL-50		15		10	
TQVWH	Data Set-Up to WR High	7TCLCL-150		380		310	
TWHQX	Data Hold After WR	TCLCL-50		40		30	
TRLAZ	RD Low to Address Float		0		0		0
TWHLH	RD or WR High to ALE High	TCLCL-40	TCLCL+40	35	90	30	65

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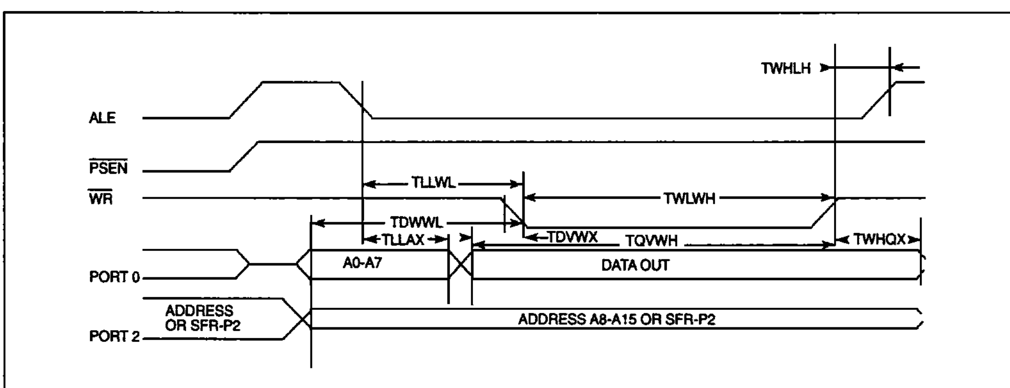
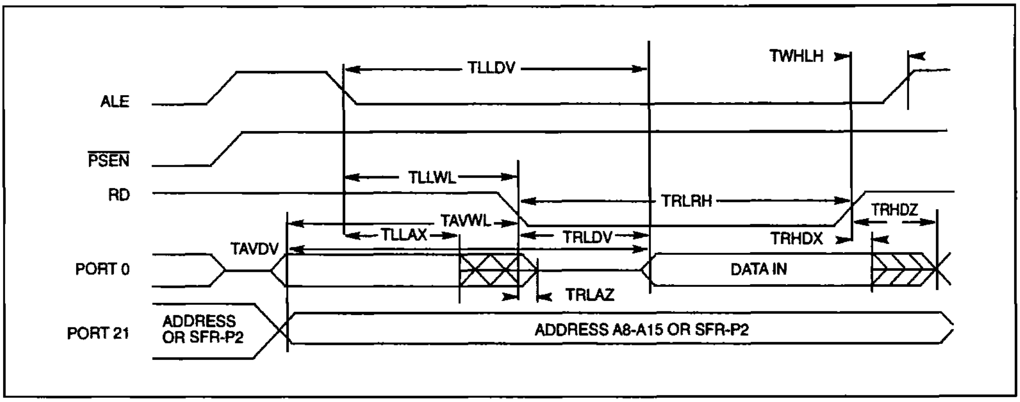
EXTERNAL DATA MEMORY WRITE CYCLE



EXTERNAL DATA MEMORY READ CYCLE

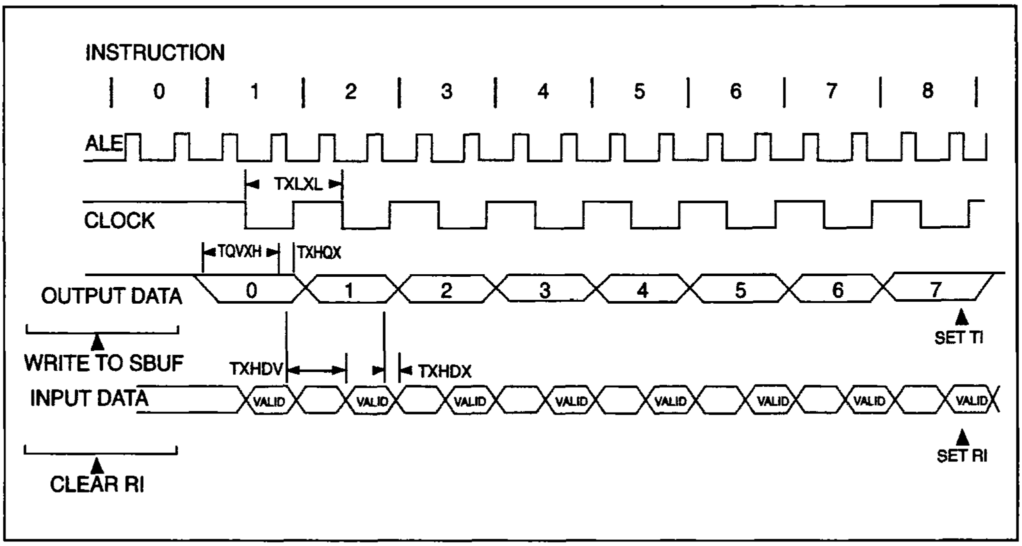


SERIAL PORT TIMING – SHIFT REGISTER MODE

T_A = 0 to + 70 °C ; VSS = 0 V ; VCC = 5 V ± 20 % ; 0 to 16 MHz
T_A = 0 to + 70 °C ; VSS = 0 V ; VCC = 5 V ± 10 % ; 16 to 20 MHz
T_A = – 40 to + 85 °C ; VSS = 0 V ; VCC = 5 V ± 20 % ; 0 to 16 MHz
T_A = – 55 to + 125 °C ; VSS = 0 V ; VCC = 5 V ± 10 % ; 0 to 12 MHz

SYMBOL	PARAMETER	0 TO 12 MHz		16 MHz		20 MHz	
		MIN	MAX	MIN	MAX	MIN	MAX
TXLXL	Serial port clock cycle time	12TCLCL		750		600	
TQVHX	Output data setup to clock rising edge	10TCLCL-133		563		450	
TXHQX	Output data hold after clock rising edge	2TCLCL-117		63		50	
TXHDX	Input data hold after clock rising edge	0		0		0	
TXHDV	Clock rising edge to input data valid		10TCLCL-133		563		450

SHIFT REGISTER TIMING WAVEFORMS

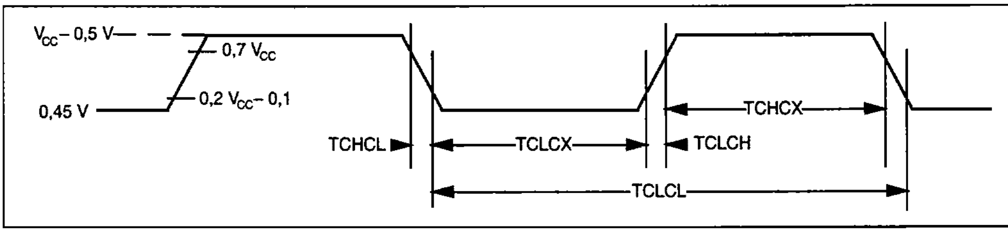


EXTERNAL CLOCK DRIVE CHARACTERISTICS (XTAL1)

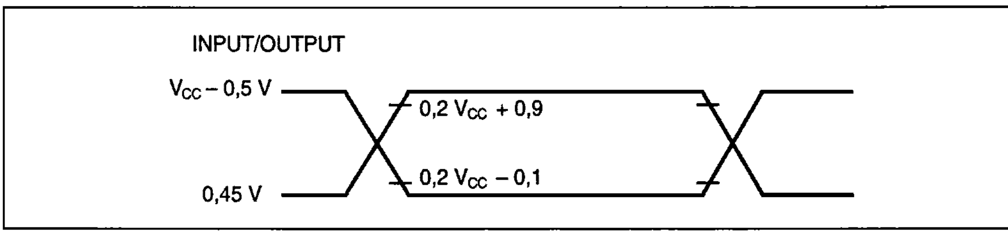
SYMBOL	PARAMETER	MIN	MAX	UNIT
TCLCL	Oscillator Period	50 (5)		ns
TCHCX	High Time	20 (5)		ns
TCLCX	Low Time	20 (5)		ns
TCLCH	Rise Time		20 (5)	ns
TCHCL	Fall Time		20 (5)	ns

(5) AT 20 MHz

EXTERNAL CLOCK DRIVE WAVEFORMS

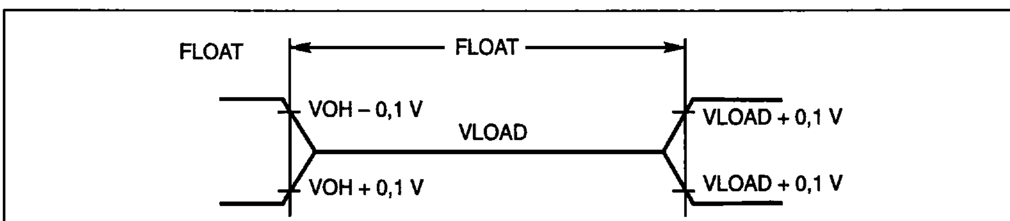


AC TESTING INPUT/OUTPUT WAVEFORMS



AC inputs during testing are driven at V_{CC} – 0.5 for a logic "1" and 0.45 V for a logic "0". Timing measurements are made at VIH min for a logic "1" and VIL max for a logic "0".

FLOAT WAVEFORMS



For timing purposes as port pin is no longer floating when a 100 mV change from load voltage occurs and begins to float when a 100 mV change from the loaded VOH/VOL level occurs. IoI/IoH ≥ ± 20 mA.

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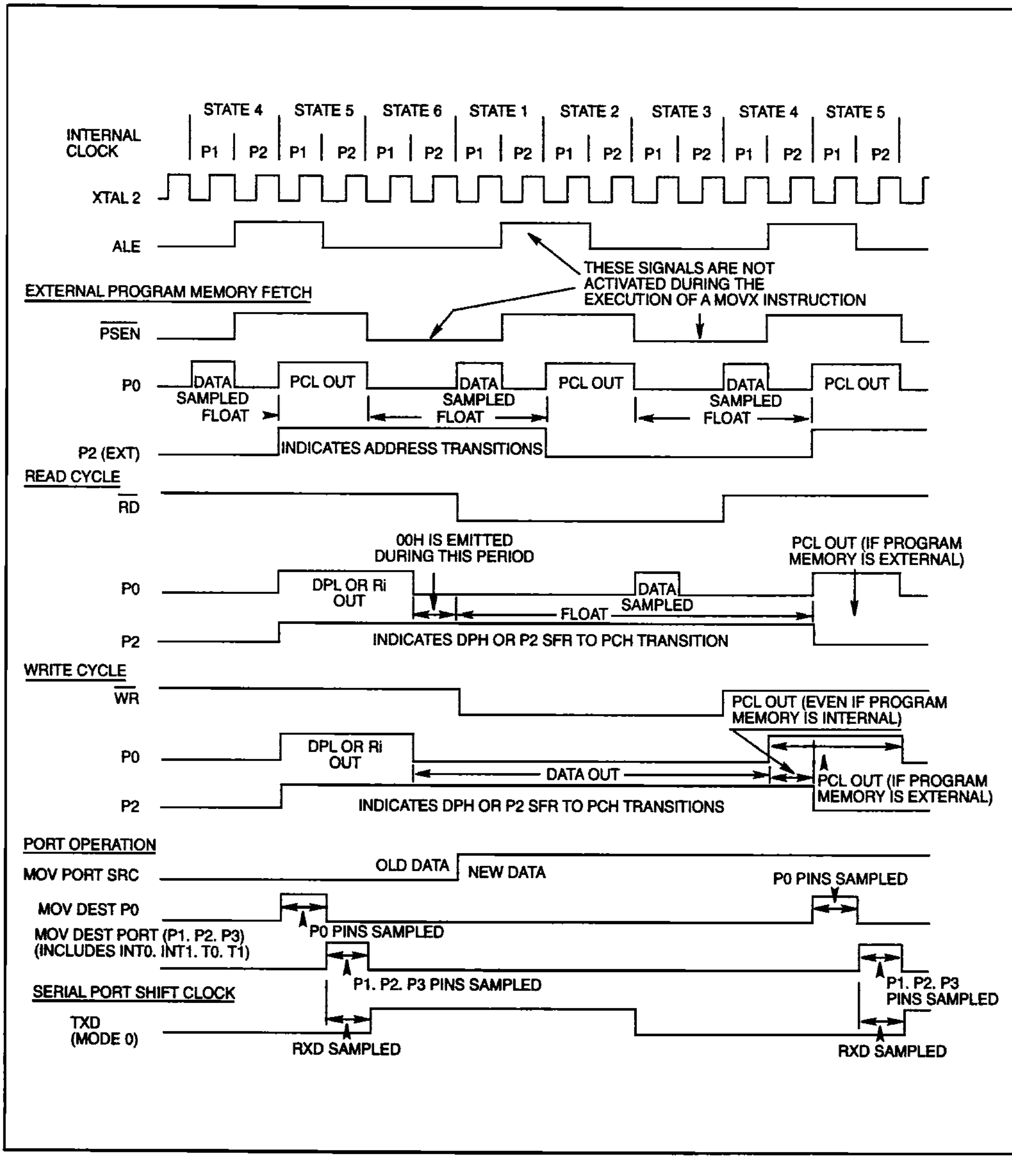
CLOCK WAVEFORMS



This diagram indicates when signals are clocked internally. The time it takes the signals to propagate to the pins, however, ranges from 25 to 125 ns. This propagation delay is dependent on variables such as temperature and pin loading. Propagation also varies from output to output and component. Typically though ($T_A = 25°C$ fully loaded) RD and WR propagation delays are approximately 50 ns. The other signals are typically 85 ns. Propagation delays are incorporated in the AC specifications.

INSTRUCTION OPCODES

MHS C51 INSTRUCTION SET DESCRIPTION

ARITHMETIC OPERATIONS

MNEMONIC		DESCRIPTION	BYTE	CYC
ADD	A, Rn	Add registrer to Accumulator	1	1
ADD	A, direct	Add direct bytes to Accumulator	2	1
ADD	A, @Ri	Add indirect RAM to Accumulator	1	1
ADD	A, #data	Add immediate data ot Accumulator	2	1
ADDC	A, Rn	Add register to Accumulator with Carry	1	1
ADDC	A, direct	Add direct byte to A with Carry flag	2	1
ADDC	A, @Ri	Add indirect RAM to A with Carry flag	1	1
ADDC	A, #data	Add immediate data to A with Carry flag	2	1
SUBB	A, Rn	Subtract register from A with borrow	1	1
SUBB	A, direct	Subtract direct byte from A with Borrow	2	1
SUBB	A, @Ri	Subtract indirect RAM from A with Borrow	1	1
SUBB	A, data	Subtract immed. data from A with Borrow	2	1
INC	A	Increment Accumulator	1	1
INC	Rn	Increment register	1	1
INC	direct	Increment direct byte	2	1
INC	@Ri	Increment indirect RAM	1	1
INC	DPTR	Increment Data Pointer	1	2
DEC	A	Decrement Accumulator	1	1
DEC	Rn	Decrement register	1	1
DEC	direct	Decrement direct byte	2	1
DEC	@Ri	Decrement indirect RAM	1	1
MUL	AR	Multiply A & B	1	4
DIV	AB	Divide A by B	1	4
DA	A	Decimal Adjust Accumulator	1	1

LOGICAL OPERATIONS

MNEMONIC		DESTINATION	BYTE	CYC
ANL	A, Rn	AND register to Accumulator	1	1
ANL	A, direct	AND direct byte to Accumulator	2	1
ANL	A, @Ri	AND indirect RAM to Accumulator	1	1
ANL	A, #data	AND immediate data to Accumulator	2	1
ANL	direct, A	AND Accumultaor to direct byte	2	1
ANL	direct, #data	AND immediate data to direct byte	3	2
ORL	A, Rn	OR register to Accumulator	1	1
ORL	A, direct	OR direct byte to Accumulator	2	1
ORL	A, @Ri	OR indirect RAM to Accumulator	1	1
ORL	A, #data	OR immediate data to Accumulator	2	1
ORL	direct A	OR Accumulator to direct byte	2	1
ORL	direct, #data	OR immediate data to direct byte	3	2
XRL	A, Rn	Exclusive-OR register to Accumulator	1	1
XRL	A, direct	Exclusive-OR direct byte to Accumulator	2	1
XRL	A, @Ri	Exclusive-OR indirect RAM to A	1	1
XRL	A, #data	Exclusive-OR immediate data to A	2	1
XRL	direct, A	Exclusive-OR Accumulator to direct byte	2	1
XRL	direct, #data	Exclusive-OR immediate data to direct	3	2
CLR	A	Clear Accumulator	1	1
CPL	A	Complement Accumulator	1	1
RL	A	Rotate Accumulator Left	1	1
RLC	A	Rotate A Left through the Carry flag	1	1
RR	A	Rotate Accumulator Right	1	1
RRC	A	Rotate A Flight through Carry flag	1	1
SWAP	A	Swap nibbles within the Accumulator	1	1

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ARITHMETIC TRANSFER

MNEMONIC		DESCRIPTION	BYTE	CYC
MOV	A, Rn	Move register to Accumulator	1	1
MOV	A, direct	Move direct byte to Accumulator	2	1
MOV	A, @Ri	Move indirect RAM to Accumulator	1	1
MOV	A, #data	Move immediate data to Accumulator	2	1
MOV	Rn, A	Move Accumulator to register	1	1
MOV	Rn, direct	Move direct byte to register	2	2
MOV	Rn, #data	Move immediate data to register	2	1
MOV	direct, A	Move Accumulator to direct byte	2	1
MOV	direct, Rn	Move register to direct byte	2	2
MOV	direct, direct	Move direct byte to direct	3	2
MOV	direct, @Ri	Move indirect RAM to direct byte	2	2
MOV	direct, #data	Move immediate data to direct byte	3	2
MOV	@Ri, A	Move Accumulator to indirect RAM	1	1
MOV	@Ri, direct	Move direct byte to indirect RAM	2	2
MOV	@Ri, #data	Move immediate data to indirect RAM	2	1
MOV	DPTR, #data 16	Load Data Pointer with a 16-bit constant	3	2
MOVC	A, @A + DPTR	Move Code byte relative to DPTR to A	1	2
MOVC	A, @A + PC	Move Code byte relative to PC to A	1	2
MOVX	A, @Ri	Move External RAM (8-bit addr) to A	1	2
MOVX	A, @DPTR	Move external RAM (16-bit addr) to A	1	2
MOVX	@Ri, A	Move A to External RAM (8-bit addr)	1	2
MOVX	@DPTR, A	Move A to External RAM (16-bit addr)	1	2
PUSH	direct	Push direct byte onto stack	2	2
POP	direct	Pop direct byte from stack	2	2
XCH	A, Rn	Exchange register with Accumulator	1	1
XCH	A, direct	Exchange direct byte with Accumulator	2	1
XCH	A, @Ri	Exchange indirect RAM with A	1	1
XCHD	A, @Ri	Exchange low-order nibble ind RAM with A	1	1

BOOLEAN VARIABLE MANIPULATION

MNEMONIC		DESCRIPTION	BYTE	CYC
CLR	C	Clear Carry flag	1	1
CLR	bit	Clear direct bit	2	1
SETB	C	Set Carry flag	1	1
SETB	bit	Set direct Bit	2	1
CPL	C	Complement Carry flag	1	1
CPL	bit	Complement direct bit	2	1
ANL	C, bit	AND direct bit to Carry flag	2	2
ANL	C,/bit	AND complement of direct bit to Carry	2	2
ORL	C,bit	OR direct bit to Carry flag	2	2
ORL	C,/bit	OR complement of direct bit to Carry	2	2
MOV	C,bit	Move direct bit to Carry flag	2	1
MOV	bit, C	Move Carry flag to direct bit	2	2

PROGRAM AND MACHINE CONTROL

MNEMONIC		DESCRIPTION	BYTE	CYC
ACALL	addr 11	Absolute subroutine Call	2	2
LCALL	addr 16	Long Subroutine Call	3	2
RET		Return from subroutine	1	2
RETI		Return from interrupt	1	2
AJMP	addr 11	Absolute Jump	2	2
LJMP	addr 16	Long Jump	3	2
SJMP	rel	Short Jump (relative addr)	2	2
JMP	@A + DPTR	Jump indirect relative to the DPTR	1	2
JZ	rel	Jump if Accumulator is Zero	2	2
JNZ	rel	Jump if Accumulator is Not Zero	2	2
JC	rel	Jump if Carry flag is set	2	2
JNC	rel	Jump if No Carry flag	2	2

PROGRAM AND MACHINE CONTROL (cont.)				
MNEMONIC		DESCRIPTION	BYTE	CYC
JB	bit, rel	Jump if direct Bit set	3	2
JNB	bit, rel	Jump if direct Bit Not sef	3	2
JBC	bit, rel	Jump if direct Bit is set & Clear bit	3	2
CJNE	A, direct, rel	Compare direct to A & Jump if Not Equal	3	2
CJNE	A, #data, ref	Comp. immed. to A & Jump if Not Equal	3	2
CJNE	Rn, #data, rel	Comp. immed. to reg & Jump if Not Equal	3	2
CJNE	@Ri, #data, rel	Comp. immed. to ind. & jump if Not Equal	3	2
DJNZ	Rn, rel	Decrement register & Jump if Not Zero	2	2
DJNZ	direct, rel	Decrement direct & Jump if Not Zero	3	2
NOP		No operation	1	1

Notes on data addressing modes :

Rn	– Working register R0-R7
direct	– 128 internal RAM locations, any I/O port, control or status register
@Ri	– Indirect internal RAM location addressed by register R0 or R1
#data	– 8-bit constant included in instruction
#data 16	– 16-bit constant included as bytes 2 & 3 of instruction
bit	– 128 software flags, any I/O pin, control or status bit

Notes on program addressing modes :

addr 16	– Destination address for LCALL & LJMP may be anywhere within the 64-k program memory address space
Addr 11	– Destination address for ACALL & AJMP will be within the same 2-k page of program memory as the first byte of the following instruction
rel	– SJMP and all conditional jumps include an 8-bit offset byte. Range is + 127 – 128 bytes relative to the first byte of the following instruction.

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INSTRUCTION OPCODES IN HEXADECIMAL ORDER

HEX CODE	NUMB. OF BYTES	MNEM.	OPERANDS
00	1	NOP	
01	2	AJMP	code addr
02	3	LJMP	code addr
03	1	RR	A
04	1	INC	A
05	2	INC	data addr
06	1	INC	@R0
07	1	INC	@R1
08	1	INC	R0
09	1	INC	R1
0A	1	INC	R2
0B	1	INC	R3
0C	1	INC	R4
0D	1	INC	R5
0E	1	INC	R6
0F	1	INC	R7
10	3	JBC	bit addr, code addr
11	2	ACALL	code addr
12	3	LCALLR	code addr
13	1	RC	A
14	1	DEC	A
15	2	DEC	data addr
16	1	DEC	@R0
17	1	DEC	@R1
18	1	DEC	R0
19	1	DEC	R1
1A	1	DEC	R2
1B	1	DEC	R3
1C	1	DEC	R4
1D	1	DEC	R5
1E	1	DEC	R6
1F	1	DEC	R7
20	3	JB	bit addr, code addr
21	2	AJMP	code addr
22	1	RET	
23	1	RL	A
24	2	ADD	A, data
25	2	ADD	A, data addr
26	1	ADD	A, @R0
27	1	ADD	A, @R1
28	1	ADD	A, R0
29	1	ADD	A, R1
2A	1	ADD	A, R2
2B	1	ADD	A, R3
2C	1	ADD	A, R4
2D	1	ADD	A, R5
2E	1	ADD	A, R6
2F	1	ADD	A, R7
30	3	JNB	bit, addr, code
31	2	ACALL	addr
32	1	RETI	code addr

HEX CODE	NUMB. OF BYTES	MNEM.	OPERANDS
33	1	RLC	A
34	2	ADDC	A, #data
35	2	ADDC	A, data addr
36	1	ADDC	A, @RD
37	1	ADDC	A, @R1
38	1	ADDC	A, R0
39	1	ADDC	A, R1
3A	1	ADDC	A, R2
3B	1	ADDC	A, R3
3C	1	ADDC	A, R4
3D	1	ADDC	A, R5
3E	1	ADDC	A, R6
3F	1	ADDC	A, R7
40	2	JC	code addr
41	2	AJMP	code addr
42	2	ORL	data addr A
43	3	ORL	data addr, #data
44	2	ORL	A, #data
45	2	ORL	A, data addr
46	1	ORL	A, @R0
47	1	ORL	A, @R1
48	1	ORL	A, R0
49	1	ORL	A, R1
4A	1	ORL	A, R2
4B	1	ORL	A, R3
4C	1	ORL	A, R4
4D	1	ORL	A, R5
4E	1	ORL	A, R6
4F	1	ORL	A, R7
50	2	JNC	code addr
51	2	ACALL	code addr
52	2	ANL	data addr, A
53	3	ANL	data addr, #data
54	2	ANL	A, #data
55	2	ANL	A, data addr
56	1	ANL	A, @R0
57	1	ANL	A, @R1
58	1	ANL	A, R0
59	1	ANL	A, R1
5A	1	ANL	A, R2
5B	1	ANL	A, R3
5C	1	ANL	A, R4
5D	1	ANL	A, R5
5E	1	ANL	A, R6
5F	1	ANL	A, R7
60	2	JZ	code addr
61	2	AJMP	code addr
62	2	XRL	data addr A
63	3	XRL	data addr, #data
64	2	XRL	A, #data
65	2	XRL	A, data addr

HEX CODE	NUMB. OF BYTES	MNEM.	OPERANDS
66	1	XRL	A, @R0
67	1	XRL	A, @R1
68	1	XRL	A, R0
69	1	XRL	A, R1
6A	1	XRL	A, R2
6B	1	XRL	A, R3
6C	1	XRL	A, R4
6D	1	XRL	A, R5
6E	1	XRL	A, R6
6F	1	XRL	A, R7
70	2	JNZ	code addr
71	2	ACALL	code addr
72	2	ORL	C, bit addr
73	1	JMP	@A + DPTR
74	2	MOV	A, #data
75	3	MOV	data addr, #data
76	2	MOV	@R0, #data
77	2	MOV	@R1, #data
78	2	MOV	R0, #data
79	2	MOV	R1, #data
7A	2	MOV	R2, #data
7B	2	MOV	R3, #data
7C	2	MOV	R4, #data
7D	2	MOV	R5, #data
7E	2	MOV	R6, #data
7F	2	MOV	R7, #data
80	2	SJMP	code addr
81	2	AJMP	code addr
82	2	ANL	C, bit addr
83	1	MOVC	A, @A + PC
84	1	DIV	AB
85	3	MOV	data addr, data addr
86	2	MOV	data addr, @R0
87	2	MOV	data addr, @R1
88	2	MOV	data addr, R0
89	2	MOV	data addr, R1
8A	2	MOV	data addr, R2
8B	2	MOV	data addr, R3
8C	2	MOV	data addr, R4
8D	2	MOV	data addr, R5
8E	2	MOV	data addr, R6
8F	2	MOV	data addr, R7
90	3	MOV	DPTR, #data
91	2	ACALL	code adddr
92	2	MOV	bit addr, C
93	1	MOVC	A, @A + DPTR
94	2	SUBB	A, #data
95	2	SUBB	A, data addr
96	1	SUBB	A, @R0
97	1	SUBB	A, @R1
98	1	SUBB	A, R0

HEX CODE	NUMB. OF BYTES	MNEM.	OPERANDS
99	1	SUBB	A, R1
9A	1	SUBB	A, R2
9B	1	SUBB	A, R3
9C	1	SUBB	A, R4
9D	1	SUBB	A, R5
9E	1	SUBB	A, R6
9F	1	SUBB	A, R7
A0	2	ORL	C, bit addr
A1	2	AJMP	code addr
A2	2	MOV	C, bit addr
A3	1	INC	DPTR
A4	1	MUL	AB
A5		reserved	
A6	2	MOV	@R0, data addr
A7	2	MOV	@R1, data addr
A8	2	MOV	R0, data addr
A9	2	MOV	R1, data addr
AA	2	MOV	R2, data addr
AB	2	MOV	R3, data addr
AC	2	MOV	R4, data addr
AD	2	MOV	R5, data addr
AE	2	MOV	R6, data addr
AF	2	MOV	R7, data addr
B0	2	ANL	C, bit addr
B1	2	ACALL	code addr
B2	2	CPL	Bit addr
B3	1	CPL	C
B4	3	CJNE	A, #data, code addr
B5	3	CJNE	A, data addr, code addr
B6	3	CJNE	@R0, #data, code addr
B7	3	CJNE	@R1, #data, code addr
B8	3	CJNE	R0, #data, code addr
B9	3	CJNE	R1, #data, code addr
BA	3	CJNE	R2, #data, code addr
BB	3	CJNE	R3, #data, code addr
BC	3	CJNE	R5, #data, code addr
BD	3	CJNE	R4, #data, code addr
BE	3	CJNE	R6, #data, code addr
BF	3	CJNE	R7, #data, code addr
C0	2	PUSH	data addr
C1	2	AJMP	code addr
C2	2	CLR	bit addr
C3	1	CLR	C
C4	1	SWAP	A
C5	2	XCH	A, data addr
C6	1	XCH	A, @R0
C7	1	XCH	A, @R1
C8	1	XCH	A, R0
C9	1	XCH	A, R1
CA	1	XCH	A, R2
CB	1	XCH	A, R3

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HEX CODE	NUMB. OF BYTES	MNEM.	OPERANDS
CC	1	XCH	A, R4
CD	1	XCH	A, R5
CE	1	XCH	A, R6
CF	1	XCH	A, R7
D0	2	POP	data addr
D1	2	ACALL	code addr
D2	2	SETB	bit addr
D3	1	SETB	C
D4	1	DA	A
D5	3	DJNZ	data addr, code addr
D6	1	XCHD	A, @R0
D7	1	XCHD	A, @R1
D8	2	DJNZ	R0, code addr
D9	2	DJNZ	R1, code addr
DA	2	DJNZ	R2, code addr
DB	2	DJNZ	R3, code addr
DC	2	DJNZ	R4, code addr
DD	2	DJNZ	R5, code addr
DE	2	DJNZ	R6, code addr
DF	2	DJNZ	R7, code addr
E0	1	MOVX	A, @DPTR
E1	2	AJMP	code addr
E2	1	MOVX	A, @R0
E3	1	MOVX	A, @R1
E4	1	CLR	A
E5	2	MOV	A, data addr

HEX CODE	NUMB. OF BYTES	MNEM.	OPERANDS
E6	1	MOV	A, @R0
E7	1	MOV	A, @R1
E8	1	MOV	A, R0
E9	1	MOV	A, R1
EA	1	MOV	A, R2
EB	1	MOV	A, R3
EC	1	MOV	A, R4
ED	1	MOV	A, R5
EE	1	MOV	A, R6
EF	1	MOV	A, R7
F0	1	MOVX	@DPTR, A
F1	2	ACALL	code addr
F2	1	MOVX	@R0, A
F3	1	MOVX	@R1, A
F4	1	CPL	A
F5	2	MOV	data addr, A
F6	1	MOV	@R0, A
F7	1	MOV	@R1, A
F8	1	MOV	R0, A
F9	1	MOV	R1, A
FA	1	MOV	R2, A
FB	1	MOV	R3, A
FC	1	MOV	R4, A
FD	1	MOV	R5, A
FE	1	MOV	R6, A
FF	1	MOV	R7, A

ORDERING INFORMATION

A Q L I M	R P S D J V T	80C31 80C51 80C51F	xxx	– L – S – 1 /B	: D : R
Temperature Range blank : Commercial I : Industrial M : Military L : Ind + BI* Q : Com + BI* A : Automotive	Package Type P : Plastic DIL S : PLCC D : Cerdip R : LCC J : J leaded LCC F : Quad Flat Pack V : S Quad Flat Pack (1.4 mm) T : T Quad Flat Pack (1.0 mm)**	Part Number 80C51 Rom 4 K x 8 80C31 External Rom 80C51F Secret ROM version	Customer Rom Code (80C51 only)	Blank : 12 MHz version – 1 : 16 MHz version – S : 20 MHz version – L : Low power. /B : Military Program.	: R Tape and Reel : D Dry Pack

* BI : Burn-In
** : Preliminary