

HYNIX SEMICONDUCTOR INC.
8-BIT SINGLE-CHIP MICROCONTROLLERS

HMS99C51

HMS99C52

User's Manual (Ver. 1.0)



Version 1.0

**Published by
MCU Application Team**

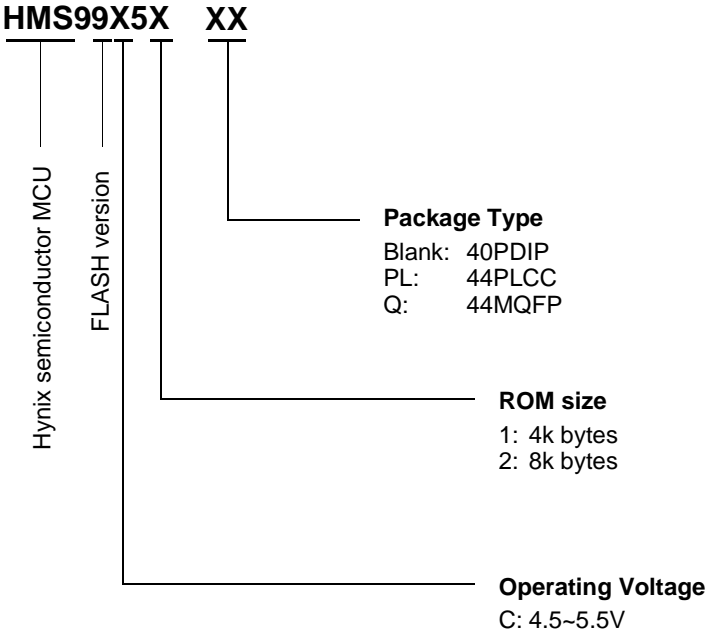
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Device Naming Structure



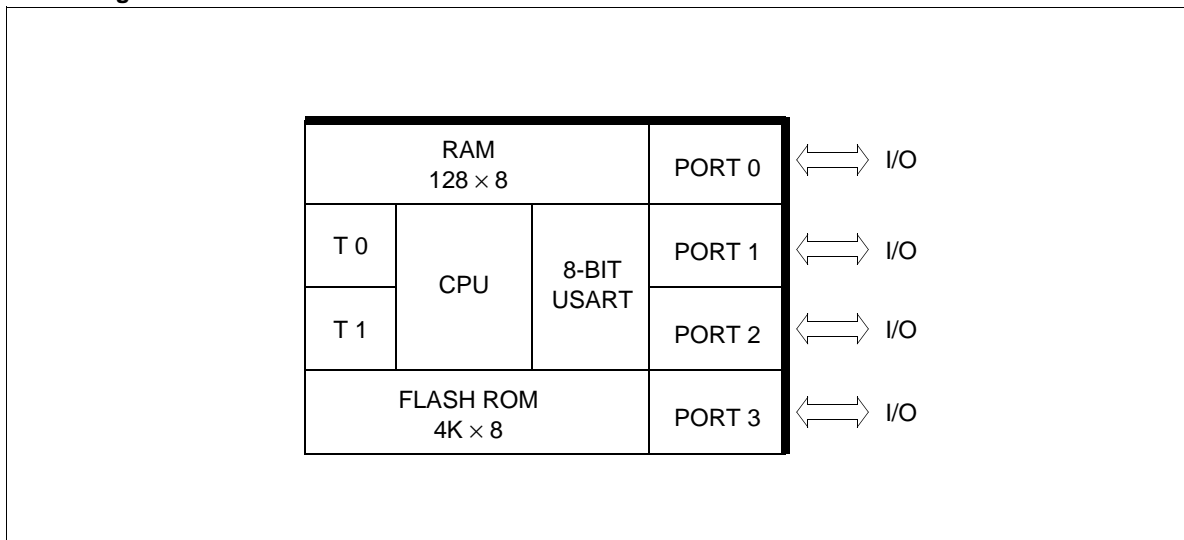
HMS99C5X Series Selection Guide

| Operating Voltage (V) | ROM size (bytes) | | RAM size (bytes) | Device Name | Operating Frequency (MHz) |
|-----------------------|------------------|-----|------------------|-------------|---------------------------|
| | FLASH | | | | |
| 4.5~5.5 | 4K | 128 | HMS99C51 | 40 | |
| | 8K | 256 | HMS99C52 | 40 | |

HMS99C51

- Fully compatible to standard MCS-51 microcontroller
- Wide operating frequency up to 40MHz
(for more detail, see "HMS99C5X Series Selection Guide")
- X2 Speed Improvement capability (**X2 Mode : 6 clocks/machine cycle**)
20MHz @5V (Equivalent to 40MHz @5V)
- 4K bytes FLASH ROM
- 128 × 8Bit RAM
- 64K external program memory space
- 64K external data memory space
- Four 8-bit ports
- Two 16-bit Timers / Counters
- USART
- Programmable ALE pin enable / disable (Low **EMI**)
- Five interrupt sources, two priority levels
- Power saving Idle and power down mode
- P-DIP-40, P-LCC-44, P-MQFP-44 package
- Temperature Ranges : -40°C ~ 85°C

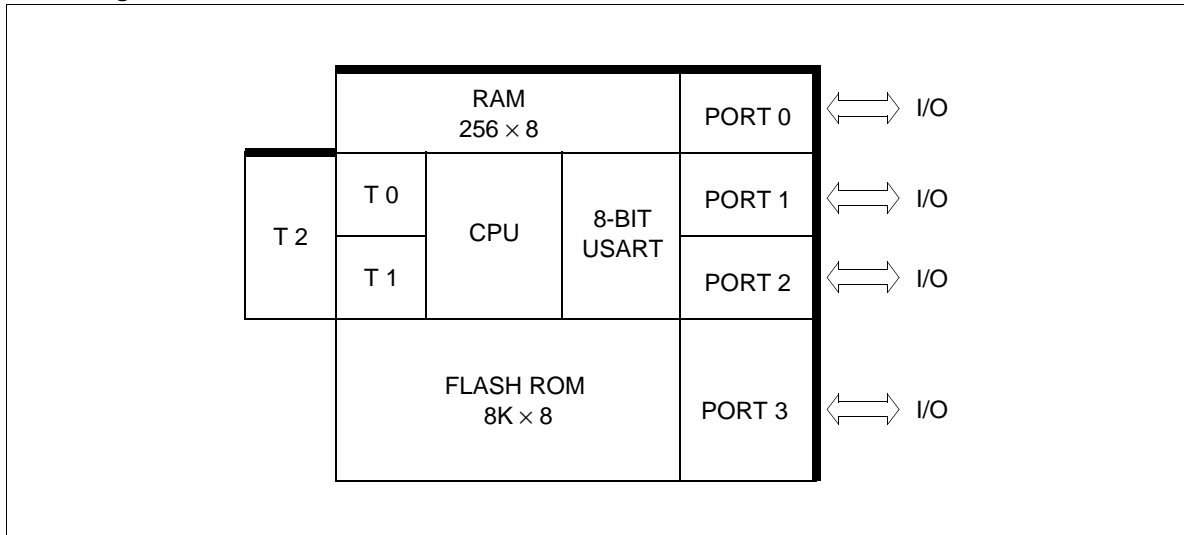
Block Diagram



HMS99C52

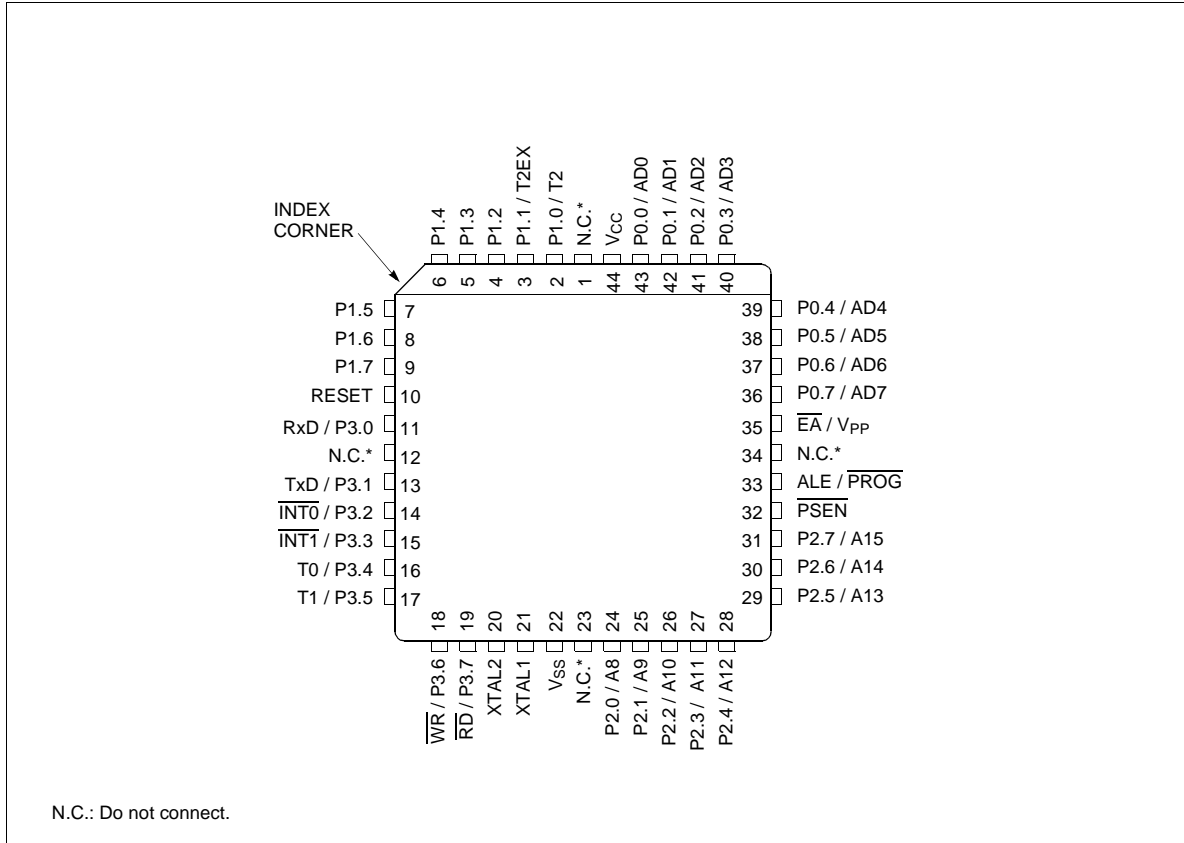
- Fully compatible to standard MCS-51 microcontroller
- Wide operating frequency up to 40MHz
(for more detail, see "HMS99C5X Series Selection Guide")
- X2 Speed Improvement capability (**X2 Mode : 6 clocks/machine cycle**)
20MHz @5V (Equivalent to 40MHz @5V)
- 8K bytes FLASH ROM
- 256 × 8Bit RAM
- 64K external program memory space
- 64K external data memory space
- Four 8-bit ports
- Three 16-bit Timers / Counters (Timer2 with up/down counter feature)
- USART
- One clock output port
- Programmable ALE pin enable / disable (Low **EMI**)
- Six interrupt sources, two priority levels
- Power saving Idle and power down mode
- P-DIP-40, P-LCC-44, P-MQFP-44 package
- Temperature Ranges : -40°C ~ 85°C

Block Diagram

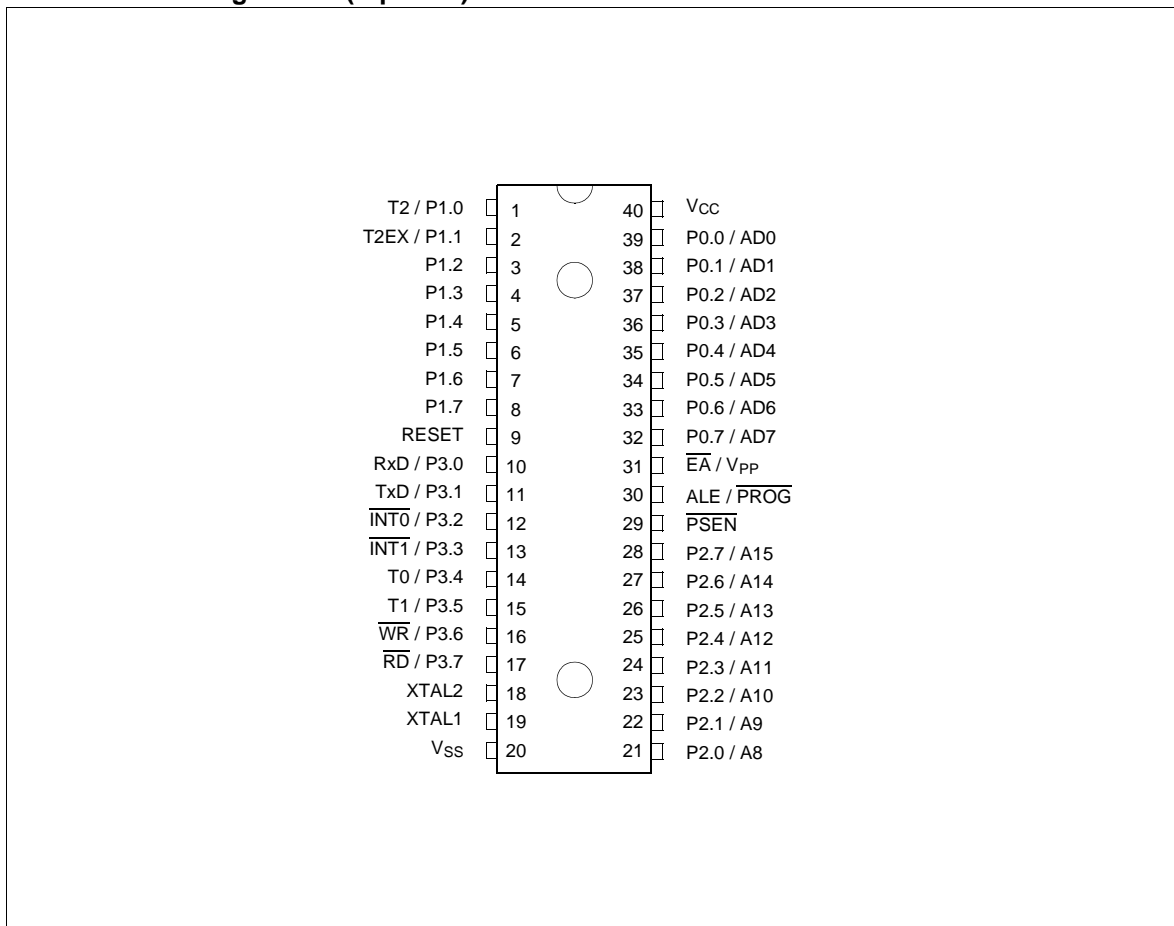


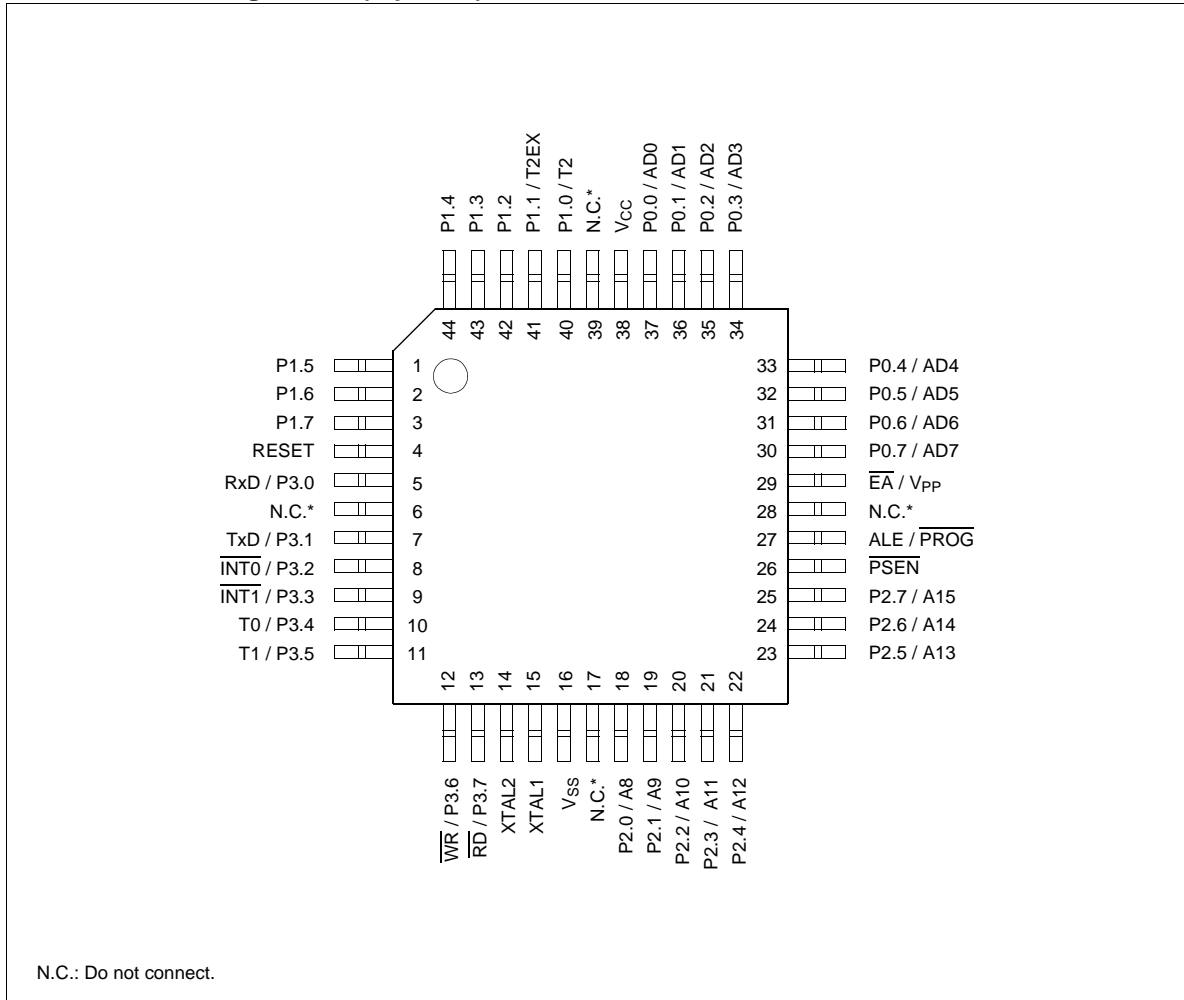
PIN CONFIGURATION

44-PLCC Pin Configuration (top view)

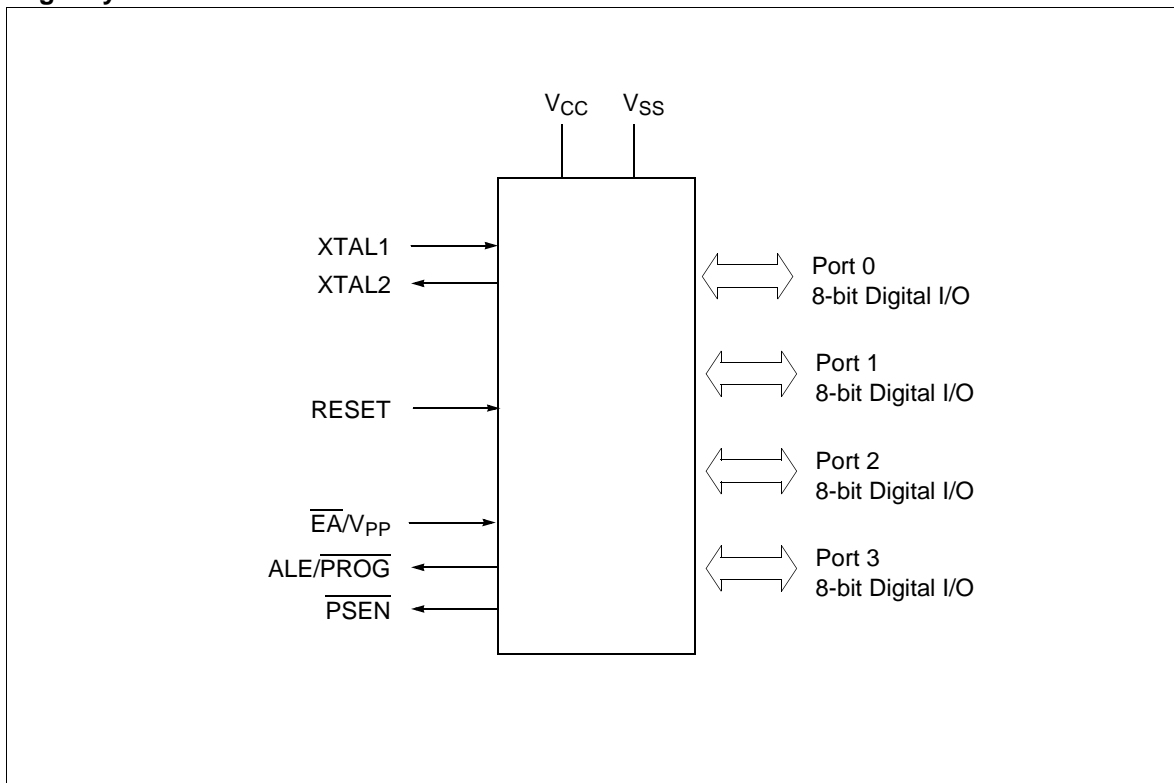


40-PDIP Pin Configuration (top view)



44-MQFP Pin Configuration (top view)


Logic Symbol



PIN DEFINITIONS AND FUNCTIONS

| Symbol | Pin Number | | | Input/ Output | Function |
|-----------|--------------|-------------|---------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | PLCC- 44 | PDIP- 40 | MQFP- 44 | | |
| P1.0-P1.7 | 2-9 | 1-8 | 40-44, 1-3 | I/O | Port1 Port 1 is an 8-bit bidirectional I/O port with internal pull-ups. Port 1 pins that have 1s written to them are pulled high by the internal pull-up resistors and can be used as inputs. As inputs, port 1 pins that are externally pulled low will source current because of the pull-ups (I_{IL} , in the DC characteristics). Pins P1.0 and P1.1 also. Port1 also receives the low-order address byte during program memory verification. Port1 also serves alternate functions of Timer 2. P1.0 / T2 :Timer/counter 2 external count input P1.1 / T2EX :Timer/counter 2 trigger input In HMS99C52: P1.0 / T2, Clock Out : Timer/counter 2 external count input, Clock Out |
| | 2 3 | 1 2 | 40 41 | | |
| | 2 | 1 | 40 | | |
| P3.0-P3.7 | 11, 13-19 | 10-17 | 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-up resistors and can be used as inputs. As inputs, port 3 pins that are externally pulled low will source current because of the pull-ups (I_{IL} , in the DC characteristics). Port 3 also serves the special features of the 80C51 family, as listed below. P3.0 / RxD receiver data input (asynchronous) or data input output(synchronous) of serial interface 0 P3.1 / TxD transmitter data output (asynchronous) or clock output (synchronous) of the serial interface 0 P3.2 / $\overline{INT0}$ interrupt 0 input/timer 0 gate control P3.3 / $\overline{INT1}$ interrupt 1 input/timer 1 gate control P3.4 / T0 counter 0 input P3.5 / T1 counter 1 input P3.6 / \overline{WR} the write control signal latches the data byte from port 0 into the external data memory P3.7 / \overline{RD} the read control signal enables the external data memory to port 0 |
| | 11 | 10 | 5 | | |
| | 13 | 11 | 7 | | |
| | 14 | 12 | 8 | | |
| | 15 | 13 | 9 | | |
| | 16 | 14 | 10 | | |
| | 17 | 15 | 11 | | |
| | 18 | 16 | 12 | | |
| 19 | 17 | 13 | | | |
| XTAL2 | 20 | 18 | 14 | O | XTAL2 Output of the inverting oscillator amplifier. |

| Symbol | Pin Number | | | Input/ Output | Function |
|--------------------------|-------------|-------------|-------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | PLCC- 44 | PDIP- 40 | MQFP- 44 | | |
| XTAL1 | 21 | 19 | 15 | I | XTAL1 Input to the inverting oscillator amplifier and input to the internal clock generator circuits. 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, since the input to the internal clocking circuitry is divided down by a divide-by-two flip-flop. Minimum and maximum high and low times as well as rise fall times specified in the AC characteristics must be observed. |
| P2.0-P2.7 | 24-31 | 21-28 | 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-up resistors and can be used as inputs. As inputs, port 2 pins that are externally pulled low will source current because of the pull-ups (I_{IL} , in the DC characteristics). 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 (MOVX @Ri), port 2 emits the contents of the P2 special function register. |
| $\overline{\text{PSEN}}$ | 32 | 29 | 26 | O | The Program Store Enable The read strobe to external program memory when the device is executing code from the external program memory. $\overline{\text{PSEN}}$ is activated twice each machine cycle, except that two $\overline{\text{PSEN}}$ activations are skipped during each access to external data memory. $\overline{\text{PSEN}}$ is not activated during fetches from internal program memory. |
| RESET | 10 | 9 | 4 | I | RESET A high level on this pin for two machine cycles while the oscillator is running resets the device. An internal diffused resistor to V_{SS} permits power-on reset using only an external capacitor to V_{CC} . |

| Symbol | Pin Number | | | Input/ Output | Function |
|----------------------------------------|---------------|-------------|---------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | PLCC- 44 | PDIP- 40 | MQFP- 44 | | |
| $\overline{\text{ALE}} / \text{PROG}$ | 33 | 30 | 27 | O | <p>The 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 (PROG) during EPROM programming.</p> <p>If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With this bit set, the pin is weakly pulled high. The ALE disable feature will be terminated by reset. Setting the ALE-disable bit has no affect if the microcontroller is in external execution mode.</p> |
| $\overline{\text{EA}} / V_{\text{PP}}$ | 35 | 31 | 29 | I | <p>External Access Enable / Program Supply Voltage $\overline{\text{EA}}$ must be external held low to enable the device to fetch code from external program memory locations 0000H to FFFFH. If $\overline{\text{EA}}$ is held high, the device executes from internal program memory unless the program counter contains an address greater than its internal memory size. This pin also receives the 12.75V programming supply voltage (V_{PP}) during EPROM programming.</p> <p>Note; however, that if any of the Lock bits are programmed, EA will be internally latched on reset.</p> |
| P0.0-P0.7 | 36-43 | 32-39 | 30-37 | I/O | <p>Port 0 Port 0 is an 8-bit 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 GMS97X5X. External pull-up resistors are required during program verification.</p> |
| V_{SS} | 22 | 20 | 16 | - | Circuit ground potential |
| V_{CC} | 44 | 40 | 38 | - | Supply terminal for all operating modes |
| N.C. | 1,12 23,34 | - | 6,17 28,39 | - | No connection |

FUNCTIONAL DESCRIPTION

The HMS99C5X series is fully compatible to the standard 8051 microcontroller family.

It is compatible with the general 8051 family. While maintaining all architectural and operational characteristics of the general 8051 family.

Figure 1 shows a block diagram of the HMS99C5X series

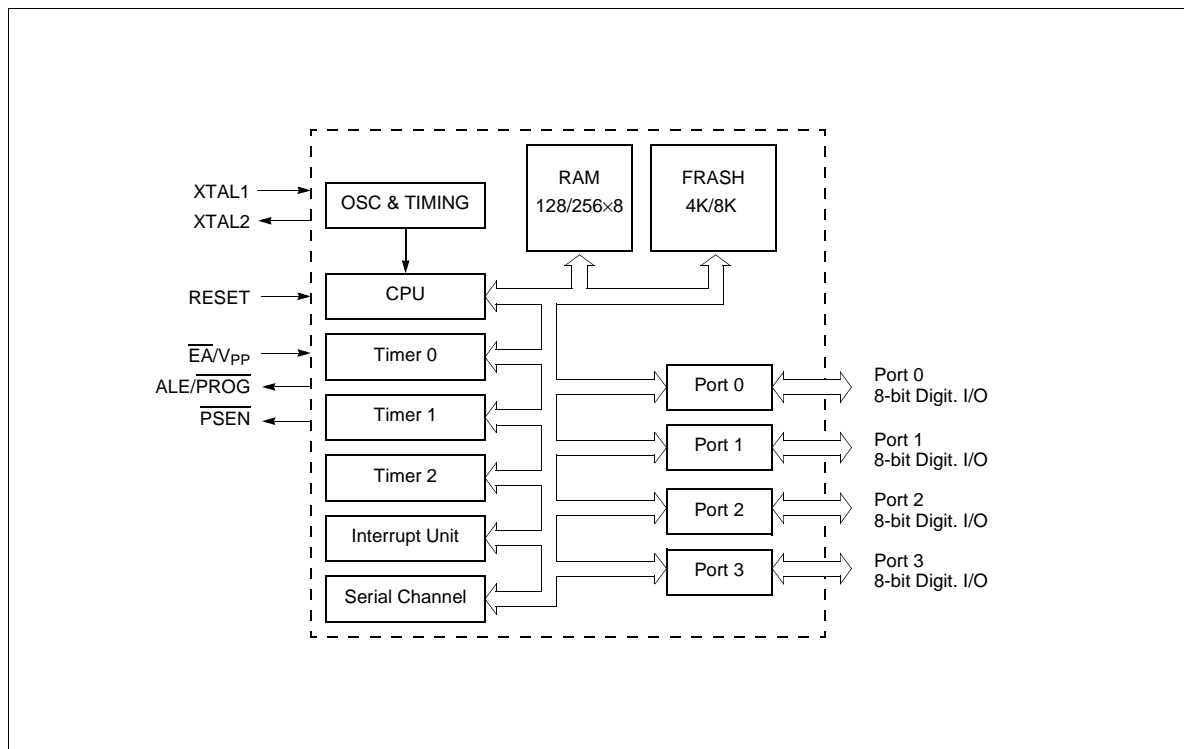
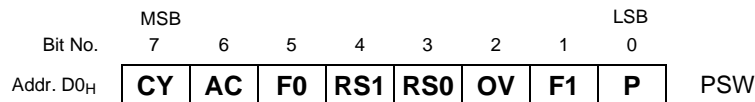


Figure 1. Block Diagram of the HMS99C5X series

CPU

The HMS99C5X series is efficient both as a controller and as an arithmetic processor. It has extensive facilities for binary and BCD arithmetic and excels in its bit-handling capabilities. Efficient use of program memory results from an instruction set consisting of 44% one-byte, 41% two-byte, and 15% three-byte instructions. With a 12 MHz crystal, 58% of the instructions are executed in 1.0µs (40MHz: 300ns).

Special Function Register PSW



| Bit | Function | | | | | | | | | | | | | | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|--|---|---|-----------------------------------------------------------------|---|---|-----------------------------------------------------------------|---|---|-----------------------------------------------------------------|---|---|-----------------------------------------------------------------|--|
| CY | Carry Flag | | | | | | | | | | | | | | | |
| AC | Auxiliary Carry Flag (for BCD operations) | | | | | | | | | | | | | | | |
| F0 | General Purpose Flag | | | | | | | | | | | | | | | |
| <table style="width: 100%; border: none;"> <tr> <td style="text-align: center;"><i>RS1</i></td> <td style="text-align: center;"><i>RS0</i></td> <td></td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">0</td> <td>Bank 0 selected, data address 00_H - 07_H</td> </tr> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> <td>Bank 1 selected, data address 08_H - 0F_H</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">0</td> <td>Bank 2 selected, data address 10_H - 17_H</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">1</td> <td>Bank 3 selected, data address 18_H - 1F_H</td> </tr> </table> | <i>RS1</i> | <i>RS0</i> | | 0 | 0 | Bank 0 selected, data address 00 _H - 07 _H | 0 | 1 | Bank 1 selected, data address 08 _H - 0F _H | 1 | 0 | Bank 2 selected, data address 10 _H - 17 _H | 1 | 1 | Bank 3 selected, data address 18 _H - 1F _H | |
| <i>RS1</i> | <i>RS0</i> | | | | | | | | | | | | | | | |
| 0 | 0 | Bank 0 selected, data address 00 _H - 07 _H | | | | | | | | | | | | | | |
| 0 | 1 | Bank 1 selected, data address 08 _H - 0F _H | | | | | | | | | | | | | | |
| 1 | 0 | Bank 2 selected, data address 10 _H - 17 _H | | | | | | | | | | | | | | |
| 1 | 1 | Bank 3 selected, data address 18 _H - 1F _H | | | | | | | | | | | | | | |
| OV | Overflow Flag | | | | | | | | | | | | | | | |
| F1 | General Purpose Flag | | | | | | | | | | | | | | | |
| P | Parity Flag Set/cleared by hardware each instruction cycle to indicate an odd/even number of "one" bits in the accumulator, i.e. even parity. | | | | | | | | | | | | | | | |

Reset value of PSW is 00_H.

SPECIAL FUNCTION REGISTERS

All registers, except the program counter and the four general purpose register banks, reside in the special function register area.

The 28 special function registers (SFR) include pointers and registers that provide an interface between the CPU and the other on-chip peripherals. There are also 128 directly addressable bits within the SFR area.

All SFRs are listed in Table 1, Table 2, and Table 3.

In Table 1 they are organized in numeric order of their addresses. In Table 2 they are organized in groups which refer to the functional blocks of the HMS99C5X series. Table 3 illustrates the contents of the SFRs

Table 1. Special Function Registers in Numeric Order of their Addresses (cont'd)

| Address | Register | Contents after Reset | Address | Register | Contents after Reset |
|------------|-------------------------|-------------------------------------|------------|---------------------------|--------------------------------------|
| 80H | P0 ¹⁾ | FFH | 88H | TCON ¹⁾ | 00H |
| 81H | SP | 07H | 89H | TMOD | 00H |
| 82H | DPL | 00H | 8AH | TL0 | 00H |
| 83H | DPH | 00H | 8BH | TL1 | 00H |
| 84H | reserved | XXH ²⁾ | 8CH | TH0 | 00H |
| 85H | reserved | XXH ²⁾ | 8DH | TH1 | 00H |
| 86H | reserved | XXH ²⁾ | 8EH | AUXR0 | XXH ²⁾ |
| 87H | PCON | 0XXX0000 _B ²⁾ | 8FH | CKCON | XXXXXXXX0 _B ²⁾ |
| 90H | P1 ¹⁾ | FFH | 98H | SCON ¹⁾ | 00H |
| 91H | reserved | 00H | 99H | SBUF | XXH ²⁾ |
| 92H | reserved | XXH ²⁾ | 9AH | reserved | XXH ²⁾ |
| 93H | reserved | XXH ²⁾ | 9BH | reserved | XXH ²⁾ |
| 94H | reserved | XXH ²⁾ | 9CH | reserved | XXH ²⁾ |
| 95H | reserved | XXH ²⁾ | 9DH | reserved | XXH ²⁾ |
| 96H | reserved | XXH ²⁾ | 9EH | reserved | XXH ²⁾ |
| 97H | reserved | XXH ²⁾ | 9FH | reserved | XXH ²⁾ |
| A0H | P2 ³⁾ | FFH | A8H | IE ¹⁾ | 0X00000B ²⁾ |
| A1H | reserved | XXH ²⁾ | A9H | reserved | XXH ²⁾ |
| A2H | reserved | XXH ²⁾ | AAH | reserved | XXH ²⁾ |
| A3H | reserved | XXH ²⁾ | ABH | reserved | XXH ²⁾ |
| A4H | reserved | XXH ²⁾ | ACH | reserved | XXH ²⁾ |
| A5H | reserved | XXH ²⁾ | ADH | reserved | XXH ²⁾ |
| A6H | reserved | XXH ²⁾ | AEH | reserved | XXH ²⁾ |
| A7H | reserved | XXH ²⁾ | AFH | reserved | XXH ²⁾ |
| B0H | P3 ¹⁾ | FFH | B8H | IP ¹⁾ | XX00000B ²⁾ |
| B1H | reserved | XXH ²⁾ | B9H | reserved | XXH ²⁾ |
| B2H | reserved | XXH ²⁾ | BAH | reserved | XXH ²⁾ |
| B3H | reserved | XXH ²⁾ | BBH | reserved | XXH ²⁾ |
| B4H | reserved | XXH ²⁾ | BCH | reserved | XXH ²⁾ |
| B5H | reserved | XXH ²⁾ | BDH | reserved | XXH ²⁾ |
| B6H | reserved | XXH ²⁾ | BEH | reserved | XXH ²⁾ |
| B7H | reserved | XXH ²⁾ | BFH | reserved | XXH ²⁾ |

Table 1. Special Function Registers in Numeric Order of their Addresses (cont'd)

| Address | Register | Contents after Reset | Address | Register | Contents after Reset |
|-------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| C0H C1H C2H C3H C4H C5H C6H C7H | reserved reserved reserved reserved reserved reserved reserved reserved | XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ | C8H ³⁾ C9H ⁴⁾ CAH ³⁾ CBH ³⁾ CCH ³⁾ CDH ³⁾ CEH CFH | T2CON ¹⁾ T2MOD RC2L RC2H TL2 TH2 reserved reserved | 00H XXXXXXXX00 _B ²⁾ 00H 00H 00H 00H XXH ²⁾ XXH ²⁾ |
| D0H D1H D2H D3H D4H D5H D6H D7H | PSW ¹⁾ reserved reserved reserved reserved reserved reserved reserved | FFH XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ | D8H D9H DAH DBH DCH DDH DEH DFH | reserved reserved reserved reserved reserved reserved reserved reserved | XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ |
| E0H E1H E2H E3H E4H E5H E6H E7H | ACC ¹⁾ reserved reserved reserved reserved reserved reserved reserved | 00H XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ | E8H E9H EAH EBH ECH EDH EEH EFH | reserved reserved reserved reserved reserved reserved reserved reserved | XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ |
| F0H F1H F2H F3H F4H F5H F6H F7H | B ¹⁾ reserved reserved reserved reserved reserved reserved reserved | 00H XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ | F8H F9H FAH FBH FCH FDH FEH FFH | reserved reserved reserved reserved reserved reserved reserved reserved | XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ XXH ²⁾ |

- 1) Bit-addressable Special Function Register.
- 2) X means that the value is indeterminate and the location is reserved.
- 3) Bit-addressable Special Function Register.
- 4) These Registers are in the HMS99C52 only.

Table 2. Special Function Registers - Functional Blocks

| Block | Symbol | Name | Address | Contents after Reset |
|--------------------|--------------------|----------------------------------------|--------------------------|--------------------------|
| CPU | ACC | Accumulator | E0H ¹⁾ | 00H |
| | B | B-Register | F0H ¹⁾ | 00H |
| | DPH | Data Pointer, High Byte | 83H | 00H |
| | DPL | Data Pointer, Low Byte | 82H | 00H |
| | PSW | Program Status Word Register | D0H ¹⁾ | 00H |
| | SP | Stack Pointer | 81H | 07H |
| Interrupt System | IE | Interrupt Enable Register | A8H ¹⁾ | 0X000000B ²⁾ |
| | IP | Interrupt Priority Register | B8H ¹⁾ | XX000000B ²⁾ |
| Ports | P0 | Port 0 | 80H ¹⁾ | FFH |
| | P1 | Port 1 | 90H ¹⁾ | FFH |
| | P2 | Port 2 | A0H ¹⁾ | FFH |
| | P3 | Port 3 | B0H ¹⁾ | FFH |
| Serial Channels | PCON ³⁾ | Power Control Register | 87H | 0XXX0000B ²⁾ |
| | SBUF | Serial Channel Buffer Reg. | 99H | XXH ²⁾ |
| | SCON | Serial Channel 0 Control Reg. | 98H ¹⁾ | 00H |
| Timer 0/ Timer 1 | TCON | Timer 0/1 Control Register | 88H ¹⁾ | 00H |
| | TH0 | Timer 0, High Byte | 8CH | 00H |
| | TH1 | Timer 1, High Byte | 8DH | 00H |
| | TL0 | Timer 0, Low Byte | 8AH | 00H |
| | TL1 | Timer 1, Low Byte | 8BH | 00H |
| | TMOD | Timer Mode Register | 89H | 00H |
| Timer 2 | T2CON | Timer 2 Control Register | C8H ¹⁾ | 00H |
| | T2MOD | Timer 2 Mode Register | C9H | 00H |
| | RC2H | Timer 2 Reload Capture Reg., High Byte | CBH | 00H |
| | RC2L | Timer 2 Reload Capture Reg., Low Byte | CAH | 00H |
| | TH2 | Timer 2, High Byte | CDH | 00H |
| | TL2 | Timer 2, Low Byte | CCH | 00H |
| | AUXR0 | Aux. Register 0 | 8EH | XXXXXXXX0B ²⁾ |
| Power Saving Modes | PCON ³⁾ | Power Control Register | 87H | 0XXX0000B ²⁾ |

1) Bit-addressable Special Function register

2) X means that the value is indeterminate and the location is reserved

3) This special function register is listed repeatedly since some bit of it also belong to other functional blocks

Table 3. Contents of SFRs, SFRs in Numeric Order

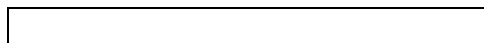
| Address | Register | Bit 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------|----------|-------|---|---|---|---|---|---|---|
| 80H | P0 | | | | | | | | |

Table 3. Contents of SFRs, SFRs in Numeric Order

| Address | Register | Bit 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------|----------|-------------|-----|-----|-----|------|-----|-----|------|
| 81H | SP | [Empty Box] | | | | | | | |
| 82H | DPL | [Empty Box] | | | | | | | |
| 83H | DPH | [Empty Box] | | | | | | | |
| 87H | PCON | SMOD | - | - | - | GF1 | GF0 | PDE | IDLE |
| 88H | TCON | TF1 | TR1 | TF0 | TR0 | IE1 | IT1 | IE0 | IT0 |
| 89H | TMOD | GATE | C/T | M1 | MT | GATE | C/T | M1 | M0 |
| 8AH | TL0 | [Empty Box] | | | | | | | |
| 8BH | TL1 | [Empty Box] | | | | | | | |
| 8CH | TH0 | [Empty Box] | | | | | | | |
| 8DH | TH1 | [Empty Box] | | | | | | | |
| 8EH | AUXR0 | - | - | - | - | - | - | - | A0 |
| 8FH | CKCON | - | - | - | - | - | - | - | X2 |
| 90H | P1 | [Empty Box] | | | | | | | |
| 98H | SCON | SM0 | SM1 | SM2 | REN | TB8 | RB8 | TI | RI |
| 99H | SBUF | [Empty Box] | | | | | | | |
| A0H | P2 | [Empty Box] | | | | | | | |
| A8H | IE | EA | - | ET2 | ES | ET1 | EX1 | ET0 | EX0 |
| B0H | P3 | [Empty Box] | | | | | | | |
| B8H | IP | - | - | PT2 | PS | PT1 | PX1 | PT0 | PX0 |



SFR bit and byte addressable



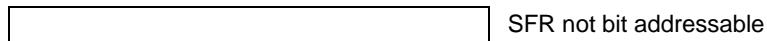
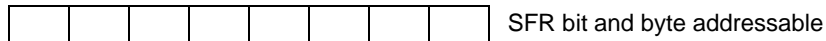
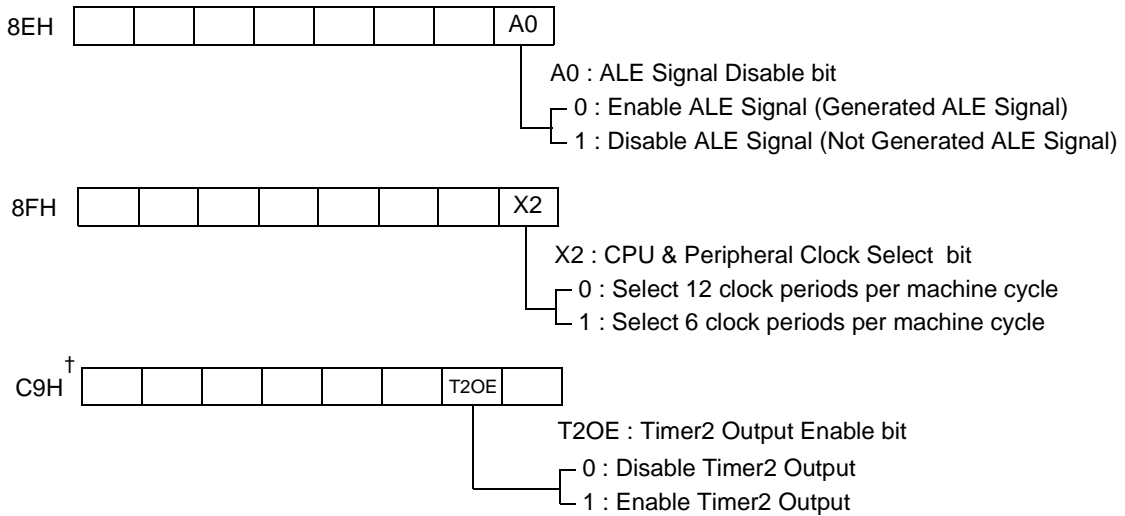
SFR not bit addressable

- : this bit location is reserved

Table 3. Contents of SFRs, SFRs in Numeric Order (cont'd)

| Address | Register | Bit 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------|----------|-------|------|------|------|-------|-----|-------------------|---------------------|
| C8H | T2CON | TF2 | EXF2 | RCLK | TCLK | EXEN2 | TR2 | $C/\overline{T2}$ | $CP/\overline{RL2}$ |
| C9H | T2MOD | - | - | - | - | - | - | T2OE † | DCEN |
| CAH | RC2L | | | | | | | | |
| CBH | RC2H | | | | | | | | |
| CCH | TL2 | | | | | | | | |
| CDH | TH2 | | | | | | | | |
| D0H | PSW | CY | AC | F0 | RS1 | RS0 | OV | F1 | P |
| E0H | ACC | | | | | | | | |
| F0H | B | | | | | | | | |

† indicates resident in the HMS99C52, not in HMS99C51.



- : this bit location is reserved

X2 MODE

The HMS99C5X core needs only 6 clock periods per machine cycle. This feature called "X2" provides the following advantages:

- Divide frequency crystals by 2 (cheaper crystals) while keeping same CPU power.
- Save power consumption while keeping same CPU power (oscillator power saving).
- Save power consumption by dividing dynamically operating frequency by 2 in operating and idle modes.
- Increase CPU power by 2 while keeping same crystal frequency.

In order to keep the original C51 compatibility, a divider by 2 is inserted between the XTAL1 signal and the main clock input of the core (phase generator). This divider may be disabled by software.

X2 Mode Description

The clock for the whole circuit and peripheral is first divided by two before being used by the CPU core and peripherals. This allows any cyclic ratio to be accepted on XTAL1 input. In X2 mode, as this divider is bypassed, the signals on XTAL1 must have a cyclic ratio between 40 to 60%. Figure 2. shows the clock generation block diagram. X2 bit is validated on XTAL1+2 rising edge to avoid glitches when switching from X2 to STD mode. Figure 3.shows the mode switching waveforms:

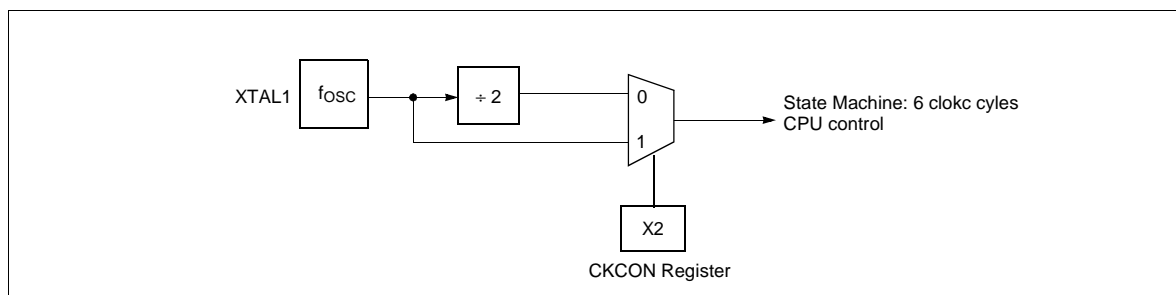


Figure 2. Clock Generation Diagram

The X2 bit in the CKCON register allows to switch from 12 clock cycles per instruction to 6 clock cycles and vice versa. At reset, the standard speed is activated (STD mode). Setting this bit activates the X2 feature(X2 mode).

CAUTION

In order to prevent any incorrect operation while operating in X2 mode, user must be aware that all peripherals using clock frequency as time reference (UART, timers) will have their time reference divided by two. For example a free running timer generating an interrupt every 30 ms will then generate an interrupt every 15 ms. UART with 2400 baud rate will have 4800 baud rate.

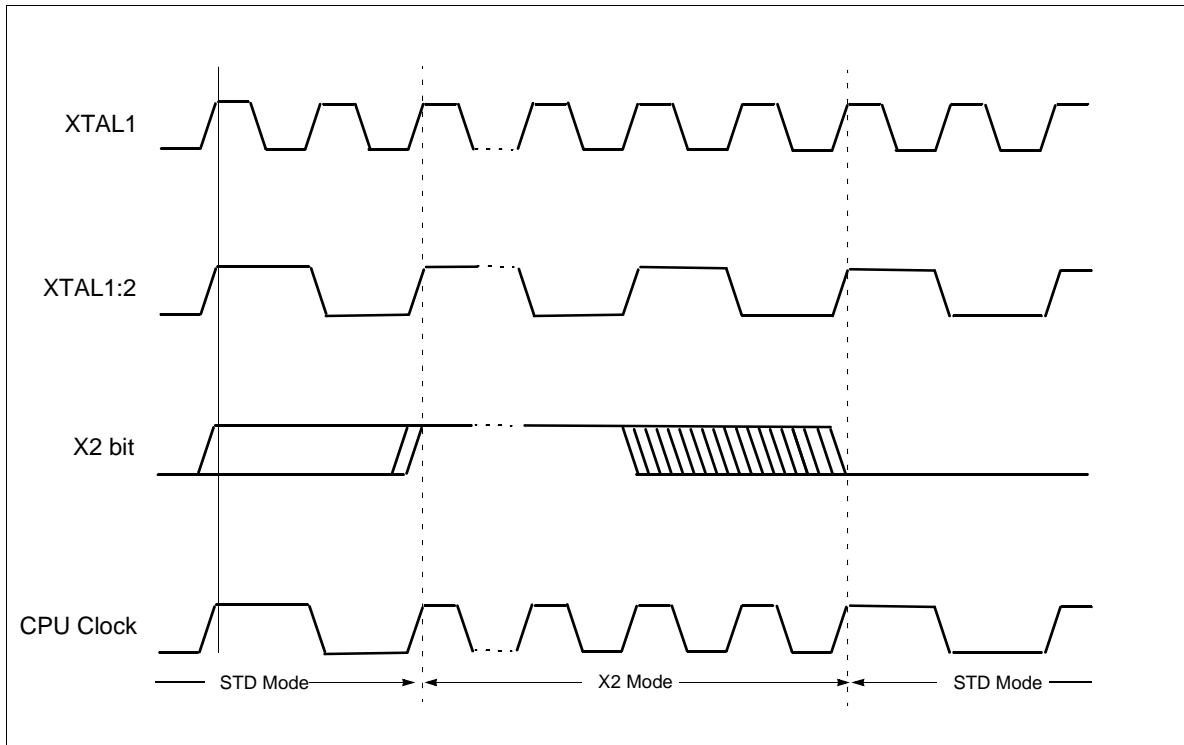


Figure 3. Mode Switching Waveforms

TIMER / COUNTER 0 AND 1

Timer/Counter 0 and 1 can be used in four operating modes as listed in Table 4:

Table 4. Timer/Counter 0 and 1 Operating Modes

| Mode | Description | TMOD | | | | Input Clock | |
|------|-----------------------------------------------------------------------------------|------|-----|----|----|-------------------------------|-------------------------------|
| | | Gate | C/T | M1 | M0 | internal | external (Max.) |
| 0 | 8-bit timer/counter with a divide-by-32 prescaler | X | X | 0 | 0 | $f_{osc} \div (12 \times 32)$ | $f_{osc} \div (24 \times 32)$ |
| 1 | 16-bit timer/counter | X | X | 0 | 1 | $f_{osc} \div 12$ | $f_{osc} \div 24$ |
| 2 | 8-bit timer/counter with 8-bit auto-reload | X | X | 1 | 0 | $f_{osc} \div 12$ | $f_{osc} \div 24$ |
| 3 | Timer/counter 0 used as one 8-bit timer/counter and one 8-bit timer Timer 1 stops | X | X | 1 | 1 | $f_{osc} \div 12$ | $f_{osc} \div 24$ |

In the "timer" function ($C/\bar{T} = "0"$) the register is incremented every machine cycle. Therefore the count rate is $f_{osc}/12$.

In the "counter" function the register is incremented in response to a 1-to-0 transition at its corresponding external input pin (P3.4/T0, P3.5/T1). Since it takes two machine cycles to detect a falling edge the max. count rate is $f_{osc}/24$. External inputs $\overline{INT0}$ and $\overline{INT1}$ (P3.2, P3.3) can be programmed to function as a gate to facilitate pulse width measurements. Figure 4 illustrates the input clock logic.

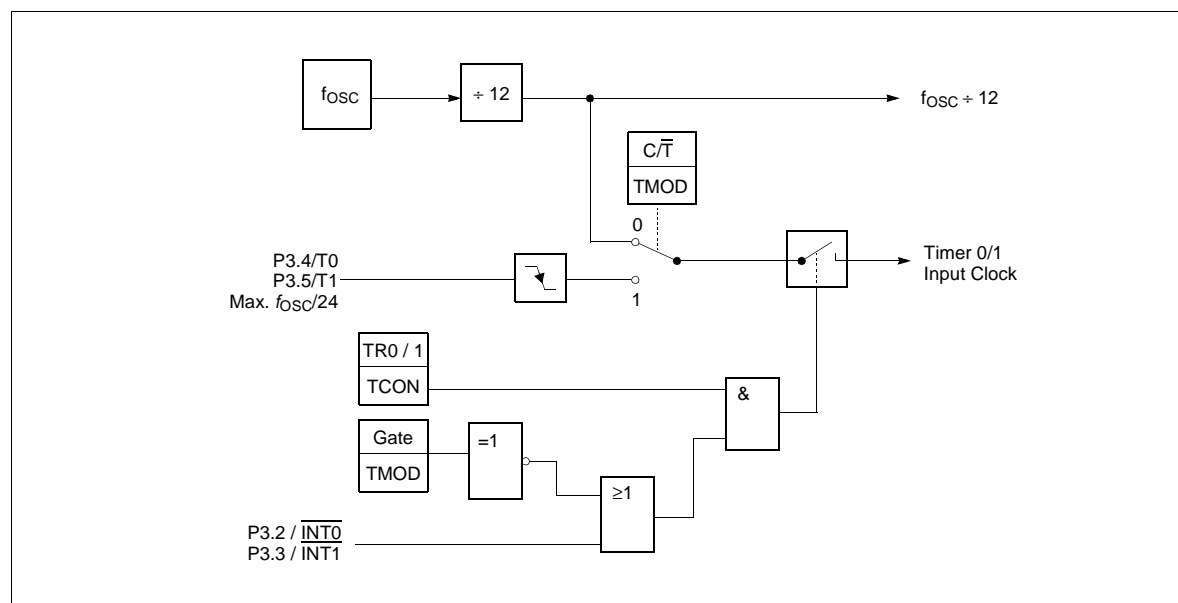


Figure 4. Timer/Counter 0 and 1 Input Clock Logic

TIMER 2

Timer 2 is a 16-bit timer/Counter with an up/down count feature. It can operate either as timer or as an event counter which is selected by bit $C/\overline{T2}$ (T2CON.1). It has three operating modes as shown in Table 5.

Table 5. Timer/Counter 2 Operating Modes

| Mode | T2CON | | | T2MOD | T2CON | P1.1/ T2EX | Remarks | Input Clock | |
|---------------------|-----------------|----------------------|-----|-------|-------|---------------|------------------------------------------|-------------|-----------------------|
| | RCLK or TCLK | CP/ $\overline{RL2}$ | TR2 | DCEN | EXEN2 | | | internal | external (P1.0/T2) |
| 16-bit Auto-Reload | 0 | 0 | 1 | 0 | 0 | X | reload upon overflow | fosc ÷ 12 | Max. fosc ÷ 24 |
| | 0 | 0 | 1 | 0 | 1 | ↓ | reload trigger (falling edge) | | |
| | 0 | 0 | 1 | 1 | X | 0 | Down counting | | |
| | 0 | 0 | 1 | 1 | X | 1 | Up counting | | |
| 16-bit Capture | 0 | 1 | 1 | X | 0 | X | 16 bit Timer/ Counter (only up-counting) | fosc ÷ 12 | Max. fosc ÷ 24 |
| | 0 | 1 | 1 | X | 1 | ↓ | capture TH2,TL2 → RC2H,RC2L | | |
| Baud Rate Generator | 1 | X | 1 | X | 0 | X | no overflow interrupt request (TF2) | fosc ÷ 12 | Max. fosc ÷ 24 |
| | 1 | X | 1 | X | 1 | ↓ | extra external interrupt ("Timer 2") | | |
| Off | X | X | 0 | X | X | X | Timer 2 stops | - | - |

Note: ↓ =  falling edge

SERIAL INTERFACE (USART)

The serial port is full duplex and can operate in four modes (one synchronous mode, three asynchronous modes) as illustrated in Table 6. The possible baud rates can be calculated using the formulas given in Table 7.

Table 6. USART Operating Modes

| Mode | SCON | | Baudrate | Description |
|------|------|-----|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| | SM0 | SM1 | | |
| 0 | 0 | 0 | $\frac{f_{OSC}}{12}$ | Serial data enters and exits through RxD. TxD outputs the shift clock. 8-bit are transmitted/received (LSB first) |
| 1 | 0 | 1 | Timer 1/2 overflow rate | 8-bit UART 10 bits are transmitted (through TxD) or received (RxD) |
| 2 | 1 | 0 | $\frac{f_{OSC}}{32}$ or $\frac{f_{OSC}}{64}$ | 9-bit UART 11 bits are transmitted (TxD) or received (RxD) |
| 3 | 1 | 1 | Timer 1/2 overflow rate | 9-bit UART Like mode 2 except the variable baud rate |

Table 7. Formulas for Calculating Baud rates

| Baud Rate derived from | Interface Mode | Baudrate |
|----------------------------------------------------------------|----------------|-----------------------------------------------------------------------------|
| Oscillator | 0 | $\frac{f_{OSC}}{12}$ |
| | 2 | $\frac{2^{SMOD}}{64} \times f_{OSC}$ |
| Timer 1 (16-bit timer) (8-bit timer with 8-bit auto reload) | 1,3 | $\frac{2^{SMOD}}{32} \times (Timer\ 1\ overflow)$ |
| | 1,3 | $\frac{2^{SMOD}}{32} \times \frac{f_{OSC}}{12 \times [256 \text{D} (TH1)]}$ |
| Timer 2 | 1,3 | $\frac{f_{OSC}}{32 \times [65536 \text{D} (RC2H, RC2L)]}$ |

INTERRUPT SYSTEM

The HMS99C5X series provides 5 (4K bytes ROM version) or 6 (above 8K bytes ROM version) interrupt sources with two priority levels. Figure 5 gives a general overview of the interrupt sources and illustrates the request and control flags.

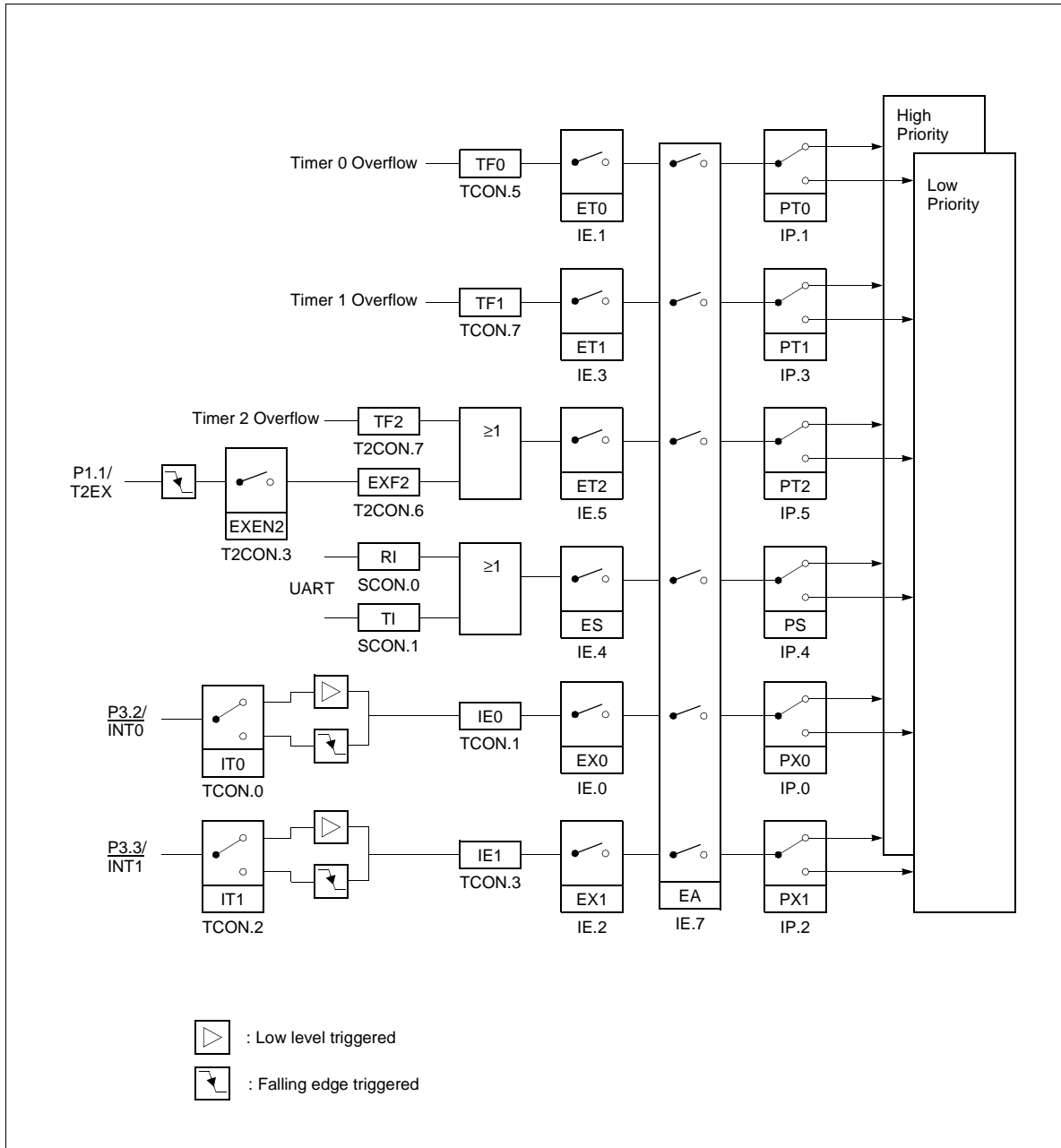


Figure 5. Interrupt Request Sources

Table 8. Interrupt Sources and their Corresponding Interrupt Vectors

| Source (Request Flags) | Vectors | Vector Address |
|------------------------|-----------------------|----------------|
| RESET | RESET | 0000H |
| IE0 | External interrupt 0 | 0003H |
| TF0 | Timer 0 interrupt | 000BH |
| IE1 | External interrupt 1 | 0013H |
| TF1 | Timer 1 interrupt | 001BH |
| RI + TI | Serial port interrupt | 0023H |
| TF2 + EXF2 | Timer 2 interrupt | 002BH |

A low-priority interrupt can itself be interrupted by a high-priority interrupt, but not by another low priority interrupt. A high-priority interrupt cannot be interrupted by any other interrupt source.

If two requests of different priority level are received simultaneously, the request of higher priority is serviced. If requests of the same priority are received simultaneously, an internal polling sequence determines which request is serviced. Thus within each priority level there is a second priority structure determined by the polling sequence as shown in Table 9.

Table 9. Interrupt Priority-Within-Level

| Interrupt Source | | Priority |
|----------------------|------------|----------|
| External Interrupt 0 | IE0 | High |
| Timer 0 Interrupt | TF0 | ↓ |
| External Interrupt 1 | IE1 | ↓ |
| Timer 1 Interrupt | TF1 | ↓ |
| Serial Channel | RI + TI | ↓ |
| Timer 2 Interrupt | TF2 + EXF2 | Low |

Power Saving Modes

Two power down modes are available, the Idle Mode and Power Down Mode.

The bits PDE and IDLE of the register PCON select the Power Down mode or the Idle mode, respectively. If the Power Down mode and the Idle mode are set at the same time, the Power Down mode takes precedence. Table 10 gives a general overview of the power saving modes.

Table 10. Power Saving Modes Overview

| Mode | Entering Instruction Example | Leaving by | Remarks |
|-----------------|------------------------------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| Idle mode | ORL PCON, #01H | - Enabled interrupt - Hardware Reset | CPU is gated off CPU status registers maintain their data. Peripherals are active |
| Power-Down mode | ORL PCON, #02H | Hardware Reset | Oscillator is stopped, contents of on-chip RAM and SFR's are maintained (leaving Power Down Mode means redefinition of SFR contents). |

In the Power Down mode of operation, V_{CC} can be reduced to minimize power consumption. It must be ensured, however, that V_{CC} is not reduced before the Power Down mode is invoked, and that V_{CC} is restored to its normal operating level, before the Power Down mode is terminated. The reset signal that terminates the Power Down mode also restarts the oscillator. The reset should not be activated before V_{CC} is restored to its normal operating level and must be held active long enough to allow the oscillator to restart and stabilize (similar to power-on reset).

ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings

| | |
|--------------------------------------------------------------------|--------------------------|
| Ambient temperature under bias (T_A)..... | -40 to + 85 °C |
| Storage temperature (T_{ST})..... | -65 to + 150 °C |
| Voltage on V_{CC} pins with respect to ground (V_{SS}) | -0.5V to 6.5V |
| Voltage on any pin with respect to ground (V_{SS}) | -0.5V to $V_{CC} + 0.5V$ |
| Input current on any pin during overload condition..... | -10mA to +10mA |
| Absolute sum of all input currents during overload condition..... | 100mA |
| Power dissipation | 200mW |

Note: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage of 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 longer periods may affect device reliability. During overload conditions ($V_{IN} > V_{CC}$ or $V_{IN} < V_{SS}$) the Voltage on V_{CC} pins with respect to ground (V_{SS}) must not exceed the values defined by the absolute maximum ratings.

DC Characteristics

DC Characteristics for HMS99C51/52

$V_{CC} = 5V \pm 10\%, -15\%$; $V_{SS} = 0V$; $T_A = -40^\circ C$ to $85^\circ C$

| Parameter | Symbol | Limit Values | | Unit | Test Conditions |
|----------------------------------------------------------------------------|-----------|--------------------|-------------------|---------|-------------------------------------------------------------------------------------------------------|
| | | Min. | Max. | | |
| Input low voltage (except \overline{EA} , RESET) | V_{IL} | -0.5 | $0.2V_{CC} - 0.1$ | V | $V_{CC} = 5.5V$ |
| Input low voltage (\overline{EA}) | V_{IL1} | -0.5 | $0.2V_{CC} - 0.1$ | V | $V_{CC} = 5.5V$ |
| Input low voltage (RESET) | V_{IL2} | -0.5 | $0.2V_{CC} + 0.1$ | V | $V_{CC} = 5.5V$ |
| Input high voltage (except XTAL1, \overline{EA} , RESET) | V_{IH} | $0.2V_{CC} + 0.9$ | $V_{CC} + 0.5$ | V | $V_{CC} = 4.5V$ |
| Input high voltage to XTAL1 | V_{IH1} | $0.7V_{CC}$ | $V_{CC} + 0.5$ | V | $V_{CC} = 4.5V$ |
| Input high voltage to \overline{EA} , RESET | V_{IH2} | $0.6V_{CC}$ | $V_{CC} + 0.5$ | V | $V_{CC} = 4.5V$ |
| Output low voltage (ports 1, 2, 3) | V_{OL} | - | 0.45 | V | $V_{CC} = 5.5V, I_{OL} = 1.6mA$ ¹⁾ |
| Output low voltage (port 0, ALE, \overline{PSEN}) | V_{OL1} | - | 0.45 | V | $V_{CC} = 5.5V, I_{OL} = 3.2mA$ ¹⁾ |
| Output high voltage (ports 1, 2, 3) | V_{OH} | 2.4 $0.9V_{CC}$ | - | V | $V_{CC} = 4.5V, I_{OH} = -80\mu A$ $V_{CC} = 4.5V, I_{OH} = -10\mu A$ |
| Output high voltage (port 0 in external bus mode, ALE, \overline{PSEN}) | V_{OH1} | 2.4 $0.9V_{CC}$ | - | V | $V_{CC} = 4.5V, I_{OH} = -800\mu A$ ²⁾ $V_{CC} = 4.5V, I_{OH} = -80\mu A$ ²⁾ |
| Logic 0 input current (ports 1, 2, 3) | I_{IL} | -10 | -65 | μA | $V_{IN} = 0.45V$ |
| Logical 1-to-0 transition current (ports 1, 2, 3) | I_{TL} | -65 | -650 | μA | $V_{IN} = 2.0V$ |
| Input leakage current (port 0, \overline{EA}) | I_{LI} | - | ± 1 | μA | $0.45 < V_{IN} < V_{CC}$ |
| Pin capacitance | C_{IO} | - | 10 | pF | $f_C = 1MHz$ $T_A = 25^\circ C$ |
| Power supply current: | | | | | |
| Active mode, 4MHz ³⁾ | I_{CC} | | 8 | mA | $V_{CC} = 5V$ ⁴⁾ |
| Idle mode, 4MHz ⁴⁾ | I_{CC} | | 4 | A | $V_{CC} = 5V$ ⁵⁾ |
| Active mode, 24 MHz ⁴⁾ | I_{CC} | | 25 | mA | $V_{CC} = 5V$ ⁷⁾ |
| Idle mode, 24MHz ⁴⁾ | I_{CC} | | 10 | mA | $V_{CC} = 5V$ ⁸⁾ |
| Active mode, 40 MHz ⁴⁾ | I_{CC} | | 30 | mA | $V_{CC} = 5V$ ⁷⁾ |
| Idle mode, 40 MHz ⁴⁾ | I_{CC} | | 15 | mA | $V_{CC} = 5V$ ⁸⁾ |
| Power Down Mode ⁴⁾ | I_{PD} | | 50 | mA | $V_{CC} = 5V$ ⁶⁾ |
| | | | | μA | |

- 1) Capacitive loading on ports 0 and 2 may cause spurious noise pulses to be superimposed on the V_{OL} of ALE and port 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 operation. In the worst case (capacitive loading: $> 50\text{pF}$ at 3.3V, $> 100\text{pF}$ at 5V), the noise pulse on ALE line 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.
- 2) Capacitive loading on ports 0 and 2 may cause the V_{OH} on ALE and $\overline{\text{PSEN}}$ to momentarily fall below the $0.9V_{CC}$ specification when the address lines are stabilizing.
- 3) I_{CC} Max at other frequencies is given by:
 active mode: $I_{CC} = 1.27 \times f_{OSC} + 5.73$
 idle mode: $I_{CC} = 0.28 \times f_{OSC} + 1.45$ (except OTP devices)
 where f_{OSC} is the oscillator frequency in MHz. I_{CC} values are given in mA and measured at $V_{CC} = 5V$.
- 4) I_{CC} (active mode) is measured with:
 XTAL1 driven with $t_{CLCH}, t_{CHCL} = 5\text{ns}$, $V_{IL} = V_{SS} + 0.5V$, $V_{IH} = V_{CC} - 0.5V$; XTAL2 = N.C.;
 $\overline{\text{EA}} = \text{Port0} = \text{RESET} = V_{CC}$; all other pins are disconnected. I_{CC} would be slightly higher if a crystal oscillator is used (appr. 1mA).
- 5) I_{CC} (Idle mode) is measured with all output pins disconnected and with all peripherals disabled;
 XTAL1 driven with $t_{CLCH}, t_{CHCL} = 5\text{ns}$, $V_{IL} = V_{SS} + 0.5V$, $V_{IH} = V_{CC} - 0.5V$; XTAL2 = N.C.;
 $\text{RESET} = \overline{\text{EA}} = V_{SS}$; Port0 = V_{CC} ; all other pins are disconnected;
- 6) I_{PD} (Power Down Mode) is measured under following conditions:
 $\overline{\text{EA}} = \text{Port0} = V_{CC}$; $\text{RESET} = V_{SS}$; XTAL2 = N.C.; XTAL1 = V_{SS} ; all other pins are disconnected.

AC Characteristics

Explanation of the AC Symbols

Each timing symbol has 5 characters. The first character is always a 't' (stand 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.

A: Address

C: Clock

D: Input Data

H: Logic level HIGH

I: Instruction (program memory contents)

L: Logic level LOW, or ALE

P: $\overline{\text{PSEN}}$

Q: Output Data

R: RD signal

T: Time

V: Valid

W: WR signal

X: No longer a valid logic level

Z: Float

For example,

t_{AVLL} = Time from Address Valid to ALE Low

t_{LLPL} = Time from ALE Low to $\overline{\text{PSEN}}$ Low

AC Characteristics for HMS99C5X series (12MHz version)

V_{CC} = 5V : $V_{CC} = 5V + 10\%, -15\%$; $V_{SS} = 0V$; $T_A = -40^\circ\text{C}$ to 85°C
 (C_L for port 0. ALE and $\overline{\text{PSEN}}$ outputs = 100pF; C_L for all other outputs = 80pF)

Variable clock : $V_{CC} = 5V$: $1/t_{CLCL} = 3.5$ MHz to 12 MHz

External Program Memory Characteristics

| Parameter | Symbol | 12 MHz Oscillator | | Variable Oscillator $1/t_{CLCL} = 3.5$ to 12MHz | | Unit |
|--------------------------------------------------------|--------------------|-------------------|------|----------------------------------------------------|-----------------|------|
| | | Min. | Max. | Min. | Max. | |
| ALE pulse width | t_{LHLL} | 127 | - | $2t_{CLCL}-40$ | - | ns |
| Address setup to ALE | t_{AVLL} | 43 | - | $t_{CLCL}-40$ | - | ns |
| Address hold after ALE | t_{LLAX} | 30 | - | $t_{CLCL}-53$ | - | ns |
| ALE low to valid instruction in | t_{LLIV} | - | 233 | - | $4t_{CLCL}-100$ | ns |
| ALE to $\overline{\text{PSEN}}$ | t_{LLPL} | 58 | - | $t_{CLCL}-25$ | - | ns |
| $\overline{\text{PSEN}}$ pulse width | t_{PLPH} | 215 | - | $3t_{CLCL}-35$ | - | ns |
| $\overline{\text{PSEN}}$ to valid instruction in | t_{PLIV} | - | 150 | - | $3t_{CLCL}-100$ | ns |
| Input instruction hold after $\overline{\text{PSEN}}$ | t_{PXIX} | 0 | - | 0 | - | ns |
| Input instruction float after $\overline{\text{PSEN}}$ | t_{PXIZ}^\dagger | - | 63 | - | $t_{CLCL}-20$ | ns |
| Address valid after $\overline{\text{PSEN}}$ | t_{PXAV}^\dagger | 75 | - | $t_{CLCL}-8$ | - | ns |
| Address to valid instruction in | t_{AVIV} | - | 302 | - | $5t_{CLCL}-115$ | ns |
| Address float to $\overline{\text{PSEN}}$ | t_{AZPL} | 0 | - | 0 | - | ns |

[†] Interfacing the HMS99C5X series to devices with float times up to 75 ns is permissible. This limited bus contention will not cause any damage to port 0 Drivers.

AC Characteristics for HMS99C5X series (12MHz)
External Data Memory Characteristics

| Parameter | Symbol | 12 MHz Oscillator | | Variable Oscillator 1/t _{CLCL} = 3.5 to 12MHz | | Unit |
|-----------------------------------------------------|--------------------|-------------------|------|-----------------------------------------------------------|-------------------------|------|
| | | Min. | Max. | Min. | Max. | |
| \overline{RD} pulse width | t _{RLRH} | 400 | - | 6t _{CLCL} -100 | - | ns |
| \overline{WR} pulse width | t _{WLWH} | 400 | - | 6t _{CLCL} -100 | - | ns |
| Address hold after ALE | t _{LLAX2} | 53 | - | t _{CLCL} -30 | - | ns |
| \overline{RD} to valid data in | t _{RLDV} | - | 252 | - | 5t _{CLCL} -165 | ns |
| Data hold after \overline{RD} | t _{RHDX} | 0 | - | 0 | - | ns |
| Data float after \overline{RD} | t _{RHDZ} | - | 97 | - | 2t _{CLCL} -70 | ns |
| ALE to valid data in | t _{LLDV} | - | 517 | - | 8t _{CLCL} -150 | ns |
| Address to valid data in | t _{AVDV} | - | 585 | - | 9t _{CLCL} -165 | ns |
| ALE to \overline{WR} or \overline{RD} | t _{LLWL} | 200 | 300 | 3t _{CLCL} -50 | 3t _{CLCL} +50 | ns |
| Address valid to \overline{WR} or \overline{RD} | t _{AVWL} | 203 | - | 4t _{CLCL} -130 | - | ns |
| \overline{WR} or \overline{RD} high to ALE high | t _{WHLH} | 43 | 123 | t _{CLCL} -40 | t _{CLCL} +40 | ns |
| Data valid to \overline{WR} transition | t _{QVWX} | 33 | - | t _{CLCL} -50 | - | ns |
| Data setup before \overline{WR} | t _{QVWH} | 433 | - | 7t _{CLCL} -150 | - | ns |
| Data hold after \overline{WR} | t _{WHQX} | 33 | - | t _{CLCL} -50 | - | ns |
| Address float after \overline{RD} | t _{RLAZ} | - | 0 | - | 0 | ns |

Advance Information (12MHz)
External Clock Drive

| Parameter | Symbol | Variable Oscillator (Freq. = 3.5 to 12MHz) | | Unit |
|-----------------------------------------|-------------------|-----------------------------------------------|---------------------------------------|------|
| | | Min. | Max. | |
| Oscillator period (V _{CC} =5V) | t _{CLCL} | 83.3 | 285.7 | ns |
| High time | t _{CHCX} | 20 | t _{CLCL} - t _{CLCX} | ns |
| Low time | t _{CLCX} | 20 | t _{CLCL} - t _{CHCX} | ns |
| Rise time | t _{CLCH} | - | 20 | ns |
| Fall time | t _{CHCL} | - | 20 | ns |

AC Characteristics for HMS99C5X series (24MHz version)

$V_{CC} = 5V + 10\%, -15\%$; $V_{SS} = 0V$; $T_A = -40^{\circ}C$ to $85^{\circ}C$
 (C_L for port 0, ALE and \overline{PSEN} outputs = 100pF; C_L for all other outputs = 80pF)

External Program Memory Characteristics

| Parameter | Symbol | 24 MHz Oscillator | | Variable Oscillator 1/t _{CLCL} = 3.5 to 24MHz | | Unit |
|-------------------------------------------------|--------------------------------|-------------------|------|-----------------------------------------------------------|------------------------|------|
| | | Min. | Max. | Min. | Max. | |
| ALE pulse width | t _{LHLL} | 43 | - | 2t _{CLCL} -40 | - | ns |
| Address setup to ALE | t _{AVLL} | 17 | - | t _{CLCL} -25 | - | ns |
| Address hold after ALE | t _{LLAX} | 17 | - | t _{CLCL} -25 | - | ns |
| ALE low to valid instruction in | t _{LLIV} | - | 80 | - | 4t _{CLCL} -87 | ns |
| ALE to \overline{PSEN} | t _{LLPL} | 22 | - | t _{CLCL} -20 | - | ns |
| \overline{PSEN} pulse width | t _{PLPH} | 95 | - | 3t _{CLCL} -30 | - | ns |
| \overline{PSEN} to valid instruction in | t _{PLIV} | - | 60 | - | 3t _{CLCL} -65 | ns |
| Input instruction hold after \overline{PSEN} | t _{PXIX} | 0 | - | 0 | - | ns |
| Input instruction float after \overline{PSEN} | t _{PXIZ} [†] | - | 32 | - | t _{CLCL} -10 | ns |
| Address valid after \overline{PSEN} | t _{PXAV} [†] | 37 | - | t _{CLCL} -5 | - | ns |
| Address to valid instruction in | t _{AVIV} | - | 148 | - | 5t _{CLCL} -60 | ns |
| Address float to \overline{PSEN} | t _{AZPL} | 0 | - | 0 | - | ns |

[†] Interfacing the HMS99C5X series to devices with float times up to 35 ns is permissible. This limited bus contention will not cause any damage to port 0 Drivers.

AC Characteristics for HMS99C5X series (24MHz)
External Data Memory Characteristics

| Parameter | Symbol | 24 MHz Oscillator | | Variable Oscillator 1/t _{CLCL} = 3.5 to 24MHz | | Unit |
|-----------------------------------------------------|--------------------|-------------------|------|-----------------------------------------------------------|-------------------------|------|
| | | Min. | Max. | Min. | Max. | |
| \overline{RD} pulse width | t _{RLRH} | 180 | - | 6t _{CLCL} -70 | - | ns |
| \overline{WR} pulse width | t _{WLWH} | 180 | - | 6t _{CLCL} -70 | - | ns |
| Address hold after ALE | t _{LLAX2} | 15 | - | t _{CLCL} -27 | - | ns |
| \overline{RD} to valid data in | t _{RLDV} | - | 118 | - | 5t _{CLCL} -90 | ns |
| Data hold after \overline{RD} | t _{RHDX} | 0 | - | 0 | - | ns |
| Data float after \overline{RD} | t _{RHDZ} | - | 63 | - | 2t _{CLCL} -20 | ns |
| ALE to valid data in | t _{LLDV} | - | 200 | - | 8t _{CLCL} -133 | ns |
| Address to valid data in | t _{AVDV} | - | 220 | - | 9t _{CLCL} -155 | ns |
| ALE to \overline{WR} or \overline{RD} | t _{LLWL} | 75 | 175 | 3t _{CLCL} -50 | 3t _{CLCL} +50 | ns |
| Address valid to \overline{WR} or \overline{RD} | t _{AVWL} | 67 | - | 4t _{CLCL} -97 | - | ns |
| \overline{WR} or \overline{RD} high to ALE high | t _{WHLH} | 17 | 67 | t _{CLCL} -25 | t _{CLCL} +25 | ns |
| Data valid to \overline{WR} transition | t _{QVWX} | 5 | - | t _{CLCL} -37 | - | ns |
| Data setup before \overline{WR} | t _{QVWH} | 170 | - | 7t _{CLCL} -122 | - | ns |
| Data hold after \overline{WR} | t _{WHQX} | 15 | - | t _{CLCL} -27 | - | ns |
| Address float after \overline{RD} | t _{RLAZ} | - | 0 | - | 0 | ns |

Advance Information (24MHz)
External Clock Drive

| Parameter | Symbol | Variable Oscillator (Freq. = 3.5 to 24MHz) | | Unit |
|-------------------|-------------------|-----------------------------------------------|---------------------------------------|------|
| | | Min. | Max. | |
| Oscillator period | t _{CLCL} | 41.7 | 285.7 | ns |
| High time | t _{CHCX} | 12 | t _{CLCL} - t _{CLCX} | ns |
| Low time | t _{CLCX} | 12 | t _{CLCL} - t _{CHCX} | ns |
| Rise time | t _{CLCH} | - | 12 | ns |
| Fall time | t _{CHCL} | - | 12 | ns |

AC Characteristics for HMS99C5X series (40MHz version)

$V_{CC} = 5V + 10\%, -15\%$; $V_{SS} = 0V$; $T_A = -40^{\circ}C$ to $85^{\circ}C$

(C_L for port 0, ALE and \overline{PSEN} outputs = 100pF; C_L for all other outputs = 80pF)

External Program Memory Characteristics

| Parameter | Symbol | 40 MHz Oscillator | | Variable Oscillator 1/t _{CLCL} = 3.5 to 40MHz | | Unit |
|-------------------------------------------------|--------------------------------|-------------------|------|-----------------------------------------------------------|------------------------|------|
| | | Min. | Max. | Min. | Max. | |
| ALE pulse width | t _{LHLL} | 40 | - | 2t _{CLCL} -20 | - | ns |
| Address setup to ALE | t _{AVLL} | 10 | - | t _{CLCL} -20 | - | ns |
| Address hold after ALE | t _{LLAX} | 10 | - | t _{CLCL} -20 | - | ns |
| ALE low to valid instruction in | t _{LLIV} | - | 56 | - | 4t _{CLCL} -65 | ns |
| ALE to \overline{PSEN} | t _{LLPL} | 15 | - | t _{CLCL} -15 | - | ns |
| \overline{PSEN} pulse width | t _{PLPH} | 80 | - | 3t _{CLCL} -20 | - | ns |
| \overline{PSEN} to valid instruction in | t _{PLIV} | - | 35 | - | 3t _{CLCL} -55 | ns |
| Input instruction hold after \overline{PSEN} | t _{PXIX} | 0 | - | 0 | - | ns |
| Input instruction float after \overline{PSEN} | t _{PXIZ} [†] | - | 20 | - | t _{CLCL} -10 | ns |
| Address valid after \overline{PSEN} | t _{PXAV} [†] | 25 | - | t _{CLCL} -5 | - | ns |
| Address to valid instruction in | t _{AVIV} | - | 91 | - | 5t _{CLCL} -60 | ns |
| Address float to \overline{PSEN} | t _{AZPL} | 0 | - | 0 | - | ns |

[†] Interfacing the HMS99C5X series to devices with float times up to 20 ns is permissible. This limited bus contention will not cause any damage to port 0 Drivers.

AC Characteristics for HMS99C5X series (40MHz)
External Data Memory Characteristics

| Parameter | Symbol | at 40 MHz Clock | | Variable Clock 1/t _{CLCL} = 3.5 to 40MHz | | Unit |
|-----------------------------------------------------|--------------------|-----------------|------|------------------------------------------------------|------------------------|------|
| | | Min. | Max. | Min. | Max. | |
| \overline{RD} pulse width | t _{RLRH} | 132 | - | 6t _{CLCL} -50 | - | ns |
| \overline{WR} pulse width | t _{WLWH} | 132 | - | 6t _{CLCL} -50 | - | ns |
| Address hold after ALE | t _{LLAX2} | 10 | - | t _{CLCL} -20 | - | ns |
| \overline{RD} to valid data in | t _{RLDV} | - | 81 | - | 5t _{CLCL} -70 | ns |
| Data hold after \overline{RD} | t _{RHDX} | 0 | - | 0 | - | ns |
| Data float after \overline{RD} | t _{RHDZ} | - | 46 | - | 2t _{CLCL} -15 | ns |
| ALE to valid data in | t _{LLDV} | - | 153 | - | 8t _{CLCL} -90 | ns |
| Address to valid data in | t _{AVDV} | - | 183 | - | 9t _{CLCL} -90 | ns |
| ALE to \overline{WR} or \overline{RD} | t _{LLWL} | 71 | 111 | 3t _{CLCL} -20 | 3t _{CLCL} +20 | ns |
| Address valid to \overline{WR} or \overline{RD} | t _{AVWL} | 66 | - | 4t _{CLCL} -55 | - | ns |
| \overline{WR} or \overline{RD} high to ALE high | t _{WHLH} | 10 | 40 | t _{CLCL} -20 | t _{CLCL} +20 | ns |
| Data valid to \overline{WR} transition | t _{QVWX} | 5 | - | t _{CLCL} -25 | - | ns |
| Data setup before \overline{WR} | t _{QVWH} | 142 | - | 7t _{CLCL} -70 | - | ns |
| Data hold after \overline{WR} | t _{WHQX} | 10 | - | t _{CLCL} -20 | - | ns |
| Address float after \overline{RD} | t _{RLAZ} | - | 0 | - | 0 | ns |

Advance Information (40MHz)
External Clock Drive

| Parameter | Symbol | Variable Oscillator (Freq. = 3.5 to 40MHz) | | Unit |
|-------------------|-------------------|-----------------------------------------------|---------------------------------------|------|
| | | Min. | Max. | |
| Oscillator period | t _{CLCL} | 30.3 | 285.7 | ns |
| High time | t _{CHCX} | 11.5 | t _{CLCL} - t _{CLCX} | ns |
| Low time | t _{CLCX} | 11.5 | t _{CLCL} - t _{CHCX} | ns |
| Rise time | t _{CLCH} | - | 5 | ns |
| Fall time | t _{CHCL} | - | 5 | ns |

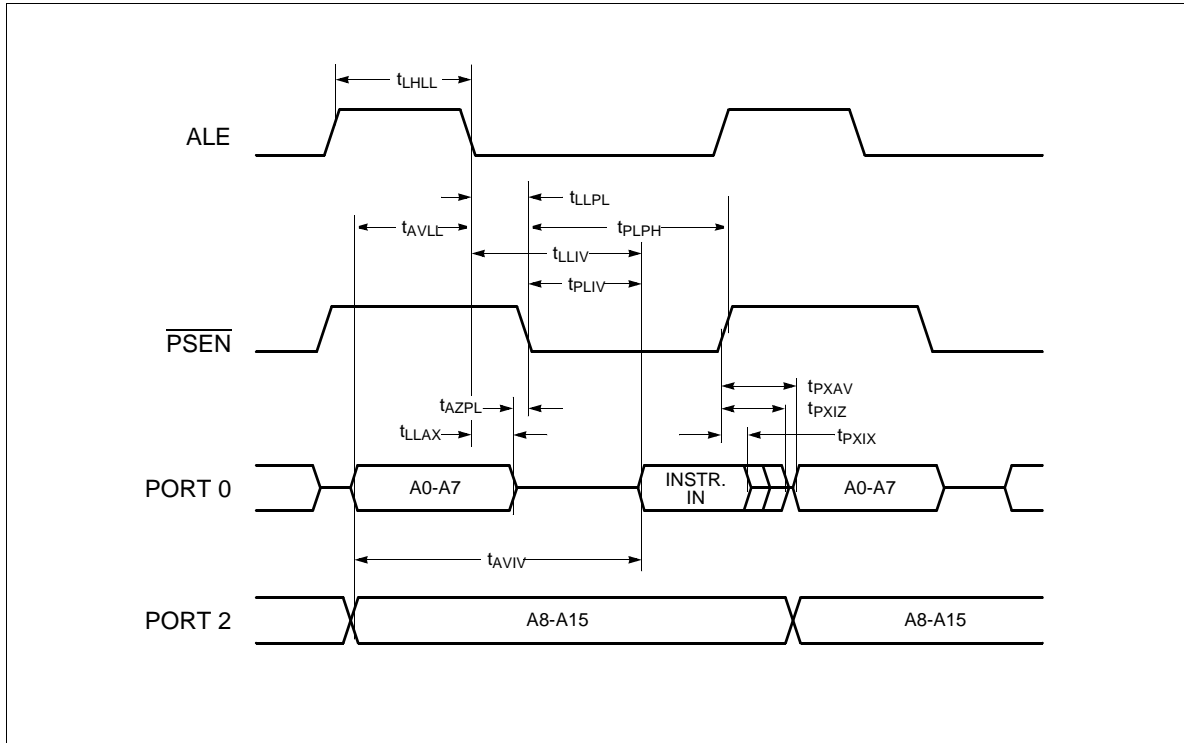


Figure 6. External Program Memory Read Cycle

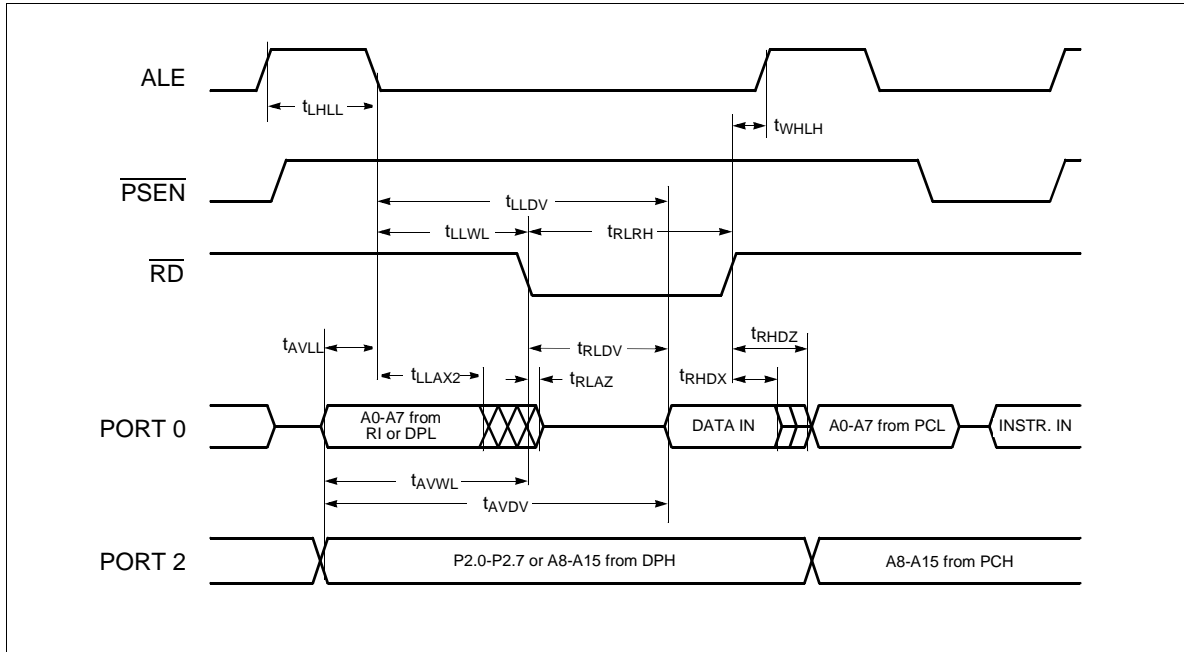


Figure 7. External Data Memory Read Cycle

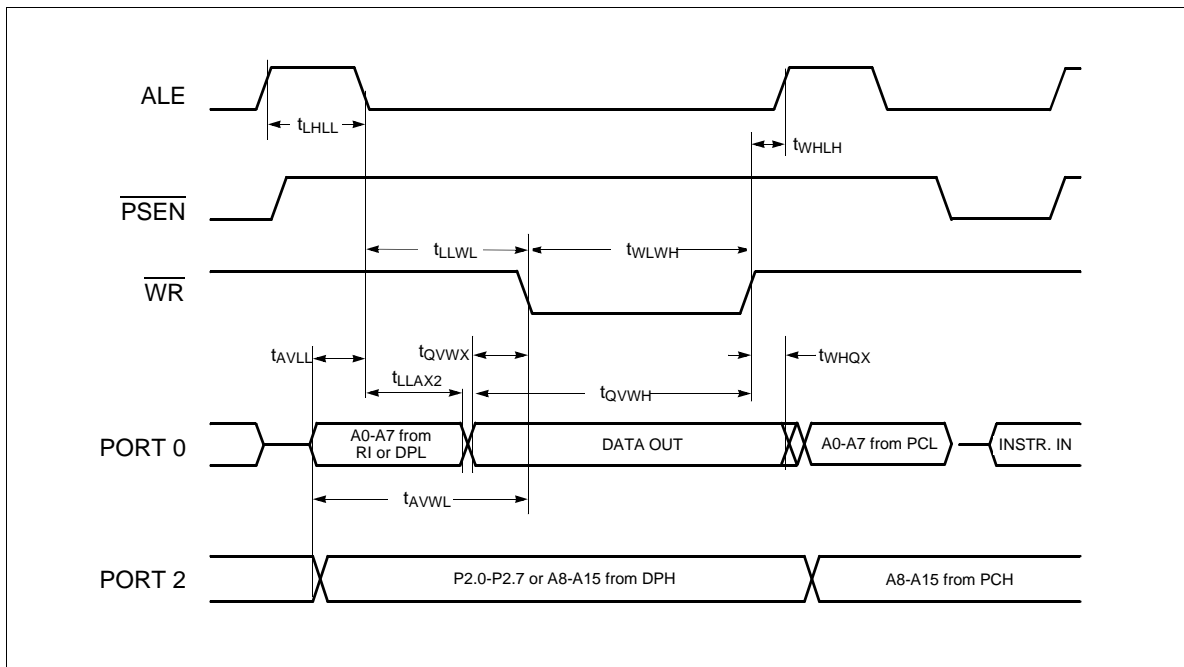


Figure 8. External Data Memory Write Cycle

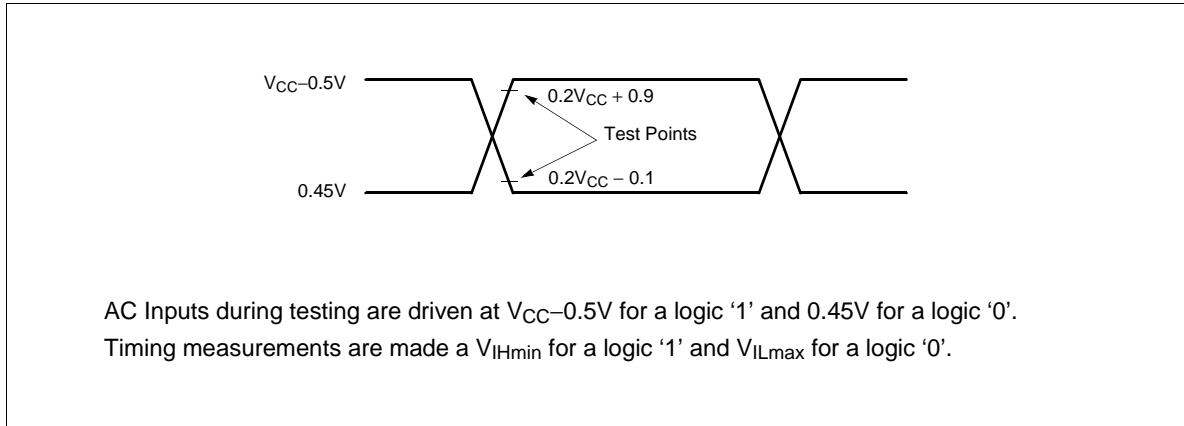


Figure 9. AC Testing: Input, Output Waveforms

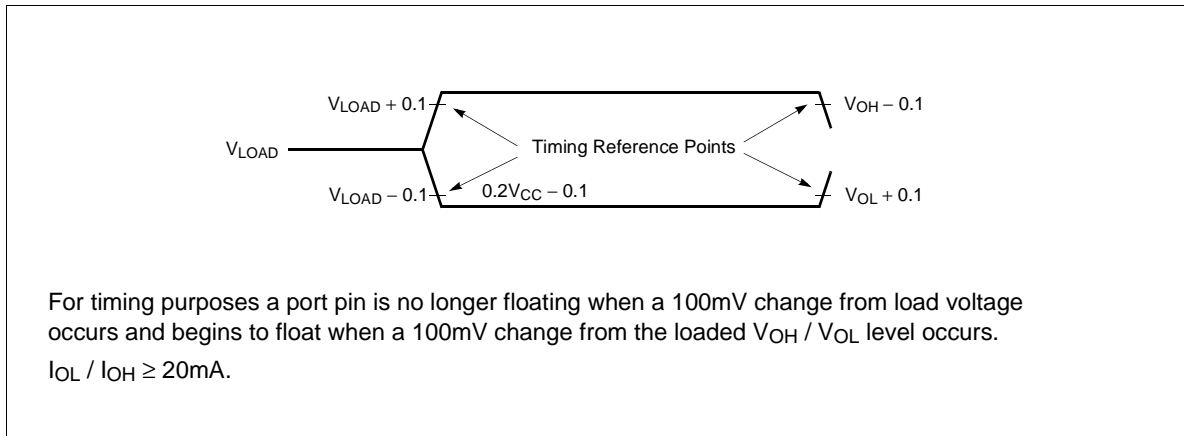


Figure 10. Float Waveforms

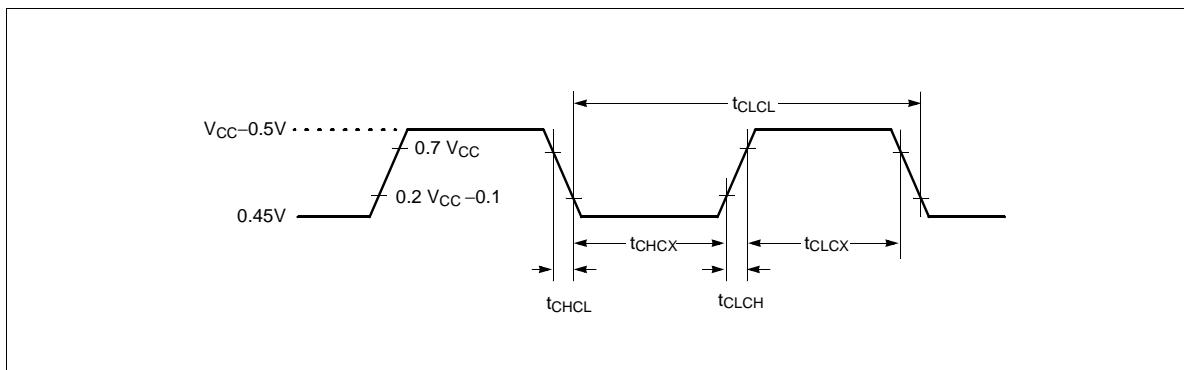


Figure 11. External Clock Cycle

OSCILLATOR CIRCUIT

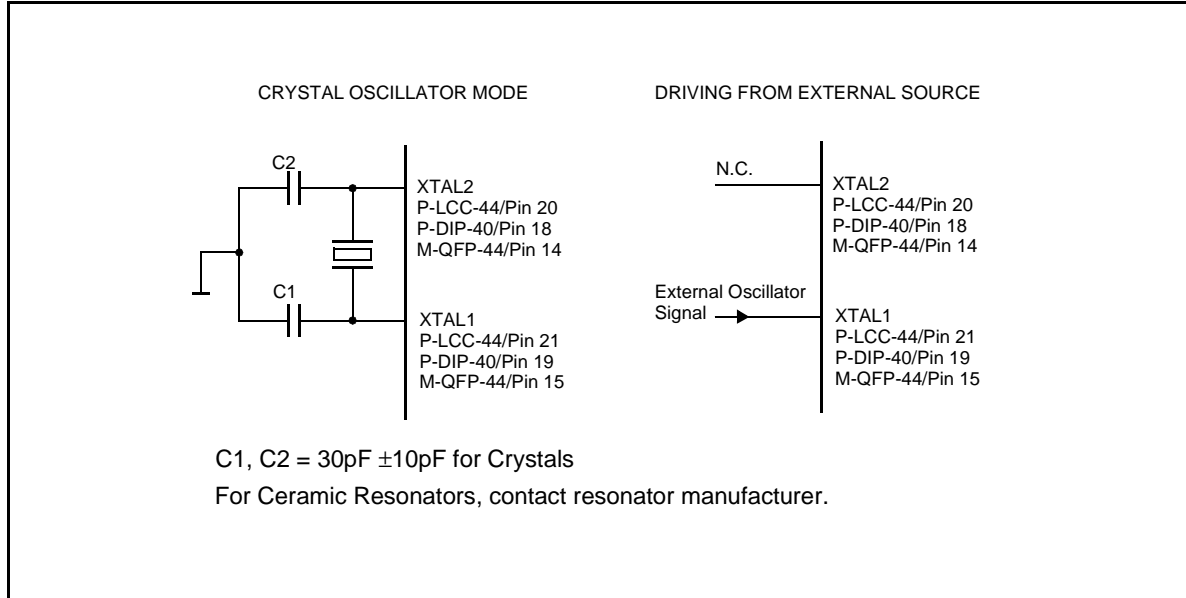
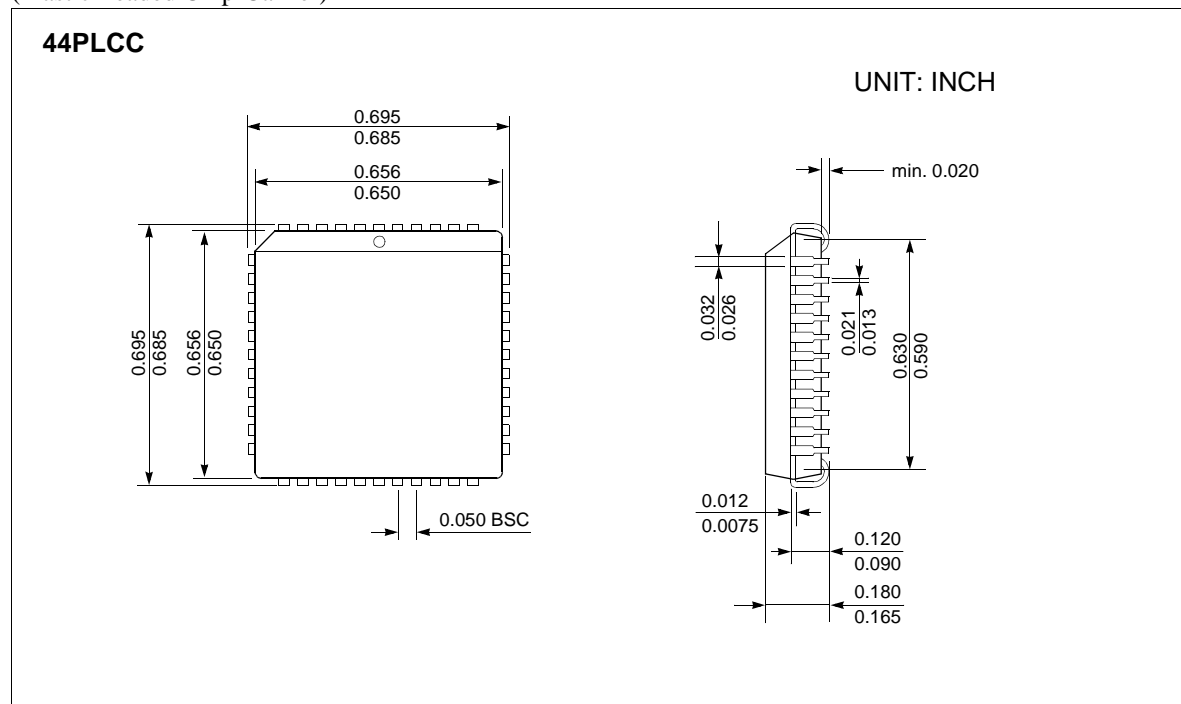


Figure 12. Recommended Oscillator Circuits

Oscillation circuit is designed to be used either with a ceramic resonator or crystal oscillator. Since each crystal and ceramic resonator have their own characteristics, the user should consult the crystal manufacturer for appropriate values of external components.

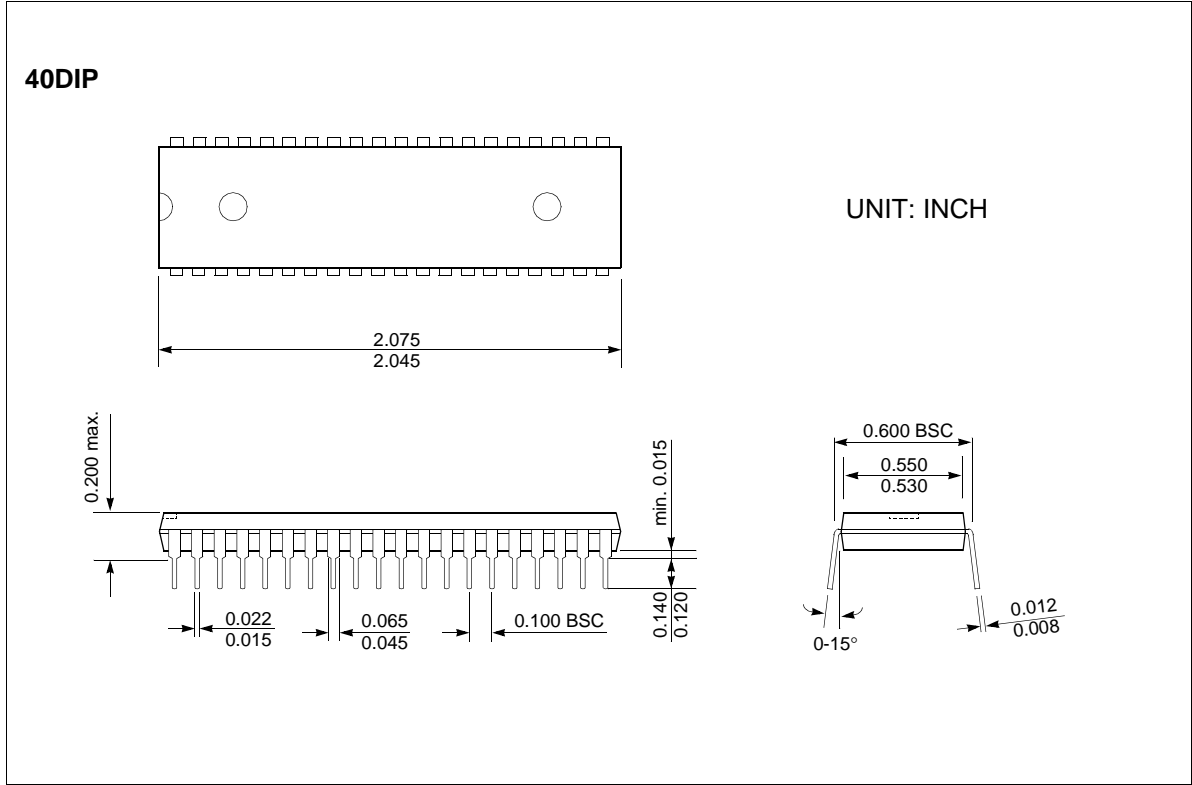
Plastic Package P-LCC-44

(Plastic Leaded Chip-Carrier)



Plastic Package P-DIP-40

(Plastic Dual in-Line Package)



Plastic Package P-MPQF-44

(Plastic Metric Quad Flat Package)

