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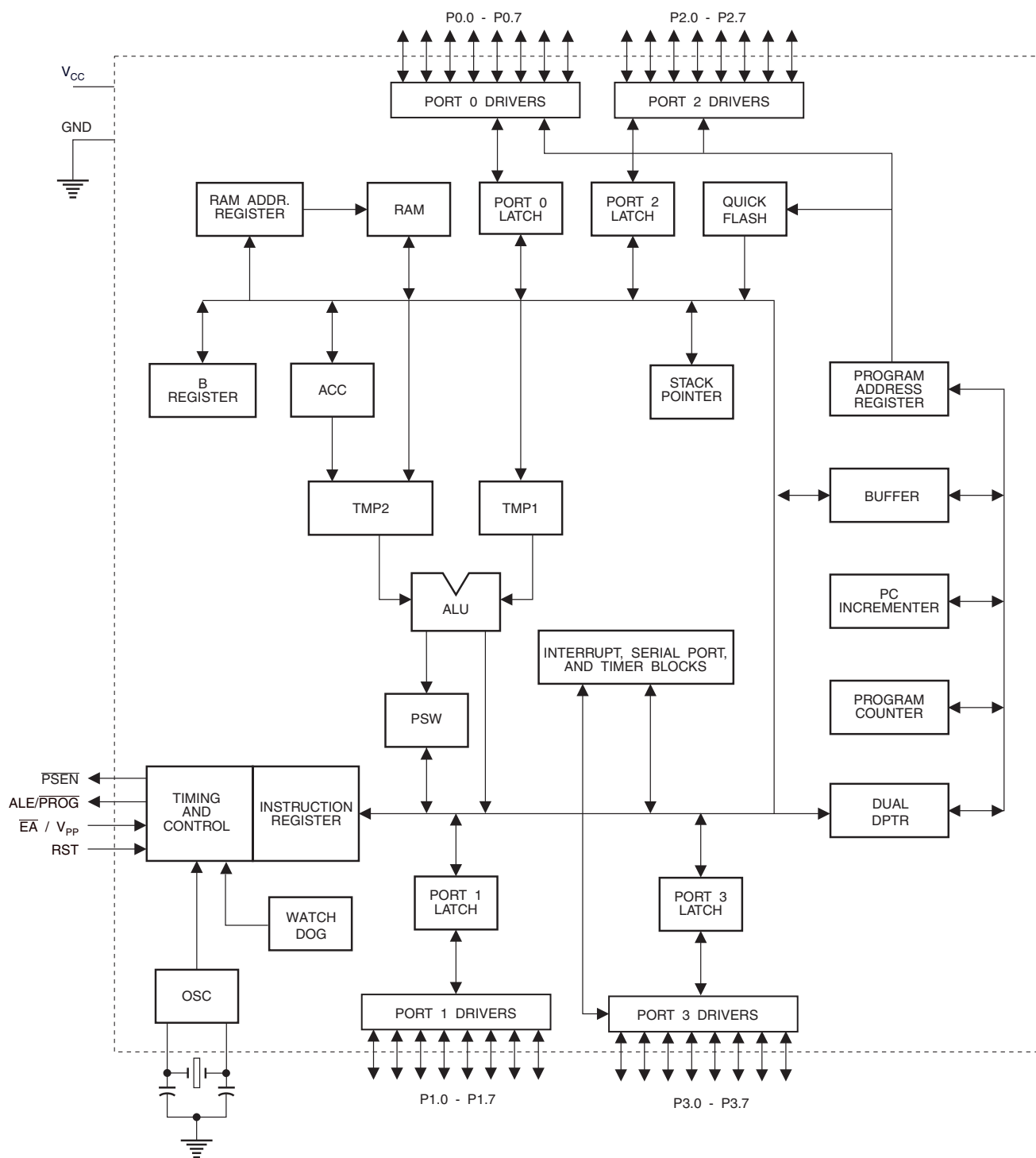
"[Embedded - Microcontrollers](#)" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

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#### Details

|                            |   |
|----------------------------|---|
| Product Status             | Obsolete  |
| Core Processor             | 8051  |
| Core Size                  | 8-Bit   |
| Speed                      | 24MHz   |
| Connectivity               | UART/USART  |
| Peripherals                | WDT   |
| Number of I/O              | 32  |
| Program Memory Size        | 20KB (20K x 8)  |
| Program Memory Type        | OTP Quick FLASH   |
| EEPROM Size                | -   |
| RAM Size                   | 256 x 8   |
| Voltage - Supply (Vcc/Vdd) | 4V ~ 5.5V   |
| Data Converters            | -   |
| Oscillator Type            | Internal  |
| Operating Temperature      | -40°C ~ 85°C  |
| Mounting Type              | Through Hole  |
| Package / Case             | 40-DIP (0.600", 15.24mm)  |
| Supplier Device Package    | 40-PDIP   |
| Purchase URL               | <a href="https://www.e-xfl.com/product-detail/microchip-technology/at87f55wd-24pi">https://www.e-xfl.com/product-detail/microchip-technology/at87f55wd-24pi</a> |

## Block Diagram



memory. This pin is also the program pulse input ( $\overline{\text{PROG}}$ ) during QuickFlash programming.

In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory.

If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

#### **$\overline{\text{PSEN}}$**

Program Store Enable is the read strobe to external program memory.

When the AT87F55WD is executing code from 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.

#### **$\overline{\text{EA/VPP}}$**

External Access Enable.  $\overline{\text{EA}}$  must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed,  $\overline{\text{EA}}$  will be internally latched on reset.

$\overline{\text{EA}}$  should be strapped to  $V_{CC}$  for internal program executions.

This pin also receives the 12-volt programming enable voltage ( $V_{PP}$ ) during QuickFlash programming.

#### **XTAL1**

Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

#### **XTAL2**

Output from the inverting oscillator amplifier.

**Table 1.** AT87F55WD SFR Map and Reset Values

|      |                   |                   |                    |                    |                  |                  |                    |      |
|------|-------------------|-------------------|--------------------|--------------------|------------------|------------------|--------------------|------|
| 0F8H |                   |                   |                    |                    |                  |                  |                    | 0FFH |
| 0F0H | B<br>00000000     |                   |                    |                    |                  |                  |                    | 0F7H |
| 0E8H |                   |                   |                    |                    |                  |                  |                    | 0EFH |
| 0E0H | ACC<br>00000000   |                   |                    |                    |                  |                  |                    | 0E7H |
| 0D8H |                   |                   |                    |                    |                  |                  |                    | 0DFH |
| 0D0H | PSW<br>00000000   |                   |                    |                    |                  |                  |                    | 0D7H |
| 0C8H | T2CON<br>00000000 | T2MOD<br>XXXXXX00 | RCAP2L<br>00000000 | RCAP2H<br>00000000 | TL2<br>00000000  | TH2<br>00000000  |                    | 0CFH |
| 0C0H |                   |                   |                    |                    |                  |                  |                    | 0C7H |
| 0B8H | IP<br>XX000000    |                   |                    |                    |                  |                  |                    | 0BFH |
| 0B0H | P3<br>11111111    |                   |                    |                    |                  |                  |                    | 0B7H |
| 0A8H | IE<br>0X000000    |                   |                    |                    |                  |                  |                    | 0AFH |
| 0A0H | P2<br>11111111    |                   | AUXR1<br>XXXXXXX0  |                    |                  |                  | WDTRST<br>XXXXXXXX | 0A7H |
| 98H  | SCON<br>00000000  | SBUF<br>XXXXXXXX  |                    |                    |                  |                  |                    | 9FH  |
| 90H  | P1<br>11111111    |                   |                    |                    |                  |                  |                    | 97H  |
| 88H  | TCON<br>00000000  | TMOD<br>00000000  | TL0<br>00000000    | TL1<br>00000000    | TH0<br>00000000  | TH1<br>00000000  | AUXR<br>XXX00XX0   | 8FH  |
| 80H  | P0<br>11111111    | SP<br>00000111    | DP0L<br>00000000   | DP0H<br>00000000   | DP1L<br>00000000 | DP1H<br>00000000 | PCON<br>0XXX0000   | 87H  |

## Special Function Registers

A map of the on-chip memory area called the Special Function Register (SFR) space is shown in Table 1.

Note that not all of the addresses are occupied, and unoccupied addresses may not be implemented on the chip. Read accesses to these addresses will in general return random data, and write accesses will have an indeterminate effect.

User software should not write 1s to these unlisted locations, since they may be used in future products to invoke

new features. In that case, the reset or inactive values of the new bits will always be 0.

**Timer 2 Registers:** Control and status bits are contained in registers T2CON (shown in Table 2) and T2MOD (shown in Table 4) for Timer 2. The register pair (RCAP2H, RCAP2L) are the Capture/Reload registers for Timer 2 in 16-bit capture mode or 16-bit auto-reload mode.

**Interrupt Registers:** The individual interrupt enable bits are in the IE register. Two priorities can be set for each of the six interrupt sources in the IP register.

**Table 2.** T2CON – Timer/Counter 2 Control Register

T2CON Address = 0C8H

Reset Value = 0000 0000B

Bit Addressable

| Bit | TF2 | EXF2 | RCLK | TCLK | EXEN2 | TR2 | C/ $\overline{T2}$ | CP/ $\overline{RL2}$ |
|-----|-----|------|------|------|-------|-----|--------------------|----------------------|
|     | 7   | 6    | 5    | 4    | 3     | 2   | 1                  | 0                    |

| Symbol              | Function   |
|---------------------|--|
| TF2                 | Timer 2 overflow flag set by a Timer 2 overflow and must be cleared by software. TF2 will not be set when either RCLK = 1 or TCLK = 1.   |
| EXF2                | Timer 2 external flag set when either a capture or reload is caused by a negative transition on T2EX and EXEN2 = 1. When Timer 2 interrupt is enabled, EXF2 = 1 will cause the CPU to vector to the Timer 2 interrupt routine. EXF2 must be cleared by software. EXF2 does not cause an interrupt in up/down counter mode (DCEN = 1).                                      |
| RCLK                | Receive clock enable. When set, causes the serial port to use Timer 2 overflow pulses for its receive clock in serial port Modes 1 and 3. RCLK = 0 causes Timer 1 overflow to be used for the receive clock.   |
| TCLK                | Transmit clock enable. When set, causes the serial port to use Timer 2 overflow pulses for its transmit clock in serial port Modes 1 and 3. TCLK = 0 causes Timer 1 overflows to be used for the transmit clock.   |
| EXEN2               | Timer 2 external enable. When set, allows a capture or reload to occur as a result of a negative transition on T2EX if Timer 2 is not being used to clock the serial port. EXEN2 = 0 causes Timer 2 to ignore events at T2EX.  |
| TR2                 | Start/Stop control for Timer 2. TR2 = 1 starts the timer.  |
| $C/\overline{T2}$   | Timer or counter select for Timer 2. $C/\overline{T2}$ = 0 for timer function. $C/\overline{T2}$ = 1 for external event counter (falling edge triggered).  |
| $CP/\overline{RL2}$ | Capture/Reload select. $CP/\overline{RL2}$ = 1 causes captures to occur on negative transitions at T2EX if EXEN2 = 1. $CP/\overline{RL2}$ = 0 causes automatic reloads to occur when Timer 2 overflows or negative transitions occur at T2EX when EXEN2 = 1. When either RCLK or TCLK = 1, this bit is ignored and the timer is forced to auto-reload on Timer 2 overflow. |

**Table 3a. AUXR: Auxiliary Register**

AUXR

Address = 8EH

Reset Value = XXX00XX0B

Not Bit Addressable

|     |   |   |   |        |        |   |   |        |
|-----|---|---|---|--------|--------|---|---|--------|
|     | – | – | – | WDIDLE | DISRTO | – | – | DISALE |
| Bit | 7 | 6 | 5 | 4      | 3      | 2 | 1 | 0      |

–

Reserved for future expansion

DISALE

Disable/Enable ALE

DISALE

Operating mode

0

ALE is emitted at a constant rate of 1/6 the oscillator frequency

1

ALE is active only during a MOVX or MOVC instruction

DISTRTO

Disable/Enable Reset out

DISRTO

0

Reset pin is driven High after WDT times out

1

Reset pin is input only

WDIDLE

Disable/Enable WDT in IDLE mode

WDIDLE

0

WDT continues to count in IDLE mode

1

WDT halts counting in IDLE mode

**Dual Data Pointer Registers:** To facilitate accessing both internal and external data memory, two banks of 16-bit Data Pointer Registers are provided: DP0 at SFR address locations 82H-83H and DP1 at 84H-85H. Bit DPS = 0 in SFR AUXR1 selects DP0 and DPS = 1 selects DP1. The user should always initialize the DPS bit to the appropriate value before accessing the respective Data Pointer Register.

**Power Off Flag:** The Power Off Flag (POF) is located at bit 4 (PCON.4) in the PCON SFR. POF is set to “1” during power up. It can be set and reset under software control and is not affected by reset.

**Table 3b. AUXR1: Auxiliary Register 1**

|       |                               |                                   |   |   |   |   |   |     |   |
|-------|-------------------------------|-----------------------------------|---|---|---|---|---|-----|---|
| AUXR1 | Address = A2H                 | Reset Value = XXXXXXX0B           |   |   |   |   |   |     |   |
|       | Not Bit Addressable           |                                   |   |   |   |   |   |     |   |
|       |                               | –                                 | – | – | – | – | – | DPS |   |
| Bit   |                               | 7                                 | 6 | 5 | 4 | 3 | 2 | 1   | 0 |
| –     | Reserved for future expansion |                                   |   |   |   |   |   |     |   |
| DPS   | Data Pointer Register Select  |                                   |   |   |   |   |   |     |   |
|       | DPS                           |                                   |   |   |   |   |   |     |   |
|       | 0                             | Selects DPTR Registers DP0L, DP0H |   |   |   |   |   |     |   |
|       | 1                             | Selects DPTR Registers DP1L, DP1H |   |   |   |   |   |     |   |

## Memory Organization

MCS-51 devices have a separate address space for Program and Data Memory. Up to 64K bytes each of external Program and Data Memory can be addressed.

### Program Memory

If the  $\overline{EA}$  pin is connected to GND, all program fetches are directed to external memory.

On the AT87F55WD, if  $\overline{EA}$  is connected to  $V_{CC}$ , program fetches to addresses 0000H through 4FFFH are directed to internal memory and fetches to addresses 5000H through FFFFH are directed to external memory.

### Data Memory

The AT87F55WD implements 256 bytes of on-chip RAM. The upper 128 bytes occupy a parallel address space to the Special Function Registers. That means the upper 128 bytes have the same addresses as the SFR space but are physically separate from SFR space.

When an instruction accesses an internal location above address 7FH, the address mode used in the instruction specifies whether the CPU accesses the upper 128 bytes of RAM or the SFR space. Instructions that use direct addressing access SFR space.

For example, the following direct addressing instruction accesses the SFR at location 0A0H (which is P2).

```
MOV 0A0H, #data
```

Instructions that use indirect addressing access the upper 128 bytes of RAM. For example, the following indirect addressing instruction, where R0 contains 0A0H, accesses the data byte at address 0A0H, rather than P2 (whose address is 0A0H).

```
MOV @R0, #data
```

Note that stack operations are examples of indirect addressing, so the upper 128 bytes of data RAM are available as stack space.

## Hardware Watchdog Timer (One-time Enabled with Reset-out)

The WDT is intended as a recovery method in situations where the CPU may be subjected to software upsets. The WDT consists of a 14-bit counter and the Watchdog Timer Reset (WDTRST) SFR. The WDT is defaulted to disable from exiting reset. To enable the WDT, a user must write 01EH and 0E1H in sequence to the WDTRST register (SFR location 0A6H). When the WDT is enabled, it will increment every machine cycle while the oscillator is running. There is no way to disable the WDT except through reset (either hardware reset or WDT overflow reset). When WDT overflows, it will drive an output RESET HIGH pulse at the RST pin.

### Using the WDT

To enable the WDT, a user must write 01EH and 0E1H in sequence to the WDTRST register (SFR location 0A6H). When the WDT is enabled, the user needs to service it by writing 01EH and 0E1H to WDTRST to avoid a WDT overflow. The 14-bit counter overflows when it reaches 16383 (3FFFH), and this will reset the device. When the WDT is enabled, it will increment every machine cycle while the oscillator is running. This means the user must reset the WDT at least every 16383 machine cycles. To reset the WDT the user must write 01EH and 0E1H to WDTRST. WDTRST is a write-only register. The WDT counter cannot be read or written. When WDT overflows, it will generate an output RESET pulse at the RST pin. The RESET pulse duration is  $98 \times TOSC$ , where  $TOSC = 1/FOSC$ . To make the best use of the WDT, it should be serviced in those sections of code that will periodically be executed within the time required to prevent a WDT reset.

### WDT During Power-down and Idle Mode

In Power-down mode the oscillator stops, which means the WDT also stops. While in Power-down mode, the user does not need to service the WDT. There are two methods of exiting Power-down mode: by a hardware reset or via a level-activated external interrupt which is enabled prior to entering Power-down mode. When Power-down is exited with hardware reset, servicing the WDT should occur as it normally does whenever the AT87F55WD is reset. Exiting Power-down with an interrupt is significantly different. The interrupt is held low long enough for the oscillator to stabilize. When the interrupt is brought high, the interrupt is serviced. To prevent the WDT from resetting the device while the interrupt pin is held low, the WDT is not started until the interrupt is pulled high. It is suggested that the WDT be reset during the interrupt service for the interrupt used to exit Power-down.

To ensure that the WDT does not overflow within a few states of exiting Power-down, it is best to reset the WDT just before entering Power-down.

Before going into the IDLE mode, the WDIDLE bit in SFR AUXR is used to determine whether the WDT continues to count if enabled. The WDT keeps counting during IDLE (WDIDLE bit = 0) as the default state. To prevent the WDT from resetting the AT87F55WD while in IDLE mode, the user should always set up a timer that will periodically exit IDLE, service the WDT, and reenter IDLE mode.

With WDIDLE bit enabled, the WDT will stop to count in IDLE mode and resumes the count upon exit from IDLE.

## UART

The UART in the AT87F55WD operates the same way as the UART in the AT87F51 and AT87F52. For further information, see the December 1997 Microcontroller Data Book, page 2-48, section titled, "Serial Interface".

### Timer 0 and 1

Timer 0 and Timer 1 in the AT87F55WD operate the same way as Timer 0 and Timer 1 in the AT87F51 and AT87F52.

### Timer 2

Timer 2 is a 16-bit Timer/Counter that can operate as either a timer or an event counter. The type of operation is selected by bit  $C/\overline{T}2$  in the SFR T2CON (shown in Table 2). Timer 2 has three operating modes: capture, auto-reload (up or down counting), and baud rate generator. The modes are selected by bits in T2CON, as shown in Table 4.

Timer 2 consists of two 8-bit registers, TH2 and TL2. In the Timer function, the TL2 register is incremented every machine cycle. Since a machine cycle consists of 12 oscillator periods, the count rate is 1/12 of the oscillator frequency.

**Table 4.** Timer 2 Operating Modes

| RCLK +TCLK | CP/ $\overline{RL}2$ | TR2 | MODE                |
|------------|----------------------|-----|---------------------|
| 0          | 0                    | 1   | 16-bit Auto-reload  |
| 0          | 1                    | 1   | 16-bit Capture      |
| 1          | X                    | 1   | Baud Rate Generator |
| X          | X                    | 0   | (Off)               |

In the Counter function, the register is incremented in response to a 1-to-0 transition at its corresponding external input pin, T2. In this function, the external input is sampled during S5P2 of every machine cycle. When the samples show a high in one cycle and a low in the next cycle, the count is incremented. The new count value appears in the register during S3P1 of the cycle following the one in which

the transition was detected. Since two machine cycles (24 oscillator periods) are required to recognize a 1-to-0 transition, the maximum count rate is 1/24 of the oscillator frequency. To ensure that a given level is sampled at least once before it changes, the level should be held for at least one full machine cycle.

## Capture Mode

In the capture mode, two options are selected by bit EXEN2 in T2CON. If EXEN2 = 0, Timer 2 is a 16-bit timer or counter which upon overflow sets bit TF2 in T2CON. This bit can then be used to generate an interrupt. If EXEN2 = 1, Timer 2 performs the same operation, but a 1-to-0 transition at external input T2EX also causes the

current value in TH2 and TL2 to be captured into RCAP2H and RCAP2L, respectively. In addition, the transition at T2EX causes bit EXF2 in T2CON to be set. The EXF2 bit, like TF2, can generate an interrupt. The capture mode is illustrated in Figure 5.

## Auto-reload (Up or Down Counter)

Timer 2 can be programmed to count up or down when configured in its 16-bit auto-reload mode. This feature is invoked by the DCEN (Down Counter Enable) bit located in the SFR T2MOD (see Table 5). Upon reset, the DCEN bit is set to 0 so that timer 2 will default to count up. When DCEN is set, Timer 2 can count up or down, depending on the value of the T2EX pin.

**Figure 5. Timer in Capture Mode**

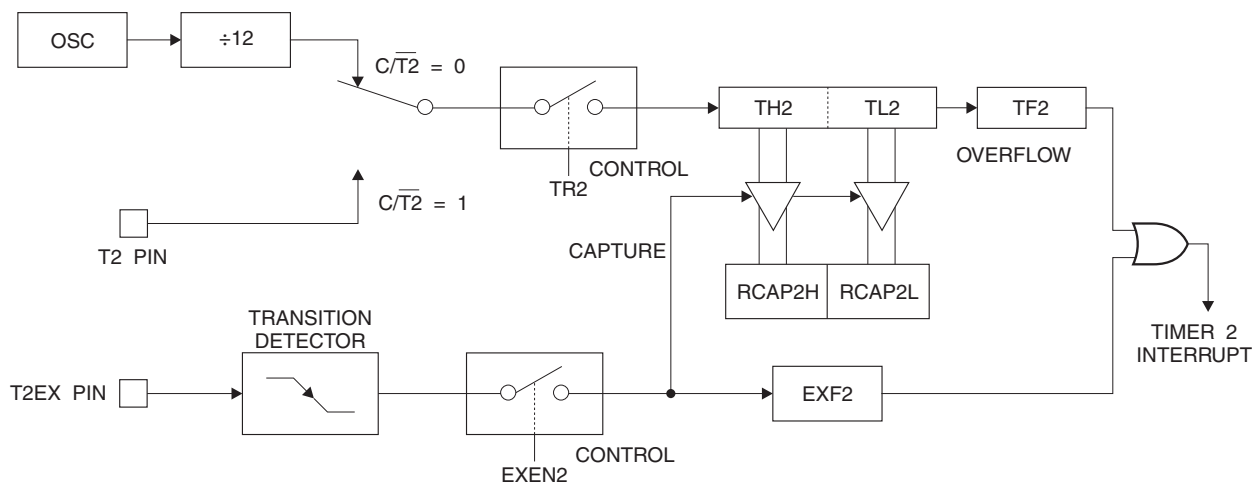


Figure 6 shows Timer 2 automatically counting up when DCEN=0. In this mode, two options are selected by bit EXEN2 in T2CON. If EXEN2 = 0, Timer 2 counts up to 0FFFFH and then sets the TF2 bit upon overflow. The overflow also causes the timer registers to be reloaded with the 16-bit value in RCAP2H and RCAP2L. The values in Timer in Capture mode RCAP2H and RCAP2L are preset by software. If EXEN2 = 1, a 16-bit reload can be triggered either by an overflow or by a 1-to-0 transition at external input T2EX. This transition also sets the EXF2 bit. Both the TF2 and EXF2 bits can generate an interrupt if enabled.

Setting the DCEN bit enables Timer 2 to count up or down, as shown in Figure 6. In this mode, the T2EX pin controls

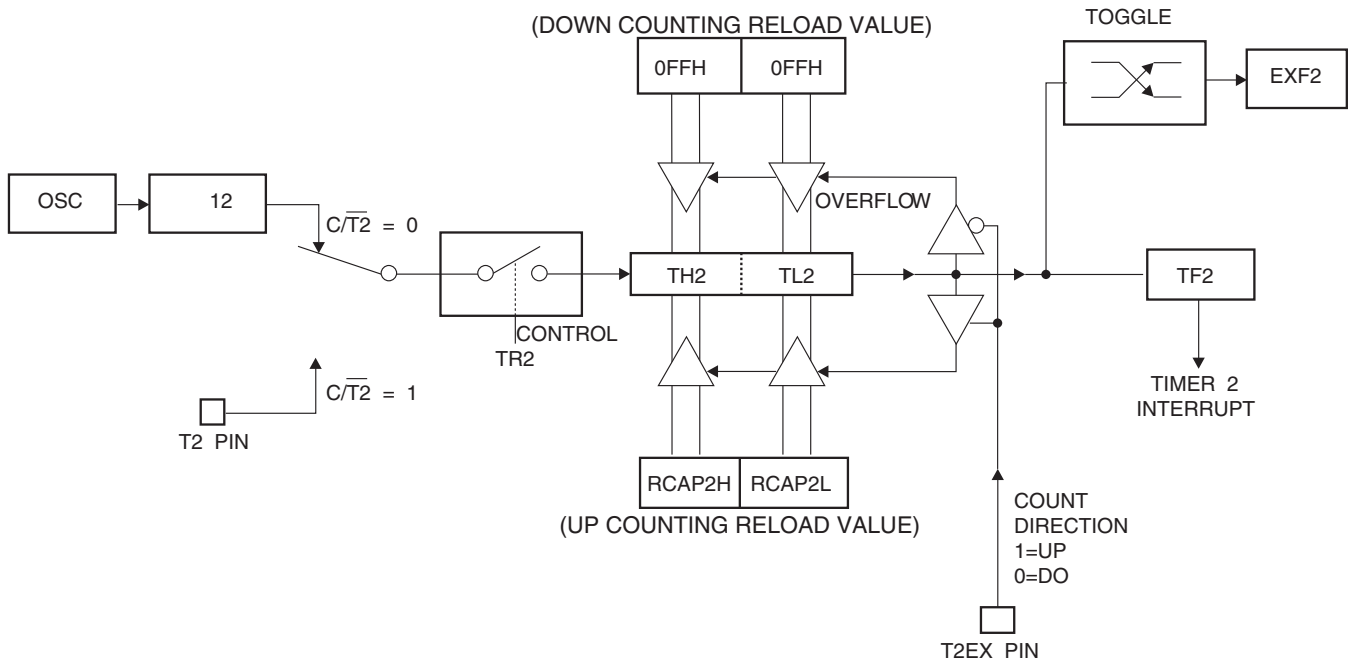
the direction of the count. A logic 1 at T2EX makes Timer 2 count up. The timer will overflow at 0FFFFH and set the TF2 bit. This overflow also causes the 16-bit value in RCAP2H and RCAP2L to be reloaded into the timer registers, TH2 and TL2, respectively.

A logic 0 at T2EX makes Timer 2 count down. The timer underflows when TH2 and TL2 equal the values stored in RCAP2H and RCAP2L. The underflow sets the TF2 bit and causes 0FFFFH to be reloaded into the timer registers.

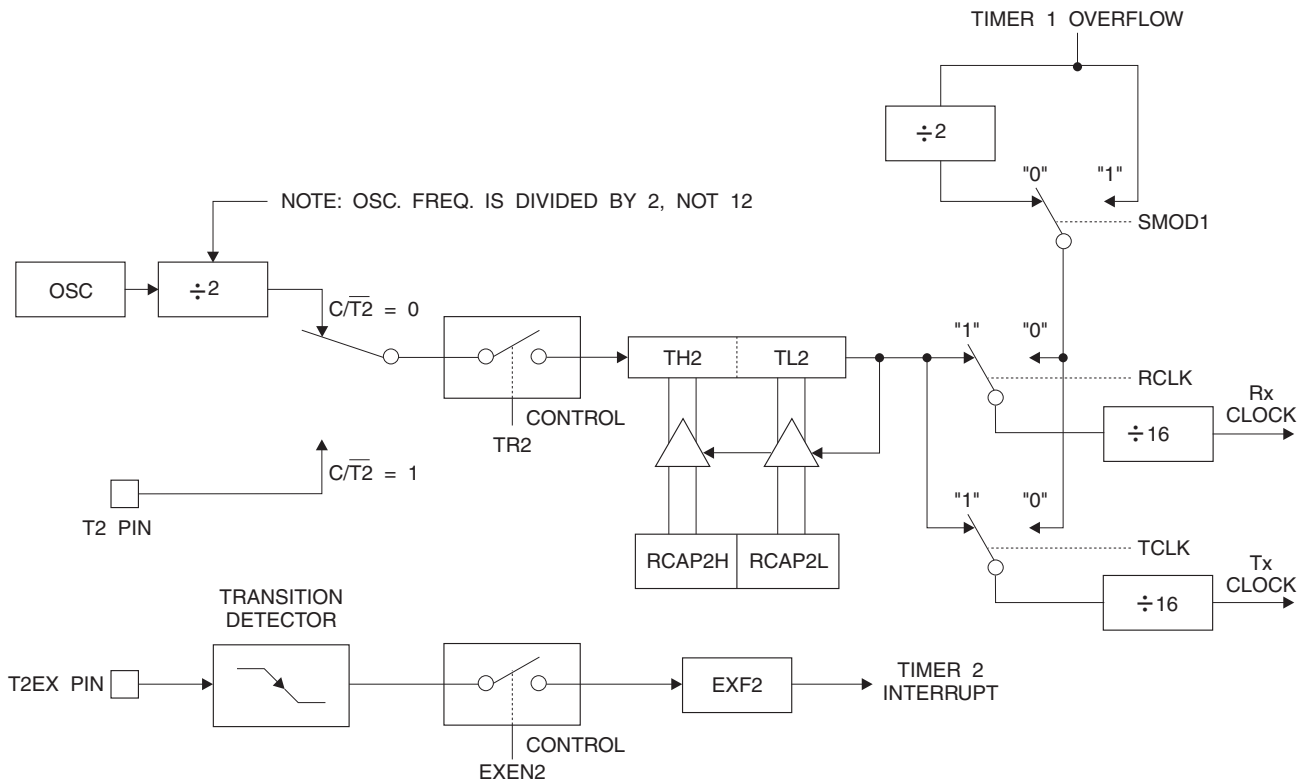
The EXF2 bit toggles whenever Timer 2 overflows or underflows and can be used as a 17th bit of resolution. In this operating mode, EXF2 does not flag an interrupt.



**Figure 7. Timer 2 Auto Reload Mode (DCEN = 1)**



**Figure 8. Timer 2 in Baud Rate Generator Mode**



## Programmable Clock Out

A 50% duty cycle clock can be programmed to come out on P1.0, as shown in Figure 9. This pin, besides being a regular I/O pin, has two alternate functions. It can be programmed to input the external clock for Timer/Counter 2 or to output a 50% duty cycle clock ranging from 61 Hz to 4 MHz at a 16 MHz operating frequency.

To configure the Timer/Counter 2 as a clock generator, bit C/T2 (T2CON.1) must be cleared and bit T2OE (T2MOD.1) must be set. Bit TR2 (T2CON.2) starts and stops the timer.

The clock-out frequency depends on the oscillator frequency and the reload value of Timer 2 capture registers (RCAP2H, RCAP2L), as shown in the following equation.

$$\text{Clock-out Frequency} = \frac{\text{Oscillator Frequency}}{4 \times [65536 - (\text{RCAP2H}, \text{RCAP2L})]}$$

In the clock-out mode, Timer 2 roll-overs will not generate an interrupt. This behavior is similar to when Timer 2 is used as a baud-rate generator. It is possible to use Timer 2 as a baud-rate generator and a clock generator simultaneously. Note, however, that the baud-rate and clock-out frequencies cannot be determined independently from one another since they both use RCAP2H and RCAP2L.

## Interrupts

The AT87F55WD has a total of six interrupt vectors: two external interrupts (INT0 and INT1), three timer interrupts (Timers 0, 1, and 2), and the serial port interrupt. These interrupts are all shown in Figure 10.

Each of these interrupt sources can be individually enabled or disabled by setting or clearing a bit in Special Function Register IE. IE also contains a global disable bit, EA, which disables all interrupts at once.

Note that Table 5 shows that bit position IE.6 is unimplemented. In the AT87F55WD, bit position IE.5 is also unimplemented. User software should not write 1s to these bit positions, since they may be used in future AT89 products.

Timer 2 interrupt is generated by the logical OR of bits TF2 and EXF2 in register T2CON. Neither of these flags is cleared by hardware when the service routine is vectored to. In fact, the service routine may have to determine whether it was TF2 or EXF2 that generated the interrupt, and that bit will have to be cleared in software.

The Timer 0 and Timer 1 flags, TF0 and TF1, are set at S5P2 of the cycle in which the timers overflow. The values are then polled by the circuitry in the next cycle. However, the Timer 2 flag, TF2, is set at S2P2 and is polled in the same cycle in which the timer overflows.

**Table 6.** Interrupt Enable (IE) Register

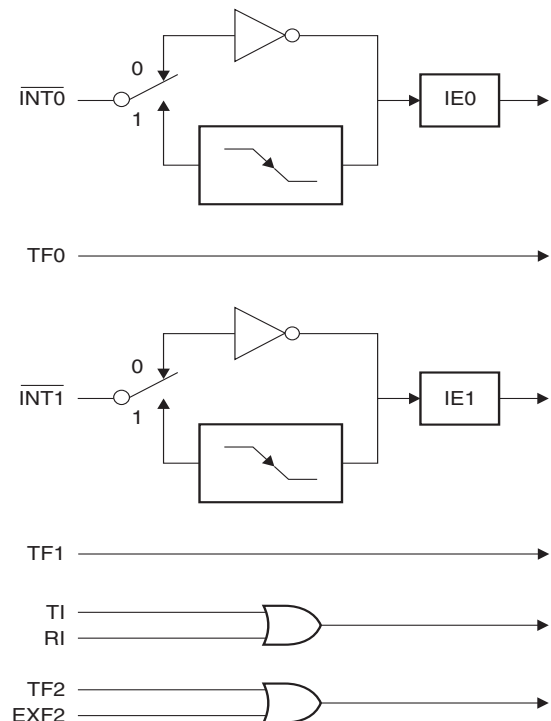
| (MSB)                                  |   |     |    | (LSB) |     |     |     |
|--|---|-----|----|-------|-----|-----|-----|
| EA                                     | – | ET2 | ES | ET1   | EX1 | ET0 | EX0 |
| Enable Bit = 1 enables the interrupt.  |   |     |    |       |     |     |     |
| Enable Bit = 0 disables the interrupt. |   |     |    |       |     |     |     |

| Symbol | Position | Function  |
|--------|----------|---|
| EA     | IE.7     | Disables all interrupts. If EA = 0, no interrupt is acknowledged. If EA = 1, each interrupt source is individually enabled or disabled by setting or clearing its enable bit. |
| –      | IE.6     | Reserved.   |
| ET2    | IE.5     | Timer 2 interrupt enable bit  |
| ES     | IE.4     | Serial Port interrupt enable bit  |
| ET1    | IE.3     | Timer 1 interrupt enable bit  |
| EX1    | IE.2     | External interrupt 1 enable bit   |
| ET0    | IE.1     | Timer 0 interrupt enable bit  |
| EX0    | IE.0     | External interrupt 0 enable bit   |

User software should never write 1s to unimplemented bits, because they may be used in future AT87 products.

**Figure 10.** Interrupt Sources



## Oscillator Characteristics

XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier that can be configured for use as an on-chip oscillator, as shown in Figure 11. Either a quartz crystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven, as shown in Figure 12. 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 voltage high and low time specifications must be observed.

## Idle Mode

In idle mode, the CPU puts itself to sleep while all the on-chip peripherals remain active. The mode is invoked by software. The content of the on-chip RAM and all the special functions registers remain unchanged during this mode. The idle mode can be terminated by any enabled interrupt or by a hardware reset.

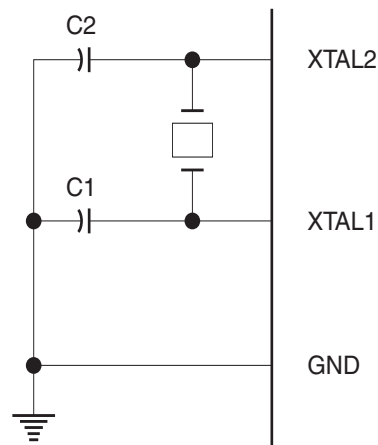
Note that when idle mode is terminated by a hardware reset, the device normally resumes program execution from where it left off, up to two machine cycles before the internal reset algorithm takes control. On-chip hardware inhibits access to internal RAM in this event, but access to the port pins is not inhibited. To eliminate the possibility of an unexpected write to a port pin when idle mode is terminated by a reset, the instruction following the one that invokes idle mode should not write to a port pin or to external memory.

## Power-down Mode

In the Power-down mode, the oscillator is stopped, and the instruction that invokes power-down is the last instruction executed. The on-chip RAM and Special Function Registers retain their values until the power-down mode is terminated. Exit from power-down can be initiated either by a hardware reset or by an enabled external interrupt. Reset redefines the SFRs but does not change the on-chip RAM. The reset should not be activated before  $V_{CC}$  is restored to

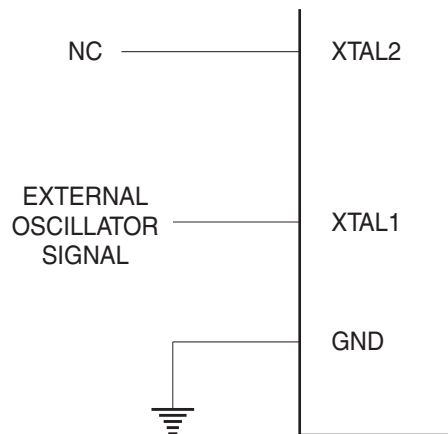
its normal operating level and must be held active long enough to allow the oscillator to restart and stabilize.

**Figure 11.** Oscillator Connections



Note: C1, C2 =  $30 \text{ pF} \pm 10 \text{ pF}$  for Crystals  
=  $40 \text{ pF} \pm 10 \text{ pF}$  for Ceramic Resonators

**Figure 12.** External Clock Drive Configuration



**Table 7.** Status of External Pins During Idle and Power-down Modes

| Mode       | Program Memory | ALE | $\overline{\text{PSEN}}$ | PORT0 | PORT1 | PORT2   | PORT3 |
|------------|----------------|-----|--------------------------|-------|-------|---------|-------|
| Idle       | Internal       | 1   | 1                        | Data  | Data  | Data    | Data  |
| Idle       | External       | 1   | 1                        | Float | Data  | Address | Data  |
| Power-down | Internal       | 0   | 0                        | Data  | Data  | Data    | Data  |
| Power-down | External       | 0   | 0                        | Float | Data  | Data    | Data  |

## Programming Interface

Every code byte in the QuickFlash array can be programmed by using the appropriate combination of control signals. The write operation cycle is self-timed and once initiated, will automatically time itself to completion.

All major programming vendors offer worldwide support for the Atmel microcontroller series. Please contact your local programming vendor for the appropriate software revision.

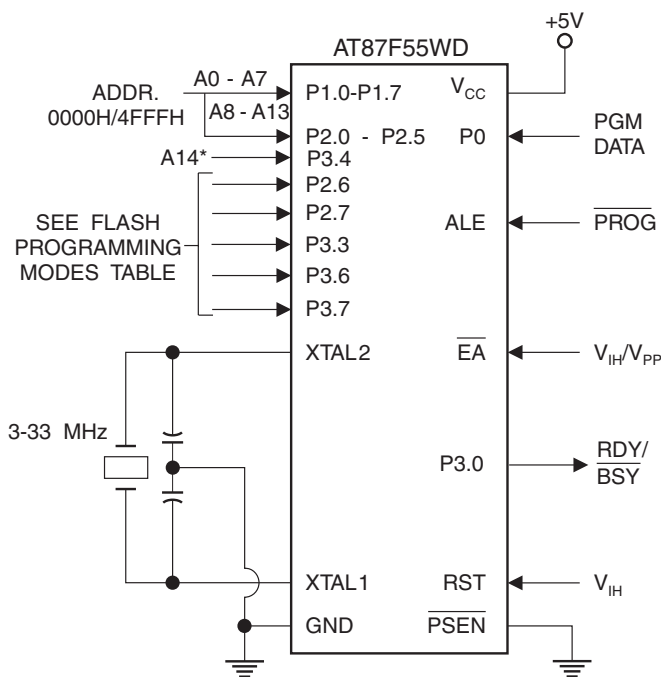
**Table 9.** QuickFlash Programming Modes

| Mode                   | V <sub>CC</sub> | RST | PSEN | ALE/<br>PROG | EA/<br>V <sub>PP</sub> | P2.6 | P2.7 | P3.3 | P3.6 | P3.7 | P0.7-0<br>Data       | P3.4    | P2.5-0 | P1.7-0 |
|------------------------|-----------------|-----|------|--------------|------------------------|------|------|------|------|------|----------------------|---------|--------|--------|
|                        |                 |     |      |              |                        |      |      |      |      |      |                      | Address |        |        |
| Write Code Data        | 5V              | H   | L    |              | 12V                    | L    | H    | H    | H    | H    | D <sub>IN</sub>      | A14     | A13-8  | A7-0   |
| Read Code Data         | 5V              | H   | L    | H            | H/12V                  | L    | L    | L    | H    | H    | D <sub>OUT</sub>     | A14     | A13-8  | A7-0   |
| Write Lock Bit 1       | 6.5V            | H   | L    |              | 12V                    | H    | H    | H    | H    | H    | X                    | X       | X      | X      |
| Write Lock Bit 2       | 6.5V            | H   | L    |              | 12V                    | H    | H    | H    | L    | L    | X                    | X       | X      | X      |
| Write Lock Bit 3       | 6.5V            | H   | L    |              | 12V                    | H    | L    | H    | H    | L    | X                    | X       | X      | X      |
| Read Lock Bits 1, 2, 3 | 5V              | H   | L    | H            | H                      | H    | H    | L    | H    | L    | D <sub>2, 3, 4</sub> | X       | X      | X      |
| Read Atmel ID          | 5V              | H   | L    | H            | H                      | L    | L    | L    | L    | L    | 1EH                  | X       | X      | 000H   |
| Read Device ID         | 5V              | H   | L    | H            | H                      | L    | L    | L    | L    | L    | 87H                  | X       | X      | 100H   |
| Read Device ID         | 5V              | H   | L    | H            | H                      | L    | L    | L    | L    | L    | 05H                  | X       | X      | 200H   |

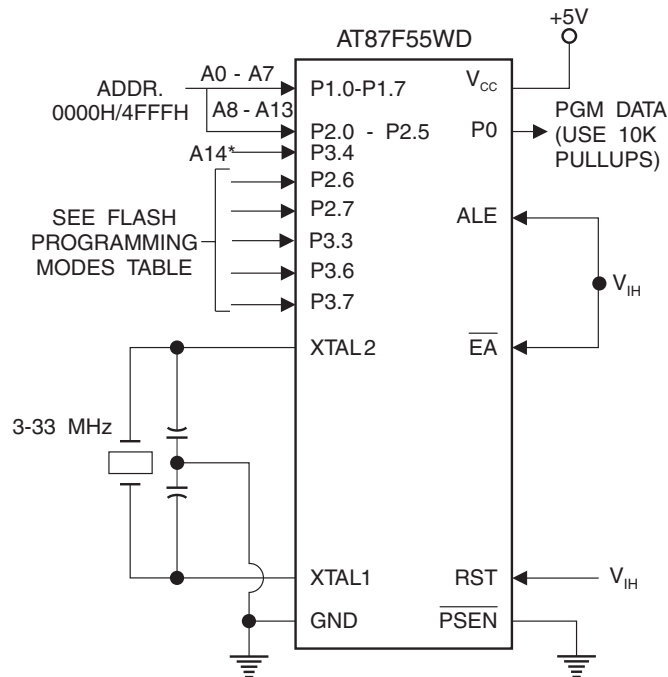
Notes: 1. Each Prog pulse is 200 ns for Write Code Data and 100  $\mu$ s for Write Lock Bits.

2. RDY/BSY signal is output on P3.0 during programming.

**Figure 13.** Programming the QuickFlash Memory



**Figure 14.** Verifying the QuickFlash Memory



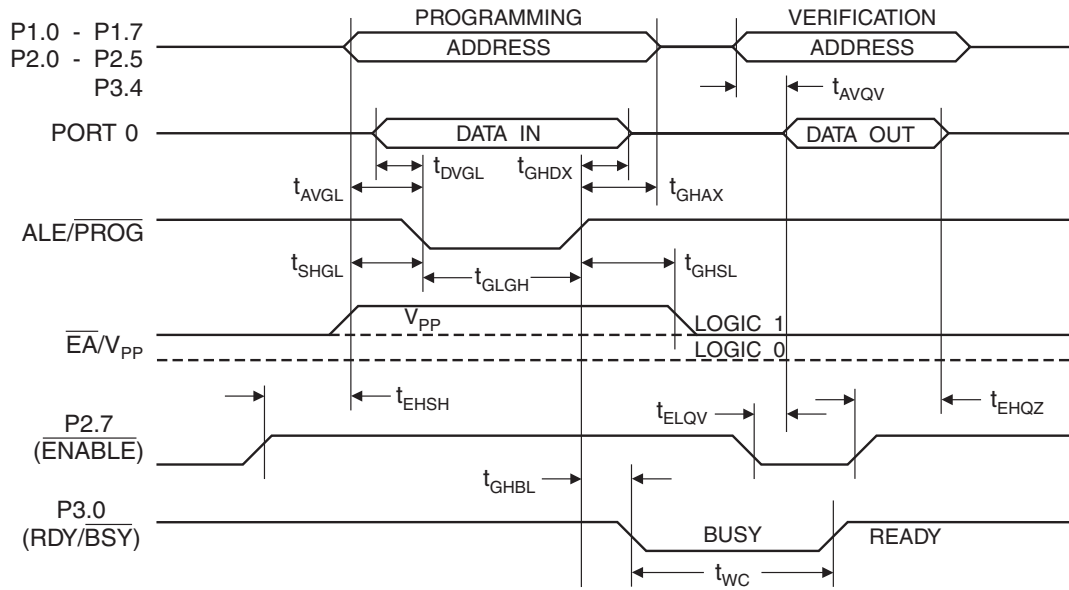
\*Programming address line A14 (P3.4) is not the same as the external memory address line A14 (P2.6).

## QuickFlash Programming and Verification Characteristics

$T_A = 20^\circ\text{C}$  to  $30^\circ\text{C}$ ,  $V_{CC} = 4.5\text{V}$  to  $5.5\text{V}$

| Symbol       | Parameter                                       | Min          | Max          | Units         |
|--------------|---|--------------|--------------|---------------|
| $V_{PP}$     | Programming Supply Voltage                      | 11.5         | 12.5         | V             |
| $I_{PP}$     | Programming Supply Current                      |              | 10           | mA            |
| $I_{CC}$     | $V_{CC}$ Supply Current                         |              | 30           | mA            |
| $1/t_{CLCL}$ | Oscillator Frequency                            | 3            | 33           | MHz           |
| $t_{AVGL}$   | Address Setup to $\overline{PROG}$ Low          | $48t_{CLCL}$ |              |               |
| $t_{GHAX}$   | Address Hold After $\overline{PROG}$            | $48t_{CLCL}$ |              |               |
| $t_{DVGL}$   | Data Setup to $\overline{PROG}$ Low             | $48t_{CLCL}$ |              |               |
| $t_{GHDX}$   | Data Hold After $\overline{PROG}$               | $48t_{CLCL}$ |              |               |
| $t_{EHSB}$   | P2.7 ( $\overline{ENABLE}$ ) High to $V_{PP}$   | $48t_{CLCL}$ |              |               |
| $t_{SHGL}$   | $V_{PP}$ Setup to $\overline{PROG}$ Low         | 10           |              | $\mu\text{s}$ |
| $t_{GHSL}$   | $V_{PP}$ Hold After $\overline{PROG}$           | 10           |              | $\mu\text{s}$ |
| $t_{GLGH}$   | $\overline{PROG}$ Width                         | 0.2          | 1            | $\mu\text{s}$ |
| $t_{AVQV}$   | Address to Data Valid                           |              | $48t_{CLCL}$ |               |
| $t_{ELQV}$   | $\overline{ENABLE}$ Low to Data Valid           |              | $48t_{CLCL}$ |               |
| $t_{EHQZ}$   | Data Float After $\overline{ENABLE}$            | 0            | $48t_{CLCL}$ |               |
| $t_{GHBL}$   | $\overline{PROG}$ High to $\overline{BUSY}$ Low |              | 1.0          | $\mu\text{s}$ |
| $t_{WC}$     | Byte Write Cycle Time                           |              | 80           | $\mu\text{s}$ |

## QuickFlash Programming and Verification Waveforms



## Absolute Maximum Ratings\*

|  |                 |
|--|-----------------|
| Operating Temperature.....                         | -55°C to +125°C |
| Storage Temperature .....                          | -65°C to +150°C |
| Voltage on Any Pin<br>with Respect to Ground ..... | -1.0V to +7.0V  |
| Maximum Operating Voltage .....                    | 6.6V            |
| DC Output Current.....                             | 15.0 mA         |

**\*NOTICE:** Stresses beyond 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 beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## DC Characteristics

The values shown in this table are valid for  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$  and  $V_{CC} = 4.0\text{V}$  to  $5.5\text{V}$ , unless otherwise noted.

| Symbol    | Parameter   | Condition   | Min                | Max                | Units            |
|-----------|---|---|--------------------|--------------------|------------------|
| $V_{IL}$  | Input Low Voltage                                     | (Except $\overline{EA}$ )                                   | -0.5               | $0.2 V_{CC} - 0.1$ | V                |
| $V_{IL1}$ | Input Low Voltage ( $\overline{EA}$ )                 |   | -0.5               | $0.2 V_{CC} - 0.3$ | V                |
| $V_{IH}$  | Input High Voltage                                    | (Except XTAL1, RST)   | $0.2 V_{CC} + 0.9$ | $V_{CC} + 0.5$     | V                |
| $V_{IH1}$ | Input High Voltage                                    | (XTAL1, RST)  | $0.7 V_{CC}$       | $V_{CC} + 0.5$     | V                |
| $V_{OL}$  | Output Low Voltage <sup>(1)</sup> (Ports 1,2,3)       | $I_{OL} = 1.6 \text{ mA}$                                   |                    | 0.45               | V                |
| $V_{OL1}$ | Output Low Voltage <sup>(1)</sup> (Port 0, ALE, PSEN) | $I_{OL} = 3.2 \text{ mA}$                                   |                    | 0.45               | V                |
| $V_{OH}$  | Output High Voltage (Ports 1,2,3, ALE, PSEN)          | $I_{OH} = -60 \mu\text{A}$ , $V_{CC} = 5\text{V} \pm 10\%$  | 2.4                |                    | V                |
|           |   | $I_{OH} = -25 \mu\text{A}$                                  | $0.75 V_{CC}$      |                    | V                |
|           |   | $I_{OH} = -10 \mu\text{A}$                                  | $0.9 V_{CC}$       |                    | V                |
| $V_{OH1}$ | Output High Voltage (Port 0 in External Bus Mode)     | $I_{OH} = -800 \mu\text{A}$ , $V_{CC} = 5\text{V} \pm 10\%$ | 2.4                |                    | V                |
|           |   | $I_{OH} = -300 \mu\text{A}$                                 | $0.75 V_{CC}$      |                    | V                |
|           |   | $I_{OH} = -80 \mu\text{A}$                                  | $0.9 V_{CC}$       |                    | V                |
| $I_{IL}$  | Logical 0 Input Current (Ports 1,2,3)                 | $V_{IN} = 0.45\text{V}$                                     |                    | -50                | $\mu\text{A}$    |
| $I_{TL}$  | Logical 1 to 0 Transition Current (Ports 1,2,3)       | $V_{IN} = 2\text{V}$ , $V_{CC} = 5\text{V} \pm 10\%$        |                    | -650               | $\mu\text{A}$    |
| $I_{LI}$  | Input Leakage Current (Port 0, $\overline{EA}$ )      | $0.45 < V_{IN} < V_{CC}$                                    |                    | $\pm 10$           | $\mu\text{A}$    |
| RRST      | Reset Pulldown Resistor                               |   | 50                 | 300                | $\text{K}\Omega$ |
| $C_{IO}$  | Pin Capacitance                                       | Test Freq. = 1 MHz, $T_A = 25^\circ\text{C}$                |                    | 10                 | pF               |
| $I_{CC}$  | Power Supply Current                                  | Active Mode, 12 MHz   |                    | 25                 | mA               |
|           |   | Idle Mode, 12 MHz   |                    | 6.5                | mA               |
|           | Power Down Mode <sup>(1)</sup>                        | $V_{CC} = 5.5\text{V}$                                      |                    | 100                | $\mu\text{A}$    |

Notes: 1. Under steady state (non-transient) conditions,  $I_{OL}$  must be externally limited as follows:

Maximum  $I_{OL}$  per port pin: 10 mA

Maximum  $I_{OL}$  per 8-bit port:

Port 0: 26 mA      Ports 1, 2, 3: 15 mA

Maximum total  $I_{OL}$  for all output pins: 71 mA

If  $I_{OL}$  exceeds the test condition,  $V_{OL}$  may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test conditions.

2. Minimum  $V_{CC}$  for Power-down is 2V.

## AC Characteristics

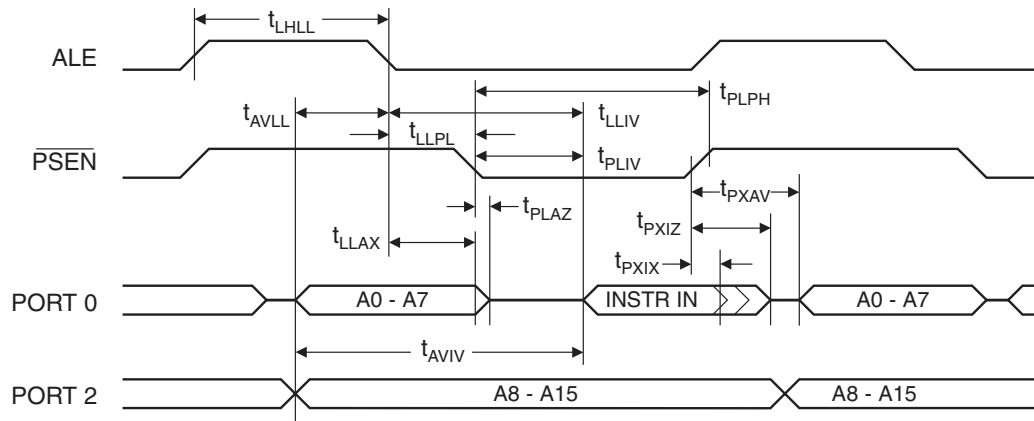
Under operating conditions, load capacitance for Port 0, ALE/ $\overline{\text{PROG}}$ , and  $\overline{\text{PSEN}}$  = 100 pF; load capacitance for all other outputs = 80 pF.

### External Program and Data Memory Characteristics

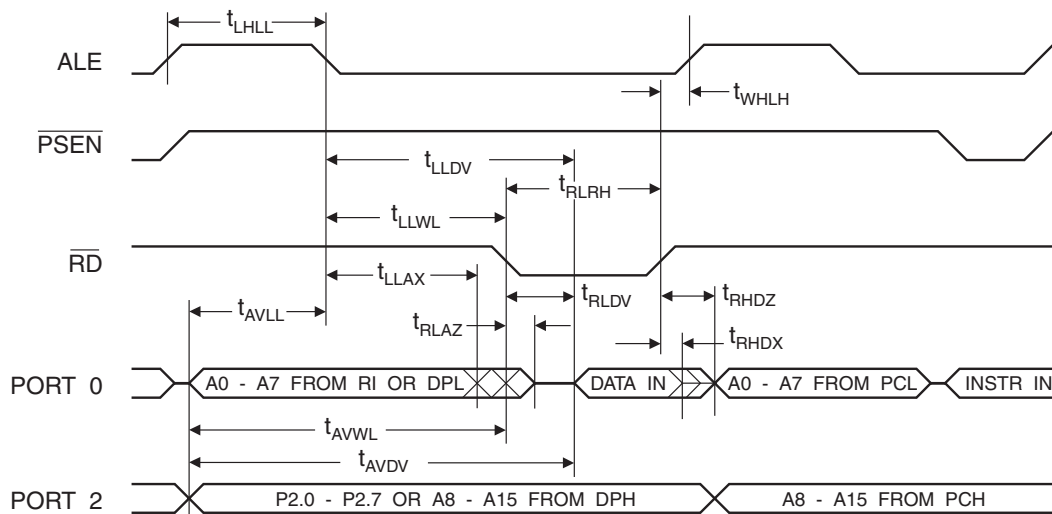
| Symbol              | Parameter   | 12 MHz Oscillator |     | Variable Oscillator    |                        | Units |
|---------------------|---|-------------------|-----|------------------------|------------------------|-------|
|                     |   | Min               | Max | Min                    | Max                    |       |
| $1/t_{\text{CLCL}}$ | Oscillator Frequency  |                   |     | 0                      | 33                     | MHz   |
| $t_{\text{LHLL}}$   | ALE Pulse Width   | 127               |     | $2t_{\text{CLCL}}-40$  |                        | ns    |
| $t_{\text{AVLL}}$   | Address Valid to ALE Low  | 43                |     | $t_{\text{CLCL}}-25$   |                        | ns    |
| $t_{\text{LLAX}}$   | Address Hold After ALE Low  | 48                |     | $t_{\text{CLCL}}-25$   |                        | ns    |
| $t_{\text{LLIV}}$   | ALE Low to Valid Instruction In                                   |                   | 233 |                        | $4t_{\text{CLCL}}-65$  | ns    |
| $t_{\text{LLPL}}$   | ALE Low to $\overline{\text{PSEN}}$ Low                           | 43                |     | $t_{\text{CLCL}}-25$   |                        | ns    |
| $t_{\text{PLPH}}$   | $\overline{\text{PSEN}}$ Pulse Width                              | 205               |     | $3t_{\text{CLCL}}-45$  |                        | ns    |
| $t_{\text{PLIV}}$   | $\overline{\text{PSEN}}$ Low to Valid Instruction In              |                   | 145 |                        | $3t_{\text{CLCL}}-60$  | ns    |
| $t_{\text{PXIX}}$   | Input Instruction Hold After $\overline{\text{PSEN}}$             | 0                 |     | 0                      |                        | ns    |
| $t_{\text{PXIZ}}$   | Input Instruction Float After $\overline{\text{PSEN}}$            |                   | 59  |                        | $t_{\text{CLCL}}-25$   | ns    |
| $t_{\text{PXAV}}$   | $\overline{\text{PSEN}}$ to Address Valid                         | 75                |     | $t_{\text{CLCL}}-8$    |                        | ns    |
| $t_{\text{AVIV}}$   | Address to Valid Instruction In                                   |                   | 312 |                        | $5t_{\text{CLCL}}-80$  | ns    |
| $t_{\text{PLAZ}}$   | $\overline{\text{PSEN}}$ Low to Address Float                     |                   | 10  |                        | 10                     | ns    |
| $t_{\text{RLRH}}$   | $\overline{\text{RD}}$ Pulse Width                                | 400               |     | $6t_{\text{CLCL}}-100$ |                        | ns    |
| $t_{\text{WLWH}}$   | $\overline{\text{WR}}$ Pulse Width                                | 400               |     | $6t_{\text{CLCL}}-100$ |                        | ns    |
| $t_{\text{RLDV}}$   | $\overline{\text{RD}}$ Low to Valid Data In                       |                   | 252 |                        | $5t_{\text{CLCL}}-90$  | ns    |
| $t_{\text{RHDZ}}$   | Data Hold After $\overline{\text{RD}}$                            | 0                 |     | 0                      |                        | ns    |
| $t_{\text{RHDZ}}$   | Data Float After $\overline{\text{RD}}$                           |                   | 97  |                        | $2t_{\text{CLCL}}-28$  | ns    |
| $t_{\text{LLDV}}$   | ALE Low to Valid Data In  |                   | 517 |                        | $8t_{\text{CLCL}}-150$ | ns    |
| $t_{\text{AVDV}}$   | Address to Valid Data In  |                   | 585 |                        | $9t_{\text{CLCL}}-165$ | ns    |
| $t_{\text{LLWL}}$   | ALE Low to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ Low   | 200               | 300 | $3t_{\text{CLCL}}-50$  | $3t_{\text{CLCL}}+50$  | ns    |
| $t_{\text{AVWL}}$   | Address to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ Low   | 203               |     | $4t_{\text{CLCL}}-75$  |                        | ns    |
| $t_{\text{QVWX}}$   | Data Valid to $\overline{\text{WR}}$ Transition                   | 23                |     | $t_{\text{CLCL}}-30$   |                        | ns    |
| $t_{\text{QVWH}}$   | Data Valid to $\overline{\text{WR}}$ High                         | 433               |     | $7t_{\text{CLCL}}-130$ |                        | ns    |
| $t_{\text{WHQX}}$   | Data Hold After $\overline{\text{WR}}$                            | 33                |     | $t_{\text{CLCL}}-25$   |                        | ns    |
| $t_{\text{RLAZ}}$   | $\overline{\text{RD}}$ Low to Address Float                       |                   | 0   |                        | 0                      | ns    |
| $t_{\text{WHLH}}$   | $\overline{\text{RD}}$ or $\overline{\text{WR}}$ High to ALE High | 43                | 123 | $t_{\text{CLCL}}-25$   | $t_{\text{CLCL}}+25$   | ns    |



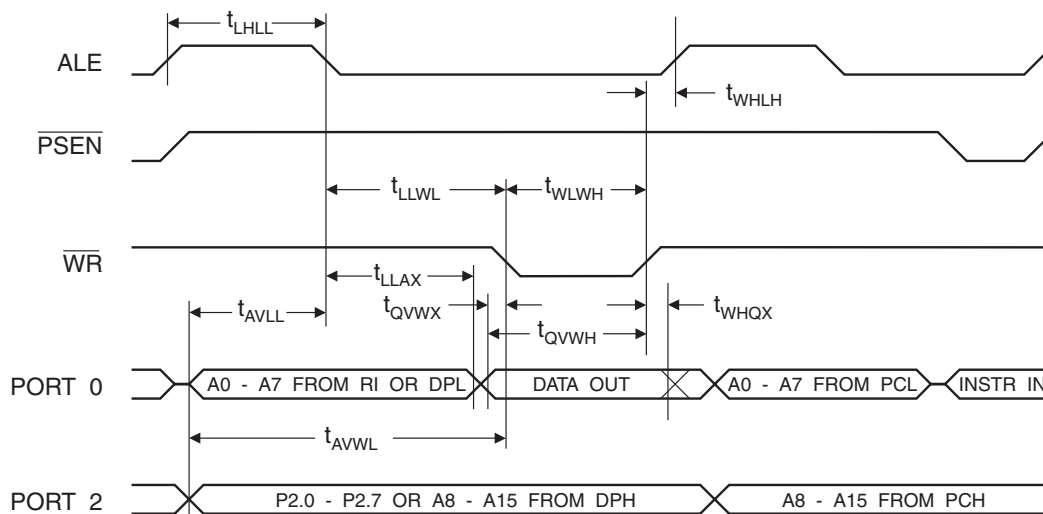
## External Program Memory Read Cycle



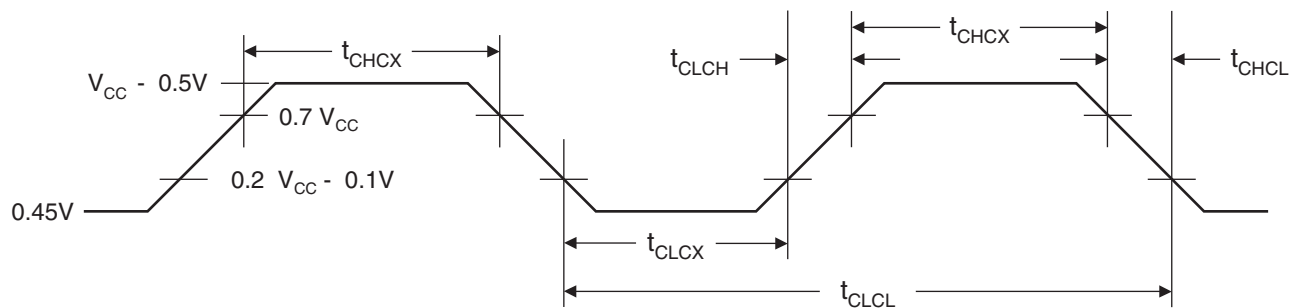
## External Data Memory Read Cycle



## External Data Memory Write Cycle



## External Clock Drive Waveforms



## External Clock Drive

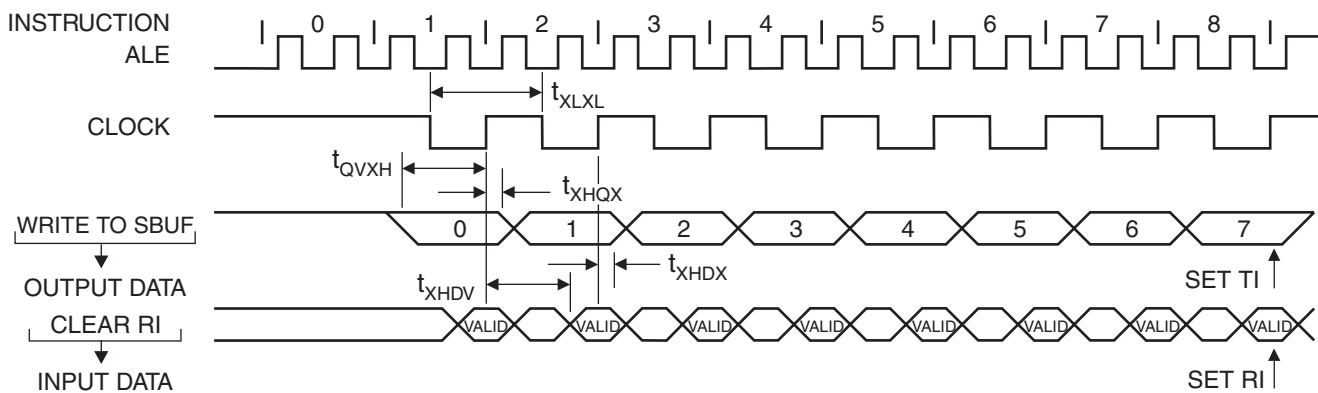
| Symbol       | Parameter            | Min | Max | Units |
|--------------|----------------------|-----|-----|-------|
| $1/t_{CLCL}$ | Oscillator Frequency | 0   | 33  | MHz   |
| $t_{CLCL}$   | Clock Period         | 30  |     | ns    |
| $t_{CHCX}$   | High Time            | 12  |     | ns    |
| $t_{CLCX}$   | Low Time             | 12  |     | ns    |
| $t_{CLCH}$   | Rise Time            |     | 5   | ns    |
| $t_{CHCL}$   | Fall Time            |     | 5   | ns    |

## Serial Port Timing: Shift Register Mode Test Conditions

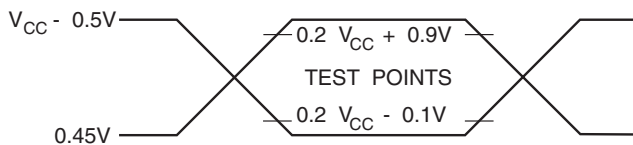
The values in this table are valid for  $V_{CC} = 4.0V$  to  $5.5V$  and Load Capacitance = 80 pF.

| Symbol            | Parameter                                | 12 MHz Osc |     | Variable Oscillator      |                          | Units |
|-------------------|--|------------|-----|--------------------------|--------------------------|-------|
|                   |  | Min        | Max | Min                      | Max                      |       |
| t <sub>XLXL</sub> | Serial Port Clock Cycle Time             | 1.0        |     | 12t <sub>CLCL</sub>      |                          | μs    |
| t <sub>QVXH</sub> | Output Data Setup to Clock Rising Edge   | 700        |     | 10t <sub>CLCL</sub> -133 |                          | ns    |
| t <sub>XHQX</sub> | Output Data Hold After Clock Rising Edge | 50         |     | 2t <sub>CLCL</sub> -80   |                          | ns    |
| t <sub>XHDX</sub> | Input Data Hold After Clock Rising Edge  | 0          |     | 0                        |                          | ns    |
| t <sub>XHDV</sub> | Clock Rising Edge to Input Data Valid    |            | 700 |                          | 10t <sub>CLCL</sub> -133 | ns    |

## Shift Register Mode Timing Waveforms



## AC Testing Input/Output Waveforms<sup>(1)</sup>



Note: 1. AC Inputs during testing are driven at  $V_{CC} - 0.5V$  for a logic 1 and 0.45V for a logic 0. Timing measurements are made at  $V_{IH}$  min. for a logic 1 and  $V_{IL}$  max. for a logic 0.

## Float Waveforms<sup>(1)</sup>



Note: 1. For timing purposes, a port pin is no longer floating when a 100 mV change from load voltage occurs. A port pin begins to float when a 100 mV change from the loaded  $V_{OH}/V_{OL}$  level occurs.



## Ordering Information

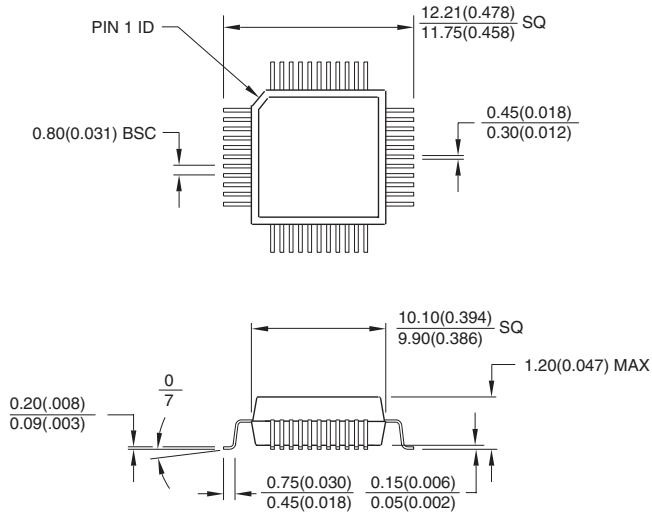
| Speed (MHz) | Power Supply | Ordering Code  | Package | Operation Range               |
|-------------|--------------|----------------|---------|-------------------------------|
| 24          | 4.0V to 5.5V | AT87F55WD-24AC | 44A     | Commercial<br>(0°C to 70°C)   |
|             |              | AT87F55WD-24JC | 44J     |                               |
|             |              | AT87F55WD-24PC | 40P6    |                               |
|             |              | AT87F55WD-24AI | 44A     | Industrial<br>(-40°C to 85°C) |
|             |              | AT87F55WD-24JI | 44J     |                               |
|             |              | AT87F55WD-24PI | 40P6    |                               |
| 33          | 4.5V to 5.5V | AT87F55WD-33AC | 44A     | Commercial<br>(0°C to 70°C)   |
|             |              | AT87F55WD-33JC | 44J     |                               |
|             |              | AT87F55WD-33PC | 40P6    |                               |

 = Preliminary Availability

| Package Type |  |
|--------------|--|
| <b>44A</b>   | 44-lead, Thin Plastic Gull Wing Quad Flatpack (TQFP)     |
| <b>44J</b>   | 44-lead, Plastic J-leaded Chip Carrier (PLCC)            |
| <b>40P6</b>  | 40-lead, 0.600" Wide, Plastic Dual Inline Package (PDIP) |

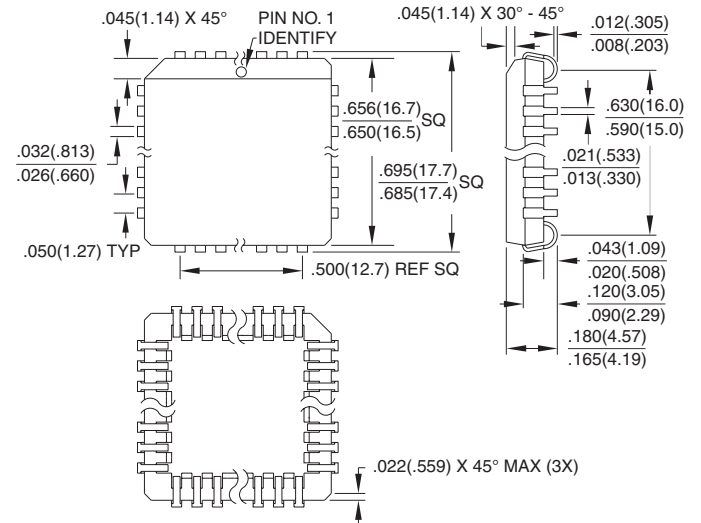
## Packaging Information

### 44A, 44-lead, Thin (1.0 mm) Plastic Gull Wing Quad Flat Package (TQFP) Dimensions in Millimeters and (Inches)\*



\*Controlling dimension: millimeters

### 44J, 44-lead, Plastic J-leaded Chip Carrier (PLCC) Dimensions in Inches and (Millimeters)



### 40P6, 40-pin, 0.600" Wide, Plastic Dual Inline Package (PDIP) Dimensions in Inches and (Millimeters) JEDEC STANDARD MS-011 AC

