

## MCU

## 8-bit A/D Type MCU

### 1. Features

- Compatible with MCS-51
- Embedded 8K Bytes OTP ROM
- 128 x 8-bit Internal RAM
- 15/19 Programmable I/O Lines for 20/24-pin Package
- Two 16-bit Timer/Counter & One 16-bit Timer
- Two External Interrupt Input (Only One Input for 20-pin Package)
- Two Channel PWM (Only One Channel PWM for 20-pin Package) Driving Capability up to 40 mA
- Embedded 1k bits EEPROM (for T81L0006B only)
- Programmable Serial UART Interface
- Low Power Idle & Power-down Modes
- Watch-dog Timer
- On-chip Crystal & RC Oscillator (Selected by Bonding Option)
- Internal Power-on Reset and External Reset Supported
- 8-Channel 8-bit A/D Converter
- SOP20/DIP20 & SOP24/DIP24 Package
- 3.3V Operating Voltage
- EEPROM Interface
- Low Voltage Reset

### 2. Applications

- Meter
- Household Appliances Controller
- Handwriting Board
- Charger
- Sport Devices
- Other Controller (Automotive, Toy...)

### 3. General Description

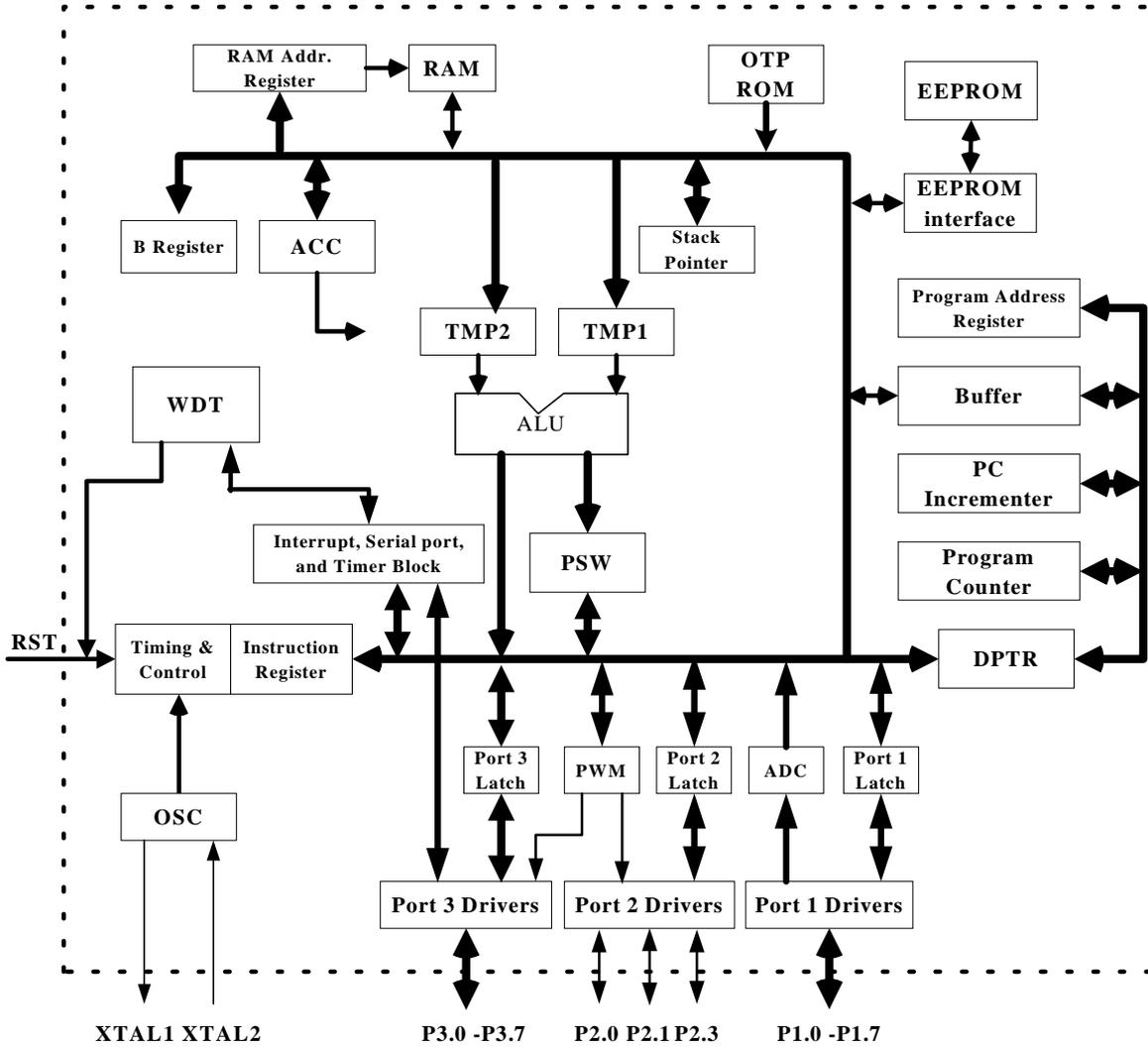
The T81L0006A/B is 8-bit microcontroller designed and developed with low power and high speed CMOS technology. It contains a 8K bytes OTP ROM, a 128 × 8 RAM, an 8-channels 8-bit A/D converter, 15/19 I/O lines, a watchdog timer, two 16-bit counter/timers, a seven source, two-priority level nested interrupt structure, two channel pulsed-width modulator (PWM), a full duplex UART, and an on-chip oscillator and clock circuits.

In addition, the T81L0006A/B has two selectable modes of power reduction-idle mode and power-down mode. The idle mode freezes the CPU while allowing the RAM, timers, serial port, and interrupt system to continue functioning. The power-down mode saves the RAM contents but freezes the oscillator, causing all other chip functions to be inoperative.

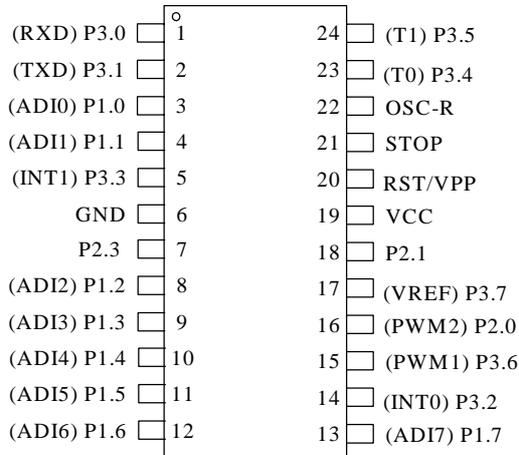
### 4. Order information

| Part number  | Oscillator type | EEPROM   | Package    |
|--------------|-----------------|----------|------------|
| T81L0006A-AK | RC              | NONE     | 24-pin DIP |
| T81L0006A-BK | Crystal         | NONE     | 24-pin DIP |
| T81L0006A-CK | RC              | NONE     | 20-pin DIP |
| T81L0006A-DK | Crystal         | NONE     | 20-pin DIP |
| T81L0006A-AD | RC              | NONE     | 24-pin SOP |
| T81L0006A-BD | Crystal         | NONE     | 24-pin SOP |
| T81L0006A-CD | RC              | NONE     | 20-pin SOP |
| T81L0006A-DD | Crystal         | NONE     | 20-pin SOP |
| T81L0006B-AK | RC              | Embedded | 24-pin DIP |
| T81L0006B-BK | Crystal         | Embedded | 24-pin DIP |
| T81L0006B-AD | RC              | Embedded | 24-pin SOP |
| T81L0006B-BD | Crystal         | Embedded | 24-pin SOP |

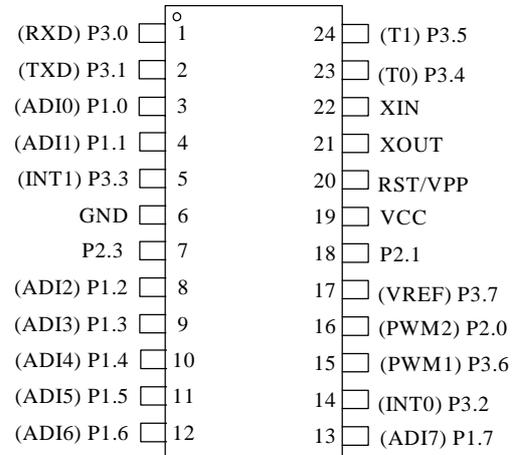
**5. Block Diagram**



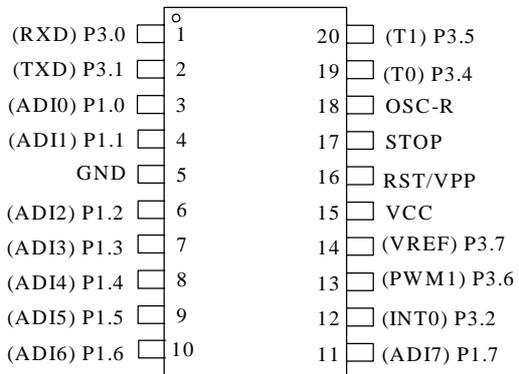
**6. Pin Configuration**



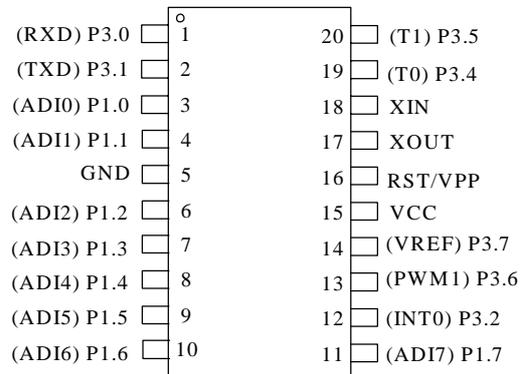
DIP-24/SOP-24 For RC Oscillator  
 T81L0006A-AK/ T81L0006A-AD  
 T81L0006B-AK/ T81L0006B-AD



DIP-24/SOP-24 For Crystal Oscillator  
 T81L0006A-BK/ T81L0006A-BD  
 T81L0006B-BK/ T81L0006B-BD



DIP-20/SOP-20 For RC Oscillator  
 T81L0006A-CK/ T81L0006A-CD



DIP-20/SOP-20 For Crystal Oscillator  
 T81L0006A-DK/ T81L0006A-DD

## 7. Pin Description

| Number (24-Pin) | Number (20-Pin) | Name        | Type | Description  |
|-----------------|-----------------|-------------|------|--|
| 1               | 1               | P3.0/(RXD)  | I/O  | General-purpose I/O pin (Default) or Serial input port.                            |
| 2               | 2               | P3.1/(TXD)  | I/O  | General-purpose I/O pin (Default) or Serial output port.                           |
| 3               | 3               | P1.0/(ADI0) | I/O  | General-purpose I/O pin (Default) or ADC input channel 0.                          |
| 4               | 4               | P1.1/(ADI1) | I/O  | General-purpose I/O pin (Default) or ADC input channel 1.                          |
| 5               | -               | P3.3/(INT1) | I/O  | General-purpose I/O pin (Default) or External interrupt source 1.                  |
| 6               | 5               | GND         |      | Ground   |
| 7               | -               | P2.3        | I/O  | General-purpose I/O pin.   |
| 8               | 6               | P1.2/(ADI2) | I/O  | General-purpose I/O pin (Default) or ADC input channel 2.                          |
| 9               | 7               | P1.3/(ADI3) | I/O  | General-purpose I/O pin (Default) or ADC input channel 3.                          |
| 10              | 8               | P1.4/(ADI4) | I/O  | General-purpose I/O pin (Default) or ADC input channel 4.                          |
| 11              | 9               | P1.5/(ADI5) | I/O  | General-purpose I/O pin (Default) or ADC input channel 5.                          |
| 12              | 10              | P1.6/(ADI6) | I/O  | General-purpose I/O pin (Default) or ADC input channel 6.                          |
| 13              | 11              | P1.7/(ADI7) | I/O  | General-purpose I/O pin (Default) or ADC input channel 7.                          |
| 14              | 12              | P3.2/(INT0) | I/O  | General-purpose I/O pin (Default) or External interrupt source 0.                  |
| 15              | 13              | P3.6/(PWM1) | I/O  | General-purpose I/O pin (Default) or PWM signal output channel 1.                  |
| 16              | -               | P2.0/(PWM2) | I/O  | General-purpose I/O pin (Default) or PWM signal output channel 2.                  |
| 17              | 14              | P3.7/(VREF) | I/O  | General-purpose I/O pin (Default) or External reference voltage input pin for ADC. |
| 18              | -               | P2.1        | I/O  | General-purpose I/O pin.   |
| 19              | 15              | VCC         |      | 3.3V power supply.   |
| 20              | 16              | RST/VPP     | I    | Reset signal input or programming supply voltage input.                            |
| 21              | 17              | XOUT/(STOP) | O    | Crystal oscillator output terminal or stop RC oscillator network.                  |
| 22              | 18              | XIN/(OSC-R) | I    | Crystal oscillator input terminal or RC oscillator external resistor connect pin.  |
| 23              | 19              | P3.4/(T0)   | I/O  | General-purpose I/O pin (Default) or Timer 0 external input pin.                   |
| 24              | 20              | P3.5/(T1)   | I/O  | General-purpose I/O pin (Default) or Timer 1 external input pin.                   |

## 8. Temperature Limit Ratings

| Parameter                   | Rating      | Units |
|-----------------------------|-------------|-------|
| Operating temperature Range | -40 to +85  | °C    |
| Storage Temperature Range   | -55 to +125 | °C    |

## 9. Electrical Characteristics

### D.C Characteristics

| Symbol              | Parameter                       | Conditions   | Min                      | Typ | Max  | Units |   |
|---------------------|---------------------------------|--|--------------------------|-----|------|-------|---|
| VCC                 | Operating Voltage               | 25°C   | 3.0                      | 3.3 | 3.6  | V     |   |
| ICC                 | Operating Current               | No load, ADC disable Vcc=3.3V  | -                        | 6   | -    | mA    |   |
| IPD                 | Power-Down Current              | No load, Vcc=3.3V  | -                        | -   | 1    | uA    |   |
| IADC                | Only ADC Enable, Others Disable | No load  | -                        | 120 | -    | uA    |   |
| VADC                | ADC Input Voltage Range         |  | 0                        | -   | VREF | V     |   |
| VREF                | VREF input voltage range        |  | 2                        | -   | VCC  | V     |   |
| V <sub>IH</sub>     | Hi-Level input voltage          | V <sub>out</sub> ≥ V <sub>VOH(MIN.)</sub><br>V <sub>out</sub> ≤ V <sub>VOL(MIN.)</sub> | 2.1                      | -   | -    | V     |   |
| V <sub>IL</sub>     | Low-Level input voltage         | V <sub>out</sub> ≥ V <sub>VOH(MIN.)</sub><br>V <sub>out</sub> ≤ V <sub>VOL(MIN.)</sub> | -                        | -   | 0.6  | V     |   |
| V <sub>OH</sub>     | Hi-Level Output voltage         | V <sub>CC</sub> =MIN.<br>V <sub>I</sub> =V <sub>IH</sub> or<br>V <sub>IL</sub>         | I <sub>OH</sub> =-7uA    | 2.9 | -    | -     | V |
|                     |                                 |  | I <sub>OH</sub> =-45uA   | 2.4 |      |       |   |
|                     |                                 |  | I <sub>OH</sub> =-70uA   | 1.9 |      |       |   |
|                     |                                 |  | I <sub>OH</sub> =-12mA** | 2.4 |      |       |   |
|                     |                                 |  | I <sub>OH</sub> =-20mA** | 1.9 |      |       |   |
| V <sub>OL1</sub> *  | Low-Level Output voltage        | V <sub>CC</sub> =MIN.<br>V <sub>I</sub> =V <sub>IH</sub> or<br>V <sub>IL</sub>         | I <sub>OL</sub> =12mA    | -   | -    | 0.2   | V |
|                     |                                 |  | I <sub>OL</sub> =25mA    |     |      | 0.4   |   |
|                     |                                 |  | I <sub>OL</sub> =40mA    |     |      | 0.6   |   |
| V <sub>OL2</sub> ** | Low-Level Output voltage        | V <sub>CC</sub> =MIN.<br>V <sub>I</sub> =V <sub>IH</sub> or<br>V <sub>IL</sub>         | I <sub>OL</sub> =4mA     | -   | -    | 0.2   | V |
|                     |                                 |  | I <sub>OL</sub> =12mA    |     |      | 0.4   |   |
|                     |                                 |  | I <sub>OL</sub> =20mA    |     |      | 0.6   |   |

Note : \* for PWM pins (P3.6/PWM1 and P2.0/PWM2).

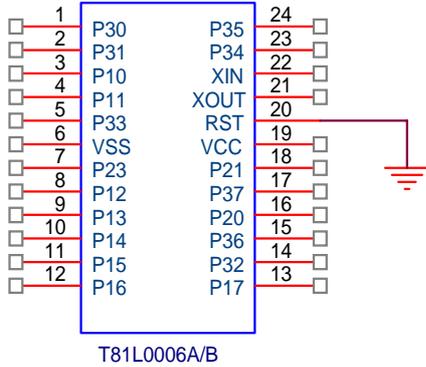
\*\* for high driving current mode.

### A.C Characteristics

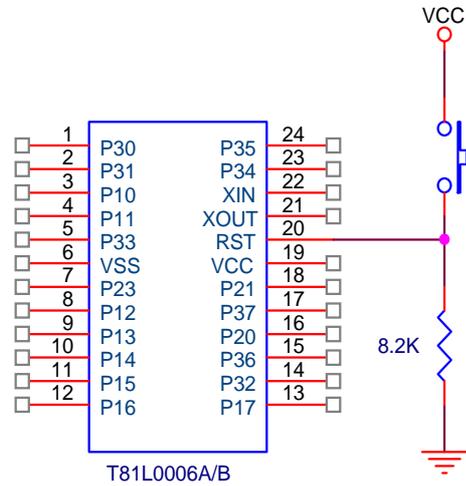
| Symbol            | Parameter                        | Conditions | Min | Typ | Max | Units        |
|-------------------|----------------------------------|------------|-----|-----|-----|--------------|
| FSYS1             | System Clock 1 (Crystal OSC)     | VCC=3.3V   | -   | 12  | 24  | MHz          |
| FSYS2             | System Clock 2 (RC OSC)          | VCC=3.3V   | -   | 12  | -   | MHz          |
| FADC              | ADC Clock Frequency              |            | -   | 125 | -   | KHz          |
| t <sub>ACT</sub>  | ADC Conversion Time              |            | -   | 128 | -   | us           |
| t <sub>RES</sub>  | External Reset High Pulse Width  |            | -   | 10  | -   | system cycle |
| t <sub>POS</sub>  | Power ON Start up Time           |            | -   | 20  | -   | ms           |
| t <sub>LHLL</sub> | ALE pulse width                  |            | 127 | -   | -   | ns           |
| t <sub>AVLL</sub> | Address Valid to ALE Low         |            | 43  | -   | -   | ns           |
| t <sub>LLAX</sub> | Address Hold after ALE Low       |            | 48  | -   | -   | ns           |
| t <sub>LLIV</sub> | ALE Low to Valid Instruction In  |            | -   | -   | 233 | ns           |
| t <sub>LLPL</sub> | ALE Low to PSEN Low              |            | 43  | -   | -   | ns           |
| t <sub>PLPH</sub> | PSEN pulse width                 |            | 205 | -   | -   | ns           |
| t <sub>PLIV</sub> | PSEN Low to Valid Instruction In |            | -   | -   | 145 | ns           |
| t <sub>AVIV</sub> | Address to Valid Instruction In  |            | -   | -   | 312 | ns           |
| t <sub>RLRH</sub> | RD pulse width                   |            | 400 | -   | -   | ns           |
| t <sub>WLWH</sub> | WR pulse width                   |            | 400 | -   | -   | ns           |
| t <sub>RLDV</sub> | RD Low to Valid data in          |            | -   | -   | 252 | ns           |
| t <sub>LLDV</sub> | ALE Low to Valid data in         |            | -   | -   | 517 | ns           |
| t <sub>AVDV</sub> | Address to Valid data in         |            | -   | -   | 585 | ns           |
| t <sub>LLWL</sub> | ALE Low to RD or WR Low          |            | 200 | -   | 300 | ns           |
| t <sub>AVWL</sub> | Address to RD or WR Low          |            | 203 | -   | -   | ns           |
| t <sub>WHLH</sub> | RD or WR High to ALE High        |            | 43  | -   | 123 | ns           |

## 10. Function Description

### 10.1 Reset

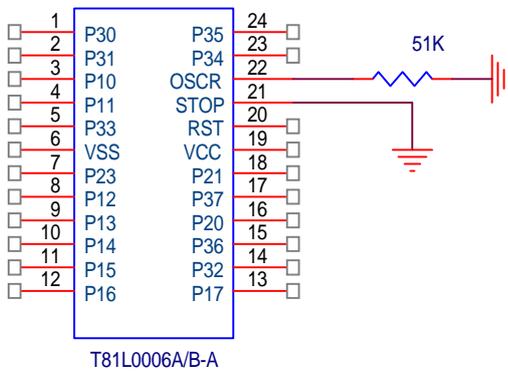


For Power on Reset only

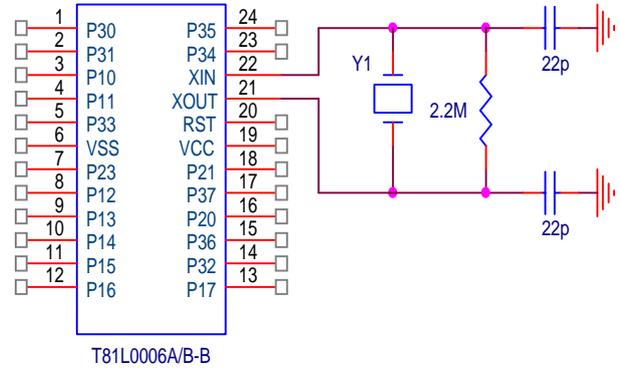


For Power on Reset and External Reset

### 10.2 Oscillation



RC Oscillator



Crystal Oscillator

**10.3 Special Function Register**

|     |       |       |        |        |     |     |       |      |
|-----|-------|-------|--------|--------|-----|-----|-------|------|
| F8H |       |       |        |        |     |     |       |      |
| F0H | B     |       |        |        |     |     |       |      |
| E8H |       |       |        |        |     |     |       |      |
| E0H | ACC   |       |        |        |     |     |       |      |
| D8H |       |       |        |        |     |     |       |      |
| D0H | PSW   |       |        |        |     |     |       |      |
| C8H | T2CON | T2MOD | RCAP2L | RCAP2H | TL2 | TH2 |       |      |
| C0H |       |       |        |        |     |     |       |      |
| B8H | IP    |       |        |        |     |     |       |      |
| B0H | P3    |       |        |        |     |     |       |      |
| A8H | IE    |       |        |        |     |     |       |      |
| A0H | P2    |       |        |        |     |     |       |      |
| 98H | SCON  | SBUF  |        |        |     |     |       |      |
| 90H | P1    |       |        |        |     |     |       |      |
| 88H | TCON  | TMOD  | TL0    | TL1    | TH0 | TH1 |       |      |
| 80H | P0*   | SP    | DPL    | DPH    |     |     | WDREL | PCON |

**\*Note: P0:Internal still keeping, but for pad dominate, no external pin assignment**

**Accumulator : ACC**

ACC is the Accumulator register. The mnemonics for Accumulator-Specific instructions, however, refer to the Accumulator simply as A.

**B Register : B**

The B register is used during multiply and divide operations. For other instructions it can be treated as another scratch pad register.

**Program Status Word : PSW**

The PSW register contains program status information as detailed in

|    |    |    |     |     |    |    |   |
|----|----|----|-----|-----|----|----|---|
| CY | AC | F0 | RS1 | RS0 | OV | -- | P |
|----|----|----|-----|-----|----|----|---|

**BIT SYMBOL FUNCTION**

- PSW.7 CY Carry flag.
- PSW.6 AC Auxiliary Carry flag. (For BCD operations.)
- PSW.5 F0 Flag 0. (Available to the user for general purposes.)
- PSW.4 RS1 Register bank select control bit 1.  
Set/cleared by software to determine working register bank. (See **Note**.)
- PSW.3 RS0 Register bank select control bit 0.  
Set/cleared by software to determine working register bank. (See **Note**.)
- PSW.2 OV Overflow flag.
- PSW.1 — User-definable flag.
- PSW.0 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.

**NOTE:** The contents of (RS1, RS0) enable the working register banks as follows:

- (0,0)— Bank 0 (00H–07H)
- (0,1)— Bank 1 (08H–0FH)
- (1,0)— Bank 2 (10H–17H)
- (1,1)— Bank 3 (18H–17H)

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**Stack Pointer : SP**

The Stack Pointer register is 8 bits wide. It is incremented before data is stored during PUSH and CALL executions. While the stack may reside anywhere in on-chip RAM, the Stack Pointer is initialized to 07H after a reset. This causes the stack to begin at locations 08H.

**Data Pointer (DPTR) : DPH & DPL**

The Data Pointer (DPTR) consists of a high byte (DPH) and a low byte (DPL). Its intended function is to hold a 16-bit address. It may be manipulated as a 16-bit register or as two independent 8-bit registers.

**Ports 1.0~1.7 & 2.0,2.1,2.3 & 3.0~3.7**

All Ports are the SFR latches, respectively. Writing a one to a bit of a port SFR (P1 or P2 or P3) causes the corresponding port output pin to switch high. Writing a zero causes the port output pin to switch low. When used as an input, the external state of a port pin will be held in the port SFR (i.e., if the external state of a pin is low, the corresponding port SFR bit will contain a '0'; if it is high, the bit will contain a '1').

**Serial Data Buffer : SBUF**

The Serial Buffer is actually two separate registers, a transmit buffer and a receive buffer. When data is moved to SBUF, it goes to the transmit buffer and is held for serial transmission. (Moving a byte to SBUF is what initiates the transmission.) When data is moved from SBUF, it comes from the receive buffer.

**Timer Registers : TH0, TL0, TH1, TL1, TH2, TL2**

Register pairs (TH0, TL0) and (TH1, TL1) and (TH2, TL2) are 16-bit Counting registers for Timer/Counters 0 and Timer1 and Timer2, respectively.

**Control Register : IP, IE, TMOD, TCON, SCON, PCON**

Special Function Registers IP, IE, TMOD, TCON, SCON, and PCON contain control and status bits for the interrupt system, the Timer/Counters, and the serial port. They are described in later sections.

**Standard Serial Interface**

The serial port is full duplex, meaning it can transmit and receive simultaneously. It is also receive-buffered, meaning it can commence reception of a second byte before a previously received byte has been read from the register. (However, if the first byte still hasn't been read by the time reception of the second byte is complete, one of the bytes will be lost.) The serial port receive and transmit registers are both accessed at Special Function Register SBUF. Writing to SBUF loads the transmit register, and reading SBUF accesses a physically separate receive register.

The serial port can operate in 4 modes:

**Mode 0:** Serial data enters and exits through RxD. TxD outputs the shift clock. 8 bits are transmitted/received (LSB first). The baud rate is fixed at 1/12 the oscillator frequency.

**Mode 1:** 10 bits are transmitted (through TxD) or received (through RxD): a start bit (0), 8 data bits (LSB first), and a stop bit (1). On receive, the stop bit goes into RB8 in Special Function Register SCON. The baud rate is variable.

**Mode 2:** 11 bits are transmitted (through TxD) or received (through RxD): start bit (0), 8 data bits (LSB first), a programmable 9th data bit, and a stop bit (1). On Transmit, the 9th data bit (TB8 in SCON) can be assigned the value of 0 or 1. Or, for example, the parity bit (P, in the PSW) could be moved into TB8. On receive, the 9th data bit goes into RB8 in Special Function Register SCON, while the stop bit is ignored. The baud rate is programmable to either 1/32 or 1/64 the oscillator frequency.

**Mode 3:** 11 bits are transmitted (through TxD) or received (through RxD): a start bit (0), 8 data bits (LSB first), a programmable 9th data bit, and a stop bit (1). In fact, Mode 3 is the same as Mode 2 in all respects except baud rate. The baud rate in Mode 3 is variable. In all four modes, transmission is initiated by any instruction that uses SBUF as a destination register. Reception is initiated in Mode 0 by the condition RI = '0' and REN = '1'. Reception is initiated in the other modes by the incoming start bit if REN = '1'.

**Multiprocessor Communications**

Modes 2 and 3 have a special provision for multiprocessor communications. In these modes, 9 data bits are received. The 9<sup>th</sup> one goes into RB8. Then comes a stop bit. The port can be programmed such that when the stop bit is received, the serial port interrupt will be activated only if RB8 = ‘1’. This feature is enabled by setting bit SM2 in SCON. A way to use this feature in multiprocessor systems is as follows: When the master processor wants to transmit a block of data to one of several slaves, it first sends out an address byte which identifies the target slave. An address byte differs from a data byte in that the 9th bit is ‘1’ in an address byte and ‘0’ in a data byte. With SM2 = ‘1’, no slave will be interrupted by a data byte. An address byte, however, will interrupt all slaves, so that each slave can examine the received byte and see if it is being addressed. The addressed slave will clear its SM2 bit and prepare to receive the data bytes that will be coming. The slaves that weren’t being addressed leave their SM2s set and go on about their business, ignoring the coming data bytes.

SM2 has no effect in Mode 0, in Mode 1 can be used to check the validity of the stop bit. In Mode 1 reception, if SM2 = ‘1’, the receive interrupt will not active unless a valid stop bit is received.

**Serial Port Control Register**

The serial port control and status register is the Special Function Register SCON, shown in Figure 11. This register contains not only the mode selection bits, but also the 9th data bit for transmit and receive (TB8 and RB8), and the serial port interrupt bits (TI and RI).

**Baud Rates**

The baud rate in Mode 0 is fixed: Mode 0 Baud Rate = Oscillator Frequency / 12. The baud rate in Mode 2 depends on the value of bit SMOD in Special Function Register PCON. If SMOD = ‘0’ (which is the value on reset), the baud rate is 1/64 the oscillator frequency. If SMOD = ‘1’, the baud rate is 1/32 the oscillator frequency.  
 Mode 2 Baud Rate =  $2^{SMOD}/64 * (\text{Oscillator Frequency})$   
 In the T81L0006A/B, the baud rates in Modes 1 and 3 are determined by the Timer 1 overflow rate.

**SCON**

|            |            |            |            |            |            |            |           |
|------------|------------|------------|------------|------------|------------|------------|-----------|
| <b>MSB</b> |            |            |            |            |            | <b>LSB</b> |           |
| <b>SM0</b> | <b>SM1</b> | <b>SM2</b> | <b>REN</b> | <b>TB8</b> | <b>RB8</b> | <b>TI</b>  | <b>RI</b> |

Where SM0, SM1 specify the serial port mode, as follows:

| SM0 | SM1 | Mode | Description    | Baud Rate                             |
|-----|-----|------|----------------|---------------------------------------|
| 0   | 0   | 0    | shift register | $f_{osc} / 12$                        |
| 0   | 1   | 1    | 8-bit UART     | Variable                              |
| 1   | 0   | 2    | 9-bit UART     | UART $F_{osc} / 64$ or $F_{osc} / 32$ |
| 1   | 1   | 3    | 9-bit UART     | Variable                              |

**Using Timer 1 to Generate Baud Rates**

When Timer 1 is used as the baud rate generator, the baud rates in Modes 1 and 3 are determined by the Timer 1 overflow rate and the value of SMOD as follows:

Mode 1, 3 Baud Rate =  $2^{SMOD}/32 * (\text{Timer 1 Overflow Rate})$

The Timer 1 interrupt should be disabled in this application. The Timer 1 itself can be configured for either “timer” or “counter” operation, and in any of its 3 running modes. In the most typical applications, it is configured for “timer” operation, in the auto-reload mode (high nibble of TMOD = 0010B). In that case the baud rate is given by the formula:

Mode 1, 3 Baud Rate =  $2^{SMOD} * (\text{Oscillator Frequency}) / 32 / 12 / [256 - (TH1)]$

One can achieve very low baud rates with Timer 1 by leaving the Timer 1 interrupt enabled, and configuring the Timer to run as a 16-bit timer (high nibble of TMOD = 0001B), and using the Timer 1 interrupt to do a 16-bit software reload.

**Using Timer 2 to Generate Baud Rates**

Timer2 is selected as the baudrate generator by setting TCLK and/or RCLK in T2CON register as followed.

**T2CON (address : C8h)**

|            |             |             |             |              |            |             |               |
|------------|-------------|-------------|-------------|--------------|------------|-------------|---------------|
| <b>MSB</b> |             |             |             |              | <b>LSB</b> |             |               |
| <b>TF2</b> | <b>EXF2</b> | <b>RCLK</b> | <b>TCLK</b> | <b>EXEN2</b> | <b>TR2</b> | <b>C/T2</b> | <b>CP/RL2</b> |

T2CON.7: TF2 Timer2 overflow flag set by timer2 overflow and must be cleared by software. TF2 will not be set when either RCLK=1 or TCLK=1.

T2CON.6: EXF2 Timer 2 external flag set when either a capture or reload is caused by a negative transition on T2EX and EXEN2=1. when timer2 interrupt is enabled, EXF2=1 will cause the CPU to vector to the timer2 interrupt routine. EXF2 must be cleared by software.

T2CON.5: RCLK Receive clock flag. When set, cause the serial port to use timer2 overflow pulses for its receive clock in

mode 1 and 3. RCLK=0 causes timer1 overflow to be used for the receive clock  
 T2CON.4: TCLK Transmit clock flag. When set, cause the serial port to use timer2 overflow pulses for its transmit clock in mode 1 and 3. TCLK=0 causes timer1 overflow to be used for the transmit clock

T2CON.3: EXEN2 Timer2 external enable flag. When set, allows a capture or reload to occur as a result of a negative transition on T2EX if timer2 is not being used to clock the serial port. EXEN2=0 causes timer2 to ignore events at T2EX.

T2CON.2: Start/stop control for timer2. A logic 1 starts the timer  
 T2CON.1: Timer or counter select. (Timer 2) , 0 as internal timer

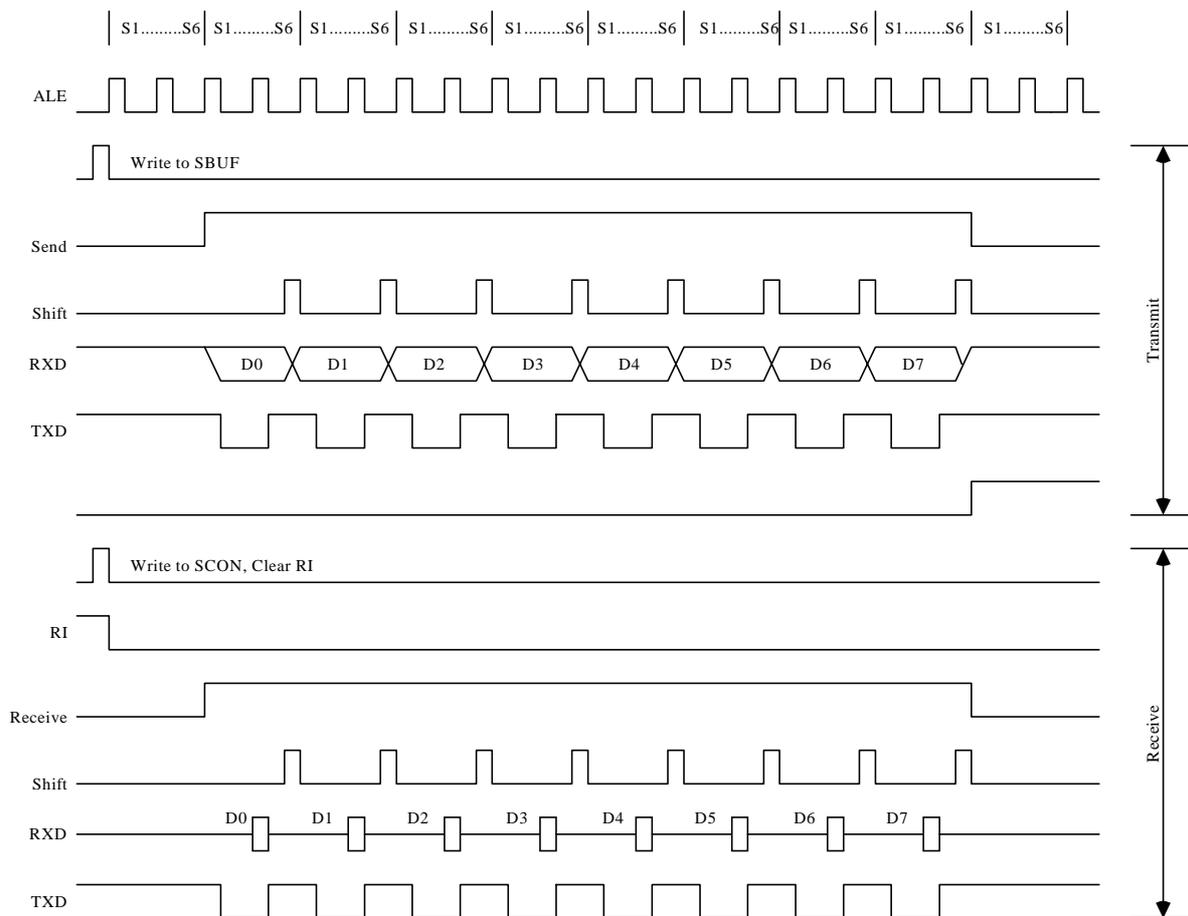
T2CON.0: Capture/Reload flag. When set, captures will occur on negative transitions at T2EX if EXEN2=1. When cleared, auto reloads will occur either with timer2 overflow or negative transitions at T2EX when EXEN2=1. When either RCLK=1 or TCLK=1, this bit is ignored and the timer is forced to auto-reload on timer2 overflow.

Note then the baudrates for transmit and receive can be simultaneously different. Setting RCLK and/or TCLK puts Timer2 into its baudrate generator mode.

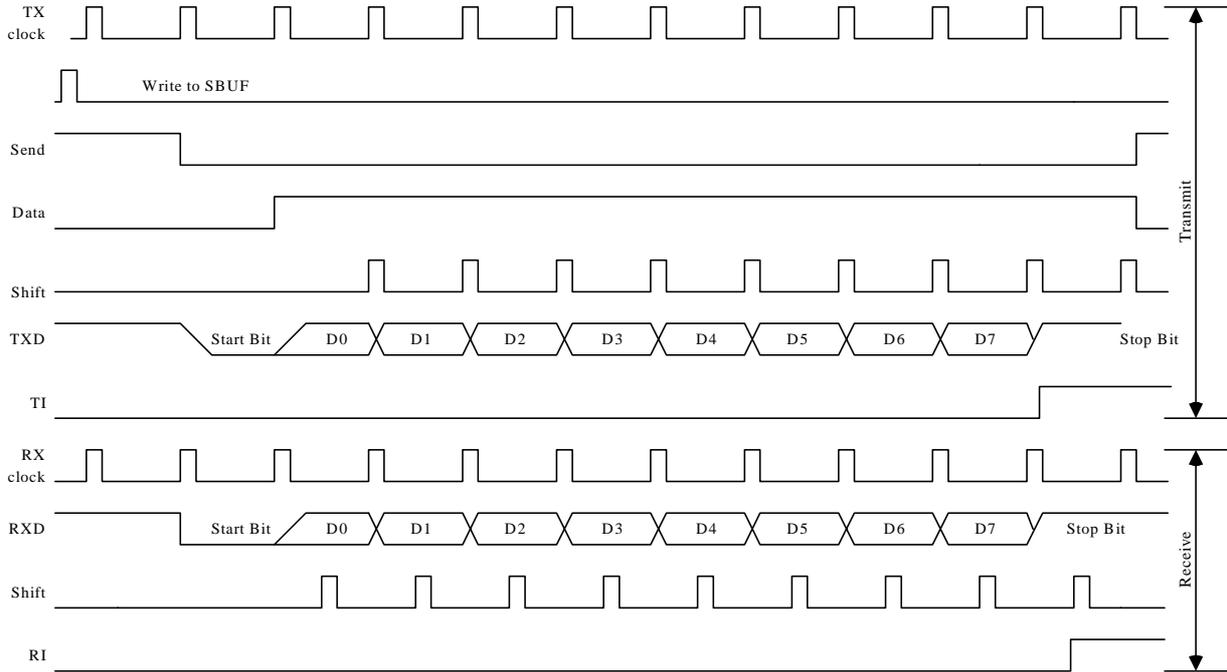
The baudrate generator mode is similar to the auto reload mode, in that a rollover is TH2 causes the Timer2 registers to be reload with the 16 bit value in registers RCAP2H and RCAP2L, which are preset by software given by the formula.

$$\text{Baudrate} = (\text{Timer2 overflow rate})/16 = (\text{Oscillator Frequency}) / (32 * (65536 - (\text{RCAP2H}, \text{RCAP2L})))$$

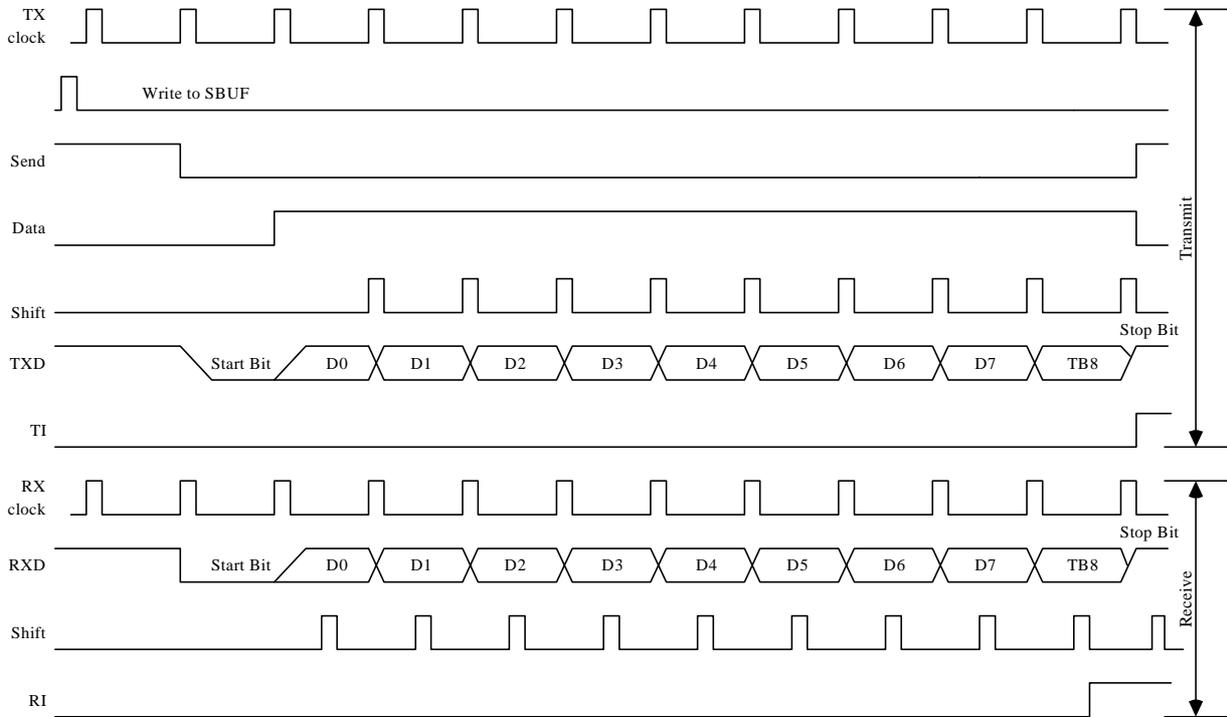
**Serial Interface Timing Diagram**



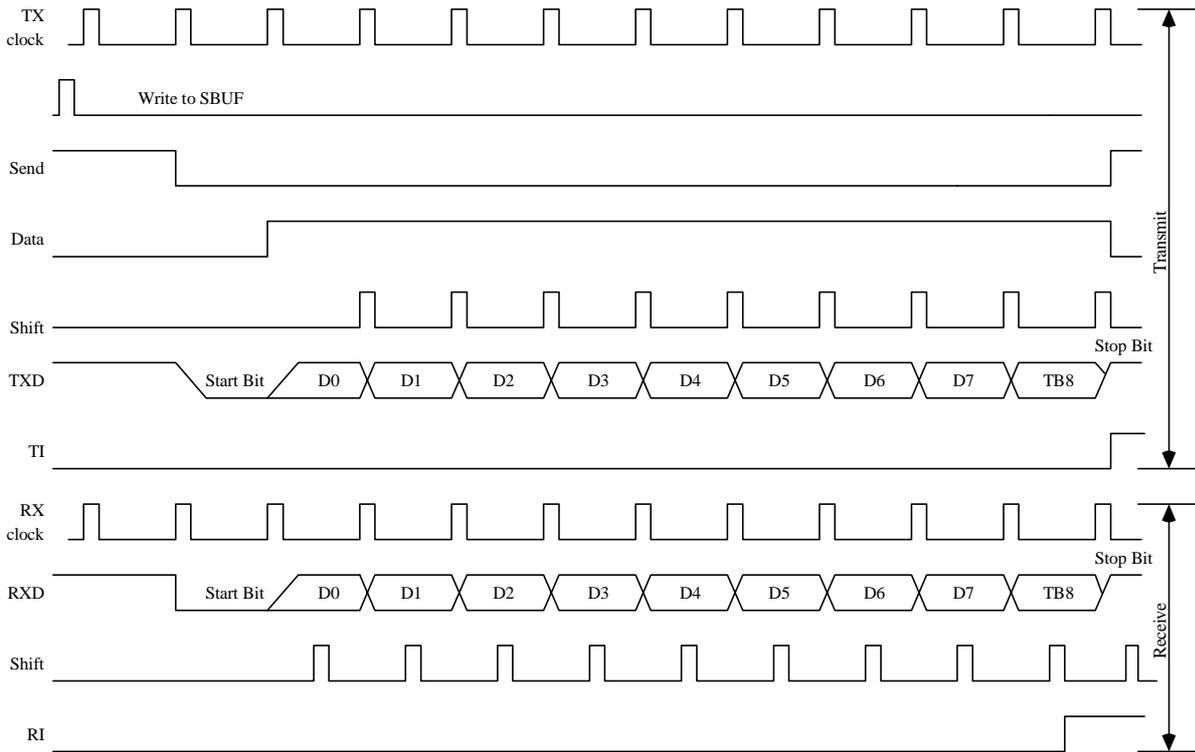
Serial Port Mode 0



Serial Port Mode 1



Serial Port Mode 2



Serial Port Mode 3

**Interrupt Enable Register : IE**

| MSB |     |     |    |     |     | LSB |     |
|-----|-----|-----|----|-----|-----|-----|-----|
| EA  | wdt | ET2 | ES | ET1 | EX1 | ET0 | EX0 |

- EA IE.7 Disables all interrupts. If EA = 0, no interrupt will be acknowledged. If EA = 1, each interrupt source is individually enabled or disabled by setting or clearing its enable bit.
- wdt IE.6 Watchdog timer refresh flag.
- ET2 IE.5 Enable or disable the Timer 2 overflow interrupt.
- ES IE.4 Enable or disable the serial port interrupt.
- ET1 IE.3 Enable or disable the Timer 1 overflow interrupt.
- EX1 IE.2 Enable or disable External Interrupt 1. (See **NOTE**)
- ET0 IE.1 Enable or disable the Timer 0 overflow interrupt.
- EX0 IE.0 Enable or disable External Interrupt 0.

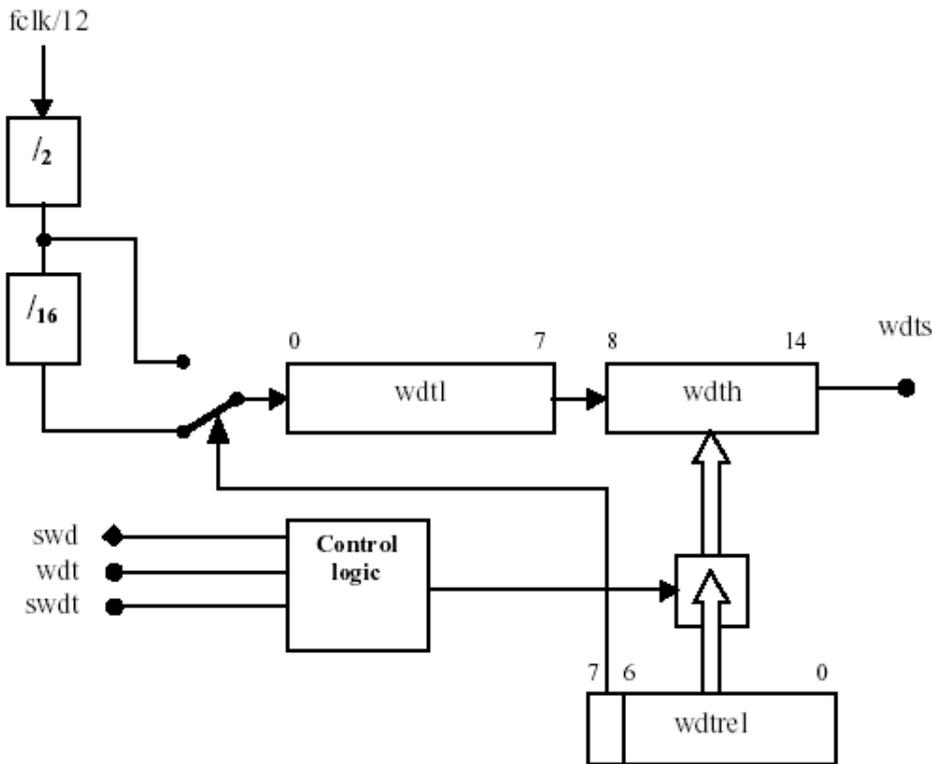
**NOTE:** if A/D converter interrupts enabled, EX1 interrupt function will be replaced.

**Watchdog Timer**

The watchdog timer is a 16-bit counter that is incremented once every 24 or 384 clock cycles. After an external reset the watchdog timer is disabled and all registers are set to zeros.

● **Watchdog Timer structure**

The watchdog consists of 16-bit counter **wdt**, reload register **wdtrel**, prescalers by 2 and by 16 and control logic. Where **wdtl**=00h while start up.



**Figure Watchdog block diagram**

● **Start procedure**

There are one way to start the watchdog. A programmer can start the watchdog as refreshing procedure. Once the watchdog is started it cannot be stopped unless **rst** signal becomes active. When **wdt** registers enters the state 7FFCh, asynchronous **wdts** signal will become active. The signal **wdts** sets the bit 6 in ip0 register and requests reset state. The **wdts** is cleared either by **rst** signal or change of the state of the **wdt** timer.

**Procedure: load wdtrel value → set “wdt” → set “swdt” in 12 instruction cycles.**

● **Refreshing the watchdog timer**

The watchdog timer must be refreshed regularly to prevent reset request signal from becoming active. This requirement imposes obligation on the programmer to issue two followed instructions. The first instruction sets **wdt** and the second one **swdt**. The maximum allowed delay between settings of the **wdt** and **swdt** is 12 instruction cycles. While this period has expired and **swdt** has not been set, **wdt** is automatically reset, otherwise the watchdog timer is reloaded with the content of the **wdtrel** register and **wdt** is automatically reset. The procedure is as “Start procedure” before.

● **Special Function Registers**

**a) Interrupt Enable 0 register (ien0)**

The ien0 register (address : A8)

|     |     |     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|-----|-----|
| MSB |     |     |     |     |     | LSB |     |
| eal | wdt | et2 | es0 | et1 | ex1 | et0 | ex0 |

**The ien0 bit functions**

| Bit    | Symbol | Function  |
|--------|--------|---|
| ien0.6 | wdt    | Watchdog timer refresh flag.<br>Set to initiate a refresh of the watchdog timer. Must be set directly before swdt is set to prevent an unintentional refresh of the watchdog timer. The wdt is reset by hardware 12 instruction cycles after it has been set. |

Note: other bits are not used to watchdog control

**b) Interrupt Enable 1 register (ien1)**

The ien1 register (Address : B8)

|     |      |     |    |     |     |     |     |
|-----|------|-----|----|-----|-----|-----|-----|
| MSB |      |     |    |     |     | LSB |     |
| -   | swdt | pt2 | ps | pt1 | px1 | pt0 | px0 |

**The ien1 bit functions**

| Bit    | Symbol | Function   |
|--------|--------|--|
| Ien1.6 | swdt   | Watchdog timer start refresh flag.<br>Set to active/refresh the watchdog timer. When directly set after setting wdt, a watchdog timer refresh is performed. Bit swdt is reset by hardware 12 instruction cycles after it has been set. |

Pay attention that when write ien1.6, it write the swdt bit, when read ien1.6, we will read out the wdts bit. Ie. Watch dog timer status flag. Set by hardware when the watchdog timer was started.

**d) Watchdog Timer Reload register (wdtrel)**

The wdtrel register ( Address : 86 )

|     |   |   |   |   |   |     |   |
|-----|---|---|---|---|---|-----|---|
| MSB |   |   |   |   |   | LSB |   |
| 7   | 6 | 5 | 4 | 3 | 2 | 1   | 0 |

**The wdtrel bit functions**

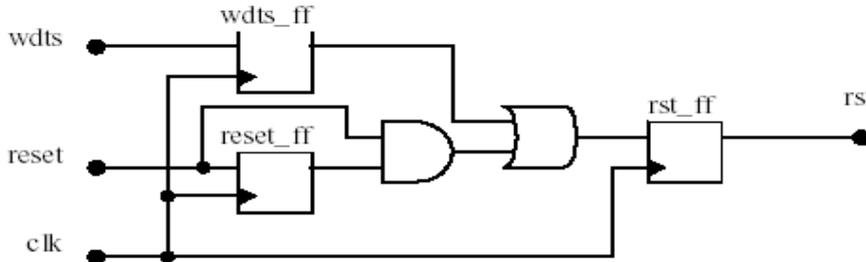
| Bit                     | Symbol | Function  |
|-------------------------|--------|---|
| wdtrel.7                | 7      | Prescaler select bit. When set, the watchdog is clocked through an additional divide-by-16 prescaler  |
| wdtrel.6 t0<br>wdtrel.0 | 6-0    | Seven bit reload value for the high-byte of the watchdog timer. This value is loaded to the wdt when a refresh is triggered by a consecutive setting of bits wdt and swdt |

The wdtrel register can be loaded and read any time

● **WDT Reset**

A high on reset pin or watchdog reset request for two clock cycles while the oscillator is running resets the device.

**Diagram**



b) Watchdog timer reset

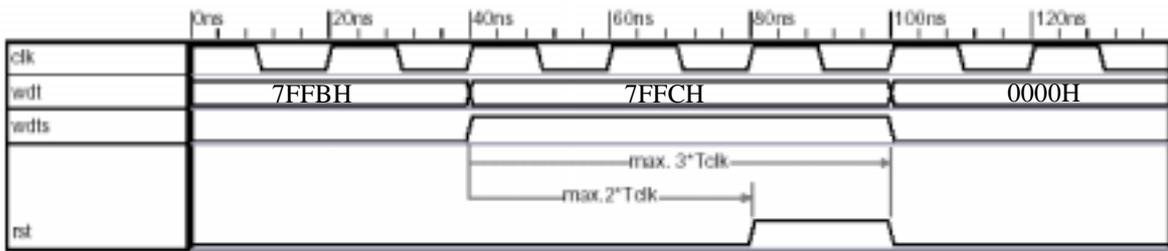


Figure Watchdog reset timing

\*\*Note :

- clk: external clock input
- Tclk: clock period
- wdt: watchdog timer registers
- wdts: watchdog timer status flag
- reset: external reset input
- rst: internally generated reset signal

● **Reset Time Formula**

Reset time=(7FFCh-wdth.wdtl)\*presc\*48/ClockFrequency  
 while presc=16 if wdtrel.7=1, presc=1 if wdtrel.7=0.

For example if you use frequency clock=12MHz, wdtrel=10111111b which means wdtrel.7=1 and wdth=3Fh  
 Then reset time= (7FFCh-3F00h)\*48/12M=66544 us

**10.4 External Register Table ( for A/D Converter , PWM, EEPROM & LVR)**

| Register Address |       | Name      | Comments  |
|------------------|-------|-----------|---|
| (A15...A5-A0)    | Hex   |           |   |
| 100... 0010 0000 | 8020H | ADM       | A/D Control & Status                              |
| 100... 0010 0001 | 8021H | ADR       | A/D Clock prescaler and A/D value LSB             |
| 100... 0010 0010 | 8022H | ADB       | A/D value MSB                                     |
| 100... 0010 1010 | 802aH | ADE       | A/D Converter Channel Enable                      |
| 100... 0010 0101 | 8025H | PWMC1     | PWM Control register1                             |
| 100... 0010 1011 | 802bH | PWMC2     | PWM Control register2 and LVR(Low Voltage Reset)* |
| 100... 0010 0110 | 8026H | PWM1      | PWM1 Value  |
| 100... 0010 0111 | 8027H | PWM2      | PWM2 Value  |
| 100... 00101000  | 8028H | SPICON    | EEPROM control & setup (for T81L0006B only)       |
| 100... 0010 1001 | 8029H | OPCODE    | EEPROM opcode (for T81L0006B only)                |
| 100... 0010 1110 | 802eH | DATAW_H   | EEPROM write high byte (for T81L0006B only)       |
| 100... 0010 1111 | 802fH | DATAW_L   | EEPROM write low byte (for T81L0006B only)        |
| 100... 0010 1100 | 802cH | DATAR_H   | EEPROM read high byte (for T81L0006B only)        |
| 100... 0010 1101 | 802dH | DATAR_L   | EEPROM read low byte (for T81L0006B only)         |
| 100... 0011 0000 | 8030H | Port3 HDS | Port3 I/O high driving set**                      |
| 100... 0011 0001 | 8031H | Port2 HDS | Port2 I/O high driving set**                      |
| 100... 0011 0010 | 8032H | Port1 HDS | Port1 I/O high driving set**                      |

**Note :**

\* LVR (Low Voltage Reset) address : 802bH, read/write

| MSB    |       |      |       |       |       |      | LSB                   |
|--------|-------|------|-------|-------|-------|------|-----------------------|
| Bit 7  | Bit 6 | Bit5 | Bit 4 | Bit 3 | Bit 2 | Bit1 | Bit 0                 |
| LVR[7] |       |      |       |       |       |      | PWM Control register2 |

LVR[7] : if LVR[7] write '1', low voltage reset function enable(under 2.1V reset).  
default is '0', low voltage reset function disable.

**\*\* Port I/O high driving set**

if write '0' = set I/O to high driving current mode.  
if write '1' = set I/O to normal driving current mode.  
default is set '1'.

Port 3 high driving address : 8030H

| MSB     |         |         |         |         |         |         | LSB     |
|---------|---------|---------|---------|---------|---------|---------|---------|
| Bit 7   | Bit 6   | Bit5    | Bit 4   | Bit 3   | Bit 2   | Bit1    | Bit 0   |
| Port3.7 | Port3.6 | Port3.5 | Port3.4 | Port3.3 | Port3.2 | Port3.1 | Port3.0 |

Port 2 high driving address : 8031H

| MSB   |       |      |       |         |       |         | LSB     |
|-------|-------|------|-------|---------|-------|---------|---------|
| Bit 7 | Bit 6 | Bit5 | Bit 4 | Bit 3   | Bit 2 | Bit1    | Bit 0   |
|       |       |      |       | Port2.3 |       | Port2.1 | Port2.0 |

Port 1 high driving address : 8032H

| MSB     |         |         |         |         |         |         | LSB     |
|---------|---------|---------|---------|---------|---------|---------|---------|
| Bit 7   | Bit 6   | Bit5    | Bit 4   | Bit 3   | Bit 2   | Bit1    | Bit 0   |
| Port1.7 | Port1.6 | Port1.5 | Port1.4 | Port1.3 | Port1.2 | Port1.1 | Port1.0 |

**10.5 A/D converter**

The data acquisition component is an 8-bit analog-to-digital converter, 8-channel multiplexer and microcontroller compatible control logic. The 8-bit A/D converter uses successive approximation conversion technique. The 8-channel multiplexer can directly access any of 8-single-ended analog signals. The device eliminates the need for external zero and full-scale adjustments. The design of the component has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The component offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make this device ideally suitable from process and machine control to consumer applications.

**A/D Converter Register Control**

|     |          |       |       |       |       |       |       |       |       |
|-----|----------|-------|-------|-------|-------|-------|-------|-------|-------|
| ADM | Default  | R/W   | R/W   | R     | R/W   | -     | R/W   | R/W   | R/W   |
|     | 00100000 | ADENB | ADS   | EOC   | ADI   | -     | CHS2  | CHS1  | CHS0  |
| ADR | Default  | -     | R/W   | R/W   | R/W   | -     | -     | -     | -     |
|     | x010xxxx | -     | ADPS2 | ADPS1 | ADPS0 | -     | -     | -     | -     |
| ADB | Default  | R     | R     | R     | R     | R     | R     | R     | R     |
|     | xxxxxxx  | ADB7  | ADB6  | ADB5  | ADB4  | ADB3  | ADB2  | ADB1  | ADB0  |
| ADE | Default  | R/W   |
|     | 00000000 | ENCH7 | ENCH6 | ENCH5 | ENCH4 | ENCH3 | ENCH2 | ENCH1 | ENCH0 |

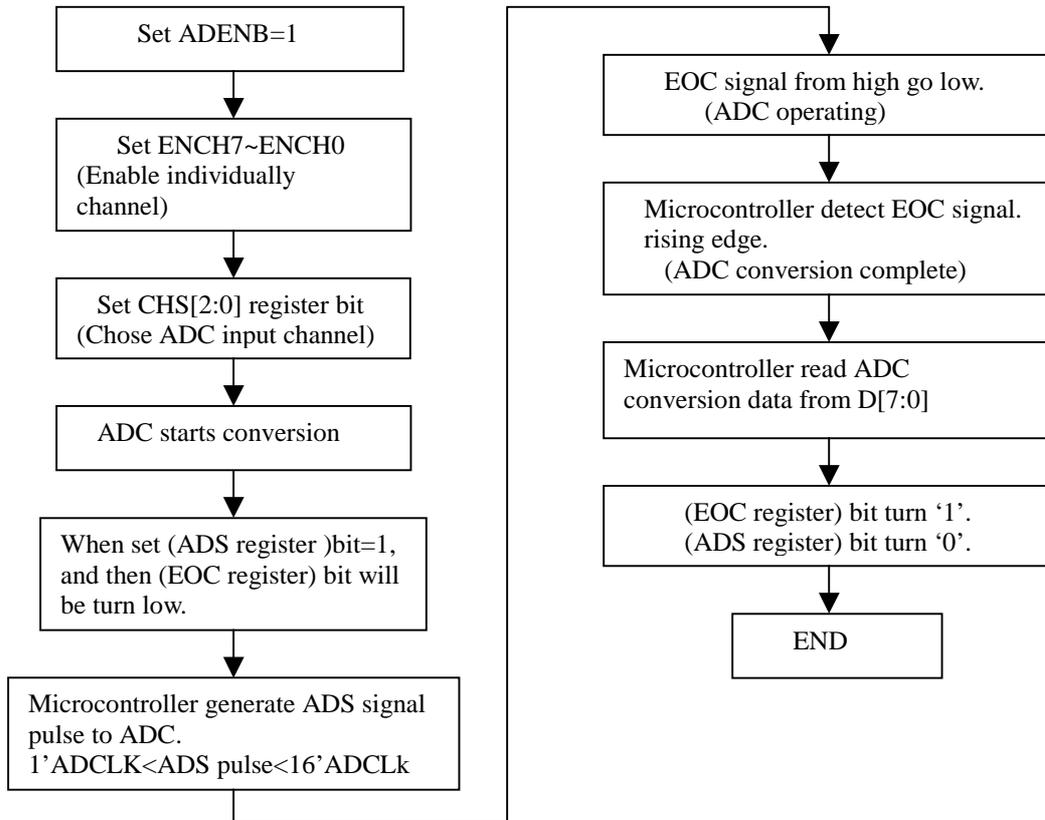
- ADENB      Disable all A/D converter input channels: 0-Disable, 1-Enable  
                  If ADENB=0, all input channel will be closed. If ADENB =1, each input channels is individually enabled or disabled by setting or clearing ENCH7~ENCH0 enable bits.
- ADI            A/D Interrupt bit: 0-Disable, 1-Enable  
                  If ADI=1, external interrupt 1 will be inhibited. A/D converter interrupt function will in place of external interrupt 1 function.
- ADS            A/D Start bit: 0-Stop, 1-Start
- EOC            A/D Status bit: 0- Busy, 1-End of converting and clear ADS bit
- CHS2: CHS0 --- Channel select

ADPS2: ADPS0 ---A/D clock divider, Input frequency = Fosc/3

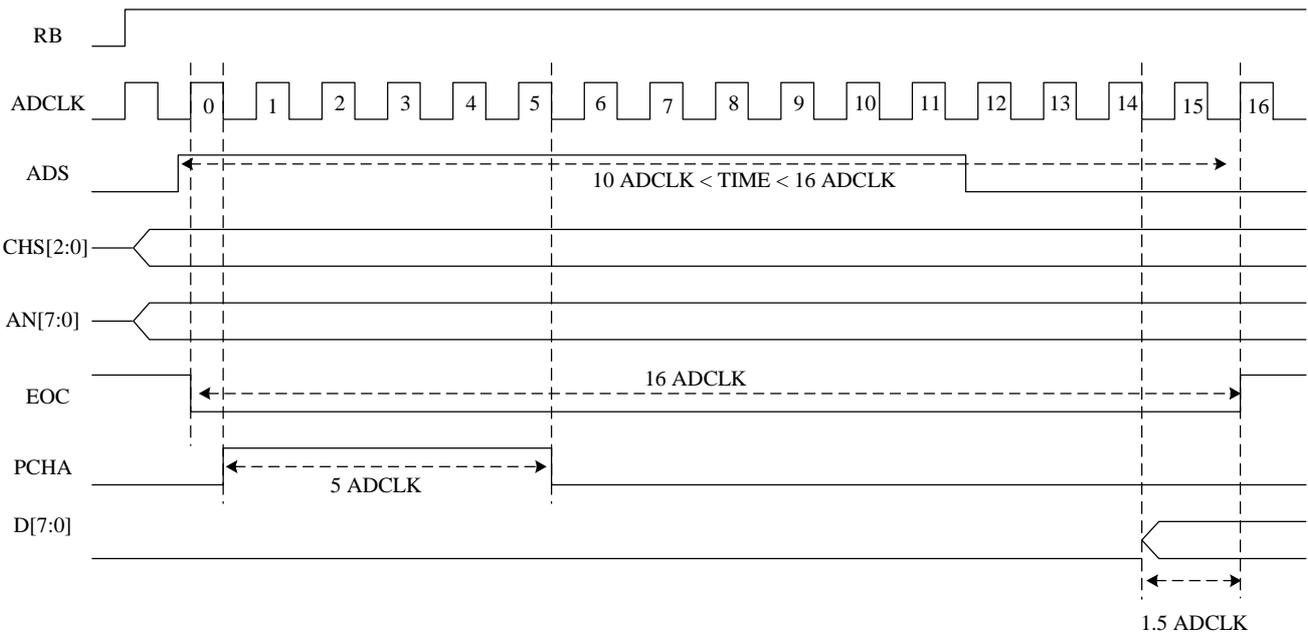
| ADPS2:1:0 | Dividers Ratio Fad: Fosc/12 |
|-----------|-----------------------------|
| 000       | 1:1                         |
| 001       | 1:2                         |
| 010       | 1:4                         |
| 011       | 1:8                         |
| 100       | 1:16                        |
| 101       | 1:32                        |
| 110       | 1:64                        |
| 111       | 1:128                       |

- ADB7 ~ADB0--- 8-bit ADC converting data
- ENCH7 ~ENCH0 --- ADC individual input channel enable bit:  
                  0-Disable, 1-Enable

**A/D converter conversion flow**



**A/D Converter Timing Diagram**



**10.6 Pulsed Width Modulator (PWM)**

The T81L0006A/B provides 2 channels 8 bits PWM output for peripheral. The frequency source of the PWM counter comes from Fosc. Writing 1 to PWMC register enable bit will enable the PWM output function. PWMPS2:1:0 control bit determine PWM output clock that range from Fosc/2 to Fosc/256. Each PWM output clock duty cycle can be programmed though set PWM0 or PWM1 register.

**PWM Register Control**

|       |         |         |         |         |         |         |         |         |             |
|-------|---------|---------|---------|---------|---------|---------|---------|---------|-------------|
| PWMC1 | Default | B7: R/W | B6: R/W | B5: R/W | B4: R/W | B3: R/W | B2: R/W | B1: R/W | B0: R/W     |
|       | 0x00    | Pwm2EN  | Pwm2PS2 | Pwm2PS1 | Pwm2PS0 | Pwm1EN  | Pwm1PS2 | Pwm1PS1 | Pwm1PS0     |
| PWMC2 | Default |         |         |         |         |         |         |         |             |
|       | 0x00    | -       | -       | -       | -       | -       | -       | -       | R/W<br>Mode |
|       |         | R/W         |
| PWM1  | 0x00    |         |         |         |         |         |         |         |             |
| PWM2  | 0x00    |         |         |         |         |         |         |         |             |

**PWMC1: PWM control register1**

Pwm1EN, Pwm2EN

PWM1, PWM2 Enable bit: 0-Disable, 1-Enable

When Enable bit=0, PWM output pin = High impedance.

PWMPS2:1:0 --- PWM dividers ratio

Fpwm= Fosc/PWMPS/256 while select 8-bit mode

Fpwm= Fosc/PWMPS/65536 while select 16-bit mode

| PS:2:1:0 | Dividers ratio Fpwm:Fosc |
|----------|--------------------------|
| 000      | 1:2                      |
| 001      | 1:4                      |
| 010      | 1:8                      |
| 011      | 1:16                     |
| 100      | 1:32                     |
| 101      | 1:64                     |
| 110      | 1:128                    |
| 111      | 1:256                    |

PWMC2: PWM control register2 Mode

PWM 16-bit mode or 8-bit mode selects : '0'= 8-bit mode, '1'= 16-bit mode

When select 16-bit mode, PWM2 register= PWM duty cycle value high byte.

PWM1 register= PWM duty cycle value low byte.

Note: 16-bit PWM just for PWM1 output

**PWM1 register:**

Set PWM1's duty cycle. --- Duty1= PWM1/256 or 16-bit PWM duty cycle value low byte.

**PWM2 register:**

Set PWM2's duty cycle. --- Duty2= PWM2/256 or 16-bit PWM duty cycle value high byte.

Set 16-bit PWM duty cycle. --- Duty= (PWM2, PWM1)/65536

**10.7 EEPROM Interface (for T81L0006B only)**

The EEPROM interface timing is fully compatible with 93C46. To access or send data from/to T81L0006B , 6 registers are going to be controlled.

**EEPROM Register Control**

|         |                |    |    |    |    |    |                   |                   |                      |
|---------|----------------|----|----|----|----|----|-------------------|-------------------|----------------------|
| SPICON  | Default<br>00H | -- | -- | -- | -- | -- | B2: R/W<br>Epdiv1 | B1: R/W<br>Epdiv0 | B0: R/W<br>Epst<br>W |
| OPCODE  | 00H            | -  | -  | -  | -  | -  | -                 | -                 | -                    |
| DATAW_H |                |    |    |    |    |    |                   |                   |                      |
| DATAW_L | 00H            |    |    |    |    |    |                   |                   |                      |
| DATAR_H |                |    |    |    |    |    |                   |                   |                      |
| DATAW_L | 00H            |    |    |    |    |    |                   |                   |                      |

**SPICON:**

|            |       |      |       |       |        |            |       |
|------------|-------|------|-------|-------|--------|------------|-------|
| <b>MSB</b> |       |      |       |       |        | <b>LSB</b> |       |
| Bit 7      | Bit 6 | Bit5 | Bit 4 | Bit 3 | Bit 2  | Bit1       | Bit 0 |
|            |       |      |       |       | Epdiv1 | Epdiv0     | Epst  |

Epst: start EEPROM timing. "1" to start and will be auto cleared after timing finish.

Epdiv[1..0]: divide input clock into EEPROM system clock.

10: divide by 64

01: divide by 32

else: divide by 16

**OPCODE**

|            |       |         |       |       |       |            |       |
|------------|-------|---------|-------|-------|-------|------------|-------|
| <b>MSB</b> |       |         |       |       |       | <b>LSB</b> |       |
| Bit 7      | Bit 6 | Bit5    | Bit 4 | Bit 3 | Bit 2 | Bit1       | Bit 0 |
| OP Code    |       | address |       |       |       |            |       |

| Instruction Set             | OP Code | Address | Input Data |
|-----------------------------|---------|---------|------------|
| Read                        | 10      | A5-A0   |            |
| WEN (Write Enable)          | 00      | 11xxxx  |            |
| Write                       | 01      | A5-A0   | D15-D0     |
| WRALL (Write All Registers) | 00      | 01xxxx  | D15-D0     |
| WDS (Write Disable)         | 00      | 00xxxx  |            |
| Erase                       | 11      | A5-A0   |            |
| ERAL                        | 00      | 10xxxx  |            |

---

## 11. I/O Ports

### Port1

Port 1 is an 8-bit bi-directional I/O port with internal pull-ups. Port 1 output buffers can sink/source four external TTL device inputs. When port 1 pins are written as 1's, these pins are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current because of the internal pull-ups.

Port 1 also serves the analog signal input of A/D converter, as listed below:

- P1.0 ADI0 (analog input signal channel 0)
- P1.1 ADI1 (analog input signal channel 1)
- P1.2 ADI2 (analog input signal channel 2)
- P1.3 ADI3 (analog input signal channel 3)
- P1.4 ADI4 (analog input signal channel 4)
- P1.5 ADI5 (analog input signal channel 5)
- P1.6 ADI6 (analog input signal channel 6)
- P1.7 ADI7 (analog input signal channel 7)

### Port2.0, 2.1, 2.3

Port2.0, 2.1, 2.3 are a bi-directional I/O port with internal pull-ups. Port2.0, 2.1, 2.3 output buffers can sink/source four external TTL device inputs. When Port2.0, 2.1, 2.3 pins are written as 1's, these pins are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port2.0, 2.1, 2.3 pins that are externally being pulled low will source current because of the internal pull-ups.

Port 2.0 also serves the output signal of PWM 2.

### Port 3

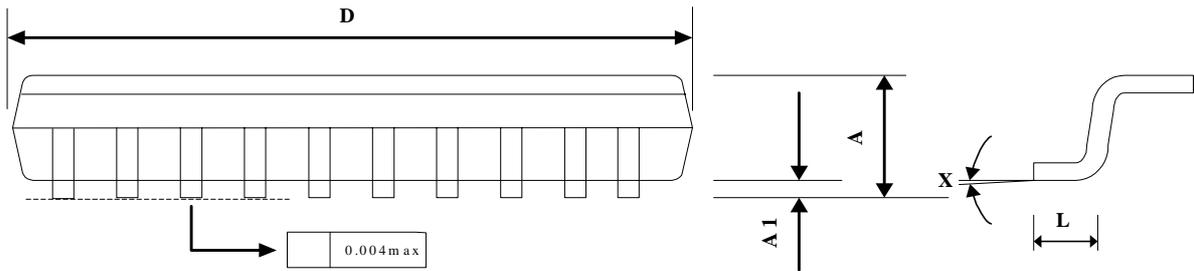
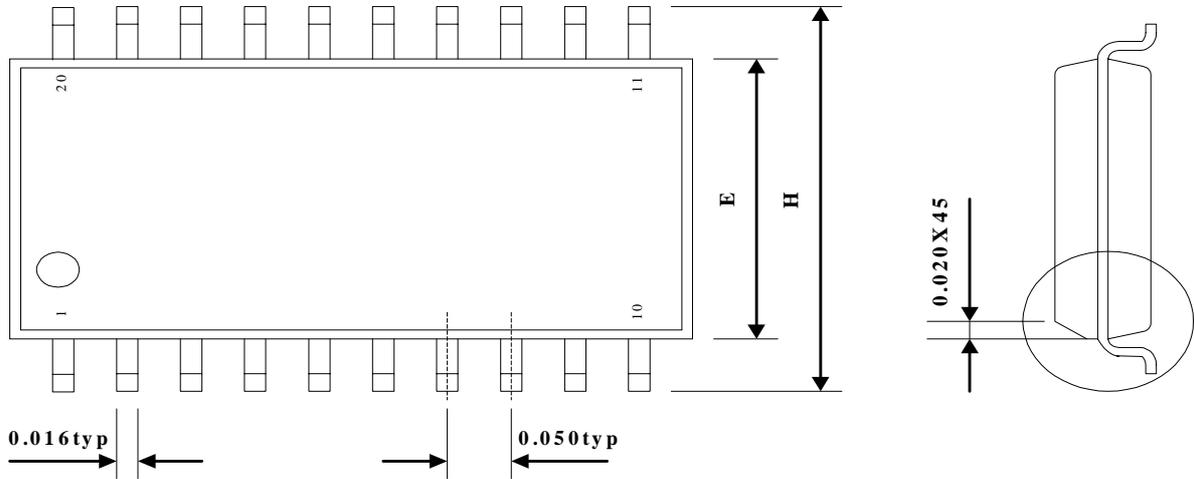
Port 3 is an 8-bit bi-directional I/O port with internal pull-ups. Port 3 output buffers can sink/source four external TTL device inputs. When port 3 pins are written as 1's, these pins are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current because of the internal pull-ups.

Port 3 also serves the functions of various special features, as listed below:

- P3.0 RXD (serial input port)
- P3.1 TXD (serial output port)
- P3.2 INT0 (external interrupt 0)
- P3.3 INT1 (external interrupt 1)
- P3.4 T0 (timer 0 external input)
- P3.5 T1 (timer 1 external input)
- P3.6 PWM1 (PWM 1 signal output)
- P3.7 VREF (external reference voltage input for ADC)

**Package Dimension**

**20/24-LEAD SOP**



20-LEAD

24-LEAD

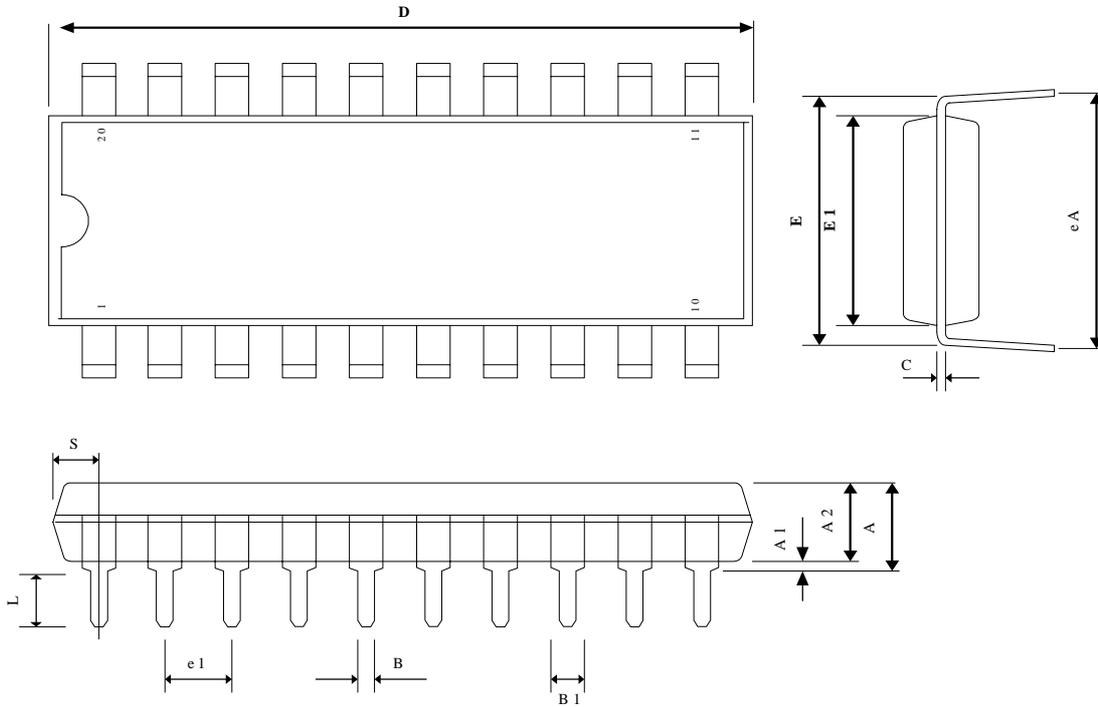
| SYMBOLS | MIN.  | MAX.  |
|---------|-------|-------|
| A       | 0.093 | 0.104 |
| A1      | 0.004 | 0.012 |
| D       | 0.496 | 0.508 |
| E       | 0.291 | 0.229 |
| H       | 0.394 | 0.419 |
| L       | 0.016 | 0.050 |
| X       | 0     | 8     |

| SYMBOLS | MIN.  | MAX.  |
|---------|-------|-------|
| A       | 0.093 | 0.104 |
| A1      | 0.004 | 0.012 |
| D       | 0.599 | 0.624 |
| E       | 0.291 | 0.229 |
| H       | 0.394 | 0.419 |
| L       | 0.016 | 0.050 |
| X       | 0     | 8     |

UNIT: INCH

**Package Dimension**

**20/24-LEAD DIP**



**20-LEAD**

| SYMBOLS | MIN.  | NOM   | MAX.  |
|---------|-------|-------|-------|
| A       | -     | -     | 0.175 |
| A1      | 0.015 | -     | -     |
| A2      | 0.125 | 0.130 | 0.135 |
| B       | 0.016 | 0.018 | 0.020 |
| B1      | 0.058 | 0.060 | 0.064 |
| C       | 0.008 | 0.010 | 0.011 |
| D       | 1.012 | 1.026 | 1.040 |
| E       | 0.290 | 0.300 | 0.310 |
| E1      | 0.245 | 0.250 | 0.225 |
| e1      | 0.090 | 0.100 | 0.110 |
| L       | 0.120 | 0.130 | 0.140 |
| eA      | 0.335 | 0.355 | 0.375 |
| S       | -     | -     | 0.075 |

UNIT: INCH

**24-LEAD**

| SYMBOLS | MIN.  | NOM   | MAX.  |
|---------|-------|-------|-------|
| A       | -     | -     | 0.175 |
| A1      | 0.015 | -     | -     |
| A2      | 0.125 | 0.130 | 0.135 |
| B       | 0.016 | 0.018 | 0.020 |
| B1      | 0.058 | 0.060 | 0.064 |
| C       | 0.008 | 0.010 | 0.011 |
| D       | 1.230 | 1.250 | 1.280 |
| E       | 0.290 | 0.300 | 0.310 |
| E1      | 0.245 | 0.250 | 0.225 |
| e1      | 0.090 | 0.100 | 0.110 |
| L       | 0.120 | 0.130 | 0.140 |
| eA      | 0.335 | 0.355 | 0.375 |
| S       | -     | -     | 0.075 |