

PROGRAMMIG 8051 TIMERS

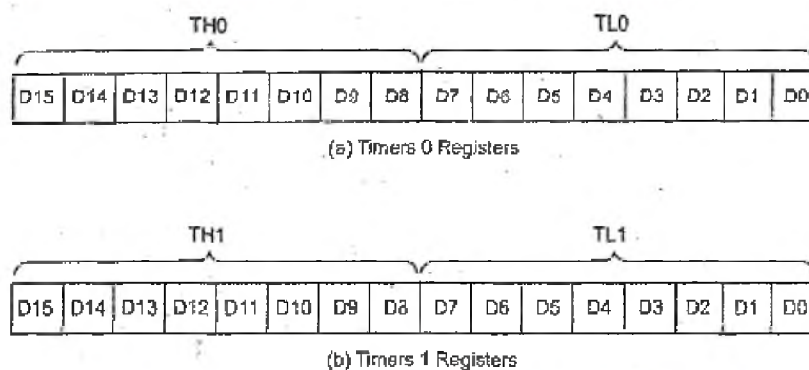
Introduction

The 8051 has two timers/counters. They can be used either as timers in order to generate a time delay or as event counters to count events happening outside the microcontroller.

Basic Registers of Timer:

Both Timer 0 and Timer 1 are 16 bits wide. Since the 8051 has an 8-bit architecture, each 16-bit timer is accessed as two separate registers of low byte and high byte.

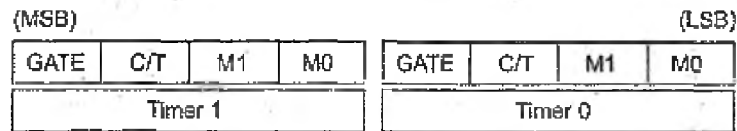
In Timer 0 and Timer 1, the low byte register is called TL0/TL1 and the high byte register is called as TH0/TH1. These two timers can be accessed like any other registers.



Structure of TMOD (Timer Mode) Register

Both the timers 0 and 1 uses the same register is called as TMOD which is used to : set the various timer operation modes.

TMOD is a 8-bit register in which the lower four bits are for Tinier 0 and the f upper four bits are for Timer 1. In each case, the lower two bits (M1 & M0) arc used to set the timer mode whereas, the upper two bits are used to specify the operation.



(i) Mode Bit-1 (M1), Mode Bit-0 (M0):

M0 and M1 bits select the timer mode and there are three modes: 0,1, and 2.

- Mode 0 is a 13-bit timer.
- Mode 1 is a 16-bit timer.
- Mode 2 is an 8-bit timer.

Modes 1 and 2 are widely used.

M1	M0	Mode	Operating Mode
0	0	0	13-bit timer mode: 8-bit timer/counter THx with TLx as 5-bit prescaler.
0	1	1	16-bit timer mode: 16-bit timer/counter THx and TLx are cascaded; there is no prescaler.
1	0	2	8 bit auto reload: 8-bit auto reload timer/counter; THx holds a value which is to be reloaded into TLx each time it overflows.
1	1	3	Split timer mode

(ii) C/T (Clock/Timer)

This bit is used to decide whether the timer is used as a delay generator or an event counter.

- (a) If C/T = 0, it is used as a timer.
- (b) If C/T = 1, it is used as a counter.

(iii) Clock Source for Timer:

The frequency for the timer is always 1/12 of the frequency of the crystal attached to the 8051.

(iv) GATE

Timers of 8051 gets started and stopped by either a software or hardware control;

- (a) GATE = 0: Software is used.

The start and stop of the timer are controlled by the way of software using the TR (timer start) bits TRO and TRI.

The SETB instruction starts and stopped by the CLR instruction.

TCON (Timer/Counter) Register

TCON register controls the timer/countet operations. The lower four bits of TCON is for interrupt functions and the upper four bits are for timer operations.

MSB				LSB			
7	6	5	4	3	2	1	0
TF1	TR1	TF0	TRO	IE1	IT1	IE0	ITO

BIT	SYMBOL	FUNCTION
TCON.7	TF1	Timer 1 overflow flag
TCON.6	TR1	Timer 1 run control bit
TCON.5	TF0	Timer 0 overflow flag
TCON.4	TRO	Timer 0 run control flag

Bit 3: IE1

- An external interrupt 1 edge flag which is set by the hardware when an interrupt on INTI pin occurred and cleared by the hardware when an interrupt gets processed.

Bit 2: IT1

this bit selects the external interrupt event type on INTI pin,

1 - Sets interrupt on falling edge.

0 = Sets interrupt on low level.

Bit X: IE0

Interrupt 0 edge flag, set by the hardware when interrupt on INTO pin occurred and cleared by the hardware when an interrupt is processed.

Bit 0: ITO

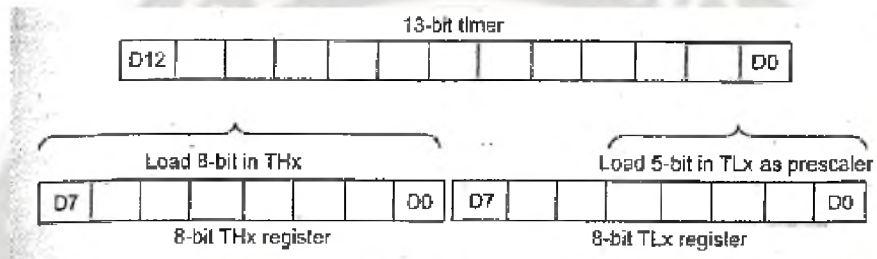
This bit selects the external interrupt event type on the INTO pin.

1 = Sets interrupt on falling edge.

0 = Sets interrupt on low level.

Mode 0:13-bit Timer Mode

Mode 0 which is a 13-bit timer mode for which 8-bit of THx and 5-bit of TLx are used. It is mostly used for interfacing possible with old MCS-48 family microcontrollers.



Higher 3-bits of TLx should be written as zero while using a timer mode 0, or it will affect the result. The 13-bit counter can hold the values between 0000 to 1FFFH in TH-TL. Therefore, when the timer reaches its maximum of 1FFFH, it rolls over to 0000, and TF is raised.

Mode 1 Programming

Mode 1 (16-bit timer mode)

Mode 1 is a 16-bit timer mode which is used to generate a delay and it uses 8-bit of THx and 8-bit of TLx to form a total 16-bit register.

Operations (or) Characteristics:

The following are the characteristics and operation of mode 1:

- It is a 16-bit timer which allows value of 0000 to FFFFH to be loaded into the timer's register TL and TH.
- After TH and TL are loaded with a 16-bit initial value, the timer must start. This is done by "SETB TRO" for Timer '0' and "SETB TRI" for Timer '1'.
- After the timer is started, it starts to count up until it reaches its limit 0 FFFFH. When it rolls over from FFFFH to 0000, it sets TF (timer flag) to HIGH.

- Each timer has its own timer flag: TF0 for Timer 0, and TF1 for Timer timer flag can be monitored. When this timer flag is raised, then we can stop the timer with the instructions “ CLR TRO ” or “ CLR TRI” for timer 0 ant; timer 1, respectively.
- After the timer reaches its limit and rolls over, then to repeat the process th' TH and TL must be reloaded with the original value, and TF must h: reloaded with 0.

Mode 2 Programming

- Operations (or) Characteristics:
- The following are the characteristics and operations of mode 2:
- After the timer is started, it starts to count up until it reaches its limit 0 FFFFH. When it rolls over from FFFFH to 0000, it sets TF (timer flag) fa, HIGH.
- Each timer has its own timer flag: TF0 for Timer 0, and TF1 for Timer Thi/r timer flag can be monitored. When this timer flag is raised, then we can stop the timer with the instructions “ CLR TRO ” or “ CLR TRI” for timer 0 ant; timer 1, respectively.
- After the timer reaches its limit and rolls over, then to repeat the process th' TH and TL must be reloaded with the original value, and TF must h: reloaded with 0.
- (iv)When the TL register rolls from FFH to 0 and TF is set to 1, then TL is reloaded automatically with the original value that is hold by the TH register. To repeat the process, we must simply clear TF and without any need by the programmer to reload the original value. This makes mode 2 an auto-reload, in contrast with mode 1 in which the programmer has to reload TH and TL.

COUNTER PROGRAMMING

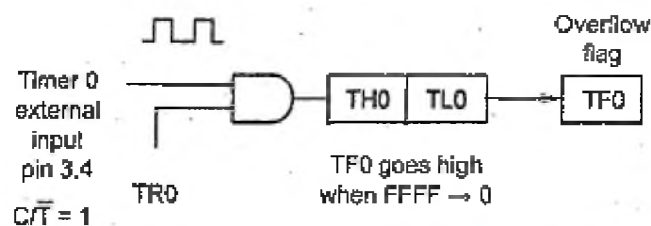
Timers can also be used as counters counting events happening: outside the If 8051. When it is used as a counter, it is a pulse outside the 8051 that incremei;;s the TH, TL registers.

A TMOD and TH, TL registers are the same as for the timer.

C/T bit in TMOD Register

- A The C/T bit in the TMOD registers decides the source of the clock for the time
- If C/T = 0, the timer gets pulses from the crystal.
- If C/T = 1, the timer is used as a counter and gets its pulses from outside the 8051.
- A The counter counts up as pulses are fed from pins 14 and 15 and these, pins are called TO (timer 0 input) and T1 (timer 1 input).
- Port 3 pins are used for Timers 0 and 1. In case of Timer 0, when C/T = 1, pin P3.4 provides the clock pulse and the counter counts up for each clock pulse coming from that pin.
- Similarly, for Timer 1, when C/T = 1 each clock pulse coming in from pin P3.5 that makes the counter count up.

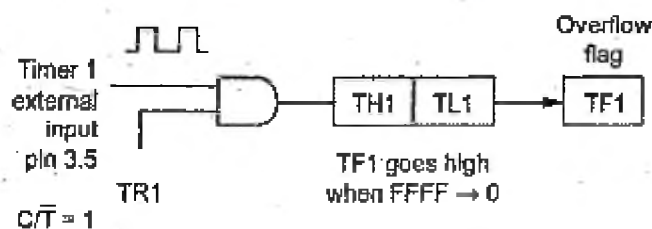
(1) Counter 0 in Mode 1:



To operate counter 0 in mode 1 we have to perform the following steps in TMOD register:

- C/ T = 1, to allow counter mode operation.
- M1 :M0 bits are set to 01 to select mode 1.
- When GATE = 0 and TR0 is set to 1 to start the counter.
- When GATE = 1, counter will run only if TR0 is set to 1 and the logic signal on external interrupt pin INTO is high.

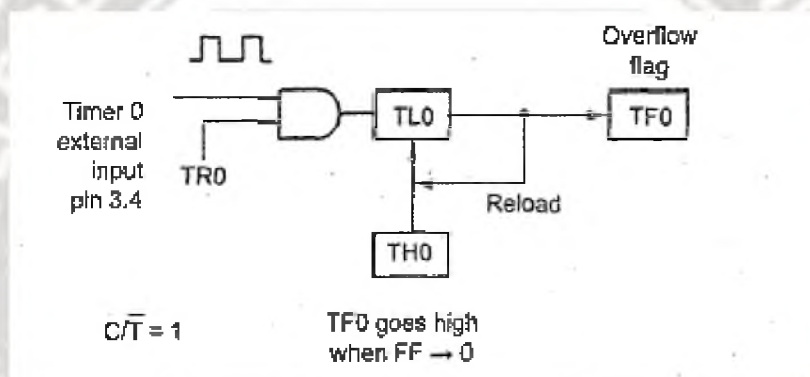
(2) Counter 1 in Mode 1:



To operate counter 1 in mode 1 we have to perform the following steps in TMOD register:

- (i) C/T = 1, to allow the counter mode operation.
- (ii) M1 :M0 bits are set to 10 to select mode 1.
- (iii) When GATE = 0 and TRI is set to 1 in order to start the counter.
- (iv) When GATE = 1, counter will run only if TRI is set to 1 and the logic signal ' ' on external interrupt pin INTI is set to high.

(3) Counter 0 in Mode 2:



To operate counter 0 in mode 2 we have to perform the following steps in TMOD register:

- (i) C/T = 1, to allow the counter mode operation.
- (ii) MEMO bits are set to 10 to select mode 2.
- (iii) When GATE = 0 and TRO is set to 1 in order to start the counter.
- (iv) When GATE = 1, counter will run only if TRO is set to 1 and the logic signal ' ' on external interrupt pin INTO is set to high.

(4) Counter 1 in Mode 2:

To operate counter 1 in mode 2 we have to perform the following steps in TMOD register:

- (i) C/T = 1, to allow counter mode operation.
- (ii) MEMO bits are set to 10 to select mode 2.
- (iii) When GATE = 0 and TRI is set to 1 in order to start the counter

