

XMUT202 Digital Electronics

Tutorial 6: Timer and Counter

A. Timer and Counter in 8051

1. What are the timers in 8051 microcontrollers? Describe them briefly. [2 marks]
2. Describe the four modes of Timer 0 and 1 in 8051 microcontrollers. [4 marks]
3. List and explain the characteristics of Timers 0 and 1 in 8051 when operated in modes 0 and 1 by completing the blank spaces provided in the table below. [8 marks]

	Mode 0 (13-bit Timer):	Mode 1 (16-bit Timer)
Timer 0	• _____ • _____ • _____ • _____	• _____ • _____ • _____ • _____
Timer 1	• _____ • _____ • _____ • _____	• _____ • _____ • _____ • _____

4. Using a flow chart diagram, explain the steps for configuring and running a timer programmed in 8051 microcontrollers. [6 marks]
5. Describe the function of watchdog timer in 8051 microcontrollers. What is its main use? [2 marks]

B. Timer and Counter Programming

1. The following shows crystal frequency for three different 8051-based microcontroller systems. Find the period of the machine cycle in each case. [6 marks]
 - a. 11.0592 MHz
 - b. 16 MHz
 - c. 20 MHz

2. For an 8051-microcontroller system of 11.0592 MHz, find how long it takes to execute each of the following instructions. [14 marks]

- a. MOV R3, #55
- b. DEC R3
- c. DJNZ R2, target
- d. LJMP
- e. SJMP
- f. NOP
- g. MUL AB

3. Find the delay introduced in the DELAY subroutine in the following program if the crystal frequency is 11.0592 MHz. [5 marks]

Program:

```
                MOV A, #55H           ;load register A with 0x55H
AGAIN:          MOV P1, A             ;issue value in register A to Port 1
                ACALL DELAY           ;jump to time delay subroutine
                CPL A                 ;complement register A
                SJMP AGAIN            ;keep doing this indefinitely
                ;time delay subroutine
DELAY:          MOV R3, #200H         ;load R3 with 200
HERE:           DJNZ R3, HERE         ;stay here until R3 becomes 0
                RET                  ;return to main program
```

4. Describe the following assembly language program for the 8051 microcontrollers that set Timer 0 to work in Mode 1 and count from 0FF00H. Hint: use the structure of the program provided to guide you writing each of the code descriptions. [7 marks]

Program:

```
                ; Set timer mode
                MOV TMOD, #01H
                ; Load initial value for the counter
                MOV TH0, #0FFH
                MOV TL0, #00H

                ; Start timer
                SETB TR0
```

```

; Wait for timer to overflow
OVERFLOW:  JNB TF0, OVERFLOW
; When timer overflows, stop it
CLR TR0
CLR TF0

```

5. With careful set up and configuration, the timers in the 8051 microcontrollers are capable for producing precise timing for execution of a program. You are required to design an assembly language program that will turn on and off an LED connected to Port P1.1 every 1 s.
 - a. Assume the crystal oscillator frequency is 11.0592 MHz, calculate the time taken to execute 1 machine cycle. [4 marks]
 - b. Determine the value to be loaded into the timer counter special function register, so it will produce a delay of 1 ms. [4 marks]
 - c. Write an assembly-language program to generate a square wave on port P1.1 with an ON time (high time) of 1 ms. Use Timer 1 and configure it as Mode 1. [12 marks]

Appendix: Timer, Counter, and Interrupt Instruction Sets

TMOD (Timer Mode):

TMOD.7	TMOD.6	TMOD.5	TMOD.4	TMOD.3	TMOD.2	TMOD.1	TMOD.0
GATE	C/T	M1	M0	GATE	C/T	M1	M0

Descriptions:

GATE:

- 1: Timer only counts when TR1 bit is high and there is an external interrupt at INT0.

C/T: Counter or Timer.

- 0: Timer 1 serves as XTAL-driven delay generator (timer).
- 1: Timer 1 counts external events.

M1: Timer 1 Mode bit 1.

M0: Timer 1 Mode bit 0.

GATE:

- 1: Timer only counts when TR0 bit is high and there is an external interrupt at INT1.

C/T: Counter or Timer.

- 0: Timer 0 serves as XTAL-driven delay generator (timer)
- 1: Timer 0 counts external events.

M1: Timer 0 Mode bit 1.

M0: Timer 0 Mode bit 0.

Timer mode configurations:

Timer Mode	M1	M0
0	0	0
1	0	1
2	1	0
3	1	1

TCON (Timer Control):

TCON.7	TCON.6	TCON.5	TCON.4	TCON.3	TCON.2	TCON.1	TCON.0
TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0

Descriptions:

TF1: Timer 1 Overflow Flag

- 1: when overflow occurs. Must be cleared in software; auto. cleared when leaving ISR

TR1: Timer 1 run bit (software controlled).

- 1: Start timer.
- 0: Stop timer.

TF0: Timer 0 Overflow Flag

- 1: When overflow occurs.
- 0: Must be cleared in software; auto. cleared when leaving ISR.

TR0: Timer 0 run bit (software controlled).

- 1: Start timer.
- 0: Stop timer.

IE1: External interrupt 1 edge flag.

- 1: External interrupt occurred.
- 0: External interrupt processed (hardware controlled; no need to edit this).

IT1: Interrupt 1 trigger type select bit.

- 1: Interrupt occurs on the falling edge of INT1.
- 0: Interrupt occurs on INT1's level being LOW.

IE0: External interrupt 0 edge flag.

- 1: External interrupt occurred.
- 0: External interrupt processed (hardware controlled; no need to edit this).

IT0: Interrupt 0 trigger type select bit.

- 1: Interrupt occurs on the falling edge of INT1.
- 0: Interrupt occurs on INT1's level being LOW.

IEN (Interrupt Enable):

IEN0.7	IEN0.6	IEN0.5	IEN0.4	IEN0.3	IEN0.2	IEN0.1	IEN0.0
EA	EC PCA	ET2	ES	ET1	EX1	ET0	EX0

Descriptions:

EA: Enable all interrupts.

- 1: interrupts may be enabled individually.
- 0: All interrupts are disabled.

EC PCA: Interrupt enable.

- 1: PCA interrupt is enabled. A C8051F020 specific interrupt.

ET2: Timer 2 overflow interrupt enable.

- 1: Timer 2 interrupt is enabled.

ES: Serial port interrupt enable bit.

- 1: Serial port interrupt is enabled.

ET1: Timer 1 overflow interrupt enable.

- 1: Timer 1 interrupt is enabled.

EX1: External interrupt 1 enable bit.

- 1: External Interrupt 1 is enabled.

ET0: Timer 0 overflow interrupt enable.

- 1: Timer 0 interrupt is enabled.

EX0: External interrupt 0 enable bit.

- 1: External Interrupt 0 is enabled.