Timers (Part-2)

Lecture 5

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Outline for today

- Review of how delays are created using Timers
- How to use ‘Auto Reload’ mode of Timers
- How to use timers in counter mode

PIN DESCRIPTION

Port 3

- Port 3 can be used as input or output
  - Port 3 does not need any pull-up resistors
- Port 3 has the additional function of providing some extremely important signals

P3 Bit	Function	Pin
P3.0	RxD	10
P3.1	TxD	11
P3.2	$\overline{\text{INT0}}$	12
P3.3	$\overline{\text{INT1}}$	13
P3.4	T0	14
P3.5	T1	15
P3.6	$\overline{\text{WR}}$	16
P3.7	$\overline{\text{RD}}$	17

Serial communications

External interrupts

Timers

Read/Write signals of external memories

PROGRAMMING TIMERS

TMOD Register

- Both timers 0 and 1 use the same register, called TMOD (timer mode), to set the various timer operation modes
- TMOD is a 8-bit register
  - The lower 4 bits are for Timer 0
  - The upper 4 bits are for Timer 1
  - In each case,
    - The lower 2 bits are used to set the timer mode
    - The upper 2 bits to specify the operation

PROGRAMMING TIMERS

TMOD Register (cont')

Gating control when set.
Timer/counter is enable only while the INTx pin is high and the TRx control pin is set
When cleared, the timer is enabled whenever the TRx control bit is set

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 TLx each time it overfolws
1	1	3	**Split timer mode**

Timer or counter selected
Cleared for timer operation (input from internal system clock)
Set for counter operation (input from Tx input pin)

COUNTER PROGRAMMING

- Timers can also be used as counters counting events happening outside the 8051
  - When it is used as a counter, it is a pulse outside of the 8051 that increments the TH, TL registers
  - TMOD and TH, TL registers are the same as for the timer discussed previously
- Programming the timer in the last section also applies to programming it as a counter
  - Except the source of the frequency

- Example:
- Assume that fclk = 12 MHz. What value do we need to load the timer’s register if we want to have a time delay of 5 ms (milliseconds)? Show the program for timer 0 to create a pulse width of 5 ms.
- Fclk = 12 MHz,
  - Ftimer = (1/12)*fclk = 1MHz
  - Tp (Timer period of a timer)= 1usec
  - 5msec= 5000 usec=> 5000 cycles of timer clock

- Example 9-10:
- Assume that fclk = 12 MHz. What value do we need to load the timer's register if we want to have a time delay of 5 ms (milliseconds)? Show the program for timer 0 to create a pulse width of 5 ms.

- Sol:

Timer frequency F_{timer} = (1/12) * fclk = 1 MHz

Cycle time of a Timer = $1/F_{timer}$ = 1 usec

5msec = 5000 usec = 5000 cycles

Max = 0xFFFF (Mode1 or 16bit mode)

Difference = $0xFFFF_{hex} - 5000_{decimal} = EC77_{hex}$

TH0 = 0xEC, TL0= 0x77

Auto-Reload Mode (Mode-2)

PROGRAMMING TIMERS

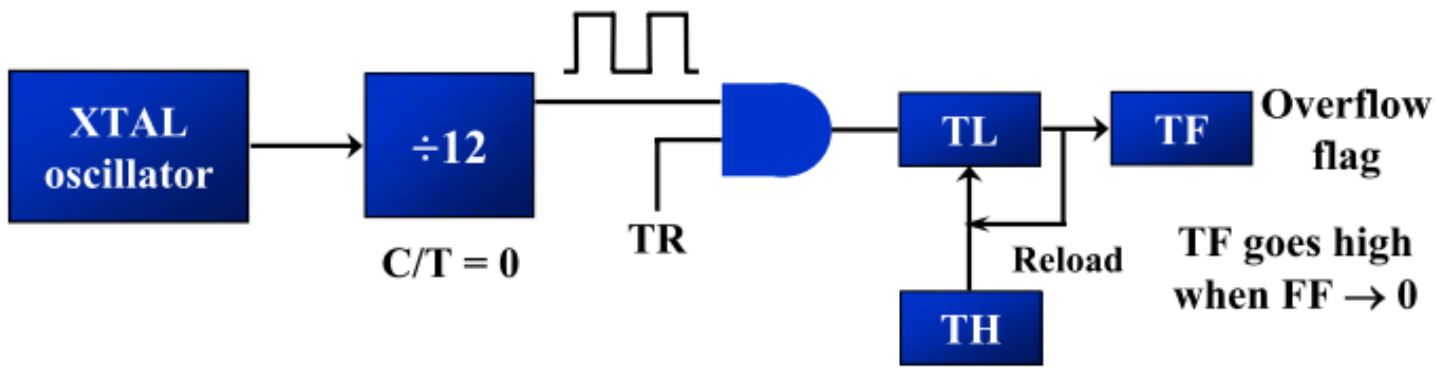
Mode 2 Programming

- The following are the characteristics and operations of mode 2:
  1. It is an 8-bit timer; therefore, it allows only values of 00 to FFH to be loaded into the timer's register TH
  2. After TH is loaded with the 8-bit value, the 8051 gives a copy of it to TL
     - Then the timer must be started
     - This is done by the instruction `SETB TR0` for timer 0 and `SETB TR1` for timer 1
  3. After the timer is started, it starts to count up by incrementing the TL register
     - It counts up until it reaches its limit of FFH
     - When it rolls over from FFH to 00, it sets high the TF (timer flag)

PROGRAMMING TIMERS

Mode 2 Programming (cont')

4. When the TL register rolls from FFH to 0 and TF is set to 1, TL is reloaded automatically with the original value kept by the TH register
   - To repeat the process, we must simply clear TF and let it go 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



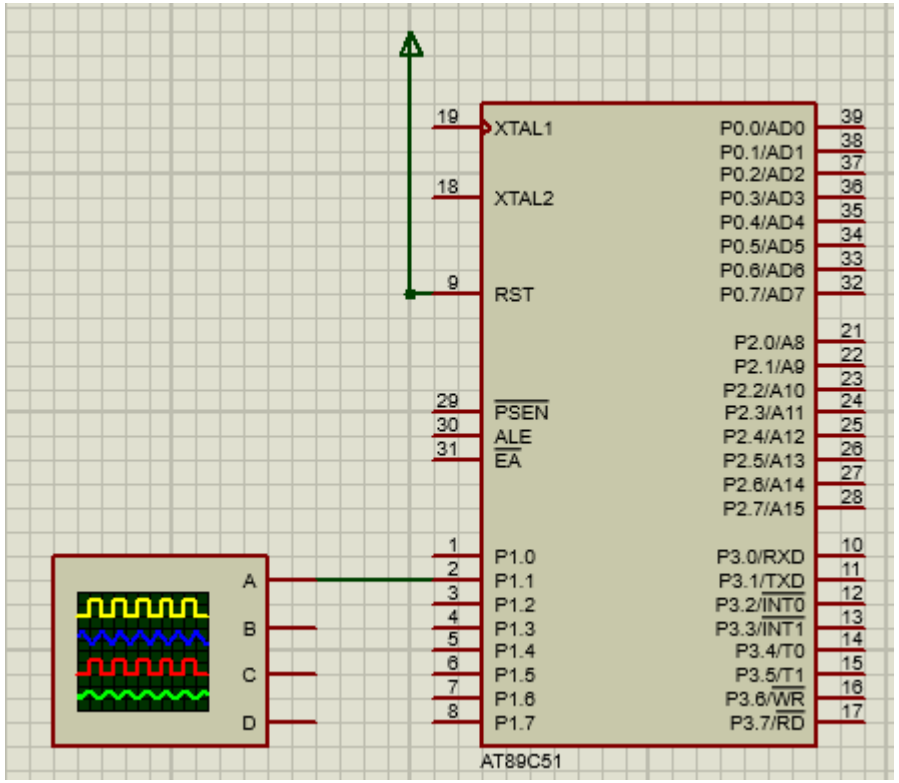
PROGRAMMING TIMERS

Mode 2 Programming

Steps to Mode 2 Program

- To generate a time delay
  1. Load the TMOD value register indicating which timer (timer 0 or timer 1) is to be used, and the timer mode (mode 2) is selected
  2. Load the TH registers with the initial count value
  3. Start timer
  4. Keep monitoring the timer flag (TF) with the `JNB TFx,target` instruction to see whether it is raised
     - Get out of the loop when TF goes high
  5. Clear the TF flag
  6. Go back to Step4, since mode 2 is auto-reload

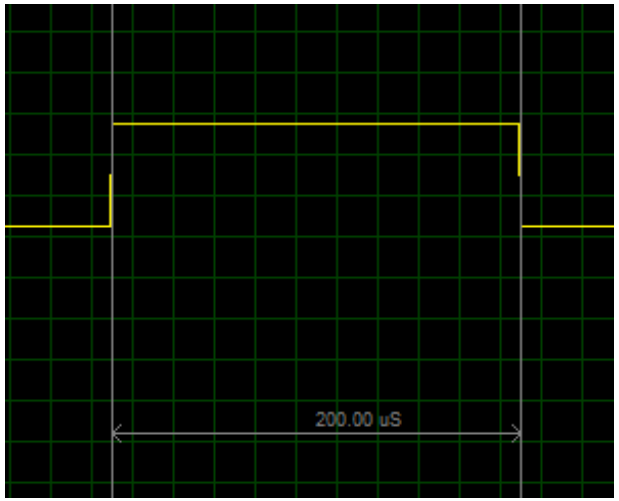
Mode-2 of Timer Auto-Reload Mode




```
#include <stdio.h>
sbit pin = P1^1;
void start_timer(void)
{
    TR0 = 1;
}
void timer0_ISR(void) interrupt 1
{
     pin^=1;
}

void init_timer(void)
{
    TMOD = 0x02; // 8-bit Auto Reload mode, Timer0
    TH0 = 0x38;  // Always load 55d in TL0.
    IE = 0x82;
}

void main(void)
 {
     init_timer();
     start_timer();
     while (1)
    {}      //Do nothing
 }
```



Counter Mode

COUNTER PROGRAMMING

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  - When it is used as a counter, it is a pulse outside of the 8051 that increments the TH, TL registers
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COUNTER PROGRAMMING

C/T Bit in TMOD Register

- The C/T bit in the TMOD registers decides the source of the clock for the timer
  - When C/T = 1, the timer is used as a counter and gets its pulses from outside the 8051
    - The counter counts up as pulses are fed from pins 14 and 15, these pins are called T0 (timer 0 input) and T1 (timer 1 input)

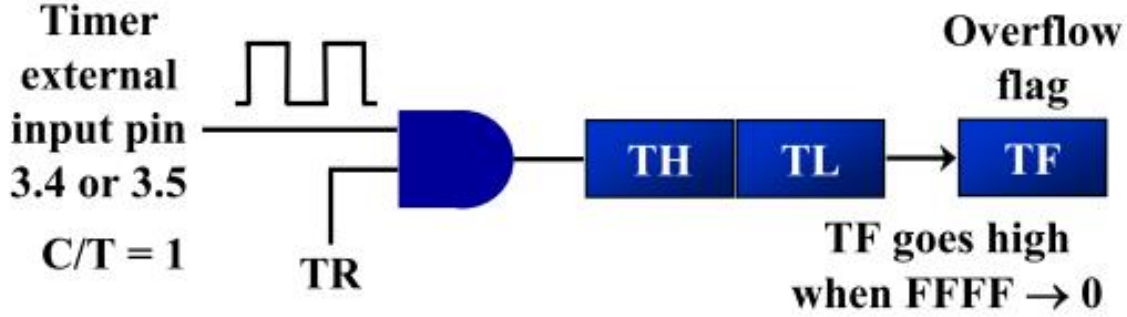
Port 3 pins used for Timers 0 and 1

Pin	Port Pin	Function	Description
14	P3.4	T0	Timer/counter 0 external input
15	P3.5	T1	Timer/counter 1 external input

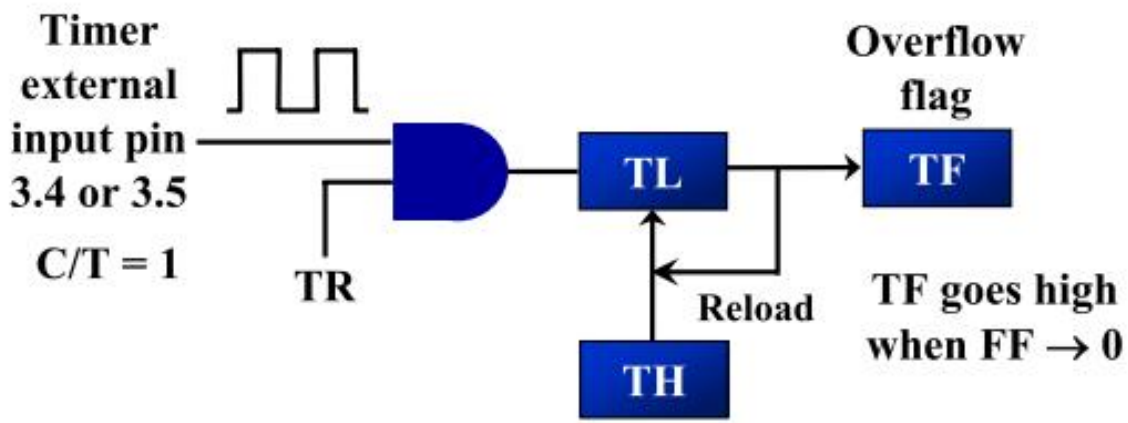
COUNTER PROGRAMMING

C/T Bit in TMOD Register (cont')

Timer with external input (Mode 1)



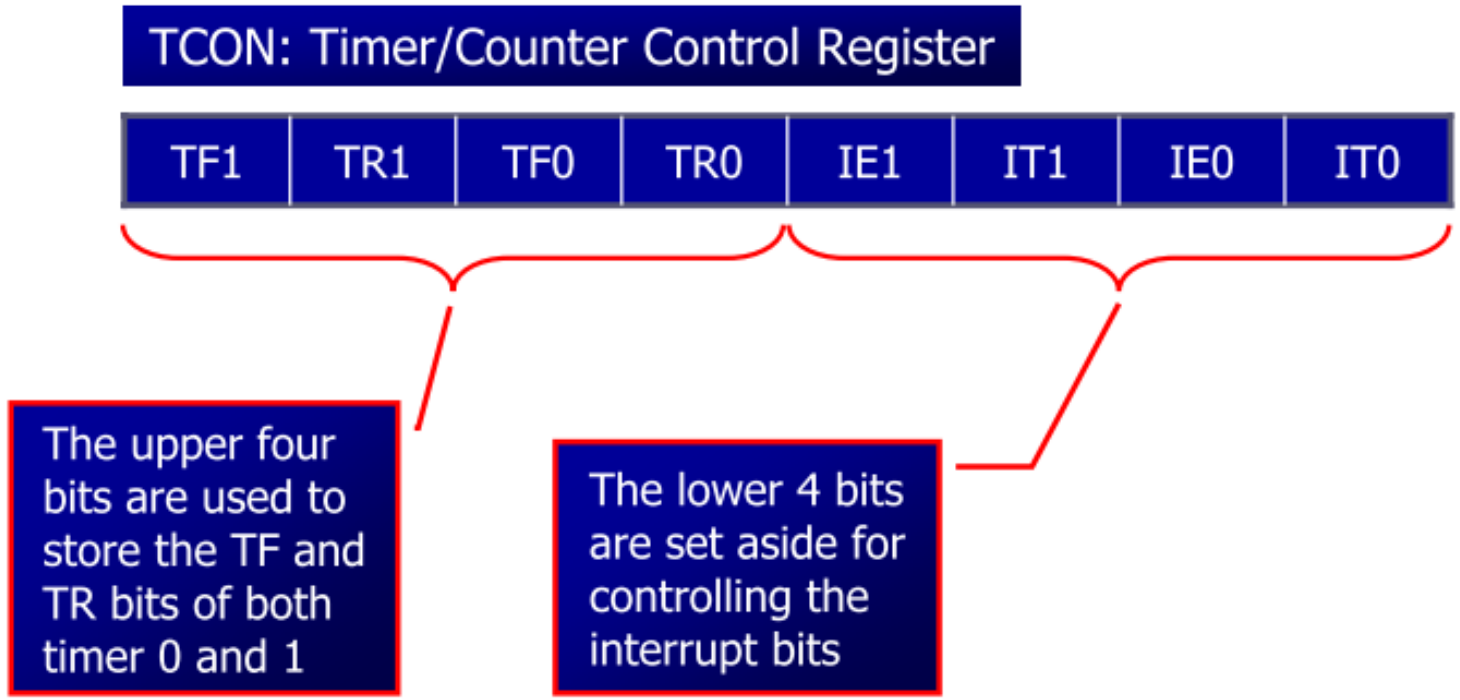
Timer with external input (Mode 2)



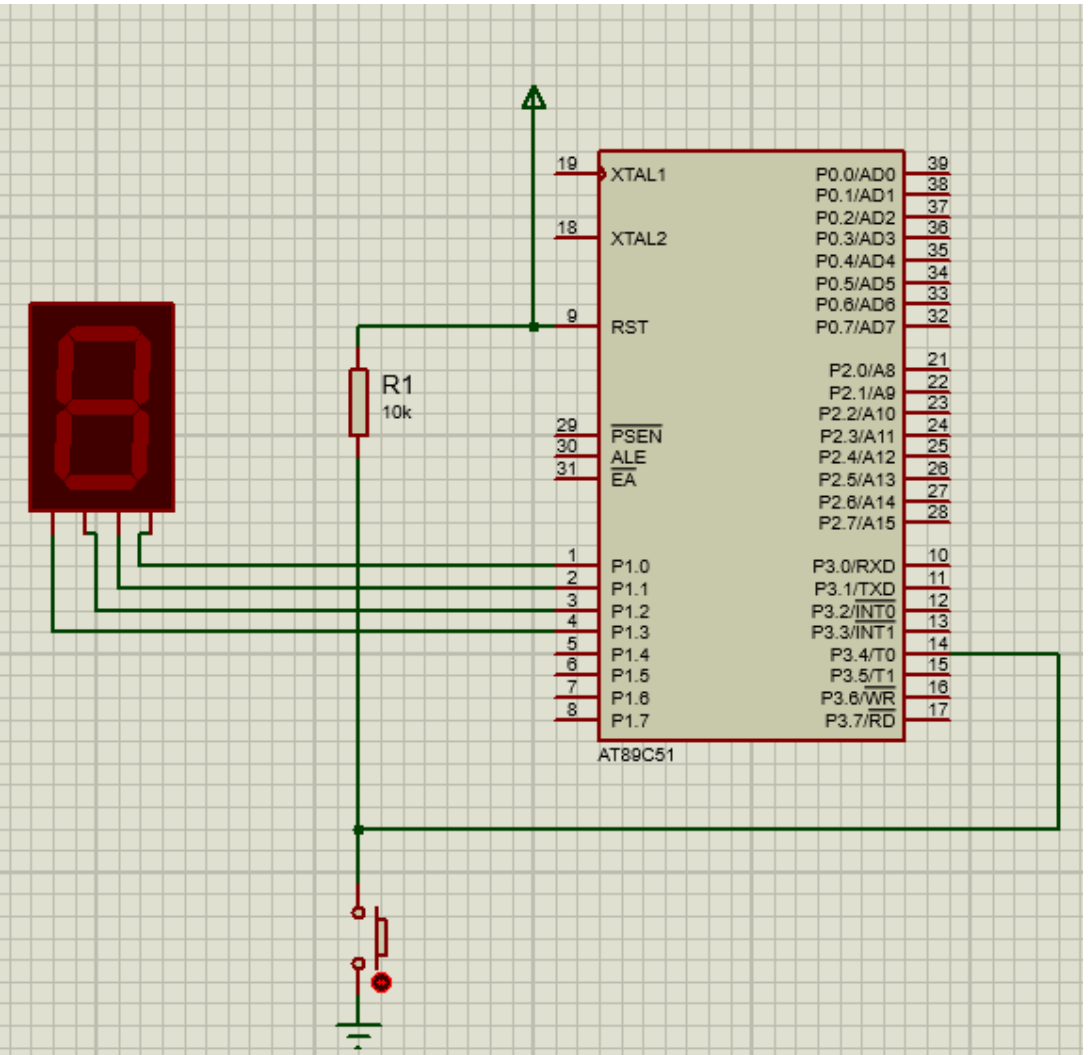
COUNTER PROGRAMMING

TCON Register

- TCON (timer control) register is an 8-bit register



Using Timer for counting




```c
#include <reg51.h>
#include <stdio.h>
sbit input_pin = P3^4;

void start_timer(void)
{
    TR0 = 1;
}

void init_timer(void)
{
    TMOD = 0x06; // Timer0 as counter (8-bit auto-reload mode)
    TH0 = 0;
    input_pin = 1; // Make P3.4 as input
}

void main(void)
 {
     init_timer();
     start_timer();
     while (1)
    {
       P1 = TL0;
    }
 }
```