Micro-Processor Based System Design

The 8051 Microcontroller

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Slides are adapted from Chung-Ping Young lectures

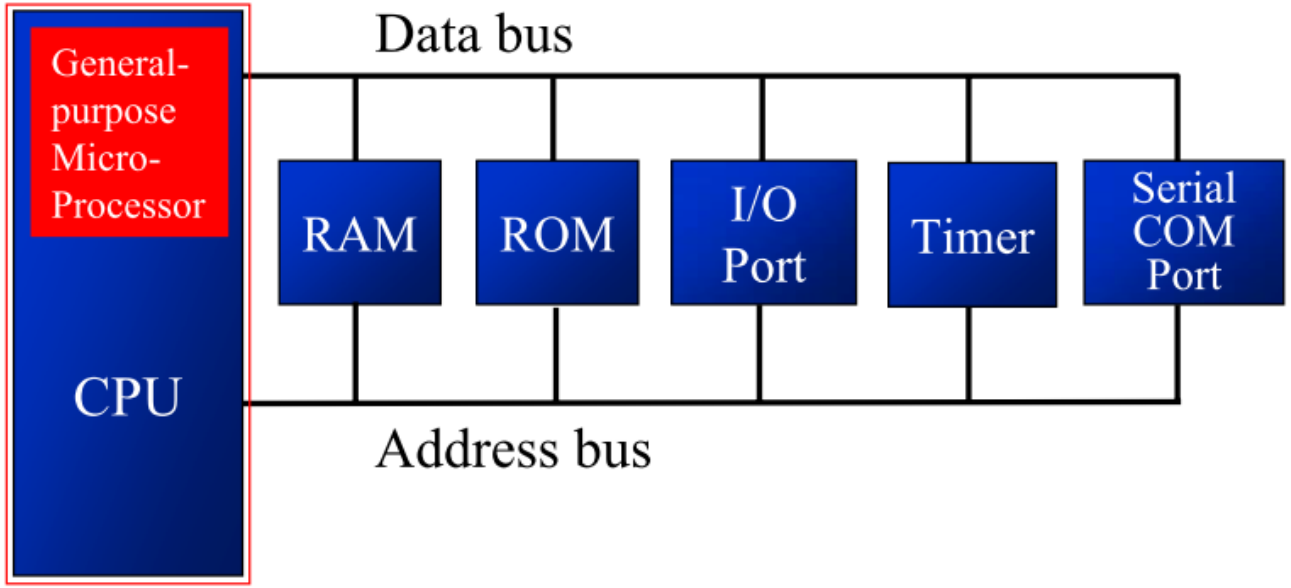
MICRO-CONTROLLERS AND EMBEDDED PROCESSORS

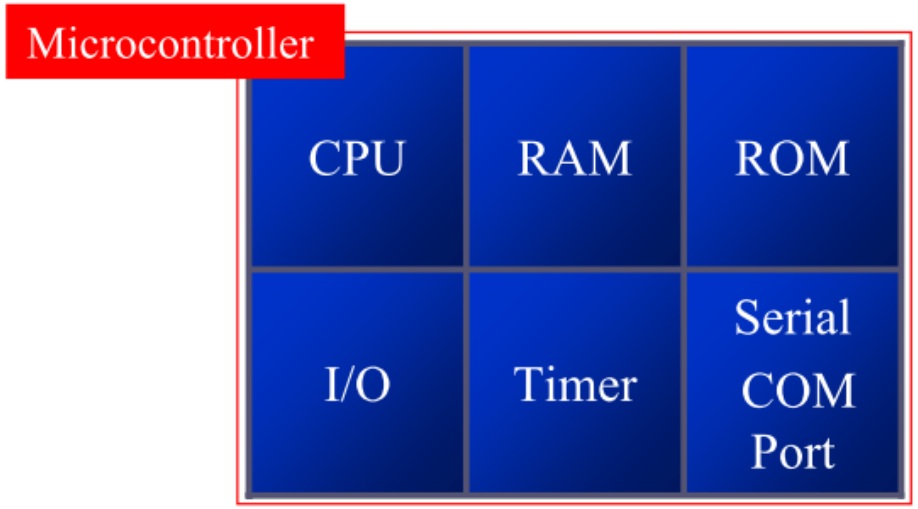
Microcontroller vs. General-Purpose Microprocessor

- General-purpose microprocessors contains
  - No RAM
  - No ROM
  - No I/O ports
- Microcontroller has
  - CPU (microprocessor)
  - RAM
  - ROM
  - I/O ports
  - Timer
  - ADC and other peripherals

MICRO-CONTROLLERS AND EMBEDDED PROCESSORS

Microcontroller vs. General-Purpose Microprocessor (cont')





MICRO-CONTROLLERS AND EMBEDDED PROCESSORS

Microcontroller vs. General-Purpose Microprocessor (cont')

- General-purpose microprocessors
  - Must add RAM, ROM, I/O ports, and timers externally to make them functional
  - Make the system bulkier and much more expensive
  - Have the advantage of versatility on the amount of RAM, ROM, and I/O ports
- Microcontroller
  - The fixed amount of on-chip ROM, RAM, and number of I/O ports makes them ideal for many applications in which cost and space are critical
  - In many applications, the space it takes, the power it consumes, and the price per unit are much more critical considerations than the computing power

taking much space, large

MICRO-CONTROLLERS AND EMBEDDED PROCESSORS

Microcontrollers for Embedded Systems

- An embedded product uses a microprocessor (or microcontroller) to do one task and one task only
  - There is only one application software that is typically burned into ROM
- A PC, in contrast with the embedded system, can be used for any number of applications
  - It has RAM memory and an operating system that loads a variety of applications into RAM and lets the CPU run them
  - A PC contains or is connected to various embedded products
    - Each one peripheral has a microcontroller inside it that performs only one task

MICRO-CONTROLLERS AND EMBEDDED PROCESSORS

Choosing a Microcontroller

- 8-bit microcontrollers
  - Motorola's 6811
  - Intel's 8051
  - Zilog's Z8
  - Microchip's PIC
- There are also 16-bit and 32-bit microcontrollers made by various chip makers

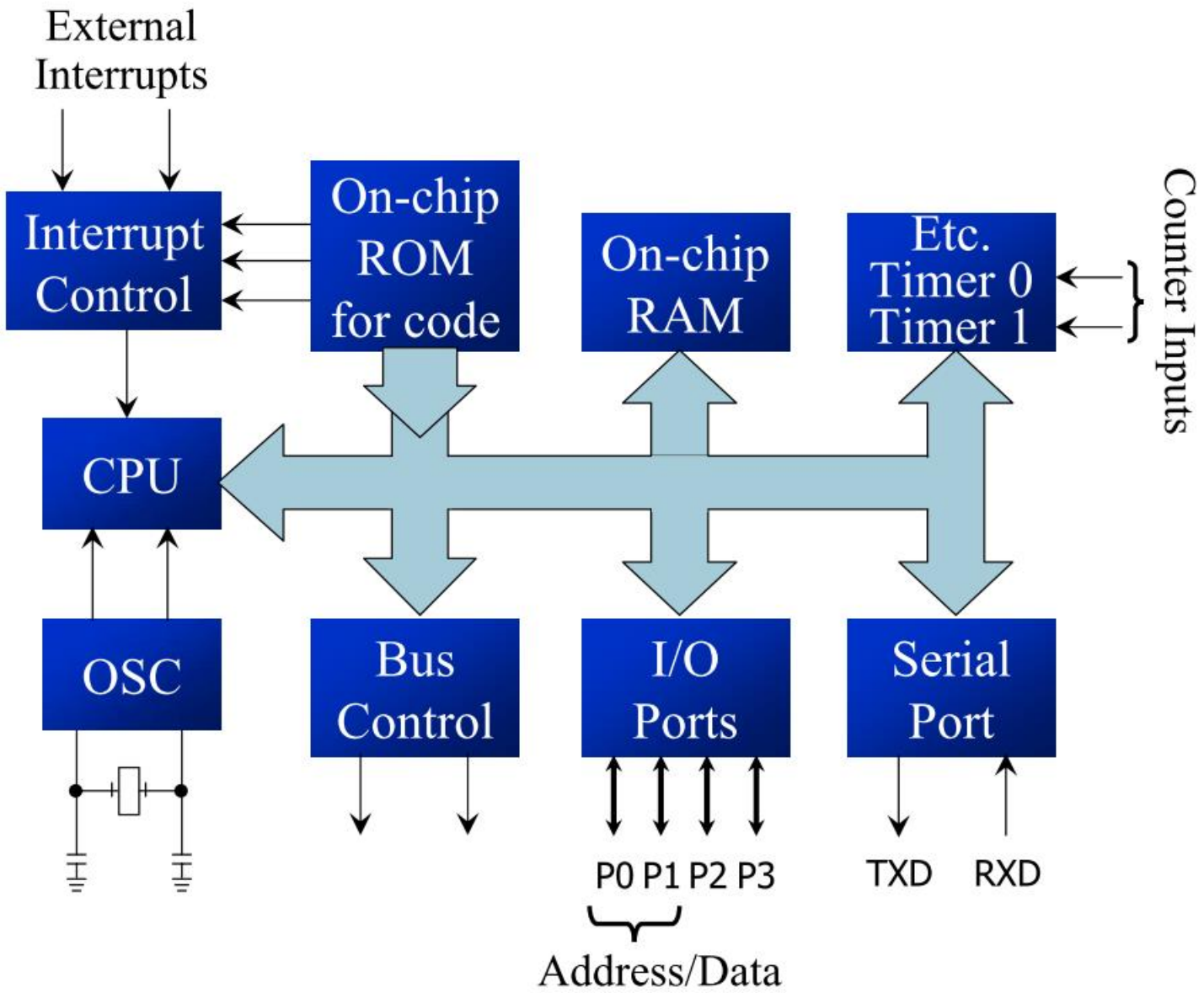
OVERVIEW OF 8051 FAMILY

8051 Microcontroller

- Intel introduced 8051, referred as MCS-51, in 1981
  - The 8051 is an 8-bit processor
    - The CPU can work on only 8 bits of data at a time
  - The 8051 had
    - 128 bytes of RAM
    - 4K bytes of on-chip ROM
    - Two timers
    - One serial port
    - Four I/O ports, each 8 bits wide
    - 6 interrupt sources
- The 8051 became widely popular after allowing other manufactures to make and market any flavor of the 8051, but remaining code-compatible

OVERVIEW OF 8051 FAMILY

8051 Microcontroller (cont')



OVERVIEW OF 8051 FAMILY

8051 Family

- The 8051 is a subset of the 8052
- The 8031 is a ROM-less 8051
  - Add external ROM to it
  - You lose two ports, and leave only 2 ports for I/O operations

Feature	8051	8052	8031
ROM (on-chip program space in bytes)	4K	8K	0K
RAM (bytes)	128	256	128
Timers	2	3	2
I/O pins	32	32	32
Serial port	1	1	1
Interrupt sources	6	8	6

8051 Assembly Language Programming

Bilal Habib

INSIDE THE 8051

Registers

- Register are used to store information temporarily, while the information could be
  - a byte of data to be processed, or
  - an address pointing to the data to be fetched
- The vast majority of 8051 register are 8-bit registers
  - There is only one data type, 8 bits

INSIDE THE 8051

Registers (cont')

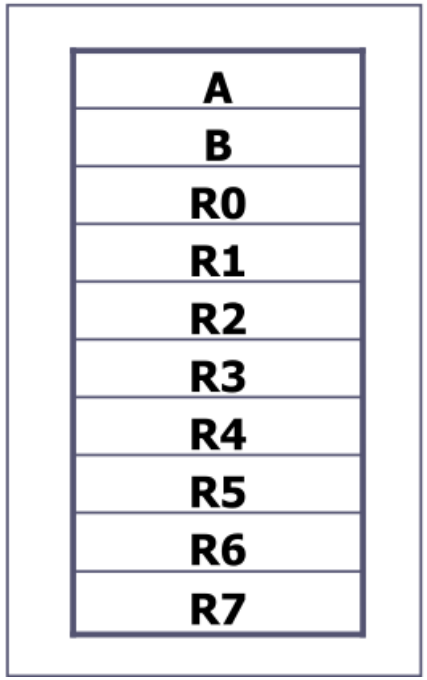
- The 8 bits of a register are shown from MSB D7 to the LSB D0
  - With an 8-bit data type, any data larger than 8 bits must be broken into 8-bit chunks before it is processed

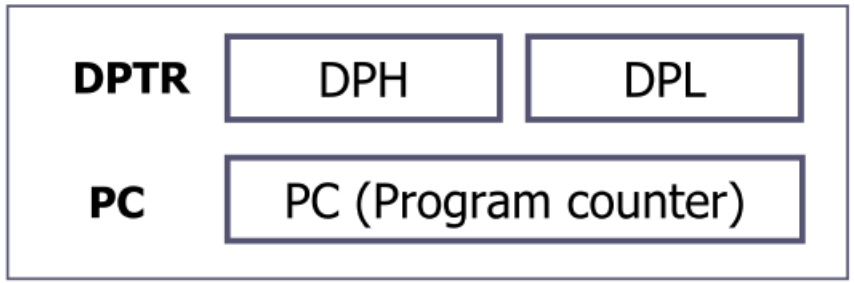
8 bit Registers

INSIDE THE 8051

Registers (cont')

- The most widely used registers
  - A (Accumulator)
    - For all arithmetic and logic instructions
  - B, R0, R1, R2, R3, R4, R5, R6, R7
  - DPTR (data pointer), and PC (program counter)





INSIDE THE 8051

MOV Instruction

MOV destination, source ;copy source to dest.

- The instruction tells the CPU to move (in reality, COPY) the source operand to the destination operand

"#" signifies that it is a value

```
MOV   A,#55H      ;load value 55H into reg. A
MOV   R0,A        ;copy contents of A into R0
                  ;(now A=R0=55H)
MOV   R1,A        ;copy contents of A into R1
                  ;(now A=R0=R1=55H)
MOV   R2,A        ;copy contents of A into R2
                  ;(now A=R0=R1=R2=55H)
MOV   R3,#95H     ;load value 95H into R3
                  ;(now R3=95H)
MOV   A,R3        ;copy contents of R3 into A
                  ;now A=R3=95H
```

8051 ASSEMBLY PROGRAMMING

Structure of Assembly Language

- In the early days of the computer, programmers coded in *machine language*, consisting of 0s and 1s
  - Tedious, slow and prone to error
- *Assembly languages*, which provided mnemonics for the machine code instructions, plus other features, were developed
  - An Assembly language program consist of a series of lines of Assembly language instructions
- Assembly language is referred to as a *low-level language*
  - It deals directly with the internal structure of the CPU

8051 ASSEMBLY PROGRAMMING

Structure of Assembly Language

- Assembly language instruction includes
  - a mnemonic (abbreviation easy to remember)
    - the commands to the CPU, telling it what those to do with those items
  - optionally followed by one or two operands
    - the data items being manipulated
- A given Assembly language program is a series of statements, or lines
  - Assembly language instructions
    - Tell the CPU what to do
  - Directives (or pseudo-instructions)
    - Give directions to the assembler

8051 ASSEMBLY PROGRAMMING

Structure of Assembly Language

- An Assembly language instruction consists of four fields:

```
[label:] Mnemonic [operands] [;comment]
```

```
   ORG   0H              ;start(origin) at location
   0
   MOV   R5, #25H        ;load 25H into R5
   MOV   R7, #34H        ;load 34H in
   MOV   A, #0           ;load 0 into
   ADD   A, R5           ;add content
                         ;now A = A +
   ADD   A, R7           ;add contents of R7 to A
                         ;now A = A + R7
   ADD   A, #12H         ;add to A value 12H
                         ;now A = A + 12H
HERE: SJMP HERE          ;stay in this loop
   END                   ;en
```

Mnemonics produce opcodes

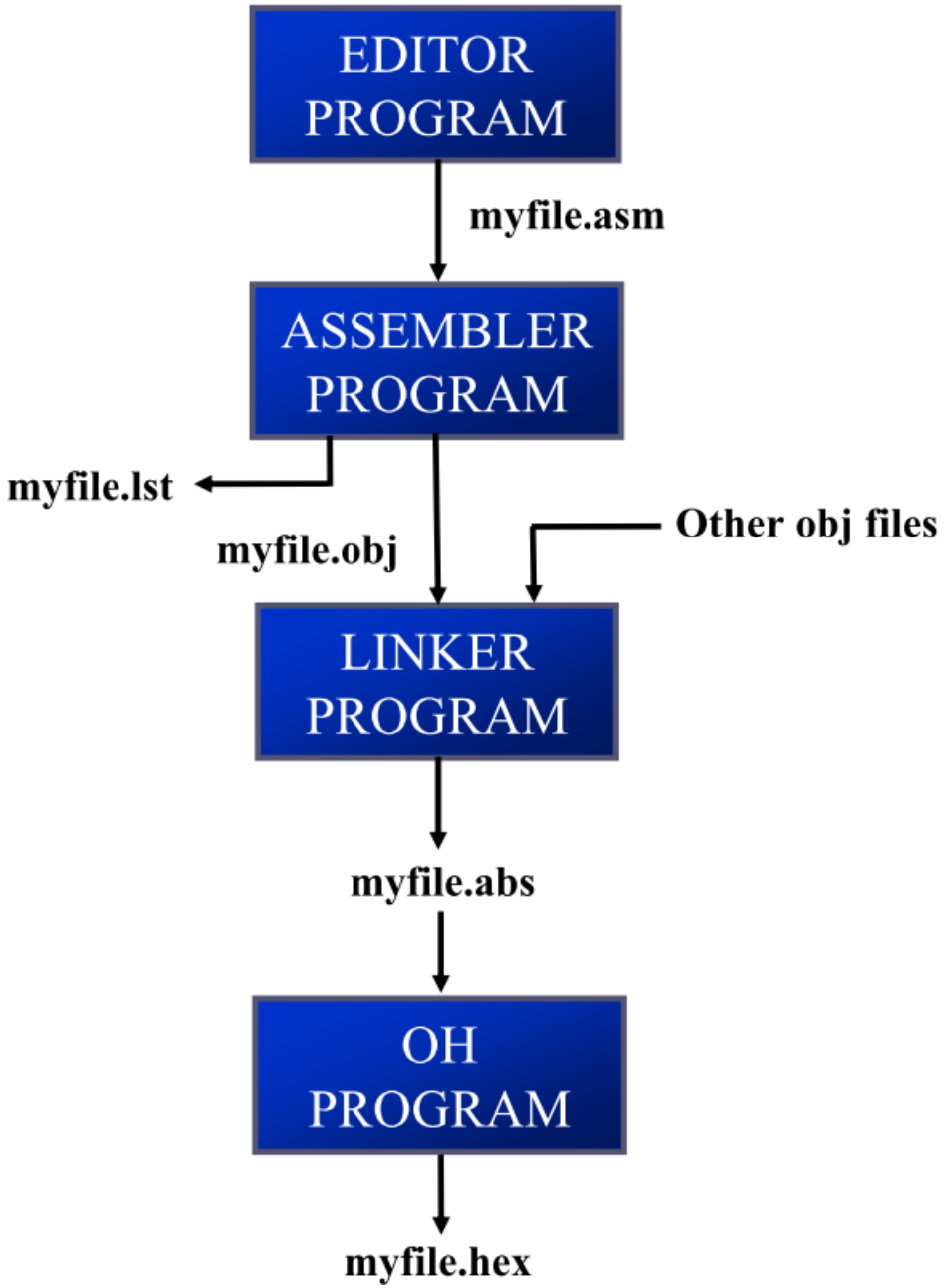
Directives do not generate any machine code and are used only by the assembler

The label field allows the program to refer to a line of code by name

Comments may be at the end of a line or on a line by themselves
The assembler ignores comments

ASSEMBLING AND RUNNING AN 8051 PROGRAM

Steps to Create a Program



PROGRAM COUNTER AND ROM SPACE

Power up

- All 8051 members start at memory address 0000 when they're powered up
  - Program Counter has the value of 0000
  - The first opcode is burned into ROM address 0000H, since this is where the 8051 looks for the first instruction when it is booted
  - We achieve this by the `ORG` statement in the source program

PROGRAM COUNTER AND ROM SPACE

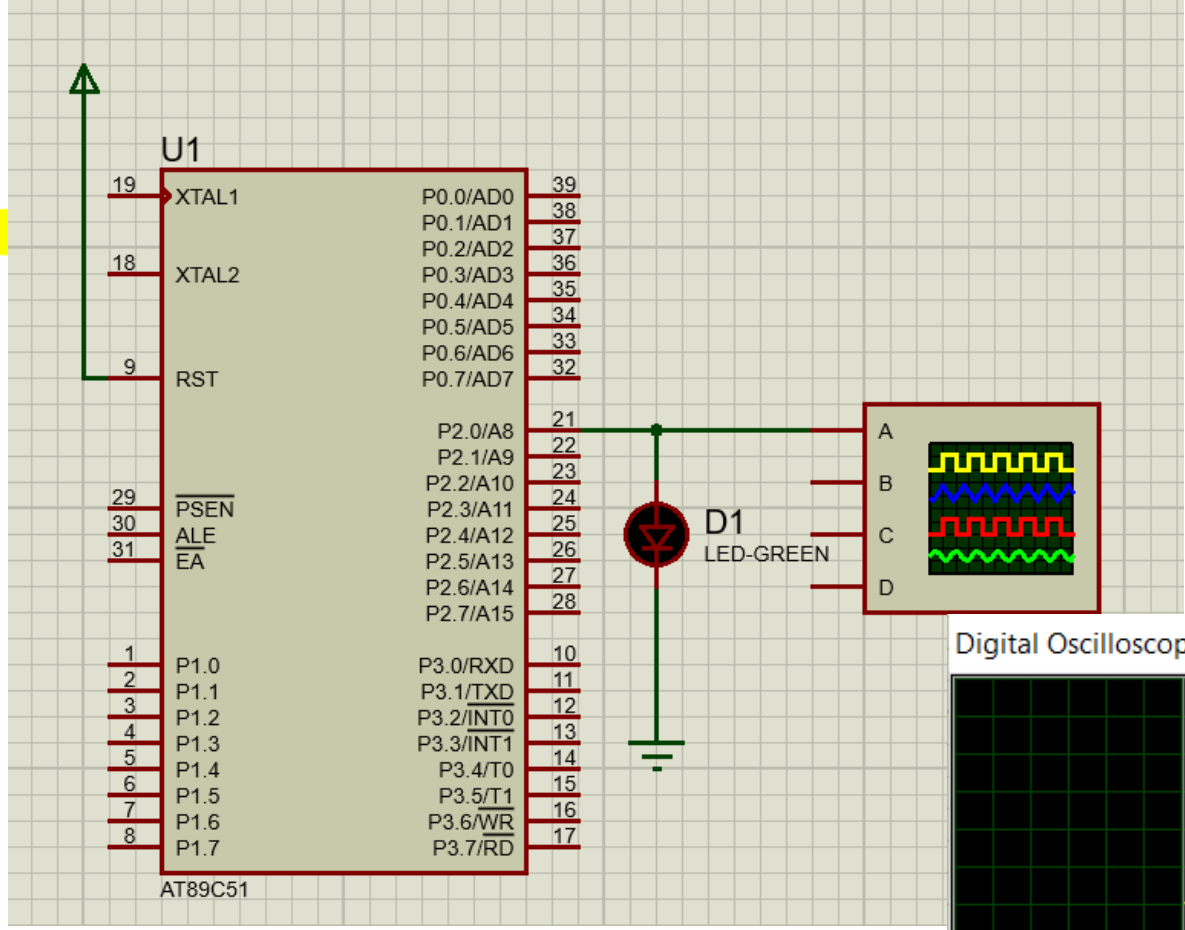
Placing Code in ROM

- Examine the list file and how the code is placed in ROM

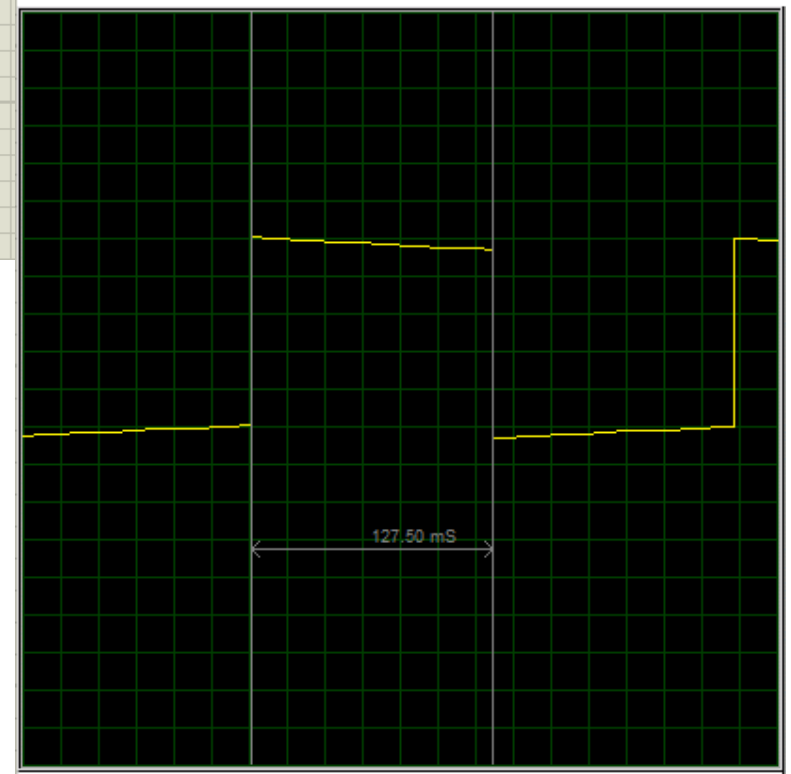
```
1 0000            ORG 0H             ;start (origin) at 0
2 0000  7D25      MOV R5,#25H        ;load 25H into R5
3 0002  7F34      MOV R7,#34H        ;load 34H into R7
4 0004  7400      MOV A,#0           ;load 0 into A
5 0006  2D        ADD A,R5           ;add contents of R5 to A
                                     ;now A = A + R5
6 0007  2F        ADD A,R7           ;add contents of R7 to A
                                     ;now A = A + R7
7 0008  2412      ADD A,#12H         ;add to A value 12H
                                     ;now A = A + 12H
8 000A  80EF      HERE: SJMP HERE    ;stay in this loop
9 000C            END                ;end of asm source file
```

ROM Address	Machine Language	Assembly Language
0000	7D25	MOV R5, #25H
0002	7F34	MOV R7, #34H
0004	7400	MOV A, #0
0006	2D	ADD A, R5
0007	2F	ADD A, R7
0008	2412	ADD A, #12H
000A	80EF	HERE: SJMP HERE

```
$NOMOD51
$INCLUDE (8051.MCU)

      ; Reset Vector
      org   0000h
      jmp   Start

      org   0100h
Start:
      ; Write your code here
    CLR P2.0
AGAIN :
    SETB P2.0
    ACALL DELAY
    CLR P2.0
    ACALL DELAY
    SJMP AGAIN


DELAY : MOV R0,#0FFH
GO : MOV R1,#0F9H
HERE : DJNZ R1,HERE
    DJNZ R0,GO
    RET

Loop:
      jmp Loop

      END
```



Digital Oscilloscope



To do:

- Read Chapter **0,1 and 2** from Mazidi book
- **Task1**: Complete it before the deadline