MICROCONTROLLER & EMBEDDED SYSTEMS

UNIT-1

1.3 MEMORY ORGANIZATION OF 8051

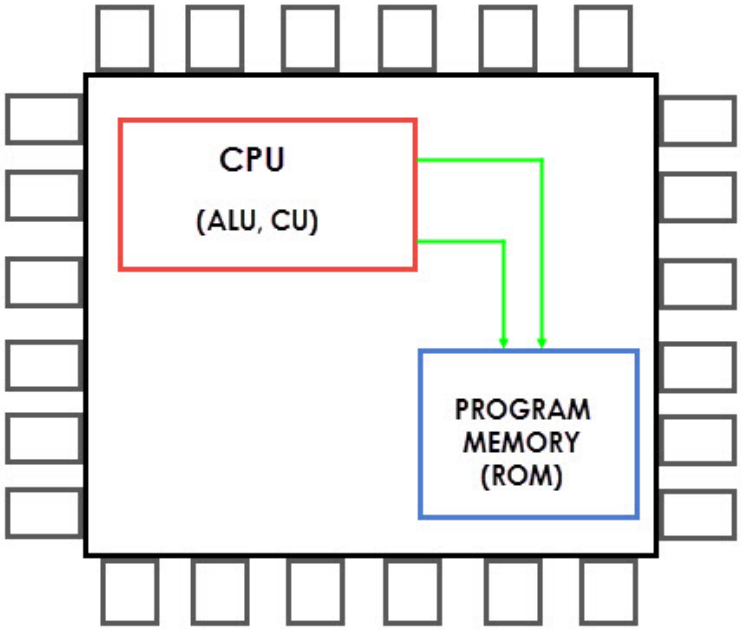
The 8051 Microcontroller Memory is divided into **Program Memory (ROM)** and **Data Memory (RAM).**

- The Program Memory of the 8051 Microcontroller is used for storing the program to be executed i.e. instructions.
- The Data Memory on the other hand, is used for storing temporary variable data and intermediate results.

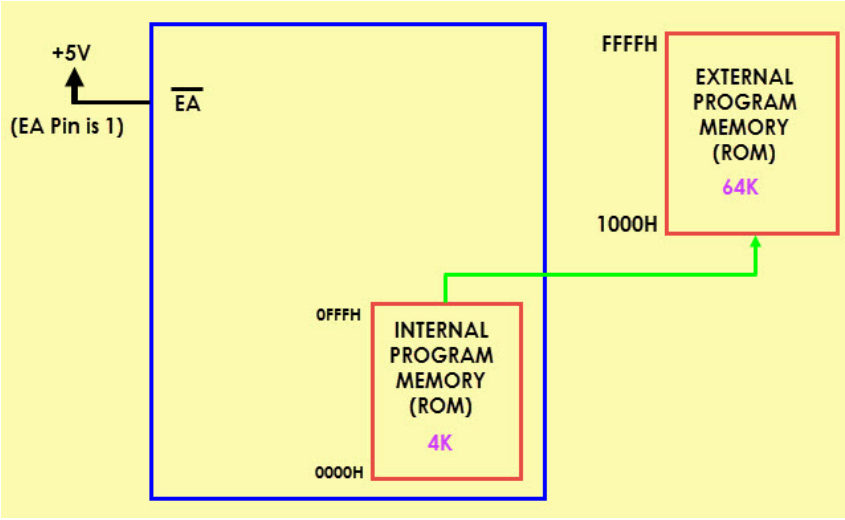
8051 Microcontroller has both Internal ROM and Internal RAM. If the internal memory is inadequate, you can add external memory using suitable circuits.

Program Memory (ROM) of 8051 Microcontroller

- In 8051 Microcontroller, the code or instructions to be executed are stored in the Program Memory, which is also called as the ROM of the Microcontroller.
- The original 8051 Microcontroller by Intel has 4KB of internal ROM. Almost all modern 8051 Microcontrollers, like 8052 Series, have 8KB of Internal Program Memory (ROM) in the form of Flash Memory (ROM) and provide the option of reprogramming the memory.



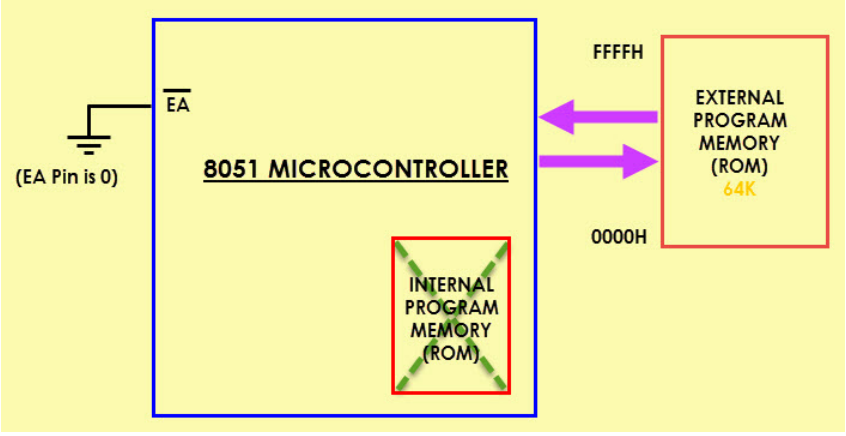
- In case of 4KB of Internal ROM, the address space is 0000H to 0FFFH. If the address space i.e. the program addresses exceed this value, then the CPU will automatically fetch the code from the external Program Memory.
- For this, the External Access Pin (EA Pin) must be pulled HIGH i.e. when the EA Pin is high, the CPU first fetches instructions from the Internal Program Memory in the address range of 0000H to 0FFFFH and if the memory addresses exceed the limit, then the instructions are fetched from the external ROM in the address range of 1000H to FFFFH.



Process of fetching instructions both from internal and external memories

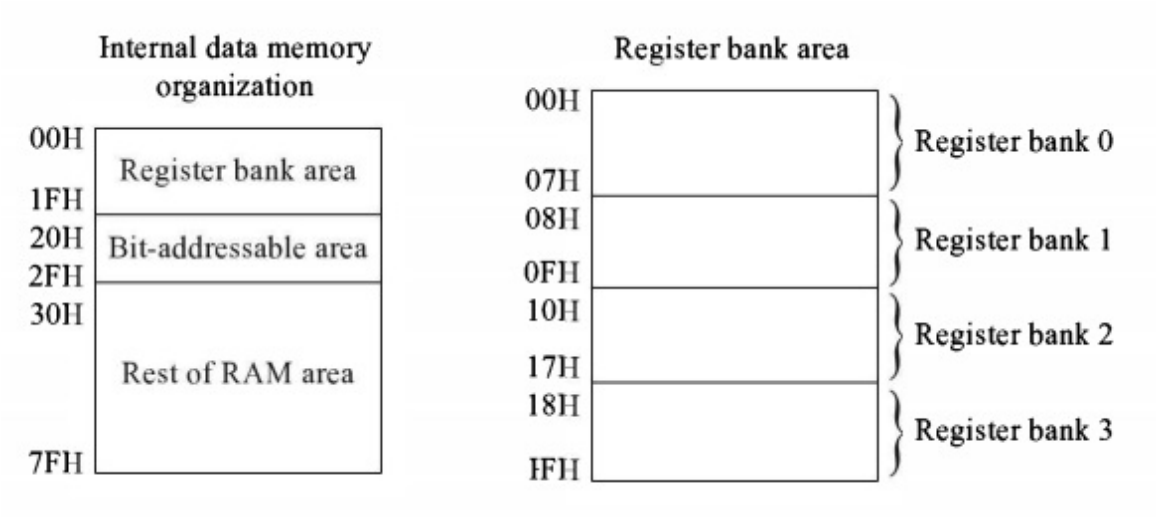
- Another way to fetch the instructions is to ignore the Internal ROM and fetch all the instructions only from the External Program Memory (External ROM). For this scenario, the EA Pin must be connected to GND. In this case, the memory addresses of the external ROM will be from 0000H to FFFFH.

Process of fetching all the instructions from external memory



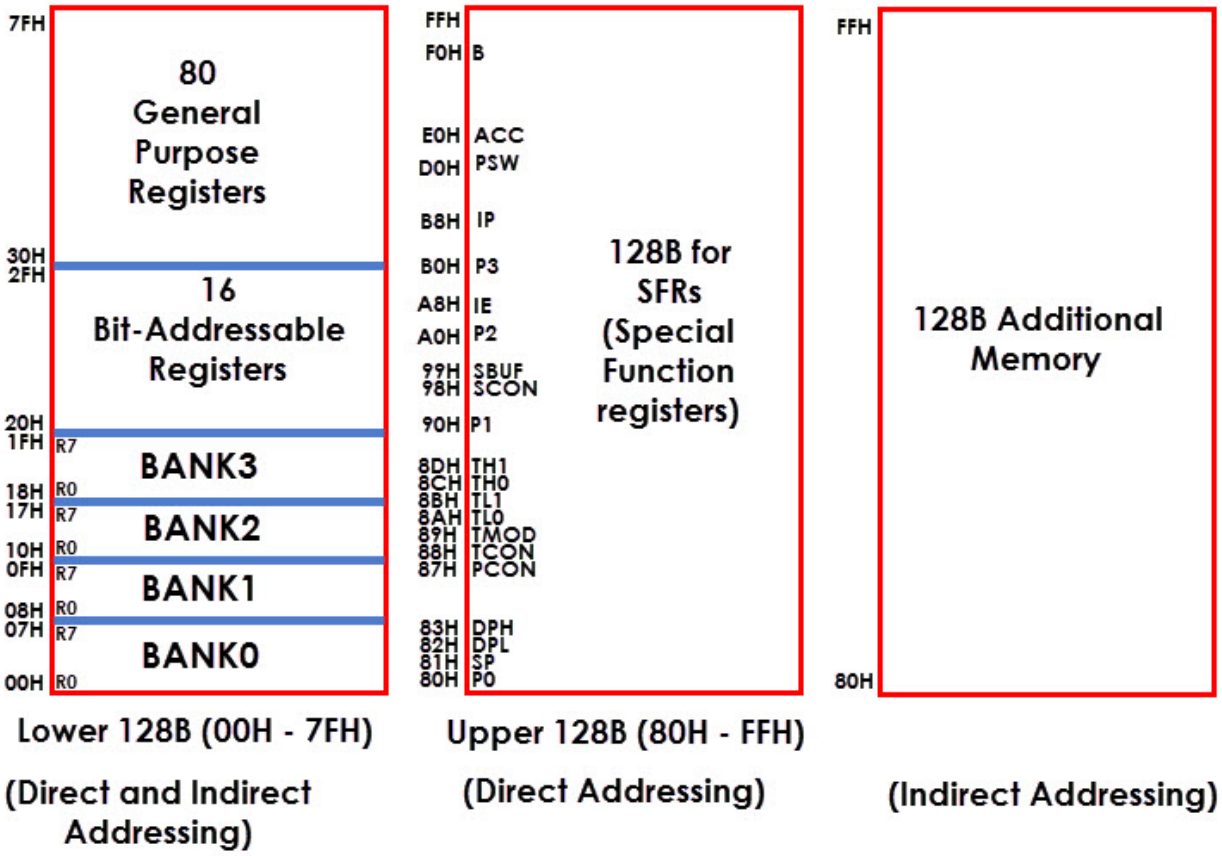
Data Memory (RAM) of 8051 Microcontroller

- The Data Memory or RAM of the 8051 Microcontroller stores temporary data and intermediate results that are generated and used during the normal operation of the microcontroller.
- Original Intel's 8051 Microcontroller had 128B of internal RAM. But almost all modern variants of 8051 Microcontroller have 256B of RAM.
- In this 256B, the first 128B i.e. memory addresses from 00H to 7FH is divided into
  - **Working Registers (organized as Register Banks)**
  - **Bit– Addressable Area**
  - **General Purpose RAM (also known as Scratchpad area).**



Working Registers:

- In the first 128B of RAM (from 00H to 7FH), the first 32B i.e. memory from addresses 00H to 1FH consists of 32 **Working Registers that are organized as four banks with 8 Registers in each Bank.**
- The 4 banks are named as Bank0, Bank1, Bank2 and Bank3. Each Bank consists of 8 registers named as R0 – R7.
- Each Register can be addressed in two ways: either by name or by address.
- **To address the register by name**, first the corresponding Bank must be selected. In order to select the bank, we have to use the RS0 and RS1 bits of the Program Status Word (PSW) Register (RS0 and RS1 are 3rd and 4th bits in the PSW Register).



- **When addressing the Register using its address** i.e. 12H for example, the corresponding Bank may or may not be selected. (12H corresponds to R2 in Bank2). The following addresses can be used to select register banks.

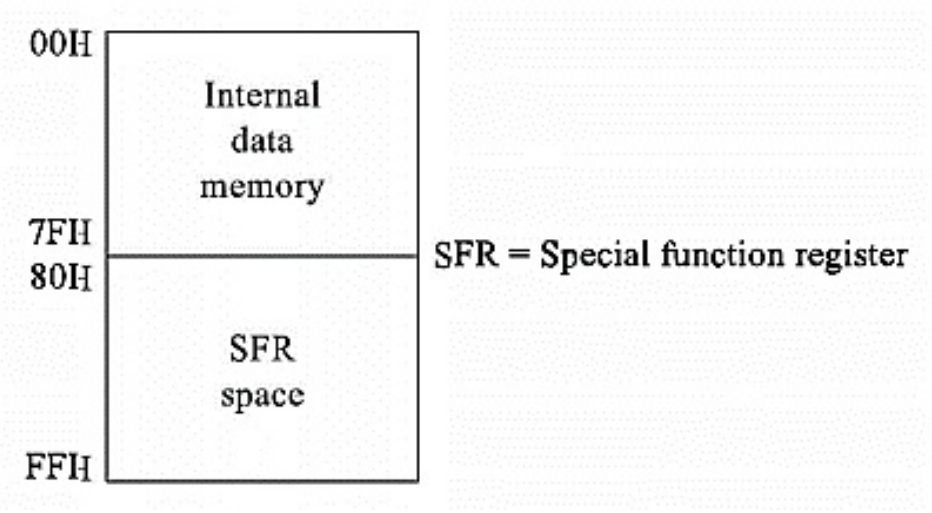
Address Range	Register Bank
00H to 07H	Register Bank 0
08H to 0FH	Register Bank 1
10H to 17H	Register Bank 2
18H to 1FH	Register Bank 3

Bit– Addressable Area:

- The next 16B of the RAM i.e. from 20H to 2FH are Bit – Addressable memory locations.
- There are total 128 bits that can be addressed individually using 00H to 7FH or the entire byte can be addressed as 20H to 2FH.
- For example 32H is the bit 2 of the internal RAM location 26H.

General Purpose RAM:

- The final 80B of the internal RAM i.e. addresses from 30H to 7FH, is the general purpose RAM area which are byte addressable.
- These lower 128B of RAM can be addressed directly or indirectly.
- The upper 128B of the RAM i.e. memory addresses from 80H to FFH is allocated for Special Function Registers (SFRs).



1.4 SPECIAL FUNCTION REGISTERS (SFRs):

- A Special Function Register (or Special Purpose Register, or simply Special Register) is a register within a microprocessor that controls or monitors the various functions of a microprocessor.
- As the special registers are closely tied to some special function or status of the processor, they might not be directly writable by normal instructions (like add, move, etc.). Instead, some special registers in some processor architectures require special instructions to modify them.
- In the 8051, register A, B, DPTR, and PSW are a part of the group of registers commonly referred to as SFR (special function registers). An SFR can be accessed by its name or by its address.
- SFRs control specific functions of the 8051 Microcontroller.
- Some of the SFRs are I/O Port Registers (P0, P1, P2 and P3), PSW (Program Status Word), A (Accumulator), IE (Interrupt Enable), PCON (Power Control), etc.
- SRFs Memory addresses are only direct addressable.

- Even though some of the addresses between 80H and FFH are not assigned to any SFR, they cannot be used as additional RAM area.
- In some microcontrollers, there is an additional 128B of RAM, which share the memory address with SFRs i.e. 80H to FFH.
- But, this additional RAM block is only accessed by indirect addressing.

Name of the Register	*Function*	*Internal RAM Address (HEX)*
ACC	Accumulator	E0H
B	B Register (for Arithmetic)	F0H
DPH	Addressing External Memory	83H
DPL	Addressing External Memory	82H
IE	Interrupt Enable Control	A8H
IP	Interrupt Priority	B8H
P0	PORT 0 Latch	80H
P1	PORT 1 Latch	90H
P2	PORT 2 Latch	A0H
P3	PORT 3 Latch	B0H
PCON	Power Control	87H
PSW	Program Status Word	D0H
SCON	Serial Port Control	98H
SBUF	Serial Port Data Buffer	99H
SP	Stack Pointer	81H
TMOD	Timer / Counter Mode Control	89H
TCON	Timer / Counter Control	88H
TL0	Timer 0 LOW Byte	8AH
TH0	Timer 0 HIGH Byte	8CH
TL1	Timer 1 LOW Byte	8BH
TH1	Timer 1 HIGH Byte	8DH

Prepared by

Shweta Sharma