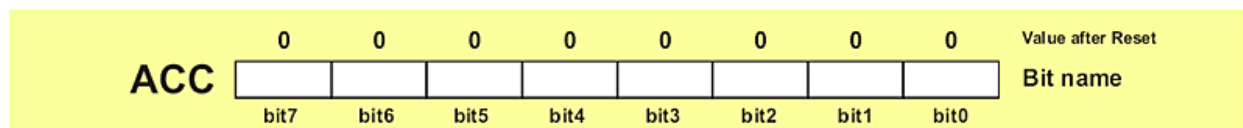# Special Function Registers (SFRs).

The 8051 family of microcontrollers provides a distinct memory area for accessing Special Function Registers (SFRs). SFRs are used in your program to control timers, counters, serial I/Os, port I/Os, and peripherals. SFRs reside from address 0x80 to 0xFF and can be accessed as bits, bytes, and words.

Special Function Registers (SFRs) are a sort of control table used for running and monitoring the operation of the microcontroller. Each of these registers as well as each bit they include, has its name, address in the scope of RAM and precisely defined purpose such as timer control, interrupt control, serial communication control etc. Even though there are 128 memory locations intended to be occupied by them, the basic core, shared by all types of 8051 microcontrollers, has only 21 such registers. Rest of locations are intensionally left unoccupied in order to enable the manufacturers to further develop microcontrollers keeping them compatible with the previous versions. It also enables programs written a long time ago for microcontrollers which are out of production now to be used today.

F8									FF
F0	B								F7
E8									EF
E0	ACC								E7
D8									DF
D0	PSW								D7
C8									CF
C0									C7
B8	IP								BF
B0	P3								B7
A8	IE								AF
A0	P2								A7
98	SCON	SBUF							9F
90	P1								97
88	TCON	TMOD	TL0	TL1	TH0	TH1			8F
80	P0	SP	DPL	DPH				PCON	87

Bit-addressable Registers

A Register (Accumulator)

|									Value after Reset
	0	0	0	0	0	0	0	0	
ACC									Bit name
	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	

A register is a general-purpose register used for storing intermediate results obtained during operation. Prior to executing an instruction upon any number or operand it is necessary to store it in the accumulator first. All results obtained from arithmetical operations performed by the ALU are stored in the accumulator. Data to be moved from one register to another must go through the accumulator. In other words, the A register is the most commonly used register and it is impossible to imagine a microcontroller without it. More than half instructions used by the 8051 microcontroller use somehow the accumulator.

B Register

Multiplication and division can be performed only upon numbers stored in the A and B registers. All other instructions in the program can use this register as a spare accumulator (A)

|									Value after Reset
	0	0	0	0	0	0	0	0	
B									Bit name
	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	
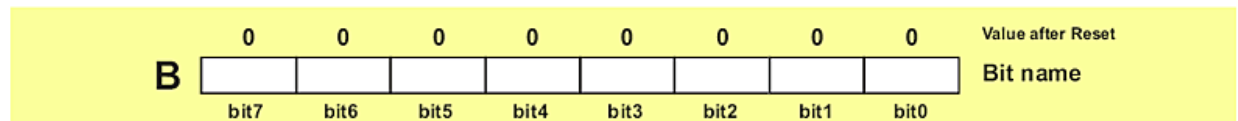
Note
During the process of writing a program, each register is called by its name so that their exact addresses are not of importance for the user. During compilation, their names will be automatically replaced by appropriate addresses.

R Registers (R0-R7)

This is a common name for 8 general-purpose registers (R0, R1, R2 ...R7). Even though they are not true SFRs, they deserve to be discussed here because of their purpose. They occupy 4 banks within RAM. Similar to the accumulator, they are used for temporary storing variables and intermediate results during operation. Which one of these banks is to be active depends on two bits of the PSW Register. Active bank is a bank the registers of which are currently used.

RAM
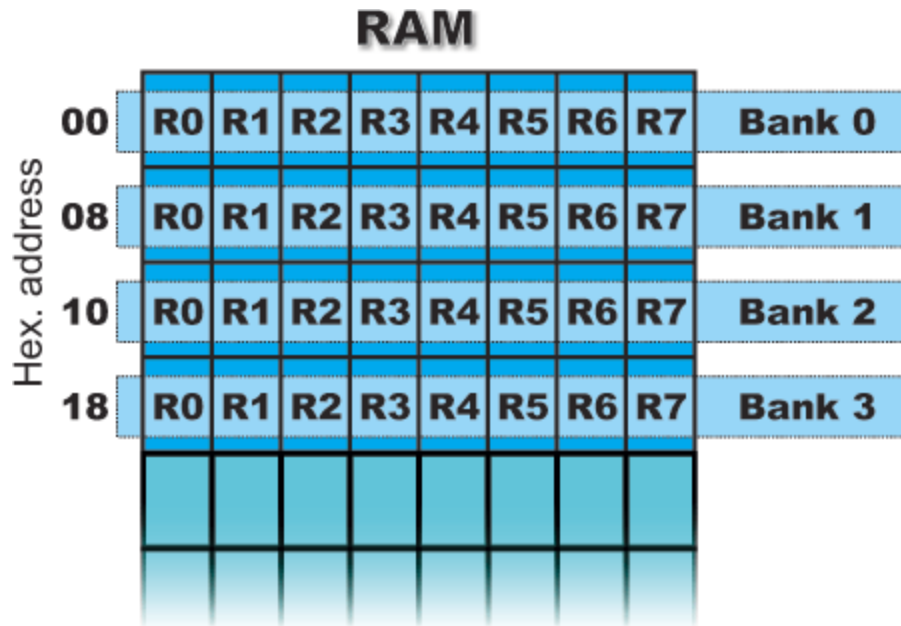
The following example best illustrates the purpose of these registers. Suppose it is necessary to perform some arithmetical operations upon numbers previously stored in the R registers: (R1+R2) - (R3+R4). Obviously, a register for temporary storing results of addition is needed. This is how it looks in the program:

```
MOV A,R3; Means: move number from R3 into accumulator

ADD A,R4; Means: add number from R4 to accumulator (result remains in accumulator)

MOV R5,A; Means: temporarily move the result from accumulator into R5

MOV A,R1; Means: move number from R1 to accumulator

ADD A,R2; Means: add number from R2 to accumulator

SUBB A,R5; Means: subtract number from R5 (there are R3+R4)
```

Program Status Word (PSW) Register
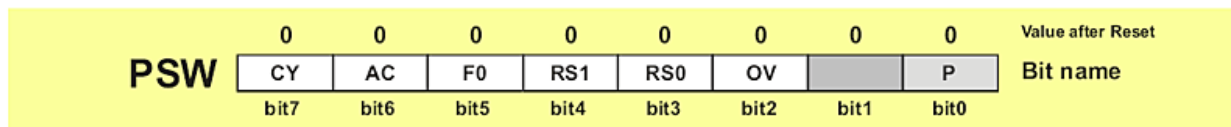
PSW register is one of the most important SFRs. It contains several status bits that reflect the current state of the CPU. Besides, this register contains

Carry bit, Auxiliary Carry, two register bank select bits, Overflow flag, parity bit and user-definable status flag. **P - Parity bit.** If a number stored in the accumulator is even then this bit will be automatically set (1), otherwise it will be cleared (0). It is mainly used during data transmit and receive via serial communication. **- Bit 1.** This bit is intended to be used in the future versions of microcontrollers. **OV Overflow** occurs when the result of an arithmetical operation is larger than 255 and cannot be stored in one register. Overflow condition causes the OV bit to be set (1). Otherwise, it will be cleared (0). **RS0, RS1 - Register bank select bits.** These two bits are used to select one of four register banks of RAM. By setting and clearing these bits, registers R0-R7 are stored in one of four banks of RAM.

| RS1	RS2	SPACE IN RAM
0	0	Bank0 00h-07h
0	1	Bank1 08h-0Fh
1	0	Bank2 10h-17h
1	1	Bank3 18h-1Fh

F0 - Flag 0. This is a general-purpose bit available for use. **AC – Auxiliary Carry Flag** is used for BCD operations only. **CY - Carry Flag** is the (ninth) auxiliary bit used for all arithmetical operations and shift instructions.

Data Pointer Register (DPTR)
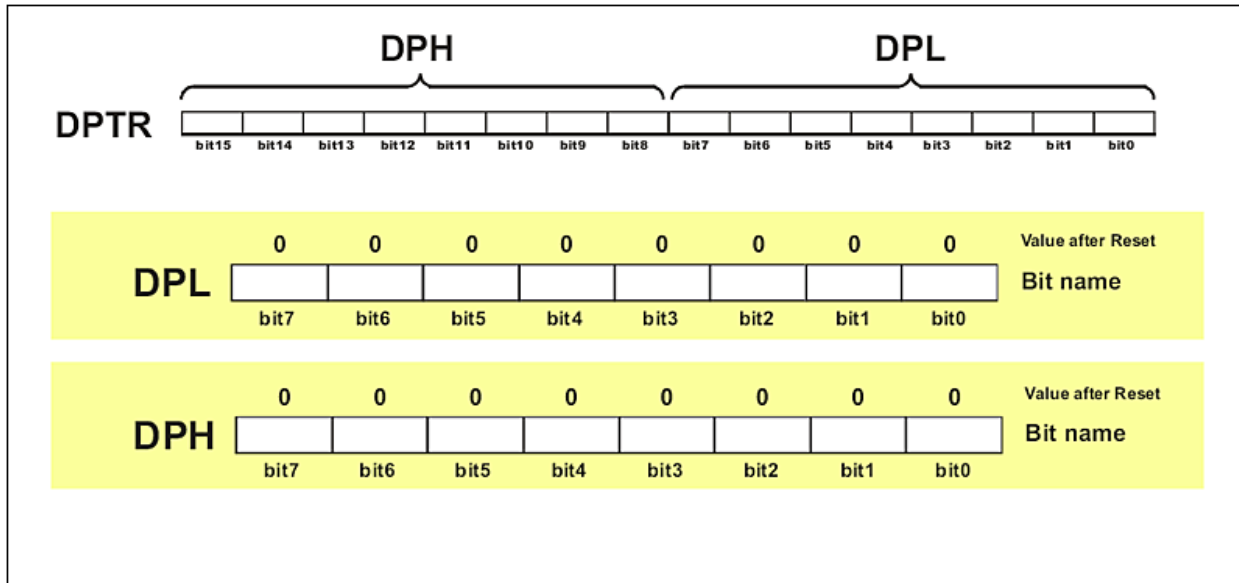
DPTR register is not a true one because it doesn't physically exist. It consists of two separate registers: DPH (Data Pointer High) and (Data Pointer Low). For this reason it may be treated as a 16-bit register or as two independent 8-bit registers. Their 16 bits are primarily used for external memory addressing. Besides, the DPTR Register is usually used for storing data and intermediate results.

Stack Pointer (SP) Register
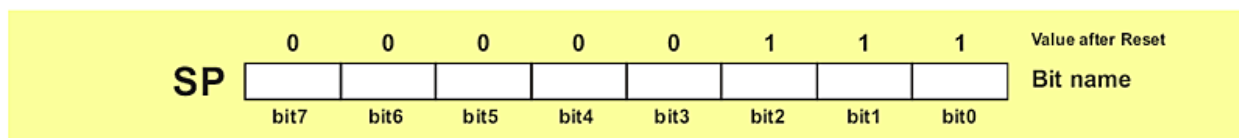
A value stored in the Stack Pointer points to the first free stack address and permits stack availability. Stack pushes increment the value in the Stack Pointer by 1. Likewise, stack pops decrement its value by 1. Upon any reset and power-on, the value 7 is stored in the Stack Pointer, which means that the space of RAM reserved for the stack starts at this location. If another

value is written to this register, the entire Stack is moved to the new memory location.

P0, P1, P2, P3 - Input/Output Registers

If neither external memory nor serial communication system are used then 4 ports with in total of 32 input/output pins are available for connection to peripheral environment. Each bit within these ports affects the state and performance of appropriate pin of the microcontroller. Thus, bit logic state is reflected on appropriate pin as a voltage (0 or 5 V) and vice versa, voltage on a pin reflects the state of appropriate port bit. As mentioned, port bit state affects performance of port pins, i.e. whether they will be configured as inputs or outputs. If a bit is cleared (0), the appropriate pin will be configured as an output, while if it is set (1), the appropriate pin will be configured as an input. Upon reset and power-on, all port bits are set (1), which means that all appropriate pins will be configured as inputs.

In short

I/O ports are directly connected to the microcontroller pins. Accordingly, logic state of these registers can be checked by voltmeter and vice versa, voltage on the pins can be checked by inspecting their bits!