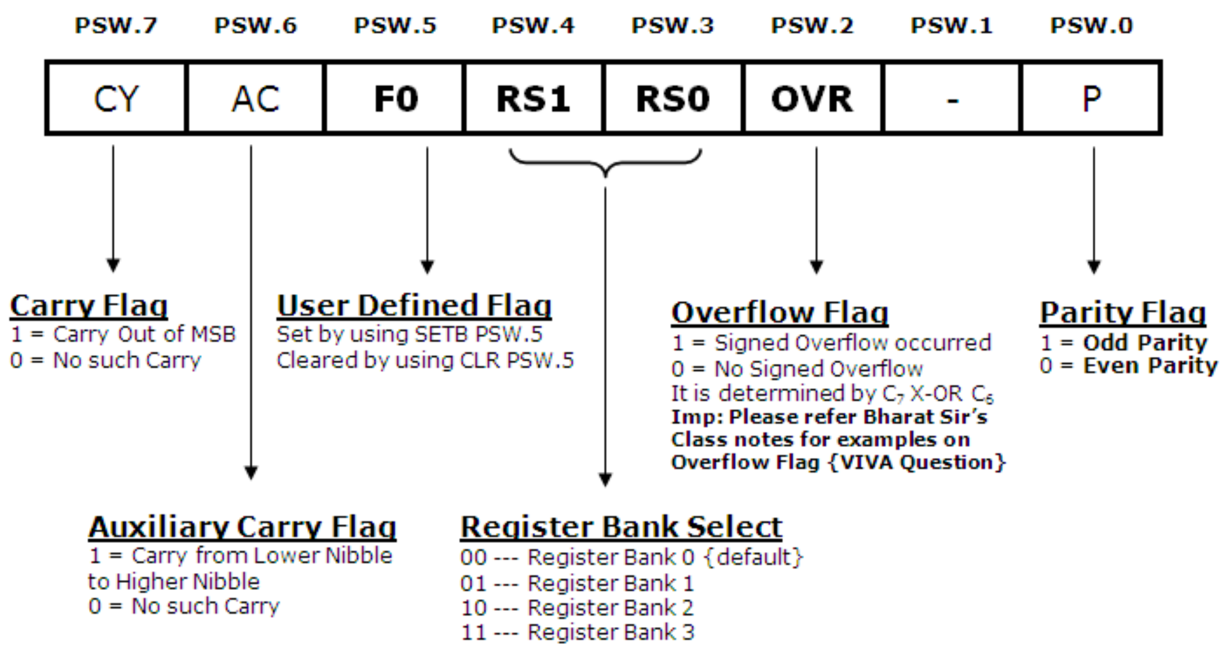
FLAG REGISTER (PSW) OF 8051



RS1 RS0	REGISTER BANK	RAM ADDRESS	SELECTED BY INSTRUCTIONS
0 0	Bank 0	00H … 07H	CLR PSW.4, CLR PSW.3
0 1	Bank 1	08H … 0FH	CLR PSW.4, SETB PSW.3
1 0	Bank 2	10H … 17H	SETB PSW.4, CLR PSW.3
1 1	Bank 3	18H … 1FH	SETB PSW.4, SETB PSW.3

INTERNAL MEMORY

8051 has two forms of internal memories.
It has 128 bytes of Internal RAM and 4 KB of Internal ROM.

INTERNAL RAM

8051 has **128 bytes of Internal RAM**.
RAM is used to store data, hence is also called **Data Memory**.
The are **128 locations** each containing one byte information.
The **address range** is **00H... 7FH**.
It contains **Register banks**, a **Bit addressable area** and a **General purpose area**.

INTERNAL ROM

8051 has **4 KB of Internal ROM.**
ROM is used to store programs, hence is also called **Program Memory or Code Memory**.
The are **4 K locations** each containing one byte information.
The **address range** is **0000H... 0FFFH**.
It mainly contains **programs.**
It may also contains some **permanent data** stored in the form of **look up tables**.
To access **programs**, the address is given by **PC** – Program Counter.
To access **data**, the address is given by **DPTR** – Data Pointer.

I/O COMPONENTS

Like any other typical microcontroller, 8051 has several I/O components.
They include I/O ports, Timers, Serial port etc.
8051 has **4, 8-bit I/O ports: P0, P1, P2 and P3.**
They support **bit and byte operations.**
They also have several **alternate functions**.
There are **two 16-bit timers**, which operate as down counters.
There is a **serial port** having pins **Rxd and Txd** to receive and transmit data serially.
There are **two external interrupt pins**.
Additionally there are **address, data and control signals** for transfers with **External RAM and External ROM**.

Finally, 8051 has **21, 8-bit internal SFRs** (Special Function Registers).
These are used to **control operations of the various I/O components** mentioned above.

FLAG REGISTER (PSW) OF 8051

PSW.7	PSW.6	PSW.5	PSW.4	PSW.3	PSW.2	PSW.1	PSW.0
CY	AC	**F0**	**RS1**	**RS0**	**OVR**	-	P

Carry Flag
1 = Carry Out of MSB
0 = No such Carry

User Defined Flag
Set by using SETB PSW.5
Cleared by using CLR PSW.5

Overflow Flag
1 = Signed Overflow occurred
0 = No Signed Overflow
It is determined by C_7 X-OR C_6
Imp: Please refer Bharat Sir's Class notes for examples on Overflow Flag {VIVA Question}

Parity Flag
1 = **Odd Parity**
0 = **Even Parity**

Auxiliary Carry Flag
1 = Carry from Lower Nibble to Higher Nibble
0 = No such Carry

Register Bank Select
00 --- Register Bank 0 {default}
01 --- Register Bank 1
10 --- Register Bank 2
11 --- Register Bank 3

PSW – PROGRAM STATUS WORD

It is an **8-bit register**.
It is also called the **"Flag register"**, as it mainly contains the status flags.
These flags indicate **status of the current result**.
They are **changed by the ALU after every arithmetic or logic operation**.
The flags can also be **changed by the programmer**.
PSW is a **bit addressable** register.
Each bit can be individually set or reset by the programmer.
The bits can be referred to by their bit numbers (**PSW.4**) or by their name (**RS1**).

CY - CARRY FLAG

It indicates the carry out of the MSB, after any arithmetic operation.

If CY = 1 : There was a carry out of the MSB
If CY = 0 : There was no carry out of the MSB

AC – AUXILIARY CARRY FLAG

It indicates the carry from lower nibble (4-bits) to higher nibble.
If the 8bits are numbered Bit 7 --- Bit 0, this is the carry from Bit 3 to Bit 4.

If AC = 1 : There was an auxiliary carry
If AC = 0 : There was no auxiliary carry

Note: It is particularly useful in an operation called DA A (Decimal Adjust after Addition).

OVR - OVERFLOW FLAG

It indicates if there was an overflow during a signed operation.
An 8-bit signed number has the range -80H… 00H… +7FH.
Any result, out of this range causes an overflow.

If OVR = 1 : There was an overflow in the result
If OVR = 0 : There was no overflow in the result

Overflow is determined by doing an Ex-Or between the 2nd last carry (C_6) and the last carry (C_7)

Note: After an overflow, the Sign (MSB) of the result becomes wrong.

P - PARITY FLAG

It indicates the Parity of the result.
Parity is determined by the number of 1's in the result.

If PF = 1 : The result has ODD parity
If PF = 0 : The result has EVEN parity

F0 – USER DEFINED FLAG

This flag is **available to the programmer**.
It can be used by us to store any **user defined information**.
For example: In an Air Conditioning unit, programmer can use this flag indicate whether the compressor is ON or OFF (1 or 0).
This flag can be changed by simple instructions like SETB and CLR.

SETB PSW.5; This makes F0 bit ← 1
CLR PSW.5; This makes F0 bit ← 0

RS1, RS0 – REGISTER BANK SELECT

The initial 32 locations (bytes) of the Internal RAM are available to the programmer as registers.
Having so many registers makes programming easier and faster.
Naming R0… R31, would tremendously increase the number of opcodes.
Hence the registers are divided into 4 banks: Bank0… Bank3.
Each bank has 8 registers named R0… R7.
At a time, only of the four banks is the "active bank".
RS1 and RS0 are used by the programmer to select the active bank.

RS1 RS0	REGISTER BANK	SELECTED BY INSTRUCTIONS
0 0	Bank 0	CLR PSW.4 CLR PSW.3
0 1	Bank 1	CLR PSW.4 SETB PSW.3
1 0	Bank 2	SETB PSW.4 CLR PSW.3
1 1	Bank 3	SETB PSW.4 SETB PSW.3

NUMERICAL EXAMPLES FOR FLAG REGISTER

			1				1	1	
	31 H	0	0	1	1	0	0	0	1
+	23 H	0	0	1	0	0	0	1	1
=	54 H	0	1	0	1	0	1	0	0

Flags Affected:	CY	AC	OVR	P
	0	0	0	1

			1	1	1	1	1	1	
	39 H	0	0	1	1	1	0	0	1
+	27 H	0	0	1	0	0	1	1	1
=	60 H	0	1	1	0	0	0	0	0

Flags Affected:	CY	AC	OVR	P
	0	1	0	0

		1							
	42 H	0	1	0	0	0	0	1	0
+	44 H	0	1	0	0	0	1	0	0
=	86 H	1	0	0	0	0	1	1	0

Flags Affected:	CY	AC	OVR	P
	0	0	1	1

The result 86H is out of range for a "Signed" Number as it has become greater than +7FH.
Such an event is called a "Signed Overflow".
In such a case the MSB of the result gives a wrong sign.
Though the result is +ve (+86H) the MSB is "1" indicating that the result is –ve.
Overflow is determined by doing an Ex-Or between the 2nd last Carry and the last Carry.
Here the 2nd last Carry (the one coming into the MSB) is "1".
The final carry (The one going out of the MSB) is "0".
As "1" Ex-Or "0" = "1", the Overflow flag is "1".

For similar examples, but on Negative numbers…
Please refer to Bharat Sir's Classroom Notes.