

5.7 USING TIMERS AS EVENT COUNTERS

Most of the discussions so far have centered on how a timer can be used for the obvious purpose of keeping track of time. However, the 8051 also allows the use of the timers to count events. Let us say you had a sensor placed across a road that would send a pulse every time a car passed over it. This could be used to determine the volume of traffic on the road. We could attach this sensor to one of the 8051's I/O lines and constantly monitor it, detecting when it pulsed high and then incrementing our counter when it went back to a low state. Let the sensor be connected to P1.0. The code to count cars passing would look something like this:

JNB P1.0,\$;If a car hasn't raised the signal, keep waiting

JB P1.0,\$;The line is high which means the car is on the sensor right now

INC COUNTER ;The car has passed completely, so we count it

8051 MEMORY AND PROGRAMMING MODEL

8051 INTERNAL RAM STRUCTURE.

Today we discuss what are the various things in Internal RAM.

The internal data memory space is divided between Internal RAM (00H - 7FH) and special function registers (80H - FFH). The Internal data memory has the range from 00H - FFH (256 bytes), out of which 00H - 7FH is for general data while 80H - FFH is mostly for specific purposes and not for general data. Hence, 00H - 7FH is considered to be Internal RAM.

The Internal RAM is further subdivided into register banks (00H - 1FH), bit addressable RAM (20H - 2FH), and general-purpose RAM (30H - 7FH).

→ Banks ~ 4 Banks (32 Bytes)

→ Bit Addressable Memory (16 Bytes)

→ General Purpose Registers (80 Bytes)

For Bit Addressable Memory 16 Bytes are allocated.
For General purpose Register (80 Bytes) are allocated.

General purpose RAM is from addresses (30H to 7FH). Locations (00H - 2FH) can similarly be used but they also have other purposes.

FFH

Special Function
Register Space.

Byte
Address
7F

80H

General Purpose RAM							
30	7F	7E	7D	7C	7B	7A	79
2F	77	76	75	74	73	72	71
2E	6F	6E	6D	6C	6B	6A	69
2D	67	66	65	64	63	62	61
2C	5F	5E	5D	5C	5B	5A	59
2B	57	56	55	54	53	52	51
2A	4F	4E	4D	4C	4B	4A	49
29	47	46	45	44	43	42	41
28	3F	3E	3D	3C	3B	3A	39
27	37	36	35	34	33	32	31
26	2F	2E	2D	2C	2B	2A	29
25	27	26	25	24	23	22	21
24	1F	1E	1D	1C	1B	1A	19
23	17	16	15	14	13	12	11
22	10F	0E	0D	0C	0B	0A	09
21	07	06	05	04	03	02	01
20	R7	R6	R5	R4	R3	R2	R1
	1FH	1EH	1DH	1CH	1BH	1AH	19H
	R7	R6	R5	R4	R3	R2	R1
	17H	16H	15H	14H	13H	12H	11H
	R7	R6	R5	R4	R3	R2	R1
	0FAH	0EH	0DH	0CH	0BH	0AH	09H
	R7	R6	R5	R4	R3	R2	R1
	07H	06H	05H	04H	03H	02H	01H

Bank 3

Bank 2

Bank 1

Bank 0 (Default
register bank)

Internal data memory organization.

Register Banks of 8051

The first 32 bytes of internal RAM (00H-1FH) are structured into Register Banks. The first 8 bytes (00H-07H) are "register bank 0". The next 8 bytes (08H-0FH) constitute "register bank 1". While the following 8 bytes (10H-17H) and the last 8 bytes (18H-1FH) form "register bank 2" and "register bank 3" respectively.

The 8051 uses 8 "R" registers which are used in many of its instructions. These "R" registers are numbered from 0 through 7 (R0, R1, R2, R3, R4, R5, R6 and R7). The 8051 set supports registers R0 through R7, and by default, after a system reset, these registers are at addresses 00H-07H. However, by manipulating certain SFRs, a program may choose to use register banks 1, 2, or 3.

The registers are generally used to assist in manipulating values and moving data from one memory location to another.

Suppose I want to access memory location 03H. In this memory location some 8-bit data are stored D₇, D₆, D₅, D₄, D₃, D₂, D₁, D₀. To access this I can use or directly use the address in the instruction.

MOV A, 03H : 8 bit data is moved from 03H to A.
the data can be any bit value.

Registers can also be used to access the memory location
MOV A, R3

The Program Status Word (PSW) should tell us which bank R3 belongs to.

Bit Memory (Bit-Addressable RAM)

The 8051, being a communications-oriented microcontroller, gives the user the ability to access a number of bit variables. These variables may be either 1 or 0. The 8051 contains 210 bit addressable locations, of which

128 are at byte addresses 20H through 2FH; and the rest are in the special function registers. Individual bit accessible through software is a powerful feature of most microcontrollers. Bits can be set, cleared, ANDed, ORed etc., with a single instruction. Most microprocessors require a read-modify-write sequence of instructions to achieve the same effect. Furthermore, the 8051 I/O ports are bit addressable, simplifying the software interface to single bit inputs and outputs.

The user may make use of these variables with commands such as SETB and CLR. For example, to set bit number 2F (hex) to 1 you would execute the instruction

SETB 2Fh.

It is important to note that bit memory is really a part of internal RAM. In fact the 128 bit variables occupy the 16 bytes of internal RAM from 20h through 2Fh. Thus if you write the value FFh to internal RAM address 20h you have effectively set bits 00h through 07h.

MOV 20h, #0FFh is equivalent to

SETB 00h
SETB 01h
SETB 02h
SETB 03h
SETB 04h
SETB 05h
SETB 06h
SETB 07h.

As illustrated, bit memory is not really a new type of memory but a subset of internal RAM. But since the 8051 provides special instructions to access these 16 bytes of memory on a bit by bit basis it is useful to think of it as a separate type of memory.

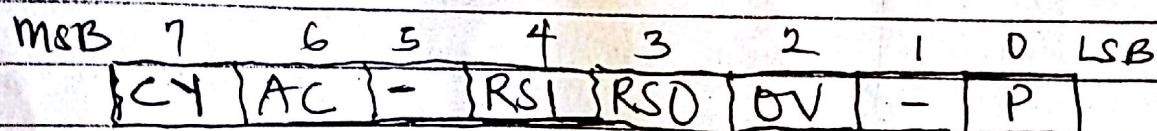
Program Status Word (PSW).

Program status word is one register that is inside the 8051 microcontroller and this register is in SFR.

Recall there are few memory locations reserved for SFR

00H to 7FH (128 Addresses) → RAM 128 Bytes
80H to FFH (128 Addresses) → Address SFRs.

The PSW is an 8-bit register at address D0H contains status bits.



In this program status word (PSW) there are four (4) conditional flags depending on the ALU operation which has been performed by the processor.

The status of the accumulator (A) register is defined by the conditional flags (4). Bit 3 and 4 are used for the selection of banks.

The carry flag (C or C') is dual purpose during the arithmetic operation of two numbers if carry is generated from the MSB then the carry flag is set and if no carry is generated the flag is reset (0) sometime if you require a borrow during subtraction the carry flag will set otherwise it remains in reset (0). (The flag is used during unsigned operation)

Auxiliary carry flag (AC) : is a non programmable flag i.e. when no instruction is available in the 8051 microcontroller the flag is used for converting decimal numbers into BCD number. If carry is generated at 13 bit position in the lower bit

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position.

e.g.	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
	1	0	1	1	1	1	0	0
	0	0	0	1	1	0	0	0

If no carry is generated at the D₃ bit position the AC flag is not set.

Flag D: This is a general purpose flag bit available for user applications.

Overflow Flag (OV): The OV flag is set after an addition or subtraction operation. If there was an arithmetic overflow. When signed numbers are added or subtracted.

Parity Bit (P): The parity bit (P) is automatically set or cleared each machine cycle to establish even parity with the accumulator. The number of 1 bit in the accumulator plus the P is always even.

1st	1	0	1	0	0	0	0	1
2nd	0	1	1	1	1	1	0	0
	0	0	0	1	1	1	0	1

CY = 1 → set
AC = 0 not set
P = 0 ✓ ✓

After the ALU operations if in A register number of ones (1's) are odd then the parity bit is set. Otherwise if the number of ones are even parity is not set (0).



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in this
Margin

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Question.....

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Bank Selection.

We shall be discussing about bit 3 and bit 4 of the PSW. These bits are RSI and RSD.

RSI = Register bank select bit no 1

RSD = Register bank select bit no 0

So these two bits are used to select the bank of registers. There are four banks (Bank 0 - 4).

Depending on the value of the banks a particular bank will be selected.

	RSI	RSD	
Bank 0	0	0	- → Default Bit position.
Bank 1	0	1	
Bank 2	1	0	
Bank 3	1	1	

When $RSI=0$ and $RSD=0$ then Bank 0 is selected

When $RSI=0$ & $RSD=1$ then Bank 1 is selected

When $RSI=1$ & $RSD=0$ then Bank 2 is selected

When $RSI=1$ & $RSD=1$ then Bank 3 is selected.

By default when you power up a system the default value of the PSW = 0 by default $RSI = RSD = 0$ and it is always selected. If you want to change the bank select any.