Coprocessor Operations using NASM

R. V. Bidwe
PICT, Pune.
rvbidwe@pict.edu

Agenda

1. Processor Vs Co-processor
2. Writing a ALP for Co-processor
3. Sample ALP for Co-processor
4. What is TSR?
5. How TSR's are executed in system
6. Sample TSR program

1. Processor Vs. Co-processor

- Difference between Processor and Co-processor

  i. **Functions and Features**
  ii. **Instruction Set**
  iii. **Register Organization**

Processor

- Processor performs operations on Integer numbers.
- Integer numbers are usually stored in Hexadecimal format with Packed BCD representation.
- Can perform Arithmetic and Logical Operations.
- Can handle data types: 16,32, and 64 bit integers.

Co-processor

- Processor performs operations on both Floating Point numbers and Integer numbers.
- Floating Point numbers are represented using IEEE standards.
- Can perform upto 68 additional arithmetic, trigonometric, exponential, & logarithmic instructions.
- Can handle data types: 16,32, and 64 bit integers; 32,64, and 80 bit floating-point real numbers; and up to 18-digit (BCD) operands.

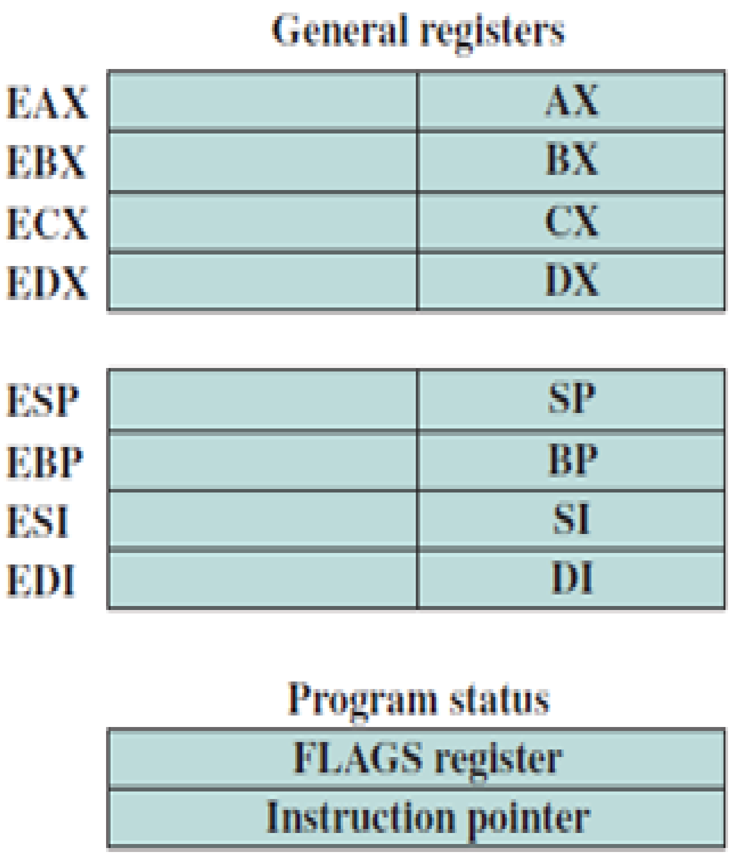
Instruction Set

- As 80386 and 80387 are completely different processors, they have different
  - **Instruction Set**
  - **Bandwidth**
  - **Clock speed**

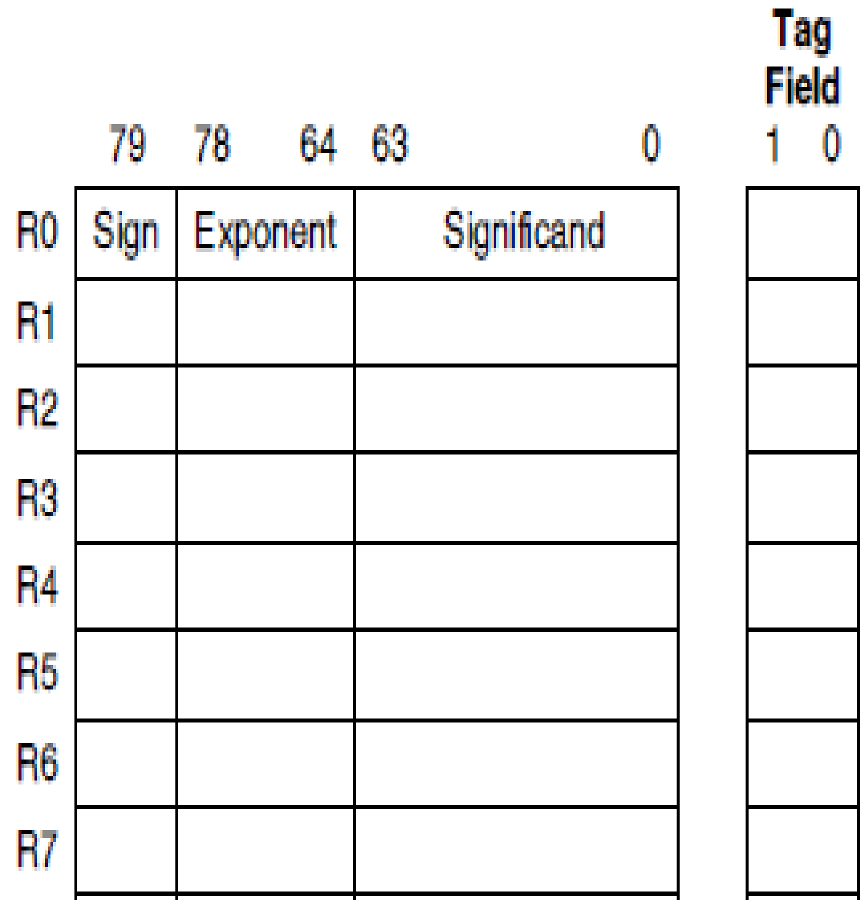
- For processor instructions, Set of Operands are expected, where actually operations are performed.

- But for Coprocessor instructions, Many of those do not have operands. In this case by default operations will be performed on TOP value.

80386 Register Organization



80387 Register Organization



Register use in Co-processor

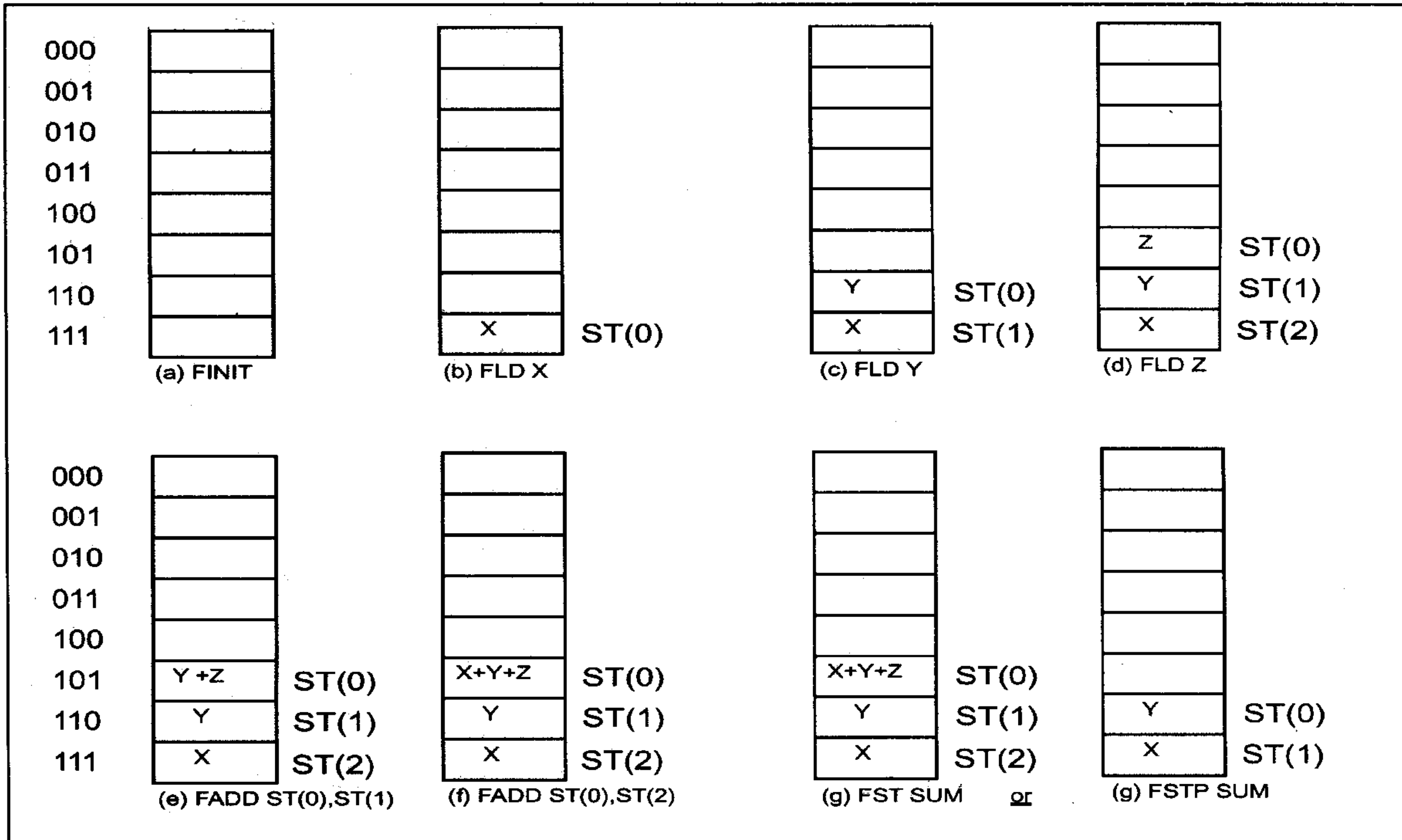


Figure 20-2. Stack Diagram for Example 20-5

Some IMP Instructions

- **FINIT: (Initialize Floating Point Unit)**
  - Initialize FPU after checking for pending unmasked floating-point exceptions.
  - Syntax: FINIT (no operand)

- **FLD:** Push one of seven commonly used constants (in double extended-precision floating-point format) onto the FPU register stack. **It sets TOP to ST0**.

Mnemonic	Description
FLD1	Push 1 to ST0
FLDL2T	Push log_2(10) to ST0
FLDL2E	Push log_2(e) to ST0
FLDPI	Push PI to ST0
FLDLG2	Push log_10(2) to ST0
FLDLN2	Push log_e(2) to ST0
FLDZ	Push 0 to ST0

- **FBST/ FBSTP: Store BCD Integer / Pop**

  – Converts the value in the ST(0) register to an 18-digit packed BCD integer, stores the result in the destination operand, and pops the register stack (For FBSTP).

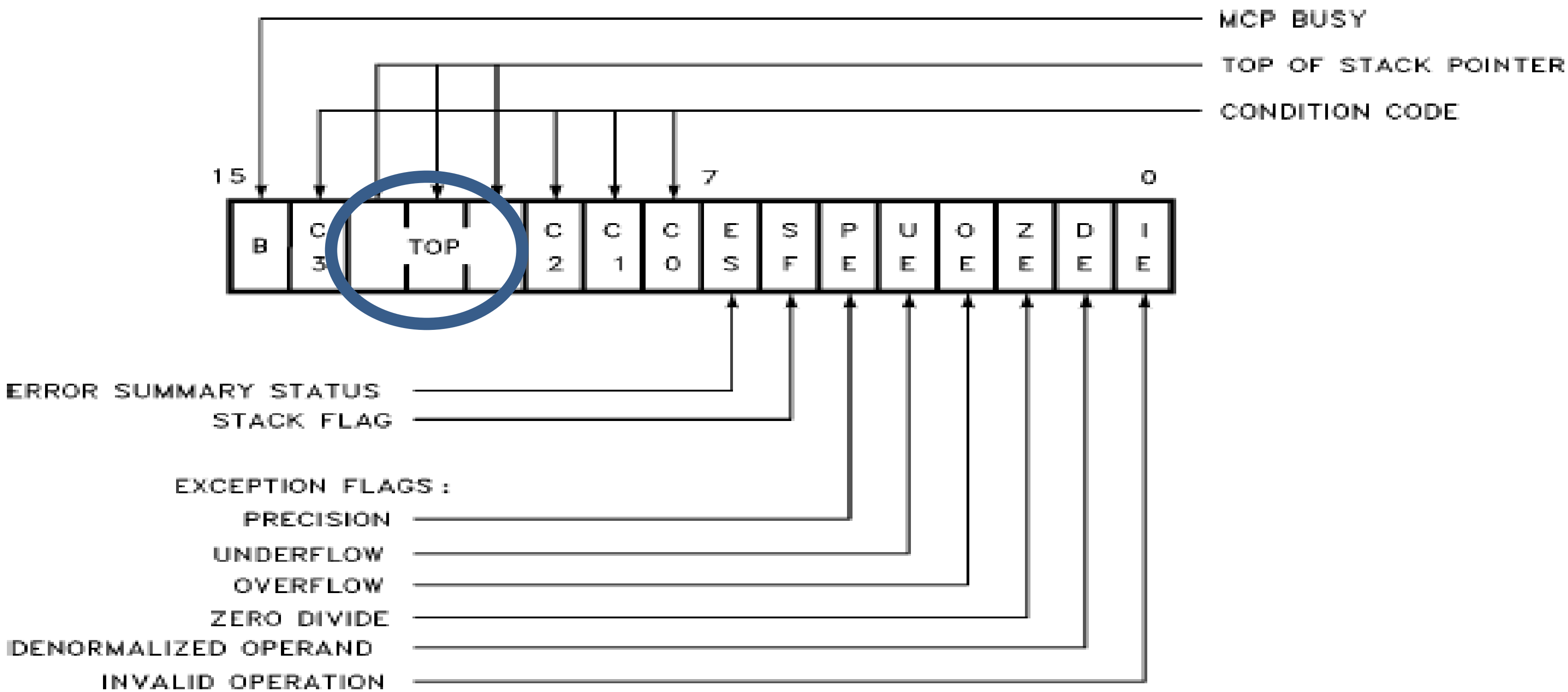
Instruction	64-Bit Mode
FBST m80bcd	Store ST(0) in m80bcd
FBSTP m80bcd	Store ST(0) in m80bcd and pop ST(0).

FBSTP Instruction

If ST0: (1234567890ABCDEF4321) in IEEE precision format.

Memory location	Data
1000000A h	
10000009 h	12
10000008 h	34
10000007 h	56
10000006 h	78
10000005 h	90
10000004 h	AB
10000003 h	CD
10000002 h	EF
10000001 h	34
10000000 h	21

Coprocessor Status Word



ES is set if any unmasked exception bit is set; cleared otherwise.
See Table 2.2 for interpretation of condition code.
TOP values:
000 = Register 0 is Top of Stack
001 = Register 1 is Top of Stack
•
•
•
111 = Register 7 is Top of Stack
For definitions of exceptions, refer to the section entitled "Exception Handling"

Writing a ALP for Co-processor

(By considering few limitations of ALP)

- Steps
  - Initialize Co-processor (TOP is set to 0)
  - Load zero to top of stack
  - Perform the required operation
  - Get answer from stack and store it in a BCD format
  - Convert the answer to ASCII and Print
  - End

Sample ALP using Co-processor

Case Study No. 1: Calculating Mean, Variance and Standard Deviation.

Case Study No. 2: Calculating Roots of Quadratic Equations.

Case Study 1

- If a, b, c, d are the four numbers then
  - **Mean = f =** $(a+b+c+d)/4$
  - **Variance = g =** $[(a-f)^2 + (b-f)^2 + (c-f)^2 + (d-f)^2]/4$
  - **SD = h =** SquareRoot(Variance)

- **Input:**
  - array: dd 102.56,198.21,100.67,230.78,67.93
  - cnt: dw 05
  - dpoint: db '.'
  - Cnt2: dw 0

Step 1: Initialize Co-processor (TOP is set to 0)

– FINIT

Step 2: Load zero to top of stack

– FLDZ

- **Step 3: Calculating Mean**

```
mov rsi,array
mov byte[cnt2],5

up:
   fadd dword[rsi]                   ;Add value to ST0.
   add rsi,4
   Dec byte[cnt2]
   Jnz up

fidiv word[cnt]
fst dword[mean]
Call print
```

- **Step 4: Calculating Variance**

```
mov rsi, array
mov byte[cnt2],5

FLDZ
up1:
    FLDZ                    ;Load zero to ST0, Sets TOP=ST0
    FLD dword[rsi]          ;Load value to ST0.
    FSUB dword[mean]
    FMUL ST0                ;multiply ST0 with ST0
    FADD                    ;Add ST0 with ST1, answer stored to ST1.
                            ; Sets TOP=ST1.
    add rsi,4
    Dec byte[cnt2]
    Jnz up

FIDIV word[cnt]
FST dword[variance]
Call print
```

- **Step 5: Calculating Standard Deviation**

```
FLD dword[variance]        ;Load variance to ST0.
FSQRT

FST dword[deviation]
Call print
```

- **Step 6: Printing the answer**

```
Print:
    Fimul dword[hdec]
    fbstp tword[resbuff]
    Mov byte[cnt2],9
    mov rsi,resbuff+9

up2:
    push rsi
    mov bl,byte[rsi]
    call disp8_proc                ;Convert value from bl to ASCII

    linuxsyscall 01,01,dispbuff,2          ;Display answer
    pop rsi
    dec rsi
    Dec byte[cnt2]
    Jnz up2
```

- **Print dpoint and remaining digits.**

Case Study 2

- Calculating the roots of quadratic equation:

Determinant (delta)= b^2-4ac

If determinant > 0,

$$\text{root1} = \frac{-b + \sqrt{(b^2 - 4ac)}}{2a}$$

$$\text{root2} = \frac{-b - \sqrt{(b^2 - 4ac)}}{2a}$$

Two Real Roots

If determinant = 0,

$$\text{root1} = \text{root2} = \frac{-b}{2a}$$

Equal Real Roots

If determinant < 0,

$$\text{root1} = \frac{-b}{2a} + i\,\frac{\sqrt{-(b^2 - 4ac)}}{2a}$$

$$\text{root2} = \frac{-b}{2a} - i\,\frac{\sqrt{-(b^2 - 4ac)}}{2a}$$

Two Imaginary Roots

section .data

```
ff1: db "%lf +i %lf",10
ff2: db "%lf -i %lf",10
formatpi: db "%d",10
formatpf: db "%lf",10
formatsf: db "%lf"
four: dq 4
two: dq 2
```

```
%macro myprintf 1
    mov rdi,formatpf                  ;Data Type
    sub rsp,8
    movsd xmm0,[%1]
    mov rax,1                  ;Number of arguments
    call printf
    add rsp,8
%endmacro
```

```
%macro myscanf 1
    mov rdi,formatsf
    mov rax,0
    sub rsp,8
    mov rsi,rsp
    call scanf
    mov r8,qword[rsp]
    mov qword[%1],r8
    add rsp,8
%endmacro
```

```
section .text
	global main
	main:
	extern printf
	extern scanf

	;------accept inputs
	myscanf a
	myscanf b
	myscanf c
```

- **Step 1: Calculate Determinant**

```
;----calculate b square
fld qword[b]
fmul qword[b]
fstp qword[b2]

;-----calculate 4ac
fild qword[four]
fmul qword[a]
fmul qword[c]
fstp qword[fac]

fld qword[b2]
fsub qword[fac]
fstp qword[delta]

;----calculate 2a
fild qword[two]
fmul qword[a]
fstp qword[ta]
```

```
btr qword[delta],63  ;--------tests the bit, sets he
                              carry flag if set and
                              clears the bit too

jc imaginary
```

- **Step 2: Printing the real roots**

```
fld qword[delta]
fsqrt
fstp qword[rdelta]

fldz
fsub qword[b]
fadd qword[rdelta]
fdiv qword[ta]
fstp qword[r1]
myprintf r1                    ;Print Root 1

fldz
fsub qword[b]
fsub qword[rdelta]
fdiv qword[ta]
fstp qword[r2]
myprintf r2                    ;Print Root 2
```

- **Step 3: Printing an imaginary roots**

[As we can not directly print “i”, Following variables are defined in Section .data

```
ff1: db "%lf +i %lf",10
ff2: db "%lf -i %lf",10 ]

fld qword[delta]
fsqrt
fstp qword[rdelta]

fldz
fsub qword[b]
fdiv qword[ta]
fstp qword[realn]

fld qword[rdelta]
fdiv qword[ta]
fstp qword[img1]
myprintf  img1                          ;Print imaginary roots
```

Printing Imaginary roots

```
mov rdi,ff1
sub rsp,8
movsd xmm0,[realn]
movsd xmm1,[img1]
mov rax,2
call printf
add rsp,8

mov rdi,ff2
sub rsp,8
movsd xmm0,[realn]
movsd xmm1,[img1]
mov rax,2
call printf
add rsp,8
```

Terminate-and-stay-resident (TSR)

- A terminate and stay resident (TSR) program is one that is **set up to be loaded and then remain in computer memory so that it is quickly accessible** when a user presses a certain keyboard combination.

- A TSR is a software program that remains in memory until it is needed, and then performs some function.

- Eg. **Screen saver, virus scanner, notepad, calculator.**

TSR’s Vs. Normal Programs

- Normal programs produces results after executing all instructions written in it.
- Instead TSR program generates an Interrupt after required event has occurred.
- For every generated interrupt a separate ISR is stored in system.
- After executing that ISR, results will be displayed in the system.

Sample TSR Program

- Case Study 1: TSR to print Real Time Clock (RTC) on screen.

Steps

- **Make Program Resident**
  - Clear Interrupt Flag
  - Push Data (if any)
  - Get Interrupt Vector from IVT
  - Set Interrupt Vector from IVT
  - Make Program resident

- **Write ISR**
- **Exit**

ISR for RTC

- Push Data
- Get Address of Video RAM
- Get System Clock
  - CH=Hours, CL=Mins, DH=Sec
- Convert Values and Print

- **Step 1: Make Program Resident**

```
INIT:
        MOV AX,CS                   ;Initialize data
        MOV DS,AX

        CLI                         ;Clear Interrupt Flag

        MOV AH,35H                  ;Get Interrupt vector Data and
                                        store it
        MOV AL,08H
        INT 21H

        MOV OLD_IP,BX
        MOV OLD_CS,ES

        MOV AH,25H                  ;Set new Interrupt vector
        MOV AL,08H
        LEA DX,MY_TSR
        INT 21H

        MOV AH,31H                  ;Make program Transient
        MOV DX,OFFSET INIT
        STI
        INT 21H
```

- **Step 2: ISR for RTC**

```
MY_TSR:
        PUSH AX
        PUSH BX
        PUSH CX
        PUSH DX
        PUSH SI
        PUSH DI
        PUSH ES

        MOV AX,0B800H              ;Address of Video RAM
        MOV ES,AX
        MOV DI,3650

        MOV AH,02H            ;To Get System Clock
        INT 1AH               ;CH=Hrs, CL=Mins,DH=Sec
```

Thank You…!!!