A REPORT
ON
SMART AC SYSTEMS

HARDWARE DESIGN AND SPECIFICATIONS

EEE F241 Microprocessor Programming and Interfacing

Submitted by Group No. 32

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PROBLEM STATEMENT

Problem No. 17: SMART AC SYSTEM

Description: This system opens/closes four AC vents based upon the current temperature in the Room. The temperature is maintained at a range of 16–35 ^{0}C. The AC vents can be gradually opened / closed. This is done in accordance with the temperature in the room. The room is a fairly large sized room so 4 temperature sensors are placed at different points of the room. Each sensor and AC vent is associated with part of the room. You can assume that the room is broken up into 4 sub-areas each with its own sensor and ac vent.

User Interface: LCD displaying Temperature in ^{0}C.
Single push button to vary temperature between 16^{0}C – 35^0 C.

The duration for which the system is ON can be set by the user in minutes ranging from 30 min. to 6 hours with a granularity of 30 min. Once the defined time has elapsed, the vents are closed.

ASSUMPTIONS

1. ALP is already stored in ROM in executable form.
2. The room is very big, so that the temperature of one part of room has no influence over the temperature of the other parts.
3. After system startup, the temperature of each part of the room varies between 16^{0}C – 35^0 C only.
4. When all AC vents are completely open, room temperature will be 16^{0}C and when all are completely closed, the room temperature will be 35^{0}C.
5. When the AC is switched off, all the vents are completely closed.
6. For each degree variation in temperature the stepper motor moves by 4 degrees.
7. The maximum angle stepper motor can be rotated is by 80 degrees.
8. When the microprocessor is switched on, its address is initialized to the starting address of the ROM.

SYSTEM DESCRIPTION

1. Intel 8086 microprocessor

2. **INPUT DEVICE:**
   i. 4 temperature sensors
   ii. 1 push button
   iii. 1 switch

3. OUTPUT DEVICES:
   i. LCD to display temperature
   ii. 4 motors to open/close AC vents (simulated via LEDs)

4. Two 8255 (Programmable Peripheral Interface) chips interfaced to 8086
   i. **8255-1:** Port-A is interfaced to the 8 data lines of LCD driverHD244780. Port-B is used for interfacing 8086 with the control lines of the LCD. PC0 is used to vary the mode of input (temperature/timer); PC1 is used for setting the values of time and temperature.
   ii. **8255-2:** Port-A takes input from ADC0808 which is interfaced with the 4 temperature sensors LM35.Port-B is used as an output port connected to the motors (LEDs). Port-C is used to select a particular sensor from which input is taken.

5. 8284 clock is used to generate clock signal for 8086. (8284 clock generator not used in proteus design.)

6. 8253 is used to generate stepped down time signals for the given problem statement making use of the clock signal from 8284.

HARDWARE DEVICES

CHIP NUMBER (No. of chips)	**CHIP**	**USE**
8086 (1)	Microprocessor	Central Processing Unit (C.P.U)
6116(2)	RAM-2K (Total-4K)	Random Access Memory containing DS and SS segments.
2732(2)	ROM-4K (Total-8K)	Read only Memory which contains the code.
74LS373(3)	8-BIT LATCH	To Latch the Address Bus.
74LS245(4)	8-BIT BUFFER (BIDIRECTIONAL)	To Buffer Data Bus
8255(2)	PROGRAMMABLE PERIPHERAL INTERFACE	Connected to Various Input/ Output Devices.
ADC0808(1)	ANALOG TO DIGITAL CONVERTER	CONVERTS ANALOG VOLTAGE SIGNAL V_{cc} TO DIGITAL FORM
8253(1)	CLOCK TIMER	TO KEEP THE TRACK OF TIME FOR WHICH THE PROCESSOR WILL WORK
LM020L (1)	LCD DISPLAY	FOR DISPLAYING TEMPERATURE AND TIME VALUES
LM 35(4)	TEMPERATURE SENSOR	TO PRODUCE ANALOG SIGNAL FOR THE TEMPERATURE IN ROOM
74154 (1)	4:16 DECODER	TO PRODUCE THE CHIP SELECT SIGNALS FOR I/O DEVICES
74138 (1)	3:8 DECODER	TO PRODUCE CHIP SELECT SIGNALS FOR ROM AND RAM
	LED-RED	TO SIMULATE THE OPENING AND CLOSING OF VENTS IN PROTEUS

MEMORY INTERFACING

This system uses 4KB of RAM (as 2x2KB chips for even and odd banks respectively) and 8KB of ROM (as 2x4KB chips for even and odd banks respectively). The memory is divided into even and odd banks because 8086 has a 16-bit data bus whereas memory is byte organized.

Random Access Memory (RAM) –6116

RAM1: 02000_H - $02FFF_H$

Even Bank: 02000_H - $02FFE_H$
Odd Bank: 02001_H – $02FFF_H$

	A_{19}	A_{18}	A_{17}	A_{16}	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
Start	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
End	0	0	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1

Read Only Memory (ROM) – 2732

ROM1: 00000_H - $01FFF_H$

Even Bank: 00000_H - $01FFE_H$

Odd Bank: 01001_H - $01FFF_H$

	A_{19}	A_{18}	A_{17}	A_{16}	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
Start	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
End	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1

I/O MAPPING

8255-A :

Serial No.	Port Name	Starting Address
1	Port A	10H
2	Port B	12H
3	Port C	14H
4	CR(Control Register)	16H

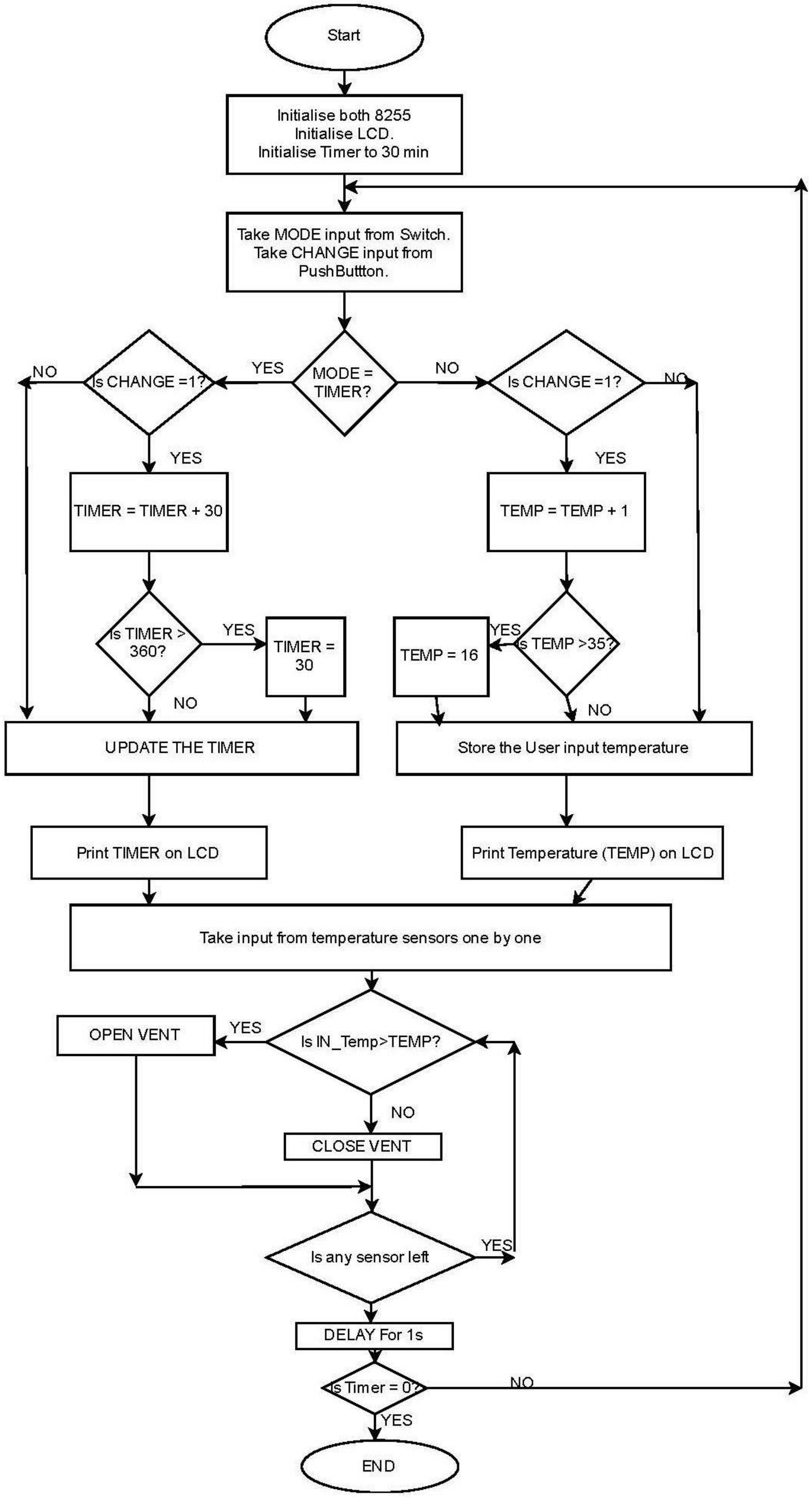
8255-B :

Serial No.	Port Name	Starting Address
1	Port A	20H
2	Port B	22H
3	Port C	24H
4	CR(Control Register)	26H

8253:

Serial No.	Port Name	Starting Address
1	COUNTER 1	30H
2	COUNTER 2	32H
3	COUNTER 3	34H
4	CR(Control Register)	36H

FLOWCHART


Start
Initialise both 8255
Initialise LCD.
Initialise Timer to 30 min
Take MODE input from Switch.
Take CHANGE input from
PushButtton.
MODE =
TIMER?
YES
NO
Is CHANGE =1?
NO
YES
Is CHANGE =1?
NO
YES
TIMER = TIMER + 30
TEMP = TEMP + 1
Is TIMER >
360?
YES
TIMER =
30
NO
TEMP = 16
YES
Is TEMP >35?
NO
UPDATE THE TIMER
Store the User input temperature
Print TIMER on LCD
Print Temperature (TEMP) on LCD
Take input from temperature sensors one by one
OPEN VENT
YES
Is IN_Temp>TEMP?
NO
CLOSE VENT
Is any sensor left
YES
DELAY For 1s
Is Timer = 0?
NO
YES
END

ALGORITHM

1. After booting, all vents are opened and the reference room temperature becomes 25^{0}C. The duration for which the system is ON has a granularity of 30 minutes.

2. The input mode of the switch has two options, either to set the temperature of the AC system or to set the duration for which the system is ON.

3. a) Corresponding to the timer mode, the user can set the duration for which the AC system is ON, ranging from 30 minutes to 6 hours (360 minutes). If the time to be set goes beyond 360, it runs back to 30 minutes.

   b) In the other mode, the temperature to be maintained is set, ranging from 16^{0}C to 35^{0}C by pressing the push button, one push increasing the temperature by 1^{0}C. The user has to set the switch, once he has completed setting the temperature.

4. The temperature as sensed by the sensor is updated after certain interval (approximately 1sec). This temperature is compared with the temperature required to be set. If the two are not same, the AC valve is opened or closed depending on the temperature difference.

5. The LCD displays the temperature which is set as well as the time duration for which the AC is ON, depending on the mode of the switch.

CODE

```
.MODEL tiny

.DATA                   ;DATA DECLARATIONS


                        ;TIMER-1 ADDRESS MAIN TIMER

CT0 EQU 30H

CT1 EQU 32H

CT2 EQU 34H

CRG EQU 36H


                        ; 8255-1 ADDRESS

PA1 EQU 10H

PB1 EQU 12H

PC1 EQU 14H

CA1 EQU 16H


                        ; 8255-2 ADDRESS

PA2 EQU 20H

PB2 EQU 22H

PC2 EQU 24H

CA2 EQU 26H
```

```
                            ; USER DATA
UTMP DB 25
TVAL DB 15
OPV  DB 00

.CODE
.STARTUP

                            ;INITIALIZING 8255-1
       MOV AL, 10001001B
       OUT CA1, AL

                            ;INITIALIZING 8255-2
       MOV AL, 90h
       OUT CA2, AL

       CALL LCD_INIT        ; INITIALIZING THE LCD

                            ; INITIALIZING THE MAIN TIMER
       MOV AL, 00110110B
       OUT CRG, AL

       MOV AL, 01110110B
       OUT CRG, AL
```

```
        MOV AL, 88H
        OUT CT0,AL
        MOV AL, 13H
        OUT CT0,AL

        MOV AL, 60H
        OUT CT1, AL
        MOV AL, 0EAH
        OUT CT1, AL

                        ;ENTERING TIME IN THE MAIN TIMER
        MOV AL, 10010100B
        OUT CRG, AL
        MOV AL, 15
        OUT CT2, AL

RPT1:
        IN AL, PC1
        AND AL, 03H
        ROR AL, 1
        JC TM1          ; JUMP TO TIMER MODE
        ROR AL, 1
        JC X1
        MOV AL, UTMP

        INC AL

        CMP AL, 35

        JLE X2

        MOV AL, 16

X2:

        MOV UTMP, AL

X1:

                                ; SHOW TEMPERATURE OUTPUT IN LCD

        CALL TEMP_WRITE

        JMP E1


                                ;TIMER MODE BEGINS FROM HERE

TM1:

        ROR AL, 1

        JC X3

        MOV AL, TVAL

        MOV AH, 00

        MOV BL, 15

        DIV BL

        MOV AH, 00

        MUL BL

        ADD AL, 15

        CMP AL, 195
        JNZ X4

        MOV AL, 15

X4:

        MOV TVAL, AL

                              ;ENTER TIME IN THE MAIN TIMER

        MOV AL, 10010100B

        OUT CRG, AL

        MOV AL, TVAL          ;MOVE THE MINUTES

        OUT CT2, AL

X3:

                              ;DISPLAY THE TIMER VALUE ON LCD

        CALL TIME_WRITE


E1:                           ;AFTER TIMER MODE


                              ;INPUT OF ROOM TEMPERATURE FROM TEMPERATURES SENSORS

                              ;AND TRANSFER IT TO AL

        MOV AL, 00            ;TEMPERATURE SENSOR 1

        CALL GET_TEMP


        CMP AL, UTMP

        JL TOK1

        MOV AL, OPV

        OR AL, 01
```

```
          MOV OPV, AL

          JMP TOK2

TOK1:

          MOV AL, OPV

          AND AL, 0FEH

          MOV OPV,AL

TOK2:


                                        ; TEMPERATURE SENSOR 2

          MOV AL, 01

          CALL GET_TEMP

          CMP AL, UTMP

          JL TOK3

          MOV AL, OPV

          OR AL, 02

          MOV OPV, AL

          JMP TOK4

TOK3:

          MOV AL, OPV

          AND AL, 0FDH

          MOV OPV,AL

TOK4:

                                        ; TEMPERATURE SENSOR 3

          MOV AL, 02
```

```
        CALL GET_TEMP

        CMP AL, UTMP

        JL TOK5

        MOV AL, OPV

        OR AL, 04

        MOV OPV, AL

        JMP TOK6

TOK5:

        MOV AL, OPV

        AND AL, 0FBH

        MOV OPV,AL

TOK6:

                                ; TEMPERATURE SENSOR 4

        MOV AL, 03

        CALL GET_TEMP

        CMP AL, UTMP

        JL TOK7

        MOV AL, OPV

        OR AL, 08

        MOV OPV, AL

        JMP TOK8

TOK7:

        MOV AL, OPV

        AND AL, 0F7H
```

```
            MOV OPV,AL;

TOK8:

            MOV AL, OPV

            OUT PB2, AL


   ;CALL DELAYX

            ; GET TIMER VAL

            ;IF ZERO REPEAT


            ;MOV AL,80H

            ;OUT CR2,AL

            ;IN AL, CT2

            ;CMP AL, 00

            ;JNZ RPT1


            JMP RPT1                ;GO BACK AND TAKE NEXT INPUT

                                    ;FROM USER


            INT 3H

.EXIT


DELAYX PROC


            MOV SI, 43690
```

```
        MOV BP, 43690
DELAY2:
        DEC BP
        NOP
        JNZ DELAY2
        DEC SI
        CMP SI,0
        JNZ DELAY2

        RET
DELAYX ENDP

GET_TEMP PROC

                                ;ASSUMING AL HAS THE ADDRESS OF SENSOR TO BE SELECTED
                 out            PC2, al

;give ale
     OR     al,00100000b
                 out    PC2,al

;give soc
     OR                 al,00110000b
                 out            PC2,al
```

```
                nop

                nop

                nop

                nop

;make ALE 0

                AND      al,11011111b

                out      PC2,al

;make SOC 0


                AND      al,11001111b

                out      PC2,al


RE1:

                      IN AL, PC1

                      AND AL, 04H

                      JZ      RE1



               OR                al,00001000b

               out               PC2, al

               in      al, PA2


RET
```

```
GET_TEMP ENDP




LCD_INIT PROC NEAR
        MOV AL, 38H                     ;INITIALIZE THE LCD FOR 2 LINES AND ALSO 5*7 MATRIX
        CALL COMNDWRT                           ;WRITE THE COMMAND TO LCD
        CALL DELAY                      ;WAIT BEFORE SENDING THE NEXT COMMAND
        MOV AL, 0EH                     ;SEND COMMAND FOR LCD ON, CURSOR ON
        CALL COMNDWRT
        CALL DELAY
        MOV AL, 01                      ;CLEAR THE LCD
        CALL COMNDWRT
        CALL DELAY
        MOV AL, 06                      ;COMMAND FOR SHIFTING CURSOR RIGHT
        CALL COMNDWRT
        CALL DELAY
        RET
LCD_INIT ENDP



DATWRIT PROC
        PUSH DX                         ;save DX
        MOV DX,PA1                      ;DX=port A address
```

```
          OUT DX, AL                          ;issue the char to LCD
          MOV AL, 00000101B                   ;RS=1, R/W=0, E=1 for H-to-L pulse
          MOV DX, PB1                         ;port B address
          OUT DX, AL                          ;make enable high
          MOV AL, 00000001B                   ;RS=1,R/W=0 and E=0 for H-to-L pulse
          OUT DX, AL
          POP DX
          RET
DATWRIT ENDP


COMNDWRT PROC                                           ;THIS PROCEDURE WRITES COMMANDS TO LCD
          MOV DX, PA1
          OUT DX, AL                          ;SEND THE CODE TO PORT A
          MOV DX, PB1
          MOV AL, 00000100B                   ;RS=0,R/W=0,E=1 FOR H-TO-L PULSE
          OUT DX, AL
          NOP
          NOP
          MOV AL, 00000000B                   ;RS=0,R/W=0,E=0 FOR H-TO-L PULSE
          OUT DX, AL
          RET
COMNDWRT ENDP
```

```
DELAY PROC
    MOV CX, 1325                        ;15.085*1325 USEC = 20 MSEC
    W1:
        NOP
        NOP
        NOP
        NOP
        NOP
    LOOP W1
    RET
DELAY ENDP

TEMP_WRITE PROC NEAR
    PUSH AX
    PUSH BX
    CALL CLS
    CALL DELAY                          ;WAIT BEFORE SENDING THE NEXT CHARACTER

    MOV BL, 10
    MOV AL, UTMP
    MOV AH,00
    DIV BL

    ADD AL, '0'                         ;DISPLAY TENS OF TEMP
```

```
        CALL DATWRIT                    ;SEND IT TO LCD
        CALL DELAY                      ;WAIT BEFORE SENDING THE NEXT CHARACTER

        MOV AL, AH
        ADD AL, '0'                     ;DISPLAY ONES OF TEMP
        CALL DATWRIT                    ;SEND IT TO LCD
        CALL DELAY                      ;WAIT BEFORE SENDING THE NEXT CHARACTER

        POP BX
        POP AX
        RET
TEMP_WRITE ENDP

TIME_WRITE PROC NEAR
        PUSH AX
        PUSH BX
        CALL CLS
        CALL DELAY                      ;WAIT BEFORE SENDING THE NEXT CHARACTER

        MOV BL, 10
        MOV AL, TVAL

        MOV AH,00
        ADD AX, AX
        DIV BL


        MOV BH, AH

        MOV AH,00

        DIV BL


        ADD AL, '0'                    ;DISPLAY HUNDREDS OF TEMP

        CALL DATWRIT                   ;SEND IT TO LCD

        CALL DELAY                     ;WAIT BEFORE SENDING THE NEXT CHARACTER


        MOV AL, AH

        ADD AL, '0'                    ;DISPLAY TENS OF TEMP

        CALL DATWRIT                   ;SEND IT TO LCD

        CALL DELAY                     ;WAIT BEFORE SENDING THE NEXT CHARACTER


        MOV AL, BH

        ADD AL, '0'                    ;DISPLAY ONES OF TEMP

        CALL DATWRIT                   ;SEND IT TO LCD

        CALL DELAY                     ;WAIT BEFORE SENDING THE NEXT CHARACTER


        POP BX

        POP AX

        RET

TIME_WRITE ENDP
```

```
CLS PROC

        MOV AL, 01                        ;CLEAR THE LCD

        CALL COMNDWRT

        CALL DELAY

        RET

CLS ENDP


END
```

CIRCUIT DIAGRAM : Included in the zip folder in pdf format.

REFERENCES

LM35 (Temperature sensor) (Device specifications)

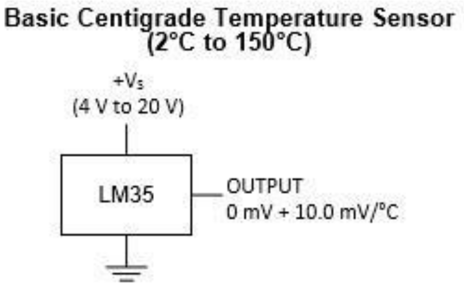
Range: -55^{o}C to 150^{o}C

Vin: 4V to 20V

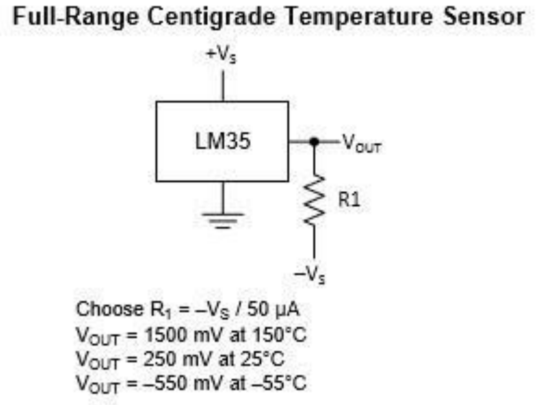
For 0^{o}C: OUTPUT = 0mV

Increment 10mV/^{o}C

(2.55 V/255)



Basic Centigrade Temperature Sensor (2°C to 150°C)



Full-Range Centigrade Temperature Sensor

Choose $R_1 = –V_S / 50\ \mu A$
V_{OUT} = 1500 mV at 150°C
V_{OUT} = 250 mV at 25°C
V_{OUT} = –550 mV at –55°C