DEPARTMENT OF COMPUTER OF SCIENCE & ENGINEERING
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MICROPROCESSOR & MICROCONTROLLER

LAB MANUAL

SOFTWARE PROGRAMS: PART –A

1. Design and develop an assembly language program to search a key element "X" in a list of 'n'

16-bit numbers. Adopt Binary search algorithm in your program for searching.

2. Design and develop an assembly program to sort a given set of 'n' 16-bit numbers in ascending order. Adopt Bubble Sort algorithm to sort given elements.

3. Develop an assembly language program to reverse a given string and verify whether it is a palindrome or not. Display the appropriate message.

4. Develop an assembly language program to compute nCr using recursive procedure. Assume that 'n' and 'r' are non-negative integers.

5. Design and develop an assembly language program to read the current time and Date from the system and display it in the standard format on the screen.

6. To write and simulate ARM assembly language programs for data transfer, arithmetic and logical operations (Demonstrate with the help of a suitable program).

7. To write and simulate C Programs for ARM microprocessor using KEIL (Demonstrate with the help of a suitable program)

HARDWARE PROGRAMS: PART –B

8. a. **Design and develop an assembly program to demonstrate BCD Up-Down Counter (00-99) on the Logic Controller Interface.**
b. Design and develop an assembly program to read the status of two 8-bit inputs (X & Y) from the Logic Controller Interface and display X*Y.

9 **Design and develop an assembly program to display messages "FIRE" and "HELP" alternately with flickering effects on a 7-segment display interface for a suitable period of time. Ensure a flashing rate that makes it easy to read both the messages (Examiner does not specify these delay values nor is it necessary for the student to compute these values).**

10. Design and develop an assembly program to drive a Stepper Motor interface and rotate the motor in specified direction (clockwise or counter-clockwise) by N steps (Direction and N are specified by the examiner). Introduce suitable delay between successive steps. (Any arbitrary value for the delay may be assumed by the student).

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11. Design and develop an assembly language program to

a. Generate the Sine Wave using DAC interface (The output of the DAC is to be displayed on the CRO).

b. Generate a Half Rectified Sine waveform using the DAC interface. (The output of the DAC is to be displayed on the CRO).

12. To interface LCD with ARM processor-- ARM7TDMI/LPC2148. Write and execute programs in C language for displaying text messages and numbers on LCD

13. To interface Stepper motor with ARM processor-- ARM7TDMI/LPC2148. Write a program to rotate stepper motor

Study Experiments:

1. Interfacing of temperature sensor with ARM freedom board (or any other ARM microprocessor board) and display temperature on LCD
2. To design ARM cortex based automatic number plate recognition system
3. To design ARM based power saving system

Course Outcomes: After studying this course, students will be able to

- Learn 80x86 instruction sets and gins the knowledge of how assembly language works.
- Design and implement programs written in 80x86 assembly language
- Know functioning of hardware devices and interfacing them to x86 family
- Choose processors for various kinds of applications.

Graduate Attributes

- Engineering Knowledge
- Problem Analysis
- Modern Tool Usage
- Conduct Investigations of Complex Problems
- Design/Development of Solutions

Conduction of Practical Examination:

- All laboratory experiments (all 7 + 6 nos) are to be included for practical examination.
- Students are allowed to pick one experiment from each of the lot.
- Strictly follow the instructions as printed on the cover page of answer script for breakup of marks
- PART –A: Procedure + Conduction + Viva: 10 + 25 +05 (40)
- PART –B: Procedure + Conduction + Viva: 10 + 25 +05 (40)
- Change of experiment is allowed only once and marks allotted to the procedure part to be made zero.

Steps to Edit a Program:

1. **Windows key + R**

2. Type command

3. CD\

4. CD Folder_Name

5. CD MASM

6. EDIT Filename.asm

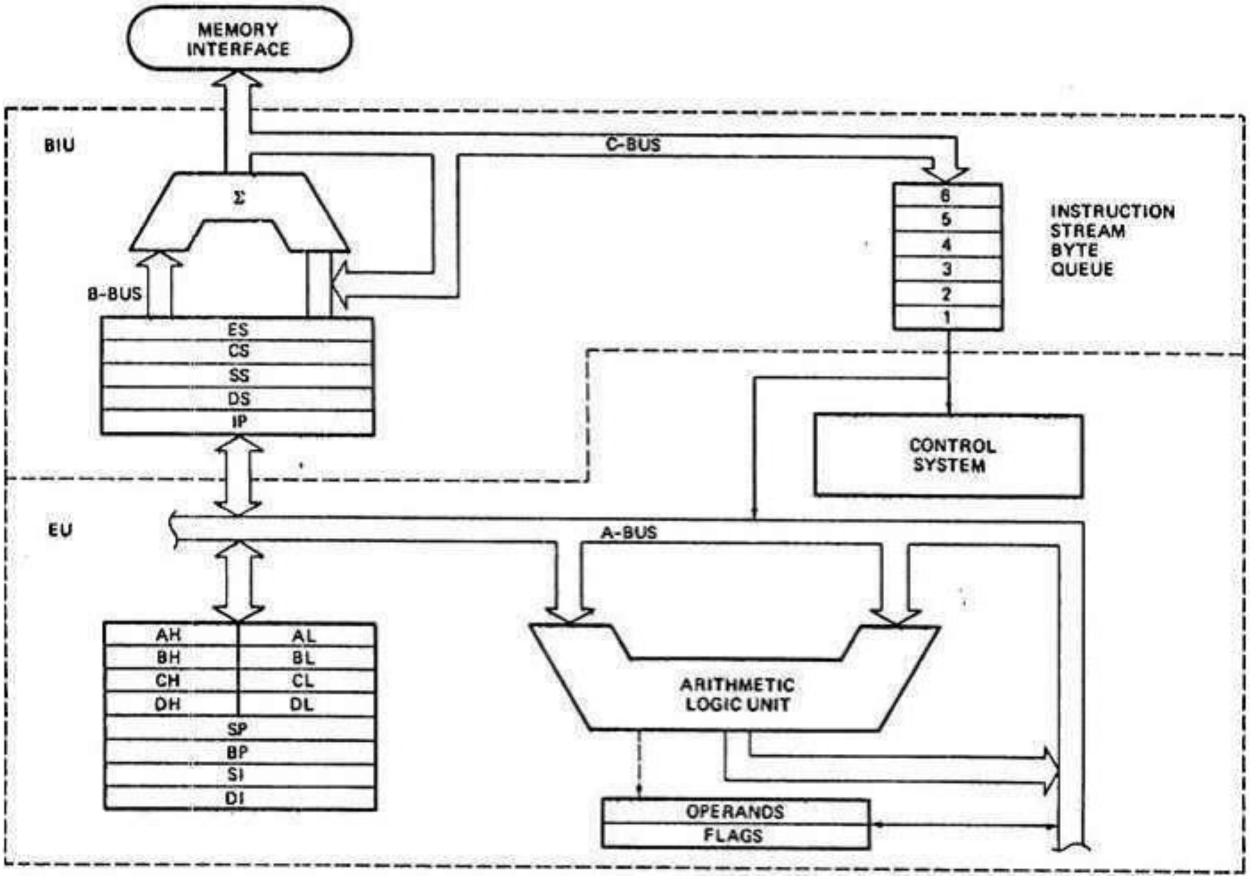
Commands to Run a Program

1. MASM   Filename.asm;

2. LINK   Filename.obj;

3. filename   (or) AFDEBUG filename

Architecture of 8086:



Internal structure of microprocessor is divided into two sections

1. Bus Interface unit (BIU)
2. Execution Unit (EU)

Bus interface unit: it accesses memory and peripherals.

Execution unit: It executes the instructions previously fetched.

Instruction Queue:

- It contains pre-fetched instructions.
- Instruction queue in 8088 in 4 bytes long
- Instruction queue in 8086 is 6 bytes long.
- Fetching next Instruction while current instruction is being executed is called **Pipelining.**

Registers:

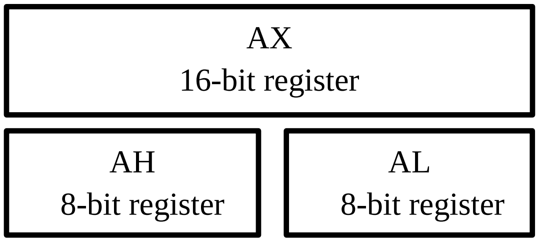
- In CPU, registers are used to store data temporarily.
- There are six types of registers in 8088/ 8086 as shown in below table.

Registers of 8088/ 8086 by category

Category	**Bits**	**Register Names**
General	16 8	AX, BX, CX, DX AH, AL, BH, BL, CH, CL, DH, DL
Pointer	16	SP (stack pointer), BP (Base Pointer)
Index	16	SI (source Index), DI (destination Index)
Segment	16	CS(code segment), DS (data segment) SS (stack segment),ES (extra segment)
Instruction	16	IP (instruction pointer)
Flag	16	FR (flag register)

General purpose registers:

- General purpose registers can be used as either 16-bit or 8-bit registers as shown below
- There are four general purpose registers AX, BX, CX, DX



AH-AL → AX register
BH-BL → BX register
CH-CL → CX register
DH-DL → DX register

AX (Accumulator):

- AX is used to store the results of the arithmetic and logic operations.

BX (Base Index register):

- BX register is used to hold the OFFSET address of DATA segment.
- BX is addressable as BH and BL

CX (counter):

- CX is used to hold the count for various instructions.

DX (data register):

- DX holds the part of the result from multiplication
- It holds the dividend for division

Segment Registers:

- Four segment registers in BIU are used to hold the upper 16 bits of the starting addresses of a Segment.

  CS, DS, ES, SS → Segment Registers.
- The segment will always start at an address with zero's in the lowest 4 bits.
- The part of the segment starting address stored in a segment register is often called Segment Base.

Instruction Pointer:

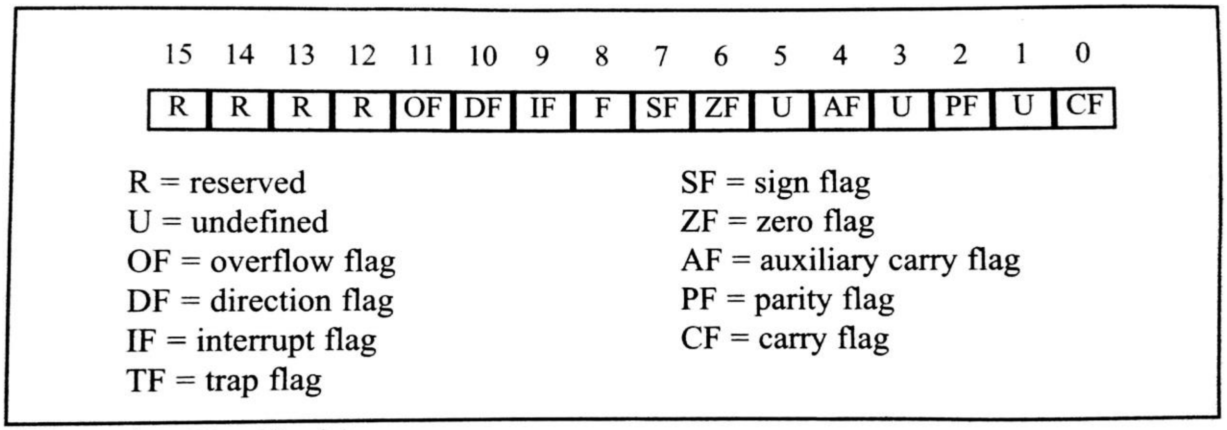
- The Instruction Pointer points to the next instruction

Pointer and Index registers:

- SP, BP, SI, DI are the different Pointer and Index Registers.
- These registers can be used for temporary storage of data just as the general purpose registers described above.
- However, their main use is to hold the 16-bit offset of a data word in one of these segments.

Flag register:

- A 16-bit flag register indicates some condition produced by the execution of an instruction or controls certain operations of the EU.
- It is a 16-bit register.
- It contains **9 active flags**.



15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
R	R	R	R	OF	DF	IF	F	SF	ZF	U	AF	U	PF	U	CF

R = reserved
U = undefined
OF = overflow flag
DF = direction flag
IF = interrupt flag
TF = trap flag

SF = sign flag
ZF = zero flag
AF = auxiliary carry flag
PF = parity flag
CF = carry flag

Figure 1-5. Flag Register

8086 flag register:

- 8086 MP has 16-bit flag register.
- It has six conditional flags and three control flags

Conditional flags:

The six conditional flags are

1. Carry flag (CF)
2. Parity flag (PF)
3. Auxiliary carry flag (AF)
4. Zero flag (ZF)
5. Sign flag (SF)
6. Overflow flag (OF)

Carry flag:

- Carry flag holds the carry after addition or the borrow after subtraction.
- It also indicates the error conditions.

Parity flag:

- Parity is the number of ones in a binary number expressed as even or odd.
- Parity flag is 0 for odd parity and logic 1 for even parity.

Auxiliary carry flag:

- Auxiliary carry flag holds the half carry after addition or the borrow after subtraction.

Zero flag:

- The Zero flag shows that the result of an arithmetic or logic operation is zero.
- If Z=1, the result is zero, if Z=0 the result is not zero.

Sign flag:

- The sign flag holds the sign of the result
- If S=1 the sign is negative, if S=0 the sign is positive.

Overflow flag:

- Overflow flag indicates that the result of arithmetic operation has exceeded the capacity of the machine.

Control flags:

The three control flags are

1. Trap flag (TF)
2. Interrupt flag (IF)

3. Direction flag (DF)

Trap flag:

- Trap flag enables debugging feature.
- If T=1 debugging is enabled, if T =0 debugging is disabled.

Interrupt flag:

- Interrupt flag controls the operation of interrupt request.
- If I =1, interrupt request is enabled, if T=0 interrupt request is disabled.

Direction flag:

- Direction flag selects either the increment or decrement mode for the DI and SI registers during string instructions.
- If D=1, the registers are automatically decremented, if D=0 the registers are automatically incremented.

Introduction to Assembly Language Programming:

A program that consists of 0s and 1s is called machine language, it is difficult to write programs in machine language, to make programming easier assembly language was developed.

Assembly language:

- Assembly language provides mnemonic for the machine codes.
- Assembly language programs must be translated into machine language by a program called Assembler.
- Assembly language is low-level language.
- To write programs in assembly language, programmer must know the number of registers and their size and other details of the CPU.

FORMAT of Assembly language instruction:

LABEL: Mnemonic Destination, source; comments

Label and comments are optional

Introduction to Program Segments:

An assembly language program has four segments

1. CODE Segment
2. DATA segment
3. STACK Segment
4. EXTRA segment

Code segment contains assembly language instructions

Data segment is used to store information (data)

Stack segment is used by CPU to store the data temporarily

Segments:

- In 8086, memory is divided into 16 segments.
- Each segment size is 64Kbytes.
- Starting of each segment ends with 0H e.g. 12340H
- Segment registers are used to hold upper 16-bits of the starting address of segment.

  e.g. if code segment starting address is 123F0H, CS holds 123FH

Physical Address:

- It is 20-bit address, it is an actual address of physical location in 1Mbyte memory.
- The range of physical address is 00000H-FFFFFH.

e.g. 12AC3H is 20-bit physical address

Offset Address:

- It is 16-bit address, it an address of location within 64-Kbyte segment.
- The range of Offset address is 0000H-FFFFH

  e.g. 12FFH is 16-bit offset address.

Logical address:

- It consists of segment value and an Offset address.

e.g. 1234H:0001H 1234H is segment value 0001H is offset address

Logical and physical address in Code segment:

- To execute an instruction, processor has to fetch an instruction from code segment.
- Logical address of an instruction always consists of a CS (code segment) and IP (instruction pointer) shown in CS: IP format.
- IP contains Offset address

Data Segment:

- In 8086 microprocessor, memory set aside for data is called Data segment.
- Data segment uses DS register and BX, SI, DI as Offset registers.
- Logical address of Data segment is shown as DS : OFFSET register

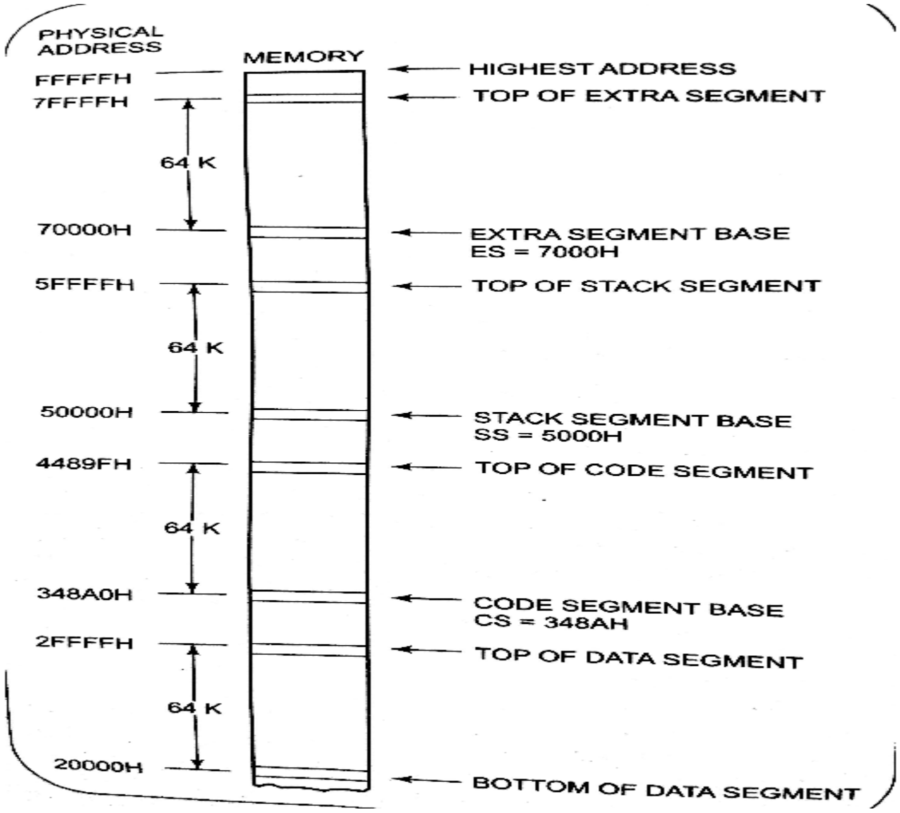
Segment registers:

At any given time 8086 works with only 4 segments, four segment registers are used to hold the 16-bits of starting addresses of four segments. The four segment registers are

1. Code segment register (CS)
2. Data segment register (DS)
3. Extra segment register (ES),
4. Stack segment register (SS)

Code segment register holds the starting address of the Code segment, DS register holds base address of data segment, ES register holds the base address of extra segment and SS register holds the base address of the stack segment.

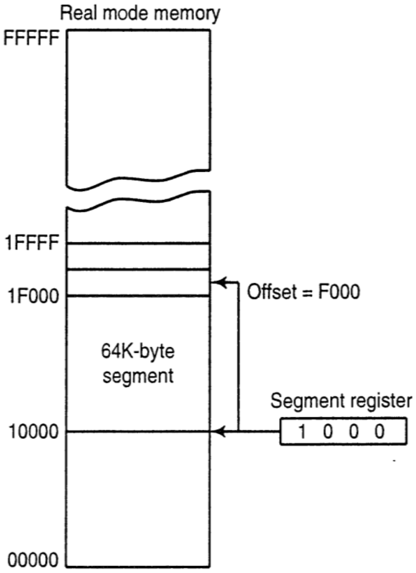
Figure below shows how these four segments are positioned in memory at any given time.



- OFFSET is the distance above the start of the segment.
- A combination of segment base address and OFFSET address is required to access memory location.
- In memory segmentation, if the beginning address of the segment is known the ending address is found by adding FFFFH.

Example : In the figure below segment address is 1000H and OFFSET is F000H,

20bit address = 1000H × 10H + F000H = 1F000H
1F000H is 20-bit address,



Model Definition:

- .Model is directive used to select the size of the memory.
- SMALL, MEDIUM, COMPACT, LARGE are the memory models.

e.g. .MODEL SMALL ; this directive defines memory model as SMALL

.MODEL MEDIUM ; in this memory model, data should fit in 64Kbytes , Code can exceed 64Kbytes
.MODEL COMPACT; data can exceed 64Kbytes, Code cannot exceed 64Kbytes
.MODEL SMALL; 64 Kbytes for Data , 64Kbytes for Code
.MODEL LARGE; both data and code can exceed 64Kbytes
.MODEL TINY; both data and code must fit in 64Kbytes

Segment Definition

- 8086 has four segment registers CS, DS, SS, ES
- Segment definition uses three directive .CODE, .DATA, .STACK.

.CODE → indicates beginning of code segment
.DATA →indicates beginning of data segment
.STACK →indicates beginning of stack segment

e..g .STACK 64 ; this directive reserves 64K bytes of memory for stack segment

Data Segment:

- In data segment, data items are declared
- Using directives DB, DW data items can be declared
- DB (Define Byte) declares data item of size byte
- DW(Define Word) declares data item of size word

Code segment:

- It is last segment in the program
- Instructions are written after .CODE directive

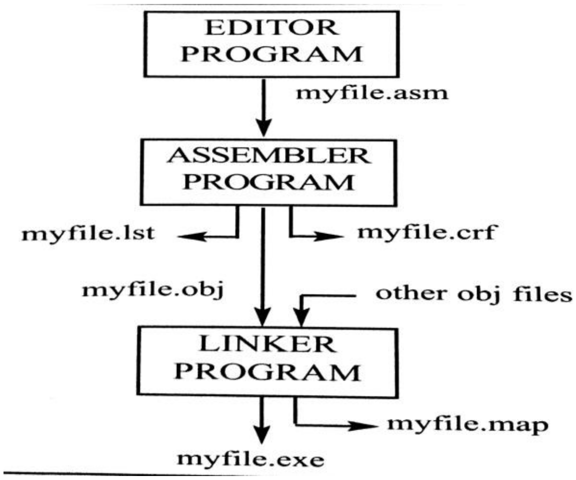
Sample program using model definition method

```
.MODEL SMALL
.DATA
MSG   DB  “RLJIT$”

.CODE
MOV   AX, @DATA
MOV   DS, AX
LEA DX, MSG
MOV AH,09H
INT 21H
END
```

Assemble Link and Run a program:

Three steps to create an executable assemble language program

1. Edit the Program
2. Assemble the program
3. Link the program



After editing the program, it must be assembled

Assembling the program:

- Translating assembly program to machine program is called assembling
- Assemble is the tool used for translation
- Assembler generates three files
    1. .ASM file
    2. .OBJ file
    3. .LST file
    4. .CRF file

.ASM file:

- it is a file created with editor

.OBJ file:

- **MASM** assembler converts .asm file (assembly language instructions) into .obj file (machine language instructions)

.**LST file:**

- This file is optional
- It lists all the opcodes and OFFSET addresses of instructions
- To get LIST file **TYPE FILENAME.lst | more**

Note: MASM assumes that list file is not wanted (NUL.LST indicates no list file)

CRF file (cross reference file):

- This file contains list of all symbols and labels used in the program as well as program line numbers in which they are specified.

Assembler directives (pseudo instructions):

- Assembler directives are the instructions to the assembler.
- Assembler directives are not translated into the machine language.
- Directives control the generation of machine code and organisation of the program.

Storing data in a memory segment:

The following directives are used to store data in a memory segment.

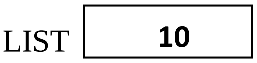
1. DB
2. DW
3. DD
4. DQ
5. DT

DB (define byte):

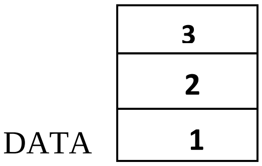
- It defines the variable of type BYTE.
- It reserves one or more byte locations in memory.

Format: **variable-name DB Initialization values**

E.g. LIST DB 10H; this statement reserves one byte location for a variable name LIST and initialize the value 10.



DATA DB 1, 2, 3; this statement reserves 3 byte locations and initialize the values 1,2, 3.



CHAR DB 'A'; this statement reserves 1 byte location and initialized with the ASCII Value of A.

NUM DB ? ; this statement reserves one byte location for variable NUM and not initialized.

DW (define word):

- It defines a variable of type word.
- Word (two bytes).
- It reserves one or more word locations in memory.

Format: variable-name DW initialization values

E.g. DATA DW 1234H; this statement reserves one word location and initializes the the value 1234H.

	12
DATA	34

DUP:

- It creates an array of size n.

```
e.g.    LIST    DB     10 DUP (?)      → reserves 10 byte locations

        DATA    DW     100  DUP (0)    → reserve 100 word locations and
                                         initializes with 0
```

EQU:

- This directive equates the constant value to the label.
- Each time the assembler finds the label in the program, it will replace the name with the value equated to that label.

```
e.g.          TEN       EQU    10
              NINE      EQU     9
```

Instruction Set:

MOV:

- It copies data from one location to another

Format: MOV Destination, Source ; copy source operand to destination

The above instructions moves source operand to destination, MOV is Mnemonic for Move operation.

```
e..g MOV   AX, BX; it moves BX value to AX
      MOV  CL, 55H; it moves 55H to CL
     MOV   CH, BH ; it moves BH value to CH
     MOV   AX, 1234H; it moves 1234H to AX
```

ADD Instruction:

This instruction adds the source and destination operands and puts the result in destination.

Format: ADD Destination, Source

Operation: Destination = source + destination

E.g. write instructions to add 25H and 34H, move numbers to any registers and then add together

```
MOV   AL, 25H;        AL = 25H
MOV   BL, 34H;        BL=34H
ADD   AL, BL;         AL = 59H (25H + 34H)
```

SUB:

- It subtracts the source from the destination and places result in the destination

Syntax: SUB destination, source

Operation: destination = destination – source

Multiplication:

1. BYTE × BYTE
2. WORD × WORD

BYTE × BYTE:

- In byte × byte multiplication, multiplicand must be in AL register and the second operand can be either in 8-bit register or 8-bit memory location and result will be stored in AX

Syntax: MUL 8-bit register / memory location

Operation : AX = AL × 8-bit register/ memory location

e.g.1	MUL BL AX= AL × BL	e.g.2 MUL NUM2 AX = AL × NUM2

WORD × WORD:

- In word×word multiplication, multiplicand must be in AX and multiplier can be in any 16-bit register or memory location and result will be stored in DX:AX
- DX contains higher word of the result and AX contains lower word of the result.

Syntax: MUL 16-bit register/memory location

DX:AX = AX * 16-bit register /memory location

e.g.1 MUL BX e.g.2 MUL WORD PTR [BX]

DX:AX = AX * BX DX:AX = AX * [BX]

[BX] is 16-bit memory location

Division of unsigned numbers:

1. Byte over byte
2. Word over word
3. Word over byte

Byte / Byte division:

- In byte / byte division, numerator (dividend) must be in AL register and AH must be zero.
- The denominator (divisor) can be in any 8-bit register or memory location
- After division, quotient will be in AL and remainder will be in AH

Syntax: DIV 8-bit register / memory location

e.g. DIV BL; AX / BL AL = quotient AH =remainder

Word/Word Division:

- In Word/Word division, numerator (dividend) is in AX and DX must be zero
- Denominator (divisor) can be in any 16-bit register or memory location
- After division, AX contains quotient, and DX contains remainder

Syntax: DIV 16-bit register / memory location

```
e.g.      MOV   AX,9000
          MOV   DX,0
          MOV   BX,100
          DIV   BX;          DX:AX/BX → 9000/ 100   AX=90   DX=0
```

Word/Byte:

- Dividend is in AX, divisor in any 8-bit register or memory location
- After division, AL contains quotient AH contains remainder

e.g. DIV BL ; AX/BL AL = quotient AH = remainder

Logic instructions:

AND:

- This instruction performs AND operation on source and destination and stores result in Destination.
- AND instruction automatically changes CF and OF to zero and PF, ZF and SF are set according to result.

Syntax: AND Destination, Source

Function: destination = destination **AND** Source

e.g. AND AL, BL ; AL = AL **AND** BL

OR:

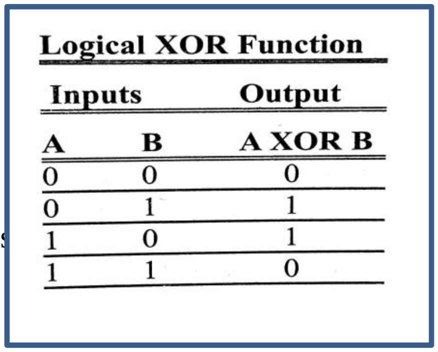
- This instruction performs OR operation on destination and source and stores result in destination.
- OR instruction automatically changes CF and OF to zero and PF, ZF and SF are set according to result.

XOR:

- It performs exclusive-OR operation on destination and source and stores result in destination.
- XOR instruction clears CF and OF and SF, OF, PF are set according to the result.

Syntax: XOR destination, source

Functions: destination = destination XOR Source



Logical XOR Function

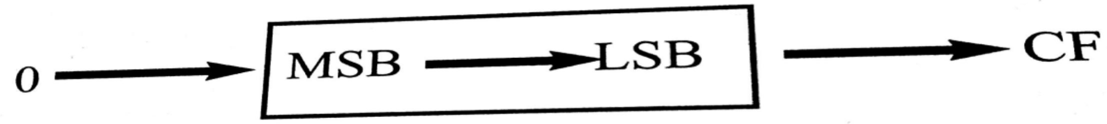
Inputs		Output
A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

SHR:

- SHR shifts the contents of the destination right by the number of bits count
- LSB bit is shifted to carry flag (CF)
- Zero is shifted to MSB
- If count is greater than 1, count should be in CL

Syntax: SHR destination, count

Operation:



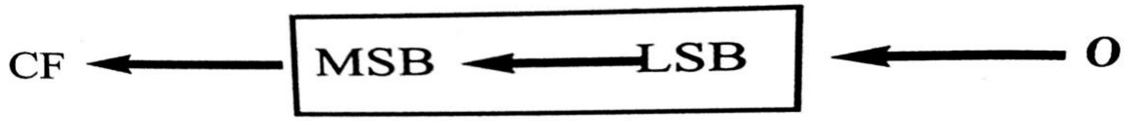
e.g. SHR AL, 1 ; the contents of AL are shifted left by one position

SHL:

- SHR shifts the contents of the destination Left by the number of bits specified in the count
- MSB bit is shifted to carry flag (CF)
- Zero is shifted to LSB
- If count is greater than 1, count should be in CL

Syntax: SHL destination, count

Operation:

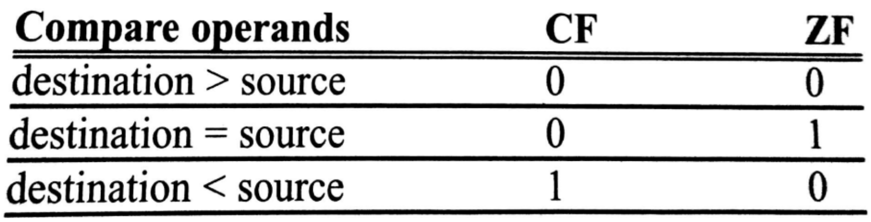


e.g SHL AL,1 ; contents of AL are shifted left by one position

CMP (compare):

- This instruction compares destination and source and changes flags CF, SF, ZF according to the result.
- Destination can be any register or memory location
- Source can be any register or memory location or immediate data.

Table 3-3: Flag Settings for Compare Instruction



Compare operands	CF	ZF
destination > source	0	0
destination = source	0	1
destination < source	1	0

Syntax: CMP Destination, Source
Operation: destination – source
Flags affected: CF, SF, ZF

Rotate Instructions:

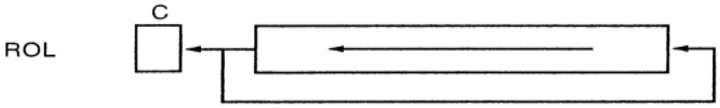
- Rotate instructions rotate the bits of any register or memory location from one end to another or through the carry.
- There are four types of rotate instructions
    1. Rotate left (ROL)
    2. Rotate Right (ROR)
    3. Rotate through carry left (RCL)
    4. Rotate through carry Right (RCR)

ROL (Rotate left):

- This instruction rotates the contents of destination left by the number of bits specified in the count.
- MSB bits are rotated into the right most bit (LSB) and into the carry flag (CF).
- If count is more than 1, CL must contain count.

Syntax: ROL Destination,Count

Operation:



e.g. MOV BH,72H ; BH=0111 0010

ROL BH,1 ; CF=0 BH = 1110 0100

To rotate the contents of BH by 4 positions, instructions are

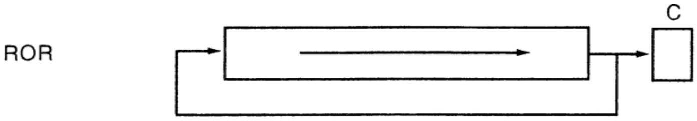
```
MOV     BH, 72H;            BH = 0111 0010
MOV     CL, 4                CL=4  number of times to rotate
 ROL    BH, CL        CF=1   BH = 0010  0111
```

ROR (Rotate Right):

- This instruction rotates the contents of destination right by the number of bits specified in the count.
- LSB bits are rotated into the left most bit (MSB) and into the carry flag (CF).
- If count is more than 1, CL must contain count.

Syntax: ROR Destination, Count

Operation:



e.g. MOV AL, 36H; AL = 0011 0110

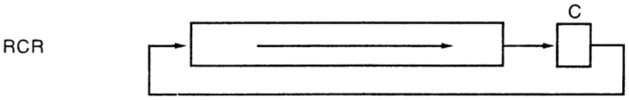
ROR AL,1 AL = 0001 1011 CF=0

RCR (Rotate right through carry):

- This instruction rotates the contents of the destination right through carry flag bit by the number of positions specified in the count.
- LSB bit is shifted into CF, and CF bit is shifted to MSB bit.
- If count is more than 1, CL must contain count.

Syntax: RCR Destination, Count

Operation:



e.g. MOV AL,06H ; AL = 0000 0110 CF=1

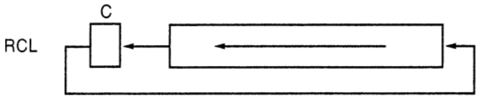
RCR AL,1 ; AL = 1000 0011 CF=0

RCL (Rotate Left through Carry):

- This instruction rotates the contents of the destination left through carry flag bit by the number of positions specified in the count.
- MSB bit is shifted into CF, and CF bit is shifted to LSB bit.
- If count is more than 1, CL must contain count.

Syntax: RCL Destination, Count

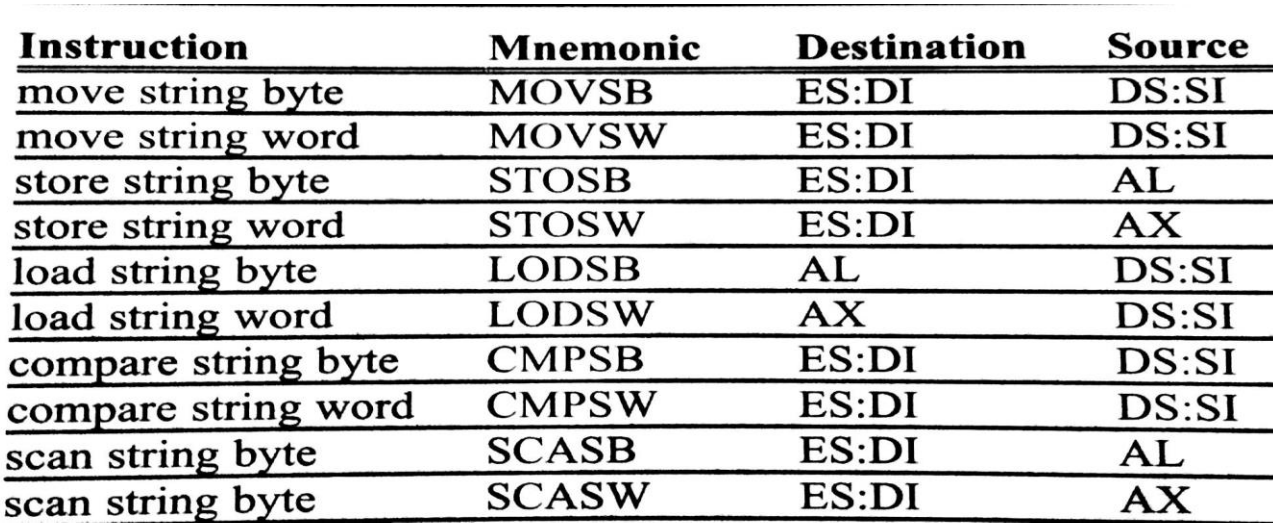
Operation:



e.g. MOV AL, 90H; CF=0 AL = 1001 0000
RCL AL,1 CF=1 AL= 0010 0000

String Instructions:

There is a group of instructions to perform operations on strings



Instruction	Mnemonic	Destination	Source
move string byte	MOVSB	ES:DI	DS:SI
move string word	MOVSW	ES:DI	DS:SI
store string byte	STOSB	ES:DI	AL
store string word	STOSW	ES:DI	AX
load string byte	LODSB	AL	DS:SI
load string word	LODSW	AX	DS:SI
compare string byte	CMPSB	ES:DI	DS:SI
compare string word	CMPSW	ES:DI	DS:SI
scan string byte	SCASB	ES:DI	AL
scan string byte	SCASW	ES:DI	AX

SI, DI Registers:

- SI and DI registers ae used by string instructions
- When DF =0 SI and DI automatically increment
- WHEN DF=1 SI and DI automatically decrement.

CLD (clear direction Flag): this instruction is used to clear the direction flag DF=0
STD (set direction flag): this instruction is used to set direction flag DF=1

REPE (repeat while equal) or REPZ (repeat while zero) :

- The REPE prefix is used for string instruction.
- **REPE** causes the string instruction to repeat until CX register reaches 0 or until unequal condition occurs (ZF=0)

REPNE (repeat while not equal) or REPNZ (repeat while not zero) :

- The REPNE prefix is used for string instruction.
- **REPNE** causes the string instruction to repeat until CX register reaches 0 or until equal condition occurs (ZF=1).

CMPSB (compare string byte):

- This instruction compares the byte in memory location (DS; SI) with the byte in memory location (ES:DI).
- It performs subtraction of the byte in ES:DI from the byte in DS:SI.
- CMPSB is normally used with REPE or REPNE prefix.

Syntax: CMPSB

Function: flags ← DS:SI – ES : DI; SI = SI ± 1; DI = DI ± 1

Flags affected: AF, CF, OF, PF, SF, ZF

Example: write a program to compare the string of length 10 in the Data Segment with the string of length 10 in the Extra Segment.

```
MOV    SI, OFFSET   STR1
MOV     DI, OFFSET STR2
CLD     this instruction is used to clear the direction flag DF=0,When DF =0  SI and DI automatically increment
MOV     CX, 10
REPE  CMPSB
```

1.Clearing the Screen using INT 10H function 06H:

The instructions to clear the screen are

```
MOV   AH,06H        ;AH=06H TO Select scroll Function
MOV   AL,00H        ;AL=00 TO Clear entire screen
MOV   BH,07         ;BH=07 Is normal attribute (white on black)
MOV   CH,00         ;CH=00 row value of start point (Upper left corner)
MOV   CL,00         ;CL=00 column value of start point
MOV   DH,24         ;DH=24 row value of end point (Lower right corner)
MOV   DL,79         ;DL=79 column value of end point
INT   10H           ;CALL BIOS interrupt
```

2.Setting the Cursor Position to a Specific Location INT 10H Function 02H:

Instructions to set the cursor position are

```
MOV   AH,02H
MOV   BH,PAGE NUMBER(0-5)
MOV   DH,ROW NUMBER(00-24)
MOV   DL,COL NUMBER(00-79)
INT   10H
```

Example: Write a code to set cursor position at ROW=15 and column = 25

```
MOV   AH,02H
MOV   BH,0            ;PAGE 0
MOV   DH,15
MOV   DL,25
INT   10H
```

Program: Write a program that 1)clears the screen 2) set cursor at center of the screen

```
;To Clear the Screen
MOV   AH,06H
MOV   AL,00
MOV   CH,00
MOV   CL,00
MOV   DH,24
MOV   DL,79
INT   10H
;Setting the cursor at center of the screen
MOV   AH,02H
MOV   BH,00           ; page  0
MOV   DH,12           ;12 row
MOV   DL,39           ;39 column
INT   10H             ;call BIOS interrupt
```

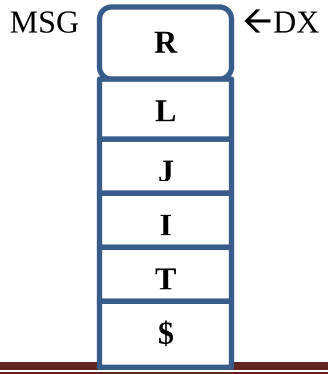
1. Outputting a String of Data to monitor INT   21H Function 09H

Instructions to display the string of data on monitor

```
        MOV   AH,09H
        MOV   DX, OFFSET address of string
        INT   21H;
```

e.g. Write a code to Display string “welcome to RLJIT”

```
MSG    DB   “ Welcome to RLJIT$”


MOV   AH,09H
MOV   DX, OFFSET MSG or LEA DX, MSG
INT   21H
```



2. Outputting a single character on monitor INT 21H Function 02H

Instructions to display a character

```
MOV   AH,02H
MOV   AL, Character to be displayed
INT   21H
```

E.g. Write a Code to Display a character ‘J’

```
MOV   AH,02H
MOV   AL,’J’
INT   21H
```

3. Inputting a Single Character with ECHO

Instructions:

```
MOV   AH,01H
INT   21H
```

After reading a character from keyboard, it will be stored in AL

4. Inputting a single character without Echo

Instructions:

```
MOV   AH,07H
INT   21H;
```

After reading a character from keyboard, it will be stored in AL

5. Inputting a String of Data from keyboard INT 21H Function 0AH

Steps:

1. Set AH=0AH
2. DX=OFFSET address at which the string of data is stored (buffer area)
3. First byte in buffer contains size of the buffer
4. Second byte contains the length of the string
5. String will be stored from the third byte

Instructions:

```
MOV   AH,0AH
MOV   DX, OFFSET Variable-Name
INT   21H
```

Carriage Return & Line Feed:

- Carriage Return & Line Feed are two ASCII characters
- ASCII of Carriage return = 13 or 0DH
- ASCII of Line Feed = 10 or 0AH
- Carriage return character returns a cursor to the beginning of current Line
- Line feed character moves cursor to next line.

8255 Programmable peripheral Interface:

- The 8255 is a popular interfacing component, that can interface any I/O device to a microprocessor.
- The parallel input-output port chip 8255 is also called as programmable *peripheral input-output port.*

8255 Features:

- The 8255 is a 40-pin chip.
- It has three ports.
- The ports are each 8-bit and are named A,B and C.
- The individual ports of the 8255 can be programmed to be input or output.

PA0-PA7:

The 8-bit port A can be programmed as all input, or as all output or all bits as bidirectional port.

PB0-PB7:

- The 8-bit port B can be programmed as all input or as all output.
- Port B cannot be used as a bidirectional port.

PC0-PC7:

- This 8 bit-port C can be all input or all output.
- It can also be split into two parts, CU (upper bits PC7-PC4) and CL (Lower bits PC3-PC0).
- In addition, any of bits PC0-PC7 can be programmed individually.
- D0-D7 data pin:
- The data pins of the 8255 are connected to the data pins of the microprocessor allowing it to send data back and forth between the microprocessor and the 8255 chip.

Mode selection of the 8255:

- The ports of the 8255 can be programmed in three different modes.

  1) Mode 0
  2) Mode 1
  3) Mode 2

Programming the 8255:

- **8255** is programmed through the internal command register.
- Command register is 8-bits wide.
- 8255 operates in two different modes.

  1. I/O mode
  2. BSR (bit set / reset mode)

I/O MODE:

Under the I/O mode of operation, further there are three modes of operation of 8255

Mode 0:

- In this mode, any of the ports A,B, CL and CU can be programmed as input or output.

- In this mode, all bits are out or all in.

Mode 1:

- In this mode, ports A and B can be used as input or output ports with handshaking capabilities.
- Handshaking signals are provided by the bits of port C.

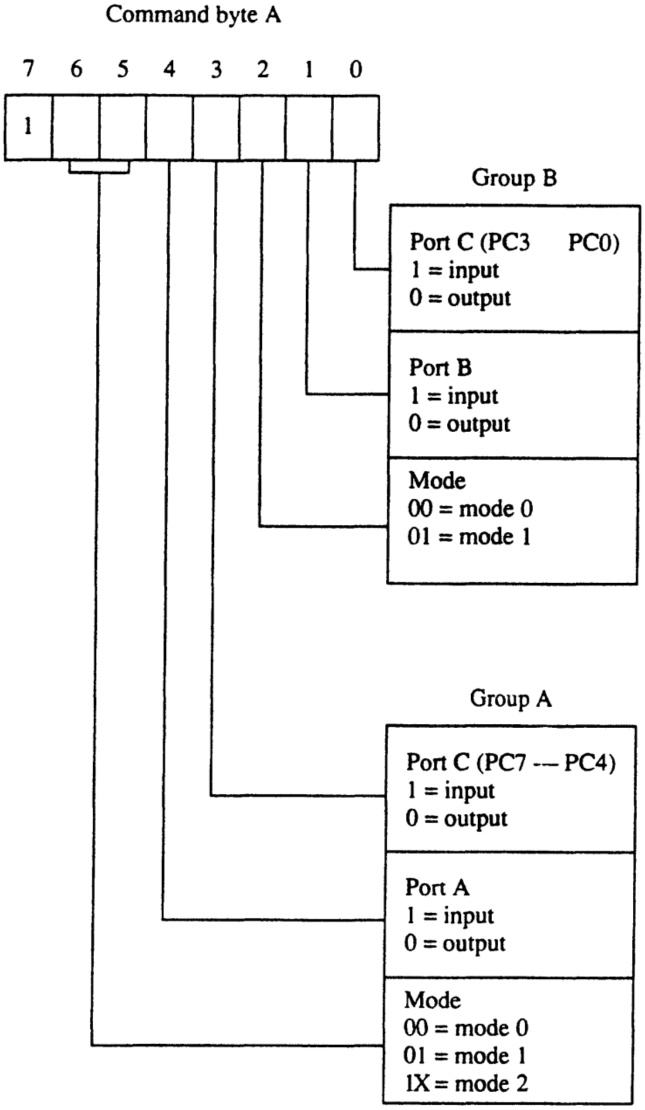
Mode 2:

- In this mode, port A can be used as bidirectional port with handshaking capabilities whose signals are provided by port C.

BSR (bit set/reset) mode:

- In BSR mode only port C ($PC_0 – PC_7$) can be used to set or reset its individual port bits.

FIGURE 10–15 The command byte of the command register in the 82C55. (a) Programs ports A, B, and C (b) Sets or resets the bit indicated in the select a bit field



1. **Design and develop an assembly language program to search a key element “X” in a list of ‘n’ 16-bit numbers. Adopt binary search algorithm in your program for searching.**

Program:

```
.MODEL  SMALL

.DATA

ARR       DW      1,2,3,4,5,6,7
LEN       DW      ($-ARR)/2
MSG1      DB      "KEY IS FOUND$"
MSG2      DB      "KEY IS NOT FOUND$"
X         DW        6

.CODE
MOV     AX,@DATA
MOV     DS,AX
MOV      SI,0000H   ;     SI  is LOW
MOV      DI,LEN
ADD      DI,DI
SUB      DI,2      ;        DI is HiGH
RPT:  CMP   SI,DI ;      Comparing    SI with  DI
      JA       KNF       ; IF  SI  >  DI   jump to KNF
      MOV    AX,X ;      AX= key
      MOV    BX,SI       ;BX (MID) =    (SI +  DI )/2
      ADD     BX,DI
      SHR      BX,1
      CMP     AX,ARR[BX] ; Comparing    AX (KEY) With middle element ARR[BX]
      JE      KF              ;   if  key = middle element   jump to KF
      JB      NEXT            ;    if  KEY <  middle element  jump to NEXT
      MOV    SI,BX          ;    if  KEY > middle element  low (SI) =  mid (bx)+2
      ADD      SI,2
      JMP      RPT

NEXT:MOV    DI,BX   ;      if key < mid element    high (di)= mid (bx)-2
       SUB  DI,2
        JMP   RPT
```

```
.MODEL  SMALL
.DATA
   ARR  DW 1,2,3,4
   LEN  DW ($-ARR)/2 ;total 14 bytes ie 14/2 ie 7 elements
   MSG1 DB "KEY IS FOUND$"
   MSG2 DB "KEY IS NOT FOUND$"
   X    DW 4                    ; Key to search

.CODE
   MAIN PROC
            MOV AX, @DATA
            MOV DS, AX

            ;setting SI as low ptr
            MOV SI, 0H
            ;setting DI as high ptr
            MOV CX, LEN       ; now CX has 7
            DEC CX           ; now CX has 6 ie last idx in array for "us"
            SHL CX, 1         ; now CS has 12 ie last idx in array for "memory"
since we r using 2 byte numbers
            MOV DI, CX        ; DI now points to last idx of array

   SEARCH_LOOP:
            CMP SI, DI
            JA  NOT_FOUND      ; If SI > DI, key not found, JA means Jump if
greater

            ; calculate mid ptr
            MOV BX, SI
            ADD BX, DI
            SHR BX, 1         ; BX = (SI + DI)/2 (word offset), BX now has mid ptr

            MOV AX, X
            CMP AX, ARR[BX]   ; Compare key with middle element
            JE  FOUND         ; JE means jump if equal
            JB  LESS_THAN     ; If key < ARR[BX], search left, JB means jump
is less
            JA  MORE_THAN

   MORE_THAN:
            MOV SI, BX
            ADD SI, 2         ; SI = mid + 1 (word offset)
            JMP SEARCH_LOOP

   LESS_THAN:
            MOV DI, BX
            SUB DI, 2         ; DI = mid - 1 (word offset)
            JMP SEARCH_LOOP

   FOUND:
            LEA DX, MSG1
            MOV AH, 09H
            INT 21H
            JMP EXIT

   NOT_FOUND:
            LEA DX, MSG2
            MOV AH, 09H
            INT 21H
            JMP EXIT

   EXIT:
            MOV AH, 4CH
            INT 21H
MAIN ENDP
END MAIN
```

```
  KF:  LEA     DX,MSG1   ;    display the message "KEY is found"
       MOV    AH,09H
       INT    21H
       JMP   EXIT     ;          jump  to exit

KNF:LEA    DX,MSG2;     display the message  "key is not found"
      MOV   AH,09H
       INT    21H

 EXIT: MOV   AH,4CH
           INT  21H
   END
```

Output: **KEY IS FOUND**

2. **Design and develop an assembly program to sort a given set of 'n' 16-bit numbers in ascending order. Adopt Bubble sort algorithm to sort given elements.**

Program:

```
.MODEL  SMALL
.DATA
ARR    DW    0005H,0004H,0003H,0002H,0001H
LEN    DB     ($-ARR)/2
.CODE
MOV    AX,@DATA
MOV    DS,AX
MOV    CL,LEN
DEC     CL
LOOP2:MOV   SI, OFFSET   ARR
            MOV    BL,CL
LOOP1:MOV   AX,[SI]   ;  move first element to AX
            ADD    SI,2          ;    use SI as pointer to second element
            CMP   AX,[SI]      ;  compare first element and second element
             JB     NEXT          ;        if first element < second element jump to next
           MOV     DX,[SI]    ;     SWAP  Logic      mov  second element to DX
           MOV     [SI],AX    ;     mov  first element to second position
           MOV    [SI-2],DX ;     mov   second element to first position
NEXT:  DEC  BL    ;    decrement no of comparisons
           JNZ   LOOP1
```

```
.MODEL  SMALL
.DATA
   ARR  DW  0004H,0003H,0003H,0002H,0001H
   LEN  EQU ($-ARR)/2
.CODE
MAIN PROC
       MOV AX,@DATA
       MOV DS,AX

       MOV CL, LEN-1

   LOOP2:
       MOV SI, OFFSET ARR
       MOV BL, LEN-1
   LOOP1:
       MOV AX, [SI]         ; move first element to AX
       CMP AX, [SI+2]        ; compare with next element
       JB  NEXT            ; if AX < [SI+2], no swap
       JA SWAP              ; else swap
   SWAP:
       MOV DX, [SI+2]        ; swap logic
       MOV [SI+2], AX
       MOV [SI], DX
   NEXT:
       ADD SI, 2           ; move to next pair
       DEC BL              ; decrement comparison count
       JNZ LOOP1
       DEC CL              ; decrement pass count
       JNZ LOOP2
       INT 3
MAIN ENDP
END MAIN
```

```
        DEC    CL        ;    decrement no of passes
        JNZ    LOOP2
        INT  3
END
```

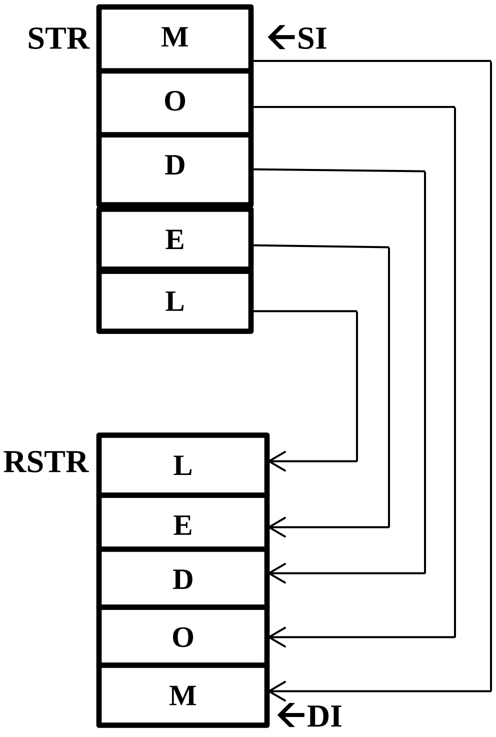
Output:

```
   Before Sorting: 000A  000B  000C  000D  000E  000F  0010  0011  0012  0013
                    05    00    04    00    03    00    02    00    01    00
   After Sorting:   01    00    02    00    03    00    04    00    05    00
```

3. Develop an assembly program to reverse a given string and verify whether it is a palindrome or not. Display appropriate message

Program:

```
.MODEL   SMALL
.DATA
STR        DB     "MODEL"
LEN        EQU    $-1-STR
RSTR       DB  10 DUP('$')
MSG        DB    "Reverse string is:$"
MSG1       DB     "String is Palindrome$"
MSG2       DB     "String is Not Palindrome$"

.CODE
MOV     AX,@DATA
MOV     DS,AX
MOV     ES,AX

LEA      SI,STR                ; SI points to STR
LEA      DI,RSTR               ; DI points to RSTR
ADD      DI,LEN-1              ; adds DI and LEN-1
MOV      CX,LEN                ; moves LEN to CX

RPT:MOV     AL,[SI]            ;moves the character pointed by SI to AL
      MOV     [DI],AL          ;moves AL value to location pointed by DI
      INC     SI               ; increment SI to point to next character
      DEC     DI               ; decrement DI to move next character
      LOOP    RPT              ; jumps back to RPT if CX≠0
```



```
LEA      DX, STR
MOV      AH,09H
INT       21H
LEA       DX,MSG
MOV       AH,09H
INT        21H
LEA        DX,RSTR
MOV       AH,09H
INT        21H
LEA      SI,STR                ; SI points to STR
LEA      DI,RSTR               ; DI points to RSTR
MOV     CX,LEN                 ; moves LEN to CX
REPE    CMPSB                  ; Compares [SI] and [DI] and repeats if CX≠0 and ZF=1
JNE      NOTPAL                ;  jumps to NOTPAL when unequal condition occurs
LEA      DX,MSG1               ; display the message “string is palindrome”
MOV     AH,09H
INT       21H
JMP      EXIT

NOTPAL:LEA     DX,MSG2 ; displays the message “string is not palindrome”
          MOV   AH,09H
          INT     21H

EXIT:MOV    AH,4CH             ; Exit to DOS
       INT      21H
       END
```

Output:

MODEL

Reverse String is: LEDOM

String is not Palindrome

4. Develop an assembly language program to compute N_{Cr} using recursive procedure. Assume that ‘n’ and ‘r’ are non-negative integers.

Program:

```
MODEL SMALL

.DATA

            N         DW      6
            R         DW      2
            NCR    DW      0
.CODE

            MOV        AX, @DATA
            MOV         DS, AX
            MOV        AX, N
            MOV        BX, R
            CALL     NCR_PROC
            MOV       AH, 4CH
            INT         21H
ncr_proc      proc

            CMP      AX, BX                  ; Compare r and n
              JZ      N1                     ; If equAL ADD 1 to result
            CMP      BX, 0                   ; If no, check if r = 0
               JZ      N1                    ; If yes, ADD 1 to result
            CMP      BX, 1                   ; If no, check if r = 1
              JZ      N2                     ; If yes, ADD n to result
            MOV      CX, AX
             DEC      CX
            CMP      CX,BX                   ; If no, check if r = n-1
            JZ      N2                       ; If yes, ADD n to result
            PUSH     AX                      ; Save n
            PUSH      BX                     ; Save r
            DEC     AX                       ; Compute n-1
            CALL      ncr_proc               ; CALL ncr_proc
            POP     BX                       ; Restore r
            POP   AX                         ; Restore n
            DEC    AX                        ; Compute n-1
            DEC    BX                        ; Compute r-1
            CALL      ncr_proc               ; CALL ncr_proc
            JMP     LAST
```

LOGIC

$NC_r = (N-1)C_r + (N-1)C_{(r-1)}$

If r = 0 (OR) r = N then $NC_r = 1$

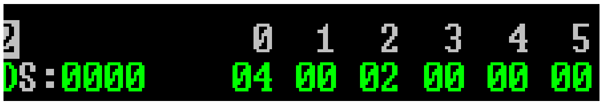
If r = 1 (OR) R = N-1 then $NC_r = N$

```
  n1:ADD     ncr, 1             ; ADD 1 to result
         RET
  n2:ADD      ncr, AX           ; ADD n to result
 last:    RET
```

ncr_proc   ENDp
END

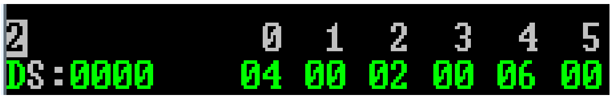
OUTPUT:

Before:



```
2            0  1  2  3  4  5
DS:0000     04 00 02 00 00 00
```

After:



```
2            0  1  2  3  4  5
DS:0000     04 00 02 00 06 00
```

5. Design and develop an assembly program to read the current time and date from the system and display it in the standard format on screen

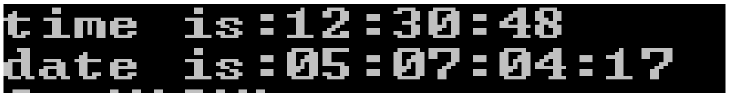
Program:

```
.MODEL SMALL
.DATA
MSG1     DB       "TIME IS$"
MSG2      DB      10,13,"DATE IS$"

.CODE
MOV      AX,@DATA
MOV      DS,AX

LEA       DX,MSG1;          display msg1
MOV       AH,09H
INT        21H
MOV     AH,2CH;                Read system time CH = hours, CL = minutes, DH = seconds
INT      21H
MOV      AL,CH;                move hours to AL
CALL      DISPLAY;             call display procedure
MOV      AL,CL;                move minutes to AL
CALL     DISPLAY
```

```
MOV      AL,DH;              Move seconds to DH
CALL     DISPLAY

LEA      DX,MSG2;                 display msg2
MOV      AH,09H
INT      21H

MOV      AH,2AH;     Read system date  AL = day (sun,mon…) DH =month DL =day CX= year
INT      21H
MOV      BX,DX;                   save month and day in BX,   BH = month BL=day
CALL     DISPLAY

MOV      AL,BL;                      move day from BL to AL
CALL     DISPLAY

MOV      AL,BH;                      move   month from BH to AL
CALL     DISPLAY

MOV      DL,':'                  ;      display character ‘:’
MOV      AH,02H
INT      21H

MOV      AX,CX;                   move year to AX=2017
MOV      DX,0;                    DX=0
MOV      BX,10;                   BX=10
DIV      BX;                      DX: AX /  BX  → 2017 / 10     AX =201 DL =07
MOV      CL,DL;                   move 7 o CL   CL =7
MOV      DX,0;                    DX=0
DIV      BX;                       DX: AX / BX   →   201 / 10    AX=20  DL =01
ADD      DL,30H;                   DL + 30H = 01 + 30H = 31H display 1
MOV      AH,02H
INT      21H

MOV      DL,CL;                  DL ← CL    DL=07
ADD      DL,30H   ;               DL + 30H  →     07  + 30H = 37H display   7
MOV      AH,02H
INT      21H

MOV      AH,4CH
INT      21H
```

```
DISPLAY     PROC
PUSH    AX ;                     save AX in stack
MOV     DL,':'              ;    disaply symbol ‘:’
MOV     AH,02H
INT     21H
POP     AX                  ;       pop AX from satck
AAM                     ;       convert packed BCD in AL to Unpacked eg.  12 → 01 02 =AX
MOV     DX,AX   ;               DX= 01 02
ADD     DX,3030H;             DX + 3030H  =  01 02 + 30 30 H =  31 32H → ASCII code of 1&2
XCHG     DH,DL            ;      display character in DH
MOV     AH,02H
INT     21H

MOV     DL,DH         ;              display character in DL
MOV     AH,02H
INT     21H
RET
DISPLAY     ENDP
END
```

OUTPUT:



```
time  is:12:30:48
date  is:05:07:04:17
```

Steps to execute program in Keil:

Project →Close Project

Project → New µvision Project→give project name→save

NXP → LPC2148→ok→yes

File →New → edit program → save file as .S

Target 1→source group 1 →Add files to group “source group1” → select your .S file

Project → Build Target → if 0 errors → debug

Check registers or memory Locations to verify output.

PROGRAM 6a : Data Transfer Instructions

```
        AREA PROG1, CODE, READONLY
        ENTRY
START
        LDR R2,=0X05
        LDR R0,=SOURCE
        LDR R1,=DEST
UP      LDR R3,[R0],#4
        STR R3, [R1],#4
        SUBS R2,#1
        BNE UP
STOP B STOP
        AREA SOURCE, DATA, READONLY
        DCD 0X10,0X20,0X30,0X40,0X50
        AREA DEST, DATA, READWRITE
        END
```

6 b. Arithmetic Instructions:

```
        AREA PROG2, CODE, READONLY
                ENTRY
        START
                LDR R1,=0X00000006
                LDR R2,=0X00000001
                ADD R5,R1,R2
                SUB R6,R1,R2
                MUL R7,R1,R2
```

```
    STOP B STOP
        END
```

6.C Logical operations

```
    AREA PROG2, CODE, READONLY
        ENTRY
    START
        LDR R1,=0X00000003
        LDR R2,=0X00000007
        AND R3,R1,R2
        ORR R4,R1,R2
        EOR R5,R1,R2
    STOP B STOP
        END
```

7. Write C programs for ARM microprocessor using KEIL (Demonstrate with help of suitable Program).

Program 1:

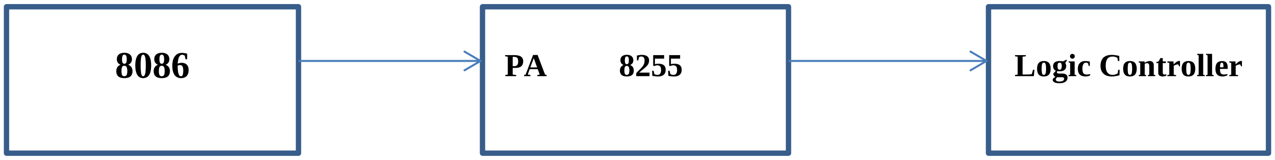
```
    #include<lpc21xx.h>
    main()
    {
    int a=6,b=2,sum,sub,mul,div;
    sum=a+b;
    sub=a-b;
    mul=a*b;
    div=a/b;
    }
```

Program 2:

```
    #include<lpc21xx.h>
    main()
    {
    int a=3, b=7, and, or, xor,not;
```

```
        and=a&b;
        or=a|b;
        xor=a^b;
        not=~a;
        }
```

8 a. Design and develop an assembly program to demonstrate BCD UP-Down Counter (00-99) on the Logic controller



Port A → Output Port

Control Word =

1	**0**	**0**	**0**	**0**	**0**	**0**	**0**

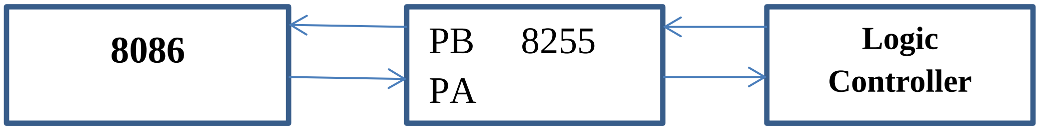
= 80H

Program:

```
.MODEL SMALL

.DATA
      PA     EQU    0D800H
      CR     EQU    0D803H
.CODE

MOV   AX, @DATA
MOV   DS, AX                 ; DATA segment Initialization
MOV   AL, 80h                ; Port A - Output
MOV   DX, CR
OUT   DX, AL                 ; Initialize 8255
MOV   DX,PA                  ;  Move port A address to DX
MOV   AL,00                  ; AL=00
RPT: OUT     DX,AL           ; send AL value to Port A
CALL  DELAY                  ; call Delay Procedure
INC   AL                     ; AL =AL +1
CMP   AL,100                 ; compare AL value with 100
JNE   RPT                    ; if AL ≠100 jump to RPT
MOV   AH,4CH                 ; Exit to DOS
INT   21H

DELAY        PROC
```

```
PUSH  CX
PUSH  BX
MOV   CX,0FFFFH
LOOP2:MOV    BX,1000H
LOOP1:DEC BX
JNZ     LOOP1
LOOP  LOOP2
POP     BX
POP     CX
RET
DELAY          ENDP
END
```

8 b. Design and develop an assembly program to read the status of two 8-bit inputs (X & Y) from the Logic Controller interface and Display X * Y.



PB (Port B) → Input Port

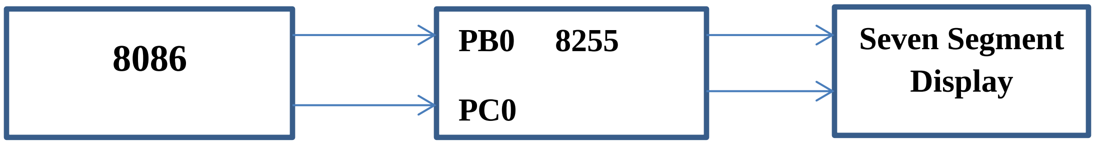
PA (Port A) → Output Port

Control Word	**=**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**= 82H**

Program:

```
.MODEL SMALL
.DATA
        PA    EQU      0D800H
        PB    EQU       0D801H
        CR     EQU      0D803H
        MSG_X       DB      10,13,"Set value for X on logic contlr & press any key...$"
        MSG_Y       DB       10,13,"Set value for Y on logic contlr & press any key...$"
.code
        MOV       AX, @DATA          ;
        MOV      DS, AX                  ; DATA segment Initialization

        MOV     AL, 82h                  ; Port A - Output, Port B - Input
        MOV     DX, CR                   ;
        OUT     DX, AL                  ; Initialize 8255

        LEA      DX, MSG_X              ; Display message & wait for keyboard hit
        MOV     AH, 09h                 ;
        INT     21h             ;
        MOV     AH, 01h                 ;
        INT     21h             ;
        MOV     DX, PB                  ;
        IN        AL, DX                ; Read DATA from Port B
        MOV     CL, AL                  ; Save read DATA IN CL

        LEA      DX, MSG_Y              ; Display message & wait for keyboard hit
        MOV     AH, 09h                 ;
        INT       21h                   ;
        MOV     AH, 01h                 ;
        INT     21h             ;

        MOV     DX, PB                  ;
        IN      AL, DX                  ; Read DATA from Port B
        MUL      CL                     ; Multiply first and second DATA

        MOV     DX, PA                  ;
        OUT     DX, AL                  ; SEND product to Port A

        MOV       AH, 4CH               ;
        INT       21h                   ; Exit to DOS
END
```

9. Design and develop an Assembly program to display messages “FIRE” & “HELP” alternately with flickering effects on a 7-segment display interface for a suitable period of time, ensure a flashing rate that makes it easy to read both the messages.



Port B → Output Port **Port C → Ouput Port**

Control Word = | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | = 80H

Send data bit to PB0

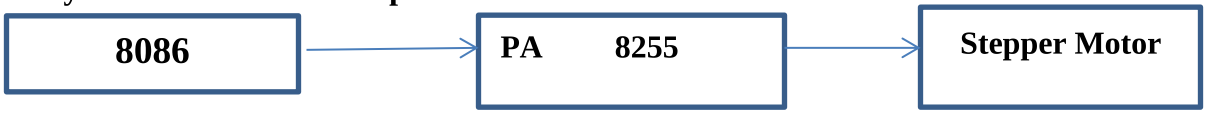
Send clock signal to PC0

program:

```
.MODEL SMALL
.DATA
        PB     EQU      0D801H
        PC     EQU      0D802H
        CR     EQU     0D803H
        FIRE    DB     86H,88H,0F9H,8EH
        HELP    DB     8CH,0C7H,86H,89H
.code
        MOV     AX, @DATA          ;
        MOV     DS, AX             ; DATA segment Initialization
        MOV    AL, 80H             ; Port A, B & C - Output
        MOV     DX, CR             ;
        OUT     DX, AL             ; Initialize 8255

        MOV     CX, 10             ; Display FIRE & HELP 10 times
  RPT: PUSH      CX
        LEA        SI, FIRE        ; Store offset address of message “DATA_fire” IN si
        CALL     DISPLAY           ; Display message “FIRE”
        CALL     DELAY
        LEA       SI, HELP         ; Store offset address of message “DATA_help” IN si
        CALL    DISPLAY                     ; Display message “HELP”
        CALL     DELAY
        POP      CX
        LOOP    RPT
        MOV AH, 4CH
        INT 21h                    ; Exit to DOS

DELAY         PROC
        PUSH    CX
        PUSH    BX
        MOV CX, 1000H
 LOOP2:MOV      BX, 0FFFFH
LOOP1:DEC       BX
        JNZ       LOOP1            ; Repeat INNER loop FFFF times
        LOOP     LOOP2             ; Repeat OUTER loop 1000h times
        POP    BX
```

```
            POP    CX
            RET
DELAY      ENDP

DISPLAY     PROC
            MOV    BL, 4            ; Four display codes to be sent
 BACK2:MOV     CL, 8                    ; Eight bits IN each display code
            MOV     AL, [SI]
 BACK1:ROL       AL, 1
            MOV     DX, PB                  ;
            OUT     DX, AL                  ; DATA bit sent over PB0
            PUSH      AX
            MOV      AL, 1                  ; SEND falling edge of the pulse over PC0
            MOV      DX, PC                 ;
            OUT      DX, AL                 ;
            DEC      AL                     ;
            OUT     DX, AL                  ;
            POP      AX
            DEC     CL
            JNZ     BACK1                   ; Check if ALl 8 bits are sent or not
            INC     SI
            DEC     BL
            JNZ     BACK2                   ; Check if ALl 4 display codes sent or not
            RET
DISPLAY      ENDP
END
```

10. Design and develop an assembly program to drive a stepper motor interface and rotate the motor in specified direction (Clock-wise or Counter – clock wise) by N steps. Introduce delay between successive steps.



Port A → output Port

Control Word =

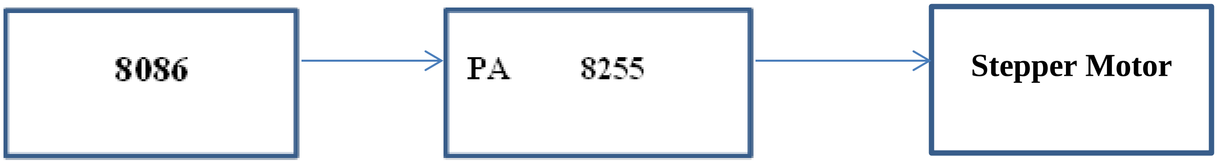
1	0	0	0	0	0	0	0	**= 80H**

Program:

```
.MODEL SMALL
.DATA
```

```
        PA    EQU    0D800H
        CR    EQU    0D803H

.CODE
        MOV     AX, @DATA          ;
        MOV    DS, AX              ; DATA segment Initialization
        MOV     AL, 80H            ; Port A, B & C - Output
        MOV    DX, CR              ;
        OUT    DX, AL              ; Initialize 8255

        MOV    CX, 10              ; Set LOOP counter to repeat clk times
        MOV    DX, PA
        MOV   AL, 11H              ; Store bit Pattern IN AL
   L1:  OUT    DX, AL
        CALL    DELAY
        ROR     AL, 1              ; Rotate AL right by one bit to get next Pattern
        LOOP    L1

        MOV   AH, 4CH              ;
        INT    21H         ; Exit to DOS

DELAY    PROC
        PUSH    CX
        PUSH    BX
        MOV    CX, 1000h
LOOP2:MOV    BX, 0FFFFH
LOOP1:DEC     BX
        JNZ       LOOP1            ; Repeat INNER LOOP FFFFH ×1000H times
        LOOP   LOOP2               ; Repeat OUTER LOOP FFFFH times
        POP     BX
        POP      CX
        RET
DELAY       ENDP
END
```

11 a. Design and develop an assembly program to generate sine wave using DAC interface (output of DAC should be displayed on the CRO)



Port A → output Port

Control Word =

1	0	0	0	0	0	0	0

= 80H

Program:

```
.MODEL SMALL
.DATA
 VALUES   DB    7FH,95H,0AAH,0BFH,0D1H,0E0H,0EDH,0F7H,0FDH,0FFH,0FDH,0F7H
          DB     0E0H,0D1H,0BFH,0A9H,95H,7FH,69H,53H,3FH,2DH,1DH,11H
          DB     7H,01H,00H,01H,07H,11H,1DH,2DH,3FH,53H,69H,7FH
        PA     EQU     0D800H
        CR    EQU     0D803H
.code
        MOV     AX, @DATA          ;
        MOV    DS, AX              ; DATA segment Initialization

        MOV     AL, 80H            ; Port A - Output
        MOV     DX, CR             ;
        OUT     DX, AL             ; Initialize 8255

BEGIN: LEA    SI, VALUES           ; Si points to Values
        MOV     CX, 36             ; Initialize counter
LOOP1:MOV      DX, PA
        MOV      AL, [SI]          ; Copy DATA from memory
        OUT       DX, AL           ; SEND to Port A
        INC     SI
        LOOP   LOOP1               ; If All 36 DATA are not sent goto label loop1 and repeat
        JMP     BEGIN              ; Repeat from BEGIN to construct more waves

END
```

11 b. Design and develop an assembly program to generate Half Rectified sine wave using DAC interface (output of DAC should be displayed on the CRO)

Program:

```
.MODEL SMALL
.DATA
 VALUES   DB    7FH,95H,0AAH,0BFH,0D1H,0E0H,0EDH,0F7H,0FDH,0FFH,0FDH,0F7H
          DB     0E0H,0D1H,0BFH,0A9H,95H,7FH,7F H,7FH,7FH,7FH,7FH,7FH
          DB     7FH,7FH,7FH,7FH,7FH,7FH,7FH,7FH,7FH,7FH,7FH,7FH
        PA     EQU     0D800H
        CR    EQU     0D803H
.code
        MOV     AX, @DATA          ;
        MOV    DS, AX              ; DATA segment Initialization

        MOV     AL, 80H            ; Port A - Output
        MOV     DX, CR             ;
        OUT     DX, AL             ; Initialize 8255

BEGIN: LEA    SI, VALUES           ; Si points to Values
        MOV     CX, 36             ; Initialize counter
LOOP1:MOV     DX, PA
        MOV      AL, [SI]          ; Copy DATA from memory
        OUT       DX, AL           ; SEND to Port A
        INC      SI
        LOOP   LOOP1               ; If All 36 DATA are not sent goto label loop1 and repeat
        JMP     BEGIN              ; Repeat from BEGIN to construct more waves

END
```

<u>Steps to execute Hardware programs in Keil:</u>

Project →Close Project

Project → New µvision Project→give project name→save

NXP → LPC2148→ok→yes

File →New → edit program → save file as .C

Target 1→source group 1 →Add files to group “source group1” → select your .c file

Target 1 → options for target ‘target 1’ → right click device →select LPC2148

Target 1 →options for target 1 → target →xtal (Mhz) = 12.0→ code generation= ARM mode →select IRAM1 and no Init

Target 1 → options for target ‘target 1’ →output → create hex file

Target 1 → options for target ‘target 1’ →Listing → select C preprocessor listing

Target 1 → options for target ‘target 1’ →Linker → select use memory layout from target dialog

Project → Build Target → if 0 errors →Flash Magic

FLASH MAGIC:

Click flash magic → device →ARM7 → LPC2148 → com port as COM 1 → baud rate as 9600 →interface none (ISP) → oscillator (MHz) = 12.0→select erase of flash code Rd plot.

Browse → select your .hex file → start

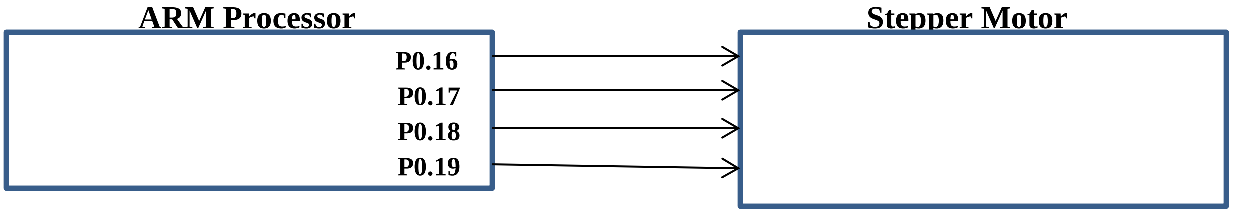
12. To interface LCD with ARM Processor, Write and execute programs in C language for displaying text messages and numbers on LCD

Program:

```
#include <LPC214x.H>                                    // Header file for LPC2148
#include <STRING.H>                                     // Header file for string manipulations
#define  LCD_DATA_PORT(DATA) (DATA << 16) //  P1.16 to P1.23 configured as LCD data port.
#define  LCD_CMD_PORT(CMD)   (CMD << 8)      //  P0.9 to P0.11  as LCD control signals.
#define  LEFT          0x18                          // Command for left shift.
#define  RIGHT         0x1C                          // Command for right shift.
#define  STABLE        0x06                          // Command for stable.

unsigned int  ENABLE  = 0x08;          // Pin P0.11 configured as LCD enable signals. (high to low)
unsigned int  RD_WR   = 0x04;          // Pin P0.10  as LCD read/write signals. (1-read, 0-write)
unsigned int  RE_SE   = 0x02; // Pin P0.9 as LCD register selection signals.(1-data, 0-command)

void DELAY_1M(unsigned int VALUE)                  // 1ms delay
  {
    unsigned int i,j;
    for(i=0;i<VALUE;i++)
      {
        for(j=1;j<1200;j++);
      }
  }
void DELAY_1S(unsigned int n)                          // 1s delay
  {
    unsigned int i,j;
    for(i=1; i<=n; i++)
    for(j=0; j<=10000; j++);
  }
void LCD_ENABLE()                              // Singal for LCD enable (high to low with 50ms)
  {
    IO0SET = LCD_CMD_PORT(ENABLE);                       // enable is set to 1
    DELAY_1M(50);                                        // 50ms delay
    IO0CLR = LCD_CMD_PORT(ENABLE);                       // enable is cleared to 0
  }
void LCD_DATA(unsigned int LDATA)                  // function to display the message
  {
    IO1PIN = LCD_DATA_PORT(LDATA);              // moving the message to LCD data port
    IO0CLR = LCD_CMD_PORT(RD_WR);              // LCD to write mode(RD_WR = 0)
    IO0SET = LCD_CMD_PORT(RE_SE);              // LCD to data mode (RE_SE = 1)
    LCD_ENABLE();                              // Latching the data to display from buffer
  }
void LCD_CMD(unsigned int LCMD)                  // function to configure the LCD
  {
    IO1PIN = LCD_DATA_PORT(LCMD);   // moving the command to LCD data port
    IO0CLR = LCD_CMD_PORT(RD_WR);              // LCD into write mode        (RD_WR = 0)
    IO0CLR = LCD_CMD_PORT(RE_SE);              // LCD into command mode (RE_SE = 0)
    LCD_ENABLE();                          // Latching the data to display from buffer
  }
void LCD_INIT()                                        // initializing the LCD with basic commands
  {
    LCD_CMD(0x38);                    // 8 Bit Mode, 2 Rows, 5x7 Font Style
    LCD_CMD(0x0C);                    // Display Switch Command : Display on, Cursor on, Blink off
    LCD_CMD(0x06);                    // Input Set : Increment Mode
    LCD_CMD(0x01);                    // Screen Clear Command , Cursor at Home
  }
void DISPLAY_MESSAGE(unsigned char ADDRESS,char *MSG)  //message display function
  {
    unsigned char COUNT,LENGTH;
    LCD_CMD(ADDRESS);
    LENGTH = strlen(MSG);
    for(COUNT=0;COUNT<LENGTH;COUNT++)
```

```
      {
        LCD_DATA(*MSG);
        MSG++;
      }
  }
void SHIFT_MESSAGE(unsigned int SHIFT, unsigned int TIME)  // Function for shift operations
  {
    while(1)
           {
             LCD_CMD(SHIFT);
             DELAY_1S(TIME);
           }
  }
int main()                                               // Main function
  {
    IO0DIR =0x00000E00;                     // Pin from P0.9 to P0.11 configured as output pins.
    IO1DIR =0X00FF0000;                    // Pin from P1.16 to P1.23 configured as output pins.
    LCD_INIT();                            // LCD initialize
    DISPLAY_MESSAGE  (0x80, " RL JALAPPA ");      // Address of first row and message
    DISPLAY_MESSAGE  (0xC0, "0123456789ABCDEF");    // Address of second row and message
    SHIFT_MESSAGE    (LEFT,500);          // Shift operations- Left, Right and no shift with speed
  }
```

13. To interface Stepper Motor with ARM Processor, Write a program to rotate stepper motor.



P0.16 – P0.19 are used as output ports

IO0DIR →It is 32-bit register, it is used to set port 0 as either output pins or input pins.

To set P0.16 – P019 as output ports IO0DIR value= 0x000F0000

IO0DIR

0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

P0.31 p0.0

IO0PIN →It is 32-bit register, this register is used to read or write values directly to the port 0

Values to rotate stepper motor

Clock-Wise	**Anti-Clock Wise**
0x00030000	0x00060000
0x00090000	0x000C0000
0x00C0000	0x00090000
0x00060000	0x00030000

Program:

```
#include <LPC214x.H>                                    // Header file for LPC2148
unsigned char COUNT=0;
unsigned int j=0;
unsigned int CLOCK[4]      = {0x00030000,0x00090000,0x000C0000,0x00060000}; // data for clockwise rotation
unsigned int ANTI_CLOCK[4] = {0x00060000,0x000C0000,0x00090000,0x00030000};  // data for anti-clockwise rotation

void DELAY_1S(unsigned int n)                                              // 1s delay
  {
     unsigned int i,j;
     for(i=1; i<=n; i++)
     for(j=0; j<=10000; j++);
  }
void CLOCK_WISE_DIRECTION(unsigned int STEP, unsigned int TIME)  //Function for clockwise
  {
    for(j=0;j<=STEP;j++)
       {
        IO0PIN = CLOCK[COUNT];
               COUNT ++;
        DELAY_1S(TIME);
               if(COUNT==4) COUNT=0;
       }
  }
void ANTI_CLOCK_WISE_DIRECTION(unsigned int STEP, unsigned int TIME) //Function for anti-
  {
    for(j=0;j<=STEP;j++)
       {
        IO0PIN = (ANTI_CLOCK[COUNT]);
```

```
            COUNT ++;
        DELAY_1S(TIME);
            if(COUNT==4) COUNT=0;
      }
  }
int main()                                                          // Main function
  {
    IO0DIR = 0x000F0000;                    // Pin from P0.16 to P0.19 configured as output pins.
    while(1)                                // infinite loop
     {
      CLOCK_WISE_DIRECTION     (10,500);          // clockwise direction with step and speed
      ANTI_CLOCK_WISE_DIRECTION(10,500);    // anti-clockwise direction with step and speed
     }
  }
```