MDA-Win8086 MANUAL

An Integrated Development Environment kit

User's Manual

Documentation Version 10.0

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◆ PREFACE ◆

The first 50 years of the 20th century witnessed the invention of the internal combustion engine, which greatly extended the physical strength of the human body.

In the second half of the century, the birth of the microprocessor further extended our mental capabilities. Applications of this amazing product in various industries have introduced so much impact on our lives, hence, it is called the second industrial Revolution.

Microcomputers represent a total change in designing systems. Both industrial and academic institutions are active in the development and search for new applications for microcomputers.

This book is designed to be used in conjunction with the "multi tech" MDA-Win8086 Microcomputers as part of a one-year laboratory class on microcomputers. With the aid of this book, students will be able to learn the fundamentals of microcomputers, from basic CPU instructions to practical applications.

The first part of this book is an introduction to the basic concepts of microcomputer programming. It lays the foundation for year studies, the second part of this book is the microcomputer hardware, such as , input/output, interrupt, timer and counter experiment, and experiments using microcomputer instructions, such as, data transfers, arithmetic and logic operations, jump and subroutine and memory address allocation in simple program. Experiments involving more complicated arithmetic operations, such as, binary to decimal conversion, decimal to binary conversion, multiplication, division are presented.

There are various experiments in this book which are designed to familiarize the student with the fundamentals of input/output programming. These programs are centered around the keyboard and display. These experiments establish the foundation for later experiments involving a simple monitor program, which leads to more complicated MDA-Win8086 programs.

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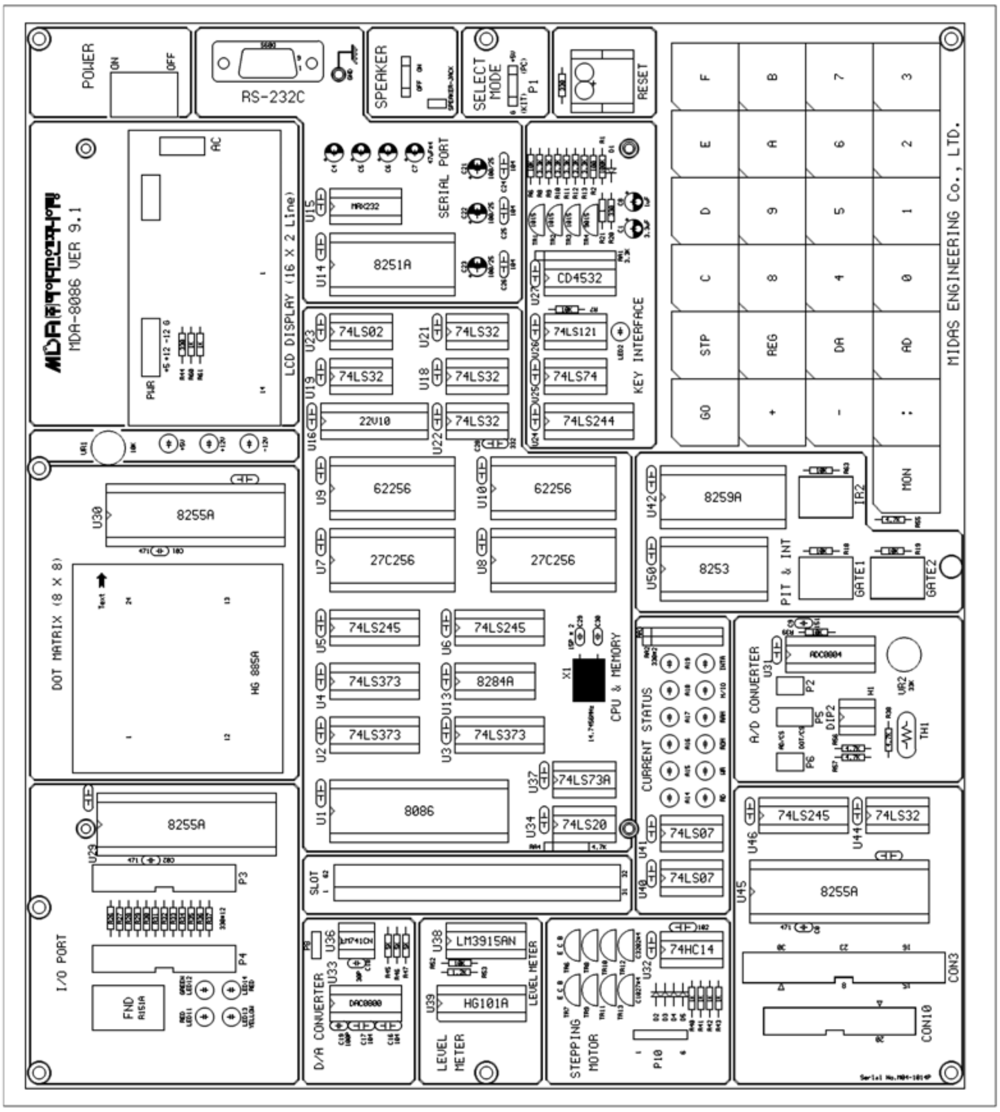


FIGURE 1. MDA-Win8086 SYSTEM CONFIGURATION

1. MDA-Win8086 SYSTEM CONFIGURATION

☞ The function of IC's at Figure 1.

① CPU(Central processing unit) : Using Intel 8086, Using 14.7456㎒.

② ROM(Read Only Memory) : It has program to control user's key input, LCD display, user's program. 64K Byte, it has data communication program.
Range of ROM Address is F0000H~FFFFFH.

③ SRAM(Static Random Access Memory) : Input user's program & data.
Address of memory is 00000H~0FFFFH, totally 64K Byte.

④ DISPLAY : Text LCD Module, 16(Characters)×2(Lines)

⑤ KEYBOARD : It is used to input machine language.
There are 16 hexadecimal keys and 8 function keys.

⑥ SPEAKER : Sound test.

⑦ RS-232C : Serial communication with IBM compatible PC.

⑧ DOT MATRIX LED : To understand & test the dot matrix structure and principle of display. It is interfaced to 8255A(PPI).

⑨ A/D CONVERTER : ADC0804 to convert the analog signal to digital signal.

⑩ D/A CONVERTER : DAC0800 (8-bits D/A converter) to convert the digital signal to the analog signal and to control the level meter.

⑪ STEPPING MOTOR INTERFACE : Stepping motor driver circuit is designed.

⑫ POWER : AC 110~220V, DC +5V 3A, +12V 1A, -12V 0.5A SMPS.

※> MDA-Win8086 ADDRESS MAP

① Memory map

ADDRESS	MEMORY	DESCRIPTION
00000H ~ 0FFFFH	RAM	PROGRAM & DATA MEMORY
F0000H ~ FFFFFH	ROM	MONITOR ROM
10000H ~ EFFFFH	USER'S RANGE	

② I/O address map

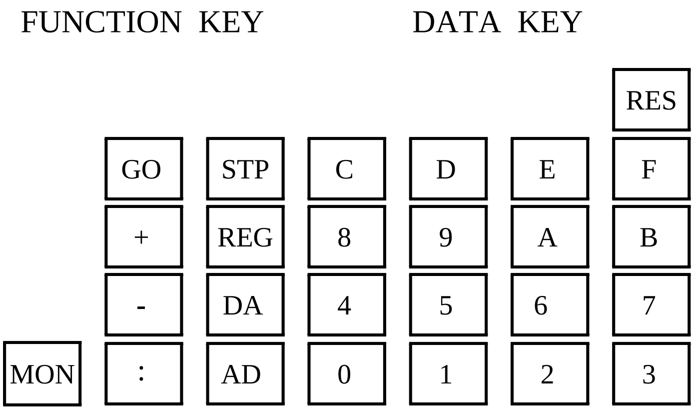
ADDRESS	I/O PORT	DESCRIPTION
00H ~ 07H	LCD & KEYBOARD	LCD Display 00H : INSTRUCTION REGISTER 02H : STATUS REGISTER 04H : DATA REGISTER KEYBOARD 01H : KEYBOARD REGISTER (Only read) 01H : KEYBOARD FLAG (Only write)
08H ~ 0FH	8251 / 8253	8251(Using to data communication) 08H : DATA REGISTER 0AH : INSTRUCTION / STATUS REGISTER 8253(TIMER/COUNTER) 09H : TIMER 0 REGISTER 0BH : TIMER 1 REGISTER 0DH : TIMER 2 REGISTER 0FH : CONTROL REGISTER
10H ~ 17H	8259/SPEAKER	8259(Interrupt controller) 10H : COMMAND REGISTER 12H : DATA REGISTER SPEAKER → 11H : SPEAKER
18H ~ 1FH	8255A-CS1/ 8255A-CS2	8255A-CS1(DOT & ADC INTERFACE) 18H : A PORT DATA REGISTER 1AH : B PORT DATA REGISTER 1CH : C PORT CONTROL REGISTER 8255-CS2(LED & STEPPING MOTOR) 19H : A PORT DATA REGISTER 1BH : B PORT DATA REGISTER 1DH : C PORT CONTROL REGISTER 1FH : CONTROL REGISTER
20H ~ 2FH	I/O EXTEND CONNECTOR	
30H ~ FFH	USER'S RANGE	

2. OPERATION INTRODUCTION

2-1. FUNCTION OF KEYS

MDA-Win8086 has high performance 64K-byte monitor program. It is designed for easy function. After power is on , the monitor program begins to work. In addition to all the key function the monitor has a memory checking routine.

The following is a simple description of the key functions.



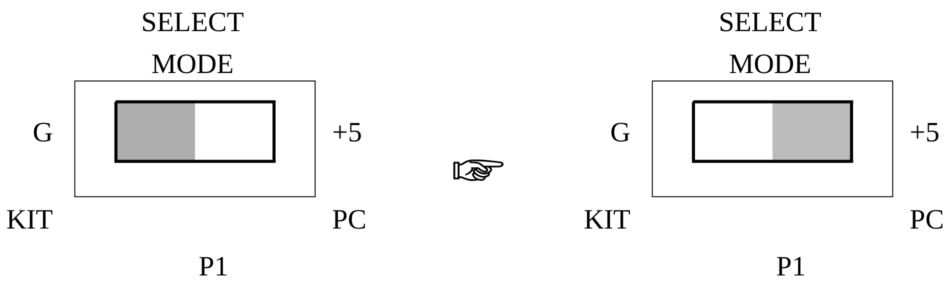
RES	system reset	STP	execute user's program, a single step
AD	set memory address	GO	go to user's program or execute monitor functions
DA	Update segment & Offset. and input data to memory	MON	Immediately break user's program and Non makable interrupt.
:	Offset.	REG	Register Display.
+	Segment & Offset +1 increment. Register display increment.		
–	Segment & Offset -1 increment. Register display decrement.		

2-2. BASIC OPERATION

On a power-up, following message will be displayed on a LCD.

MDE8086 Kit V9.5 Midas 2109-5964/5	Or	Serial monitor ! Midas 2109-5964/5
Figure 1-1.		Figure 1-2.

To select the Machine Code and Serial monitor mode with P1 switch.



Machine Code   Serial monitor

※ RES System Reset Key

Whenever RES is pressed, the display becomes FIGURE 1-1 or FIGURE 1-2.

※ AD , : . HEXA-DIGIT KEY : Substitute to segment & offset address

EXAMPLE 1) Check the contents in memory.

KEY	LCD
AD	Seg. 0set data 0000 1000 FF ↓ ↓ ↓ Input data offset [The contents of memory 0000:1000 (It may be different)]
F	Seg. 0set data 000F 1000 FF ↓ ↓ ↓ Input data offset [The contents of memory 000F:1000 (It may be different)]
0	Seg. 0set data 00F0 1000 FF ↓ ↓ ↓ Input data offset [The contents of memory 00F0:1000 (It may be different)]
0	Seg. 0set data 0F00 1000 FF ↓ ↓ ↓ Input data offset [The contents of memory 0F00:1000 (It may be different)]

Key	LCD	
0	Seg. 0set data F000 1000 FF	↓ Input data ↓ offset ↓ [The contents of memory F000:1000 (It may be different)]
:	Seg. 0set data F000 1000 FF	↓ segment ↓ offset ↓ [The contents of memory F000:1000 (It may be different)]
0	Seg. 0set data F000 0000 FF	↓ Input data ↓ offset ↓ [The contents of memory F000:0000]

※ AD , + , -

KEY : Increment and decrement to segment & offset address.

When the power is on or press the RES key, following message will be displayed on LCD.

MDE8086 Kit V9.5 Midas 2109-5964/5

When the AD key is pressed,

KEY	LCD
AD	Seg. 0set data 0000 1000 FF ↓ ↓ ↓ Input data offset [The contents of memory 0000:1000 (It may be different)]
+	Seg. 0set data 0001 1000 FF ↓ ↓ segment +1 increment [The contents of memory 0001:1000 (It may be different)]
+	Seg. 0set data 0002 1000 FF ↓ ↓ segment +1 increment [The contents of memory 0002:1000(It may be different)]
-	Seg. 0set data 0001 1000 FF ↓ ↓ segment -1 increment [The contents of memory 0001:1000 (It may be different)]

※ AD , : ,

HEXA-DIGIT KEY : Update to memory contents.

EXAMPLE 2) Let's store the following like to 01000H ~ 01003H contents.

< ADDRESS DATA>

ADDRESS	DATA
01000	AB
01001	CD
01002	EF
01003	34

KEY	LCD
RES	MDE8086 Kit V9.5 Midas 2109-5964/5
AD	Seg. 0set data 0000 1000 FF ↓ segment ↓ offset ↓ [The contents of memory 0000:1000]
DA	Seg. 0set data 0000 1000 FF ↓ segment ↓ offset ↓ [The contents of memory 0000:1000 (It may be different)]
A B	Seg. 0set data 0000 1000 AB
+	Seg. 0set data 0000 1001 FF ↓ Offset increment

KEY	LCD
[C] [D]	Seg. 0set data 0000 1001 CD
[+]	Seg. 0set data 0000 1002 FF ↓ Offset increment
[E] [F]	Seg. 0set data 0000 1002 EF
[+]	Seg. 0set data 0000 1003 FF ↓ Offset increment
[3] [4]	Seg. 0set data 0000 1003 34
[+]	Seg. 0set data 0000 1004 FF ↓ Offset increment

※ [REG] , [+] , [-] KEY : Display to register contents.

KEY	LCD
[RES]	AX=0000 BX=0000 CX=0000 DX=0000 ↓ Current register contents.
[+]	SP=0540 BP=0000 SI=0000 DI=0000

Key	Display
+	DS=0000 ES=0000 SS=0000 CS=0000
+	IP=1000 FL=0000 =....................

↓

Current register contents.

Key	Display
-	DS=0000 ES=0000 SS=0000 CS=0000
-	SP=0540 BP=0000 SI=0000 DI=0000

3. EXAMPLE PROGRAM

♣ **STP** Single Step

Store a following program in RAM and execute it by single steps.

ADDRESS	MACHINE CODE	MNEMONIC	
1000	B8 0000	MOV	AX ,0
1003	9E	SAHF	
1004	05 8947	ADD	AX, 4789H
1007	15 8864	ADC	AX, 6488H
100A	04 88	ADD	AL, 88H
100C	80 D4 33	ADC	AH, 33H
		;	
100F	2D 6735	SUB	AX, 3567H
1012	1D 0080	SBB	AX, 8000H
1015	2C 45	SUB	AL, 45H
1017	80 DC 78	SBB	AH, 78H
		;	
101A	B0 FF	MOV	AL, FFH
101C	FE C0	INC	AL
101E	FE C8	DEC	AL
1020	98	CBW	
1021	F6 D8	NEG	AL
		;	
1023	B0 F0	MOV	AL, F0H
1025	B3 11	MOV	BL, 11H
1027	F6 E3	MUL	BL
		;	
1029	B8 00F0	MOV	AX, F000H
102C	BB 3412	MOV	BX, 1234H
102F	F7 EB	IMUL	BX

```
                                        ;
1031         B8 F000                    MOV    AX, 00F0H
1034         B3 10                      MOV    BL, 10H
1036         F6 F3                      DIV       BL
                                        ;
1038         BA FFFF                           MOV    DX, -1
103B         B8 FFFF                    MOV    AX, -1
103E         BB 0100                    MOV    BX, 1
1041         F7 FB                      IDIV      BX
                                        ;
1043         CC                         INT        3
```

① Again, using with machine code input program from 1000H.

② It is valid only when the display is in current Flag form. Pressing "STP" key causes the CPU to execute one instruction point according to the user's PC. After execution, the monitor regains control and displays the new PC and its contents. The user may examine and modify registers and memory contents after each step.

KEY	LCD
RES	MDE8086 Kit V9.5 Midas 2109-5964/5
AD	Seg. 0set data 0000 1000 B8

↓ segment ↓ offset ↓

[The contents of memory 0000:1000]

1) MOV AX, 0

STP

(Next address)

IP=1003 FL=0100
=...t......

Current Flag content (It means single step)

Result verify !

+

AX=0000 BX=0000
CX=0000 DX=0000

Current Register content

2) SHAF

STP

(Next address)

IP=1004 FL=0100
=...t......

3) ADD AX, 4789H

STP

(Next address)

IP=1007 FL=0100
=...t......

Result verify !

+

AX=4789 BX=0000
CX=0000 DX=0000

4) ADC AX, 6488H

STP

(Next address)

IP=100A FL=0994
=o..ts.ap.

(over flag set, alternate carry set, sign flag set, parity flag set)

Result verify !

+

AX=AC11 BX=0000
CX=0000 DX=0000

5) ADD AL, 88H

(Next address)
↓

STP

IP=100C FL=0184
=o..ts..p.

(sign flag set, parity flag set)

Result verify !

+

AX=AC99 BX=0000
CX=0000 DX=0000

6) ADC AH, 33H

(Next address)
↓

STP

IP=100F FL=0180
=...ts....

Result verify !

+

AX=DF99 BX=0000
CX=0000 DX=0000

7) SUB AX, 3567H

(Next address)
↓

STP

IP=1012 FL=0180
=...ts....

Result verify !

+

AX=AA32 BX=0000
CX=0000 DX=0000

8) SBB AX, 8000H

(Next address)
↓

STP

IP=1015 FL=0100
=...t.....

Result verify !

+

AX=2A32 BX=0000
CX=0000 DX=0000

9) SUB AL, 45H

(Next address)
↓

STP

IP=1017 FL=0195
=...ts.apc

Result verify !

[+]

AX=2AED	BX=0000
CX=0000	DX=0000

10) SBB AH, 78H

[STP]

(Next address) ↓

IP=101A	FL=0185
=...ts..pc	

Result verify !

[+]

AX=B1ED	BX=0000
CX=0000	DX=0000

11) MOV AL, FFH

[STP]

(Next address) ↓

IP=101C	FL=0185
=...ts..pc	

Result verify !

[+]

AX=B1FF	BX=0000
CX=0000	DX=0000

12) INC AL

[STP]

(Next address) ↓

IP=101E	FL=0155
=...t.zapc	

Result verify !

[+]

AX=B100	BX=0000
CX=0000	DX=0000

13) DEC AL

[STP]

(Next address) ↓

IP=1020	FL=0195
=...ts.apc	

Result verify !

[+]

AX=B1FF	BX=0000
CX=0000	DX=0000

14) CBW

[STP]

(Next address) ↓

IP=1021	FL=0195
=...ts.apc	

Result verify !

[+]

AX=FFFF BX=0000
CX=0000 DX=0000

15) NEG AL

[STP]

(Next address)
↓
IP=1023 FL=0111
=...t..a.c

Result verify !

[+]

AX=FF01 BX=0000
CX=0000 DX=0000

16) MOV AL, F0H

[STP]

(Next address)
↓
IP=1025 FL=0111
=...t..a.c

Result verify !

[+]

AX=FFF0 BX=0000
CX=0000 DX=0000

17) MOV BL, 11H

[STP]

(Next address)
↓
IP=1027 FL=0111
=...t..a.c

Result verify !

[+]

AX=FFF0 BX=0011
CX=0000 DX=0000

18) MUL BL

[STP]

(Next address)
↓
IP=1029 FL=0905
=o..t...pc

Result verify !

[+]

AX=0FF0 BX=0011
CX=0000 DX=0000

19) MOV AX, F000H

[STP]

(Next address)
↓
IP=102C FL=0905
=o..t...pc

Result verify !

[+]

AX=F000	BX=0011
CX=0000	DX=0000

20) MOV BX, 1234H

(Next address)
↓

[STP]

IP=102F	FL=0905
=o..t...pc	

Result verify !

[+]

AX=F000	BX=1234
CX=0000	DX=0000

21) IMUL BX

(Next address)
↓

[STP]

IP=1031	FL=0985
=o..ts..pc	

Result verify !

[+]

AX=C000	BX=1234
CX=0000	DX=FEDC

22) MOV AX, 00F0H

(Next address)
↓

[STP]

IP=1034	FL=0985
=o..ts..pc	

Result verify !

[+]

AX=00F0	BX=1234
CX=0000	DX=FEDC

23) MOV BL, 10H

(Next address)
↓

[STP]

IP=1036	FL=0985
=o..ts..pc	

Result verify !

[+]

AX=00F0	BX=1210
CX=0000	DX=FEDC

24) DIV BL

(Next address)
↓

[STP]

IP=1038	FL=0145
=...t.z.pc	

Result verify !

[+]

AX=000F BX=1210
CX=0000 DX=FEDC

25) MOV DX, -1

(Next address)
↓

[STP]

IP=103B FL=0145
=...t.z.pc

Result verify !

AX=000F BX=1210
CX=0000 DX=FFFF

[+]

26) MOV AX,-1

(Next address)
↓

[STP]

IP=103E FL=0145
=...t.z.pc

Result verify !

AX=FFFF BX=1210
CX=0000 DX=FFFF

[+]

27) MOV BX, 1

(Next address)
↓

[STP]

IP=1041 FL=0145
=...t.z.pc

Result verify !

AX=FFFF BX=0001
CX=0000 DX=FFFF

[+]

28) IDIV BX

(Next address)
↓

[STP]

IP=1043 FL=0144
=...t.z.p.

Result verify !

AX=FFFF BX=0001
CX=0000 DX=0000

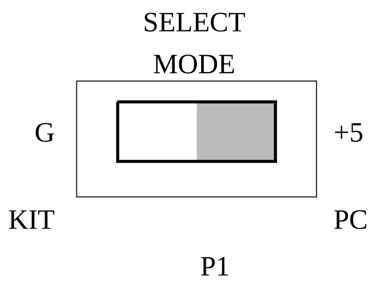
[+]

4. Serial Monitor

<u>Serial monitor</u> is the basic monitor program to do data communicate between MDA-Win8086 and your computer.

4-1. How to setup the serial monitor

Adjust the P1 switch as following figure.



Serial monitor

4-2. How to connect MDA-Win8086 to your PC

① Connect the MDA-Win8086 Kit to a spare serial port on your PC.

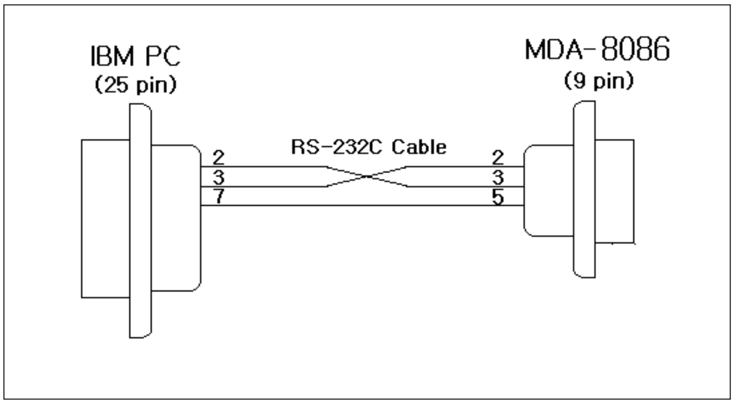


FIGURE 4-1. PC 25 PIN - MDA-Win8086 9 PIN connection

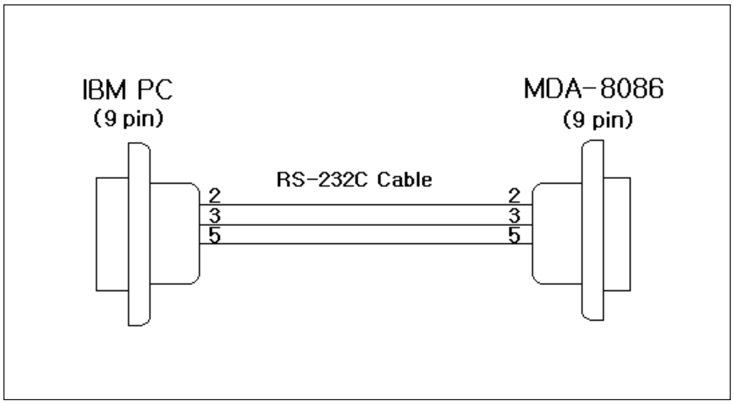
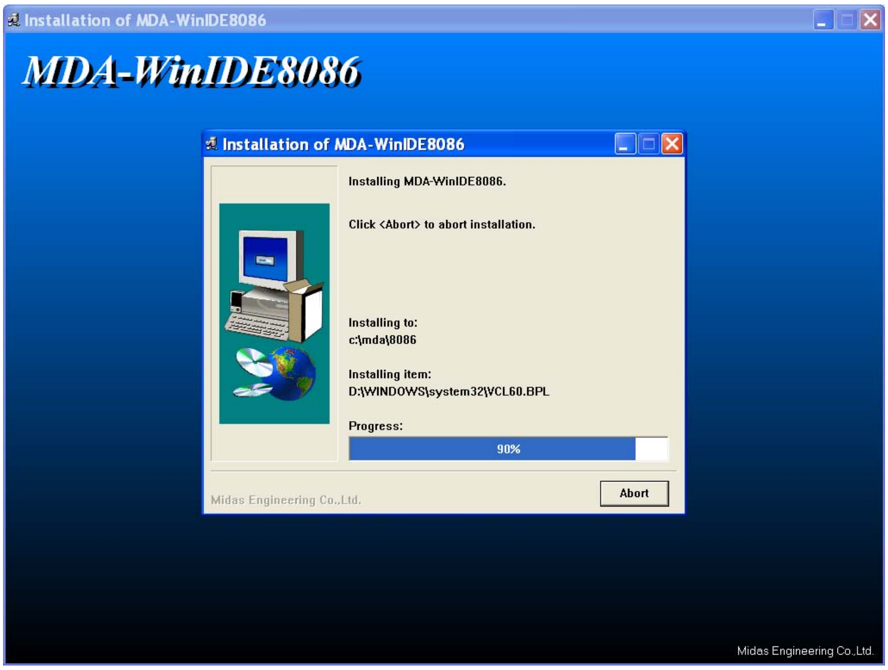


FIGURE 4-2. PC 9 PIN - MDA-Win8086 9 PIN connection

4-3. MDA-WinIDE8086 Installation

① Insert the CD in the CD-ROM driver, and double click the file "SETUP.EXE".

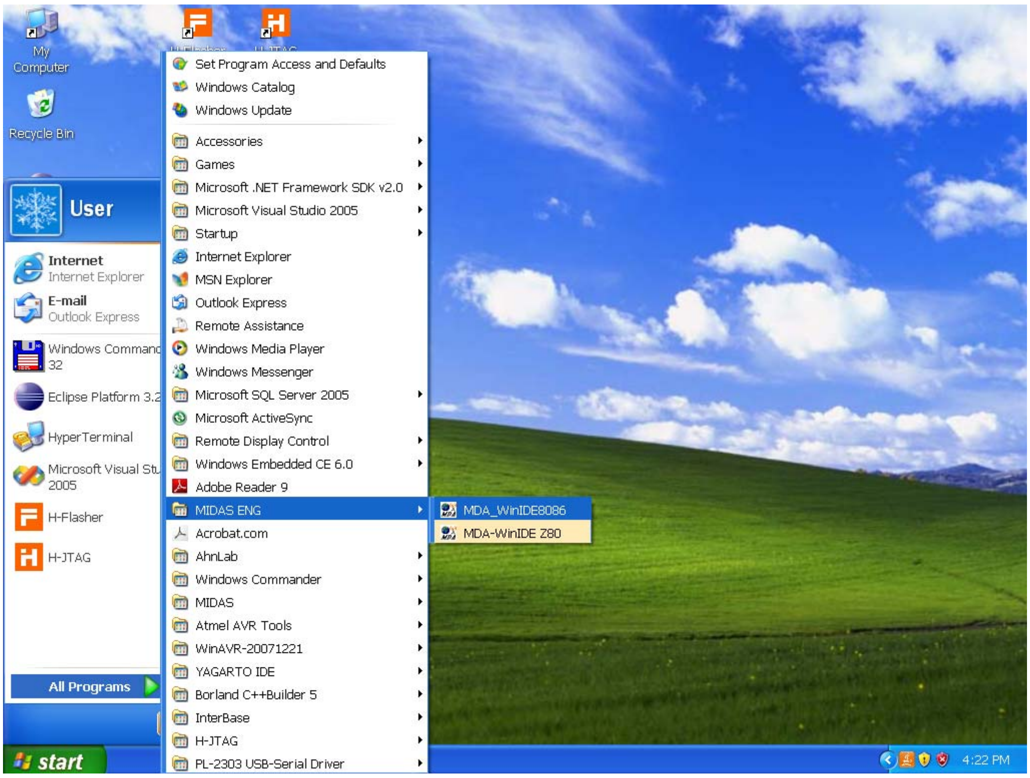
② The installation begins.



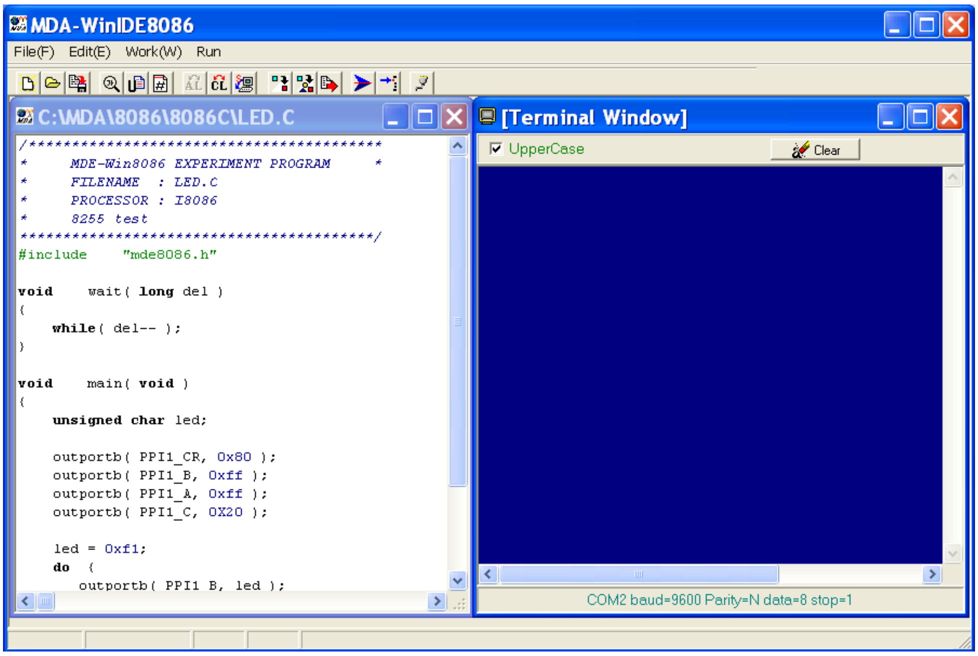
4-4. Tutorial

4-4-1 Launching MDA-WinIDE8086

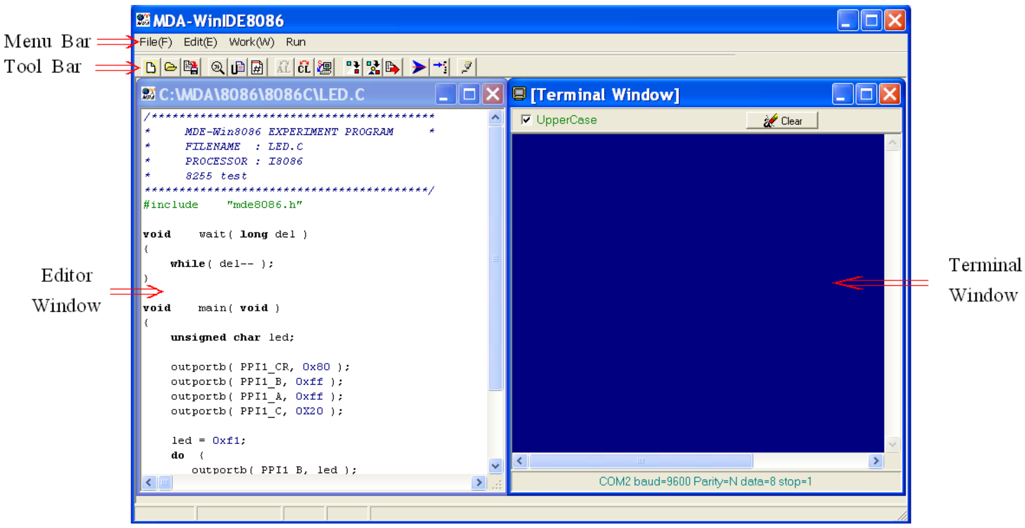
(1) Click the **Start** button in the task bar, then click **All Programs** and **MIDAS ENG**. Then click the **MDA-WinIDE8086** program icon



(2) The **MDA-WinIDE8086** window will be displayed.



4-4-2. About MDA-WinIDE8086

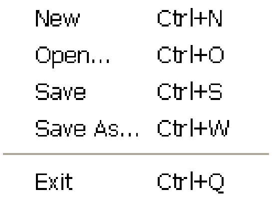


(1) Menu bar

Gives access to the MDA-WinIDE8086 menu.

① File menu

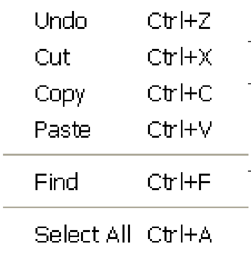
The File menu provides command s for opening source files, saving and exiting from the MDA-WinIDE8086 window.



New	Create empty text file
Open	Open a file in text editor
Save	Save current text file
Save As	Save current text file under given name
Exit	Exit MDA-WinIDE8086 window

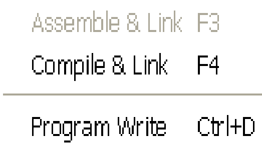
② Edit menu

The Edit menu provides command for editing and searching in editor windows.



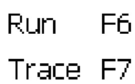
Undo	Undo last editor action
Cut	Cut and copy selected text from editor
Copy	Copy selected text form editor
Paste	Paste any text form clipboard to the editor
Find	Open a find dialog to search through the current source file
Select All	Select all text at once

③ Work menu



Assemble & Link	Assemble and link a source file you are editing
Compile & Link	Compile and link a source file your are editing
Program Write	Download a file to MDA-Win8086

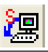
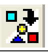
④ Run menu



Run	Start execution of the program
Trace	Execute one instruction

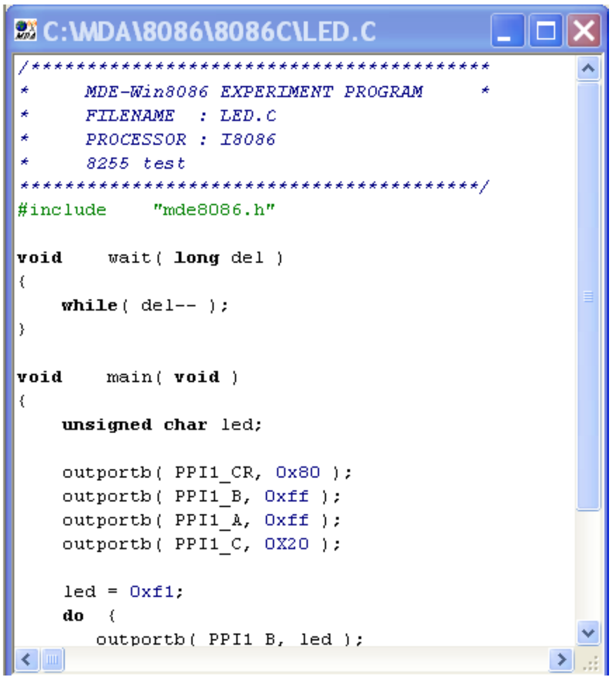
(2) Tool bar

The tool bar provides button s for the most useful commands on the MDA-WinIDE8086 menus.

Button	Menu	Command
	New	Create empty text file
	Open	Open a file in text editor
	Save	Save current text file
	Find	Open a find dialog
	Undo	Undo last editor action
	Show Line Number	Show line number
	Assemble & Link	Assemble and link a source file you are editing
	Compile & Link	Compile and link a source file you are editing
	Program write	Download an "ABS" file to MDA-Win8086 kit
	Memory dump	Dump memory contents
	Fill data	Fill memory with any data
	Move block	Move memory block
	Run	The program will be executed
	Trace	Execute one instruction
	Port setting	To change the modem's port setting

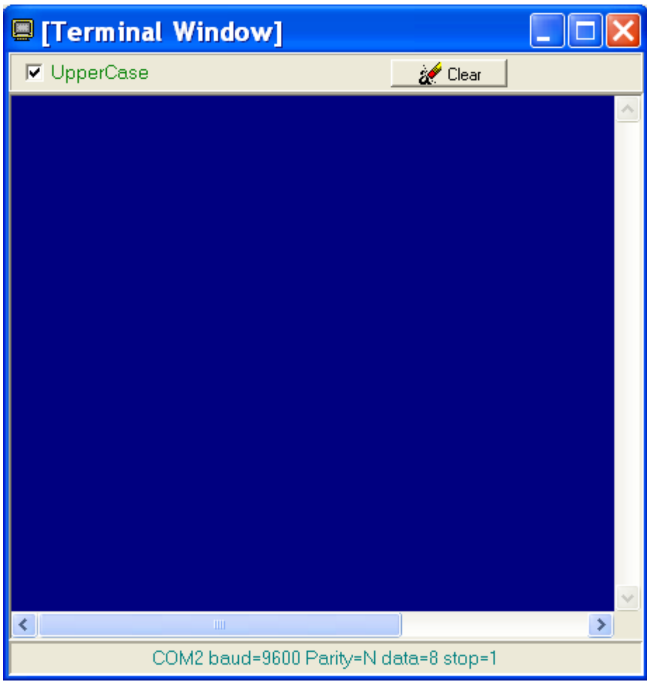
(4) Editor window

Source file is displayed in the editor window. The MDA-WinIDE8086 editor automatically recognizes the syntax of C program and Assemble program.



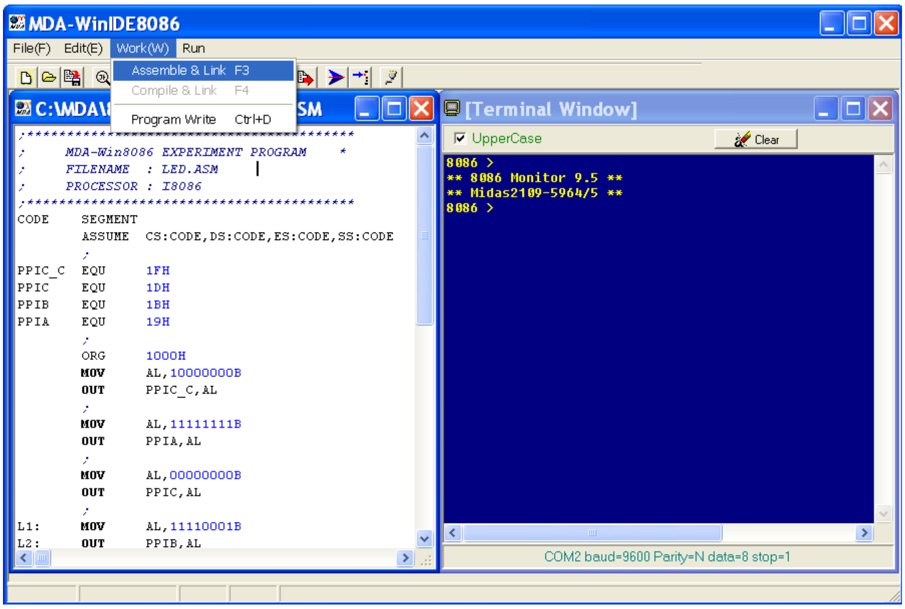
⑸ Terminal window

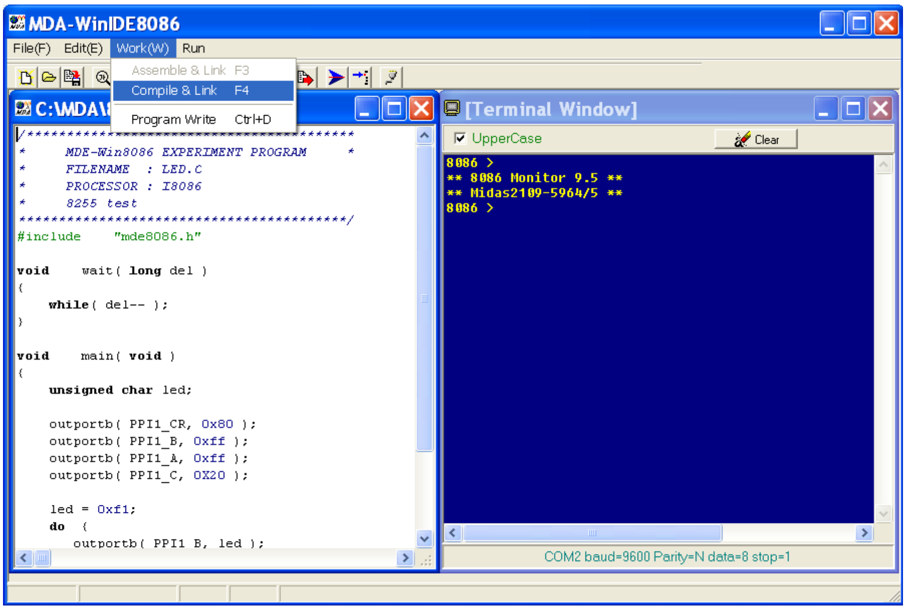
Terminal window is that you can use to connect the MDA-Win8086 kit.



4-4-3. Assembling and Compiling the source

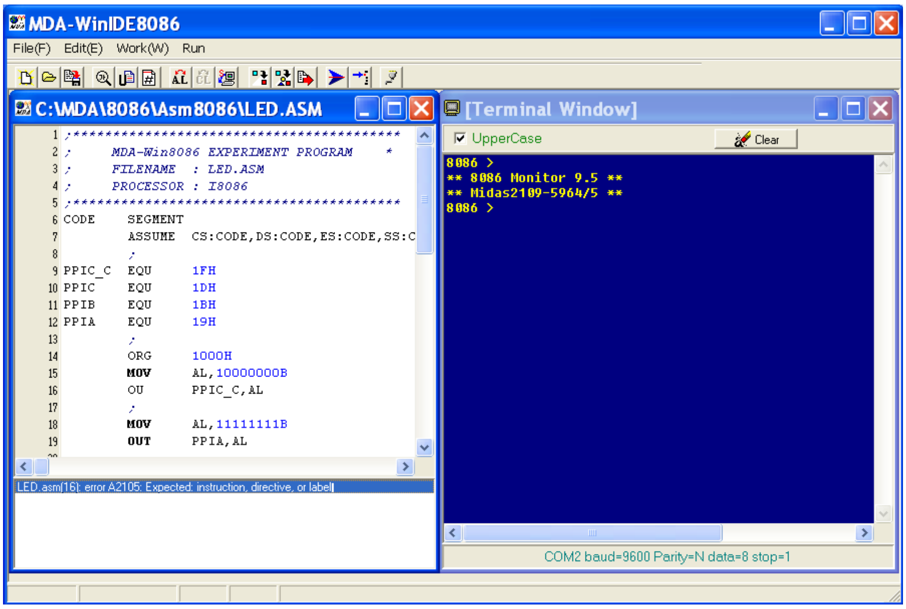
(1) Click AL / CL button for assembling/compiling to generate an ABS file.





4-4-4. Troubleshooting

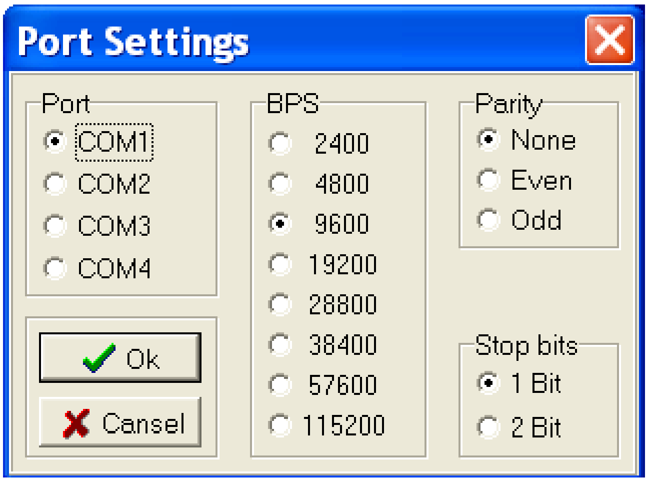
The output window lists tool information during the code generation. You may check on error messages to correct syntax errors in your program.



4-4-5. Port setting

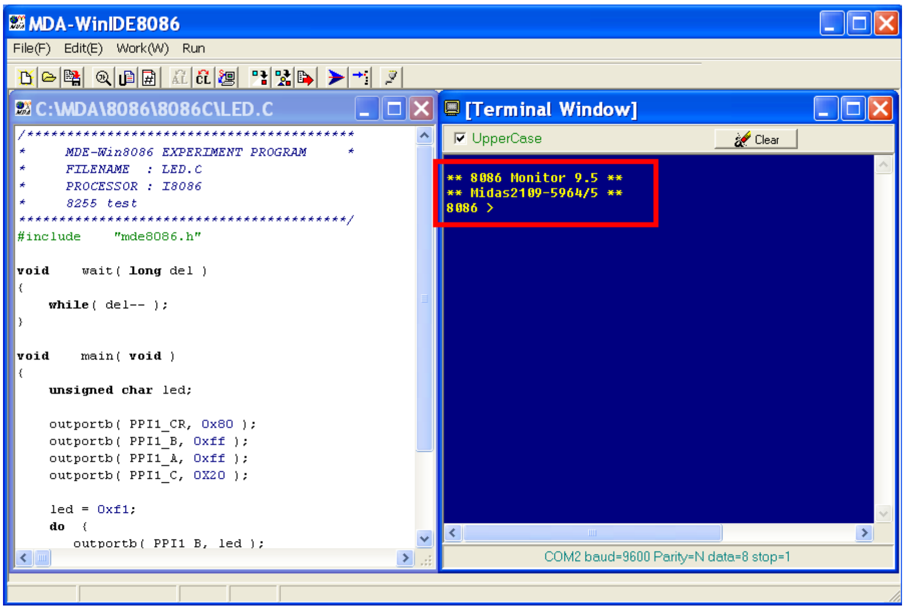
(1) After connect the MDA-Win8086 kit to a spare serial port on your PC, press RESET KEY, then "8086>" prompt will be displayed.

If "8086>" prompt is not displayed, click the  button to setup port.



⑵ Select the serial port to connected to your PC. (ie. COM1, COM2, COM3 or COM4) BPS : 9600, Parity : None, Stop bits : 1

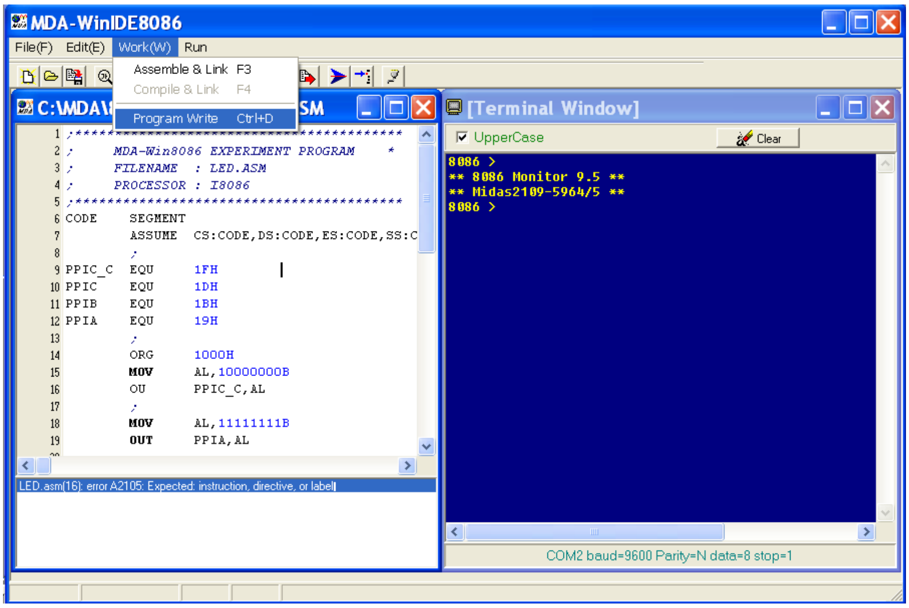
⑶ Press MDA-Win8086 RESET KEY again then "8086>" prompt will be displayed.



4-4-6. Download and execute the source file

1. Download

Click  button or select Program Write from the Work menu. You can also type 'L' and "Enter" key on Terminal window, then press "Page Up" button from your keyboard.



2. Execute

(1) Run

Click  button or select "Run" from the Run menu.

You can also type 'G' and "Enter" key on Terminal window.

The Run command in the work menu starts execution of the program. The program will be executed until it is stopped by pressing RESET KEY.

(2) Trace

Click  button or select "Trace" from the Run menu.

You can also type 'T' and "Enter" key on Terminal window.

The Trace command in the work menu executes one instruction.

4-4-7. Other serial monitor command

User can only use command which stored at serial monitor. Serial monitor can execute to command when user type command and then CR(carriage return) key.

5. Serial monitor command

⌘ If there is no any command at serial monitor, error message will be displayed with bell sound and serial monitor prompt will be displayed again.

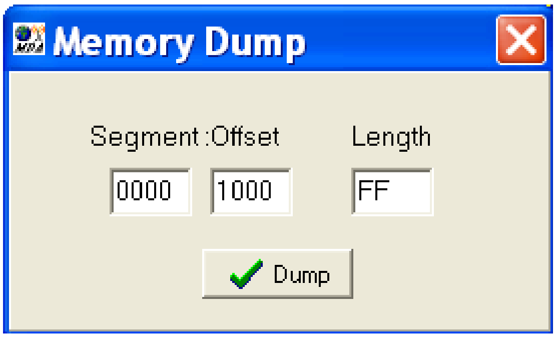
```
** 8086 Monitor 9.5 **
** Midas 2109-9964/5 **

8086 > ⏎ ← Carriage Return

8086 >?⏎
      HELP.......................................:COMMAND
      E segment : offset.........................: Enter Data To Memory
      D segment : offset length..................: Dump Memory Contents
      R [register name]..........................: Register Display & Change
      M address1, length, address2...............: Move Memory From 1 to 2
      F address, length, data....................: Fill Memory With Any Data
      L Return key...............................: Program Down Load
      G segment : offset.........................: Execute Program
      T..........................................: Program 1 step execute
```

① Memory modify command.

```
    Segment Offset
       ↓      ↓
8086 >E 0000:1000⏎
0000:1000 FF ? 11⏎
0000:1001 FF ? 22⏎
0000:1002 FF ? 33⏎
0000:1003 FF ? 44⏎
0000:1004 FF ? 55⏎
0000:1005 FF ? /  ⏎ ← (Offset decrement)
0000:1004 55 ? /  ⏎
```

② Memory display command.

Click  button, then memory dump window will be displayed.

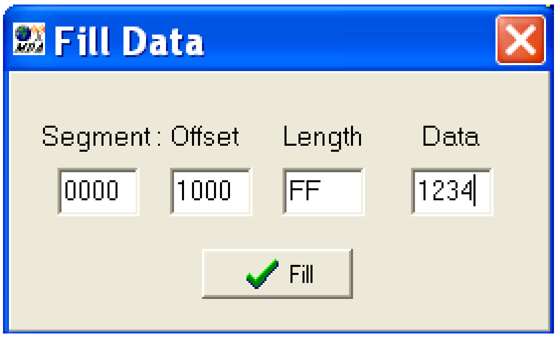


Enter Segment, Offset, and Length, then click "Dump" button.
You can also enter the memory dump command on Terminal window.

```
          Segment  Offset  Length
                ↓     ↓       ↓
8086 >D 0000:1000     FF↵
0000:1000 11 22 33 44 55  FF FF FF - FF FF FF FF FF FF FF FF    ."3DU.........
0000:1010 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:1020 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:1030 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:1040 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:1050 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:1060 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:1070 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:1080 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:1090 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:10A0 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:10B0 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:10C0 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:10D0 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:10E0 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
0000:10F0 FF FF FF FF FF FF FF FF - FF FF FF FF FF FF FF FF    ..................
8086 >                                           Display the ASCII code to data
```

③ Fill certain data in memory.

Click  button, then Fill Data window will be displayed.



Enter Segment, Offset, Length, and Data, then click "Fill" button.
You can also enter the Fill Data command on Terminal window.

```
    Segment  Offset   Length  Data
          ↓      ↓        ↓      ↓
8086 >F  0000:1000   FF   1234↵
```

☞ Verify

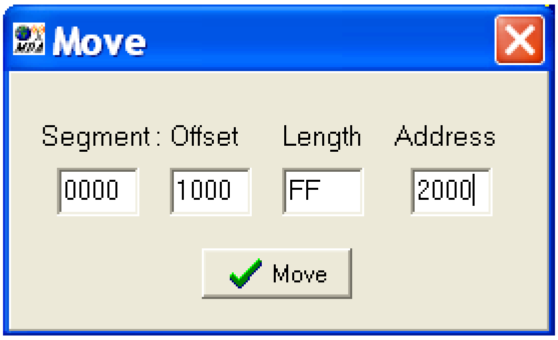
```
8086 >D  0000:1000  FF↵
0000:1000  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1010  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1020  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1030  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1040  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1050  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1060  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1070  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1080  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:1090  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:10A0  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:10B0  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:10C0  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:10D0  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
0000:10E0  12  34  12  34  12  34  12  34  -  12  34  12  34  12  34  12  34    .4.4.4.4.4.4.4.4
```

```
0000:10F0  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
```

④ Block move command.

The Block Move command is used to move blocks of memory from one area to another.

Click  button, then Move window will be displayed.



Enter Segment, Offset, Length, and Address, then click "Move" button.
You can also enter the Block Move command on Terminal window.

```
      Segment  Offset  Length  Data
               ↓    ↓      ↓      ↓
8086 >M  0000:1000   FF  2000↵
```

☞ Resulting ?

```
8086 >D  0000:2000↵
0000:2000  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2010  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2020  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2030  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2040  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2050  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2060  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2070  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2080  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
0000:2090  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34      .4.4.4.4.4.4.4.4
```

```
0000:20A0  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34    .4.4.4.4.4.4.4.4
0000:20B0  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34    .4.4.4.4.4.4.4.4
0000:20C0  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34    .4.4.4.4.4.4.4.4
0000:20D0  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34    .4.4.4.4.4.4.4.4
0000:20E0  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34    .4.4.4.4.4.4.4.4
0000:20F0  12 34 12 34 12 34 12 34 - 12 34 12 34 12 34 12 34    .4.4.4.4.4.4.4.4
```

⑤ Display Registers command.

The R command is used to display the i8086 processor registers.

```
8086 >R↵
        AX=0000  BX=0000  CX=0000  DX=0000
        SP=0540  BP=0000  SI=0000  DI=0000
        DS=0000  ES=0000  SS=0000  CS=0000
        IP=1000  FL=0000  = . . . . . . . . .
```

☞ Individual register change

```
8086 >R AX↵
AX=0000  1234↵
BX=0000  4567↵
CX=0000  7788↵
DX=0000  1111↵
SP=0540↵
```

☞ Result

```
8086 >R↵
        AX=1234  BX=4567  CX=7788  DX=1111
        SP=0540  BP=0000  SI=0000  DI=0000
        DS=0000  ES=0000  SS=0000  CS=0000
        IP=1000  FL=0000  = . . . . . . . . .

8086 >R IP↵
IP=1000↵
8086 >
```

5. 8086 INTERRUPT SYSTEM

The 8086 interrupts can be classified into three types. These are

1. Predefined interrupts
2. User-defined software interrupts
3. User-defined hardware interrupts

The interrupt vector address for all the 8086 interrupts are determined from a table stored in locations 00000H through 003FFH. The starting addresses for the service routines for the interrupts are obtained by the 8086 using this table. Four bytes of the table are assigned to each interrupt: two bytes for IP and two bytes for CS. The table may contain up to 256 8-bit vectors. If fewer than 256 interrupts are defined in the system, the user need only provide enough memory for the interrupt pointer table for obtaining the defined interrupts.

The interrupt address vector (contents of IP and CS) for all the interrupts of the 8086 assigns every interrupt a type code for identifying the interrupt. There are 256 type codes associated with 256 table entires. Each entry consists of two addresses, one for storing the IP contents and the other for storing the CS contents. Each 8086 interrupt physical address vector is 20 bits wide and is computed from the 16-bit contents of IP and CS.

For obtaining an interrupt address vector, the 8086 calculates two addresses in the pointer table where IP and CS are stored for a particular interrupt type.

For example, for the interrupt type nn(instruction INT nn), the table address for IP=4×nn and the table address for CS=4×nn+2. For servicing the 8086's nonmaskable interrupt (NMI pin), the 8086 assigns the type code 2 to this interrupt. The 8086 automatically executes the INT2 instruction internally to obtain the interrupt address vector as follows:

Address for IP = 4 × 2 = 00008H

Address for CS = 4 × 2 + 2 = 0000AH

The 8086 loads the values of IP and CS from the 20-bit physical address 00008H and 0000AH in the pointer table. The user must store the desired 16-bit values of IP and CS in these locations. Similarly, the IP and CS values for other interrupts are calculated. The 8086 interrupt pointer table layout is shown in table 6-1.

Interrupt type code ↓		20-bit Memory Address ↓
0	IP	00000H
	CS	00002H
1	IP	00004H
	CS	00006H
2		00008H
		0000AH
.		.
.		.
.		.
.		.
.		.
.		.
255	IP	003FEH
	CS	00400H

TABLE 6-1. 8086 INTERRUPT POINTER TABLE

In response to an interrupt, the 8086 pushes flags, CS, and IP onto the stack, clears TF and IF flags, and then loads IP and CS from the pointer table using the type code.

Interrupt service routine should be terminated with the IRET(Interrupt Return) instruction which pops the top three stack words into IP, CS, and flags, thus returning to the right place in the main program. The 256 interrupt type codes are assigned as follows;

- ▶ Types 0 to 4 are for the predefined interrupts.
- ▶ Types 5 to 31 are reserved by intel for future use.
- ▶ Types 32 to 255 are acailiable for maskable interrupts.

5-1. PREDEFINED INTERRUPTS (0 TO 4)

The predefined interrupts include DIVISION ZERO (type 0), SINGLE STEP (type 1), NONMASKABLE INTERRUPT pin(type 2), BREAKPOINT INTERRUPT (type 3), and INTERRUPT ON OVERFLOW (type 4). The user must provide the desired IP and CS values in the interrupt pointer table. The user may also imitate these interrupts through hardware or software. If a predefined interrupt is not used in a system, the user may assign some other function to the associated type.

The 8086 is automatically interrupted whenever a division by zero is attempted. This interrupt is nonmaskable and is implemented by intel as part of the execution of the divide instruction. When the TF(TRAP flag) is set by an instruction, the 8086 goes into the single step mode. The TF can be cleared to zero as follows;

```
PUSHF                        ; Save flags
MOV     BP, SP               ; Move [SP] → [BP]
AND     [BP+0], 0FEFFH  ; Clear TF
POPF
```

Note that in the above [BP+0] rather than [BP] is used since BP cannot be used without displacement. Now, to set TF, the AND instruction in the above should be replaced by OR [BP+0], 0100H.

Once TF is set to one, the 8086 automatically generates a TYPE 1 interrupt after execution of each instruction. The user can write a service routine at the interrupt address vector to display memory locations and/or register to debug a program. Single step is nonmaskable and cannot be enabled by STI (enable interrupt) or CLI (disable interrupt) instruction. The nonmaskable interrupt is initiated via the 8086 NMI pin.

It is edge triggered (LOW to HIGH) and must be active for two clock cycles to guarantee recognition. It is normally used for catastrophic failures such as power failure. The 8086 obtains the interrupt vector address by automatically executing the INT2(type 2) instruction internally.

Type 3 interrupt is used for breakpoint and is nonmaskable. The user inserts the one-byte instruction INT3 into a program by replacing an instruction. Break points are useful for program debugging.

The INTERRUPT ON OVERFLOW is a type 4 interrupt. This interrupt occurs if the overflow flag(OF) is set and the INT0 instruction is expected. The overflow flag is affected, for example, after execution of signed arithmetic such as MULS (signed multiplication) instruction. The user can execute the INTO instruction after the MULS. If there is an overflow, an error service routine written by the user at the type 4 interrupt address vector is executed.

5-2. INTERRUPT EXPERIMENT

◎ 1. Internal Interrupt : Division by zero (type 0)

< Sample Program 5-1. Internal Interrupt : Division by zero (type 0)

```
        ; FILENAME   : INT1.ASM
        ; PROCESSOR  : I8086

ADDRESS     MACHINE CODE           MNEMONIC
0000                       CODE    SEGMENT
                                   ASSUME  CS:CODE,DS:CODE,ES:CODE,SS:CODE
                                   ;
1000                               ORG     1000H
1000   B8 1234                     MOV     AX,1234H
1003   B3 00                       MOV     BL,00H
1005   F6 F3                       DIV     BL
1007   90                          NOP
1008   90                          NOP
```

```
1009   CC                              INT      3
                                       ;
100A                          CODE     ENDS
                                       END
```

< Sample Program 5-2. Overflow Interrupt >

```
        ; FILENAME   : INT2.ASM
        ; PROCESSOR  : I8086

ADDRESS     MACHINE CODE               MNEMONIC
0000                          CODE     SEGMENT
                                       ASSUME  CS:CODE,DS:CODE,ES:CODE,SS:CODE
                                       ;
1000                                   ORG      1000H
1000   B8 1234                         MOV      AX,1234H
1003   BB 7234                         MOV      BX,7234H
1006   03 C3                           ADD      AX,BX
1008   CE                              INTO
1009   90                              NOP
100A   90                              NOP
100B   CC                              INT      3
                                       ;
100C                          CODE     ENDS
                                       END
```

5-3. USER-DEFINED SOFTWARE INTERRUPTS

The user can generate an interrupt by executing a two-byte interrupt instruction INT nn. The INT nn instruction is not maskable by the interrupt enable flag(IF). The INT nn instruction can be used to test an interrupt service routine for external interrupts. Type codes 0 to 255 can be used. If predefined interrupt is not used in a system, the associated type code can be utilized with the INT nn instruction to generate software(internal) interrupts.

< Sample Program 5-3. Software Interrupt >

```
        ; FILENAME   : INT3.ASM
        ; PROCESSOR  : I8086

ADDRESS    MACHINE CODE           MNEMONIC
0000                      CODE     SEGMENT
                                   ASSUME  CS:CODE,DS:CODE,ES:CODE,SS:CODE
                                           ;
= 0084                    V_TAB    EQU     21H*4
= 0000                    SEG_D    EQU     0000H
                                   ;
1000                               ORG     1000H
1000   B8 0000                     MOV     AX,SEG_D
1003   8E D8                       MOV     DS,AX
1005   BB 0084                     MOV     BX,V_TAB
1008   B8 101F R                   MOV     AX,OFFSET INT_SER
100B   89 07                       MOV     WORD PTR [BX],AX
                                   ;
100D   43                          INC     BX
100E   43                          INC     BX
                                   ;
100F   BA 0000                     MOV     DX,0
1012   89 17                       MOV     WORD PTR [BX],DX
                                   ;
1014   B8 1234                     MOV     AX,1234H
1017   BB 6789                     MOV     BX,6789H
101A   CD 21                       INT     21H
101C   90                          NOP
101D   90                          NOP
101E   CC                          INT     3
                                   ;
101F   03 C3              INT_SER: ADD     AX,BX
1021   CF                          IRET
                                   ;
```

```
                    CODE    ENDS
                            END
```

5-4. 8259A INTERRUPT CONTROL

The Intel 8259A Programmable interrupt controller handes up to eight sectored priority interrupts for the CPU. It is cascadable for up to 64 vectored probity interrupts without additional circuity. It is packaged in a 28-pin DIP, uses NMOS technology and requires a single +5V supply. Circuity is static, requiring no clock input.

The 8259A is designed to minimize the software and real time overhead in handling multi-level priority interrupts. It has several modes, permitting optimization for a variety of system requirements.

Refer to 8259A data sheet for more detail.

The 8259A and MDA-Win8086 interface is shown in Figure 5-1.

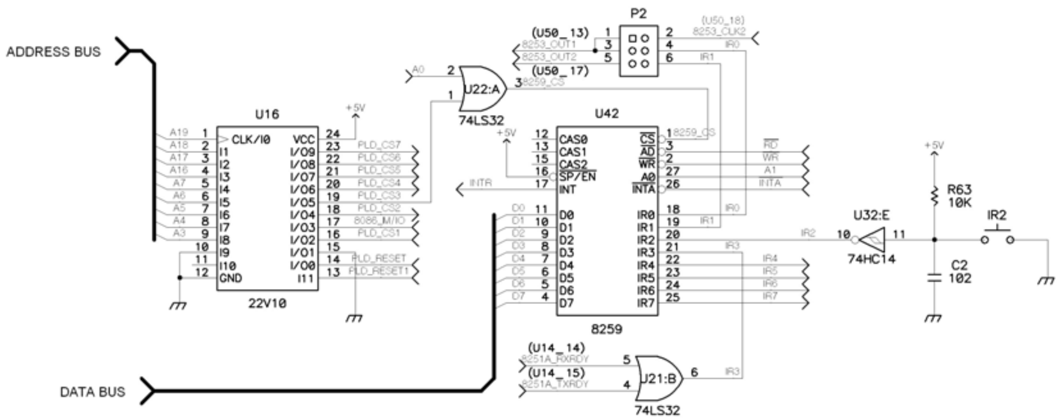


FIGURE 5-1. 8259A INTERFACE

6. 8253 INTERFACE

The 8253 is programmable interval timer/counter specifically designed for use with the Intel Micro-computer systems. Its function is that of a gernal purpose, multi-timing element that can be treated as an array of I/O ports in the system software.

The 8253 solves one of the most common problems in any microcomputer system, the generation of accurate time delays under software control. Instead of setting up timing loops in systems software, the programmer configures the 8253 to match his requirements, initialize one of the counters of the 8253 with the desired quantity, then upon command the 8253 will count out the delay and interrupt the CPU when it has completed its tasks. It is easy to see that the software overhead is finial and that multiple delays can easily be maintained by assignment of priority levels.

Other counter/timer functions that are non-delay in nature but also common to most microcomputers can be implemented with the 8253.

※ Programmable Rate Generator
※ Event Counter
※ Binary Rate Multiplier
※ Real Time Clock
※ Digital One-shot
※ Complex Motor Controller

Refer to 8253 data sheet for more detail.

The 8253 and MDA-Win8086 interface is shown in figure 6-1.

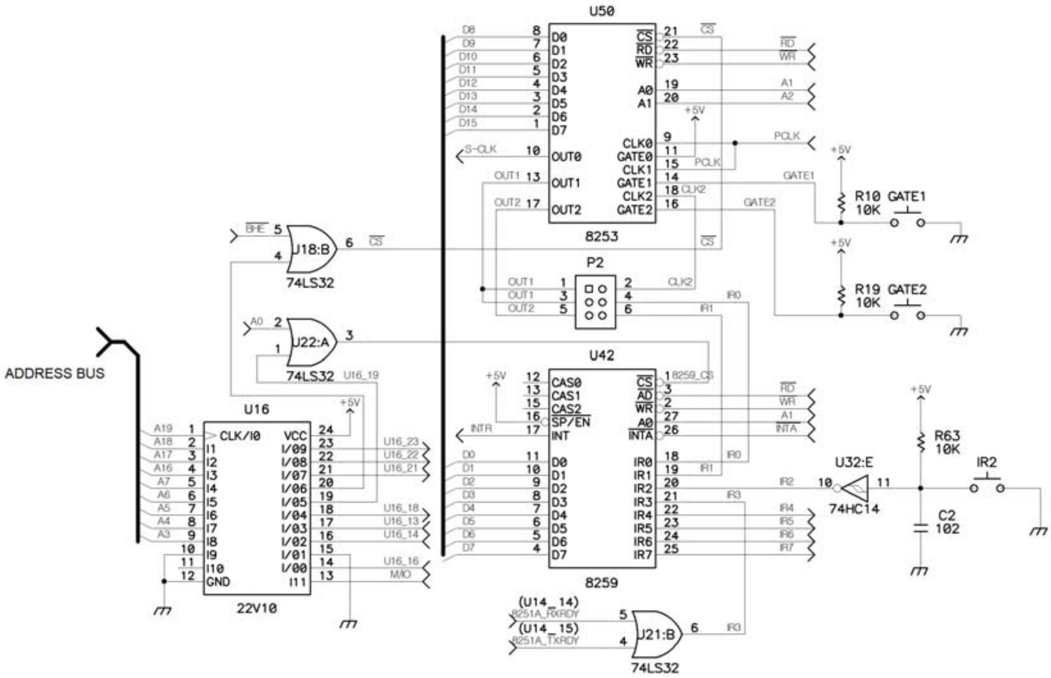
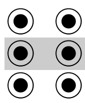


FIGURE 6-1. 8253 INTERFACE

< Sample Program 6-1. LED ON/OF USING 8253 >

※ Setup jumper cap in P2, like following;



Purpose

Source file

C:\MDA\8086\8086C\D8253.C

C:\MDA\8086\ASM8086\D8253.ASM

Experiment 1. 8255A Interface

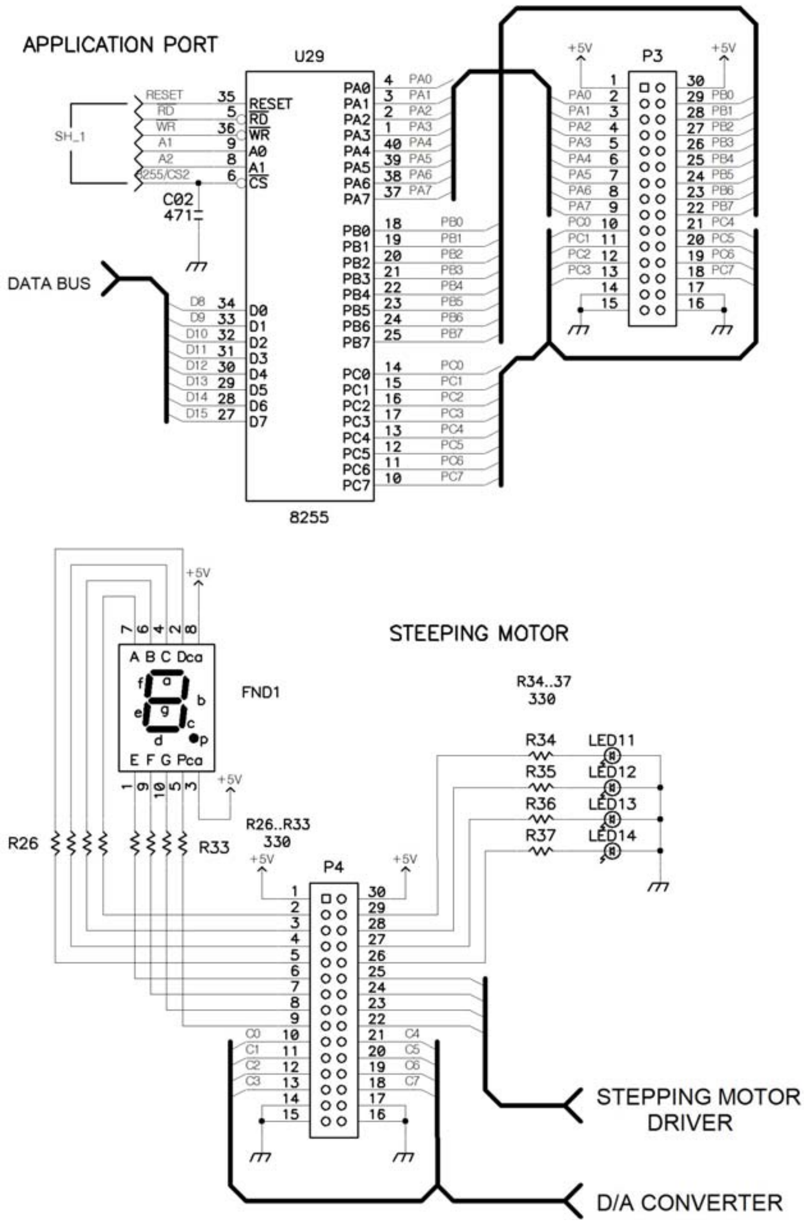


FIGURE 1-1. 8255A INTERFACE

1-1. LED

Purpose

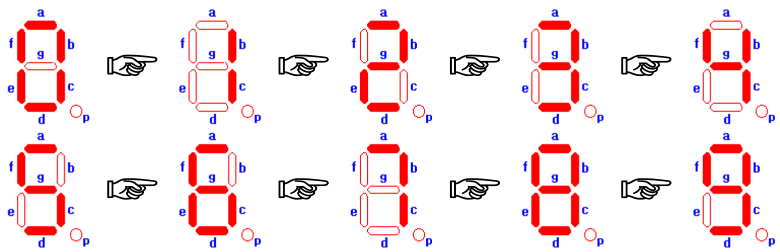
Source file

C:\MDA\8086\8086C\LED.C

C:\MDA\8086\ASM8086\LED.ASM

1-2. 7-Segment

Purpose



Source file

C:\MDA\8086\8086C\FND.C

C:\MDA\8086\ASM8086\FND.ASM

Experiment 2. Dot-Matrix LED

2-1. Dot-Matrix LED Display

General description :

The KMD D1288C is 1.26 inch height 3mm diameter and 8 × 8 dot matrix LED displays. The KMD D1288C are dual emitting color type of red, green chips are contained in a dot with milky and white lens color.

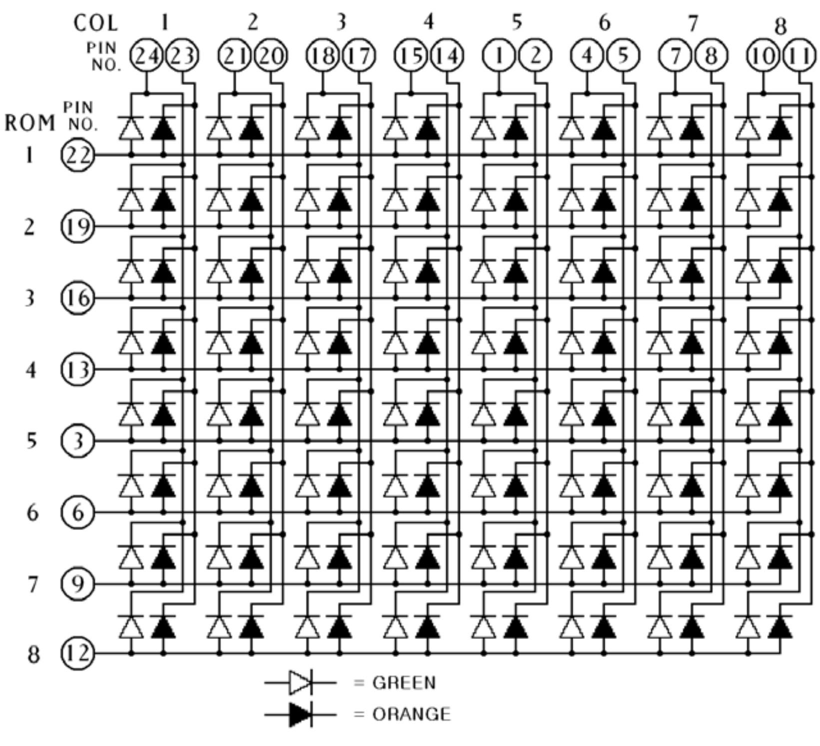


FIGURE 2-1. DOT MATRIX INTERNAL CIRCUIT DIAGRAM

2-2. Dot-Matrix LED Interface

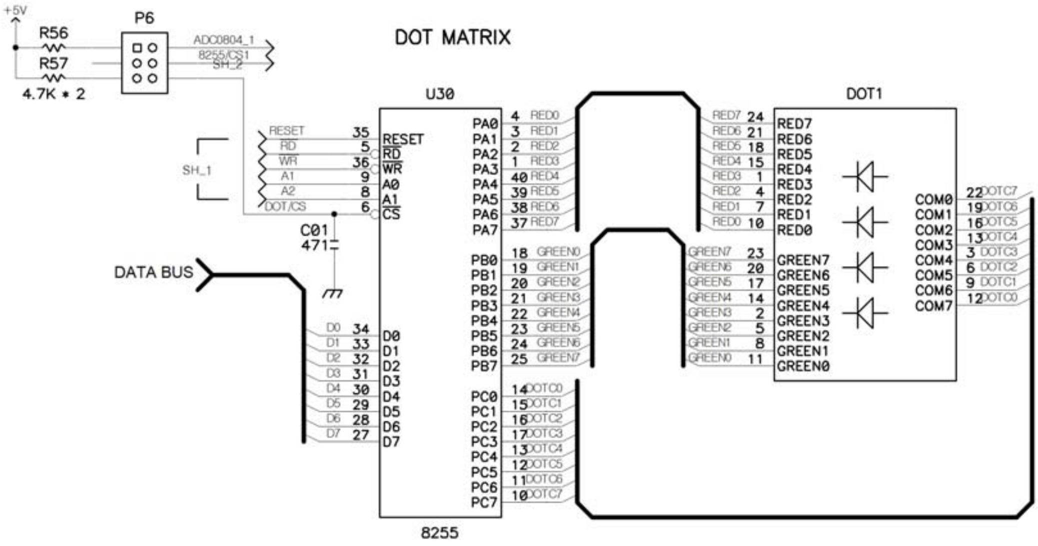
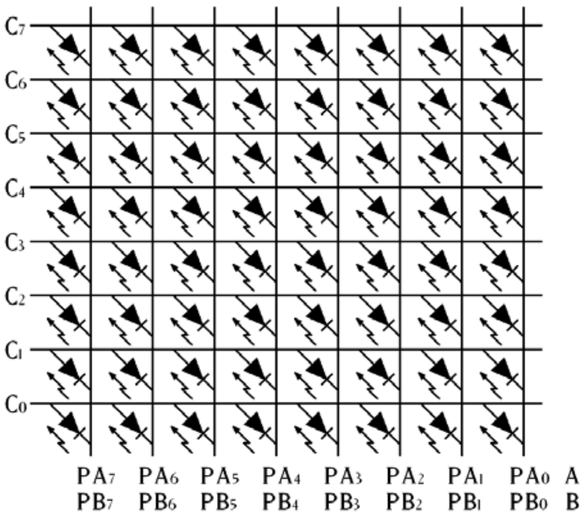


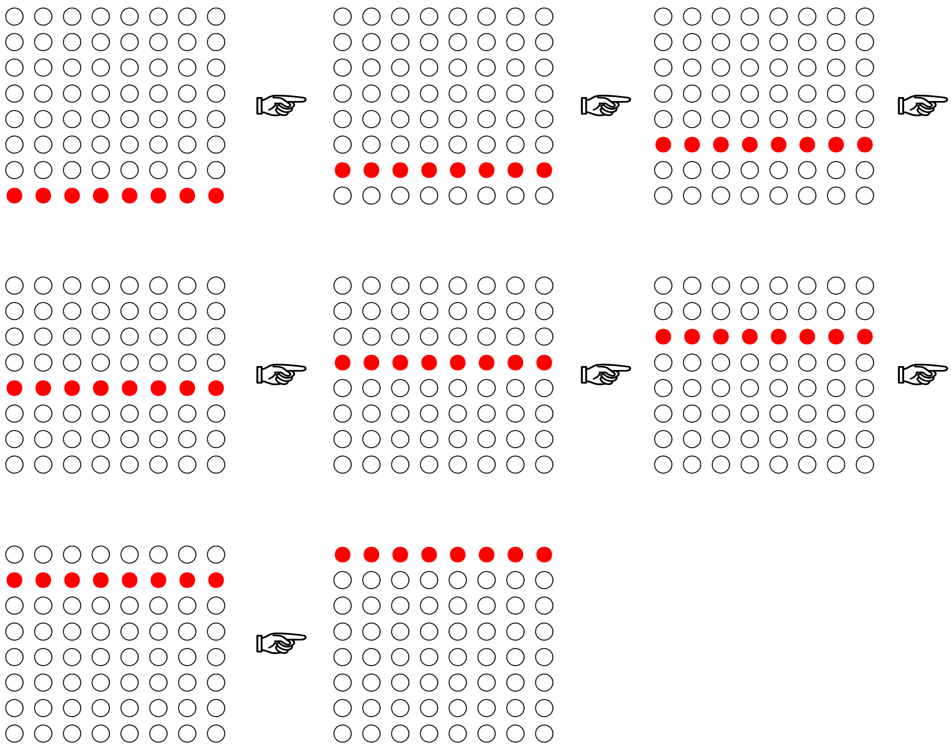
FIGURE 2-2. DOT-MATRIX LED INTERFACE

< Experiment 2-1. Dot-matrix Experiment >

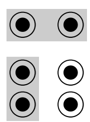


1. Matrix - Scroll bottom to top

Purpose



※ Setup jumper cap, like following;



P6

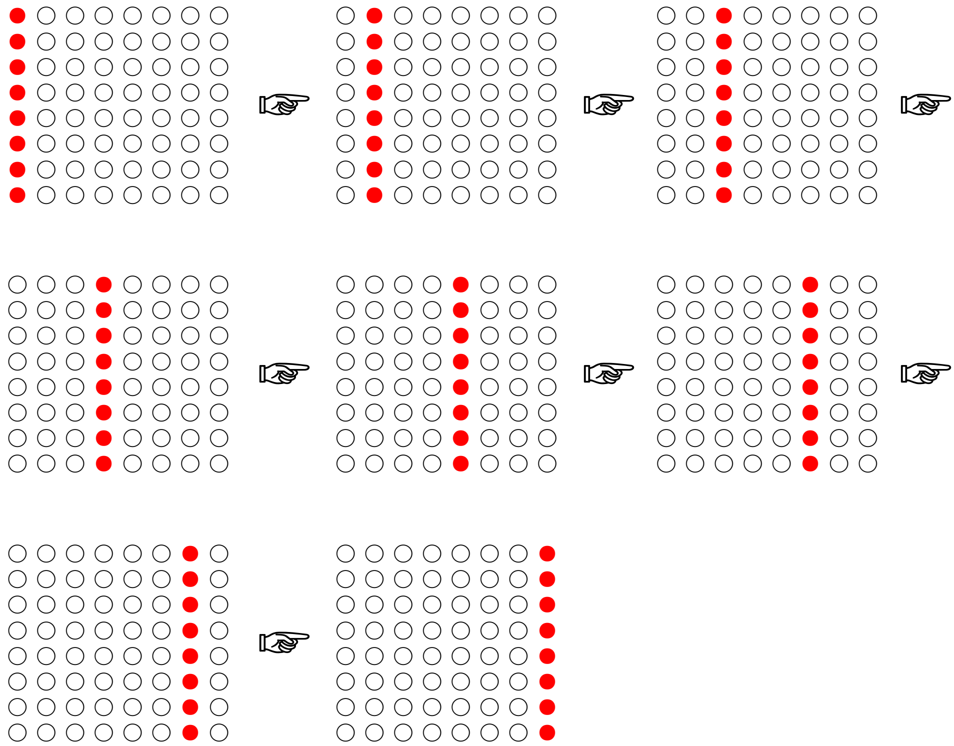
Source file

C:\MDA\8086\8086C\MATRIX.C

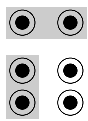
C:\MDA\8086\ASM8086\MATRIX.ASM

2. Matrix - Scroll left to right

Purpose



※ Setup jumper cap, like following;



P6

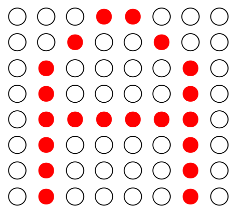
Source file

C:\MDA\8086\8086C\MATRIX_1.C

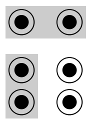
C:\MDA\8086\ASM8086\MATRIX_1.ASM

3. Matrix - Display 'A'

Purpose



※ Setup jumper cap, like following;



P6

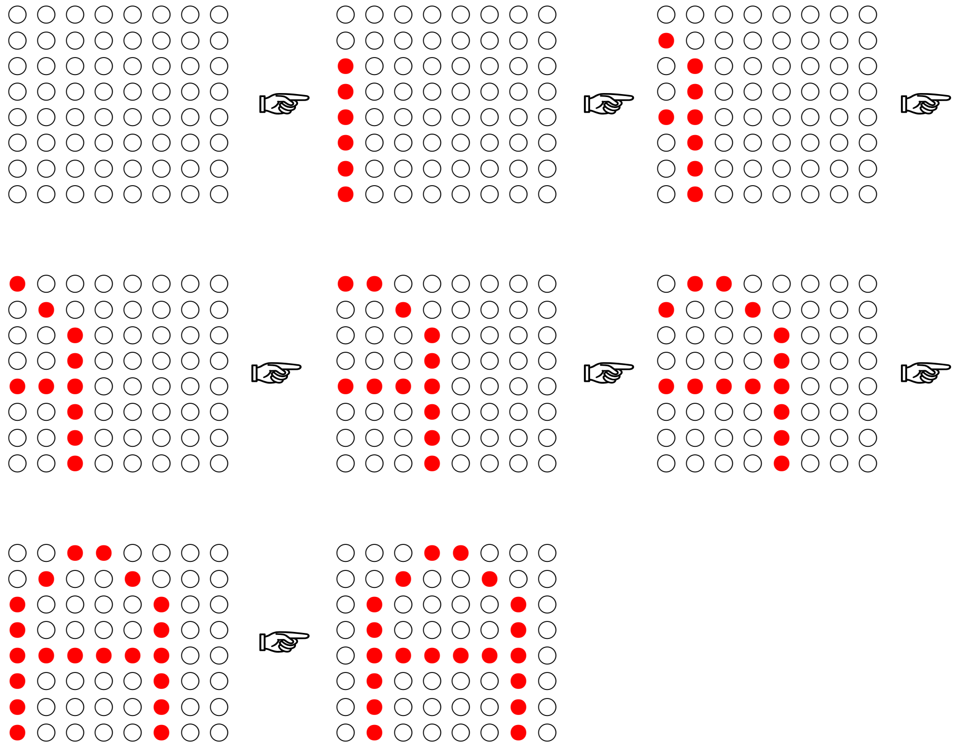
Source file

C:\MDA\8086\8086C\MATRIX_2.C

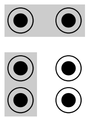
C:\MDA\8086\ASM8086\MATRIX_2.ASM

4. Matrix - Scroll 'A' left to right

Purpose



※ Setup jumper cap, like following;



P6

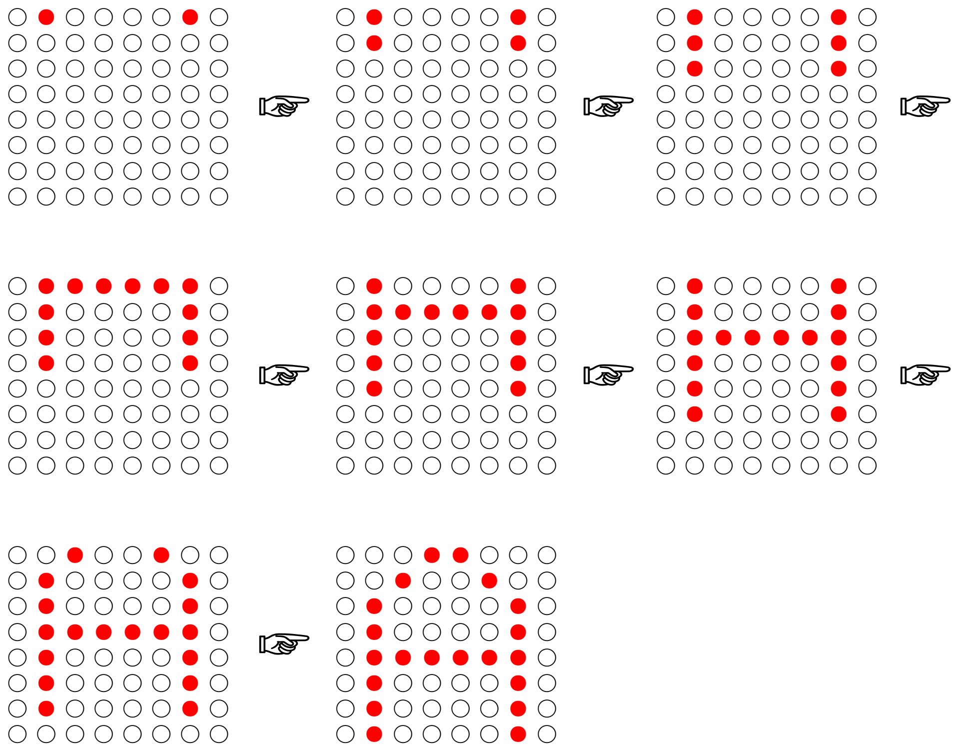
Source file

C:\MDA\8086\8086C\MATRIX_3.C

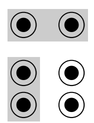
C:\MDA\8086\ASM8086\MATRIX_3.ASM

5. Matrix - Scroll 'A' top to bottom

Purpose



※ Setup jumper cap, like following;



P6

Source file

C:\MDA\8086\8086C\MATRIX_4.C

C:\MDA\8086\ASM8086\MATRIX_4.ASM

2-3. SPEAKER Interface

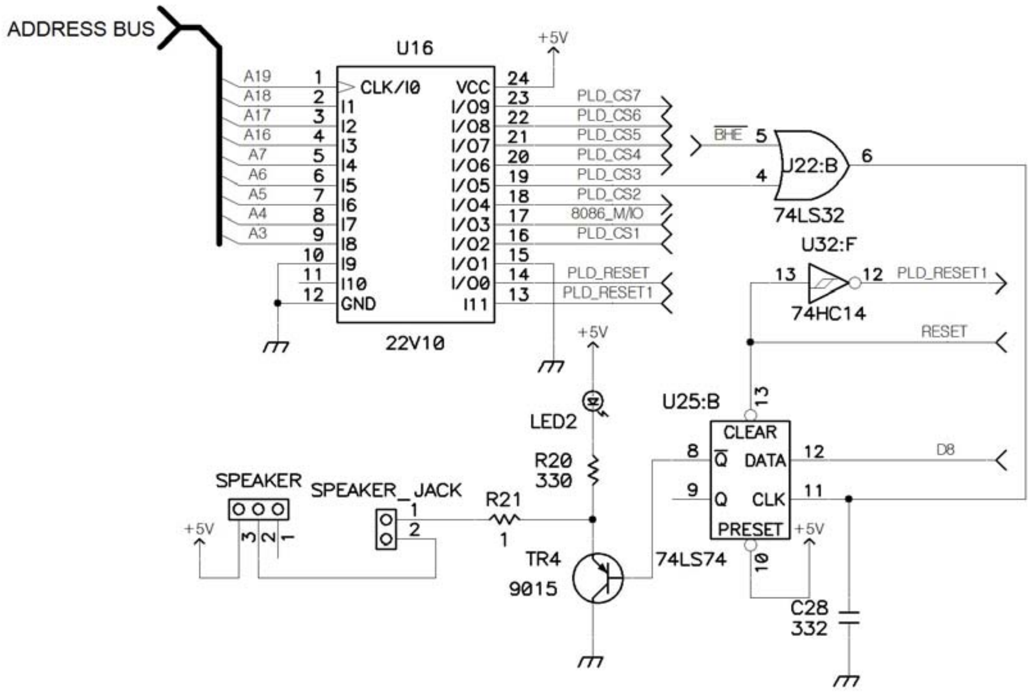


FIGURE 2-3. SPEAKER INTERFACE

1. Make sound

Purpose

Make a laser beam sound.

Source file

C:\MDA\8086\8086C\SPEAK.C

C:\MDA\8086\ASM8086\SPEAK.ASM

2. Make the musical scale

Purpose

Keypad	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Scale	G	A	B	C	D	E	F	G	A	B	C	D	E	F	G	A

Source file

C:\MDA\8086\8086C\SPEAK_1.C

C:\MDA\8086\ASM8086\SPEAK_1.ASM

Experiment 3. 8251A Interface

8251A is an advanced design of the industry standard USART, the Intel 8251. The 8251A operates with an extended range of Intel microprocessors that includes the new 8085 CPU and maintains compatibility with the 8251. Familiarization time is minimal because of compatibility and involves only knowing the additional features and enhancements, and reviewing the AC and DC specification of the 8251A.

The 8251A incorporates all the key features of the 8251 and has the following additional features and enhancements;

◐ 8251A has double-buffered data paths with separate I/O registers for control, status, Data in, and Data out, which considerably simplifies control programming and minimizes CPU overhead.

◐ In asynchronous operations, the Receiver detects and handles "break" automatically relieving the CPU of this task.

◐ A refined Rx initialization prevents the Receiver from starting when in "break" state, preventing unwanted interrupts from a disconnected USART.

Refer to 8251A data sheet for more detail.

The 8251A and MDA-Win8086 interface is shown in figure 3-1.

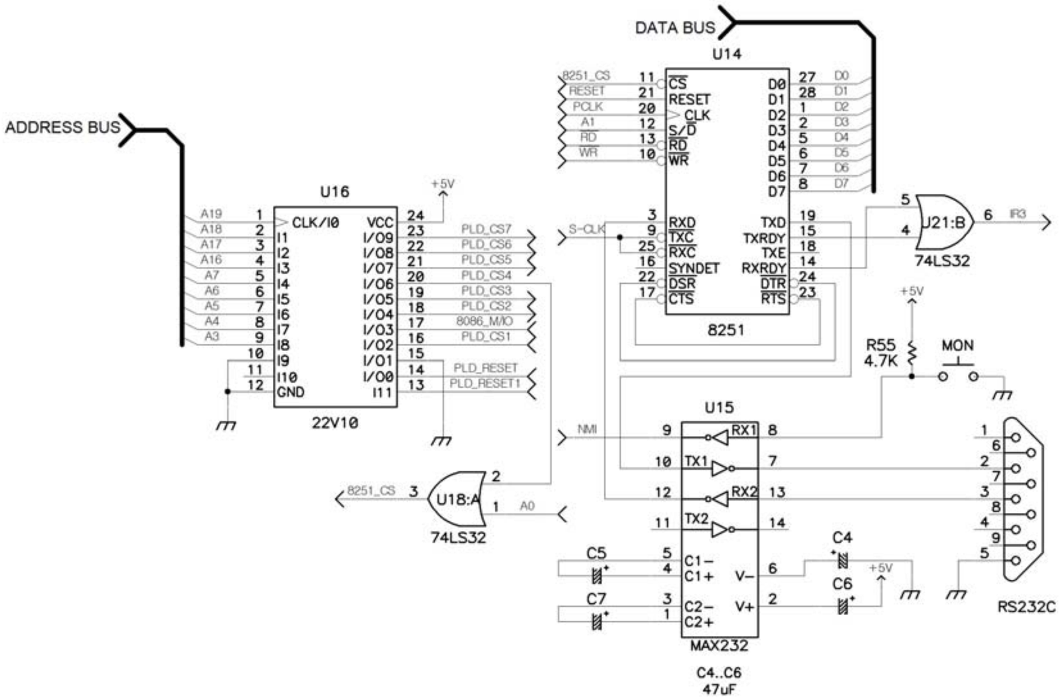
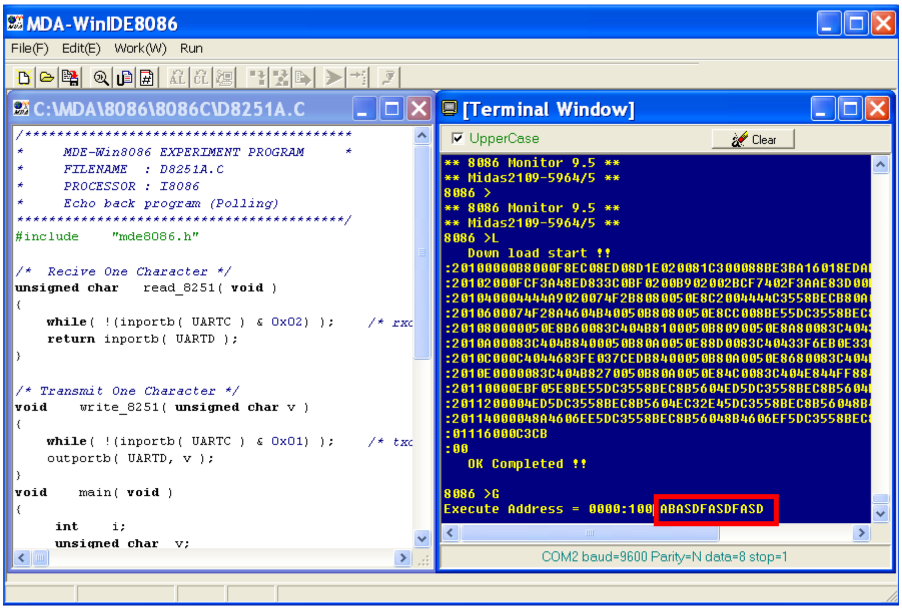


FIGURE 3-1. 8251A INTERFACE

1. UART

Purpose

If you type a keyboard of your PC, the key code that you typed will be echo back.



(1) Polling method

Source file

C:\MDA\8086\8086C\D8251A.C

C:\MDA\8086\ASM8086\D8251A.ASM

(2) Interrupt

Source file

C:\MDA\8086\8086C\D8251A_1.C

C:\MDA\8086\ASM8086\D8251A_1.ASM

Experiment 4. LCD Display

4-1. LCD

* 16 CHARACTERS × 2 LINE MODULE

1) PHYSICAL DATA

Module size	80.0W × 36.0H × 9.30D mm
Min. view area	65.6W × 13.8D mm
Character construction	5 × 7 dots
Character size	2.85W × 3.8H mm
Character Pitch	3.65 mm
Dot size	0.55W × 0.5H mm

2) Pin Connections

Pin NO.	**Symbol**	**Level**	**Function**	
1	Vss	-	0V	Power supply
2	Vdd	-	5V	
3	VL	-	-	
4	RS	H/L	H : Data input L : Instruction input	
5	R/W	H/L	H : Data read L : Data write	
6	E	H. H→L	Enable signal	
7	D0	H/L	Data bus line	
8	D1	H/L		
9	D2	H/L		
10	D3	H/L		
11	D4	H/L		
12	D5	H/L		
13	D6	H/L		
14	D7	H/L		

3) INSTRUCTION

Instruction	CODE										Description	Execution time(max) fosc is 250 KHz
	RS	R/W	D7	D6	D5	D4	D3	D2	D1	D0		
Clear display	0	0	0	0	0	0	0	0	0	1	Clears entire display	1.64 ms
Return Home	0	0	0	0	0	0	0	0	1	*	Returns display being shifted to original position	1.64 ms
Entry Mode set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies shift of display	40 μs
Display ON/OFF Control	0	0	0	0	0	0	1	D	C	B	D : Display ON/OFF C : Cursor ON/OFF B : Cursor Blink/Not	40 μs
Cursor or Display Shift	0	0	0	0	0	1	S/C	R/L	*	*	Moves cursor and Shifts display	40 μs
Function Set	0	0	0	0	1	DL	N	F	*	*	Refer to Remark	40 μs
Set CGRAM	0	0	0	1	ACG						Sets CG RAM Addr.	40 μs
Set DD RAM Addr.	0	0	1	ADD							Sets DD RAM Address	40 μs
Read Busy Flag & Addr	0	1	BF	AC							BF : Busy flag Reads AC contents.	40 μs
Write Data CG or DD	1	0	Write data								Writes data into DD RAM or CG RAM	40 μs
Read Data from CG or DD RAM	1	1	Read data								Reads data from DD RAM or CG RAM	40 μs
Remark	I/D= 1: Increment 0: Decrement S= 1: Accompanies display shift S/C=1:Display shift. 0:cursor move R/L=1:Shift right. 0: Shift left. DL= 1 : 8bits 0 : 4 bits N = 1 : 2 lines 0 : 1 lines F = 1 : 5×10dots 0 : 5×7dots BF = 1: Internally operating 0: Can accept instruction * NO EFFECT										DD RAM : Display data RAM CG RAM : Character generator RAM ACG : CG RAM address ADD : DD RAM address Corresponds to cursor address AC : Address counter used for both DD and CG RAM address	

4) INITIALIZATION SEQUENCE

Step	Execution time
POWER ON	
⇓	
Wait till VCC is 4.5V min	
⇓	
RS = 0, WRITE 38H *1	(Execution time : 40 ㎲)
⇓	
RS = 0, WRITE 0EH	(Execution time : 40 ㎲)
⇓	
RS = 0, WRITE 08H	(Execution time : 40 ㎲)
⇓	
RS = 0, WRITE 02H	(Execution time : 1.64 ㎳)
⇓	
RS = 0, WRITE 01H	(Execution time : 1.64 ㎳)
⇓	
RS = 0, WRITE ADDR. *2	(Execution time : 40 ㎲)
⇓	
RS = 1, WRITE DATA *3	(Execution time : 40 ㎲)

* 1. Should use this instruction only once in operation.

* 2. ADDR is the setting data cursor position to debug.
In data, MSB(D7) should be "1" and other 7 bits (D0 ~ D6) are cursor position.

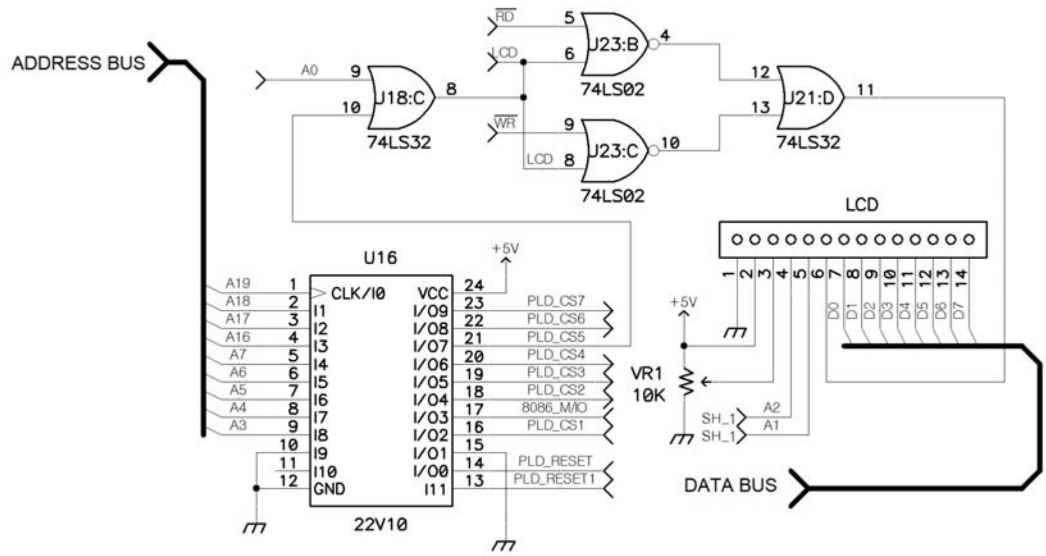
* 3. DATA mean the ASCII codes.

5) CHARACTER FONT TABLE

Lower Nible \ Upper Nible	0000	0010	0011	0100	0101	0110	0111	1000	1010	1011	1100	1101	1111
XXXX0000	CG RAM (1)		0	@	P	`	p		ｰ	ﾀ	ﾐ	α	p
XXXX0001	(2)	!	1	A	Q	a	q	｡	ｱ	ﾁ	ﾑ	ä	q
XXXX0010	(3)	"	2	B	R	b	r	｢	ｲ	ﾂ	ﾒ	β	θ
XXXX0011	(4)	#	3	C	S	c	s	｣	ｳ	ﾃ	ﾓ	ε	∞
XXXX0100	(5)	$	4	D	T	d	t	､	ｴ	ﾄ	ﾔ	μ	Ω
XXXX0101	(6)	%	5	E	U	e	u	･	ｵ	ﾅ	ﾕ	σ	ü
XXXX0110	(7)	&	6	F	V	f	v	ｦ	ｶ	ﾆ	ﾖ	ρ	Σ
XXXX0111	(8)	'	7	G	W	g	w	ｧ	ｷ	ﾇ	ﾗ	g	π
XXXX1000	(1)	(	8	H	X	h	x	ｨ	ｸ	ﾈ	ﾘ	√	x̄
XXXX1001	(2)	)	9	I	Y	i	y	ｩ	ｹ	ﾉ	ﾙ	⁻¹	y
XXXX1010	(3)	*	:	J	Z	j	z	ｪ	ｺ	ﾊ	ﾚ	j	千
XXXX1011	(4)	+	;	K	[	k	{	ｫ	ｻ	ﾋ	ﾛ	ˣ	万
XXXX1100	(5)	,	<	L	¥	l	|	ｬ	ｼ	ﾌ	ﾜ	¢	円
XXXX1101	(6)	-	=	M	]	m	}	ｭ	ｽ	ﾍ	ﾝ	£	÷
XXXX1110	(7)	.	>	N	^	n	→	ｮ	ｾ	ﾎ	ﾞ	ñ	
XXXX1111	(8)	/	?	O	_	o	←	ｯ	ｿ	ﾏ	ﾟ	ö	█

NOTE : CGRAM is a CHARACTER GENERATOR RAM having a storage function of character pattern which enable to change freely by users program

4-2. LCD Interface



1. Message display

Purpose

Display the message like below.

```
S e r i a l   m o n i t o r   !
M D A - W i n 8 0 8 6   K i t !
```

Source file

C:\MDA\8086\8086C\LCD.C

C:\MDA\8086\ASM8086\LCD.ASM

2. Scroll the message center to left

Purpose

Scroll the message.

S	e	r	i	a	l		m	o	n	i	t	o	r		!
M	D	A	-	W	i	n	8	0	8	6		K	i	t	!

Source file

C:\MDA\8086\8086C\LCD_1.C
C:\MDA\8086\ASM8086\LCD_1.ASM

3. Scroll the message left to right

Purpose

Scroll the message, "MDA-Win8086 Training Kit".

M	D	A	-	W	i	n	8	0	8	6		T	r	a	i

Source file

C:\MDA\8086\8086C\LCD_2.C
C:\MDA\8086\ASM8086\LCD_2.ASM

4. Display the pressed key on LCD

Purpose

Display the pressed keypad on LCD

			K	e	y		C	o	d	e					
							0	0							

Source file

C:\MDA\8086\8086C\LCD_3.C
C:\MDA\8086\ASM8086\LCD_3.ASM

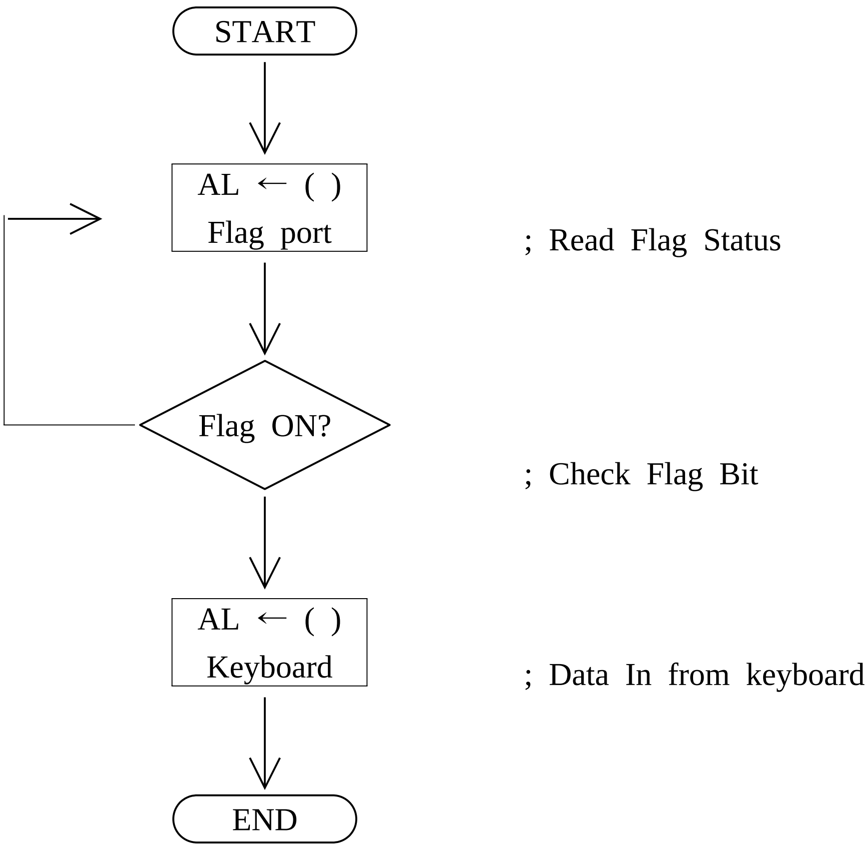
Experiment 5. Keyboard Interface

5-1. Keyboard Interface

※ Position Code

Key	0	1	2	3	4	5	6	7
Code	00	01	02	03	04	05	06	07
Key	8	9	A	B	C	D	E	F
Code	08	09	0A	0B	0C	0D	0E	0F
Key	:	STP	GO	REG	−	+	DA	AD
Code	10	11	12	13	14	15	16	17

※ Key Input Flowchart



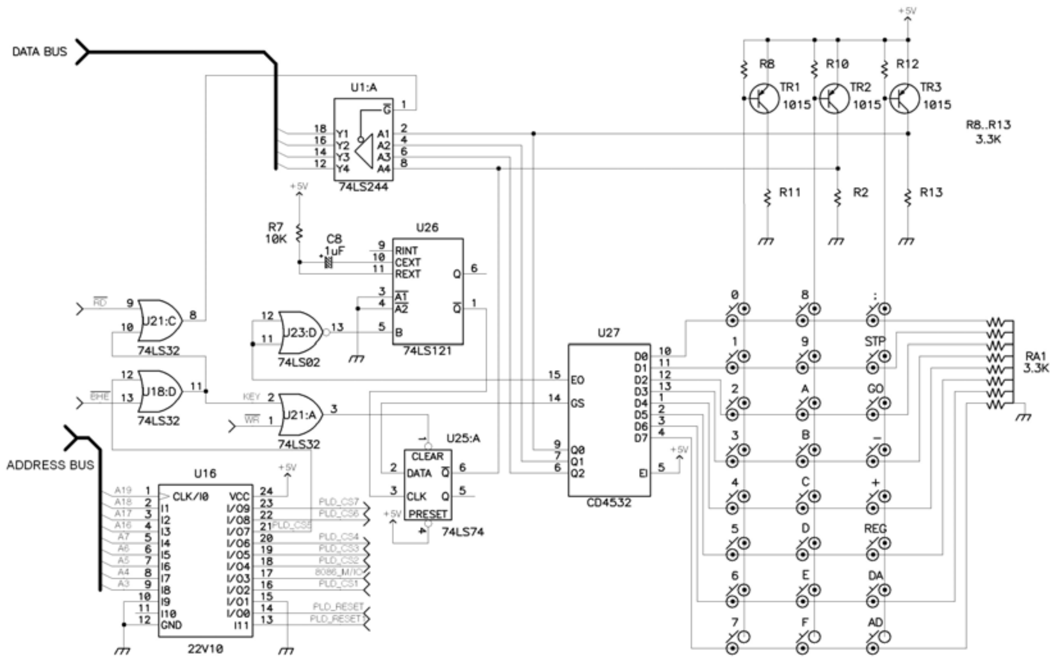


FIGURE 5-1. KEYBOARD INTERFACE

< Sample Program 5-1. Key input subroutine >

```
SCAN:   IN      AL,KEY
                TEST    AL,10000000B
                JNZ     SCAN
                ;
                AND     AL,00011111B
                MOV     BX,0
                MOV     DS,BX
                MOV     BYTE PTR K_BUF,AL
                ; KEY CLEAR
                OUT     KEY,AL
                ; SPEAKER AND LED ON?
                CALL    TONE
                RET
                ;
```

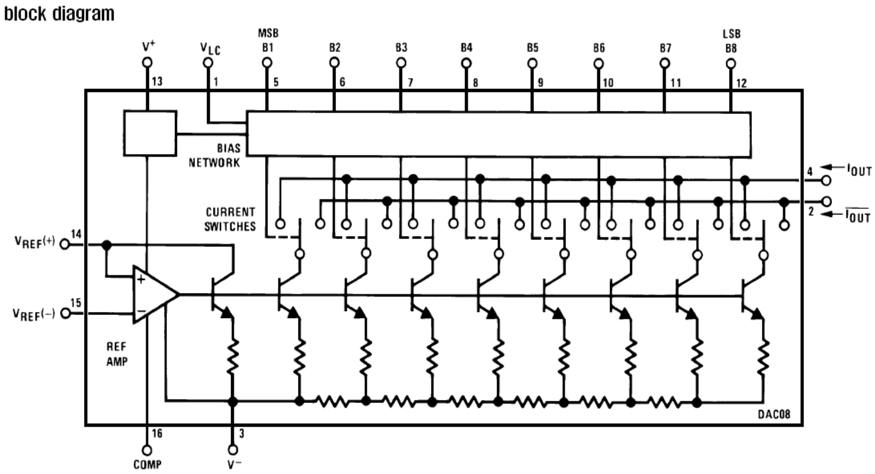
```
TONE:   PUSH    CX
        PUSH    AX
        ;
        MOV     AH,50
        MOV     AL,1
TONE2:  MOV     CX,200
        OUT     SPK,AL
TONE1:  LOOP    TONE1
        XOR     AL,1
        DEC     AH
        JNZ     TONE2
        ;
        XOR     AL,AL
        OUT     SPK,AL
        ;
        POP     AX
        POP     CX
        RET
```

EXPERIMENT 6. D/A CONVERTER

6-1. D/A Converter Specification

General Description :

The DAC0800 is a monolithic 8-Bit high-speed current output digital to analog converter (DAC) featuring typical setting times of 100ns. When used as a multiplying DAC monotonic performance over a 40 to 1 reference current range is possible. The DAC0800 also features high compliance complementary current outputs to allow differential output voltage of 20 Vpp with simple resistor loads as shown in FIGURE 6-1.



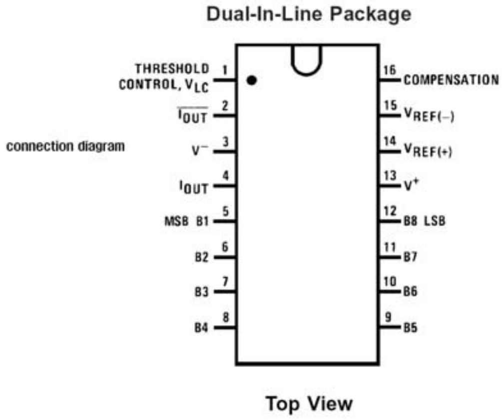


FIGURE 6-1. DAC0800 BLOCK DIAGRAM

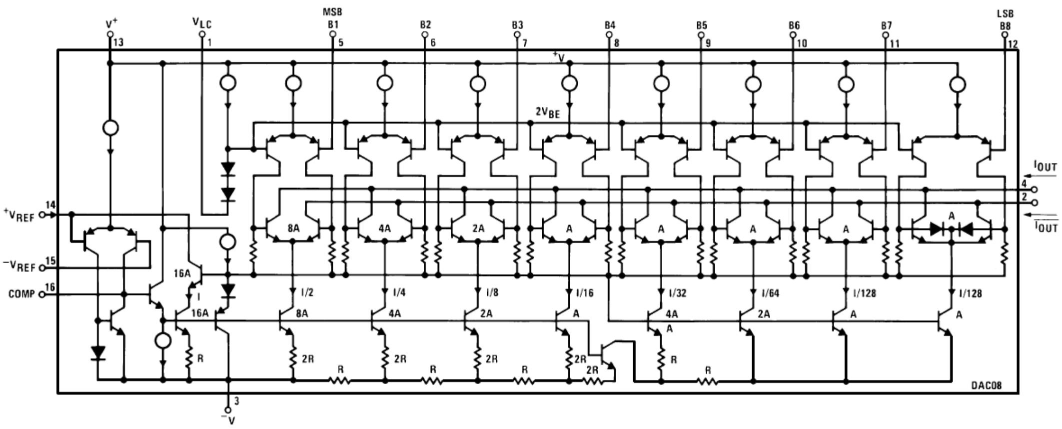
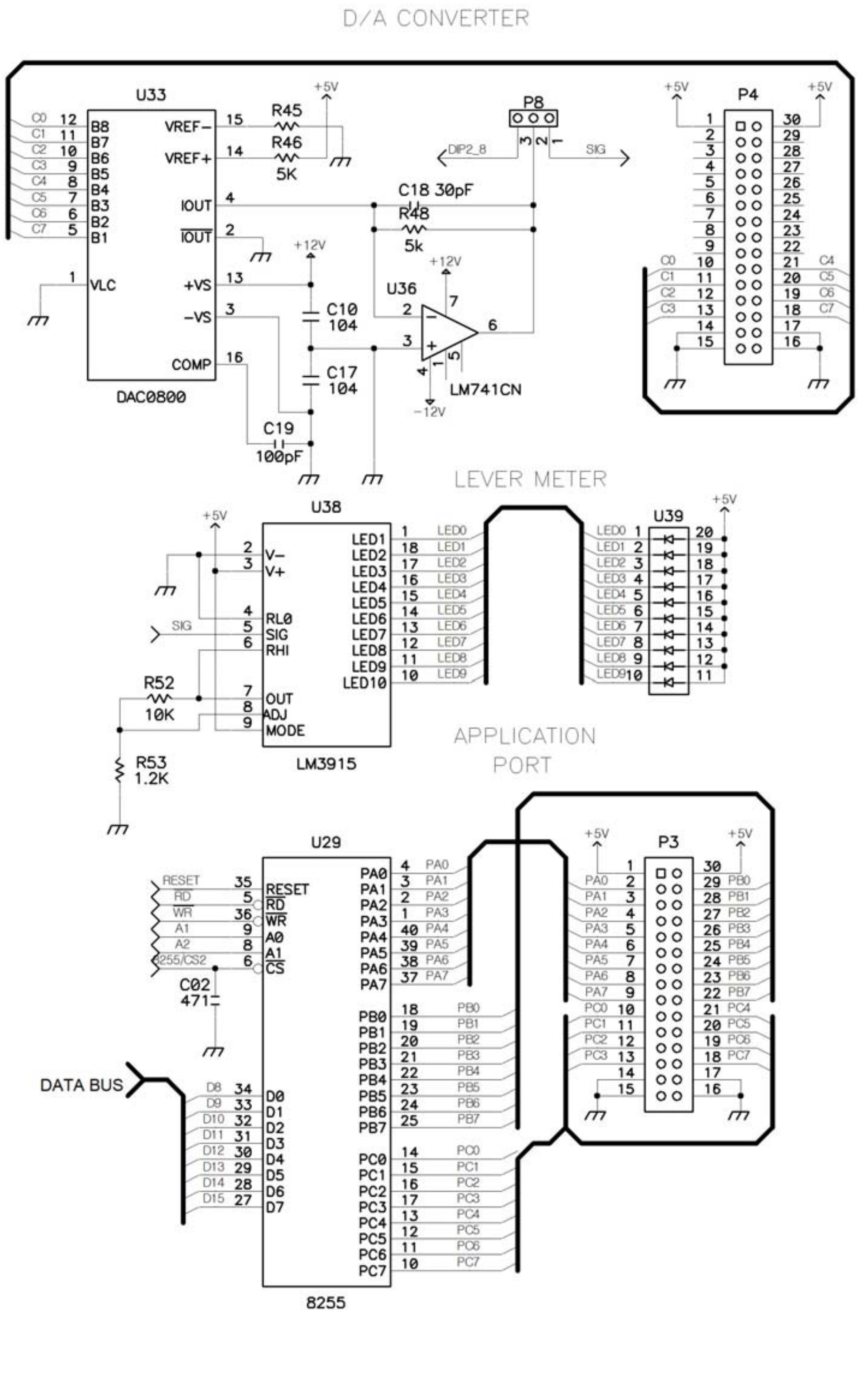


FIGURE 6-2. DAC0800 BLOCK DIAGRAM(continue)

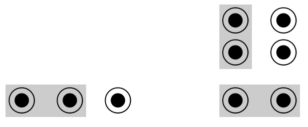
6-2. D/A Converter Interface



6-3. D/A Converter Experiment

1. DAC

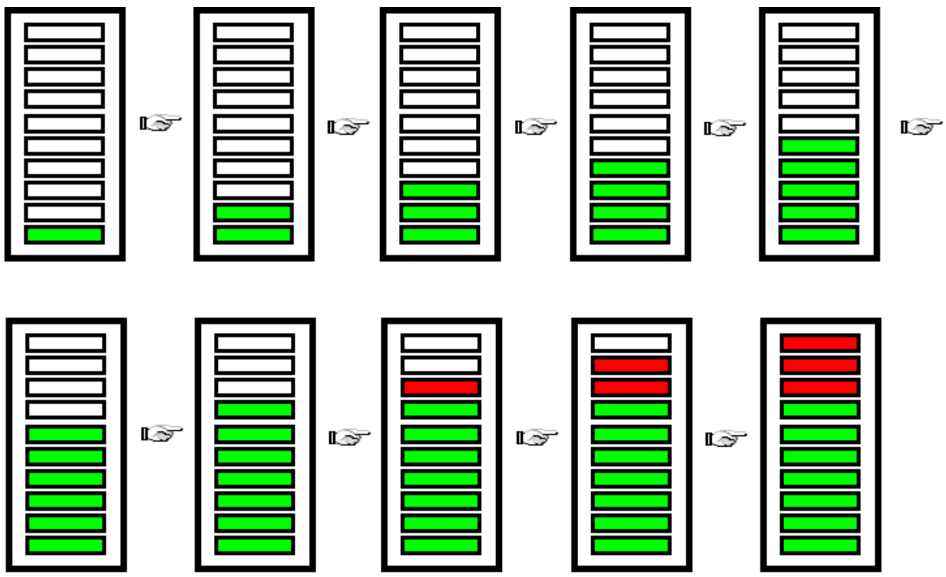
※ Setup jumper cap, like following;



P8 P6

Purpose

Bar LED will be increased.



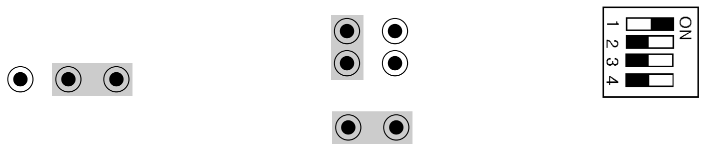
Source file

C:\MDA\8086\8086C\DAC.C

C:\MDA\8086\ASM8086\DAC.ASM

1. DA - AD

※ Setup jumper cap, like following;



P8 P6 DIP2

Purpose

		D	A						A	D					
		0	0	0			0	.	0	0	0		V		

Source file

C:\MDA\8086\8086C\DAC_1.C

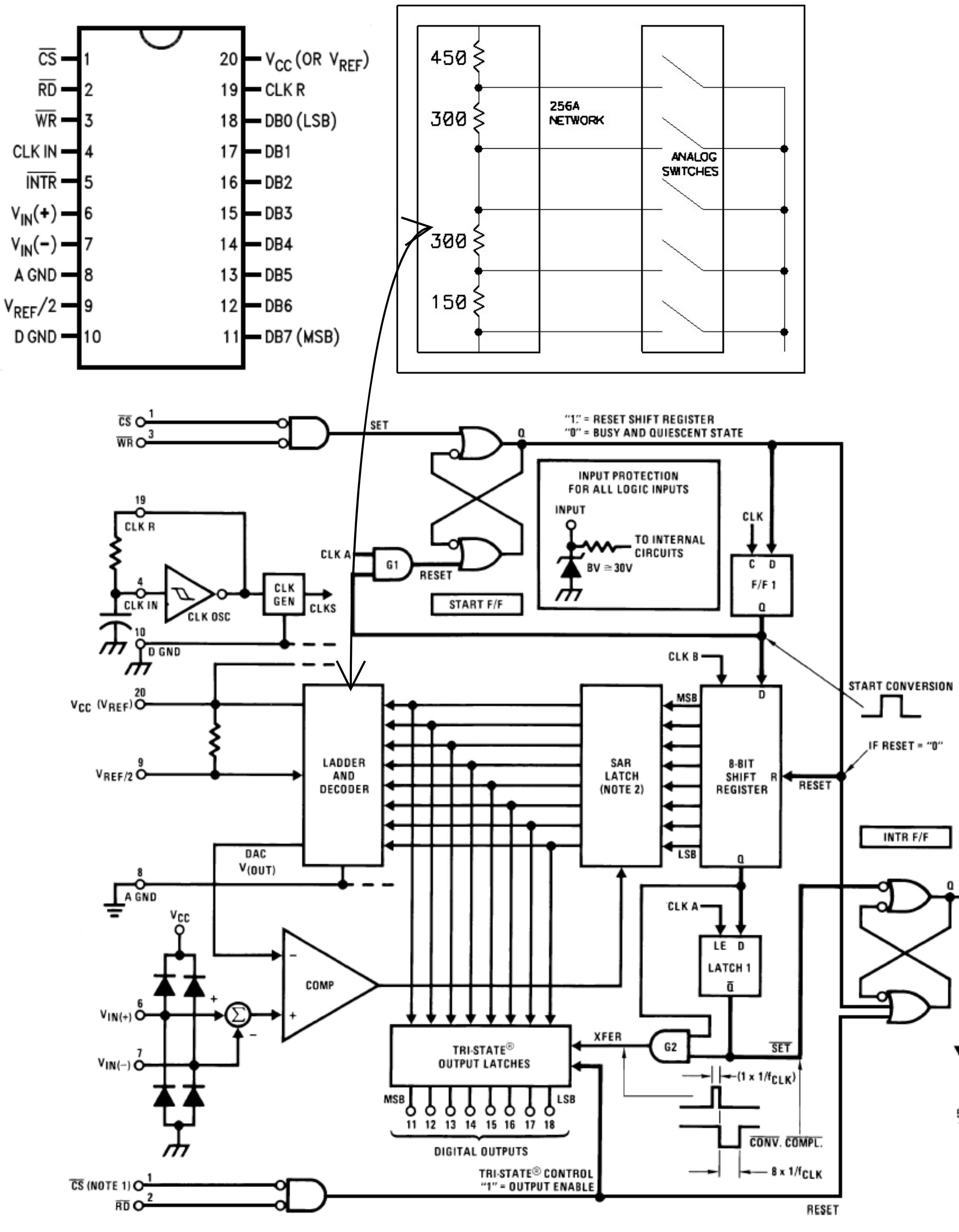
C:\MDA\8086\ASM8086\DAC_1.ASM

Experiment 7. A/D Converter

7-1. A/D Converter Specification

General Description :

The ADC0800 is an 8-bit monolithic A/D converter using P-channel ion-implanted MOS technology. It contains a high input impedance comparator 256 series resistors and analog switches control logic and output latches. Conversion is performed using a successive approximation technique where the unknown analog voltage is compared to the resister tie points using analog switches. When the appropriate tie point voltage matches the unknown voltage, conversion is complete and the digital outputs contain an 8-bit complementary binary word corresponding to the unknown. The binary output is TRI-STATE to permit busting on common data lines.

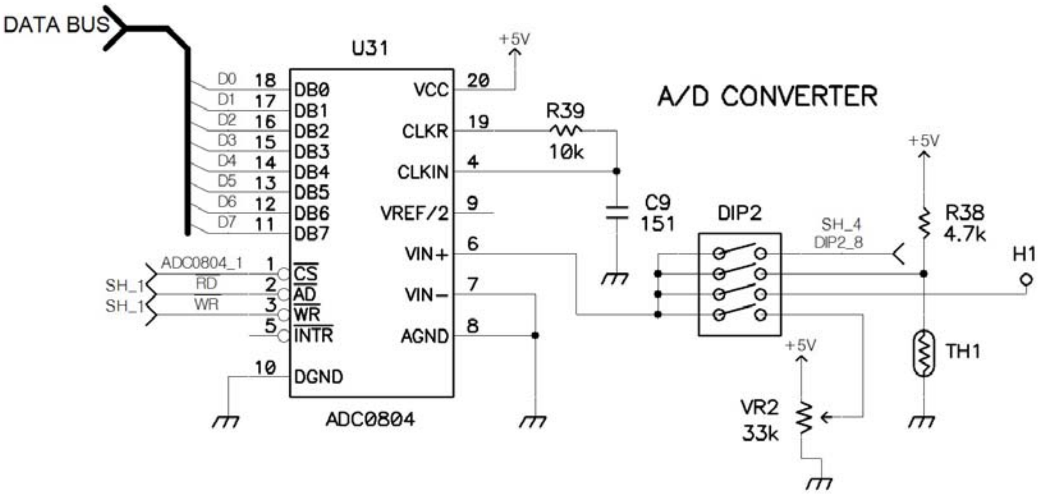


Note 13: $\overline{CS}$ shown twice for clarity.

Note 14: SAR = Successive Approximation Register.

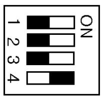
FIGURE 7-1. ADC0804 BLOCK DIAGRAM

7-2. A/D Converter Interface



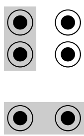
7-3. A/D Converter Experiment

① Setting DIP2 switch on the left of ADC0804 like follow.



DIP2

② Setup jumper cap, like following;



P6

Purpose

When you adjust the VR, ADC value will be displayed on the LCD module.

```
  Volt Meter
    3.364 [V]
```

Source file

C:\MDA\8086\8086C\ADC.C

C:\MDA\8086\ASM8086\ADC.ASM

EXPERIMENT 8. Stepping Motor Control

8-1. Stepping Motor Specification

The stepping motor is a device which can transfer the incoming pulses to stepping motion of a predetermined angular displacement. By using suitable control circuity the angular displacement can be made proportional to the number of pulses. Using microcomputer, one can have better control of the angular displacement resolution and angular speed of a stepping motor. In the past few years the stepping motor has improved in size reduction, speed and precision. Stepping motor will have wider applications in the future.

Stepping motors are suitable for translating digital inputs into mechanical motion. In general, there are three types of stepping motor:

(1). VR(Variable Reluctance) stepping motors
(2). Hybrid stepping motors
(3). PM(Permanent Magnet) stepping motors

Table 1-4. Stepping motor characteristics comparison

Motor type / Characteristics	PM	VR	Hybrid
Efficiency	High	Low	High
Rotor Inertia	High	Low	Low
Speed	High	High	Low
Torque	Fair	Low	High
Power O/P	High	Low	Low
Damping	Good	Poor	Poor
Typical Step Angle	1.8° 15° 30°	7.5° 15° 30°	0.18° 0.45°

Figure 8-1 is used to explain the operation of simplified stepping motor (90°/step). Here the A coil and B coil are perpendicular to each other. If either A or B coil is excited(a condition which is known as single-phase excitation), the rotor can be moved to 0°, 90°, 180°, 270°degree position depending on the current's ON/OFF conditions in the coils, see FIGURE 8-1(a). If both coils have current flowing at the same time, then the rotor positions can be 45°, 135°, 225°, 315°degrees as shown in FIGURE 8-1(b). This is known as two-phase exception. In FIGURE 8-1(c), the excitation alternates between 1-phase and 2-phase, then the motor will rotates according to 0°, 45°, 90°, 135°, 180°, 225°, 270°, 315°sequence. This is 1-2 phase excitation, each step distance is only half of step movement of either 1-phase or 2-phase excitation.

Stepping motor can rotate in clockwise or counter-clockwise direction depending on the current pulse sequence applied to the excitation coils of the motor. Referring to the truth tables in FIGURE 8-1(a), (b), (c). If signals are applied to coil A and B according to Step 1,2,3,4,5,6,7,8, then counter-clockwise movement is achieved. And vice-versa is true. If signals are applied according to step 8,7,6,5,4,3,2,1, then clockwise movement is achieved.

Commercial stepping motor uses multimotor rotor, the rotor features two bearlike PM cylinders that are turned one-half of tooth spacing. One gear is south pole, the other gear is north pole. If a 50-tooth rotor gear is used, the following movement sequences will proceed.

A. single-phase excitation:

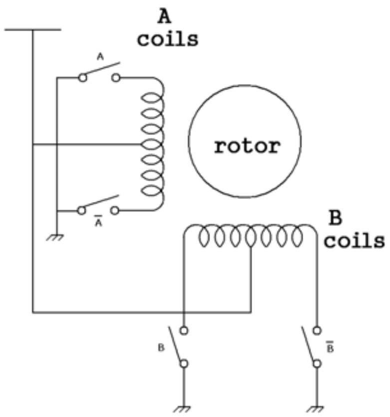
The stepping position will be 0°,1.8°, 3.6°, ... 358.2°, total 200 steps in one round.

B. two-phase excitation:

The stepping positions will be 0.9°, 2.7°, 4.5°, ... 359.1°, total 200 steps in one round.

C. single-phase and two-phase excitations combined:

The stepping positions will be 0°, 0.9°, 1.8°, 2.7°, 3.6°, 4.5°, ... 358.2°, 359.1°, total 400 steps in one round.



		A	B	A_	B_
STEP	**1**	1	0	0	0
	2	0	1	0	0
	3	0	0	1	0
	4	0	0	0	1
	5	1	0	0	0
	6	0	1	0	0
	7	0	0	1	0
	8	0	0	0	1

(a) 1-phase excitation

		A	**B**	**A_**	**B_**
STEP	**1**	1	1	0	0
	2	0	1	1	0
	3	0	0	1	1
	4	1	0	0	1
	5	1	1	0	0
	6	0	1	1	0
	7	0	0	1	1
	8	1	0	0	1

(b) 2-phase excitation

		A	**B**	**A_**	**B_**
STEP	**1**	1	0	0	0
	2	1	1	0	0
	3	0	1	0	0
	4	0	1	1	0
	5	0	0	1	0
	6	0	0	1	1
	7	0	0	0	1
	8	1	0	0	1

(c) 1-2 phase excitation

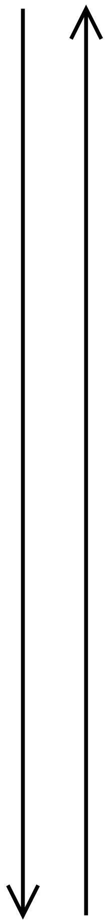
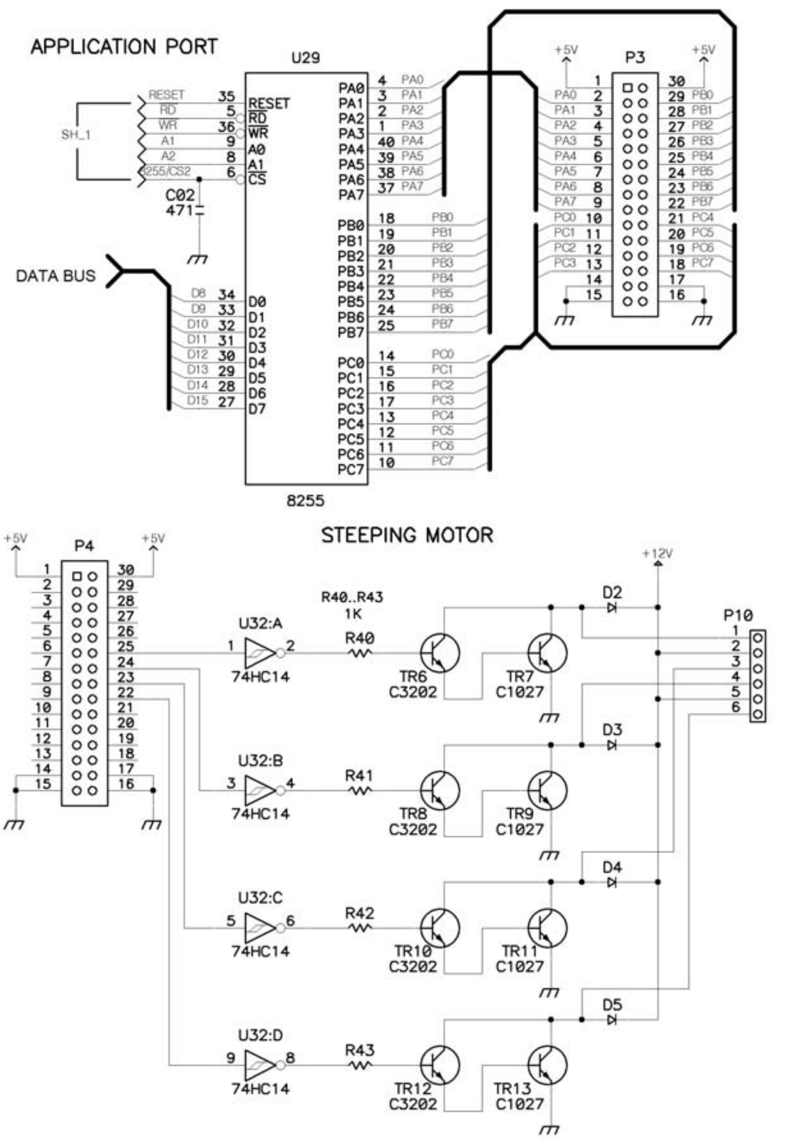


FIGURE 8-1. Half-step and full-step rotation

Since stepping motor makes step-by-step movement and each step is equidistant, the rotor and stator magnetic field must be synchronous. During start-up and stopping, the two fields may not be synchronous, so it is suggested to slowly accelerate and decelerate the stepping motor during the start-up or stopping period.

8-2. Stepping Motor Interface



8-3. Stepping Motor Experiment

1. Stepping motor

Purpose

Stepping motor test - 1 phase magnetization

Source file

C:\MDA\8086\8086C\STEPMO.C

C:\MDA\8086\ASM8086\STEPMO.ASM

2. Stepping motor control

Purpose

Keypad	Function
0	Left 45 degree
1	Right 45 degree
2	Left 90 degree
3	Right 90 degree
4	Left 180 degree
5	Right 180 degree
6	Left Revolution
7	Right Revolution

Source file

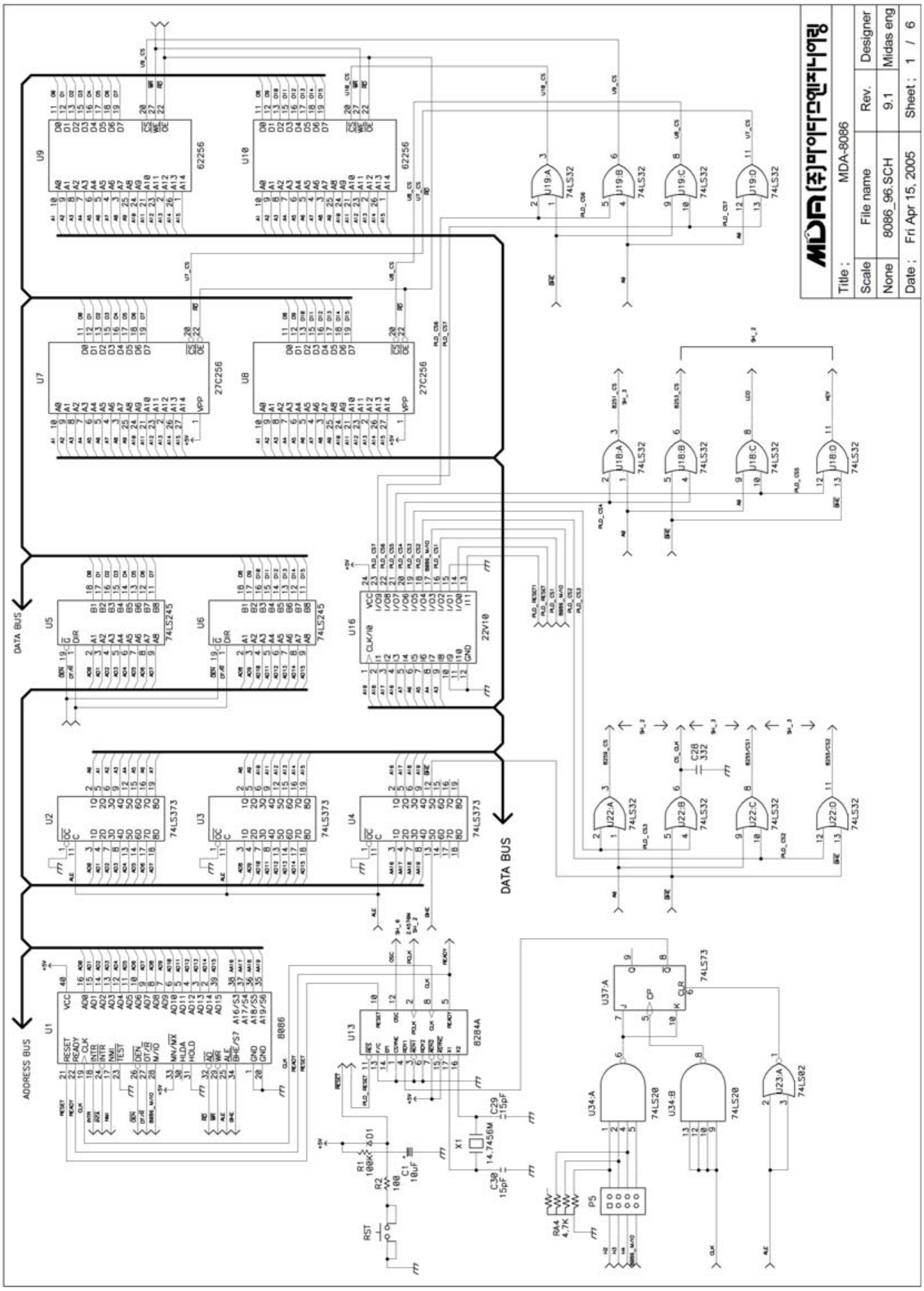
C:\MDA\8086\8086C\STEPMO_1.C

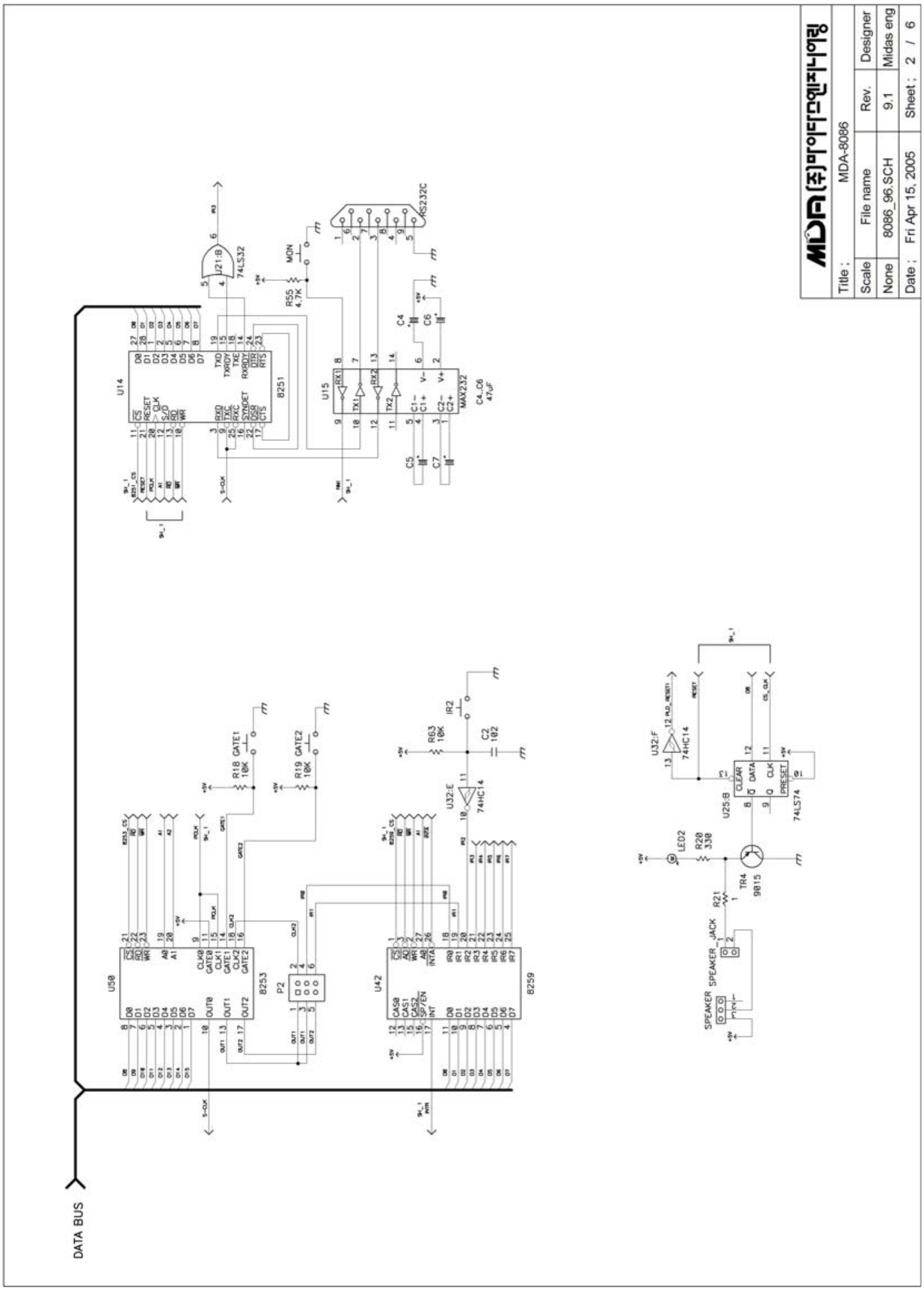
C:\MDA\8086\ASM8086\STEPMO_1.ASM

Appendix.

- 1 MDA-Win8086 Circuit Diagram
- 2 MDA-Win8086 External Connector
- 3 8086 Pin Configuration
- 4 8086 Instruction Set Summary

1. MDA-Win8086 Circuit Diagram

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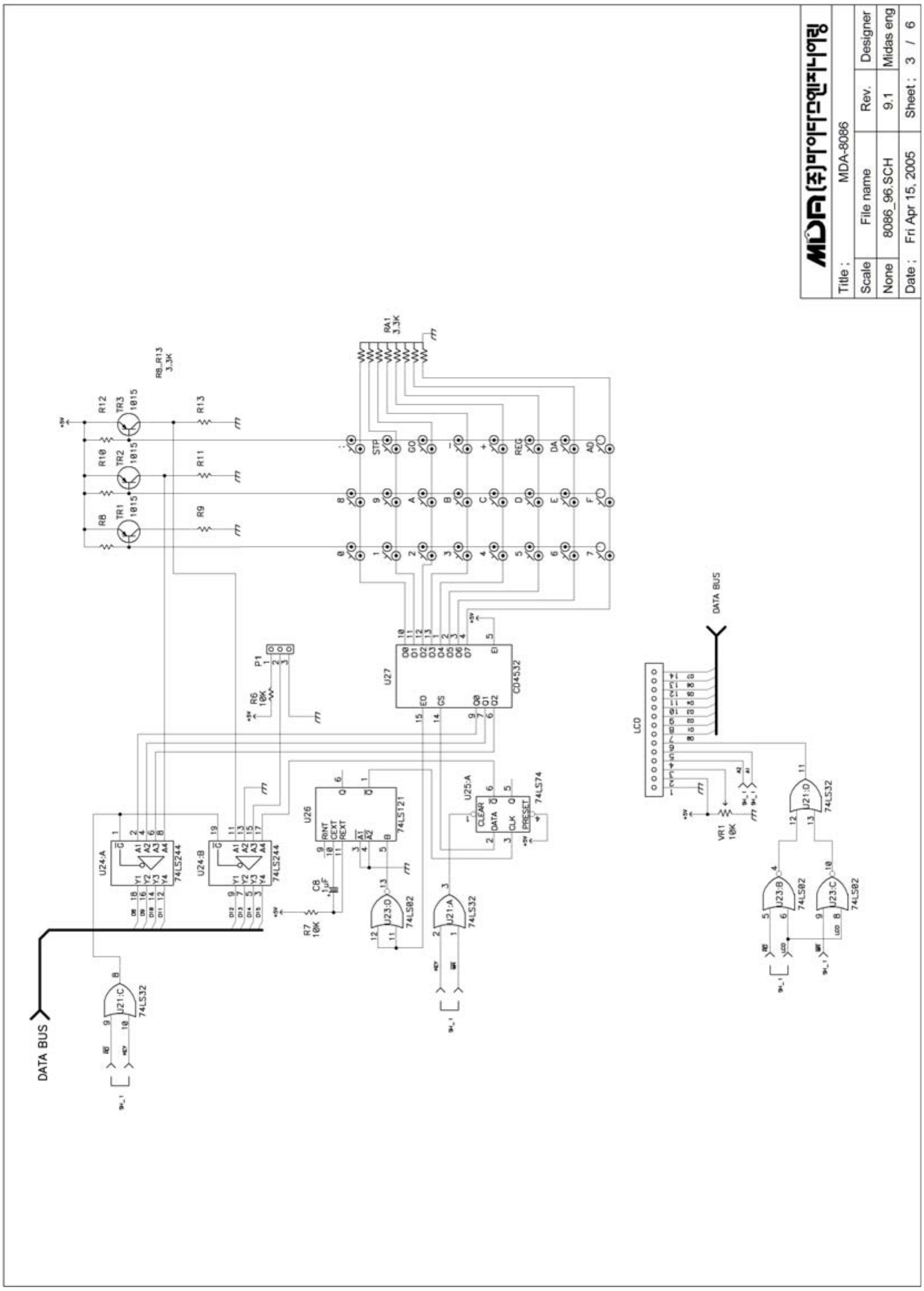
File name 8086_96.SCH
Rev. 9.1
Designer Midas eng
Date ; Fri Apr 15, 2005
Sheet ; 2 / 6
DATA BUS
U14
8251
U15
MAX232
RS232C
U21:B
74LS32
U50
8253
U42
8259
P2
U32:E
74HC14
U32:F
U25:B
74LS74
TR4
9015
LED2
SPEAKER
SPEAKER_JACK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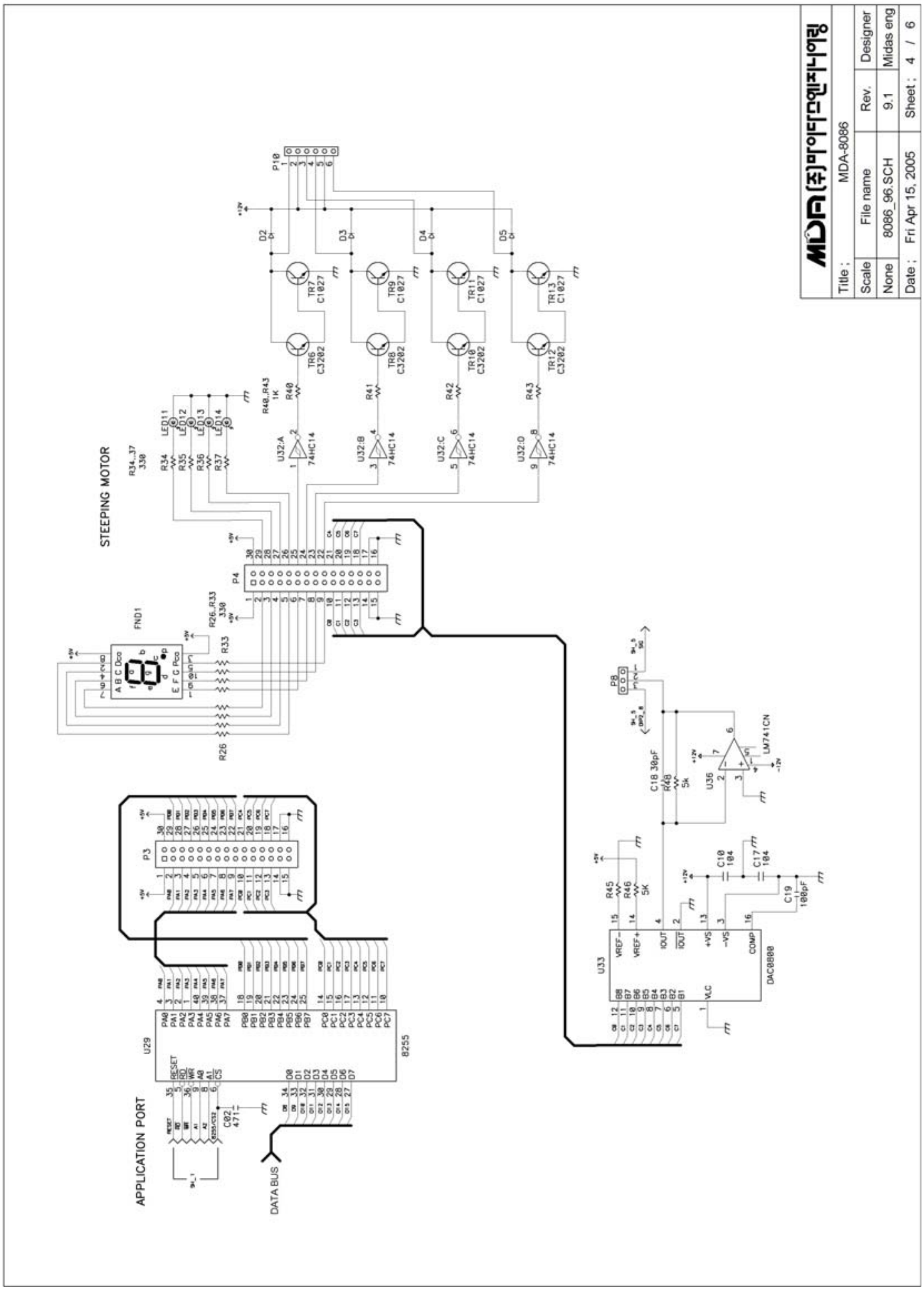
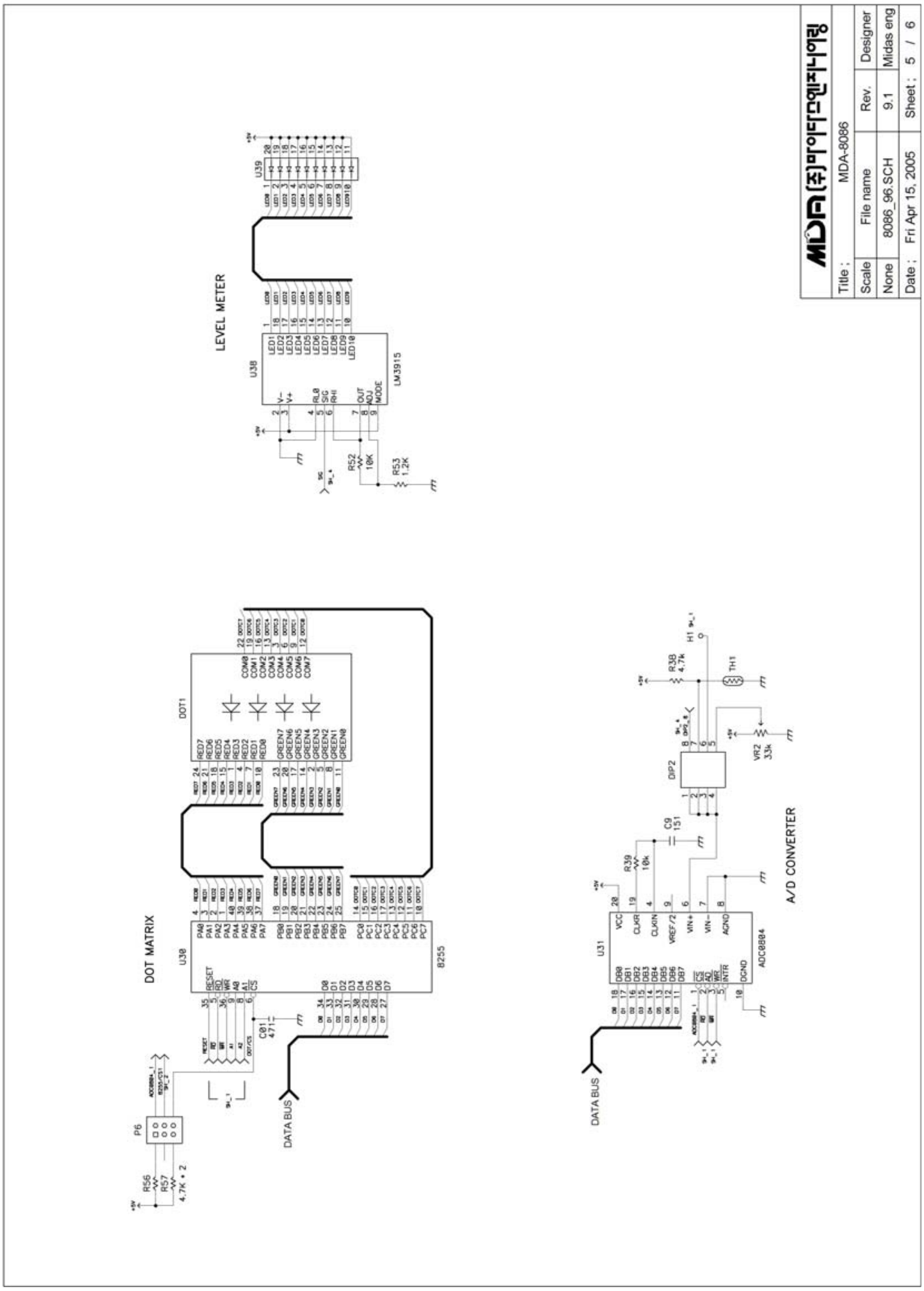
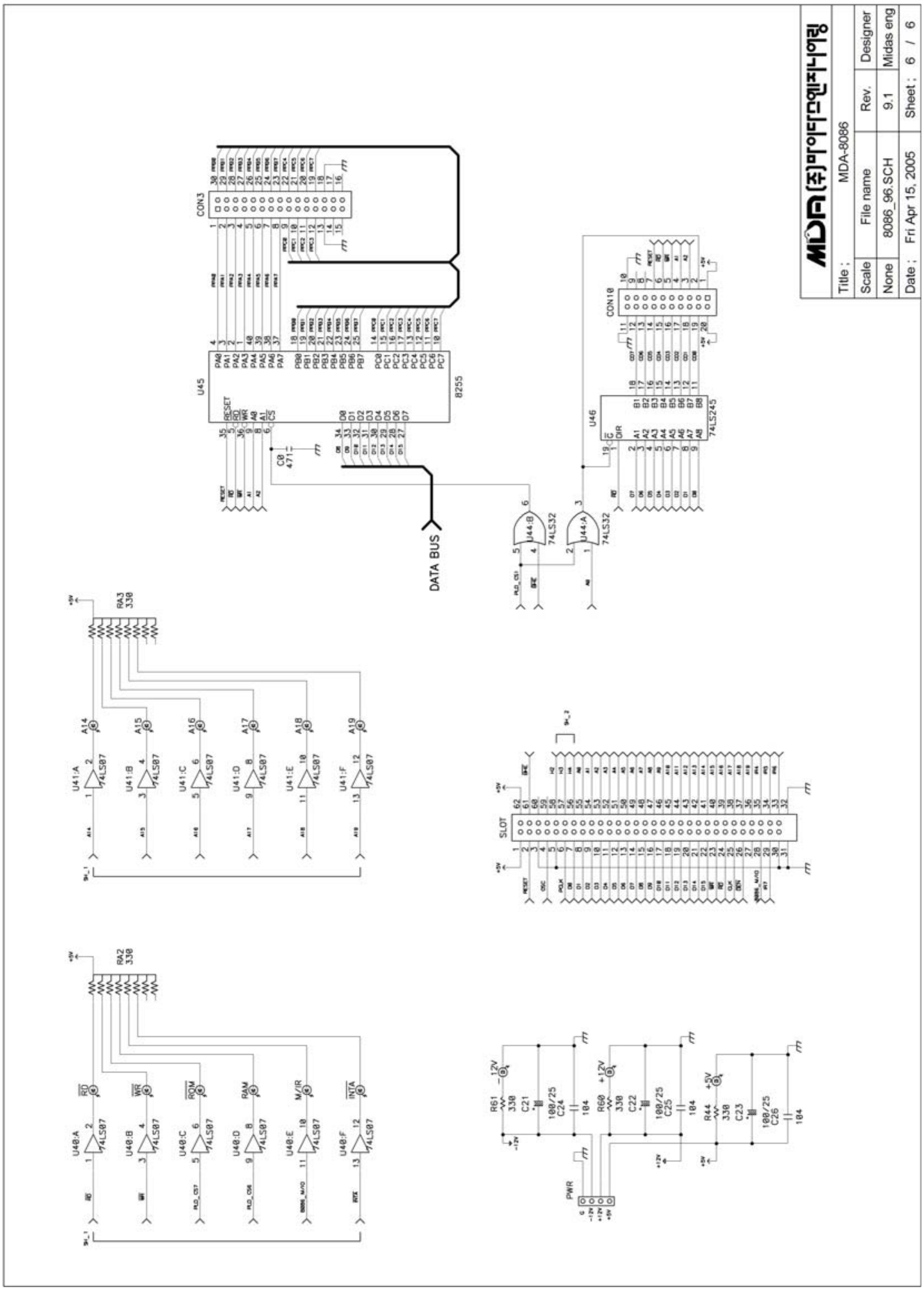
Scale
None
File name
8086_96.SCH
Rev.
9.1
Designer
Midas eng
Date : Fri Apr 15, 2005
Sheet : 3 / 6
DATA BUS
LCD
74LS244
74LS121
74LS74
74LS32
74LS02
CD4532


STEEPING MOTOR
APPLICATION PORT
DATA BUS
U29
8255
U33
DAC0800
U36
LM741CN
P3
P4
P8
P10
FND1
Title ;
MDA-8086
Scale
None
File name
8086_96.SCH
Rev.
9.1
Designer
Midas eng
Date :
Fri Apr 15, 2005
Sheet ;
4 / 6


DOT MATRIX
LEVEL METER
A/D CONVERTER
DATA BUS
DATA BUS
U30
8255
DOT1
U31
ADC0804
U38
LM3915
U39
DIP2
P6
Title ; MDA-8086
Scale
None
File name
8086_96.SCH
Rev.
9.1
Designer
Midas eng
Date : Fri Apr 15, 2005
Sheet : 5 / 6


MDA (주)마이다스엔지니어링
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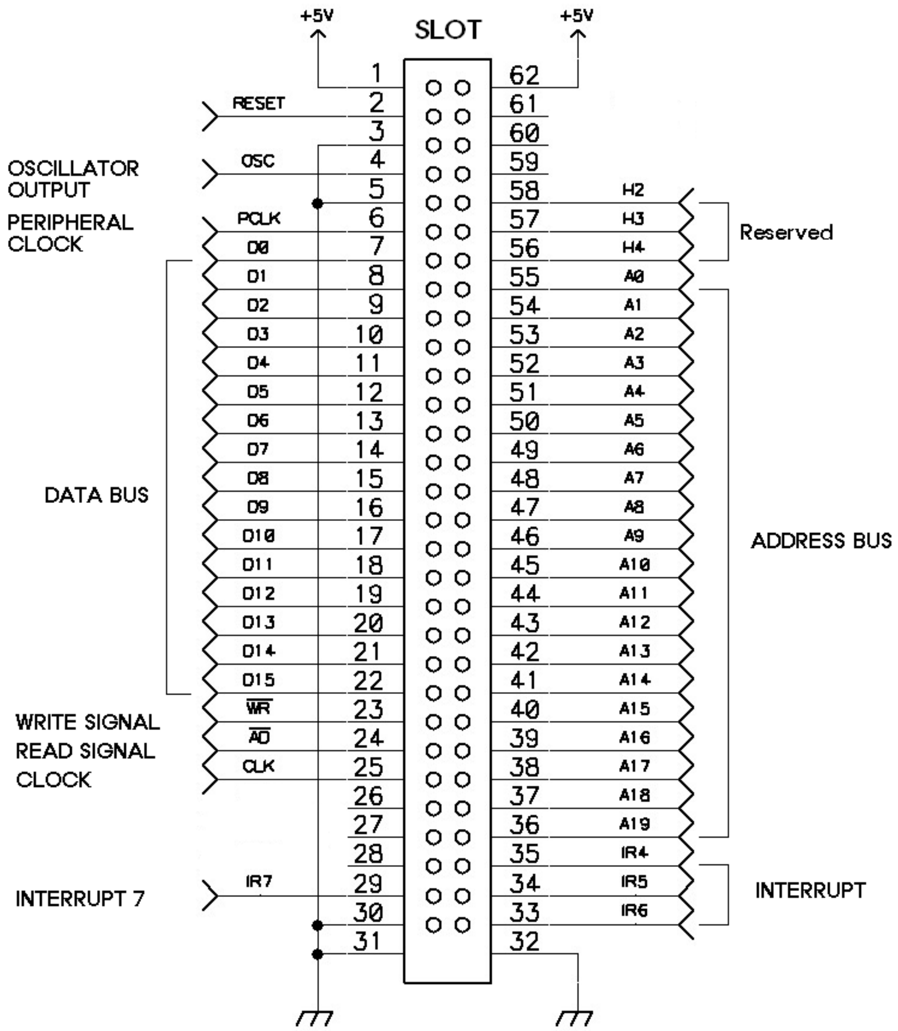
Scale
None
File name
8086_96.SCH
Rev.
9.1
Designer
Midas eng
Date : Fri Apr 15, 2005
Sheet : 6 / 6

2. MDA-Win8086 External Connector

(1) SLOT

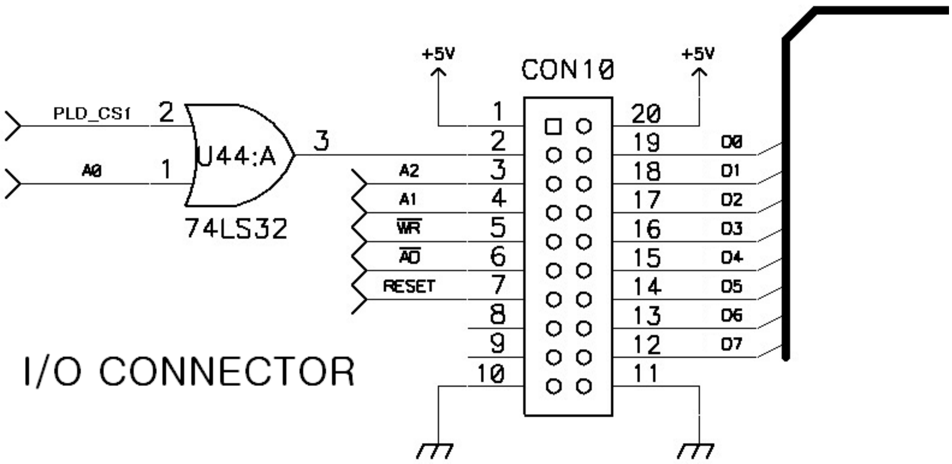


⑵ Extern 8255 Connector

① CON10

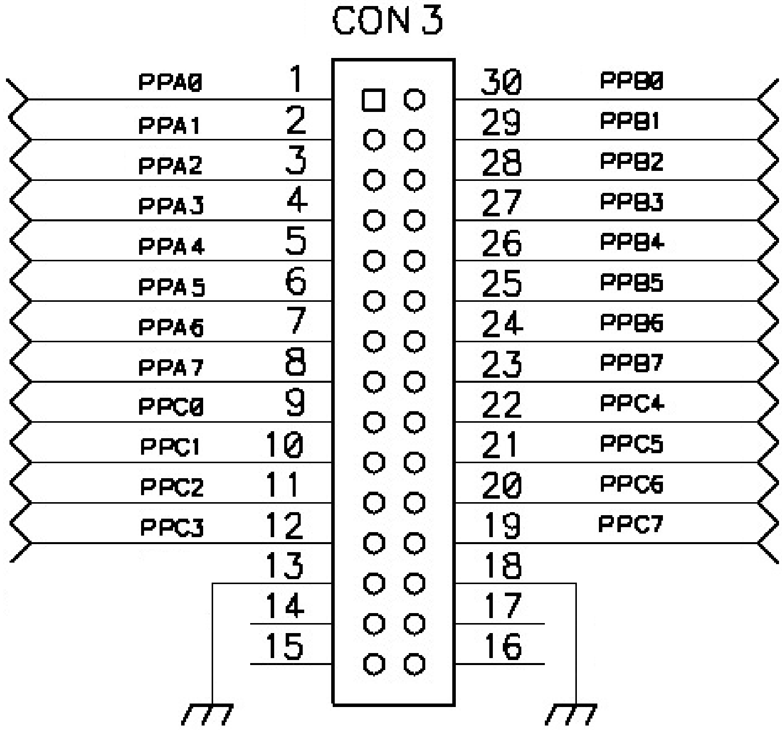
Address map

PORT	8255A ADDRESS
A PORT	20H
B PORT1	22H
C PORT2	24H
CONTROL REGISTER	26H

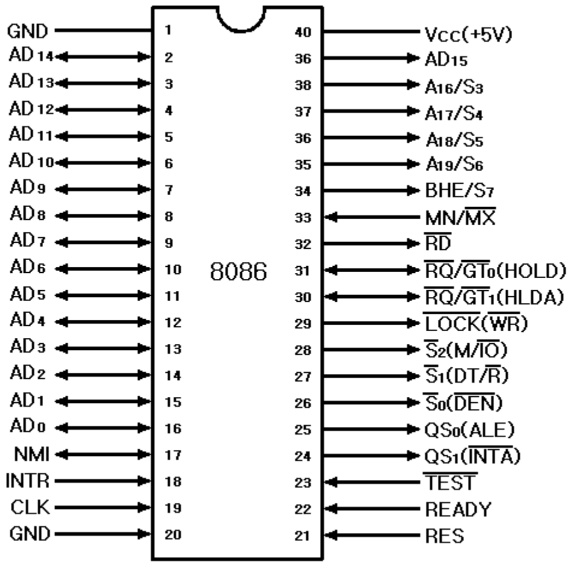


I/O Connector (CON10) Circuit Diagram

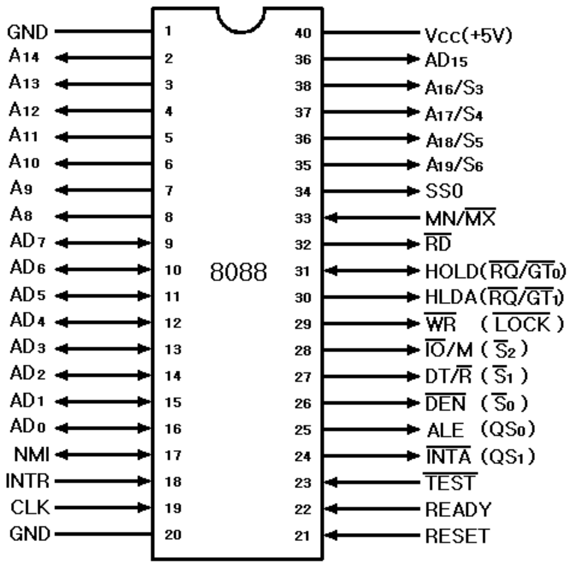
② CON3


CON 3
PPA0
PPA1
PPA2
PPA3
PPA4
PPA5
PPA6
PPA7
PPC0
PPC1
PPC2
PPC3
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
PPB0
PPB1
PPB2
PPB3
PPB4
PPB5
PPB6
PPB7
PPC4
PPC5
PPC6
PPC7

3. 8086 Pin Configuration



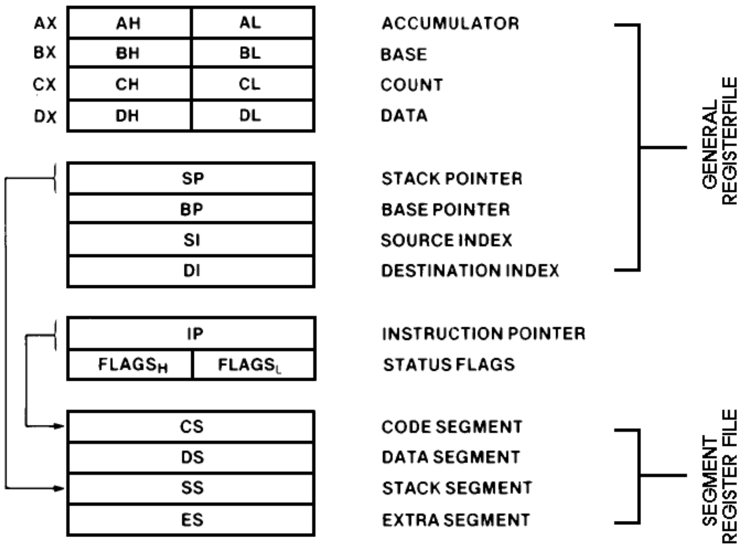
(a) 8086



(b) 8088

4. 8086 Instruction Set Summary.

8086
REGISTER MODEL



Instructions which reference the flag register file as a 16-bit object use the symbol FLAGS to represent the file:

FLAGS = X:X:X:X:(OF):(DF):(IF):(TF):(SF):(ZF):X:(AF):X:(PF):X:(CF)

x = don't care

AF : AUXILIARY CARRY - BCD
CF : CARRY FLAG
PF : PARITY FLAG
SF : SIGN FLAG
ZF : ZERO FLAG

DF : DIRECTION FLAG [STRINGS]
IF : INTERRUPT ENABLE FLAG
OF : OVERFLOW FLAG [DF & SF]
TF : TRAP - SINGLE STEP FLAG

OPERAND SUMMARY

"reg" fleld bit assignments :

16-Bit (w = 1)	8-Bit (w = 0)	Segment
000 AX	000 AL	00 ES
001 CX	001 CL	01 CS
010 DX	010 DL	10 SS
011 BX	011 BL	11 DS
100 SP	100 AH	
101 BP	101 CH	
110 SI	110 DH	
111 DI	111 BH	

SECOND INSTRUCTION BYTE SUMMARY

mod	xxx	r/m

mod	Displacement
00	DISP : 0". disp-low and disp-high are absent
01	DISP : disp-low sign-extended to 16-bits. disp-high is absent
10	DISP = disp-high ; disp-low
11	r/w is treated as a "reg" field

r/m	Operand Address
000	(BX) + (SI) + DISP
011	(BX) + (DI) + DISP
010	(BP) + (SI) + DISP
011	(BP) + (DI) + DISP
100	(SI) + DISP
101	(DI) + DISP
110	(BP) + DISP
111	(BX) + DISP

DISP follows 2nd byte of instruction (before data if required)

* except if mod = 00 and r/m = 110 then EA = disp-high; disp-row

Operand address (EA) Timing (clocks):

Add 4 clocks for word operands at ODD ADDRESSES
immed offset = 6
Base(BX, BP, SI, DI) = 5
Base +DISP = 9
Base + Index (BP + DI, BX + SI) = 7
Base + Index (BP + SI, BX + DI) = 8
Base + Index (BP + DI, BX + SI) + DISP = 11
Base + Index (BP + SI, BX + DI) + DISP = 12

DATA TRANSFER				
MOV = Move:	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0
Register/Memory to/from Register	1 0 0 0 1 0 d w	mod reg r/m		
Immediate to Register/Memory	1 1 0 0 0 1 1 w	mod 0 0 0 r/m	data	data if w = 1
Immediate to Register	1 0 1 1 w reg	data	data if w = 1	
Memory to Accumulator	1 0 1 0 0 0 0 w	addr-low	addr-high	
Accumulator to Memory	1 0 1 0 0 0 1 w	addr-low	addr-high	
Register/Memory to Segment Register	1 0 0 0 1 1 1 0	mod 0 reg r/m		
Segment Register to Register/Memory	1 0 0 0 1 1 0 0	mod 0 reg r/m		
PUSH = Push:				
Register/Memory	1 1 1 1 1 1 1 1	mod 1 1 0 r/m		
Register	0 1 0 1 0 reg			
Segment Register	0 0 0 reg 1 1 0			
POP = Pop:				
Register/Memory	1 0 0 0 1 1 1 1	mod 0 0 0 r/m		
Register	0 1 0 1 1 reg			
Segment Register	0 0 0 reg 1 1 1			
XCHG = Exchange:				
Register/Memory with Register	1 0 0 0 0 1 1 w	mod reg r/m		
Register with Accumulator	1 0 0 1 0 reg			
IN = Input from:				
Fixed Port	1 1 1 0 0 1 0 w	port		
Variable Port	1 1 1 0 1 1 0 w			
OUT = Output to:				
Fixed Port	1 1 1 0 0 1 1 w	port		
Variable Port	1 1 1 0 1 1 1 w			
XLAT = Translate Byte to AL	1 1 0 1 0 1 1 1			
LEA = Load EA to Register	1 0 0 0 1 1 0 1	mod reg r/m		
LDS = Load Pointer to DS	1 1 0 0 0 1 0 1	mod reg r/m		
LES = Load Pointer to ES	1 1 0 0 0 1 0 0	mod reg r/m		
LAHF = Load AH with Flags	1 0 0 1 1 1 1 1			
SAHF = Store AH into Flags	1 0 0 1 1 1 1 0			
PUSHF = Push Flags	1 0 0 1 1 1 0 0			
POPF = Pop Flags	1 0 0 1 1 1 0 1			

ARITHMETIC	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0
ADD = **Add:**				
Reg./Memory with Register to Either	0 0 0 0 0 0 d w	mod reg r/m		
Immediate to Register/Memory	1 0 0 0 0 0 s w	mod 0 0 0 r/m	data	data if s: w = 01
Immediate to Accumulator	0 0 0 0 0 1 0 w	data	data if w = 1	
ADC = **Add with Carry:**				
Reg./Memory with Register to Either	0 0 0 1 0 0 d w	mod reg r/m		
Immediate to Register/Memory	1 0 0 0 0 0 s w	mod 0 1 0 r/m	data	data if s: w = 01
Immediate to Accumulator	0 0 0 1 0 1 0 w	data	data if w = 1	
INC = **Increment:**				
Register/Memory	1 1 1 1 1 1 1 w	mod 0 0 0 r/m		
Register	0 1 0 0 0 reg			
AAA = ASCII Adjust for Add	0 0 1 1 0 1 1 1			
BAA = Decimal Adjust for Add	0 0 1 0 0 1 1 1			
SUB = **Subtract:**				
Reg./Memory and Register to Either	0 0 1 0 1 0 d w	mod reg r/m		
Immediate from Register/Memory	1 0 0 0 0 0 s w	mod 1 0 1 r/m	data	data if s w = 01
Immediate from Accumulator	0 0 1 0 1 1 0 w	data	data if w = 1	
SSB = **Subtract with Borrow**				
Reg./Memory and Register to Either	0 0 0 1 1 0 d w	mod reg r/m		
Immediate from Register/Memory	1 0 0 0 0 0 s w	mod 0 1 1 r/m	data	data if s w = 01
Immediate from Accumulator	0 0 0 1 1 1 w	data	data if w = 1	
DEC = **Decrement:**				
Register/memory	1 1 1 1 1 1 1 w	mod 0 0 1 r/m		
Register	0 1 0 0 1 reg			
NEG = Change sign	1 1 1 1 0 1 1 w	mod 0 1 1 r/m		
CMP = **Compare:**				
Register/Memory and Register	0 0 1 1 1 0 d w	mod reg r/m		
Immediate with Register/Memory	1 0 0 0 0 0 s w	mod 1 1 1 r/m	data	data if s w = 01
Immediate with Accumulator	0 0 1 1 1 1 0 w	data	data if w = 1	
AAS = ASCII Adjust for Subtract	0 0 1 1 1 1 1 1			
DAS = Decimal Adjust for Subtract	0 0 1 0 1 1 1 1			
MUL = Multiply (Unsigned)	1 1 1 1 0 1 1 w	mod 1 0 0 r/m		
IMUL = Integer Multiply (Signed)	1 1 1 1 0 1 1 w	mod 1 0 1 r/m		
AAM = ASCII Adjust for Multiply	1 1 0 1 0 1 0 0	0 0 0 0 1 0 1 0		
DIV = Divide (Unsigned)	1 1 1 1 0 1 1 w	mod 1 1 0 r/m		
IDIV = Integer Divide (Signed)	1 1 1 1 0 1 1 w	mod 1 1 1 r/m		
AAD = ASCII Adjust for Divide	1 1 0 1 0 1 0 1	0 0 0 0 1 0 1 0		
CBW = Convert Byte to Word	1 0 0 1 1 0 0 0			
CWD = Convert Word to Double Word	1 0 0 1 1 0 0 1			

STRING MANIPULATION

REP = Repeat	1 1 1 1 0 0 1 z		
MOVS = Move Byte/Word	1 0 1 0 0 1 0 w		
CMPS = Compare Byte/Word	1 0 1 0 0 1 1 w		
SCAS = Scan Byte/Word	1 0 1 0 1 1 1 w		
LODS = Load Byte/Wd to AL/AX	1 0 1 0 1 1 0 w		
STOS = Stor Byte/Wd from AL/A	1 0 1 0 1 0 1 w		

CONTROL TRANSFER

CALL = **Call:**

Direct within Segment	1 1 1 0 1 0 0 0	disp-low	disp-high
Indirect within Segment	1 1 1 1 1 1 1 1	mod 0 1 0 r/m	
Direct Intersegment	1 0 0 1 1 0 1 0	offset-low	offset-high
		seg-low	seg-high
Indirect Intersegment	1 1 1 1 1 1 1 1	mod 0 1 1 r/m	

JMP = **Unconditional Jump:**	**7 6 5 4 3 2 1 0**	**7 6 5 4 3 2 1 0**	**7 6 5 4 3 2 1 0**
Direct within Segment	1 1 1 0 1 0 0 1	disp-low	disp-high
Direct within Segment-Short	1 1 1 0 1 0 1 1	disp	
Indirect within Segment	1 1 1 1 1 1 1 1	mod 1 0 0 r/m	
Direct Intersegment	1 1 1 0 1 0 1 0	offset-low	offset-high
		seg-low	seg-high
Indirect Intersegment	1 1 1 1 1 1 1 1	mod 1 0 1 r/m	

RET = **Return from CALL:**

Within Segment	1 1 0 0 0 0 1 1		
Within Seg Adding Immed to SP	1 1 0 0 0 0 1 0	data-low	data-high
Intersegment	1 1 0 0 1 0 1 1		
Intersegment Adding Immediate to SP	1 1 0 0 1 0 1 0	data-low	data-high
JE/JZ = Jump on Equal/Zero	0 1 1 1 0 1 0 0	disp	
JL/JNGE = Jump on Less/Not Greater or Equal	0 1 1 1 1 1 0 0	disp	
JLE/JNG = Jump on Less or Equal/ Not Greater	0 1 1 1 1 1 1 0	disp	
JB/JNAE = Jump on Below/Not Above or Equal	0 1 1 1 0 0 1 0	disp	
JBE/JNA = Jump on Below or Equal/ Not Above	0 1 1 1 0 1 1 0	disp	
JP/JPE = Jump on Parity/Parity Even	0 1 1 1 1 0 1 0	disp	
JO = Jump on Overflow	0 1 1 1 0 0 0 0	disp	
JS = Jump on Sign	0 1 1 1 1 0 0 0	disp	
JNE/JNZ = Jump on Not Equal/Not Zero	0 1 1 1 0 1 0 1	disp	
JNL/JGE = Jump on Not Less/Greater or Equal	0 1 1 1 1 1 0 1	disp	
JNLE/JG = Jump on Not Less or Equal/ Greater	0 1 1 1 1 1 1 1	disp	
JNB/JAE = Jump on Not Below/Above or Equal	0 1 1 1 0 0 1 1	disp	
JNBE/JA = Jump on Not Below or Equal/Above	0 1 1 1 0 1 1 1	disp	
JNP/JPO = Jump on Not Par/Par Odd	0 1 1 1 1 0 1 1	disp	
JNO = Jump on Not Overflow	0 1 1 1 0 0 0 1	disp	
JNS = Jump on Not Sign	0 1 1 1 1 0 0 1	disp	
LOOP = Loop CX Times	1 1 1 0 0 0 1 0	disp	
LOOPZ/LOOPE = Loop While Zero/Equal	1 1 1 0 0 0 0 1	disp	
LOOPNZ/LOOPNE = Loop While Not Zero/Equal	1 1 1 0 0 0 0 0	disp	
JCXZ = Jump on CX Zero	1 1 1 0 0 0 1 1	disp	

INT = **Interrupt**

Type Specified	1 1 0 0 1 1 0 1	type	
Type 3	1 1 0 0 1 1 0 0		
INTO = Interrupt on Overflow	1 1 0 0 1 1 1 0		
IRET = Interrupt Return	1 1 0 0 1 1 1 1		

	7 6 5 4 3 2 1 0	7 6 5 4 3 2 1 0
PROCESSOR CONTROL		
CLC = Clear Carry	1 1 1 1 1 0 0 0	
CMC = Complement Carry	1 1 1 1 0 1 0 1	
STC = Set Carry	1 1 1 1 1 0 0 1	
CLD = Clear Direction	1 1 1 1 1 1 0 0	
STD = Set Direction	1 1 1 1 1 1 0 1	
CLI = Clear Interrupt	1 1 1 1 1 0 1 0	
STI = Set Interrupt	1 1 1 1 1 0 1 1	
HLT = Halt	1 1 1 1 0 1 0 0	
WAIT = Wait	1 0 0 1 1 0 1 1	
ESC = Escape (to External Device)	1 1 0 1 1 x x x	mod x x x r/m
LOCK = Bus Lock Prefix	1 1 1 1 0 0 0 0	

NOTES:
AL = 8-bit accumulator
AX = 16-bit accumulator
CX = Count register
DS = Data segment
ES = Extra segment
Above/below refers to unsigned value
Greater = more positive;
Less = less positive (more negative) signed values
if d = 1 then "to" reg; if d = 0 then "from" reg
if w = 1 then word instruction; if w = 0 then byte instruction
if s w = 01 then 16 bits of immediate data form the operand
if s w = 11 then an immediate data byte is sign extended to form the 16-bit operand
if v = 0 then "count" = 1; if v = 1 then "count" in (CL)
x = don't care
z is used for string primitives for comparison with ZF FLAG

MIDAS

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Web ; www.midaseng.com

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Serial No. 090601

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