ROBO-LEFTER
User Manual

Content

Part I

About Robo-Lefter

1. About Robo-Lefter

2. Specifications

3. How it Works

1. About Robo-Lefter

Robo-Lefter is a maze solving micro-mouse. It is easily constructed and designed for beginners.

(1) Purpose : Robo-Lefter was created in order to help young minds develop an interest in robotics. When operational, Robo-Lefter provides the user with a tangible result and a sense of accomplishment.

(2) Benefits : Although simple in its construction, Robo-Lefter employs a micro-controller to control both sensors and motors. Early exposure to such technology ensures familiarity and encourages progress to higher level robots.

2. Specifications

(1) CPU : ATMEL AVR ATmega103 (8BIT RISC MCU)

(2) CPU speed : 6MHz -> 6MIPS

(3) Motors : DC motor with two gear boxes.

(4) Sensor : 3 pairs (front, side and diagonal - 60°)
Type : CL-1L5

(5) Emitter : 3 pairs (front, side and diagonal - 60°)
Type : ST-1KLA

(6) Algorithm: Follows the left wall

(7) Development Environment: C Language, ICC (ImageCraft C Compiler),
ISP(Downloads in a Windows environment)

3. How it Works

Robo-Lefter has six infrared emitters and six corresponding sensors. These sensors determine its position relative to the walls. Thus, even though it follows the left wall, it positions itself in the center of the lane. Each wheel is powered by its own motor, and steering is controlled by these motors. When turning, one wheel slows down while the other maintains its speed.

Robo-Lefter employs a left turn algorithm. Thus, if the left wall goes forward without a break, the robot goes forward until it senses either a break in the wall or a wall to the front. If a break in the left wall is found, Robo-Lefter makes a left turn. If Robo-Lefter approaches a corner where there is a wall to the left and one to the front, it makes small right turns until it no longer senses the front wall. It then resumes its path along the left wall.

Robo-Lefter uses an ATmega103 Micro-controller. Programmable Flash memory is contained within the Micro-controller.

Part Ⅱ

Board

1. Placement Diagram

2. Circuit Diagram

3. Parts List

4. Assembly

1. Placement Diagram

Refer to the REF.PDF file on page 1 of the enclosed CD

2. Circuit Diagram

(1) Main board circuit diagram : Refer to the REF.PDF file on page 2 of the enclosed CD

(2) CPU board circuit diagram : Refer to the REF.PDF file on page 3 of the enclosed CD

3. Parts List

NO.	Reference	Type	Value	Amt.	Description
1	C1, C11, C15, C16	Capacitor	220uF/10V	4	Electrical Capacitor
2	C2~C7	〃	103	6	Monolithic Capacitor
3	C8, C12, C13, C18, C19	〃	104	5	Monolithic Capacitor
4	C9, C10	〃	20pF	2	Ceramic Capacitor
5	C14	〃	1uF	1	Electrical Capacitor
6	D1~D6	Infrared Emitting Diodes	CL-1L5	6	Infrared emitter
7	D7	Diode	1N4148	1	Switching Diode
8	D10	LED	RED 3Φ	1	
9	FND1	FND	SND417A	1	
10	J1~J4	Connector	CON16A	4	2×8 Header(Female)
11	J5, J7	〃	CON2	2	5267
12	J9	〃	CON3	1	5045
13	J12	〃	CON10AP	1	HIF3F/10 Right angle
14	LED	Array LED	LN10204	1	10 LED Array
15	Q1~Q6	Phototransistors	ST-1KLA	6	Light Sensor
16	RA1	Array Resistor	330Ω / 9pin	1	
17	RA2	〃	470Ω / 7pin	1	
18	RA3	〃	47KΩ / 7pin	1	
19	R1	Resistor	1KΩ	1	
20	R3, R5, R12~R19	〃	330Ω	10	
21	R6~R11	〃	10Ω	6	
22	R20~R22	〃	10KΩ	3	
23	R25	〃	470Ω	1	
24	SW1	Switch	TM01 S/W	1	Red Reset Switch
25	SW2, SW3	〃	Tack(4mm)	2	Mode, Select Switch
26	SW4	〃	Push S/W (2285)	1	Power Switch
27	U1, U3	Motor Driver	LB1630	2	Use with 8PIN socket
28	U1, U3	Socket	8PIN DIP	2	Solder the socket
29	U4	Array Tr	ULN2803	1	Use with 18PIN socket
30	U4	Socket	18PIN DIP	1	Solder the socket

31	U5	Regulator	LM2940T/TO220	1	
32	XTAL1	X-tal	6MHz	1	
33		MAIN P.C.B		1	86mm×105mm
34		Flat Cable	1M	1	
35		Bolt		7	3×5(2), 3×8(5)
36		Motor Securing Bolt		4	3×14
37		Nut		1	3Φ
38		Insulating washer		4	3Φ
39		Motor Assembly		1	SET
40		Wheel		2	
41		Tire		2	
42		Frame		1	SET
43		CPU Board		1	
44		Downloading Adaptor		1	Connects to printer port

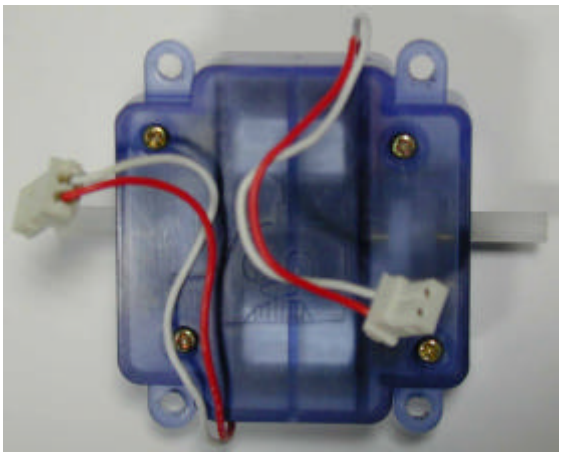

Fig 2.1 Motor Assembly

Fig 2.2 Downloading Adaptor

Fig 2.3 Flat cable

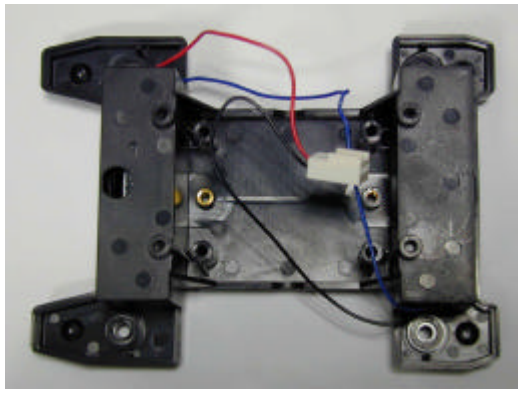

Fig 2.4 Frame

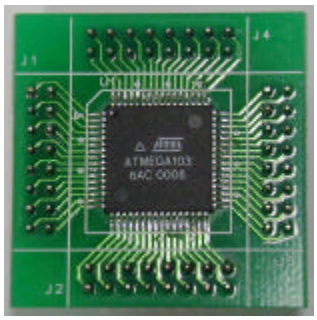

Fig 2.5 CPU Board

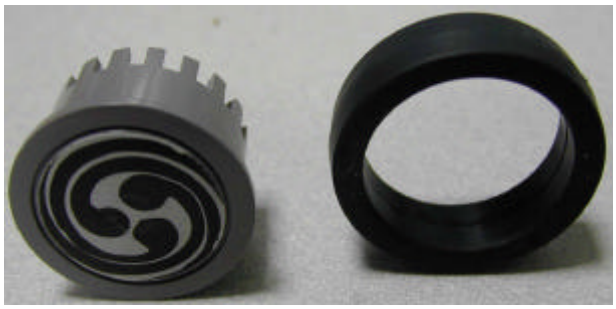

Fig 2.6 Wheel and Tire

4. Assembly

Main PCB Top View Fig 2.7

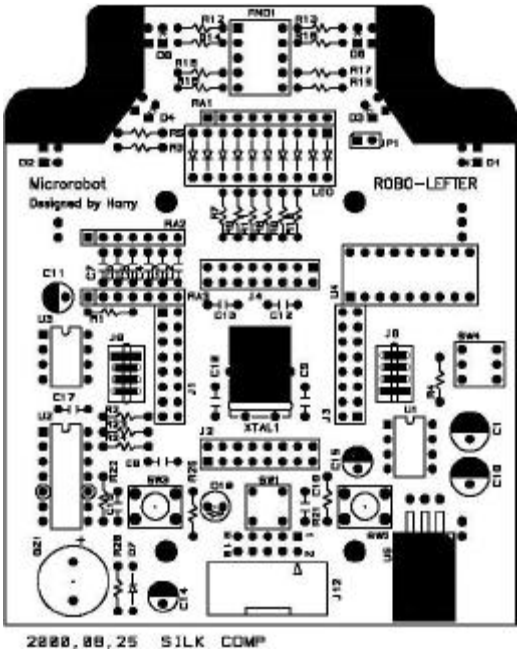

Fig 2.7

Main PCB Bottom View Fig 2.8

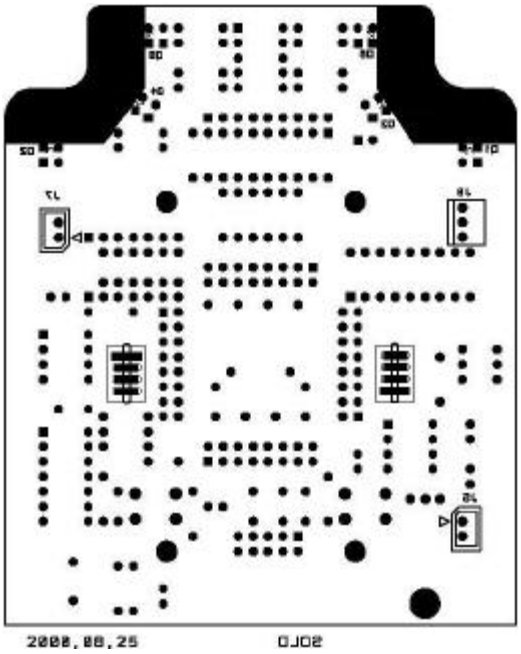

Fig 2.8

(1)~(4) Refer to Fig 2.9

(1) Bend pins of the LM2940 to 90° . Put in position U5 and insert pins. Ensure there is no space between heat sink and the PCB.

(2) Use the 3×8 bolt and nut to secure the LM2940. Solder the pins to the PCB.

(3) Insert the 220uF electrical condensers in positions C15 and C16. Put negative leg in the black side of the circle. Solder.

(4) Insert the push switch in position SW4. Solder.

(5) Insert 5045(3Pin) connector in position J9. (Refer to Fig. 2.14)
Note: Insert from bottom of PCB. Place according to illustration on back of PCB.

(6) Insert the batteries. Attach the 5051 female connector to the J9 male connector. Depress push switch. Use voltmeter to check LM2940. Place voltmeter on positive pin and middle pin. Output should be between ***4.97~5V***. If the reading is below ***4.95V***, the robot will be unstable.

(7)~(15) Refer to Fig 2.10

(7) Turn off power. Disconnect connector at position J9. Bend legs of 6MHz crystal and insert in the X-TAL1 position. Solder head and legs.

(8) Insert the 20pF ceramic condensers in positions C9 and C10. Solder.

(9) Insert the 10KΩ resistors in positions R20 · R21 · R22. Insert the 1KΩ resistor in position R1. Insert the 470Ω resistor in position R25. Solder.

(10) Insert diode 1N4148 in position D7. Make sure the line is toward Cathode. Solder.

(11) Insert the 1uF electrical condenser in position C14. Insert the 104 monolithic condensers in positions C8 · C12 · C13 · C18 · C19. Solder.

(12) Insert the red LED in position D10. Make sure the short leg is toward Cathode. Solder.

(13) Insert the 2×5 angled connector in position J12. Solder.

(14) Insert the red switch in position SW1. Insert the tack switches in positions SW2 · SW3. Solder.

(15) Insert the 2×8 female connectors in positions J1 · J2 · J3 · J4. Solder.

(16) Attach the CPU board to the 2×8 female connectors.(Refer to Fig 2.11)

(17) Attach the downloading adaptor to the printer port on the PC. Attach the flat cable to the downloading adaptor and 2×5 angled connector.

(18) Connect female angle connector 5051 to the 5045 male connector. Depress push switch. Download the executable program using the ISP program. Check for errors.
(Refer to part 3 section 3 **How to use AVR ISP**)

(19) Disconnect flat cable completely. Turn off power. Disconnect connector at position J9. Remove the CPU board.

(20) Insert the 330Ω(331) 9PIN array resistor in position RA1. Solder. (Refer to Fig 2.12)

(21)~(24) Refer to Fig 2.13

(21) Insert the array LED in location LED. Solder.

(22) Insert the 47KΩ(473) 7PIN array resistor in position RA3. Solder.

(23) Insert the 103 monolithic condensers in positions C2 through C7. Solder.

(24) Insert the 470Ω(471) 7PIN array resistor in position RA2. Solder.

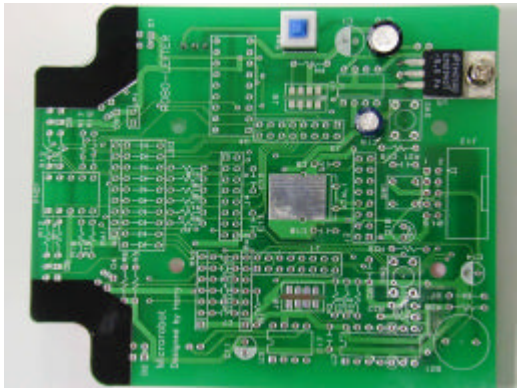

Fig 2.9

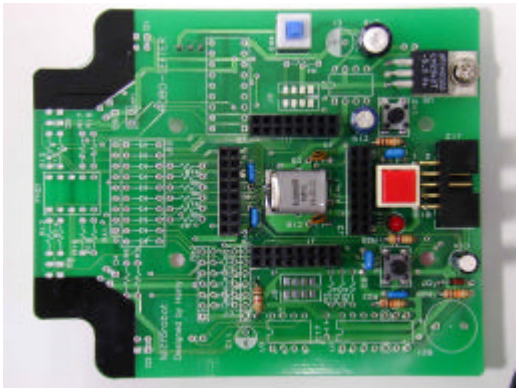

Fig 2.10

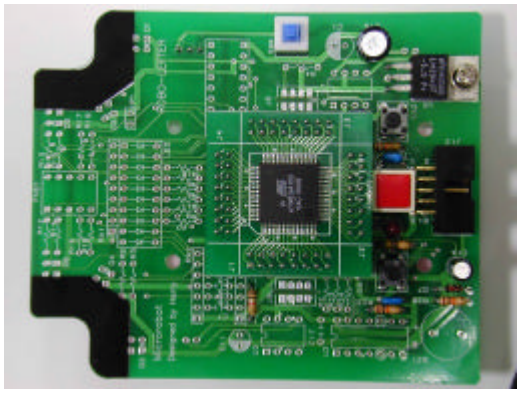

Fig 2.11

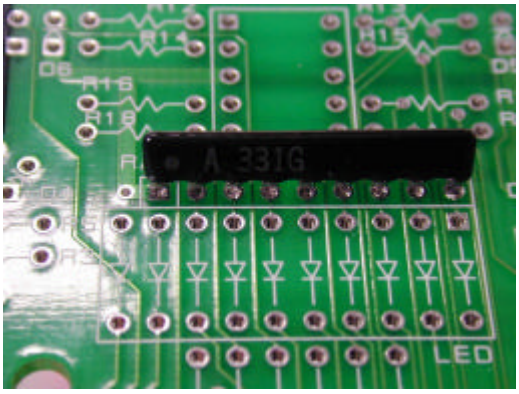

Fig 2.12

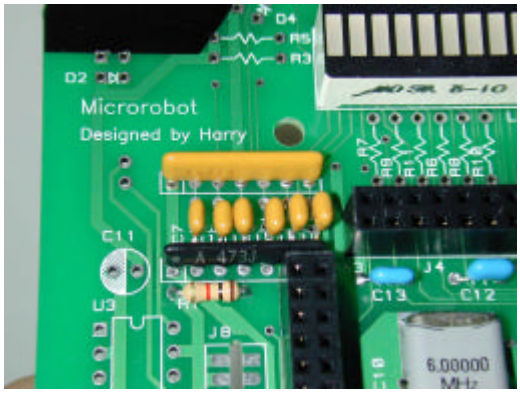

Fig 2.13

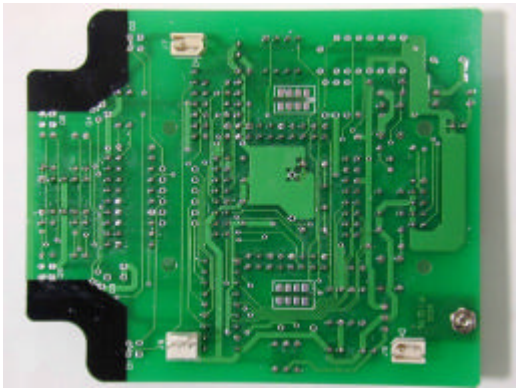

Fig 2.14

(25)~(29), (31) Refer to Fig 2.17

(25) Insert the FND(8-segment) in location FND1. Solder.

(26) Insert the 330Ω resistors in positions R3, R5, R12~R19. Insert the 10Ω resistors in positions R6~R11. Solder.

(27) Insert the 220uF/10V electrical condensers in positions C1, C11. Solder.

(28) Insert the 8pin sockets in positions U1, U3. Solder.

(29) Insert the 18pin socket in position U4. Solder.

(30) Insert 5064(2Pin) connectors in positions J5, J7. Note: Insert from bottom of PCB. Place according to illustration on back of PCB. (Refer to Fig. 2.14)

※ Please note : U2 · C17 · R2 · R4 · R23 · R24 · J6 · J8 and BZ1 are not used in this model. For upgrading only.

※ Warning : Make sure that neither sensors nor emitters extend past the edge of the PCB! Also, ensure that both sensors and emitters are aligned at 0° , 60° , 90° . If not, there will be interference.

(31) Insert the six infrared emitting diodes(CL-1L5 has a clear bulb) in positions D1 through D6. Ensure the longer leg is inserted in the hole with the square pad(anode). Solder.

(32) Insert the six phototransistors(ST-1KLA has a clear bulb with a metal casing) in positions Q1 through Q6 from the bottom of the PCB. (Refer to Fig 2.15(Q2 · Q4 · Q6), Fig 2.16(Q1 · Q3 · Q5).) Ensure the leg closer to the node is inserted in the hole with the round pad. Solder.

(33)~(35) Refer to Fig 2.18

(33) Insert the ULN2803 in the U4 18pin socket.

(34) Insert the two LB1630's in the U1 and U3 8pin sockets.

(35) Attach the CPU board to the 2×8 female connectors.

(36)~(37) Refer to Fig 2.19

(36) Place the motor assembly in the frame flat side up. Make sure the wires attached to the frame are above the motor assembly. Secure using the 3×14 bolts.

(37) Put the tires on the wheels and attach to the axle.

(38) Remove the raised portion from two of the screw receptors in the frame. Make sure all four are the same height.

(39) Attach the forward 5264 female connector to the J7 male connector. Attach the rear 5264 female connector to the J5 male connector. Attach the 5051 female connector to the J9 male connector.

(40) Place the insulating washers on the 3×8 bolts. Attach the PCB to the frame using these bolts.

(41) Secure the battery covers with 3×5 black bolts.

(42) Final operational test in part 4.

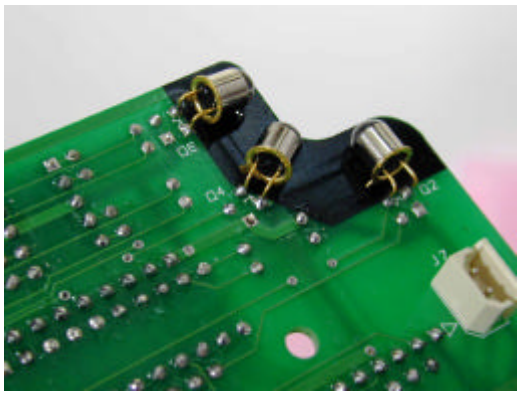

Fig 2.15

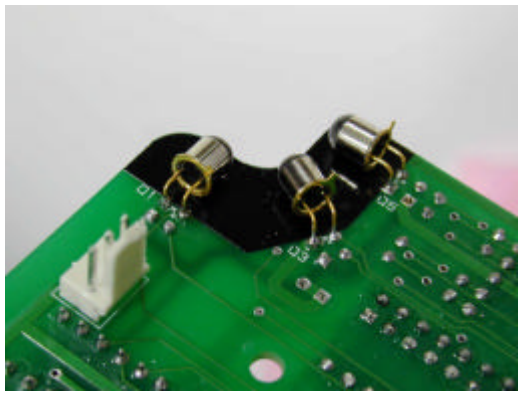

Fig 2.16

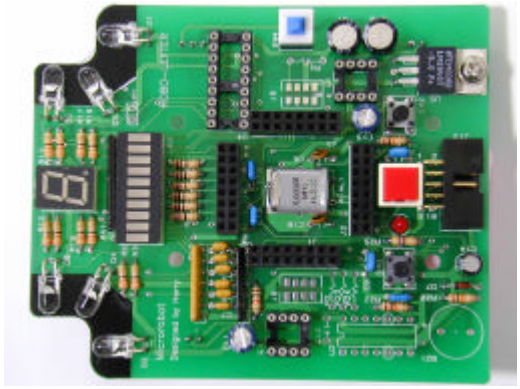

Fig 2.17

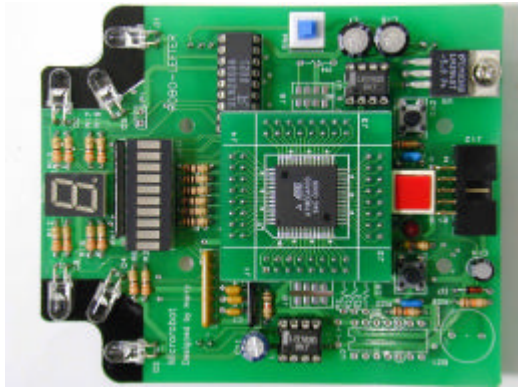

Fig 2.18

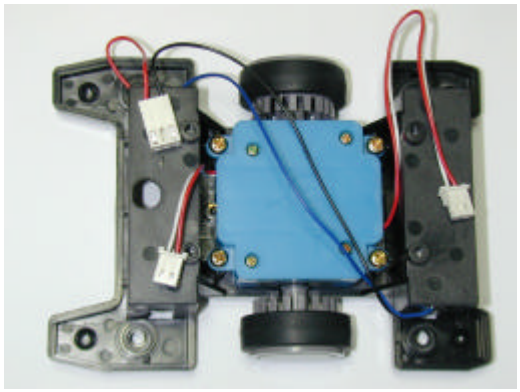

Fig 2.19

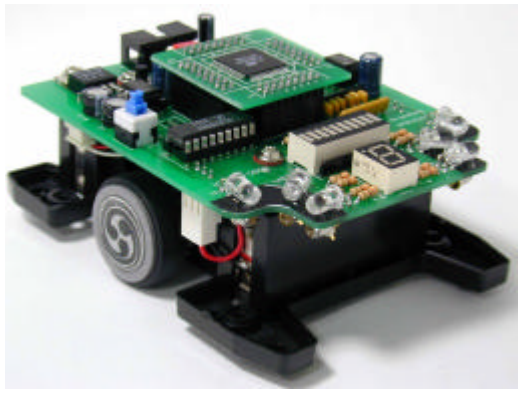

Fig 2.20

Part Ⅲ

Software Tools

1. AVR Development Program Installation

2. How to use ICC (ImageCraft C Compiler)

3. How to use AVR ISP (In-System Programing)

1. AVR Development program Installation

(1) Introduction:
In this application three development tool are utilized: wavrasm, AVR Studio, AVR ISP. Atmel provides these tools online. For your convenience we have included these tools on the enclosed CD. Wavrasm is an avr assembler for Windows, AVR Studio is Emulator / Simulator for Windows and AVR ISP enables the user to download programs from a PC to the Robot in a Windows environment.

(2) For proper operation, your PC must support the following:
① Window 95, 98
② At least Pentium-100
③ At least 4MBytes of RAM
④ CD-ROM Drive

(3) AVR ISP installation:
① Run the setup.exe file contained in the avr_isp folder found on the enclosed CD. The following window appears. Follow the instructions on the screen.

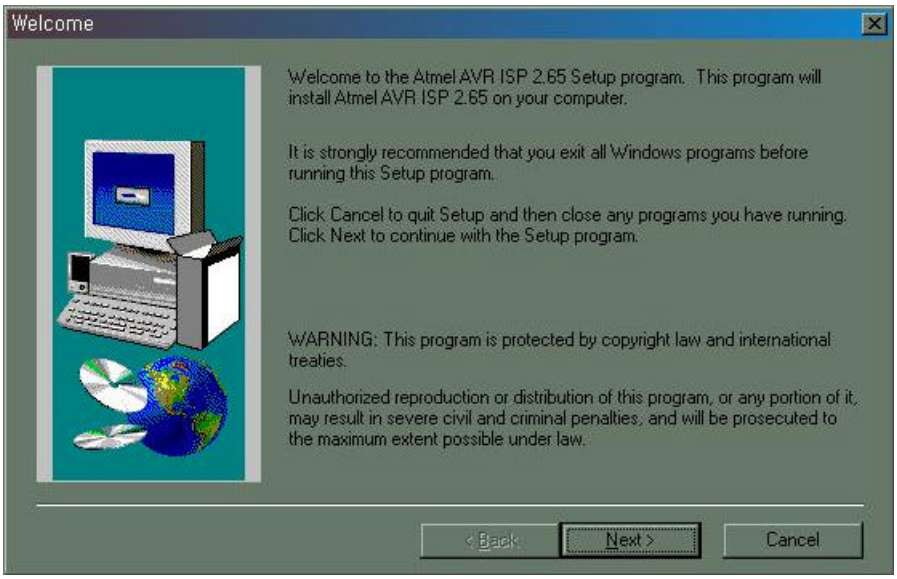

Fig 3.1

(4) ICC installation:
Run the iccavrdem.exe file contained on the enclosed CD. The iccavrdem.exe file is a shareware program with a 30 day time limit.

※ Warning : The time limit cannot be extended!
If you attempt any of the following, the program will immediately terminate.
ⓐ Changing the date.
ⓑ Using datecrack. (hacking program)
ⓒ Reinstallation. (Deleting the registry files doesn't help)
ⓓ Any type of date tampering.

① When iccavrdem.exe is run, the following window appears. Follow the instructions on the screen.

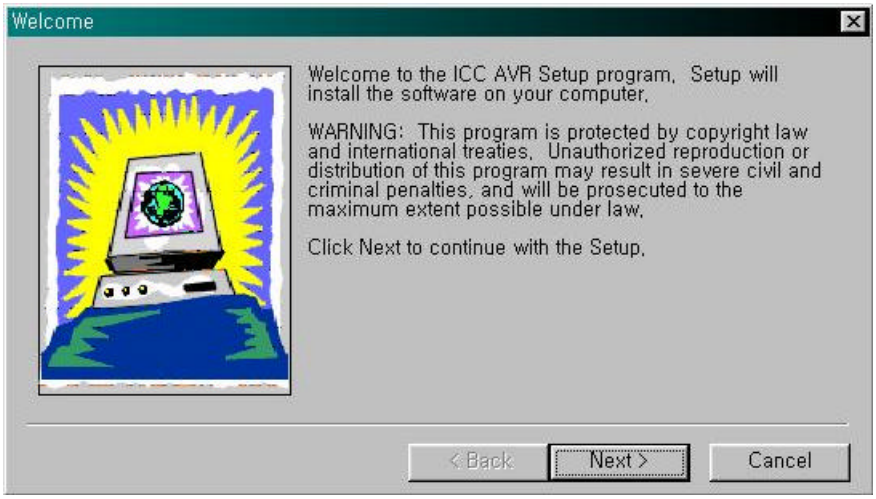

Fig 3.2

2. How to use ICC

(1) About ICC:
Microrobot provides an Imagecraft C compiler on the enclosed CD. This is a shareware product with a 30 day time limit. Other companies which provide C compilers for use with Micro-controllers include IAR and Codevision.

The compiler creates several types of files. Three of these are: .hex file for downloading ; .cof file for simulator ; and .s file for assembly.

If the user wishes, ICC can be purchased. Using the purchased version differs only slightly from the shareware version but works much better. If the user is going to continue programming we recommend purchasing ICC.

ICC supports ATmega series, AT90S series and some ATtiny series Micro-controllers.

(2) Instructions:
First, copy source folder in the provided CD to the root folder of C drive.
Then, change the attributes of all files from Read-Only. To do this, select all files(Ctrl+A) and the right click on the selected files, select properties and de-select Read-Only.

① Go to start START → PROGRAM → ImageCraft Development Tools → ICC AVR. The following screen appears. (Fig 3.3)

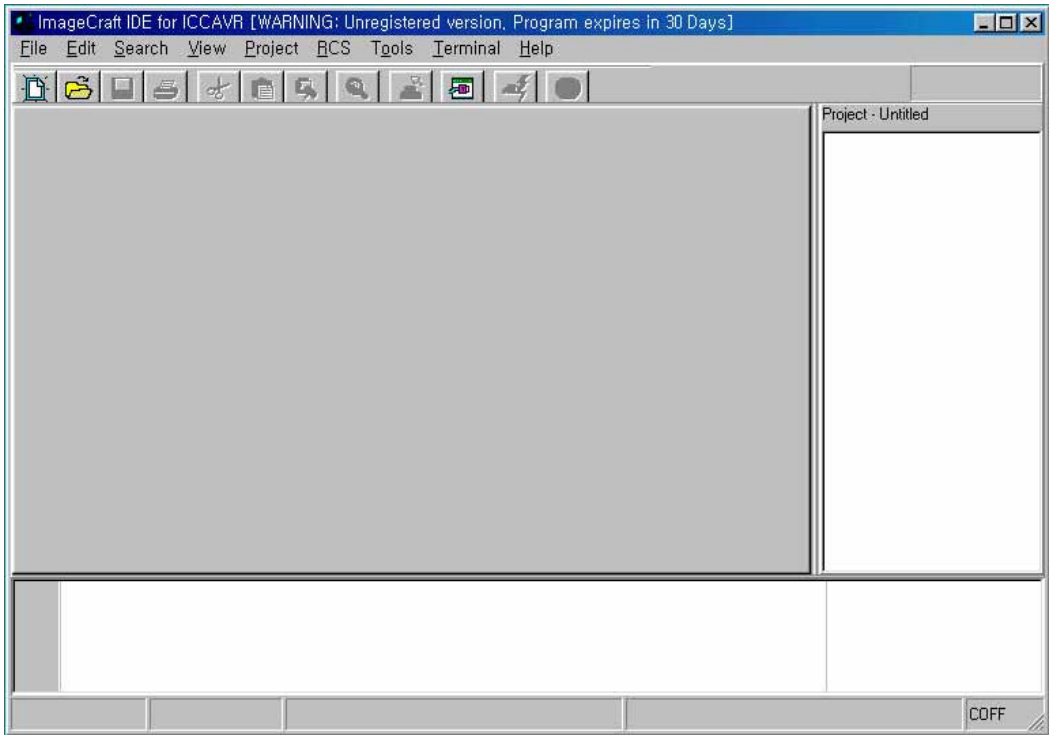

Fig 3.3

②Click File → Open or  icon. Open c:\source\mouse.c . (Fig 3.4)

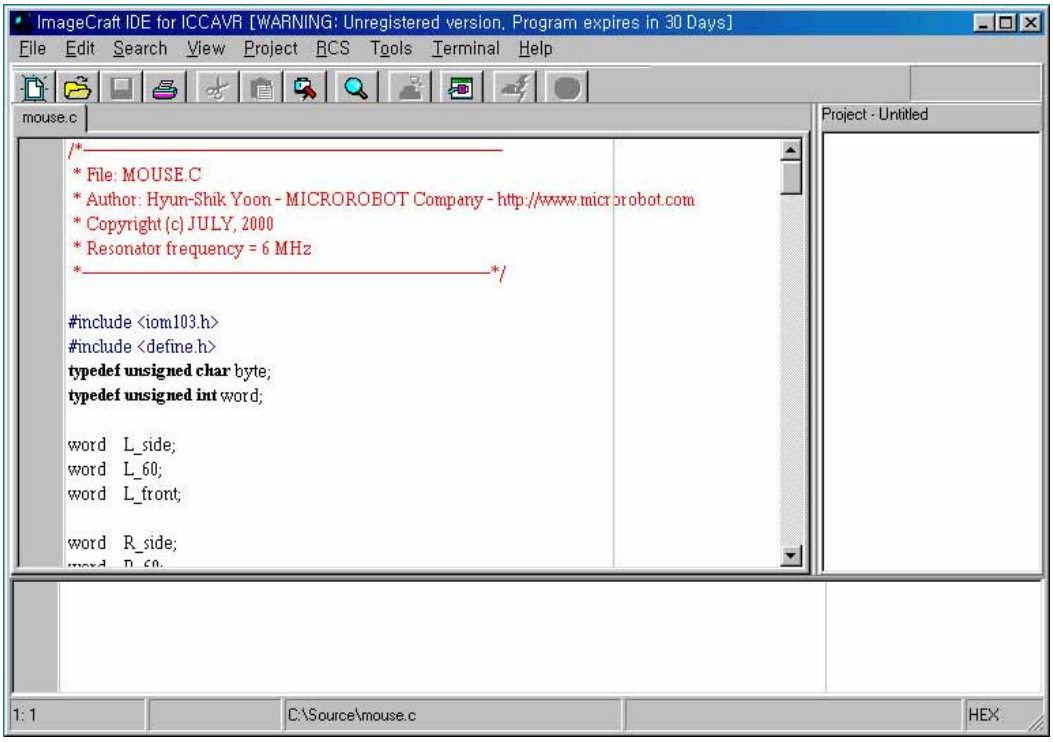

Fig 3.4

Note : Pay special attention when using the compile file submenu and the project options submenu.

③ Click Project → Options → Target. The following screen appears. (Fig 3.5)

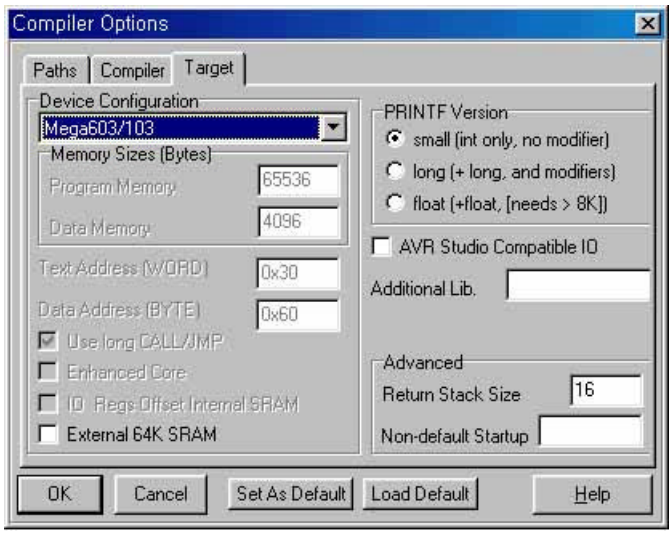

Fig 3.5

Click on the Device Configuration drop down menu and select Mega603/103.

Next, click Compiler.(Fig 3.6)

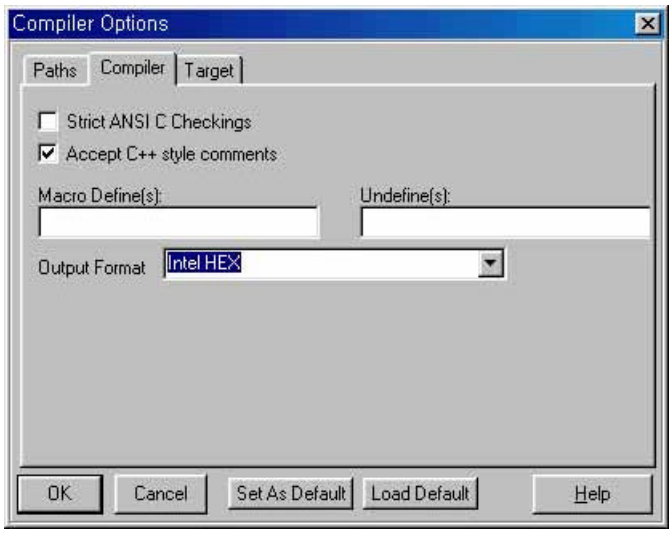

Fig 3.6

Ensure the Accept C++ style comments box is checked. Click the Output Format drop down arrow and select Intel HEX.

Next, click Paths.(Fig 3.7)

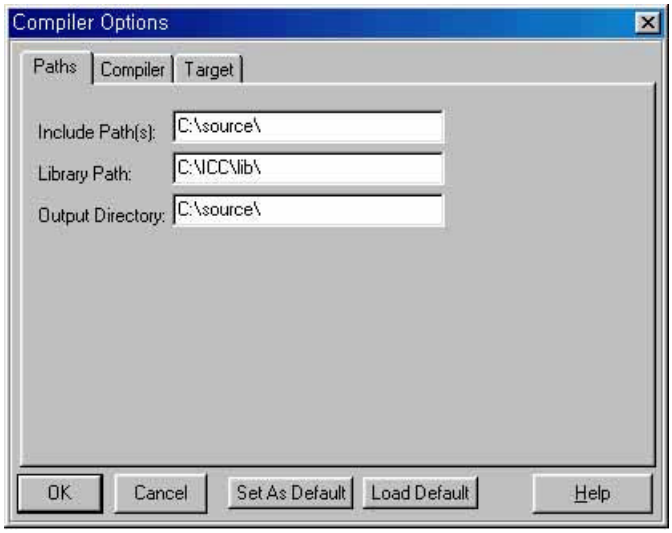

Fig 3.7

The user enters his own source file in Include Path(s) and puts the same source file name in Output Directory. Click Set As Default. Click OK.

④ Click File → Compile File → To output; or push Ctrl+F9.(Fig 3.8)

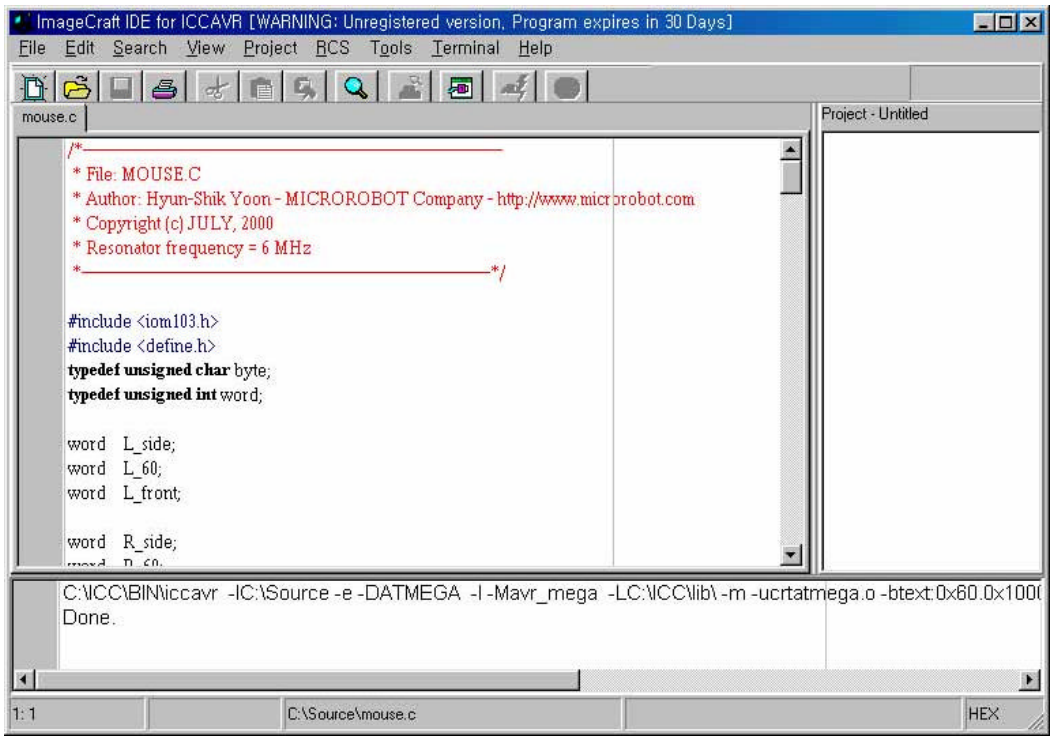

Fig 3.8

When compilation is complete, "Done" appears at the bottom of the screen.

For more information, go to getting_started_iccvar.pdf in the pdf folder.

3. How to Use AVR ISP

(1) About AVR ISP:
AVR ISP enables the user to download programs from a PC to the Robot in a Windows environment. AVR ISP allows for the downloading of program memory and data from EEPROM.

(2) Instructions:
① Go to start START → PROGRAM → Atmel AVR Tools → Atmel AVR ISP. The following screen appears.(Fig 3.9)

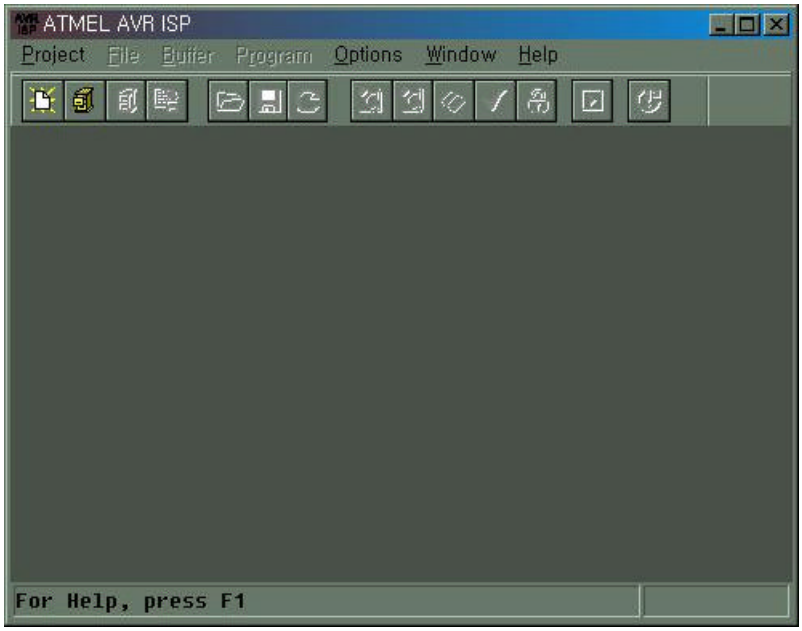

Fig 3.9

② Click Project → New Project or  icon. The following menu appears. Select the device highlighted below. Click Ok (Fig 3.10)

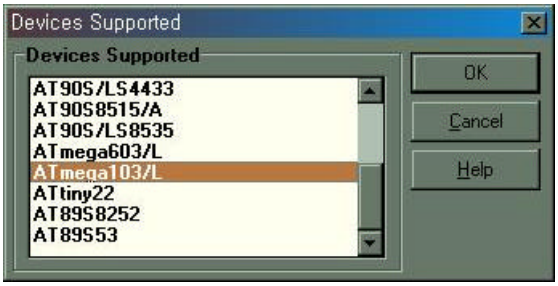

Fig 3.10

③ The following window appears.

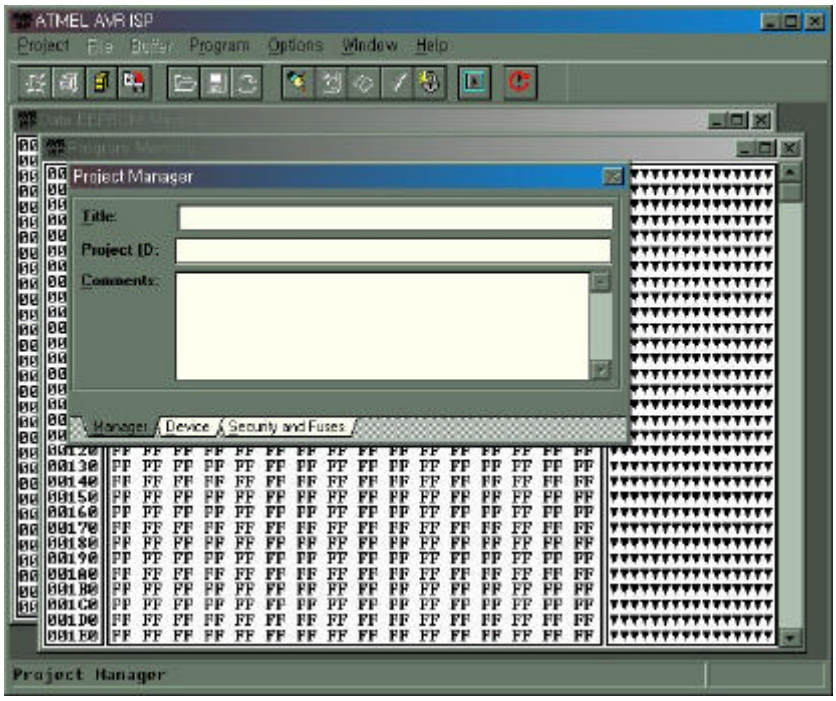

Fig 3.11

Select the Program Memory window.

④ The following window appears.

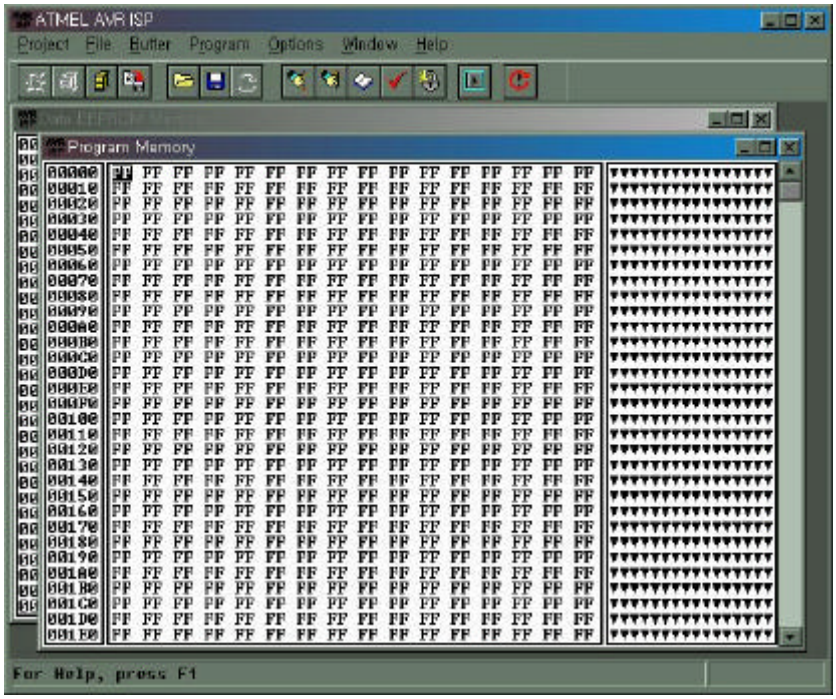

Fig 3.12

Click File → Load or  icon. Open c:\source\mouse.hex .

⑤ The following window appears.

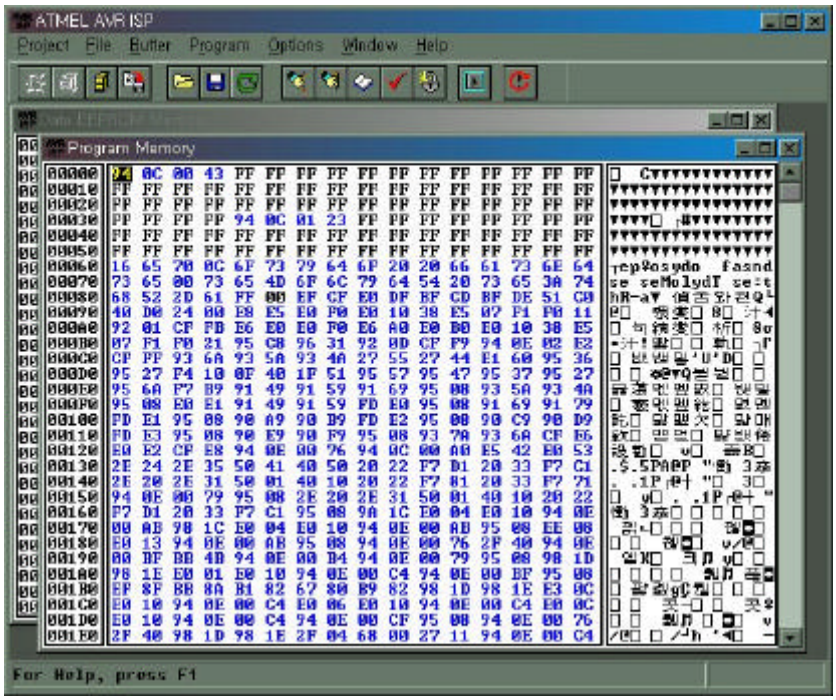

Fig 3.13

⑥ Click Project → Save Project or  icon. This saves the project.

⑦ Click Program → Auto-Program Options. Check the options as shown below.

Fig 3.14

☞ Click Option → Advanced. Check ☐Disable Signature Check.
Note : This box must be checked. If not a warning message appears.

⑧ To complete downloading, click Program → Auto-Program or push F5 or Click  icon.

⑨ If "verify failed" message appears, check downloading adaptor or flat cable.

Part Ⅳ

Robo-Lefter Operation

1. Motor and sensor testing

2. Adjusting sensors

1. Motor and sensor testing

Once the downloading has been completed, it is time to check for faulty solders, incorrect parts placement, etc.

The switch to the left of the reset switch(red switch) is the mode switch. The switch to the right of the reset switch is the select switch. First, press the reset switch. Next, press the mode switch twice. The number '1' appears and the second LED on the array lights up. (Fig 4.1) Press the select switch once. The motor should begin running after 1 second.

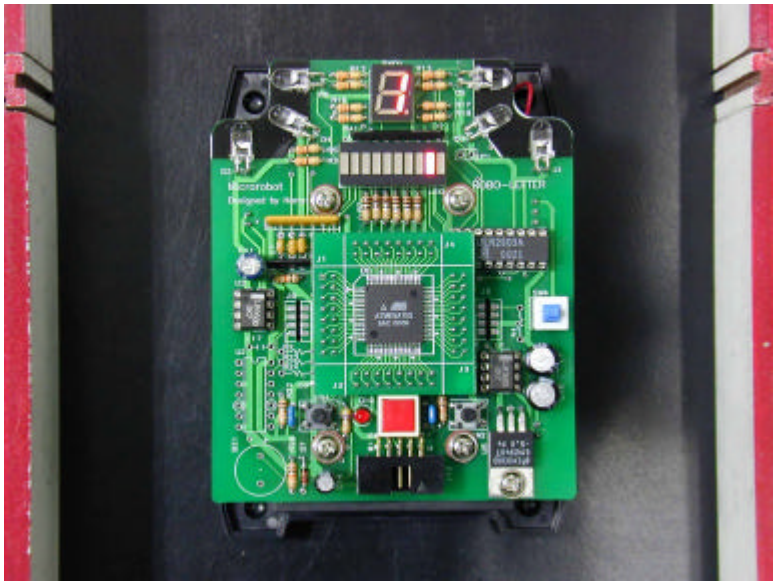

Fig 4.1

If the motor runs roughly or if it moves unevenly, you must reprogram it to run at a higher speed. Do the following:

Go to c:\source\define.h
Change settings as follows:

#define L_SP0	300	→	500
#define R_SP0	300	→	500

Save.
Then look at the top of the screen for mouse.c. Click on it. Push Ctrl+F9 to recompile. Redownload the program.

If there is an obvious difference in speed between the two wheels, return to c:\source\define.h and adjust the speed as desired. Redownload.

Once the motor works properly, check the sensors and emitters.
First, press the reset switch. Next, press the mode switch three times. The number '2' appears and the third LED on the array lights up.(Fig 4.2)
Press the select switch once. The number '5' appears. Now move your hand towards and away from the left side of the robot. More lights should appear on the LED array the closer your hand is to the robot and vice versa. (Fig 4.3)

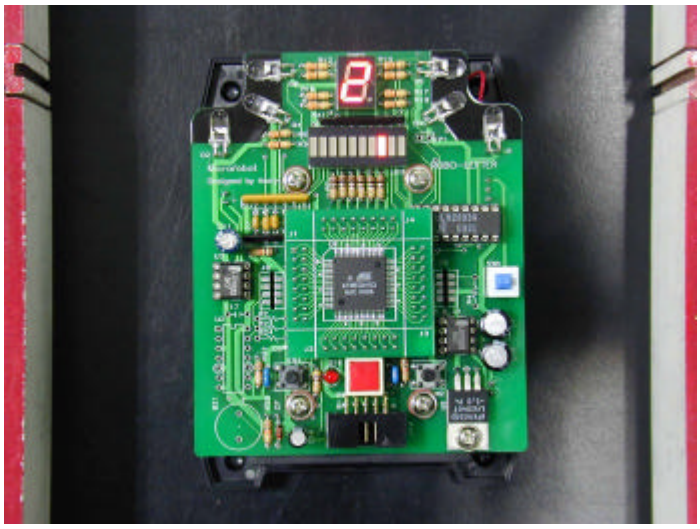

Fig 4.2

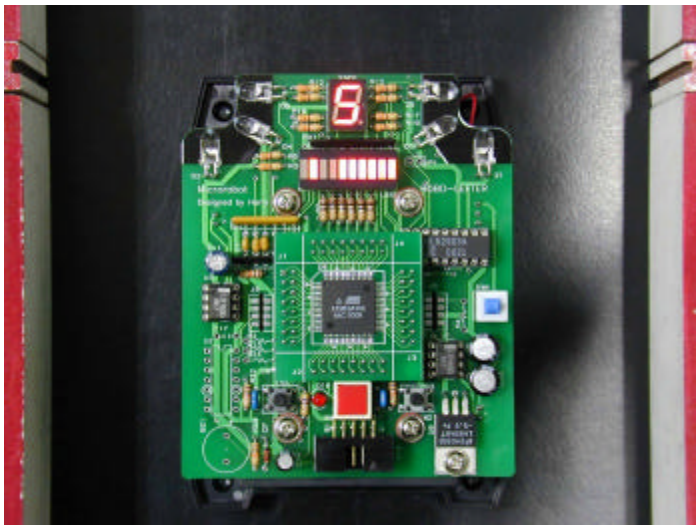

Fig 4.3

Now press the mode switch one time. The number '6' appears. This refers to the left diagonal sensor which is set to 60° . Again, the closer your hand is to the sensor, the more lights that should appear on the LED array.

Press mode switch again. An 'F' appears. This refers to the left forward facing sensor. Test using the same method as before.

Press mode switch again. An 'F.' appears. This refers to the right forward facing sensor. Test using the same method as before.

Press mode switch again. The number '6.' appears. This refers to the right diagonal sensor which is set to 60° . Test using the same method as before.

Press mode switch again. A '5.' appears. This refers to the right side sensor. Test using the same method as before.

If you missed one of the tests, press the mode switch until the desired number or letter appears, and perform test.

When testing is complete, press reset.

2. Adjusting sensors

Before Robo-Lefter begins to solve the maze, its sensors must be adjusted so that it is able to position itself within the maze.

(1) Press the reset switch. Next, press the mode switch four times. The number '3' appears and the fourth LED on the array lights up. (Fig 4.4)

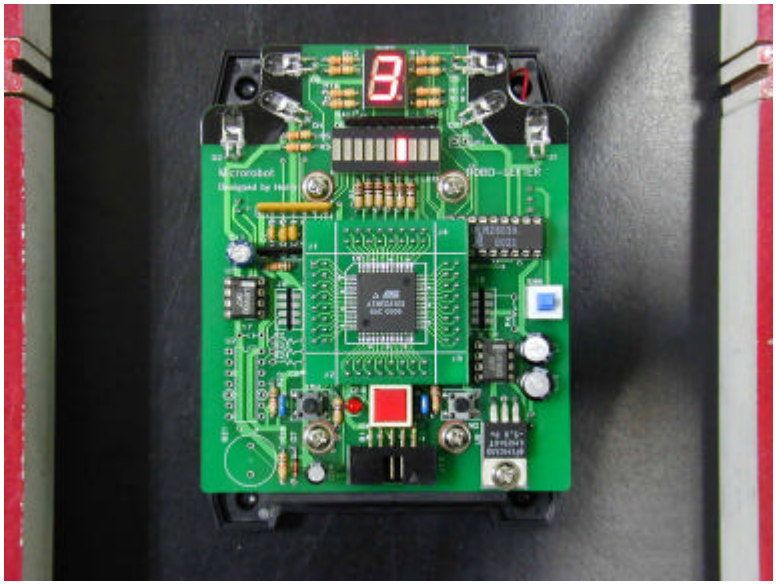

Fig 4.4

(2) Press the select switch once. A 'C' appears. (Fig 4.5)
Place Robo-Lefter in the center of lane. Press the select switch once.
This records the value of reflected light received by the side and diagonal sensors.

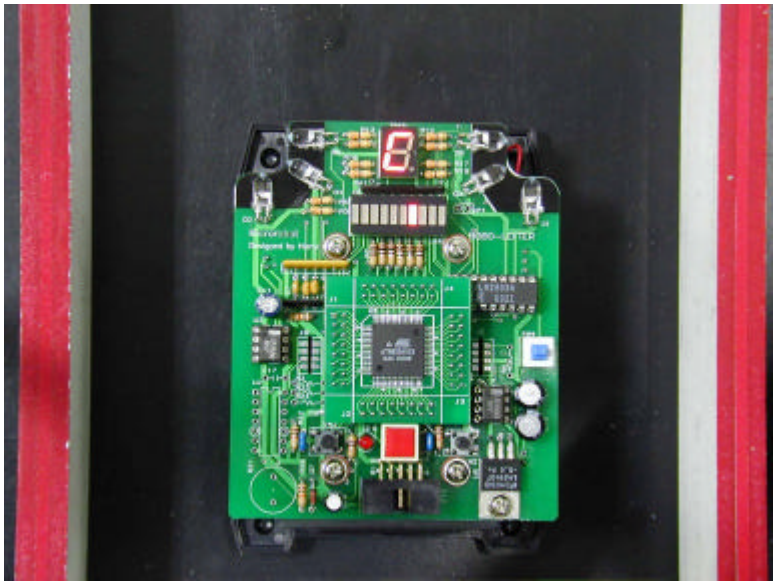

Fig 4.5

(3) An 'L' appears. (Fig 4.6)
Place Robo-Lefter against the left wall and press the select switch.
This records the value of reflected light received by the side and diagonal sensors.

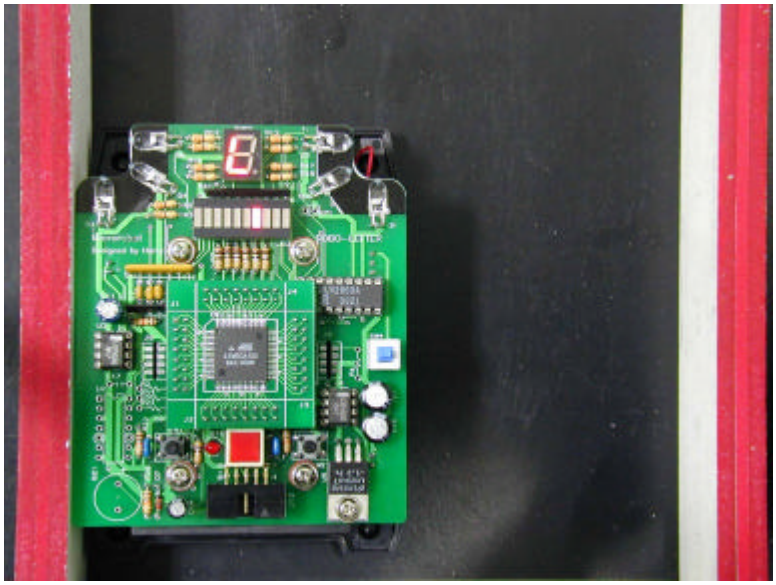

Fig 4.6

(4) An 'R' appears. (Fig 4.7)
Place Robo-Lefter against the right wall and press the select switch.
This records the value of reflected light received by the side and diagonal sensors.

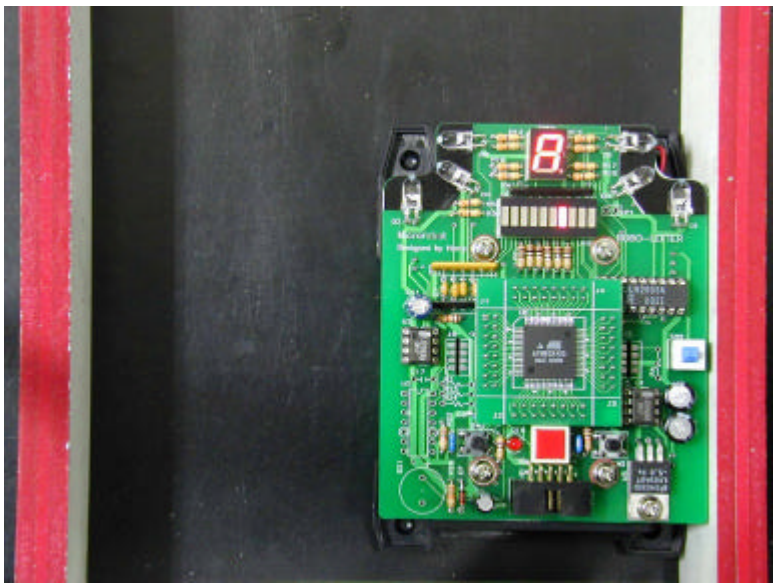

Fig 4.7

(5) A '1' appears. (Fig 4.8)
Place Robo-Lefter 3 to 4 Cm from a front wall and press the select switch.
This records the value of reflected light received by the forward sensors.

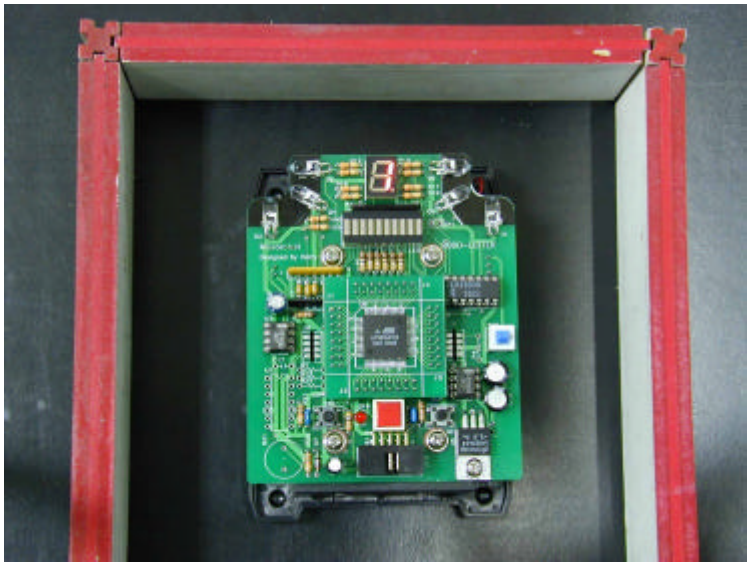

Fig 4.8

(6) A '2' appears. (Fig 4.9)
Place Robo-Lefter so that the posts are in line with the wheels and press the select switch. This records a second value of reflected light. When Robo-Lefter turns right, it continues to do so until the value received by the forward sensor is less than the recorded second value.
Sensor adjustment is now complete.

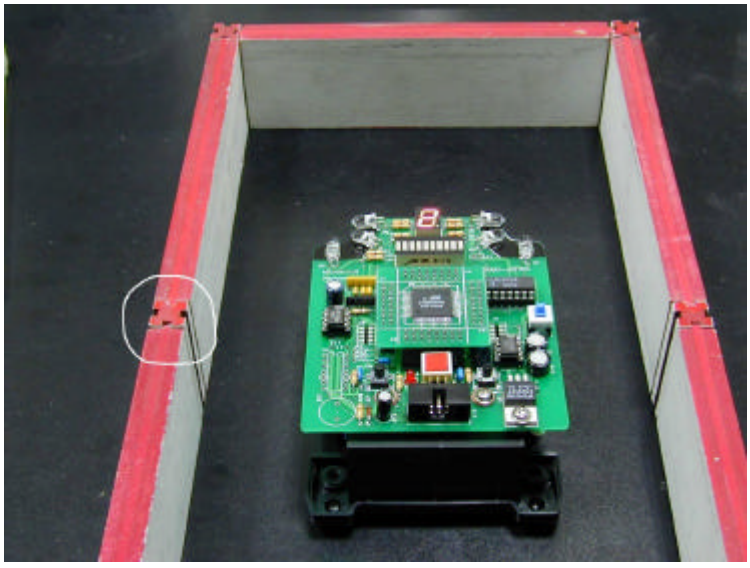

Fig 4.9

Robo-Lefter is now ready to solve the maze.
Press reset once. Press the mode switch once. A '0' appears.
Press the select switch once. A '1.' appears and Robo-Lefter begins operation.

Part Ⅳ

Robo-Lefter C Program

Robo-Lefter has four modes : motor testing, sensor testing, sensor adjusting, and run. Motor testing, sensor testing, and sensor adjusting modes have already been described. The following pertains to run mode.

Robo-Lefter's movement depend on three conditions:

ⓐ If there is a break in the left wall, Robo-Lefter turns left;

ⓑ If the wall continues without a break, and no forward wall is sensed, Robo-Lefter goes forward;

ⓒ If neither ⓐ nor ⓑ, Robo-Lefter turns right.

During operation, Robo-Lefter is programmed to make the necessary adjustments allowing it to stay in the center of the lane.

※ Basic adjustments

Every motor is slightly different. For proper operation it may be necessary to make some adjustments.

define.h - User adjustable settings are found at the end of this file.

```
/****************** current values ***************************/
#define L_SP0          300          // left-wheel speed. 0-1023
#define R_SP0          300          // right-wheel speed. 0-1023

#define SM_RAT1        1.4          // turn differential - outside wheel
#define SM_RAT2        0.55         // turn differential - inside wheel

#define CO_RAT1        1.4          // center lane adjustments - outside wheel
#define CO_RAT2        0.55         // center lane adjustments - inside wheel
```

For competition, the user may wish to make the mouse go faster. However, note that this means the sensors will have to be re-adjusted so that Robo-Lefter will have time to brake, turn, etc. Set #1 sensing mode further from the forward wall. When adjusting #2 tuning mode, note that while the wheels had been aligned with the posts, they must be repositioned closer to the forward wall but not closer to the forward wall than the #1 sensing mode.

Program files.
1. mouse.c : Main program.
2. iom3.h : All information regarding the ATmega103 Micro-controller registers.
3. define.h : Program constant definitions.
4. inter.h : Contains interrupt functions.
5. function.h : Functions.
6. init.h : Micro-controller initialization functions.

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