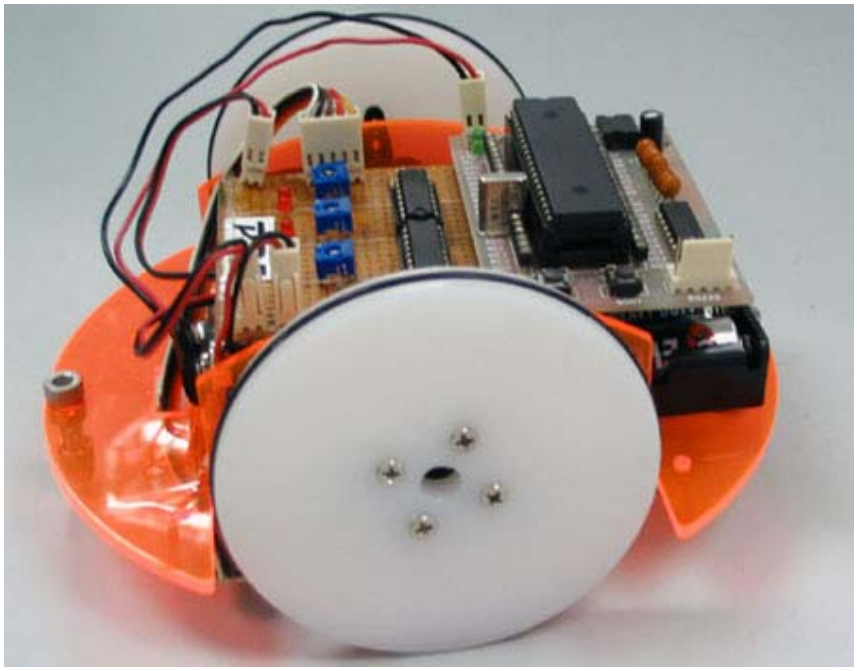
PR5

Line Following Robot



Version 1.0

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Cytron Technologies Sdn. Bhd.

OVERVIEW

This document describes the development of Cytron Technologies DIY (Do It Yourself) Project PR5. This robot is able to follow the line and it is provides with LCD for display. Schematic and source code is provided.

FEATURES

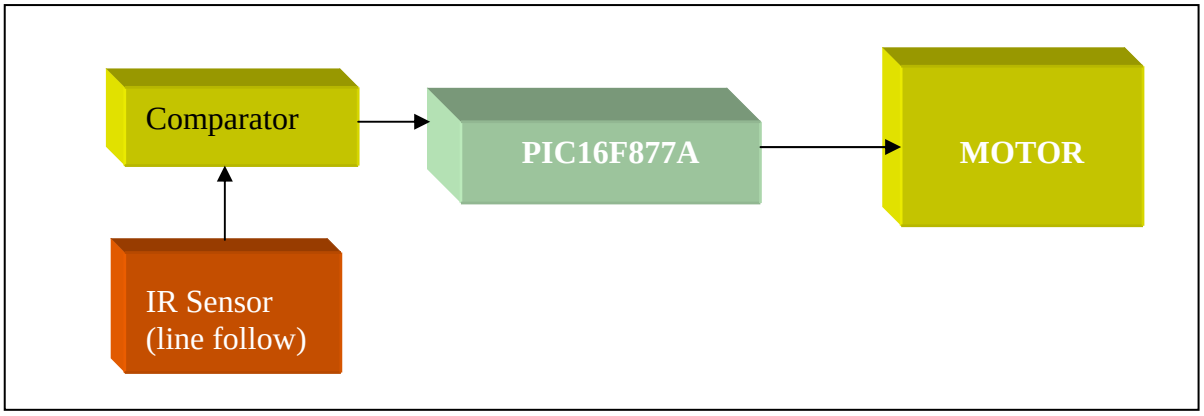
PIC16F877A

- 8-bit microcontroller with 33 I/O
- operate with 5V supply
- operating speed 20MHz

LINE-FOLLOWING

- Using 3 pairs of infrared sensor

SYSTEM OVERVIEW



GENERAL DESCRIPTION

PR5 is an open source microcontroller Do It Yourself kit. This PIC microcontroller based project designed for user to start develop smart robot which capable of line following. It also provides buzzer for user to indicate the condition or status of the robot that useful for debugging and testing.

PIC16F877A

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 40- or 44-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. Features of the device:

- 256 bytes of EEPROM data memory
- self programming
- 2 Comparators
- 8 channels of 10-bit Analog-to-Digital (A/D) converter
- 2 capture/compare/PWM functions
- synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus
- Universal Asynchronous Receiver Transmitter (UART).

All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications.

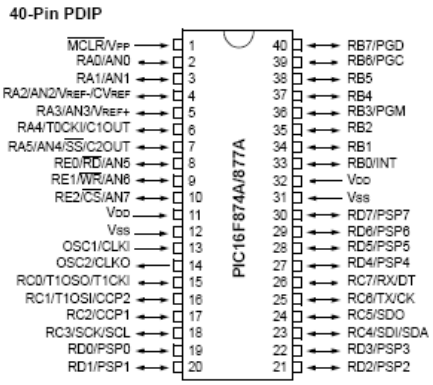


Figure 1

Figure 1 shows the pin diagram for PIC16F877A. For more information about the PIC microcontroller, please refer to the datasheet. The datasheet can be found in microchip web site at: http://www.microchip.com

PIC START-UP KIT SK40A

PIC Start-Up Kit SK40A series is a user friendly kit which enable plug n use feature.

This kit is designed to offer:

- Compact, powerful, flexible and robust start up platform!
- Suitable for hobbyists and expects.
- Save development and soldering time.
- No extra components required for the PIC to function. Is ready to rock!

- All 33 I/O pins are nicely labeled to avoid miss-connection by users.
- Ready with bootloader hardware allowing user to load program easily via PC serial port to PIC.
- No programmer is needed to re-program the PIC.
- No more frustrated work plugging PIC out and back for re-programming.
- Perfectly fit to 40 pins PIC16F and PIC18F.

SK40A come with:

- 5V voltage regulator (1A max)
- 20MHz oscillator
- Reset button
- Bootloader button
- Bootloader hardware and bootloader serial cable
- And all the necessities to eliminate users difficulty in controlling the PIC.

Users are able to utilize the function of PIC by directly plugging in the I/O components in whatever way that is convenient to user. With bootloader firmware on PIC, you can start developing projects and have fun with this kit. This kit comes WITHOUT PIC microcontroller to provide the freedom for user to choose PIC type.

HARDWARE

This project will require following hardware:

a. 1 x PIC16F877A
b. 1 x PIC Start-up kit SK40A
c. Related electronic components

Please refer to Appendix A for the board layout of PR5. The source code and schematic are provided free therefore Cytron Technologies will not be responsible for any further modification or improvement.

Comparator (LM324)

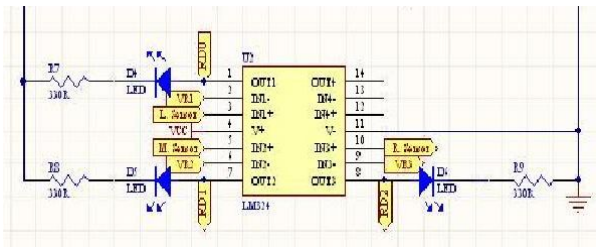


Figure 2

The value from the IR sensor is compared with the value from the preset which can be adjusted by user. The output is logic 1 if IR sensor value is larger than preset and vise versa. The LED is used to indicate logic 1 or logic 0. The LED will turn ON when logic 1 and turn OFF when logic 0.

PIC Start-up Kit SK40A

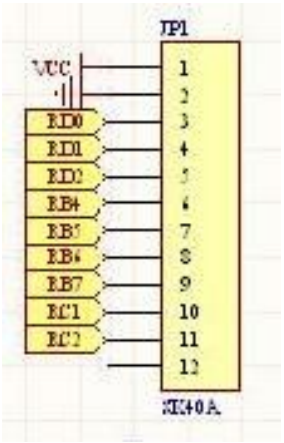


Figure 3

For the instruction of using this PIC SK40A programmer, please refer to the particular PIC programmer user's manual at:
http://www.cytron.com.my/listProductCategory.asp?cid=82#51

Donut board

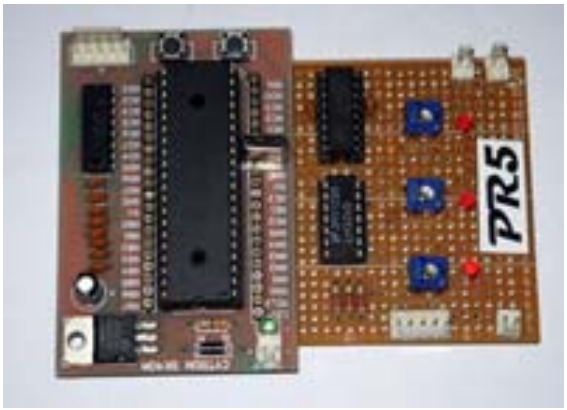


Figure 4

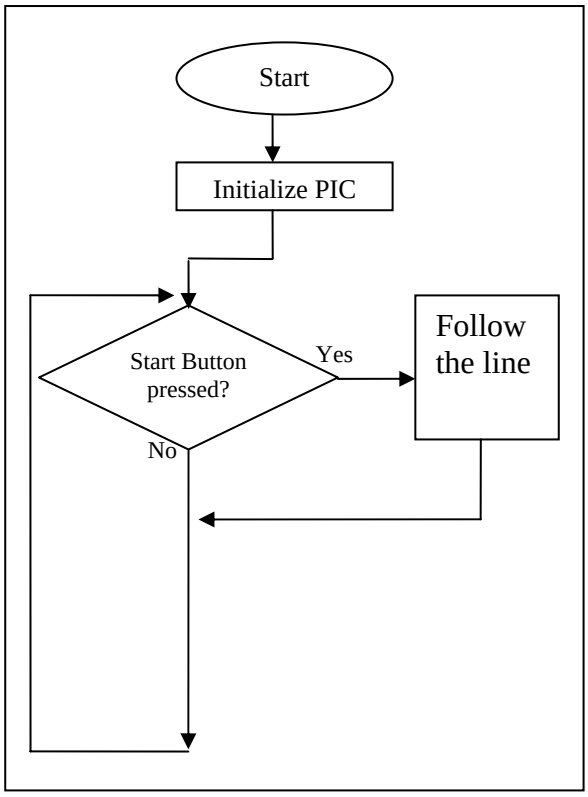
Components:

1. PIC Start-up Kit SK40A x 1
2. PIC16F877A x 1
3. IR Receiver x 3
4. IR Emitter x 3
5. LED x 3
6. Trimmer 10K x 3
7. Resistor 330 ohm x 6
8. Resistor 4.7 kohm x 3
9. Comparator LM324 x 1
10. Motor Driver L293D x 1
11. 14 Pins IC Socket x 1
12. 16 Pins IC Socket x 1
13. PCB Connector 2 Ways x 3
14. PCB Connector 5 Ways x 2
15. Rainbow Cable 5 Ways x 1
16. Wrapping Wire x 3
17. RC Servo Motor C36S (modified) x 2
18. Robot Base x 1

19. Servo Wheel x 2
20. Screw for Wheel x 8
21. Castor BTU-720 x 2
22. 9V Battery Snap x 1
23. 4AA Battery Holder x 1
24. Donut Board x 1

SOFTWARE

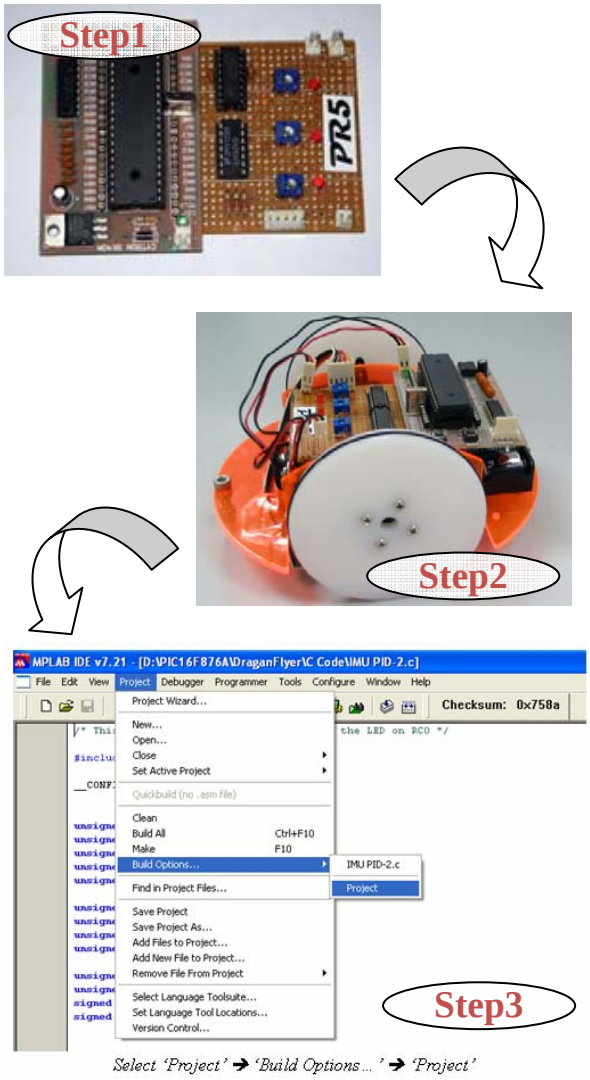
Flow Chart:



For more information about the software for this system, please refer to the source code provided. The explanation of each instruction is provided in the source code as the comment of each line.

The source code is provided free and Cytron Technologies will not be responsible for any further modification or improvement.

Just three simple steps



Select 'Project' ➔ 'Build Options...' ➔ 'Project'

Line Following Algorithm Concept

Now that we have learn about IR sensor, we will move on to line following. In line following, you will have to know about IR sensor and also controlling motors. For this project, we will be applying what we have learnt in **PR4**. But first of all you will have to learn about controlling motor.

1. Controlling The Motor

1.1 Basic

When we say motor, we actually mean D.C. motor. This is because we are using D.C power supply for all of our projects. As an example, the PIC16F877A needs 5V DC to power it where else the Bluetooth modules needs 3.3V DC.

There are different types of DC motors available in the market such as DC geared motor, servo motor and stepper motor, but for this project, we will be focusing on servo motor. Typical servo motors only allow 180° rotate which is not suitable for a wheeled robot to move from a place to another place. Thus, we had made some modification to the servo motor so that it can rotate 360° continuously. At the remaining of the text, we only concentrate on the continuous rotating servo motor.

To move the motor, just connect the power supply to the terminal on the motor while to move it in opposite direction, change the polarity of the connection between the power supply and the terminal. For this line following robot, we will be using two motors.

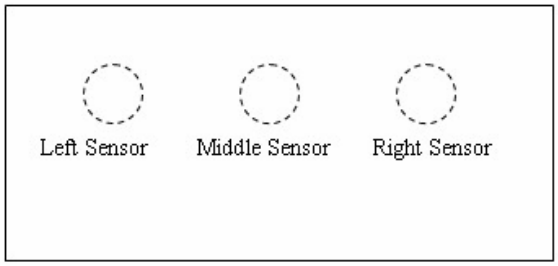
1.2 Motor driver L293D

In a line following robot, usually the motor is powered by a different source from the main circuit the motor will move faster and more powerful. For our application, 4.8V is more suitable.

From the schematics below, you can see that there is 6 pins connected to the microcontroller and 2 pins to each motor. Out of which is the microcontroller. Therefore, an additional component is required to enable the microcontroller to control the motors. For this project, we will be using L293D for this purpose. A servo motor usually needs 4.8V or 6.0V to operate. Higher voltage will generate more power to the motor, thus the 6 pins, 3 is for the left motor and the other 3 is for the right motor. Now lets concentrate on only 1 side of L293D, 3 pins for the microcontroller and 2 pins for the motor. Form the 3 pins, 2 pins is for the direction of the motor and 1 pin (connected to Pin C1 or C2) is for PWM which is to control the speed of the motor. If controlling of speed is not required, just provide this pin with 5 volt to enable it to move. The direction of the motors depends on the connection of the terminal but can also be determined through the program. Therefore, the sample program has to be modified according to your robot.

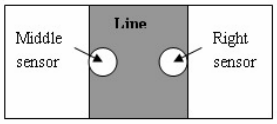
2. IR sensors

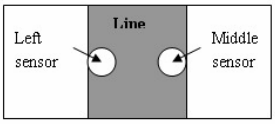
For this project, we will be using three pairs of IR sensors which will be attached to the bottom of the robot. These 3 sensors will be classified as left sensor, middle sensor and right sensor. A view of the placement of the sensors is as below:



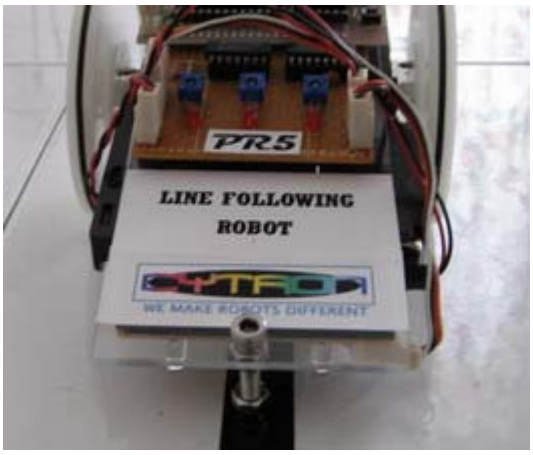
View from the top of the robot

The distance between 2 sensor depends on the width. The sensor should be placed in such a way that maximum distance of two sensors is equal to the width of the line as shown in figure below.





Tuning the comparator to trigger at certain intensity of infrared light is called “Teaching”. We will need a small Philips screw driver to tune the VR or preset to desire voltage. Place the robot on a white floor with black tape (line) as shown in picture:



To teach the robot for line detection, you may follow these steps:

1. Adjust the robot so that the center infrared sensor is on top of white floor, make sure the wheels and castor of the robot touches the floor properly.
2. Use the screw driver to adjust the preset of center sensor until indicator LED (center) light ON.
3. Now adjust the robot to move the center sensor towards the black line where the reflection of infrared is poor.
4. At this point, make sure the indicator LED is OFF. If the LED is still on, it means you have

over tune the preset. Tune it back so that the indicator is OFF.

5. Repeat step a. - d. for a few time and make sure the indicator LED ON and OFF correctly at the right spot.
6. Repeat step a. - e. to "teach" left sensor and right sensor.
7. Now your robot has been "taught".

Let's see how this robot can follow line based of the response from each sensor. In our discussion, we will bypass the comparator by assuming that this robot have been taught. Once a particular sensor sensed black line, it will trigger the PIC.

Example of how the sensors function when the robot follows a black line on a white floor:

Sensor			Response
Left	Middle	Right	
W	B	W	Go Straight
B	W	W	Turn Left
W	W	B	Turn Right

Where, W = White
B = Black

This is the concept of a line following robot. We can see that when the middle sensor detects the line, the robot will move forward. This is because the line is in the center of the robot. But when the left sensor or the right sensor detects the black line, this means that the robot have strayed from the line. If the robot strayed to the right, the left sensor will detect the line and the brain will react by turning left to go back to the line. As for the right sensor, it reacts in the opposite way.

3. Coordinating the motor and sensor

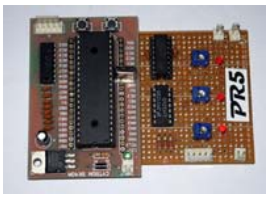
Now that you know how the sensors detect a line, we will continue to learn how the robot moves. The robot uses the concept of two separate moving wheels. The table below shows the combination of the wheels to move the robot in the desired direction.

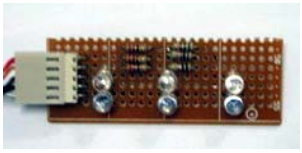
	Left Wheel	Right Wheel	Movement
1	Forward	Forward	Forward
2	Backward	Backward	Backward
3	Forward	Stop	Right Turn
4	Stop	Forward	Left Turn
5	Forward	Backward	Sharp Right Turn
6	Backward	Forward	Sharp Left Turn

When you reach this part, you have learnt the basic concept of line following algorithm. What you have to do now is Prepare your PCB board!

1. Get the electronic components on hand and solder them up!

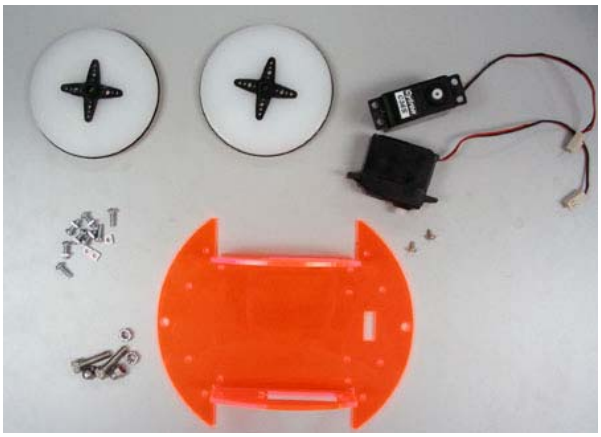
Prepare your donut board! Solder the SK40A onto your donut board. Follow the schematic that is shown in Appendix A. If you are not sure, you can test it out first on your protoboard. It is advisable to start with the sensor part and test it first before soldering the motor part. This is because the sensors can be tested without the need to program the microcontroller. Test the sensors by placing it on a white surface and after that on a black surface, If the LEDs lights when it is placed on the white surface and turn off when placed on the black surface, then your sensors are connected correctly. You can then proceed with your motor part. Make sure that all the polarity of the components are according to the schematic.





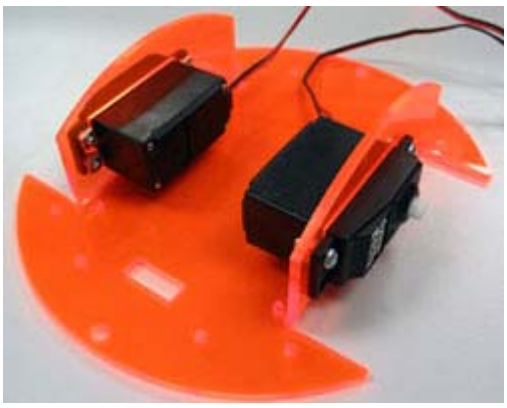
2. Building your robot

The figure below shows the components for the movement of the line following robot. These components are only recommendations. Other motors, wheels, bases and castors that you like can also be used. In this chapter, we will be learning how to assemble all the components shown to build the robot.



2.1 Assembling the motors and base

i. First, screw the two motors on both side of the acrylic base included. Make sure that the shaft of the motors is positioned in the center of the base.

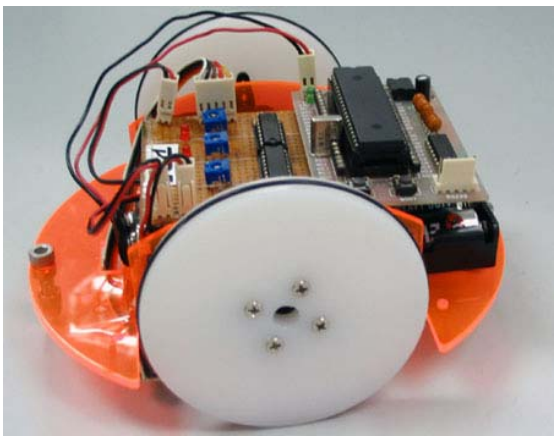


ii. After the motor have been mounted on the base, assemble the wheels onto the motor and screw it using the silver small screw that is included with the motor.

iii. For the castor, insert the bolts through the hole on the front and on the back and tighten the nuts.

2.2 Completing the Assembly

Stick the completed circuit (main circuit and sensors) and battery holders onto the base. The arrangement of the circuit and holders are completely dependant on your creativity.



3. Programming the microcontroller

After all robot have been completed, its time to program the microcontroller. For this project, we will be using C programming. The bootloader will still be used to program it (refer to PR3). There will be some changes when using MPLAB and Bootloader. Download the sample source code (PR5.hex) and try it on your robot. If the wheel does not turn in the required direction, just download the program (PR5.c) and change it to suit your robot.

3.1 MPLAB and PICC Lite

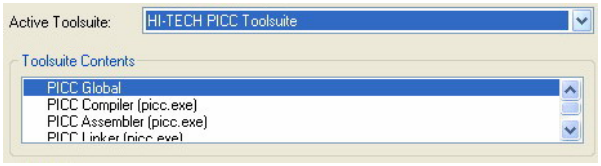
- Install MPLAB
- Install PICC Lite

1. Start the MPLAB IDE program.

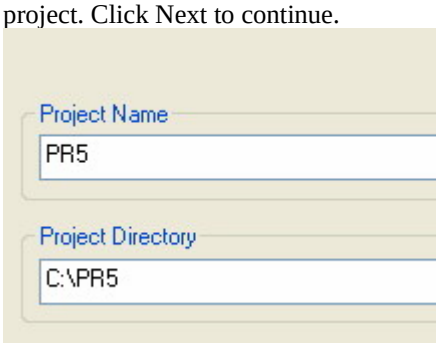
2. Set up a new project. Select Project-> Project Wizard then Click Next to continue.

3. Choose the correct device which is PIC16F877A and click Next to continue.

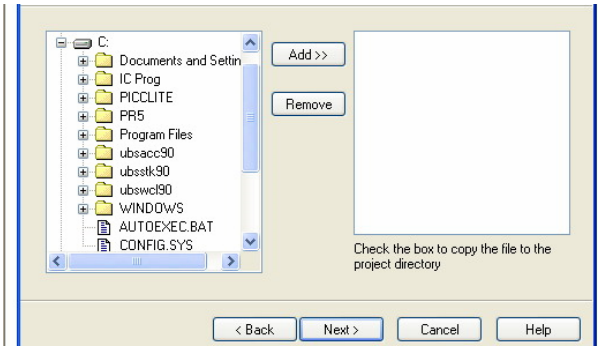
4. Select HI-TECH PICC Toolsuite as your language toolsuite from the Active Toolsuite drop-down menu. Click Next to continue. .

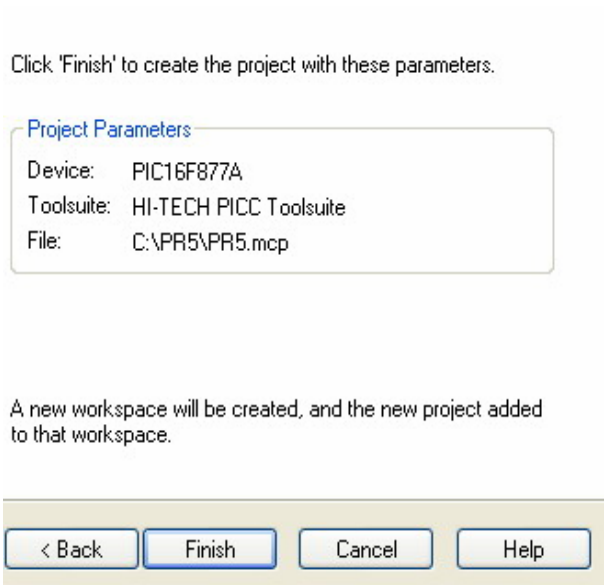


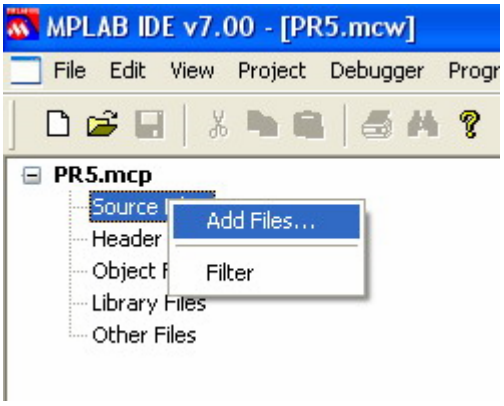
5. Enter a name and select the location for the project. Click Next to continue.



6. Click Next then select Finish to complete.

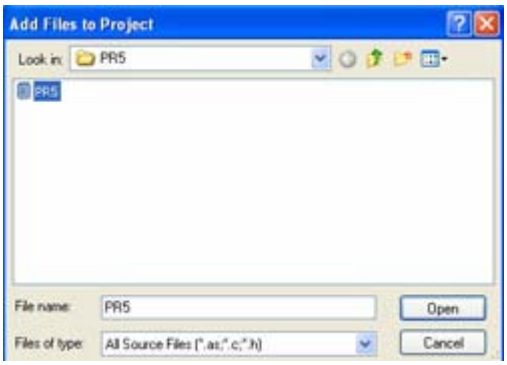




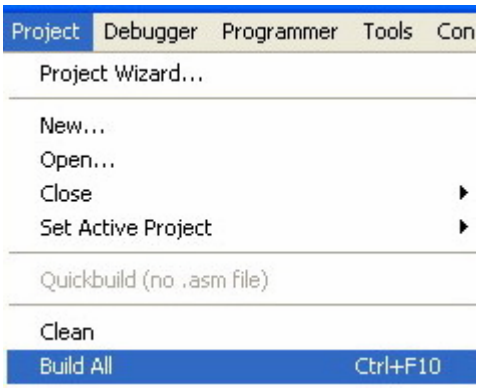


7. Download the sample program to the folder that you have created the project.

8. Right click on the *Source files* and select *Add Files*.



9. Add the PR5.c file.

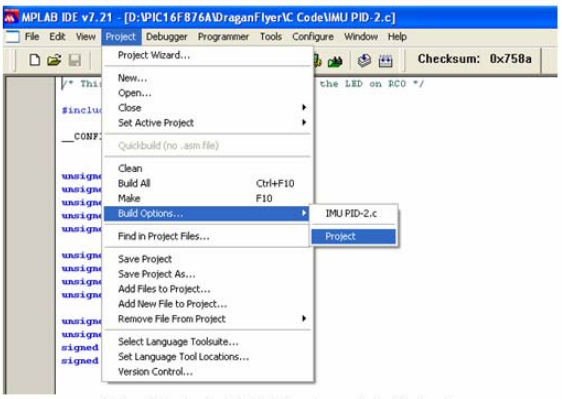


10. Now you are ready to build your project. Select Project-> Build All or press CRTL+F10.

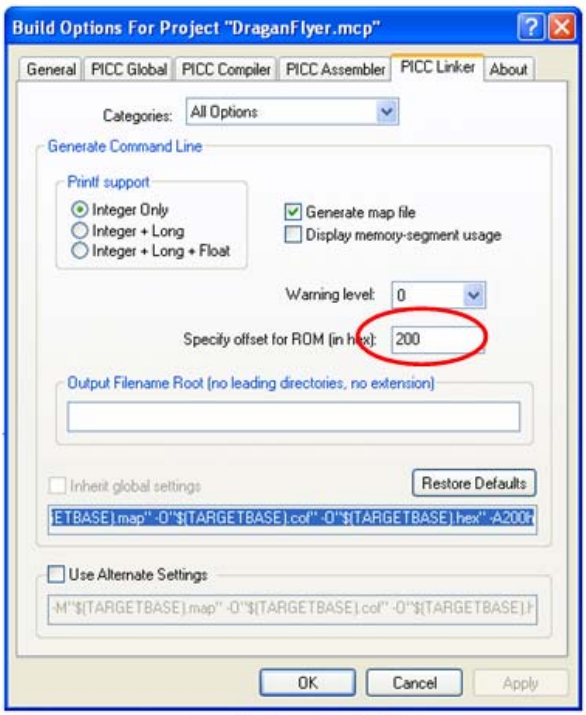
11. MPLAB will generate a HEX file that will be transferred to the PIC Microcontroller using the bootloader.

3.2 Bootloader

- Please click here to review how to setup bootloader.
- There is some changes when using C programming:
  For source code written in C language with PICC Lite Compiler, there must be offset 200 in the "PICC Linker" option (Please refer to the pictures below).



Select 'Project' ➔ 'Build Options ... ' ➔ 'Project'



Specify the offset 200

3.3 Changing the program

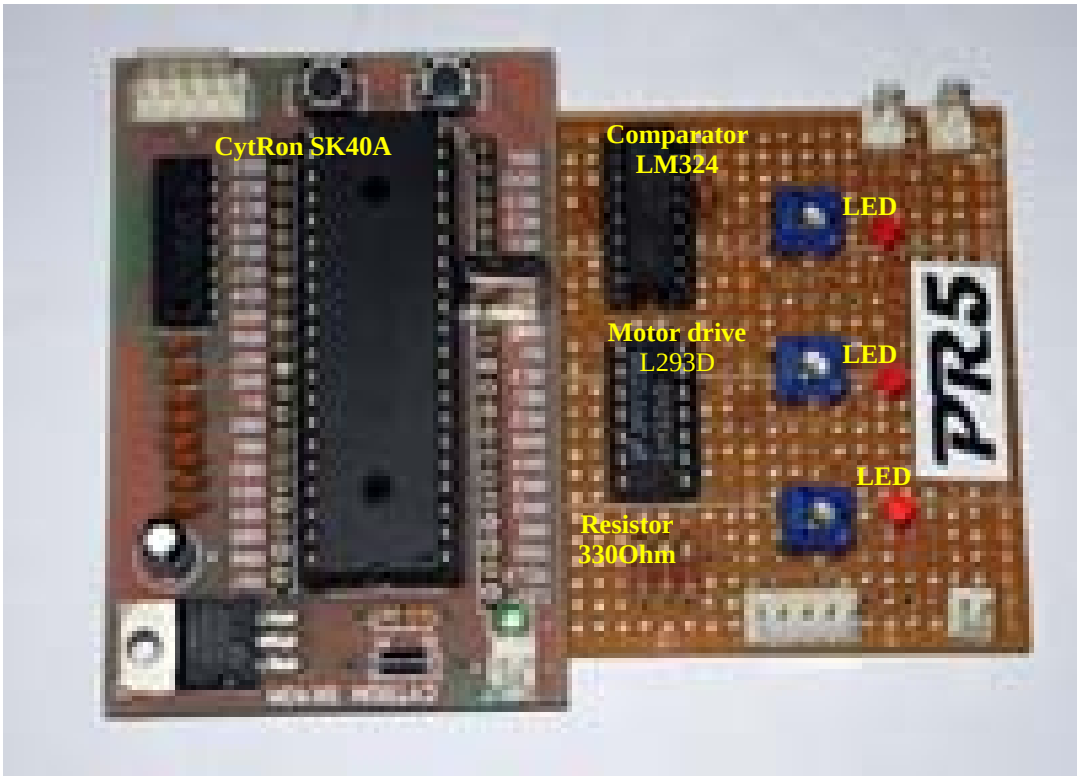
```
for(;;)
{
    if (RD1==1)                 //check middle sensor
    {
        PORTB=0b01011111;       //move forward
        j=0b01011111;           //save memory
    }
    else if (RD0==1)            //check left sensor
    {
        PORTB=0b01001111;       //move right motor
        j=0b01001111;           //save memory
    }
    else if (RD2==1)            //check right sensor
    {
        PORTB=0b00011111;       //move left motor
        j=0b00011111;           //save memory
    }
    else
    {
        PORTB=j;                //read memory
    }
}
```

The figure above is part of the program. If the robot is not moving in the direction that is supposed to, change the value for Port B that is circled in the program above. The four values represent RB7, RB6, RB5 and RB4 respectively. So to change the direction of the right wheel, change the value for RB7 and RB6 (first 2 digit) from 01 to 10. For the left wheel, change the value for RB5 and RB4 (next 2 digit) from 01 to 10. If the value is 00, that means that the motor stops. The value for 'j' has to be the same as Port B.

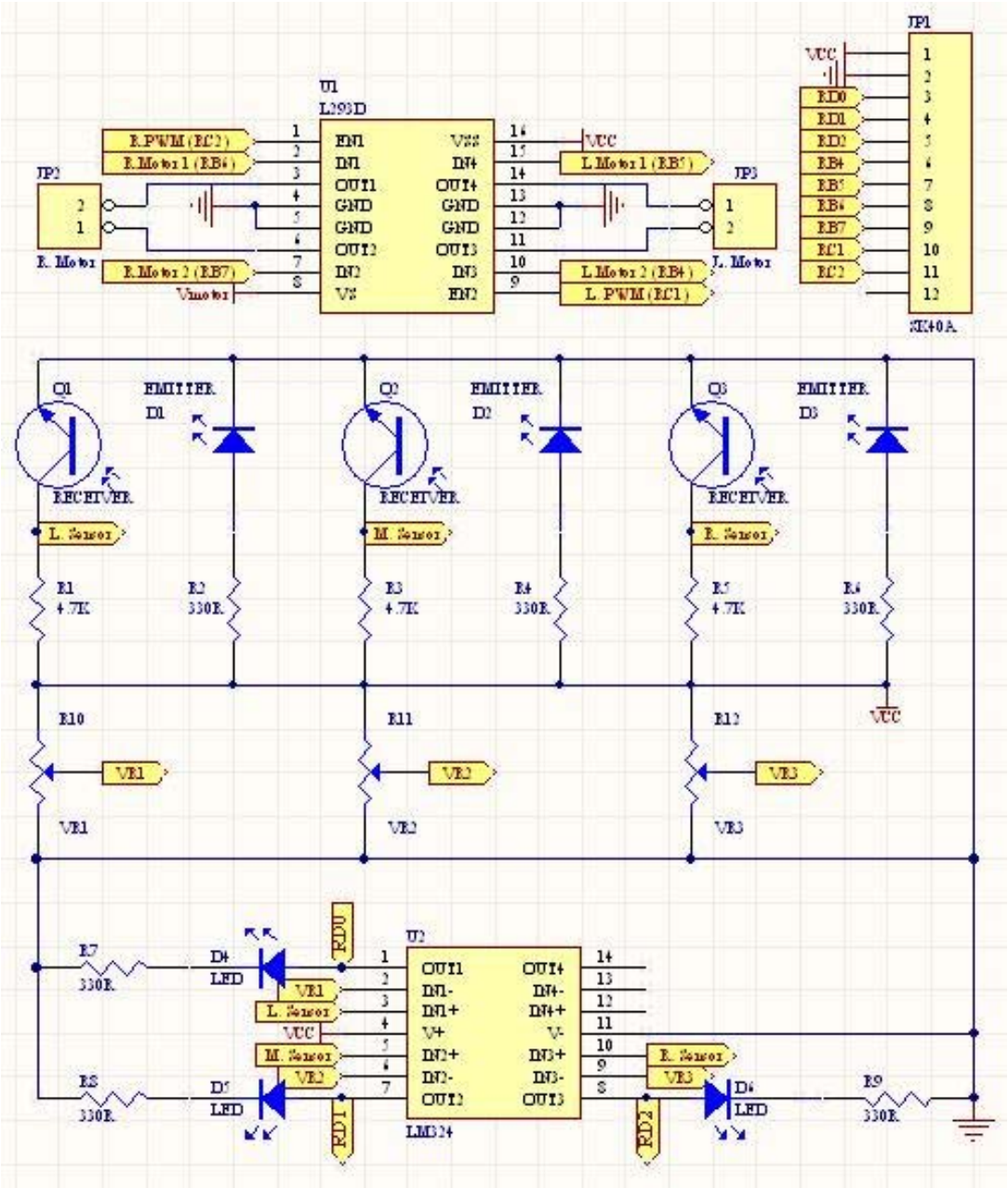
WARRANTY

No warranty will be provided as this is DIY project. Thus, user is advice to check the polarity of each electronic component before soldering it to board.

Appendix A:
Donut Board Layout



Appendix B:
Schematic



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