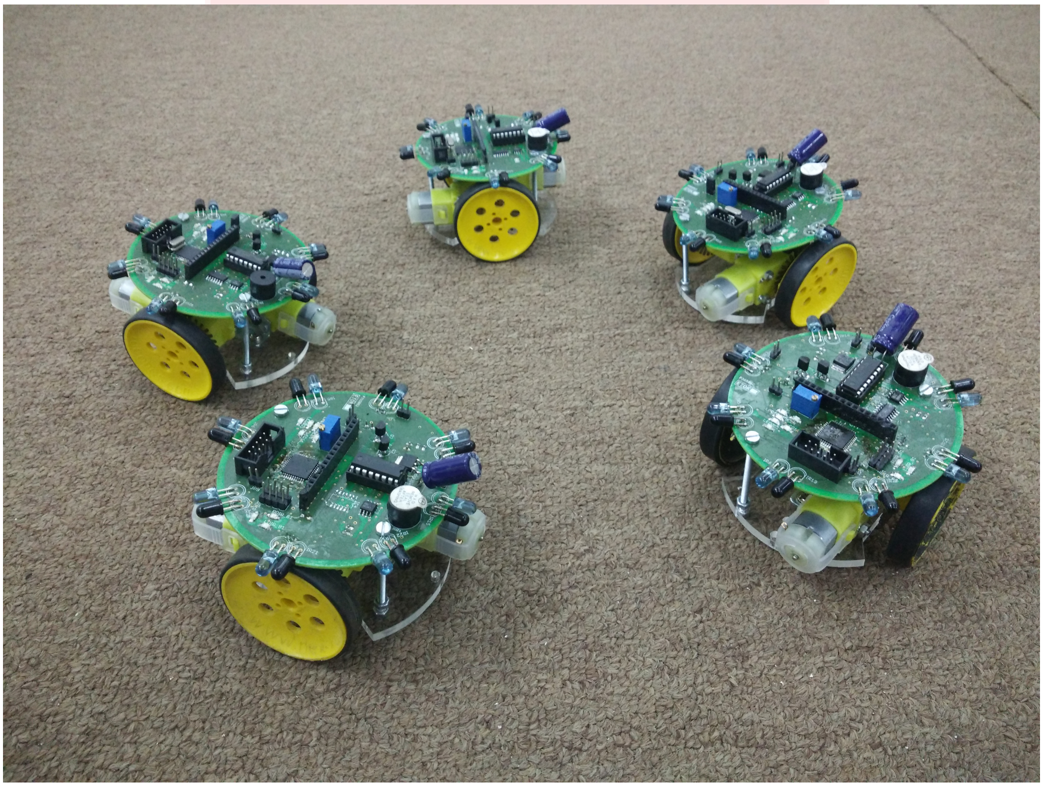
eYSIP2017

Distributed robotics - multi swarm robots
Hardware manual



Intern 1 Mr. Chinmay C
Intern 2 Mr. R Hariharan
Mentor 1 Ms. Rutuja
Mentor 2 Ms. Deepa
Duration of Internship: 22/05/2017 – 07/07/2017

2017, e-Yantra Publication

Contents

1 Introduction 2

2 Mini Bots Block Diagram 4

3 Mini bots technical specification 5

4 Powering up Mini bots 7

5 Battery Maintenance 9

6 Motion control 10

7 Position encoders 14

8 Infrared proximity and Directional light intensity sensors 17

9 LCD contrast and backlight setting 22

10 Battery voltage sensor 23

11 Atmega 16 programmer 24

12 Schematics 25

13 Layout 26

Introduction

Thanks for choosing the Mini bots mobile robot platform. Mini bots will give you good exposure to the world of swarm robotics and embedded systems. Thanks to its innovative architecture and adoption of the Open Source Philosophy in its software and hardware design, you will be able to create and contribute to complex applications that run on this platform, helping you acquire expertise as you spend more time with them.

Safety precautions:

1. Robots electronics is static sensitive. Use robot in static free environment.
2. If robots battery low buzzer starts beeping, immediately charge the batteries.
3. To prevent fire hazard, do not expose the equipment to rain or moisture.
4. Refrain from dismantling the unit or any of its accessories once robot is assembled.
5. Never allow NiMH battery to deep discharge.
6. Mount all the components with correct polarity.
7. Keep wheels away from long hair or fur.
8. Keep the robot away from the wet areas. Contact with water will damage the robot.
9. To avoid risks of fall, keep your robot in a stable position.
10. Do not attach any connectors while robot is powered ON.
11. Never leave the robot powered ON when it is not in use.

Inappropriate Operation:
Inappropriate operation can damage your robot. Inappropriate operation includes, but is not limited to:

1. Dropping the robot, running it off an edge, or otherwise operating it in an irresponsible manner.
2. Interfacing new hardware without considering compatibility
3. Overloading the robot above its payload capacity.
4. Exposing the robot to wet environments.
5. Continuing to run the robot after hair, yarn, string, or any other item has become entangled in the robots axles or wheels.
6. All other forms of inappropriate operation.
7. Using robot in areas prone to static electricity.

Mini Bots Block Diagram

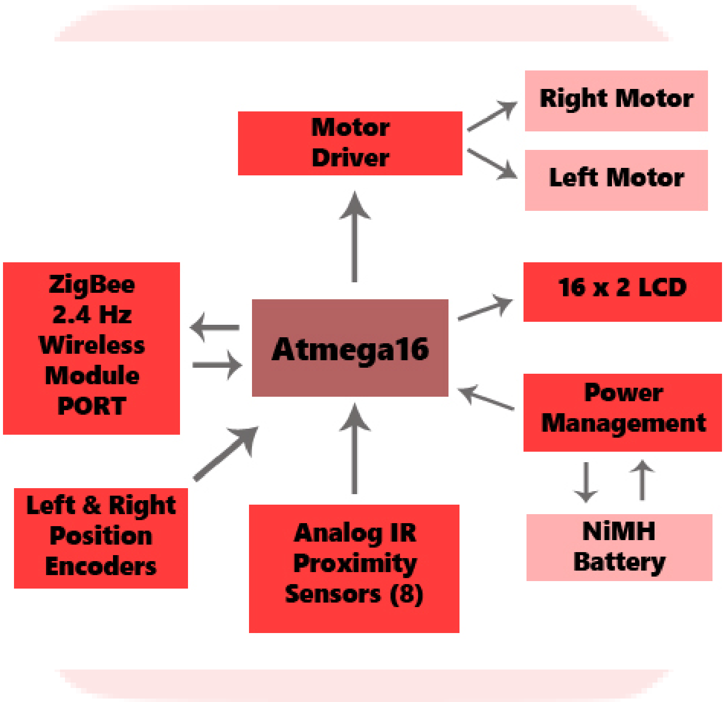


Figure 2.1: Block diagram of hardware

Mini bots technical specification

1. **Microcontroller:**
   ATMEL ATMEGA16
2. **Sensors:**
   Eight IR proximity sensors
   Two Position Encoders
   Battery voltage sensing
3. **Indicators:**
   2 x 16 Characters LCD
   Indicator LEDs
   Buzzer
   Battery low indication
4. **Locomotion:**
   Two 60 RPM DC geared motors
   Top Speed: 66cm/second
5. **Operational Modes:**
   Standalone (Autonomous Control)
   Distributed (multi robot communication)
6. **Communication:**
   Simplex infrared communication (From infrared to robot)
   Zigbee communication (port provided)
7. **Dimensions:**
   Diameter: 15cm

Height: 7cm

8. **Power:**
   6 AA size NiMH rechargeable batteries

Top view of PCB

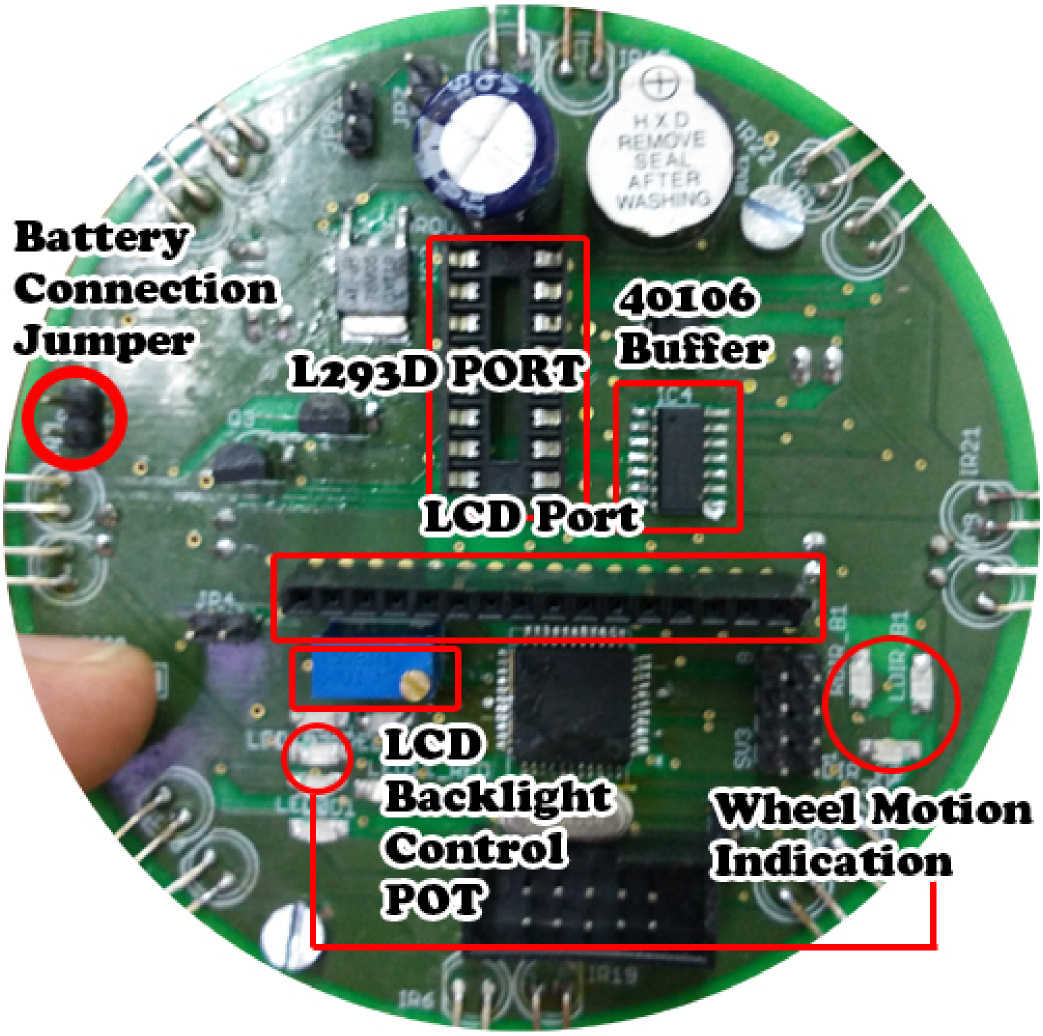


Figure 3.1: Top view of PCB

Powering up Mini bots

- Mini bots are powered by six AA sized NiMH rechargeable batteries. 2.1Ah battery gives about two hour battery operation. Battery is available as preassembled 6 cell pack or robot has AA sized 6 cell battery holder.

- Before connecting the battery pack or inserting batteries in the socket, make sure that battery connection jumper of the robot is not put. You need to charge the battery before first use. Use any AC adaptor / SMPS which can give accurate 12V DC and 1Amp current.

- Mini bots are powered by 6 NiMH rechargeable batteries of 0.8Ah and above capacity. When it is fully discharged voltage drops to about 7V. Battery pack should not be discharged below 6V (1V per cell) to extend the battery life. Mini bots have onboard smart battery detector which monitors battery status. Nickel Metal Hydride batteries must be recharged externally.
  Power management block on the Mini bots performs following functions.
  1. Battery low warning in case battery is below critical level
  2. Regulated supply for onboard payload.
  3. Battery charging when robot is powered off and external battery charger is connected.

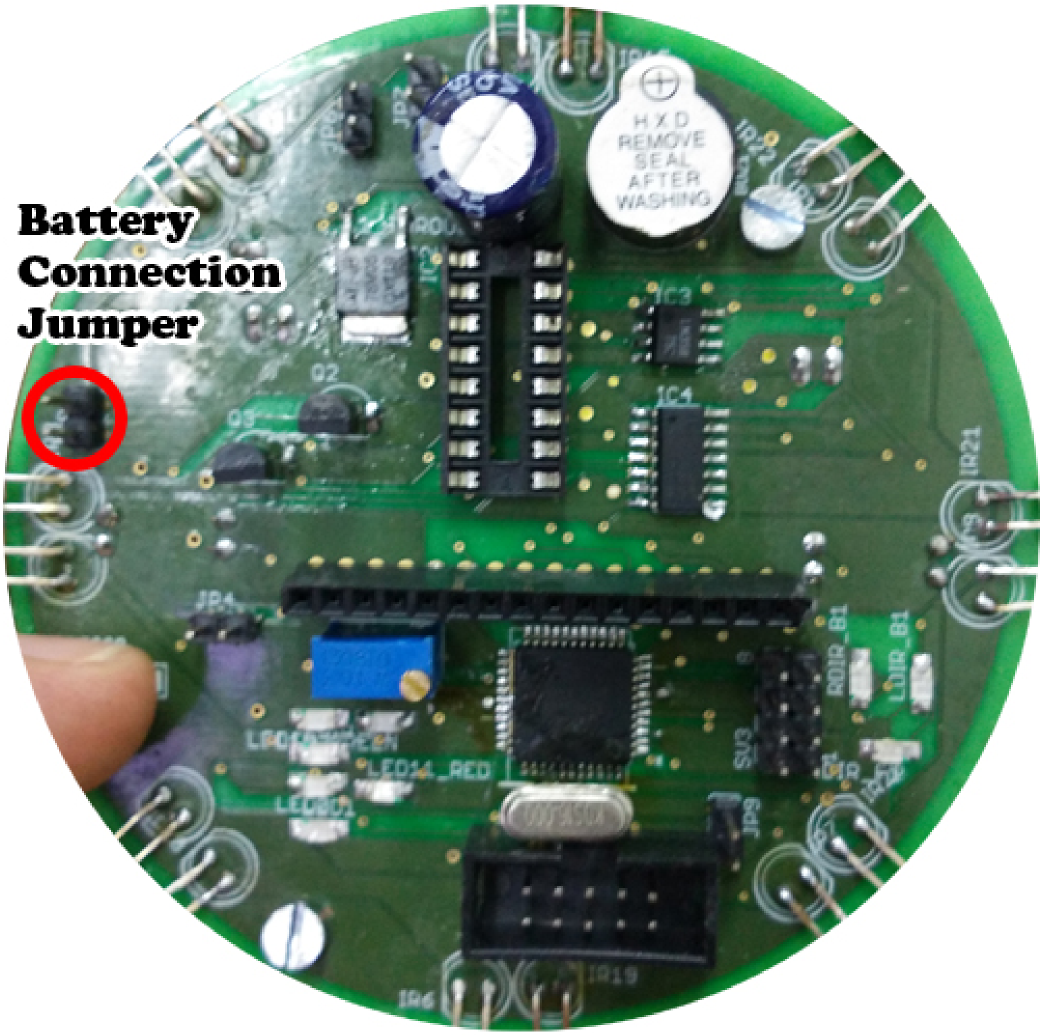


Figure 4.1: Battery connection jumper

Battery Maintenance

Battery Maintenance

- Fully charged NiMH battery will get completely discharged with in a week of storage. Always charge the battery before use. If fully charged battery is kept in storage for about a month and afterwards even if its fully charged again, it can deliver only 1/3rd power of its rating. In such case to restore battery to its full potential again, perform at least 2-3 charge discharge cycles.
  To ensure long life, charge battery at least once a week and discharge it till robot starts giving battery low warning. Before storage, charge the battery again.
  Disconnect the battery connector if robot is to be stored for long duration of time.

Motion control

- Mini bots has two 60 RPM DC geared motors in differential drive configuration. Robot has top speed of about 66cm per second. Using this configuration, the robot can turn with zero turning radius by rotating one wheel in clockwise direction and other in counterclockwise direction.
  Motion control involves direction control and velocity control. Motors are controlled by L293D dual motor driver which can provide up to 600mA of current to each motor. To change the direction of the motor, appropriate logic levels (High/Low) are applied to L293Ds direction control pins. Velocity control is done using Pulse Width Modulation (PWM).
  LEDs are connected at the input and the output stage of the motor driver for quick interpretation of the motion commands.

- Figure 6.2 shows the PWM waveforms for motor velocity control. In case (A), ON time is 90 percent of time period. This wave has more average value. Hence more power is delivered to the motor. In case (B), the motor will run slower as the ON time is just 10 percent of time period.

-	Microcontroller pin	Function	
1	PD4 (OC1B)	Pulse width modulation for the left motor	
2	PD5 (OC1A)	Pulse width modulation for the right motor	
3	PD6	Left motor direction control	
4	PD7	Left motor direction control	
5	PB2	Right motor direction control	
6	PB4	Right motor direction control	

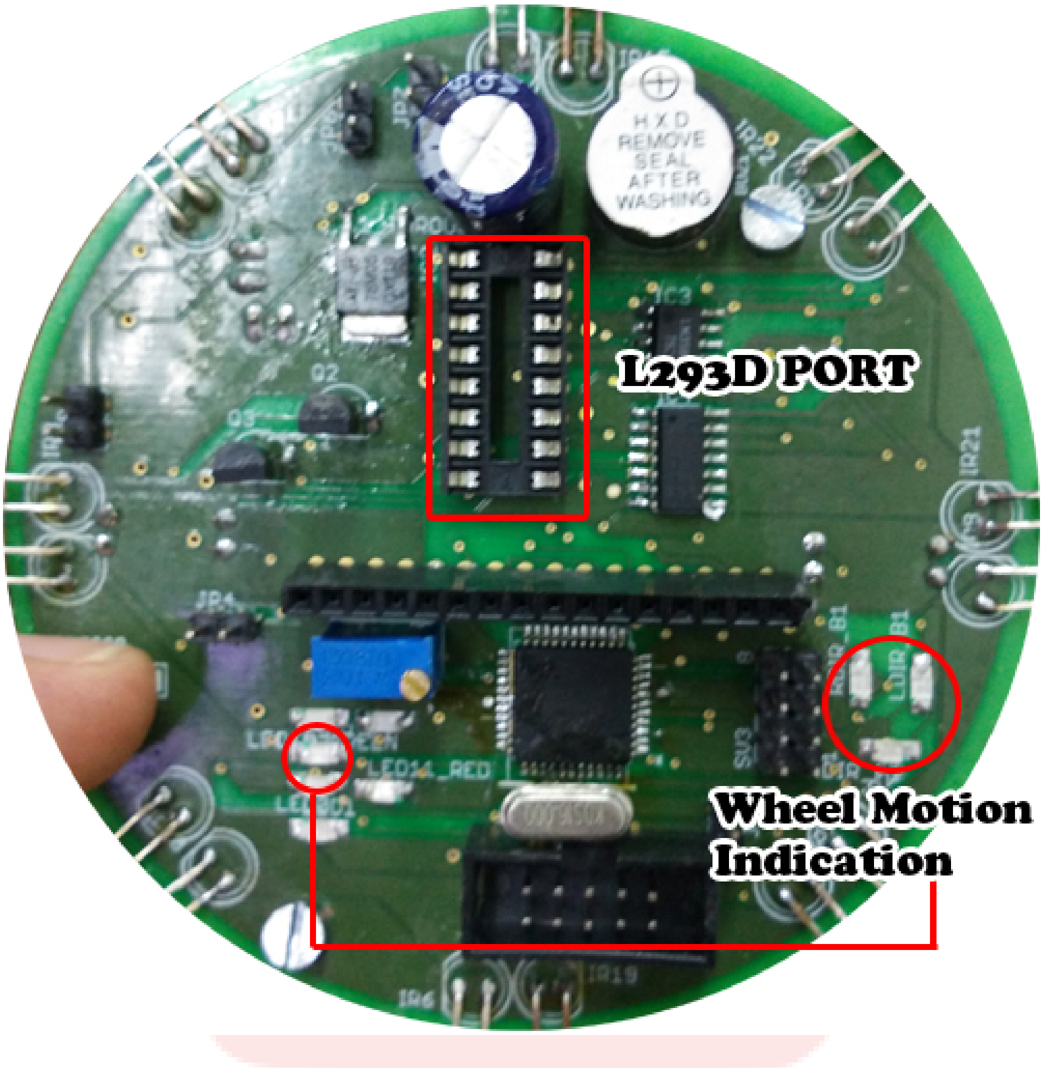


Figure 6.1: L293d port and wheel motion indication

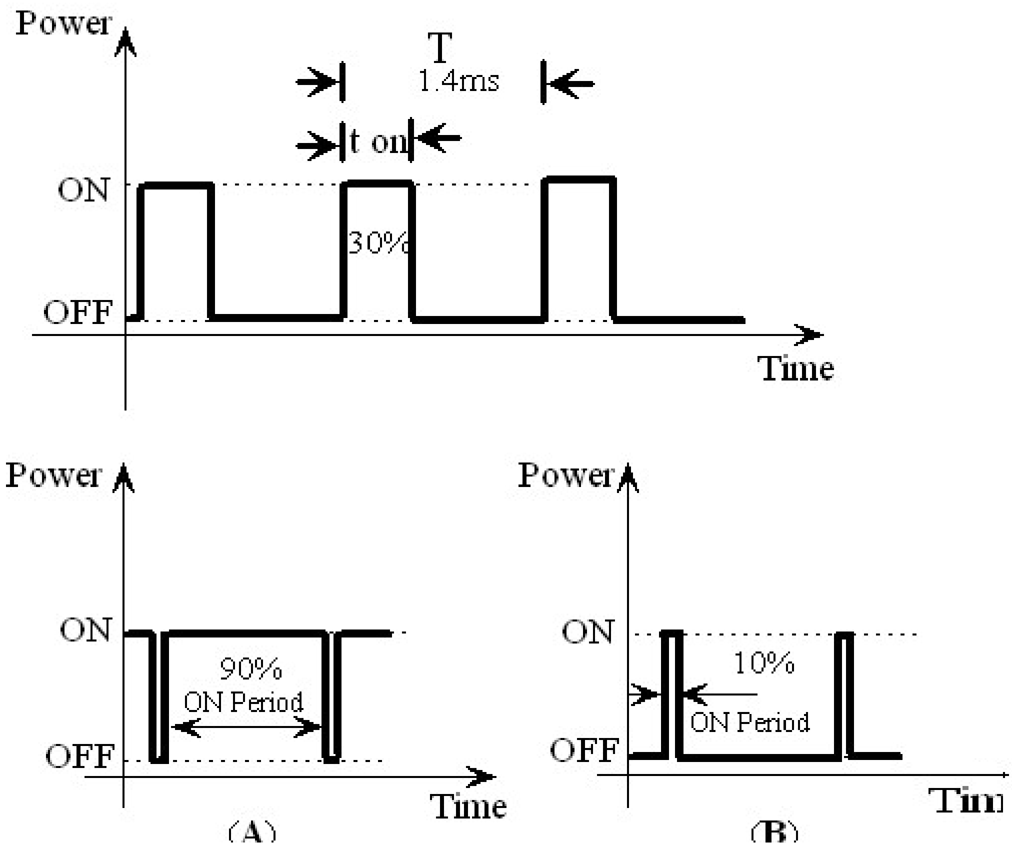


Figure 6.2: Pulse width modulation

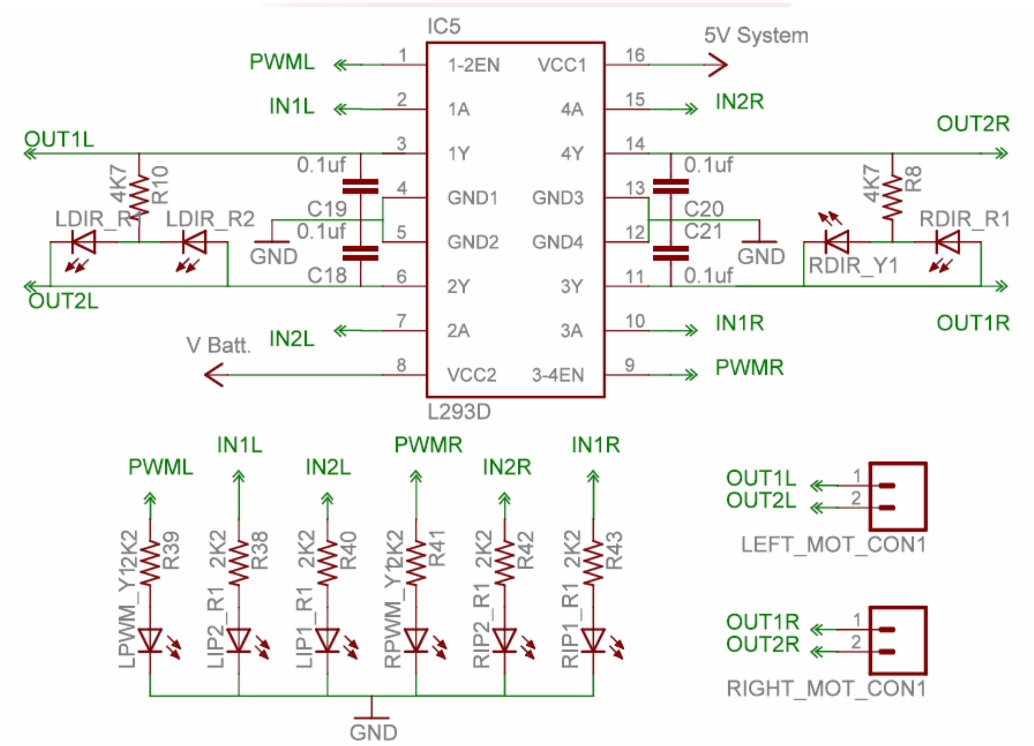


Figure 6.3: Motor driver schematics

Position encoders

- Position encoders give position / velocity feedback to the robot. It is used in closed loop to control robots position and velocity. Position encoder consists of slotted disc which rotates between optical encoder (optical transmitter and receiver). When slotted disc moves in between the optical encoder we get square wave signal whose pulse count indicates position and time period / frequency indicates velocity.
  Optical encoder MOC7811 is used for position encoder on the robot. It consists of IR LED and the photo transistor mounted in front of each other separated by a slot in black opaque casing with small slot shaped window facing each other. When IR light falls on the photo transistor it gets in to saturation and gives logic 0 as the output. In absence of the IR light it gives logic 1 as output. A slotted encoder disc is mounted on the wheel is placed in between the slot. When encoder disc rotates it cuts IR illumination alternately because of which photo transistor gives square pulse train as output. Output from the position encoder is cleaned using Schmitt trigger based inverter (not gate) IC CD40106. CD40106 also drives left and right position encoder status LEDs.

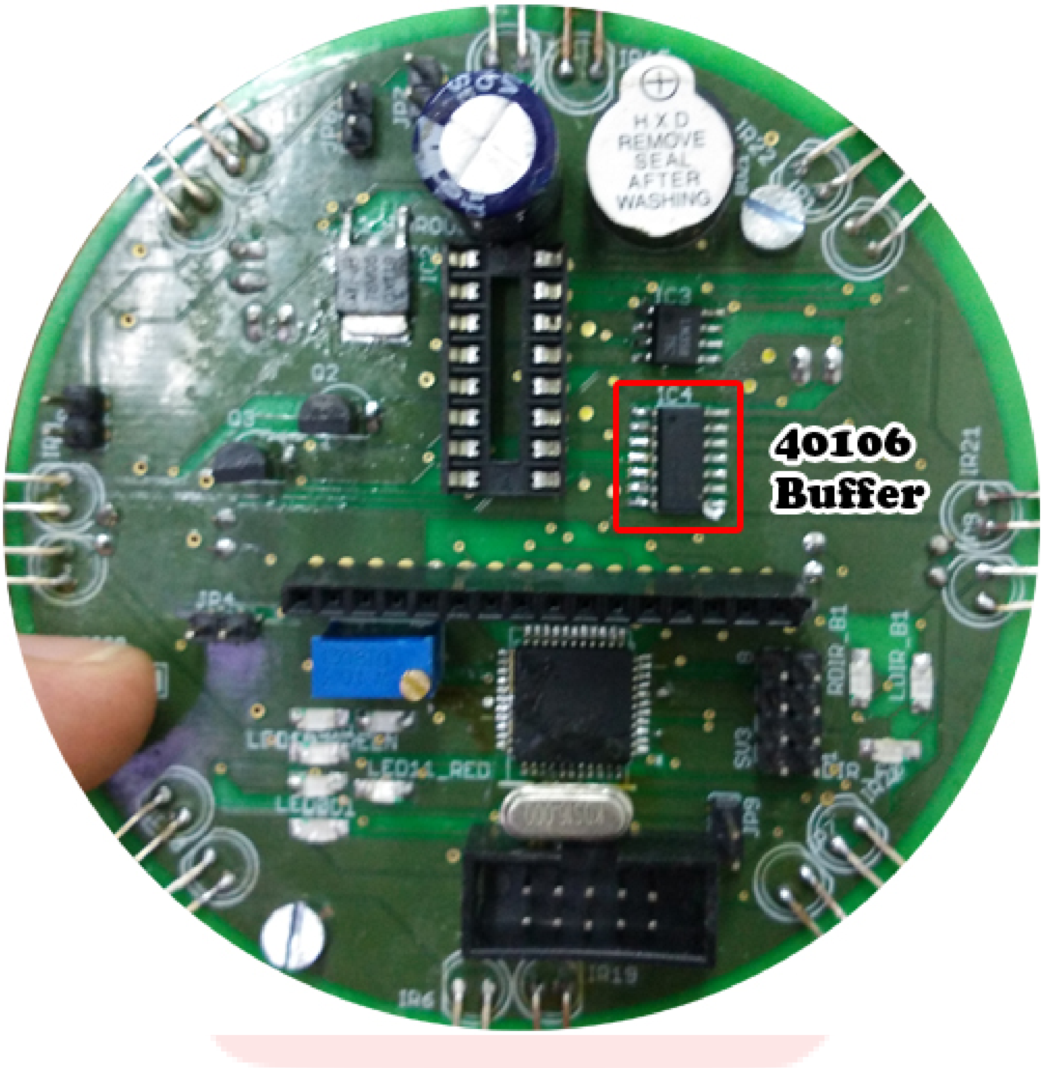


Figure 7.1: 40106 hex buffer

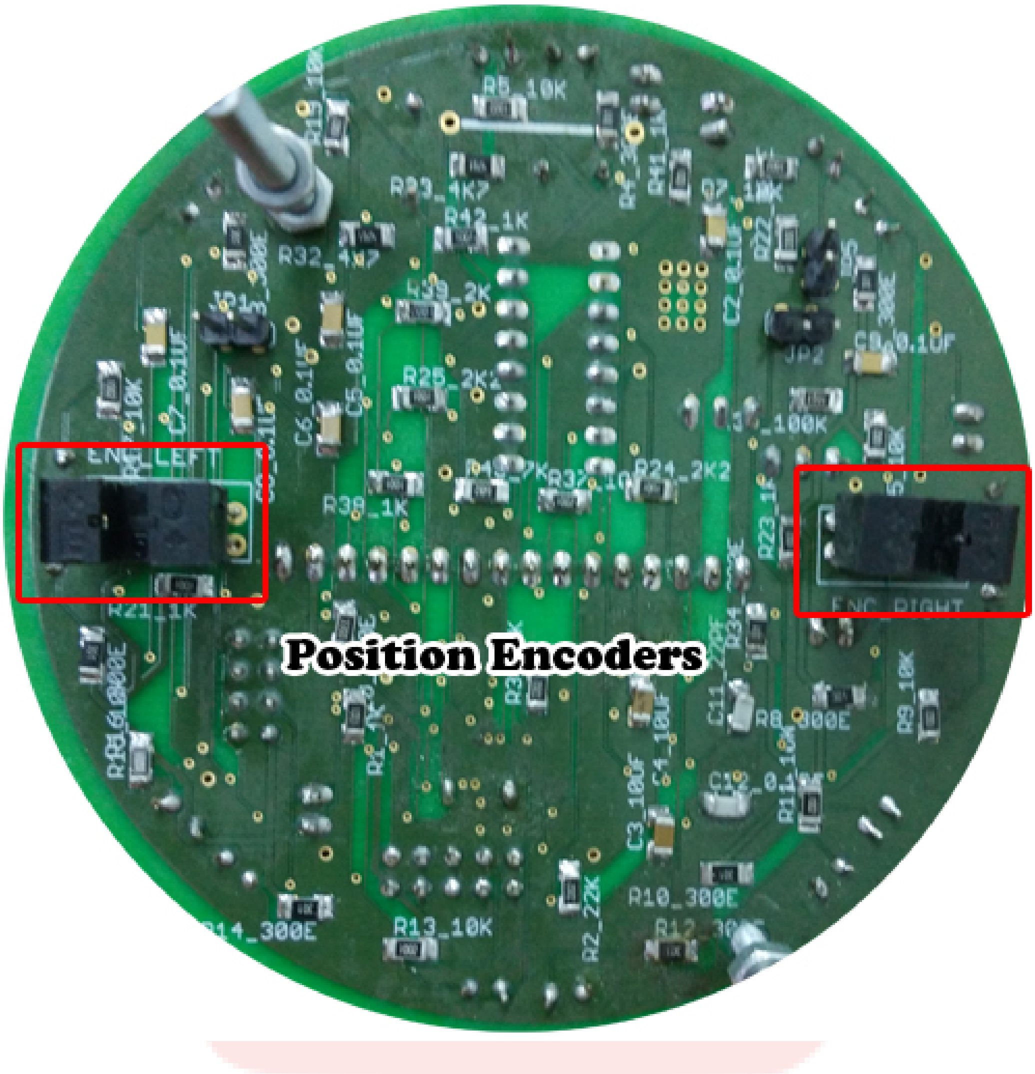


Figure 7.2: Position encoders

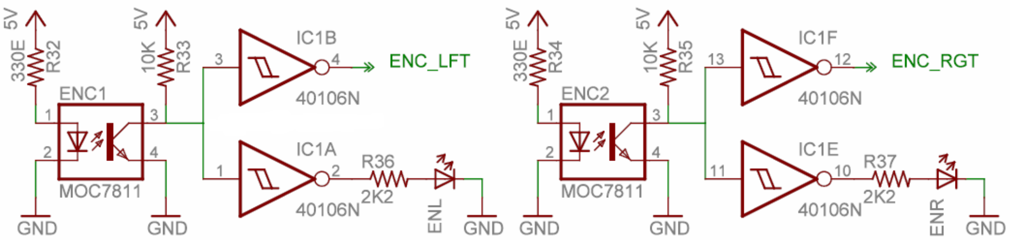


Figure 7.3: Position encoders schematics

Infrared proximity and Directional light intensity sensors

- Infrared proximity sensors are used to detect proximity of any obstacles in the short range. IR proximity sensors have about 10cm sensing range. Mini bots has 8 IR proximity sensors.
  In the absence of the obstacle there is no reflected light hence no leakage current will flow through the photo transistor and output voltage of the photo transistor will be around 5V. As obstacle comes closer, more light gets reflected and falls on the photo transistor and leakage current flowing through the photo transistor starts to increase which causes voltage across the diode to fall.
  If IR LEDs are disabled using jumpers then same photo transistors works as directional light intensity sensors. IR sensors detect the light from the transmitters present on the neighbouring robots for determining direction and distance of robots.

Figure 8.1: IR sensors

LCD

- To interface LCD with the microcontroller in default configuration requires 3 control signals and 8 data lines. This is known as 8 bit interfacing mode which requires total 11 I/O lines. To reduce the number of I/Os required for LCD interfacing we can use 4 bit interfacing mode which requires 3 control signals with 4 data lines. In this mode higher nibble and lower nibble of commands/data set needs to be sent separately.LCD is interfaced in 4 bit mode. The three control lines are referred to as EN, RS, and RW.

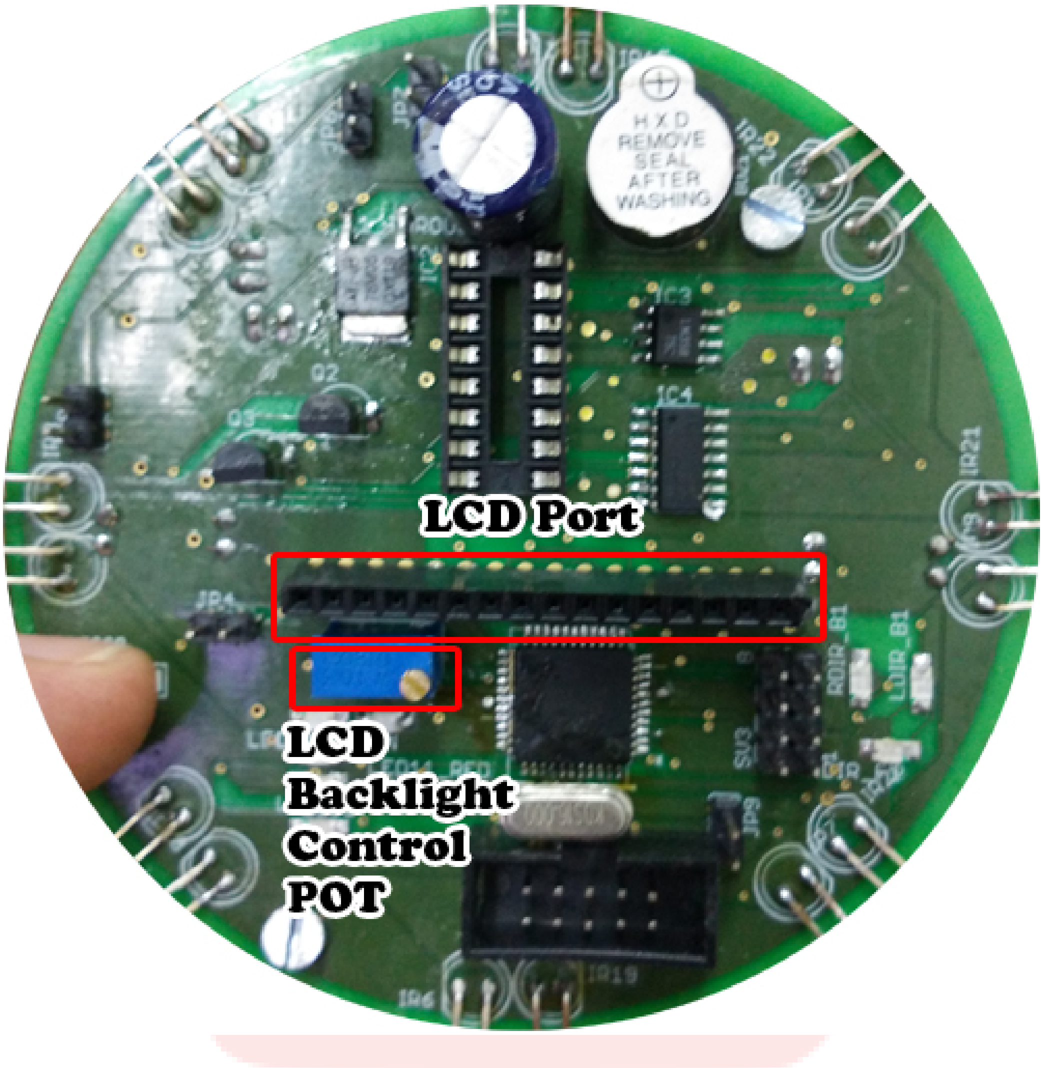


Figure 8.2: LCD port

- The EN line is called "Enable". This control line is used to tell the LCD that microcontroller has sent data to it or microcontroller is ready to receive data from LCD. This is indicated by a high-to-low transition on this line. To send data to the LCD, program should make sure that this line is low (0) and then set the other two control lines as required and put data on the data bus. When this is done, make EN high (1) and wait for the minimum amount of time as specified by the LCD datasheet, and end by bringing it to low (0) again.
  The RS line is the "Register Select" line and it is connected to PC0. When RS is low (0), the data is treated as a command or special in-

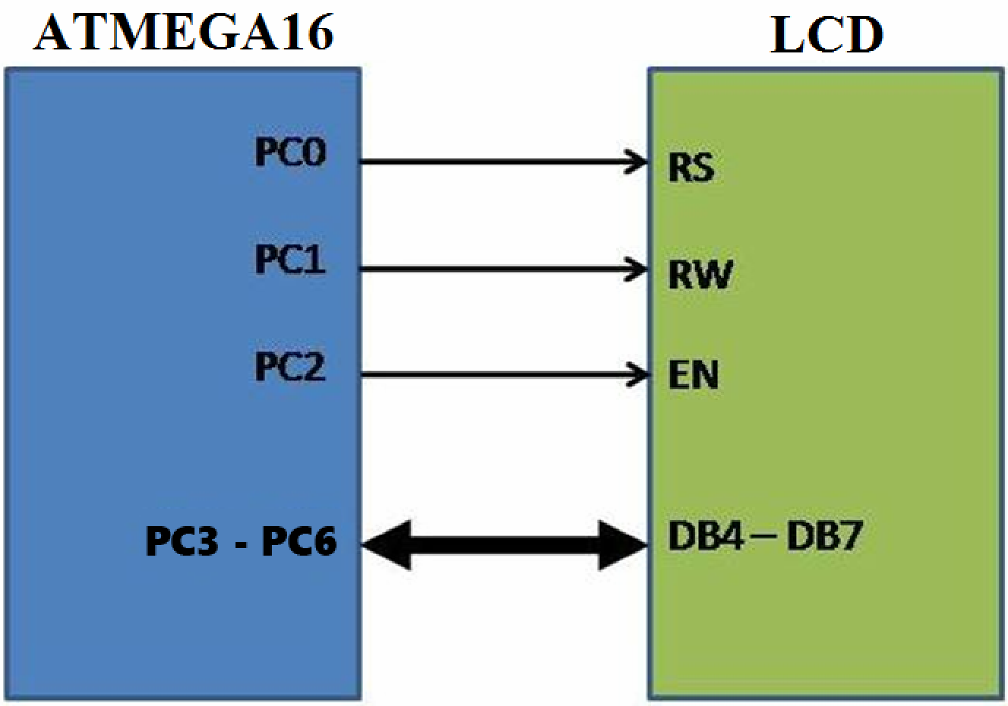


Figure 8.3: Block diagram of lcd connection to atmega16

struction by the LCD (such as clear screen, position cursor, etc.). When RS is high (1), the data being sent is treated as text data which should be displayed on the screen.
The RW line is the "Read/Write" control line. When RW is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying (or reading from) the LCD.
The data bus is bidirectional, 4 bit wide. The MSB bit of data bus is also used as a Busy flag. When the Busy flag is 1, the LCD is in internal operation mode, and the next instruction will not be accepted. When RS = 0 and R/W = 1, the Busy flag is output. The next instruction must be written after ensuring that the busy flag is 0.

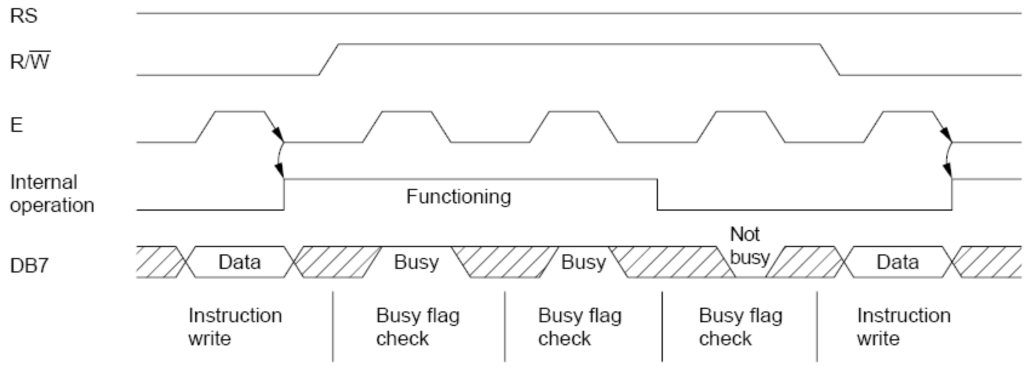


Figure 8.4: Timing diagram for lcd

LCD contrast and backlight setting

LCD contrast and backlight setting

- Contrast of the LCD can be adjusted by adjusting the potentiometer. To save power its backlight can also be turned off by removing jumper.

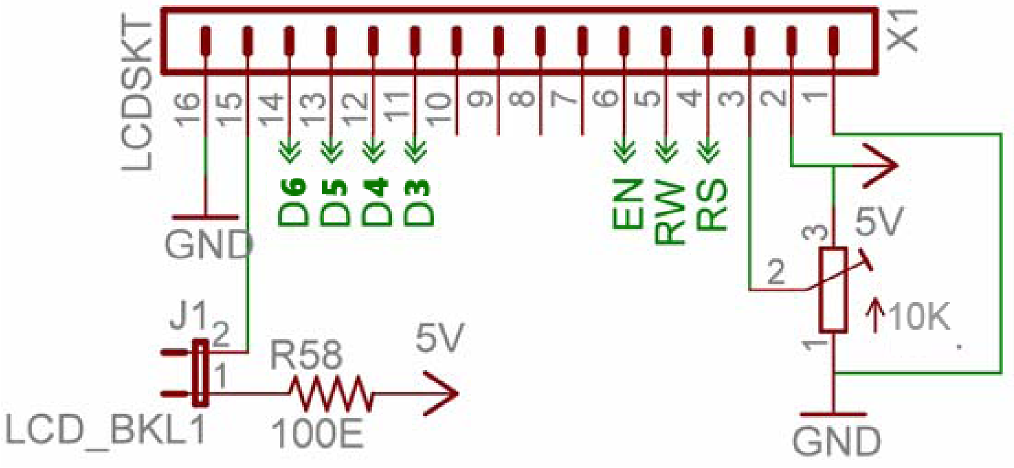


Figure 9.1: Schematics of Lcd connection

Battery voltage sensor

Battery voltage sensor

- Two registers of 22K ohms are used to scale down the battery voltage below 5V and given to the comparator circuit. Voltage divider network of these register will give half of the battery voltage.

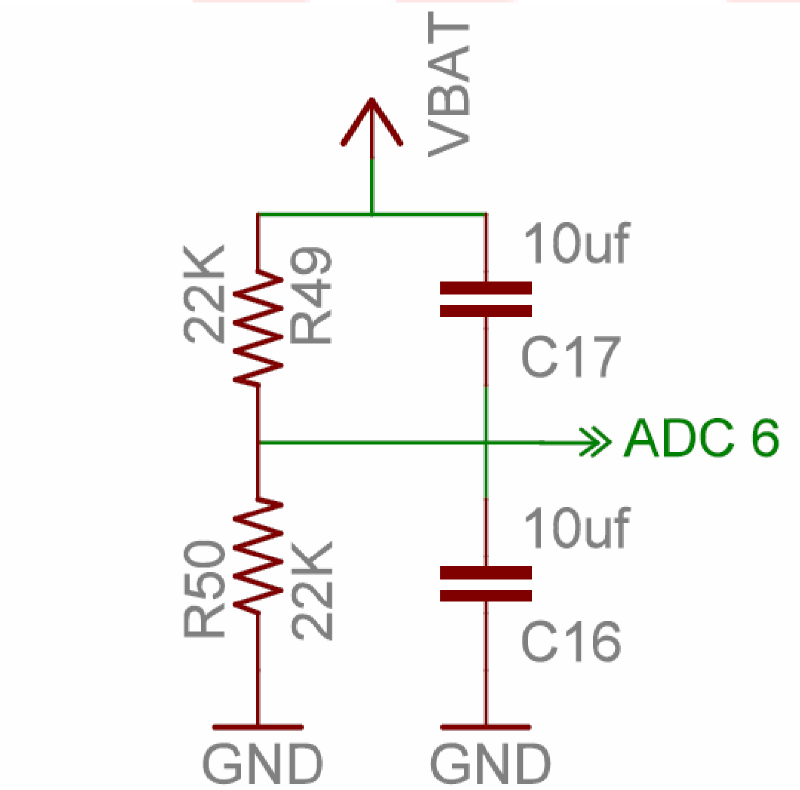


Figure 10.1: Battery sensing circuit

Atmega 16 programmer

Atmega 16 programmer

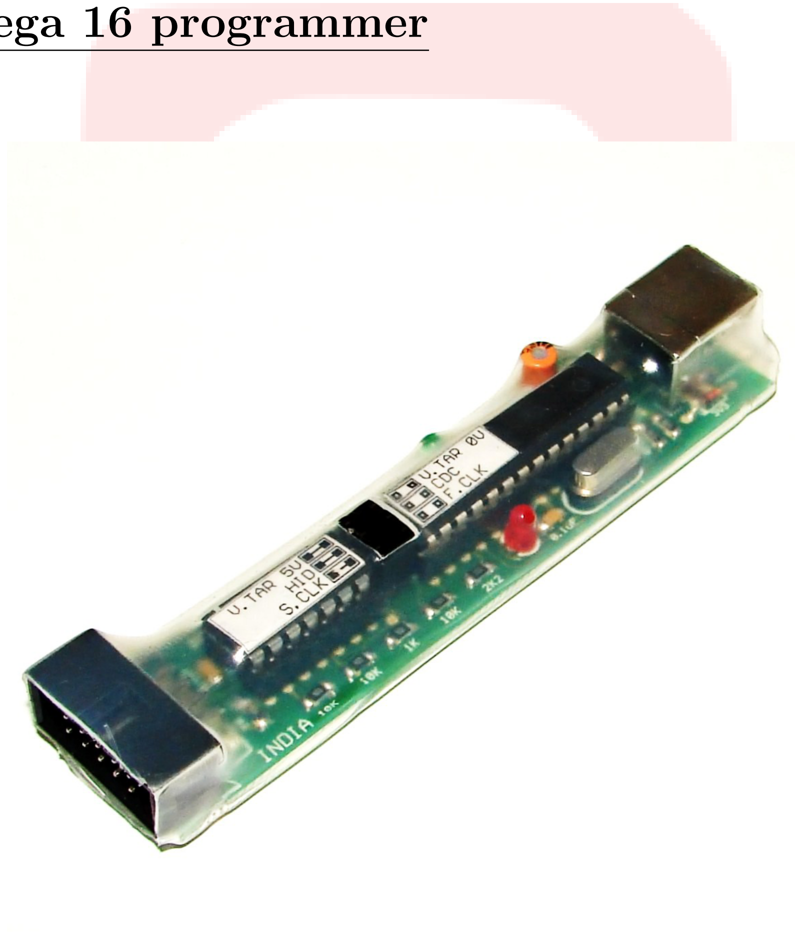


Figure 11.1: ISP programmer

- Mini bots have ATMEGA16 microcontroller running at 16MHz. Robot is programmed by ISP (In System Programming) using AVR USB programmer from NEX Robotics or ATMELs AVR ISP mkII.

Schematics

Schematics

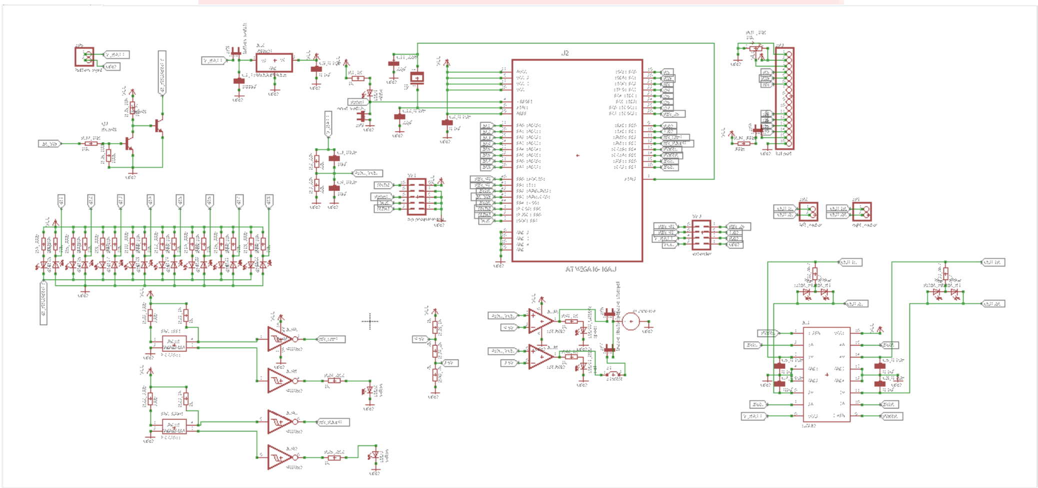


Figure 12.1: Complete schematic of pcb

Layout

Layout

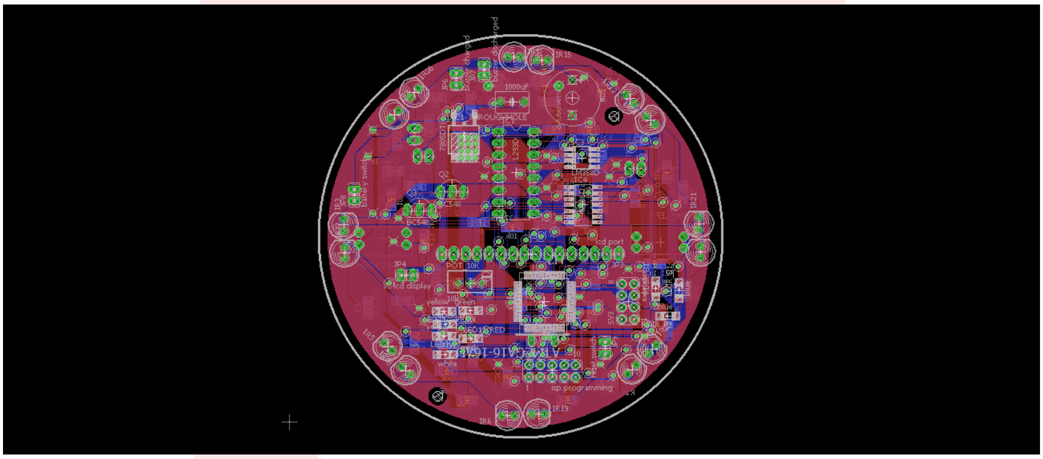


Figure 13.1: Complete layout of pcb

SR NO	PIN NAME	USED FOR
1	(XCO/T0)PB0	Expansion pin
2	(T1)PB1	Expansion pin
3	(INT2/AIN0)PB2	Logic output 1 for Left motor
4	(OC0/AIN1)PB3	IR switch
5	(SS)PB4	ISP (In System Programming)
6	(MOSI)PB5	ISP (In System Programming)
7	(MISO)PB6	ISP (In System Programming)
8	(SCK)PB7	ISP (In System Programming)
9	RESET	Microcontroller reset
10	VCC	5V
11	GND	Ground
12	XTAL1	Crystal 16 MHz
13	XTAL2	Crystal 16 MHz
14	(RXD)PD0	UART Receive*
15	(TXD)PD1	UART Transmit*
16	(INT0)PD2	Position Encoder input for Left Motor
17	(INT1)PD3	Position Encoder input for Right Motor
18	(OC1B)PD4	PWM output for Left Motor
19	(OC1A)PD5	PWM output for Right Motor
20	(ICP1)PD6	Logic output 1 for Left motor
21	(OC2)PD7	Logic output 1 for Left motor
22	PC0(SCL)	LCD control line RS (Register Select)
23	PC1(SDA)	LCD control line RW(Read/Write Select)
24	PC2(TCK)	LCD control line EN(Enable Signal)
25	PC3(TMS)	LCD data lines (4-bit mode)
26	PC4(TDO)	LCD data lines (4-bit mode)
27	PC5(TDI)	LCD data lines (4-bit mode)
28	PC6(TOSC1)	LCD data lines (4-bit mode)
29	PC7(TOSC2)	Expansion pin
30	AVCC	5V
31	AGND	Ground
32	AREF	ADC reference voltage pin (5V external)
33	PA7 (ADC7)	ADC input for analog IR proximity sensor
34	PA6(ADC6)	ADC input for analog IR proximity sensor
35	PA5(ADC5)	ADC input for analog IR proximity sensor
36	PA4(ADC4)	ADC input for analog IR proximity sensor
37	PA3(ADC3)	ADC input for analog IR proximity sensor
38	PA2(ADC2)	ADC input for analog IR proximity sensor
39	PA1(ADC1)	ADC input for analog IR proximity sensor
40	PA0(ADC0)	ADC input for analog IR proximity sensor