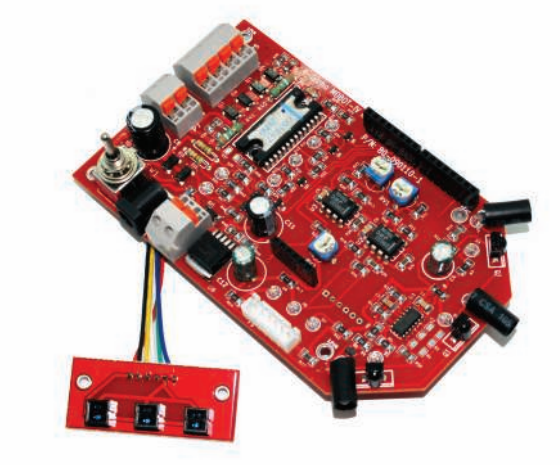
P-BOT INTERFACE MODULE

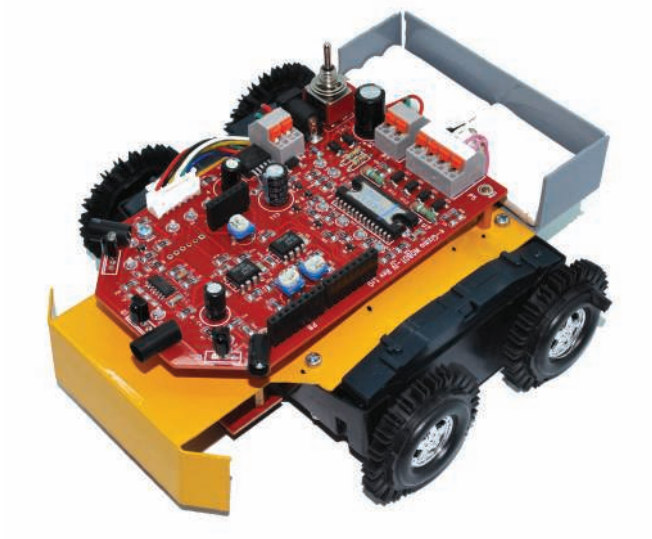
General Purpose Mobile Robot Interface Module

Technical Manual Rev 1r0



P-BOT I/F Module is a universal mobile robot interface board that contains an elaborate set of electronics subsystems that will enable you to build mobile robots with ease. It has a 2-channel DC motor drive, 3-channel collision sensor, and a 3-channel analog comparator that works seamlessly with line sensor array or equivalent sensors.

Compatible controllers can be installed just as easily by merely installing the controller board piggy back style into the allotted sockets. Unlike our previous generations of robot controller, P-BOT Module has no on-board controller. This allows you to use a controller that suits your preference. The controller socket is compatible with Arduino, gizDuino, picGuino (PIC Microcontroller), and a Zilog Encore! base microcontroller module. You can even construct and install your own custom controller board if you want to.



P-BOT Interface Module installed on a mobile robot chassis.

P-BOT Mobile Robot with gizDuino Controller installed.

SYTEM BLOCK DIAGRAM

A simplified block diagram of the P-BOT module is shown in figure 1. It consists of a motor driver circuit, a 3 channel analog comparator, and a 3 channel collision sensor circuit.

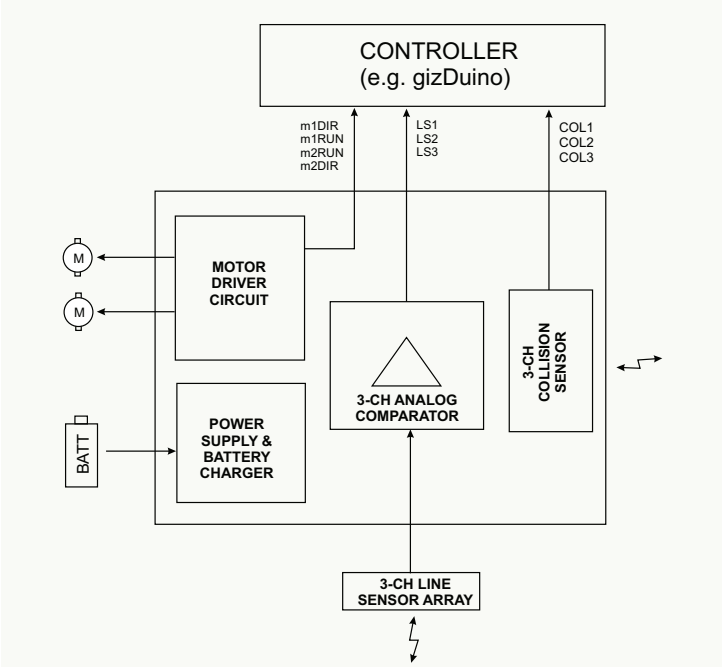


Figure 1. System Block Diagram of the P-BOT Module.

Motor Driver Circuit. The motor driver circuit U7 is the bridge circuit between your controller and the motor. Through this circuit, the controller can orchestrate the operation of the motor through a series of simple logic output combinations.

For example, to turn on motor 1, simply set the M1RUN input to logic High. To change motor rotation direction (forward/reverse), change the logic state of M1DIR accordingly. Note the forward or reverse rotation will depend on the polarity of your motor connection. If the motor run the in the opposite direction that you expected in a particular M1DIR state (e.g. Logic High), simply swap the motor1 connections at the motor output terminals. If you want to change the speed of rotation, you can easily do so by PWM control of M1RUN input.

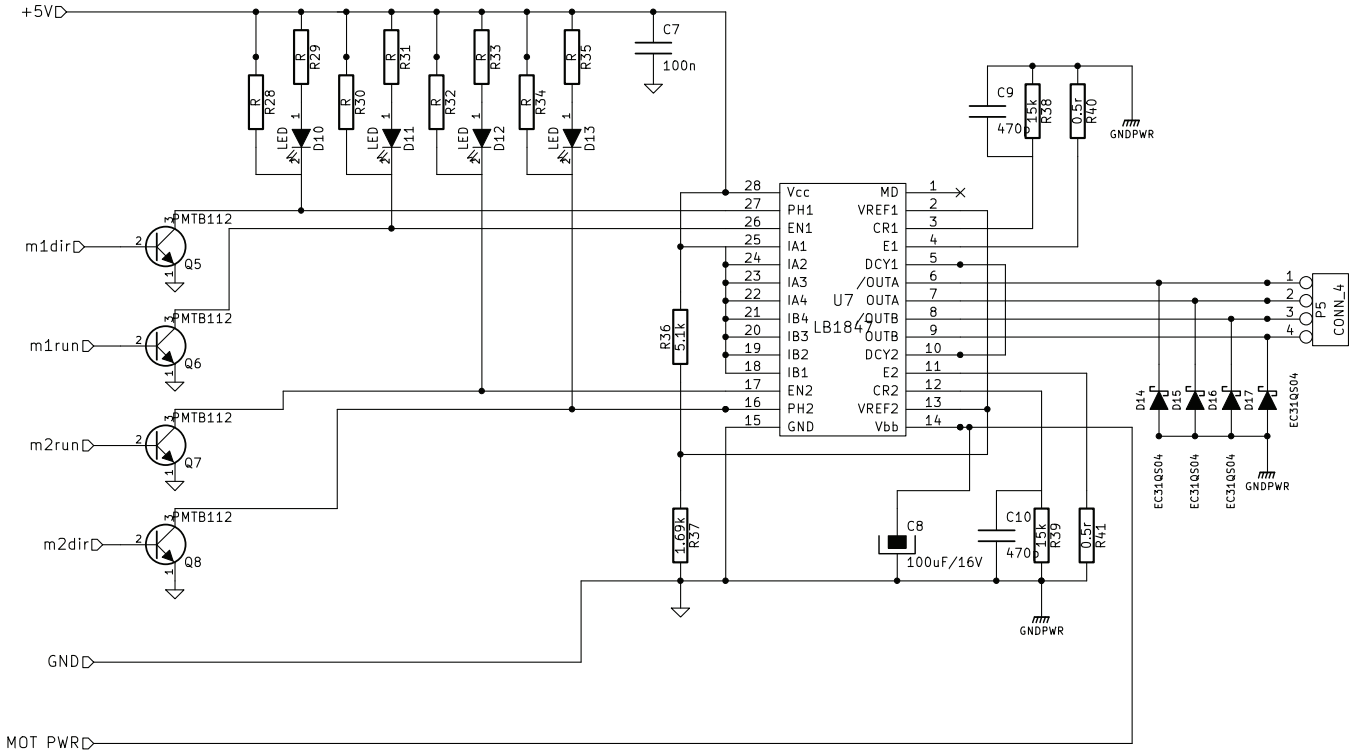


Figure 2. Motor Driver circuit schematic. R37 is omitted in the production release of the P-BOT module.

M2RUN and M2DIR work exactly the same way for motor2 output. U7 is actually a stepper motor driver configured to function as two channel DC motor driver. Buffer circuits Q5 to Q7 are added to ensure logic compatibility with the installed controller. LED D10-D13 provides a visual state indicator of the motor driver control inputs.

3-Ch Analog Comparator for line sensors. The analog comparator essentially converts the analog voltage appearing at its input into a single bit digital logic signal. The operation is quite simple and straightforward. A reference voltage is fed to the + input of the comparator. If the analog input fed through the – input exceeds the reference voltage, the comparator output switches to logic low. Otherwise, it assumes a logic High state.

The sensitivity of the three comparators can be independently set by adjusting their reference voltage through their corresponding adjust trimmers (RV1, RV2, RV3).

The 3-channel analog comparator is a general purpose analog interface circuit. It can be used as well with other sensors with 0-5VDC output range functioning as a single bit analog to digital converter.

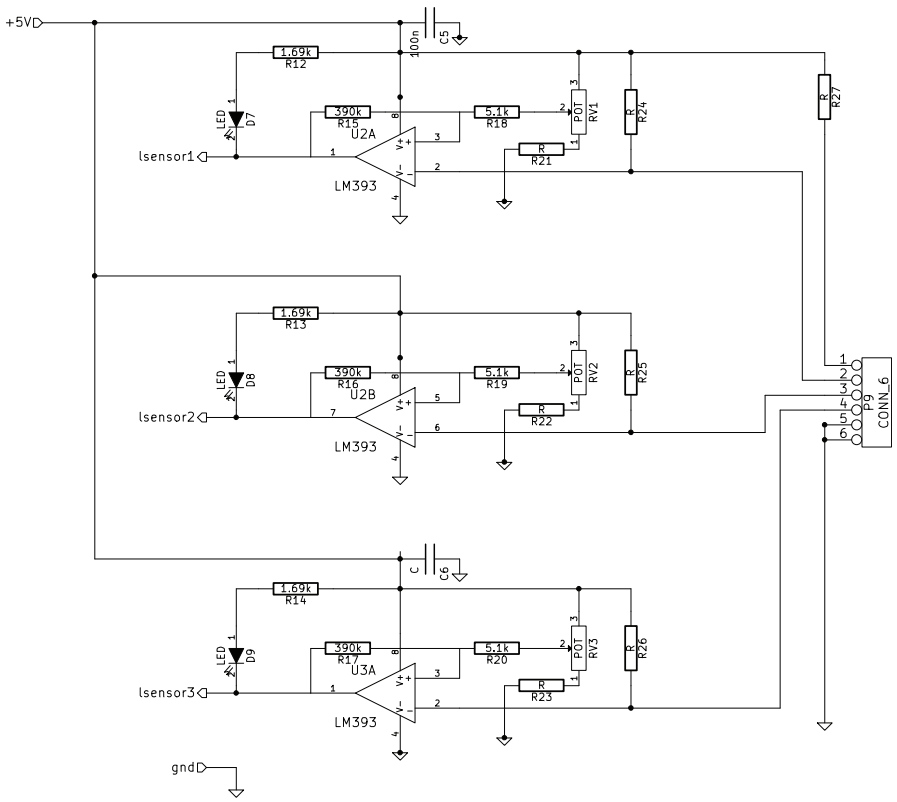


Figure 3. Three channel Analog Comparator section circuit schematic. This circuit converts the analog input voltage of the line sensors into a logic output.

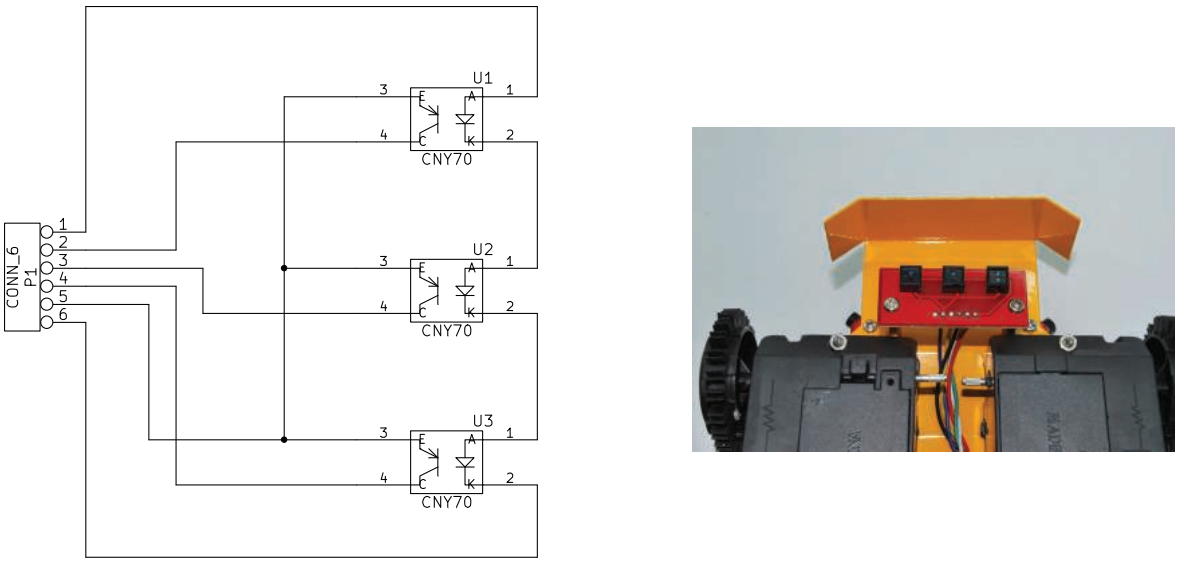


Figure 4. Line Sensor Array circuit schematic. The line sensor array P1 plugs directly into the analog comparator P9 to complete a line sensing circuit. Photo to the right shows the line sensor array PWB assembly mounted under the P-BOT mobile robot chassis.

3-Ch Collision Sensor. The on-board collision sensor is an Infrared IR reflection sensor that is capable of detecting up to 20cm away from the sensor tip. Detection distance is a bit dependent on the color of the reflecting surface. Dark and dull surface generally results in shorter detection range. In some tests, detection distance drops to as low as 5cm with objects that has black and dull surface.

The collision detector detects object by sniffing for any reflected beam send by an array infared emitter (LED). Any object that crosses the beam will reflect back a minute portion of the beam send by the emitters. If the object comes close enough and within the sensor detection view, the beam it reflects back is enough to trigger the detector, annunciating detection.

The IR detector array consists of Q2 to Q4. D4-D6 forms the emitter array. The IR detectors will respond only to IR beams that are chopped at a 40khz rate. U1C and U1D circuit, buffered by Q1, performs this chopping function. U1A and U1B can be activated for special applications where further modulation of the chopping circuit may be desirable. This part of the circuit is disabled by default with the installation of R50. To enable this function, remove R50 and install (solder) R1, R2, and C2.

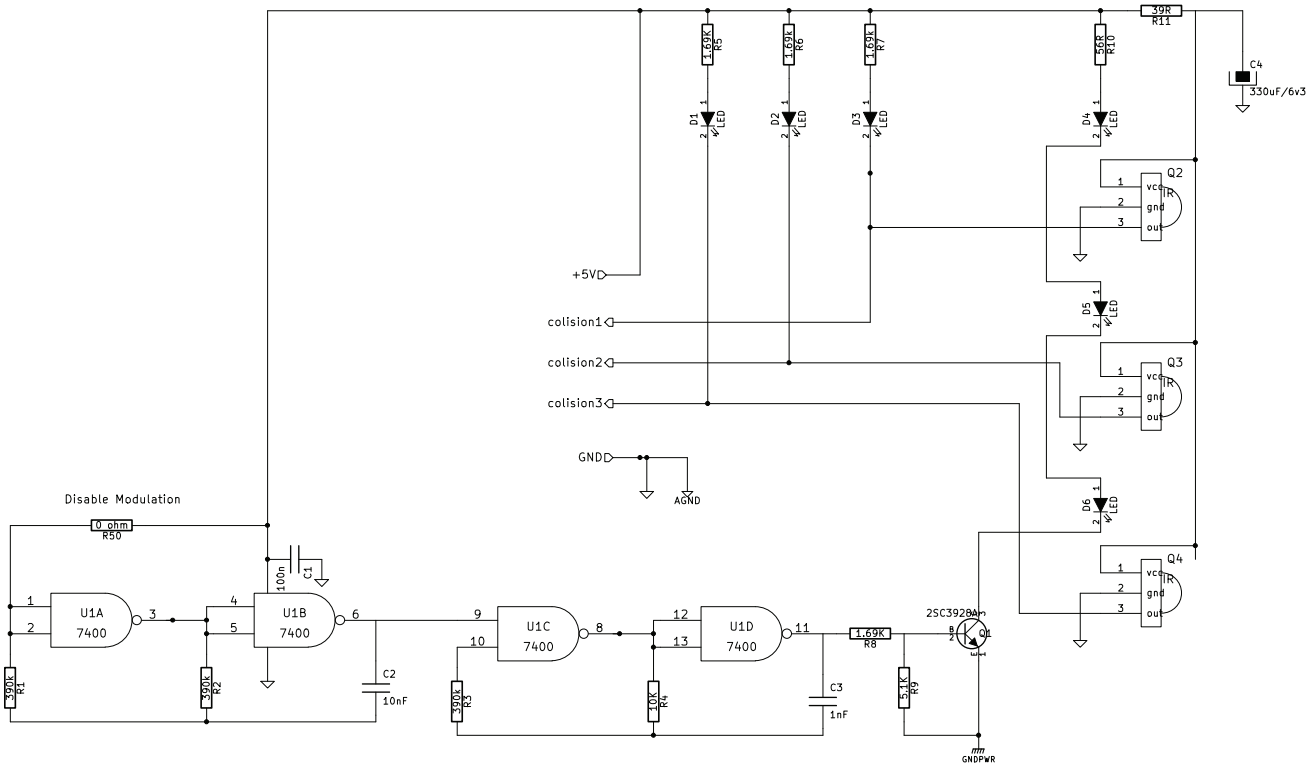


Figure 5. Three channel collision detection circuit schematic.

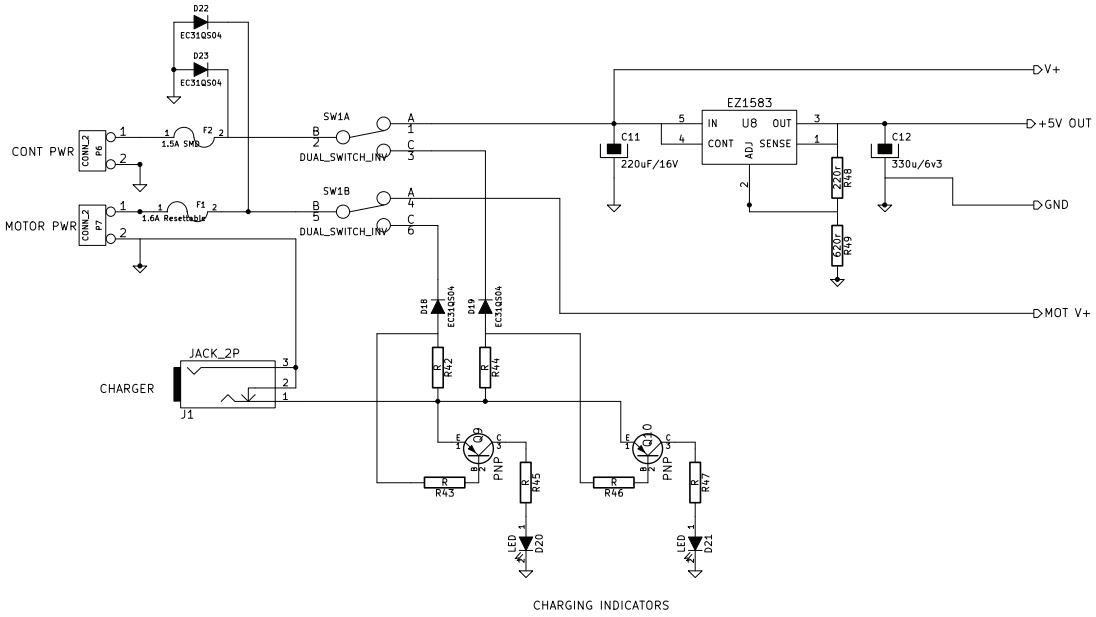


Figure 6. Power distribution and charger circuit. D22 and D23 protects the rest of the circuit in the event the power supply polarity is connected the wrong way by quickly blowing fuse F1 and F2 correspondingly.

The power supply distribution and charging circuit completes the P-BOT Module. Power to the logic circuit is fed through terminal P6. A low dropout voltage regulator conditions the power from the battery into a stable 5V for distribution to the rest of the logic circuit. Power to the motor driver, on the other hand, is fed through terminal P7.

Each power input terminals are fitted with fuse (F1 and F2) and reverse protection diode D22,D23. These components will keep the power from getting through if it is connected in reverse polarity by blowing the corresponding fuse(s).

The Power switch is a three position switch with center OFF position. The charger circuit is activated by switching the switch in ‘CHARGE’ position. An external regulated 9V, 500mA or greater, power source must supply the charging power through the J1 Charger Input.

Q9 and associated components forms a charge monitor circuit for the motor battery. This circuit will turn ON the charging indicator LED D20 if the charging current goes in excess of 100mA. Q10 and associated components performs similar function for the Logic battery charging.

BOARD LAYOUT

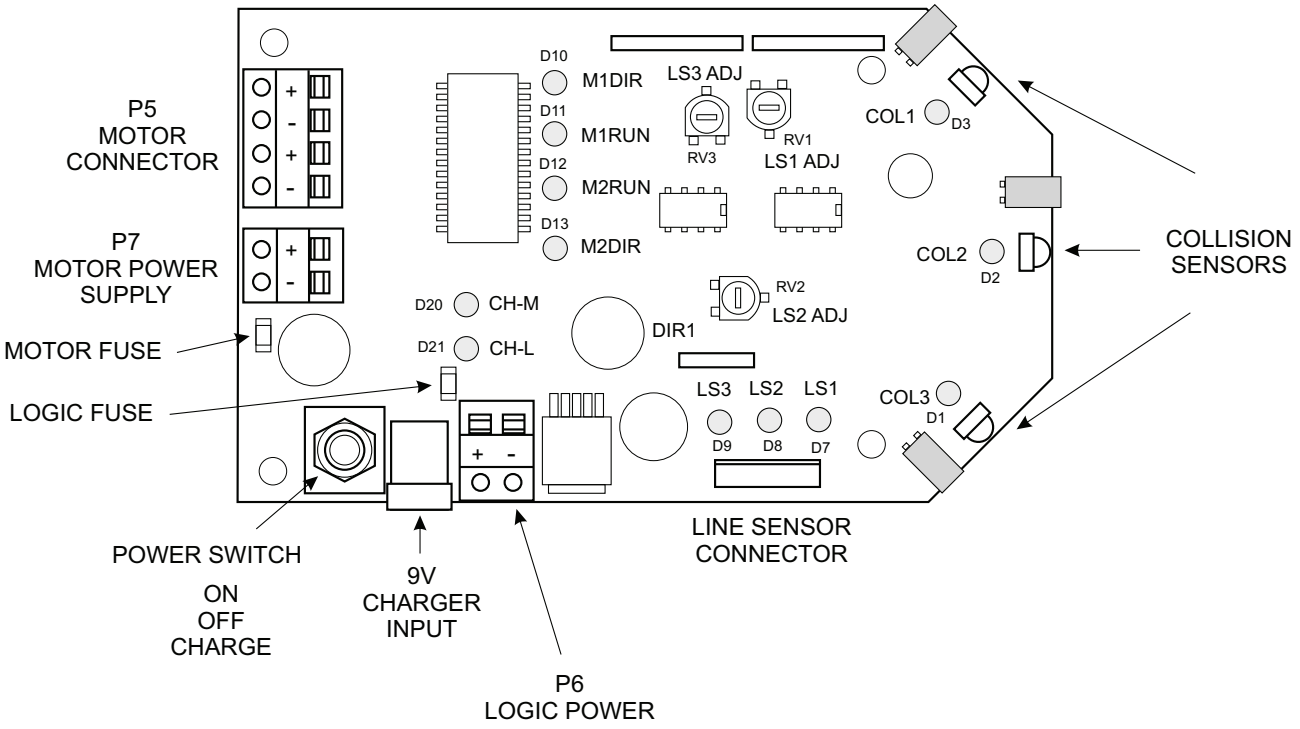


Figure 7. Board layout of the P-BOT Module showing the location of LED indicators, adjustment pots, and major components.

Table 1. INDICATORS and Gizduino I/O Map

LED	ID	Description	ON State	gizDuino Port
D1	COL3	Collision Sensor 3	LOW	Digital I/O -2
D2	COL2	Collision Sensor 2	LOW	Digital I/O -3
D3	COL1	Collision Sensor 1	LOW	Digital I/O -4
D7	LS1	Line Sensor 1 (Analog Comparator 1)	LOW	Digital I/O -5
D8	LS2	Line Sensor 2 (Analog Comparator 2)	LOW	Digital I/O -6
D9	LS3	Line Sensor 3 (Analog Comparator 3)	LOW	Digital I/O -7
D10	M1DIR	Motor 1 Direction Control	HIGH	Digital I/O -8
D11	M1RUN	Motor 1 RUN Control	HIGH	Digital I/O -9
D12	M2RUN	Motor 2 RUN Control	HIGH	Digital I/O -10
D13	M2DIR	Motor 2 Direction Control	HIGH	Digital I/O -11
D20	CH-M	Charging Indicator, MOTOR Battery		
D21	CH-L	Charging Indicator, Logic Battery		

Table 2. Line Sensor Sensitivity Adjustments

COMP	ID	Description
RV1	LS1 ADJ	Line Sensor Adjust 1
RV2	LS2 ADJ	Line Sensor Adjust 2
RV3	LS3 ADJ	Line Sensor Adjust 3

Table 3. Fuse Protection

ID	Description	Ratings and Size
F1	Motor Power Fuse	1.5A SMD 1206
F2	Logic Power Fuse	1.5A SMD 1206

WIRING DIAGRAM

With the P-BOT module, the only essential components that need wirings to build a complete mobile robot platform are the motor and battery power source. Figure 8 shows how to wire the motors and the batteries to build the P-BOT mobile robot platform. This wiring example uses two 3.6V NiMH batteries connected in series to provide 7.2V supply for both the logic and motor circuits. The line sensor array, if used, can be simply plugged into its corresponding connector P9.

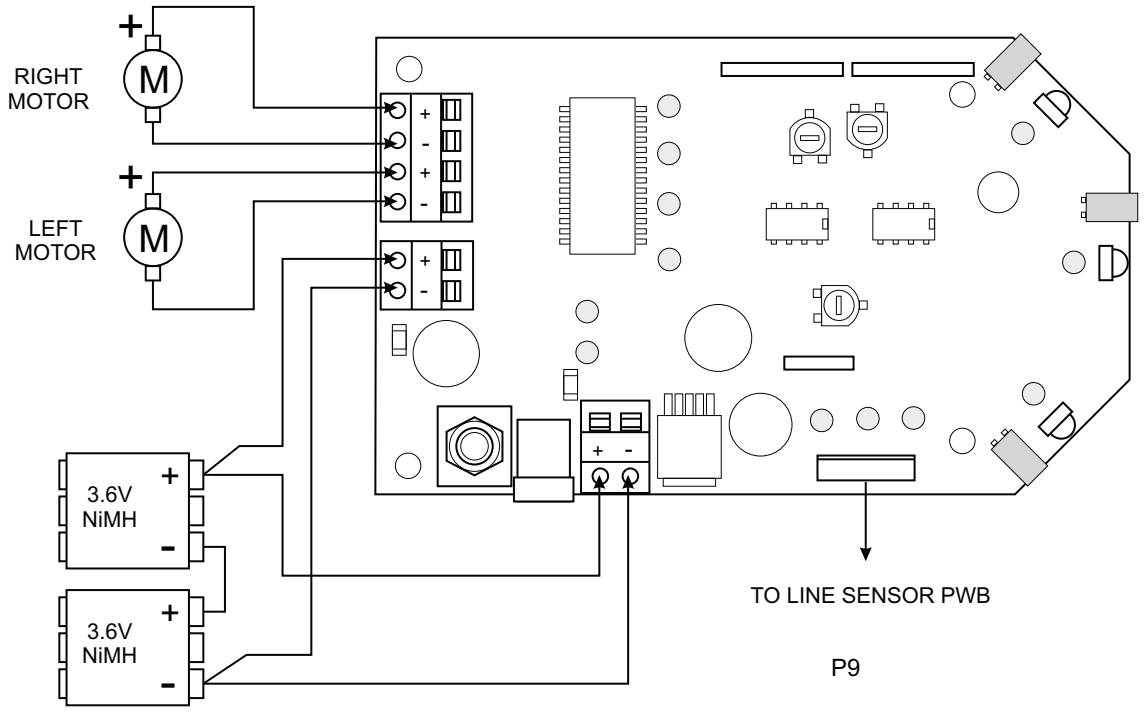


Figure 8. Motor and Battery Wiring Diagram using common battery supply for both the motor and logic power supply input.

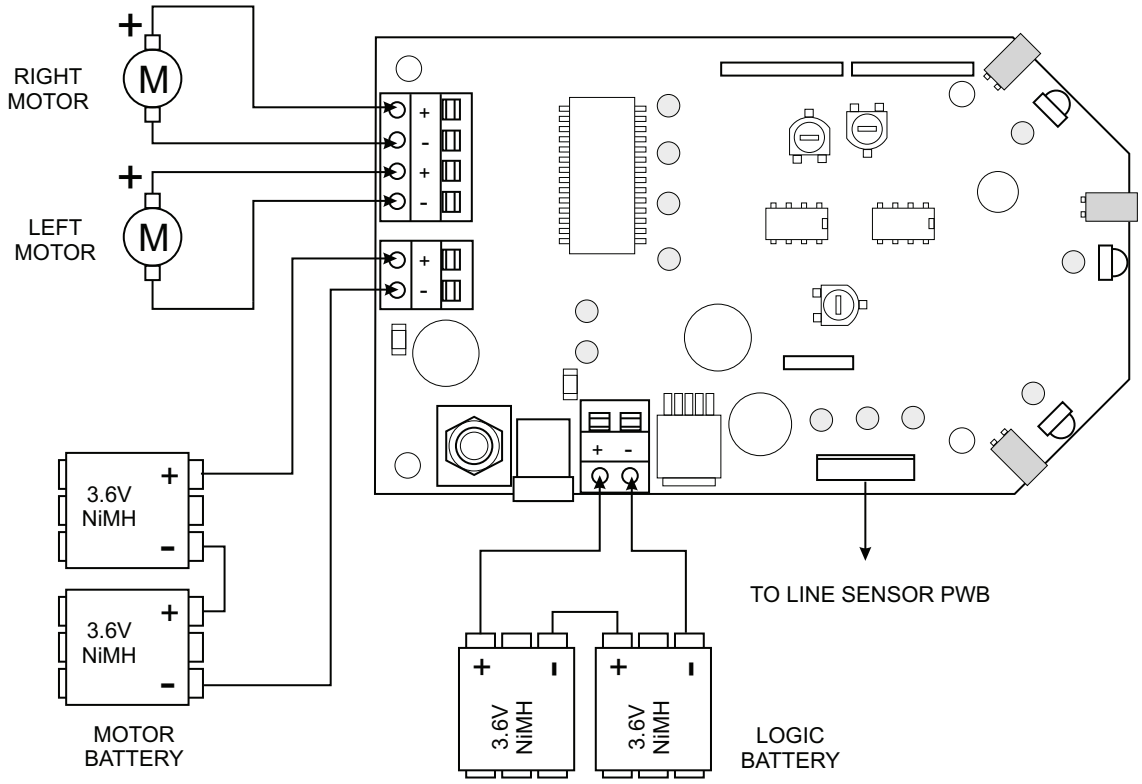


Figure 9. Motor and Battery Wiring Diagram. Two sets of batteries powers the motor and logic circuit separately.

APPLICATION HINTS

Fuse Replacement

As already mentioned, each battery power input ports are protected with a 1.5A fuse. This fuse will blow to minimize damage in case you made an error in wiring your battery or shorted a high current path in the module.

If the P-BOT Module stopped working, check the battery first if they still carry sufficient charge. Next step, if the battery is OK, is to check these fuses F1 and F2. If a fuse needs replacement, desolder to remove the old busted fuse and replace it with a new one of the correct type and size (1.5A 1206 SMD).

Checking and Adjusting Sensor Sensitivity

You can check (and adjust, if necessary) the operation of the sensors even without a controller board installed. In fact, it is much easier to do this without a controller. All sensors have their own corresponding LED indicators that will allow you the check their operation with a quick glance.

The collision sensor sensitivity is fixed and cannot be adjusted. Wave your palm about 10cm away from one collision sensor. Its LED indicator should light as soon as your hand pass up front the sensor, and turn OFF again as your hand is withdrawn out of range. Repeat the test with the remaining two collision sensors.

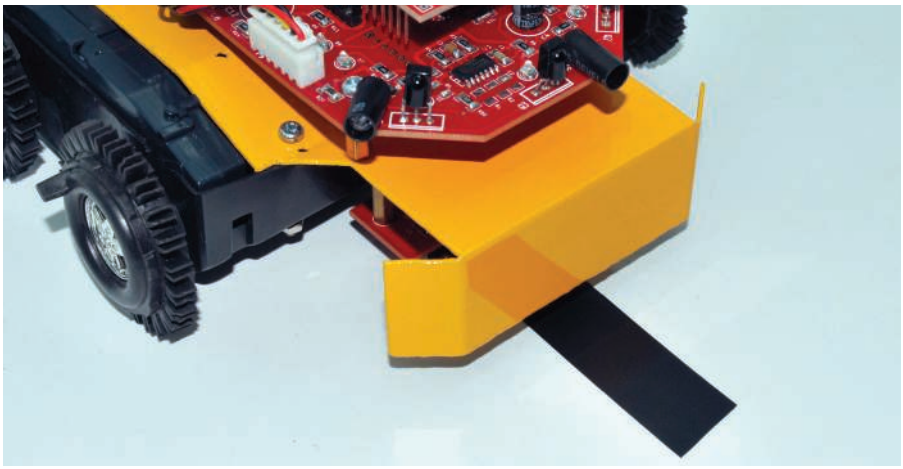


Figure 10. Line sensors can be checked using a short strip of black electrical tape laid out over a light colored test surface

The line sensors must be tested with the line sensor array PWB already mounted under the chassis. To test the line sensor, prepare a test surface by lay outing a strip of black electrical tape over a light-colored surface. Run the mobile robot by hand to make the line sensor move slowly over and across the tape width. Observe the line sensor LEDs. They should flicker ON and OFF as they pass across the tape. The corresponding LED should stay ON as long as its sensor is positioned over the tape, and turns OFF otherwise.

The sensitivity of these sensors can be adjusted to preferred settings by adjusting its corresponding trimmer resistor. RV1, RV2, RV3 adjusts the corresponding sensitivity of sensors LS1 to LS3.

Battery Power

P-BOT Module has two separate battery power input ports, one for the motor circuitry, and another for the logic that powers the sensor circuits and the installed controller. The logic power will work with 7-10VDC input, while the motor power input voltage essentially depends upon the ratings of the installed motor. DC motor supply voltage of up to 16VDC can be safely installed at this terminal.

For installations that require essentially the same supply voltage for the logic and motor circuit, the two supply terminals can be paralled together. If noise coupling from the motor circuitry becomes a problem (indicated by frequent crashing of the controller board), separating the supply (using two separate sets of batteries) usually fixes the problem.

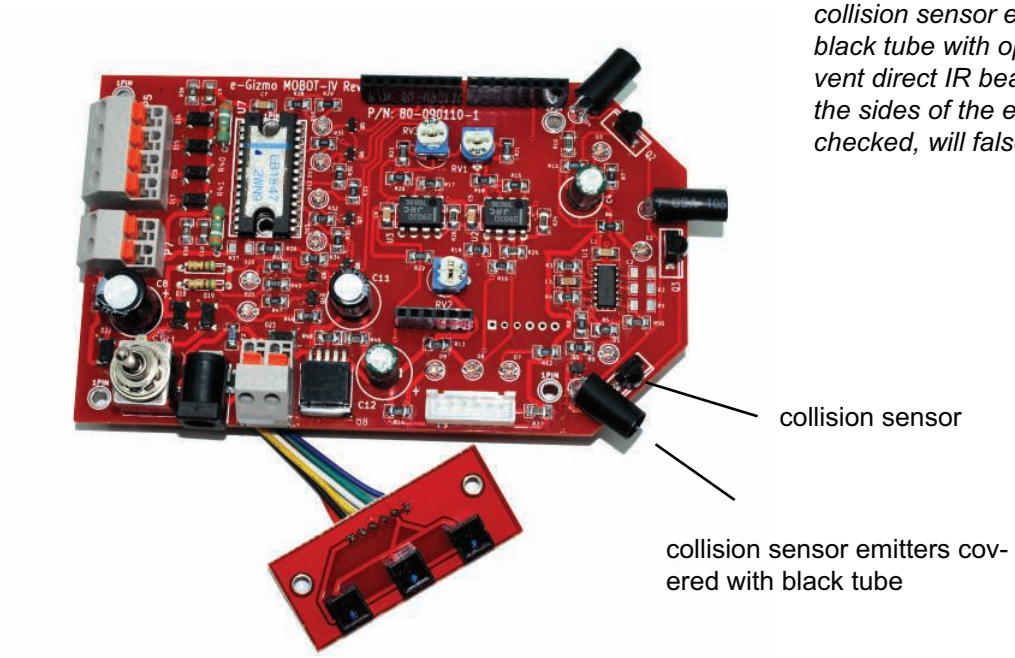


Figure 11. Photo of P-BOT module with the line sensor array PWB. Note that the collision sensor emitter are covered with black tube with open ends. This will prevent direct IR beams from leaking through the sides of the emitter, which if left unchecked, will false trigger the sensors.

Charging Batteries

To charge the installed rechargeable batteries, a 9V 500mA regulated supply must be plugged into the charger DC input jack. Switch the power switch to 'Charge' position. The battery will be charged at a rather slow rate and should be fully charged after 6 to 14 hours of charging. See table 4 for details. Because of slow charging rate, there is very little risk of damage due to overcharging even if the charger is left ON for an extended period of time. You do not have to fully charge the battery in order to use the mobile robot. Just keep in mind usage time is roughly proportional to the time the battery spent charging.

The battery charging indicator will light to indicate charging. The charging indicator brightness is roughly proportional to the rate of charge, high charging current results in brightly lit indicator. The indicator light will completely extinguish when charging current falls below 100mA.•

Table 4. Estimated battery charging and usage time

Battery Capacity 2 x 3.6V	Connection	Estimated Charging Time(Hour)	Estimated Usage Time (minutes) Note 1
Common 600mAH	Figure 8	6	40
Separate 600mAH	Figure 9	12	60
Common 1200mAH	Figure 8	12	60

Note 1:
P-BOT Mobile Robot usage time with both motors running continously and randomly changing in forward and reverse motion. Longer usage time will be realized if motors are not