# FIRE BIRD VI

## LPC1769 ARM CORTEX M3
## ROBOTIC RESEARCH PLATFROM
## Hardware Manual



NEX ROBOTICS

www.nex-robotics.com

Designed and Manufactured by: NEX Robotics Pvt. Ltd.

# *FIRE BIRD VI*

# HARDWARE MANUAL

## Important:

**User must go through hardware and software manuals before using robot.**

**Version 8**
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## Notice

The contents of this manual are subject to change without notice. All efforts have been made to ensure the accuracy of contents in this manual. However, should any errors be detected, NEX Robotics welcomes your corrections. You can send us your queries / suggestions at info@nex-robotics.com




- **Robot's electronics is static sensitive. Use robot in static free environment.**
- **Read the Robot's manual completely before start using this robot**

## Recycling:

Almost all of the robot parts are recyclable. Please send the robot parts to the recycling plant after its operational life. By recycling we can contribute to cleaner and healthier environment for the future generations.

# Table of Contents

# 1. Introduction

Fire Bird VI is a reliable, versatile and rugged robot for the advanced research in robotics. It's easy to use and intuitive interface gets you started on development very quickly. It's unique architecture allows it to be used in many areas of applications such as Mapping and autonomous navigation, Collaborative robotics, tele-presence and many more. Fire Bird VI supports many optional accessories such as on-board computer for vision processing, laser range finder based navigation, vision based stereo range finders, integrated inertial correction to compensate for slippage, digital compass, GPS/DGPS receiver, support for Manipulators and Grippers.

## Safety precautions:

- Robot’s electronics is static sensitive. Use robot in static free environment.
- Do not access any part of the robot unless robot is in the antistatic environment and user is wearing antistatic strap.
- Read the assembling and operating instructions before working with the robot.
- If robot’s battery low buzzer starts beeping, immediately charge the batteries.
- To prevent fire hazard, do not expose the equipment to rain or moisture.
- Refrain from dismantling the unit or any of its accessories once robot is assembled.
- Charge the Lithium Polymer battery only with the charger provided with the robot.
- Charge the Lithium Polymer battery in the open area and on the concrete or ceramic flooring.
- Never allow Lithium Polymer battery to deep discharge. It its deep discharged, charger will refuse to charge the battery because of safety concerns.
- Mount all the components with correct polarity.
- Keep wheels away from long hair or fur.
- Keep your hands away from the wheels. Do not wear loose clothes while operating the robot. Loose cloth may get entangled in robot’s wheels and can cause serious injury.
- Keep the robot away from the wet areas. Contact with water will damage the robot.
- To avoid risks of fall, keep your robot in a stable position.
- Do not attach any connectors while robot is powered ON.
- Never leave the robot powered ON when it is not in use.
- Before operating the robot, make sure that you have access to at least “Class A/B” type fire extinguisher.
- Read carefully paragraphs marked with ⚠ caution symbol.

## Inappropriate Operation:

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

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

# 2. Overview of Fire Bird VI Robot

Fire Bird VI is reliable, versatile and rugged robot for the advance research in robotics. It's a fully programmable robot with on-board PC. Fire Bird VI is designed in collaboration with IIT Bombay and manufactured by NEX Robotics. Fire Bird VI robot comes fully assembled and ready to use. It has high quality gear motors with the resolution 360 ticks per revolution position encoder. Motors are driven by smart motion controller with velocity and acceleration control. By selecting correct locomotion drive, robot can be used in indoor and outdoor environment. Robot has 8 ultrasonic range sensors with range of 6 meters covering robot from all sides, 8 IR proximity sensors and 8 line sensors and many more expandable interfaces. Depending on the robot configuration, it is powered by Lithium Polymer or NiMh batteries.

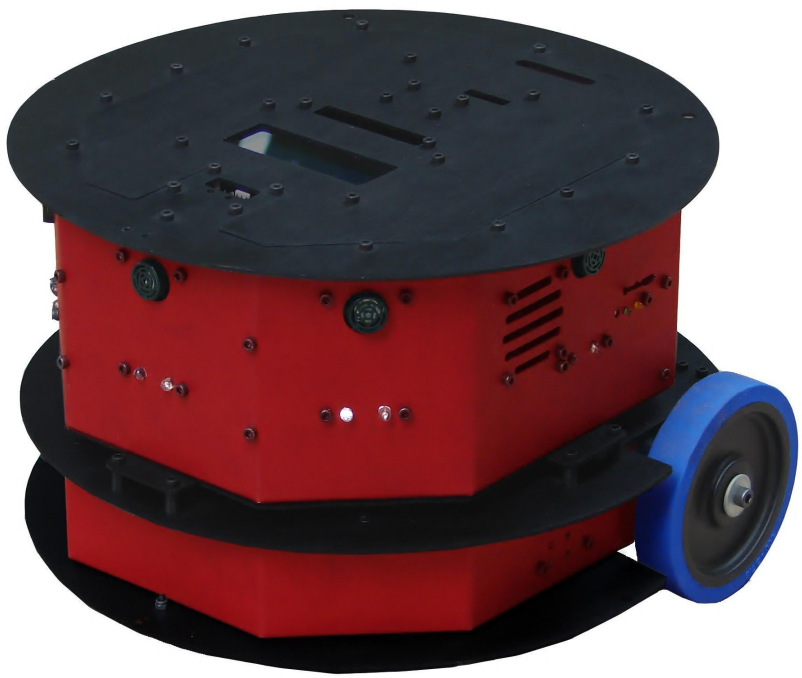


**Figure 2.1 Fire Bird VI Robot**

## 2.1 Avatars of Fire Bird VI Robot

Fire Bird VI is available in different drive configurations. In all configurations basic architecture remains the same.

**1. Fire Bird VI**

In its basic configuration robot has two wheel differential drive and caster wheels at the front side for the support. It is the most recommended configuration for accurate locomotion. This configuration is only used in the indoor environment.

**2. Fire Bird VI 4 wheel drive**

In this configuration robot has 4 wheels in differential configuration. It has better ability to tackle obstacles but accuracy in locomotion is slightly reduced.

**3. Fire Bird VI robot with omnidirectional drive**

In this configuration robot has 4 omnidirectional wheels for enhanced locomotion. Because of this robot can move in any direction while maintaining its orientation.

**4. Fire Bird VI robot with mecanum wheels**

In this configuration robot has 4 mecanum wheels for enhanced locomotion. Because of this robot can move in any direction while maintaining its orientation.

**5. Fire Bird VI with automotive drive**

In this configuration robot's locomotion drive is replaced with all terrain dune buggy chassis which have true differential for back wheels and realistic front wheel steering assembly. This robot is designed to behave like automobile. It is most suited for outdoor environment.

## 2.2 Block Diagram of Fire Bird VI

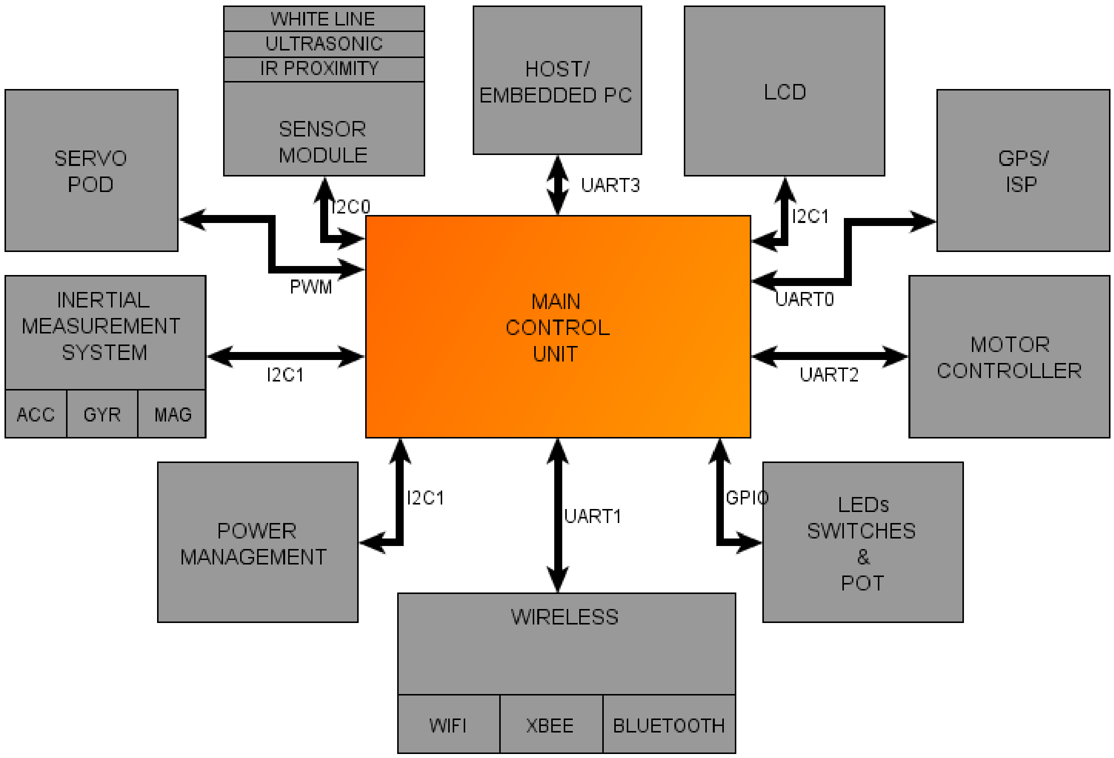



**Figure 2.2 Block Diagram of Fire Bird VI Robot**

Fire Bird VI uses ARM cortex-M3 based LPC1769 microcontroller running at 120 MHz as main microcontroller. Almost all the peripherals of the robot have their own microcontroller for doing processor intensive tasks like sensor data acquisition, closed loop motion control etc. These peripherals are interfaced with the main microcontroller LPC1769 ARM cortex-M3 over UART, I2C and SPI bus. Because of this architecture main microcontroller is free to execute complex algorithms while slave peripherals do most of the sensing and motion control tasks. Since all the peripherals are interfaced over UART, I2C and SPI bus you can integrate your own modules seamlessly with the robot.

## 2.3 Technical Specifications

**Main Microcontroller:** ARM Cortex-M3 based LPC1769

**High level controller: (Interfaced over Serial / WiFi / Blue Tooth / ZigBee)**

- Embedded PC
- Any Embedded controller board with UART / WiFi interface

**Sensors:**

- 8 x MaxBotix EZ4 Ultrasonic sensors with 6m range or Sharp IR range sensors with range up to 150cm (Optional)
- 8 x IR Proximity Sensors (Optional)
- 8 x White Line Sensors (Optional)
- 1 x L3G4200D 3 axis Digital Gyroscope (Optional)
- 1 x LSM303DLHC 3 axis accelerometer and 3 axis Magnetometer (Optional)
- 1 x GPS receiver module (Optional)
- MaxBotix EZ4 ultrasonic range sensor with Pan & Tilt servo pod (Optional)
- Sharp 100 to 500cm IR range sensor with Pan & Tilt servo pod (Optional)

**Motion control**

- 2 Wheel differential drive configuration with caster wheel as support
- Position encoder with 360 count per output shaft rotation.
- High performance microcontroller based motion controller with precise velocity and position control

**Servo pod control**

- 3 servo control PWM signals for camera / sensor pod

**Display:**

- 4 x 20 Alphanumeric LCD (Optional)

**Power**

- NiMH / Lithium Polymer battery
- Smart battery monitoring circuit with voltage, current and battery temperature reading
- Intelligent battery charger

**Communication:**

- 3 UART / RS232 serial ports
- USB
- 2.4GHz XBee wireless module (Optional)
- Wi-Fi (Optional)

- Bluetooth (Optional)

**Misc:**

- SD MMC card holder, Expansion headers for GPIOs, I2C, SPI, UARTs, Power etc.
- 4 General purpose switches
- 4 User LEDs

**Programming**

- USB JTAG (included)
- Serial R232 port based In System Programming

## 2.4 A Quick look at Fire Bird VI robot

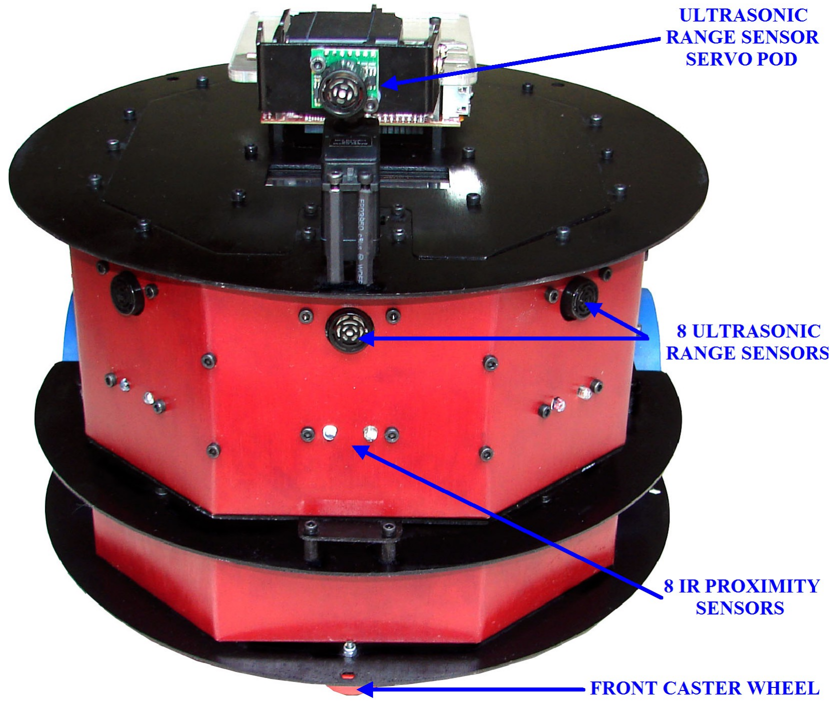



**Figure 2.3: Fire Bird VI front view**

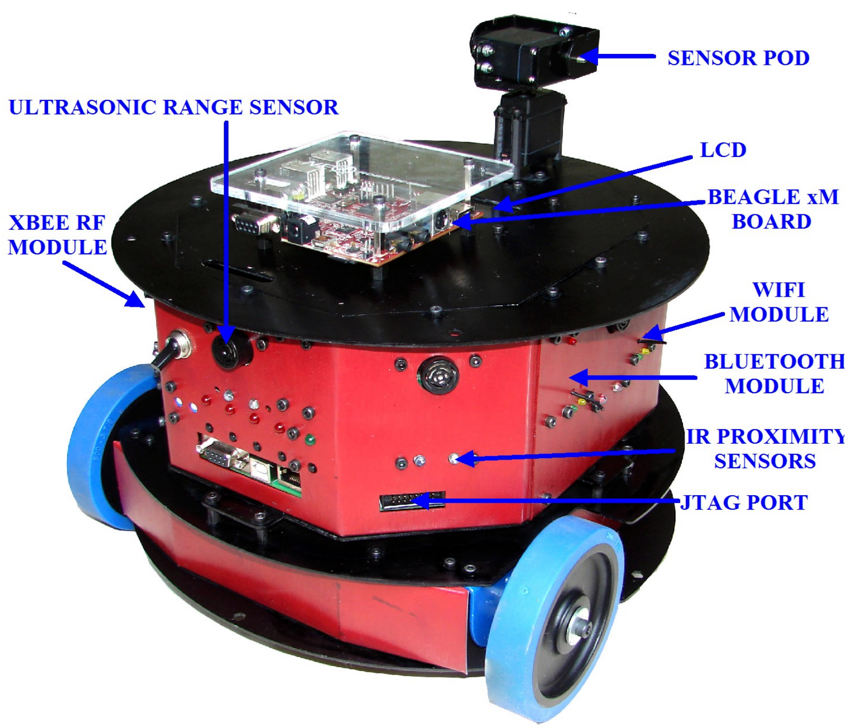



**Figure 2.4: Rear side view**

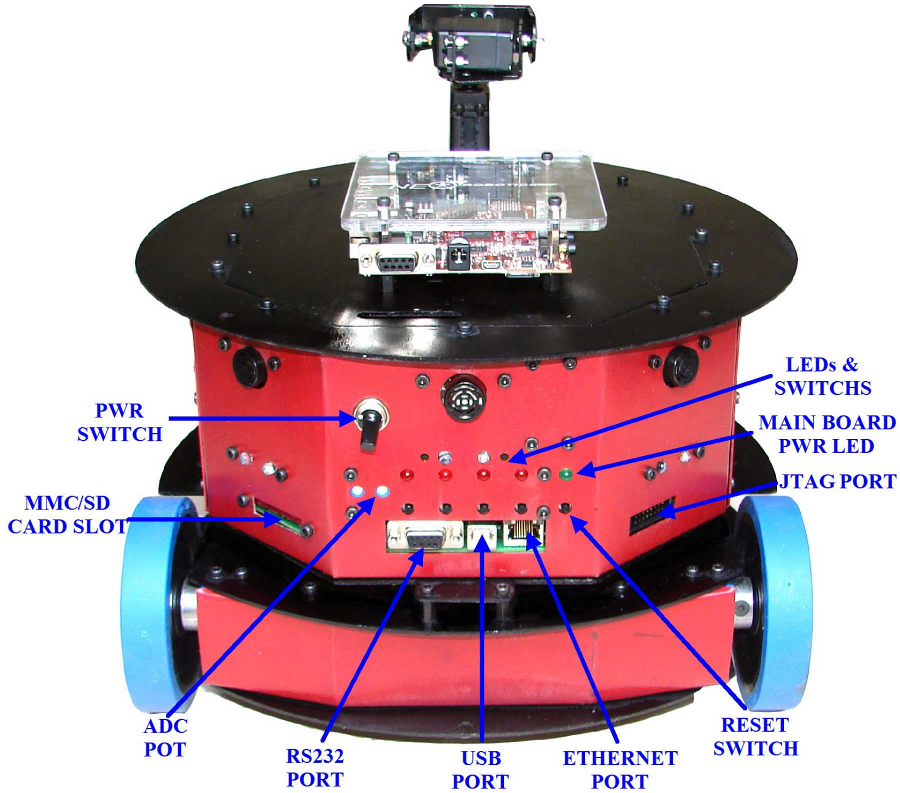



**Figure 2.5: Rear View**

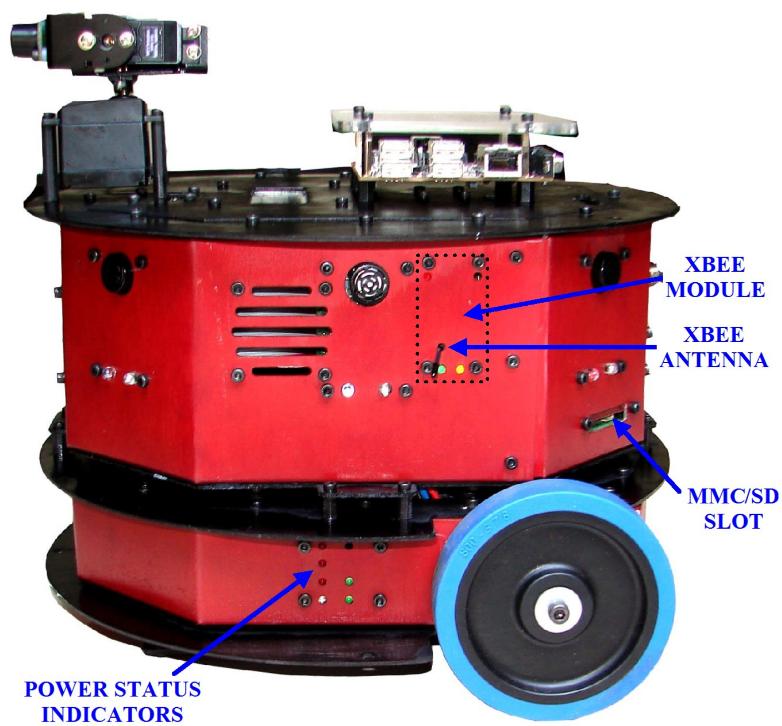



**Figure 2.6: Left Side View**

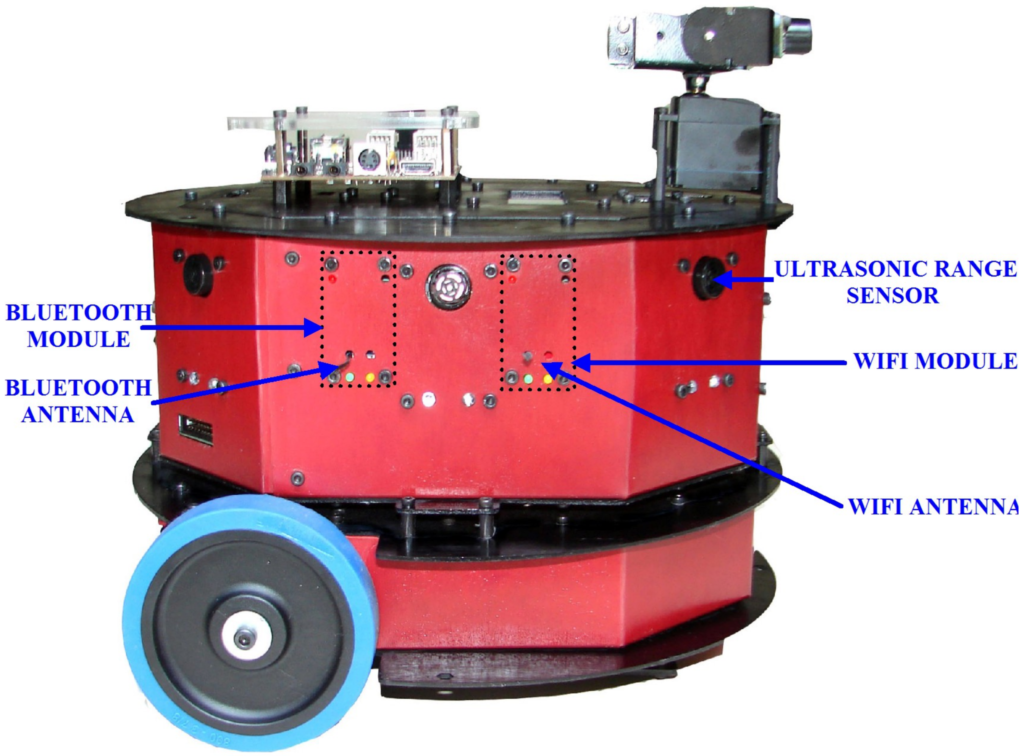



**Figure 2.7: Right Side View**

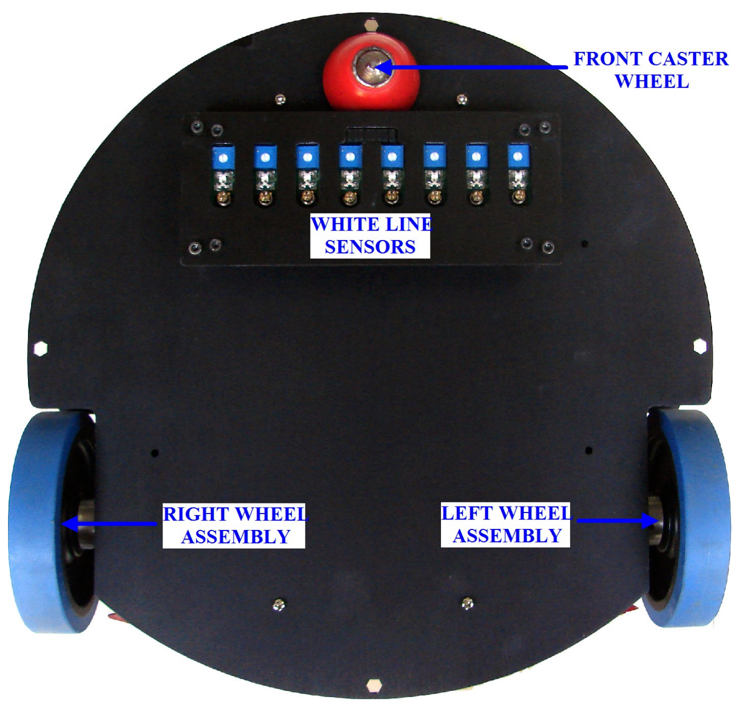



**Figure 2.8: Bottom View Left & Right Wheel Assembly**

# 3. Fire Bird VI Hardware Description

## 3.1 Main Board

The main board consists of ARM cortex-M3 based LPC1769 microcontroller running at 120 MHz. This board connects all the peripherals of the robot to the main microcontroller. Almost all the peripherals of the robot has their own microcontroller for doing processor intensive tasks like sensor data acquisition, closed loop motion control etc. These peripherals are interfaced with the main microcontroller LPC1769 ARM cortex-M3 over UART, I2C and SPI bus. Because of this architecture main microcontroller is free to execute complex algorithms while slave peripherals do the most of the sensing and motion control tasks. Since all the peripherals are interfaced over UART, I2C and SPI bus you can integrate your own modules seamlessly with the robot.

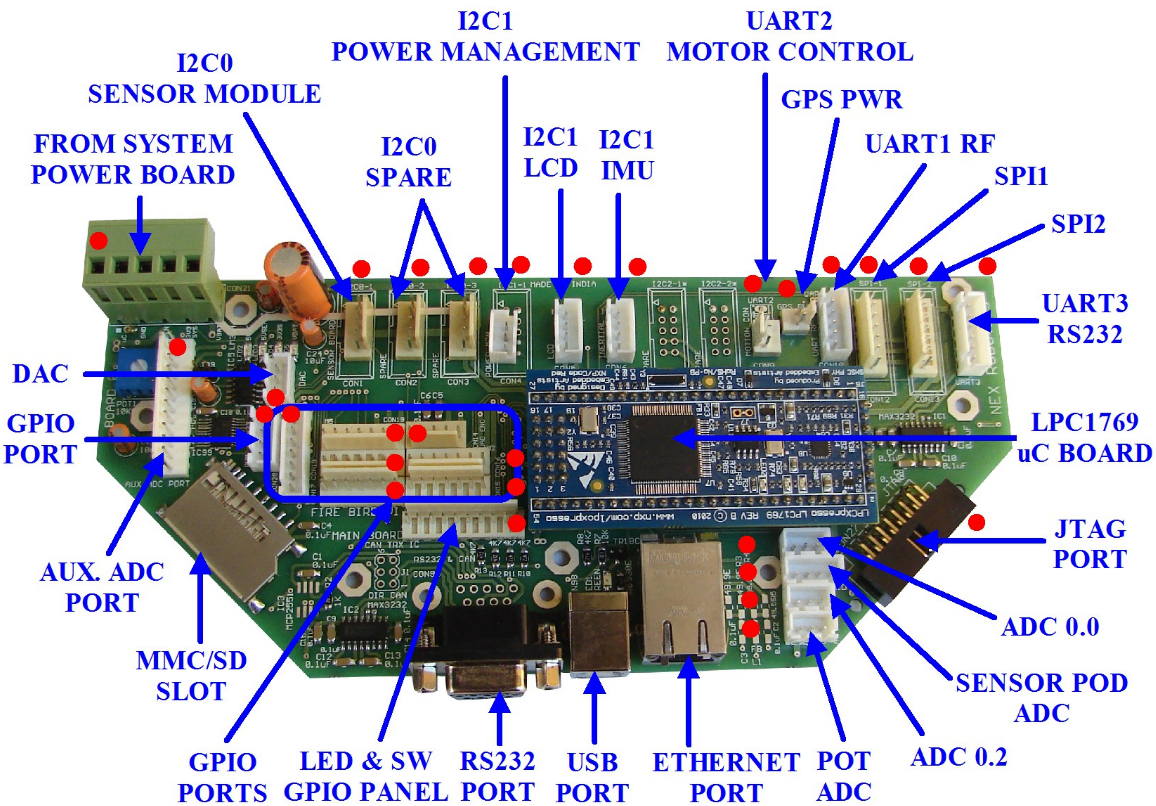



**Figure 3.1: Main Board (Red dot indicates pin number 1)**

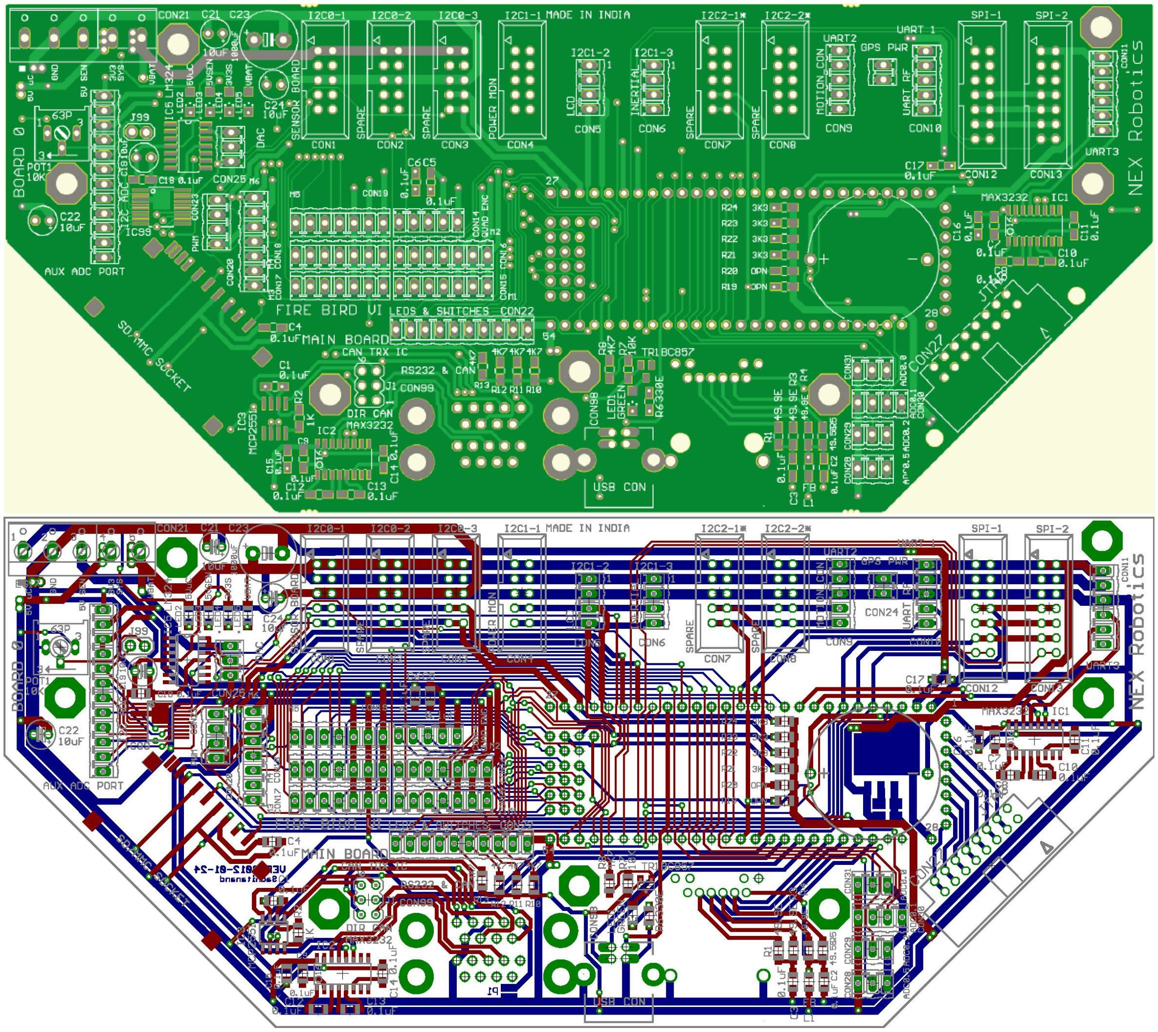


**Figure 3.2: PCB Layout of Main Board**

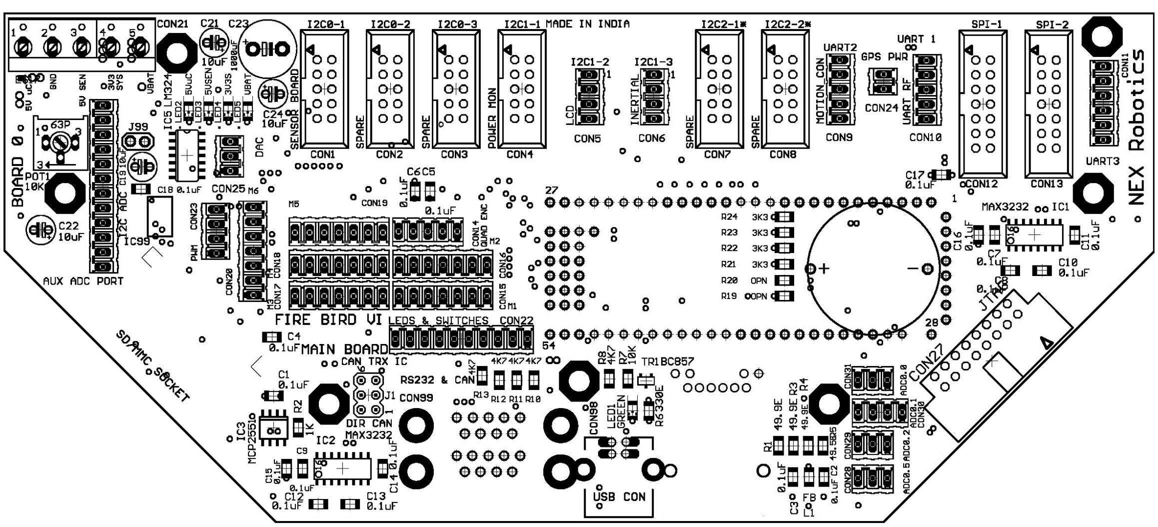



**Figure 3.3: Silkscreen of Main Board**

| Port Type | Connector | Port Name | Function | Pin Functions |
|---|---|---|---|---|
| I2C0 | CON1 | Sensor Board | Connects Sensor microcontroller module with main controller | 1: V System<br>2: 5V Sensor<br>3: Ground<br>4: SDA0<br>5: SCL0 |
| I2C0 | CON2 | Spare | Reserved for add-on modules | 1: V System<br>2: 5V Sensor<br>3: Ground<br>4: SDA0<br>5: SCL0 |
| I2C0 | CON3 | Spare | Reserved for add-on modules | 1: V System<br>2: 5V Sensor<br>3: Ground<br>4: SDA0<br>5: SCL0 |
| I2C0 | CON95 | AUX ADC Port | 12Bit, 8channel ADC interfaced over I2C0 | 1: Ground<br>2: 5V System<br>3: 5V Sensor<br>4: 5V Sensor<br>5: Analog I/P 1<br>6: Analog I/P 2<br>7: Analog I/P 3<br>8: Analog I/P 4<br>9: Analog I/P 5<br>10: Analog I/P 6<br>11: Analog I/P 7<br>12: Analog I/P 8 |
| I2C1 | CON4 | Power Mon | Connected to the power management module | 1: Ground<br>2: SDA1<br>3: SCL1 |
| I2C1 | CON5 | LCD | Connected to I2C 4x20 alphanumeric LCD | 1: 5V Sensor<br>2: Ground<br>3: SDA1<br>4: SCL1 |
| I2C1 | CON6 | Inertial | Connected to 9DOF inertial module comprising L3G4200D 3 axis Digital Gyroscope and LSM303DLHC 3 axis accelerometer and 3 axis Magnetometer (If installed else reserved for add-on modules) | 1: 5V Sensor<br>2: Ground<br>3: SDA1<br>4: SCL1 |
| UART0 and CAN | CON99 | RS232 and CAN | UART0 of LPC1769 microcontroller. CAN port is not connected to the connector. UART0 is on RS232 logic level. Its a DB9 connector at the back side of the PCB | 1: NC<br>2: RXD<br>3: TXD<br>4: NC<br>5: Ground<br>6: NC<br>7: NC<br>8: NC<br>9: NC |

| | | | | |
|---|---|---|---|---|
| UART1 | CON10 | UART RF | Can be connected to any one wireless module out of XBee (ZigBee, Bluetooth or WiFi). This UART is on 3V3 logic level and not on RS232 level | 1: V System<br>2: 5V Sensor<br>3: Ground<br>4: TXD2<br>5: RXD2 |
| I2C2* | CON7 | Spare | Not connected | N.A. |
| I2C2* | CON8 | Spare | | |
| UART2 | CON9 | Motion Con | Connected to the motor controller. This UART is on 3V3 logic level. | 1: Ground<br>2: TXD<br>3: RXD |
| UART3 | CON11 | UART 3 | Can be connected to the External PC / any embedded board. This UART is on RS232 logic level | 1: V System<br>2: 5V System<br>3: Ground<br>4: RS232 TXD3<br>5: RS232 RXD3 |
| SPI1 | CON12 | SPI1-1 | SPI1 bus reserved for add-on modules with pin P2.7 as slave select | 1: V System<br>2: 5V Sensor<br>3: Ground<br>4: MOSI1<br>5: MISO1<br>6: SCK1<br>7: SS2 |
| SPI1 | CON13 | SPI1-2 | SPI1 bus reserved for add-on modules with pin P2.6 as slave select | 1: V System<br>2: 5V Sensor<br>3: Ground<br>4: MOSI1<br>5: MISO1<br>6: SCK1<br>7: SS3 |
| Quadrature Encoder | CON14 | Quad Enc | Quadrature Encoder interface for LPC1769 microcontroller | 1: QEI Phase A<br>2: QEI Phase B<br>3: QEI Index<br>4: 5V SEN<br>5: Ground |
| Motor Con Port | CON15 | M1 | Can be used for driving DC motor via motor driver. 1 PWM pin for velocity control, 2 GPIO pins for direction control and 1 interrupt pin for position encoder are available on this port | 1: 5V Sys<br>2: 5V Sen<br>3: Ground<br>4: DIR1 (QEI PHA)<br>5: DIR 2 (P1.18)<br>6: EINT0* (sheared with back panel SW1)<br>7: PWM 1.1 |
| Motor Con Port | CON16 | M2 | Can be used for driving DC motor via motor driver. 1 PWM pin for velocity control, 2 GPIO pins for direction control and 1 interrupt pin for position encoder are available on this port | 1: 5V Sys<br>2: 5V Sen<br>3: Ground<br>4: DIR1 (P1.22)<br>5: DIR 2 (PWM 1.21)<br>6: EINT1* (sheared with back panel SW2)<br>7: PWM 1.2 |
| Motor Con Port | CON17 | M3 | Can be used for driving DC motor via motor driver. 1 PWM pin for velocity control, 2 GPIO pins for direction | 1: 5V Sys<br>2: 5V Sen<br>3: Ground |

| | | | | |
|---|---|---|---|---|
| | | | control and 1 interrupt pin for position encoder are available on this port | 4: DIR1 (P3.26)<br>5: DIR 2 (PWM 3.25)<br>6: EINT2* (sheared with back panel SW3)<br>7: PWM 1.3 |
| Motor Con Port | CON18 | M4 | Can be used for driving DC motor via motor driver. 1 PWM pin for velocity control, 2 GPIO pins for direction control and 1 interrupt pin for position encoder are available on this port | 1: 5V Sys<br>2: 5V Sen<br>3: Ground<br>4: DIR1 (P4.28)<br>5: DIR 2 (PWM 4.29)<br>6: EINT3* (sheared with back panel SW3)<br>7: PWM 1.4 |
| Motor Con Port | CON19 | M5 | Can be used for driving DC motor via motor driver. 1 PWM pin for velocity control, 2 GPIO pins for direction control and 1 interrupt pin for position encoder are available on this port | 1: 5V Sys<br>2: 5V Sen<br>3: Ground<br>4: DIR1 (P0.17)<br>5: DIR 2 (PWM 0.18)<br>6: NC<br>7: PWM 1.5 |
| Motor Con Port | CON20 | M6 | Can be used for driving DC motor via motor driver. 1 PWM pin for velocity control, 2 GPIO pins for direction control and 1 interrupt pin for position encoder are available on this port | 1: 5V Sys<br>2: 5V Sen<br>3: Ground<br>4: DIR1 (P0.21)<br>5: DIR 2 (PWM 0.22)<br>6: NC<br>7: PWM 1.6 |
| Powe r In | CON21 | -- | Power from System Power board | 1: 5V uC<br>2: Ground<br>3: 5V Sensor<br>4: 3V3 System<br>5: V System |
| 3 PWM Ch | CON23 | PWM | PWM1.4 to PWM1.6 available for interfacing | 1: PWM 1.4<br>2: PWM 1.5<br>3: PWM 1.6<br>4: Ground |
| Powe r | CON24 | GPS Pwr | Provides 5V supply to the GPS receiver (if installed). Can also be used to provide 5V to any external device. | 1: 5V Sensor<br>2: Ground |
| DAC | CON25 | DAC | DAC out from LPC1769 microcontroller | 1: Ground<br>2: Analog Out<br>3: V System |
| JTAG | CON27 | JTAG | JTAG port of LPC1769 microcontroller | |
| ADC 0.5 | CON28 | ADC0. 5 | ADC0.5 of LPC1769 microcontroller. In default condition, connected to the potentiometer at the back panel | 1: Ground<br>2: AD0.5<br>3: 3V3 SYS |
| ADC 0.2 | CON29 | ADC0. 2 | ADC0.2 of LPC1769 microcontroller | 1: Ground<br>2: AD0.2<br>3: 3V3 SYS |
| ADC 0.1 | CON30 | ADC0. 1 | ADC0.1 of LPC1769 microcontroller. Used for Sensor (Ultrasonic / Sharp IR Range sensor if installed) | 1: Ground<br>2: P1.29<br>3: AD0.1<br>4: 3V3 System |

| | | | | |
|---|---|---|---|---|
| ADC 0.0 | CON31 | ADC0.0 | ADC0.0 of LPC1769 microcontroller | 1: Ground<br>2: AD0.0<br>3: 3V3 SYS |
| Ethernet | CON96 | Ethernet | Ethernet interface of LPC1769 microcontroller | Refer to Schematics<br>Not in use |
| USB | CON98 | USB | USB of LPC1769 microcontroller | Refer to Schematics |
| GPIO | CON22 | LED and Switches Panel | 4 GPIOs and 4 GPIOs /Interrupts are connected to the 4 LEDs and 4 Switches of the back side panel | 1: Ground<br>2: LPC1769 Reset<br>3: EINT0<br>4: EINT1<br>5: EINT2<br>6: EINT3<br>7: P1.25<br>8: P1.26<br>9: P1.27<br>10: P1.28 |

**Table 3.1 Ports and corresponding connectors on main board**

**Jumper J99:** If inserted, connects pot 1 to the ADC0 of the 12Bit external ADC which is interfaced with LPC1769 microcontroller over I2C0 bus.

**Important:**
For the location of the pin number 1 of the each connector on the main board refer to Figure 3.1.

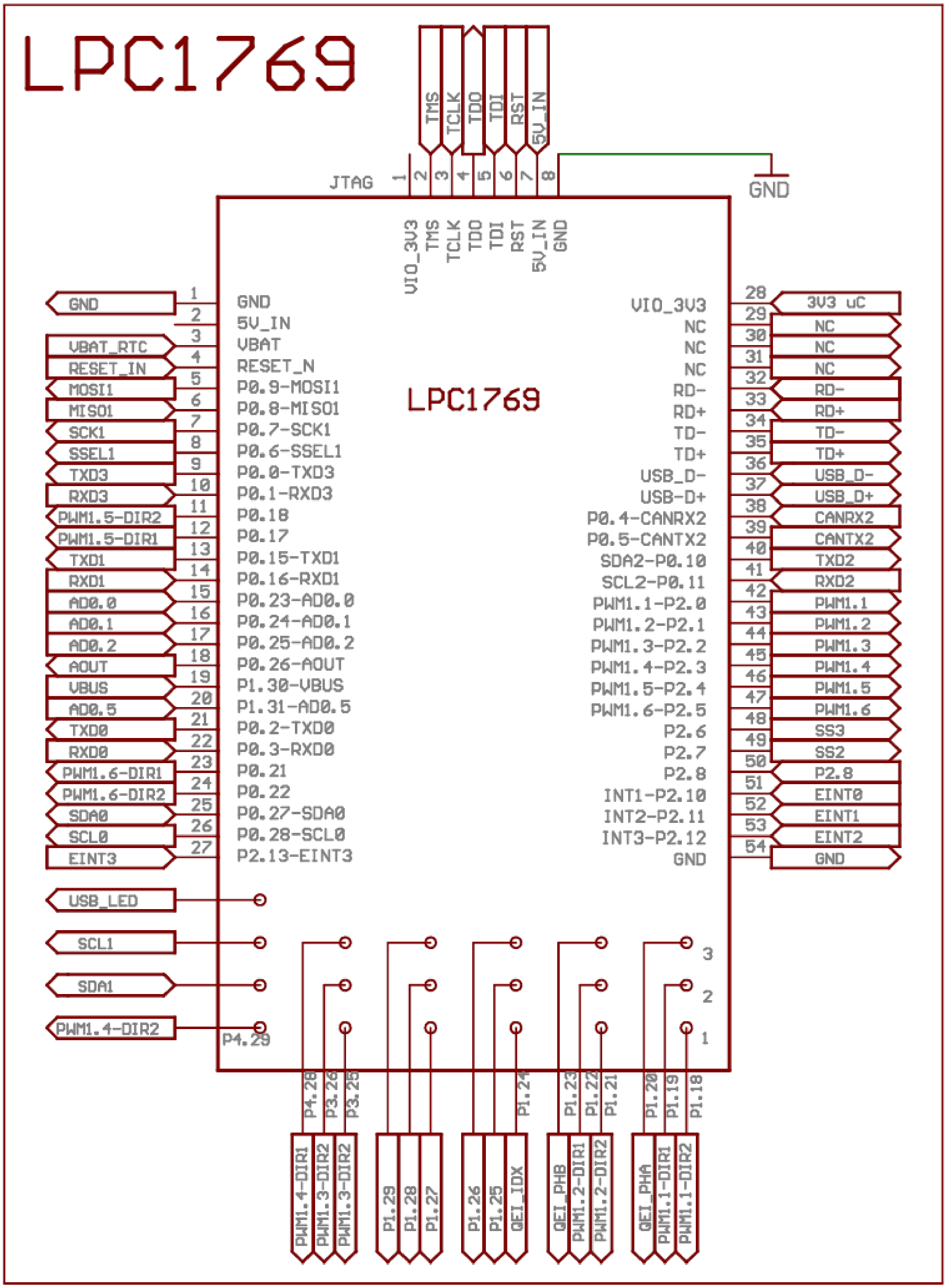



**Figure 3.4: LPC1769 microcontroller schematic**

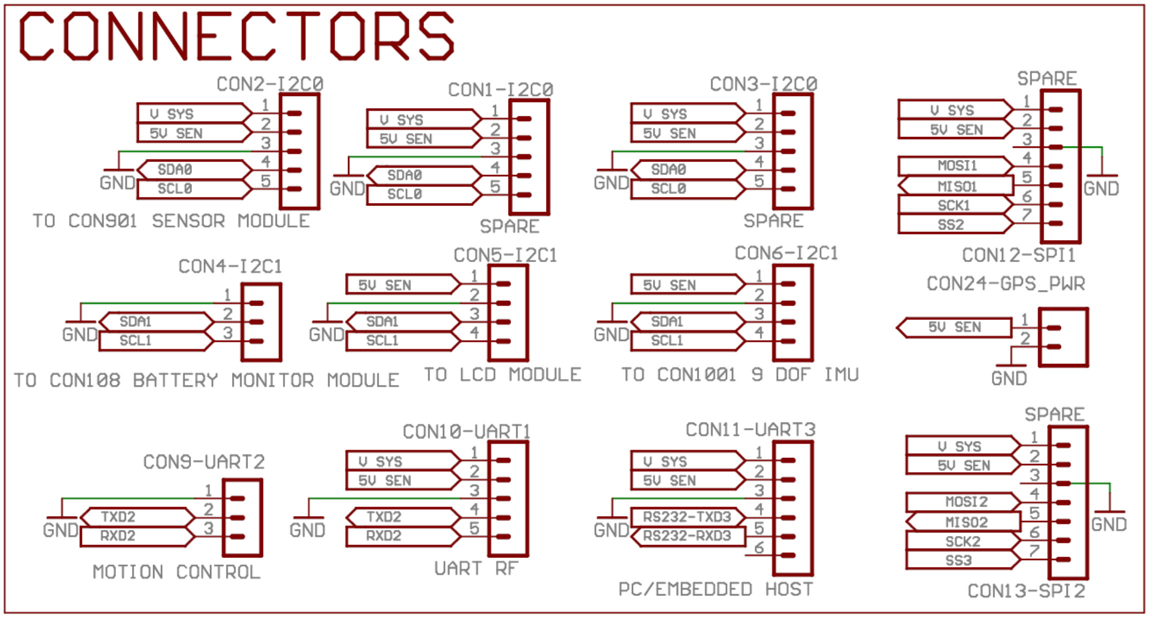



**Figure 3.5: LPC1769 microcontroller's I2C, SPI and UART Bus connections**

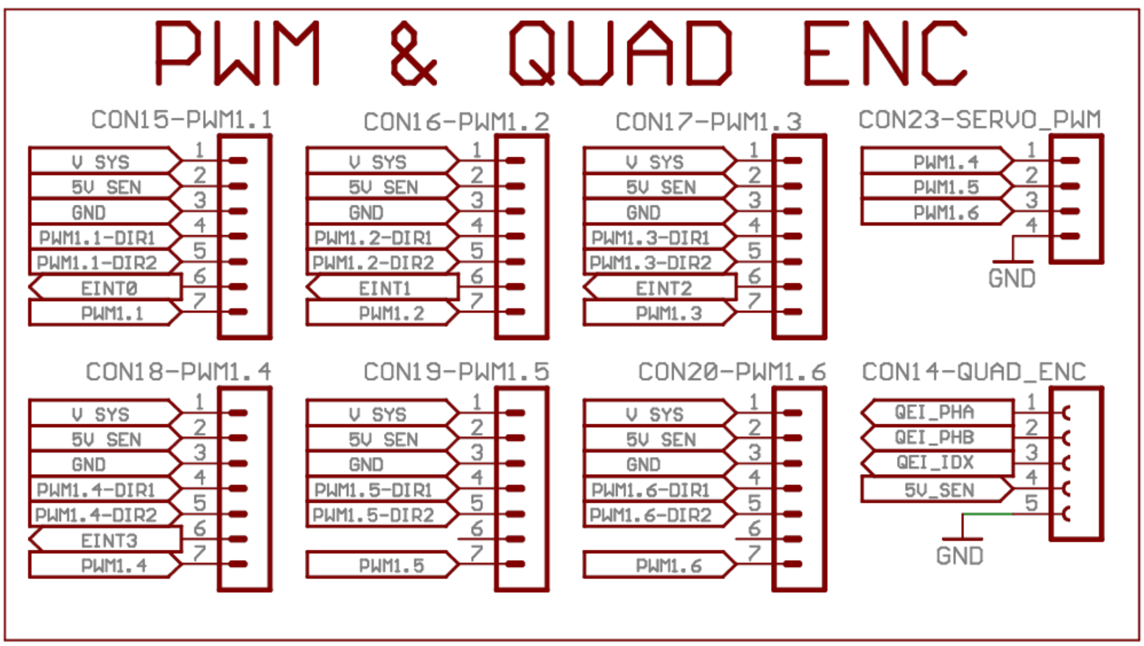



**Figure 3.6: LPC1769 microcontroller's Additional GPIO / motor control port**

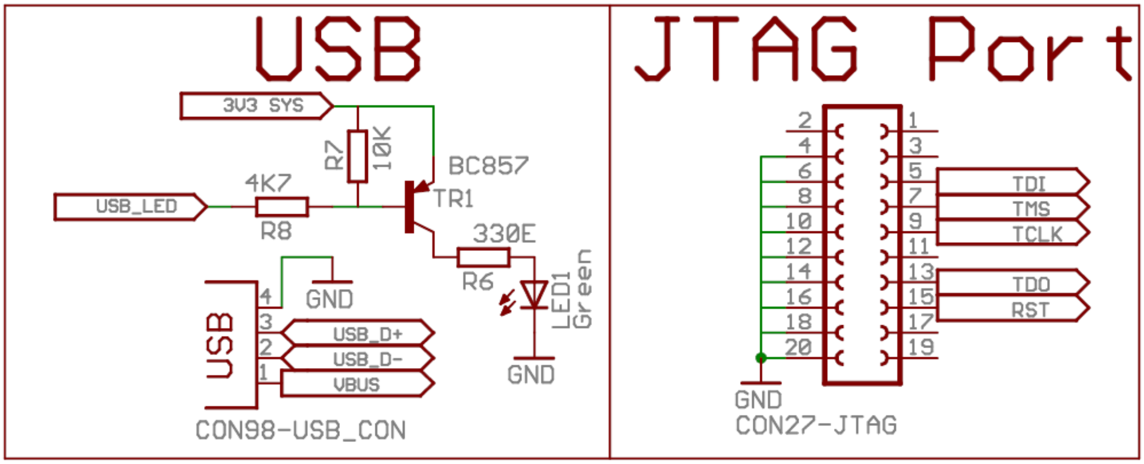



**Figure 3.7: LPC1769 microcontroller's USB and JTAG port**

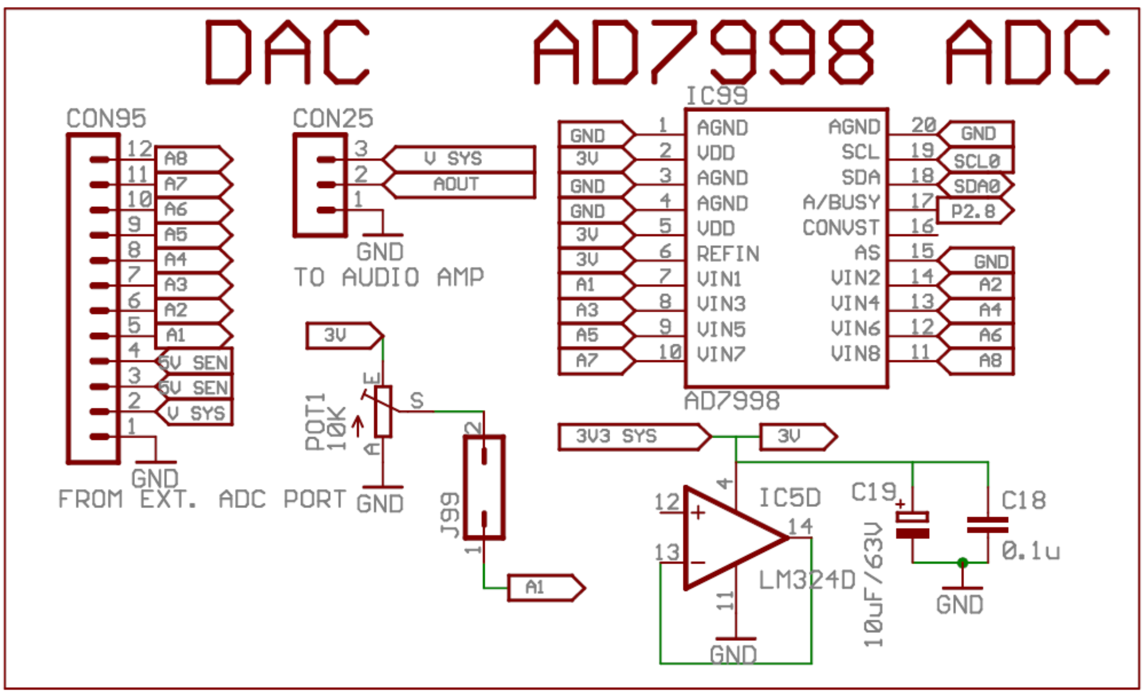



**Figure 3.8: LPC1769's DAC and I2C based ADC**

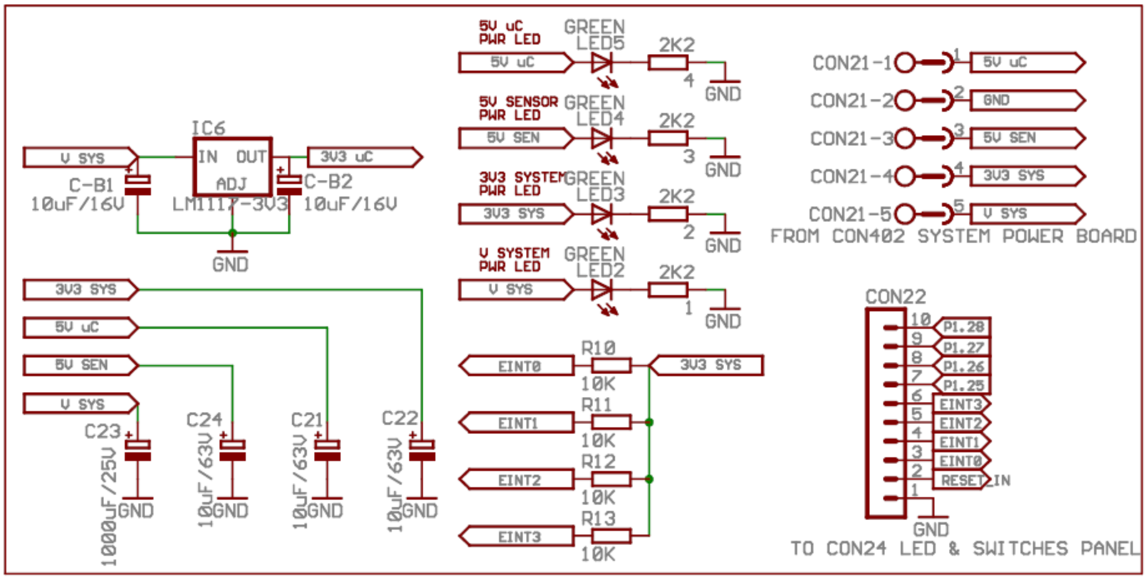


**Figure 3.9: LPC1769's GPIO and LED panel**

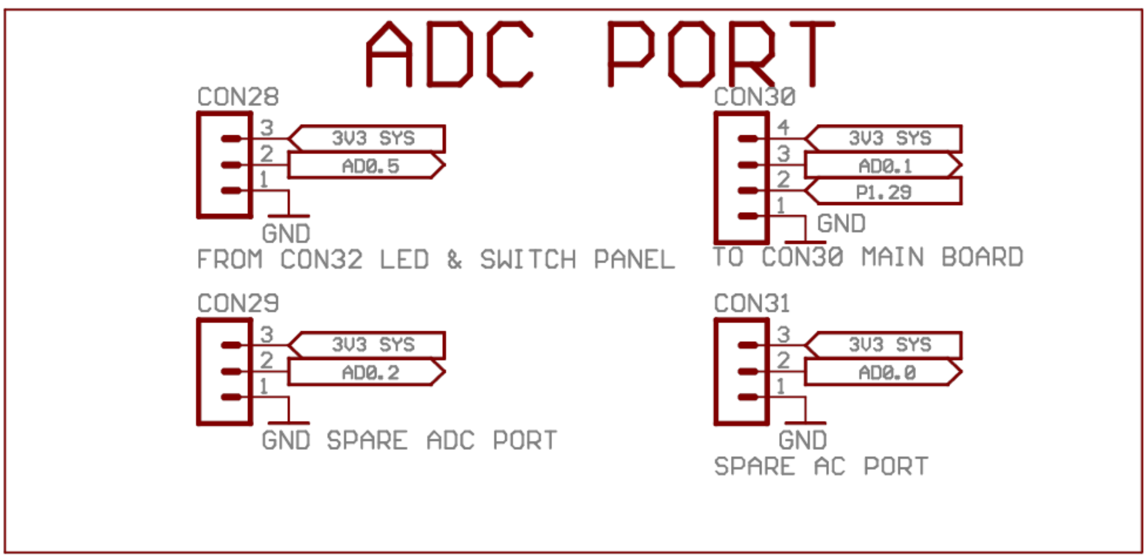



**Figure 3.10: LPC1769's ADC port**

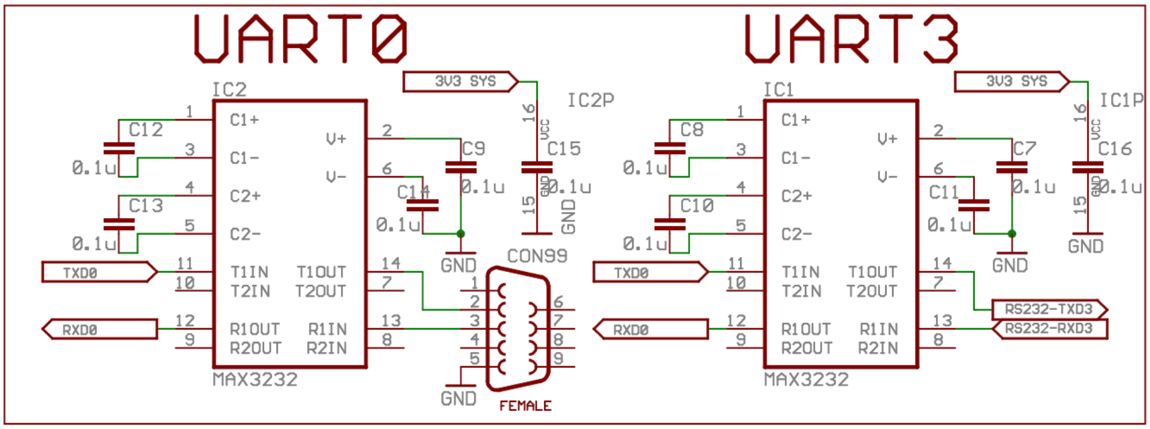



**Figure 3.11: LPC1769 microcontroller's RS232 level UARTs**

### 3.1.1 JTAG Interface

Figure 3.5 shows the JTAG port. It can be directly connected the the JTAG board provided with the robot.  For JTAG pin connection details refer to the Table 3.1 and schematics from Figure 3.4.


**Figure 3.12: JTAG Port**

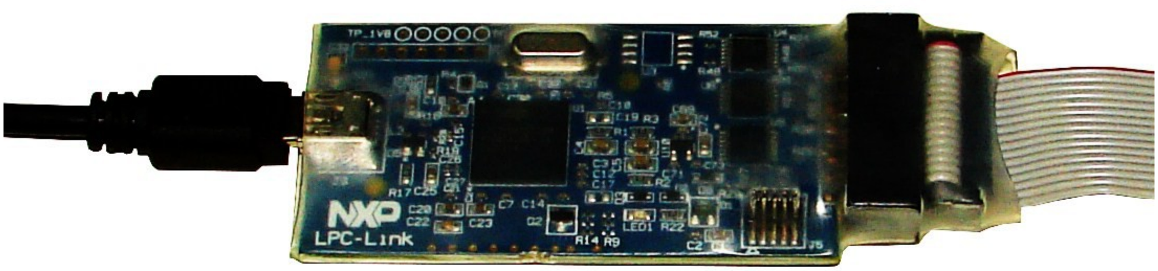



**Figure 3.13: JTAG debugger for LPC1769**

## 3.2 Power Management

### 3.2.1 Power Management Module

Power management module is connected to the LPC1769 over I2C1 port via wire harness number 3 which has 3 pin JST connectors at the both ends.

Power management module does following tasks:

1. Monitors robot's battery voltage, current, temperature of the battery bay and reports it to the main controller over I2C1 bus.
2. Gives audio visual indication of the battery charge status
3. Isolates supply going to the motor from system supply and also provides fuse protection to the system and motor supply.
4. Power switching is done through relay to prevent overloading on the power switch.

For how to access voltage, current and temperature data, refer to the robot's software manual.

Power Management module distributes battery power into two different power rails as follows:

**System power (V SYSTEM)**
System power rail powers robot’s sensors, main board and other peripherals.

**Motor Power (V MOTOR)**
Motor power powers motion controller and the drive motors of the robot.

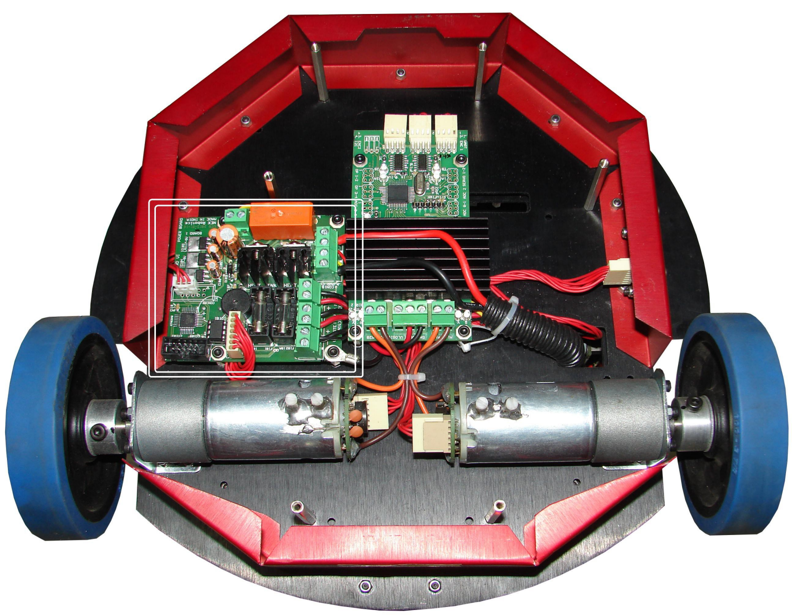


**Figure 3.14: Location of the Power Management Board**

**Temperature sensor**
LM35 temperature sensor is mounted near the battery below the battery bay to monitor battery temperature. It is connected to the power management module. Battery temperature value is accessed by the LPC1769 microcontroller via power management module over I2C1 bus.

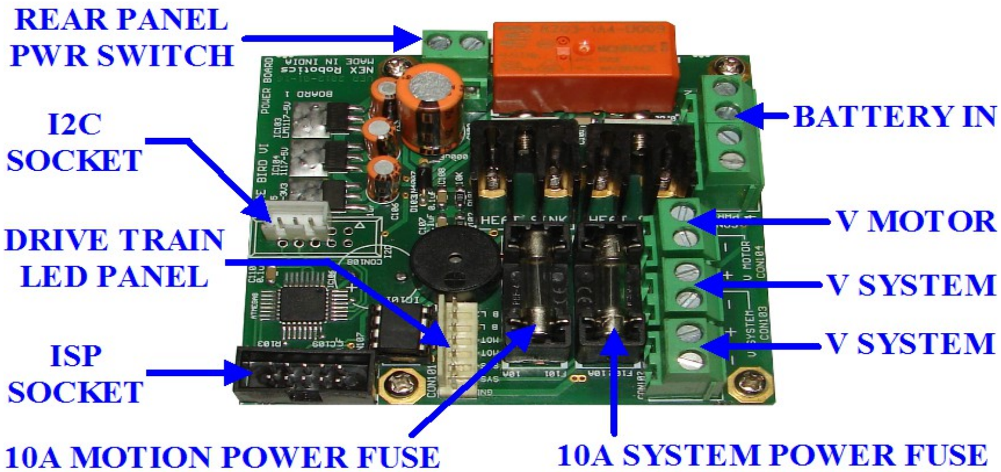



**Figure 3.15: Power Management Module connections**

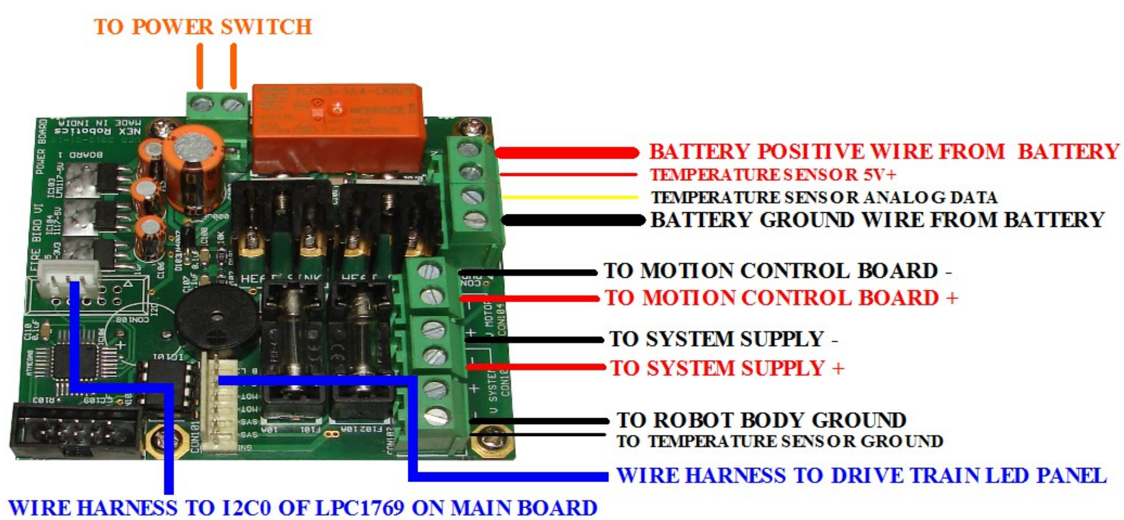



**Figure 3.16: Power management board wiring diagram**

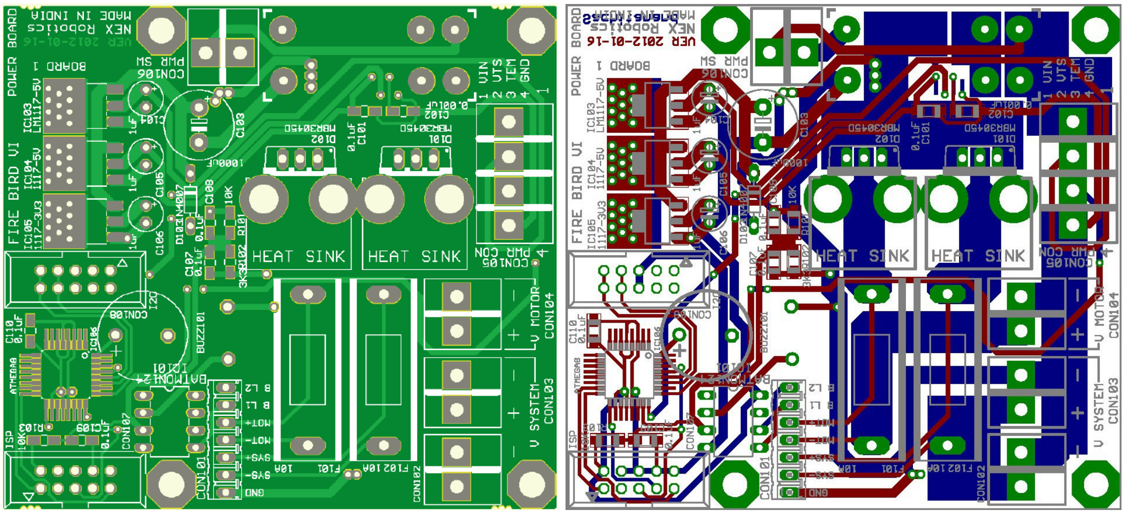



**Figure 3.17: PCB Layout of Power Management Module**

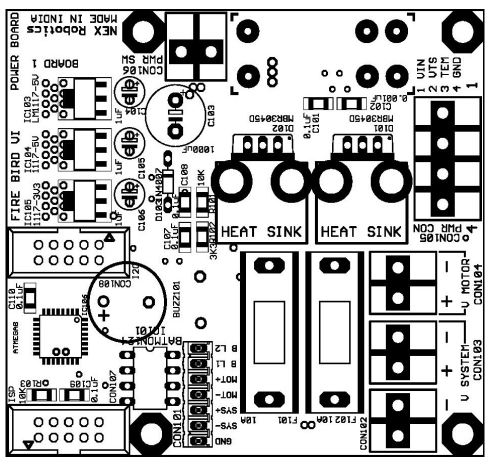



**Figure 3.18: Silkscreen of Power Management Module**

### 3.2.2 Power Status Indication LEDs (Drive Train LED Panel)

Power Status indicator board is connected to the Power management board via wire harness number 4 which has 7 pin 2510 relimate connectors at the both ends. Power status LEDs indicates presence of system power and motor power. The fuse blow indicator LEDs indicate if any fuses are blown due to abrupt current surges. Depending on the model, robot can be powered by Lithium Polymer or NiMh battery. Battery level status is indicated by 2 LEDs as shown in table 3.2 and table 3.3.

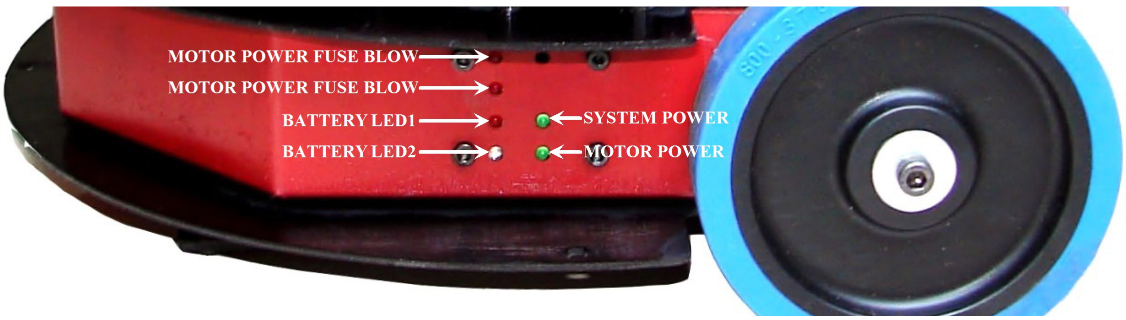



**Figure 3.19: Power Status Indication LEDs**

| **Battery Voltage NiMh Battery** | **LED and buzzer status indication** |
|---|---|
| Above 13V | Blue LED (LED2) is ON |
| 13V to 12V | Blue LED (LED2) blinks |
| 12V to 11V | Red LED (LED1) blinks |
| Below 11V | If battery voltage is below 11V for more than 5 seconds then Battery Red (LED1) blinks and buzzer beeps at 2Hz (fast beep). It will continuously do so even if battery voltage again goes above 11V. Only way to get out of this state is by switching off the robot and replacing the battery. |

**Table 3.2: Battery status indication for NiMH battery**

| **Battery Voltage Lithium Polymer Battery** | **LED and buzzer status indication** |
|---|---|
| Above 11.1V | Blue LED (LED2) is ON |
| 11.1V to 10.2V | Battery LED2 blinks |
| 10.2V to 9.9V | Battery LED1 blinks and buzzer beeps at 0.5Hz (slow beep) |
| Below 9.9V | If battery voltage is below 9.9V for more than 5 seconds then Battery LED1blinks and buzzer beeps at 2Hz (fast beep). It will continuously do so even if battery voltage again goes above 9.9V. Only way to get out of this state is by switching off the robot and replacing the battery. |

**Table 3.3: Battery status indication for Lithium Polymer battery**


Figure 3.20 Power status LED indication Board

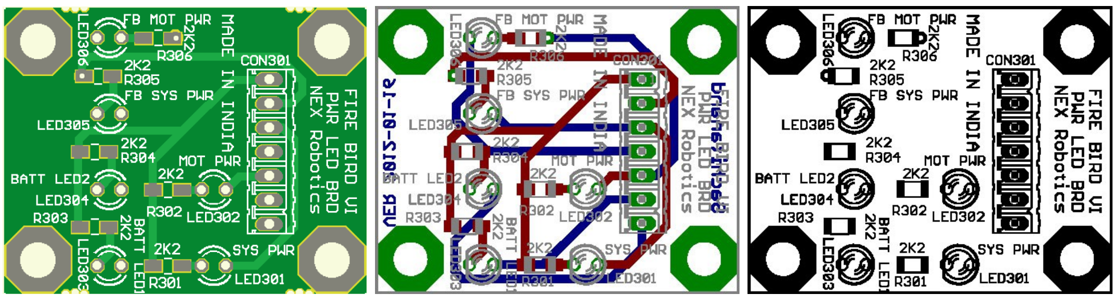



Figure 3.21: PCB Layout of Power status LED indication Board

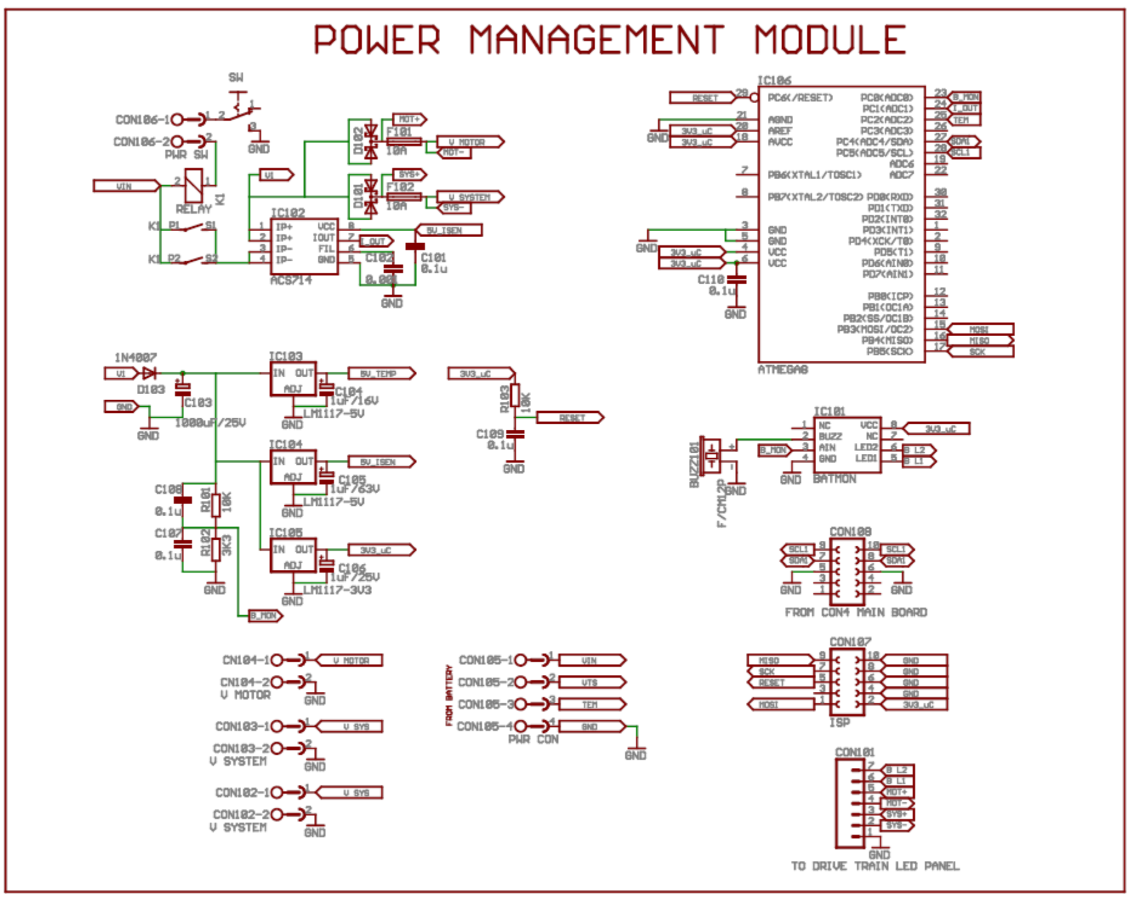



Figure 3.22: Power Management Module Schematic

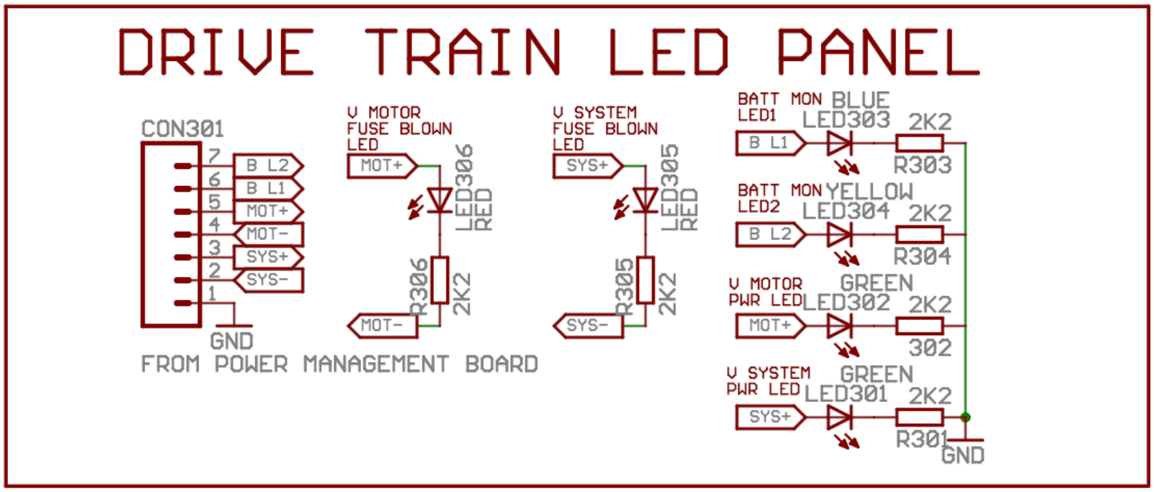



**Figure 3.23: Drive Train LED Panel Switches**

### 3.2.3 NiMH Battery Pack and its Charger

Depending on the model Fire Bird VI can be powered by 12V, 5000mAh NiMH battery. When battery is fully charged, its voltage increases up to 15V (1.5V per cell) and when it is fully discharged, its voltage drops to 10V (1V per cell). After battery is discharged to 10.5V, its voltage falls very rapidly. When Battery level reaches below 11V, robot starts giving continuous beeps. Once robot start giving continuous warning, immediately replace the battery. If NiMh battery goes below 10V then to regain its full charge storage capacity, you need to charge and discharge it 3-5 times. To extend battery life, always charge and discharge the battery at least twice a month.


**Figure 3.24: NiMH battery and its charger**

NiMH battery can be charged using battery charger provided with the robot or it can also be charged with B6AC universal charger. B6AC charger is shown in fig 3.27 in the right side. We recommend to charge the batteries using intelligent battery charger provided by NEX Robotics.

**Battery charging procedure:**

- Remove the battery from the robot. First insert battery's 5 pin 2510 relimate connector to the battery charger.
- Connect SMPS provided with the battery charger with the charger.
- Now turn on the SMPS adapter. After a small delay, yellow LED will turn on along with the one long beep two short beeps followed by delay of 1 second. This tone will be sounded only once. This audio tone confirms that robot is entered in the battery charging mode. If you do not here this tone, then repeat above steps.
- When battery is fully charged, yellow LED will turn off and buzzer gives 1 or 2 short beeps followed by 1 second delay continuously. Depending on the version sometimes robot will also give 1 long beep followed by delay.

- If there is any fault then charger will give different buzzer beeps to indicate nature of fault. Following section describes the interpretation of the battery state with beeping buzzer.

## Battery status indication based on the buzzer beeps:

**1. Battery entered in the charging mode:**
When SMPS is connected to the battery charging connector and powered up and if robot enters in battery charging mode, it gives 1 long beep followed by 2 short beeps only once. During battery charging mode yellow LED remains ON. It blinks for 3-4 seconds after 3-4 minutes.

**2. Battery is fully charged:**
When battery is fully charged, yellow LED will turn off and buzzer gives 1 or 2 short beeps followed by 1 second delay.

**3. Charge termination due to over current:**
During charging process, if charge current exceeds safe threshold value then robot terminates charging and buzzer gives 4 short beep repeated after delay of 1 second continuously.

**4. Charge termination due to time out:**
If battery is not fully charged in 8 hours, then robot stops battery charging and buzzer gives 3 short beeps repeated after delay of 1 second. If battery is unused for long time then it is possible that robot terminates battery charging due to timeout. In such case, discharge the battery fully and again start charging. You should repeat this 3 to 4 times till issue gets resolved. If the issue is still not resolved, then batteries have reached end of its usable life but you can still use battery with the robot. However the run time of the charged battery will be reduced significantly.

**5. Charge termination due to battery failure:**
At any time during battery charging if robot detects failure in the battery then it stops charging battery and buzzer gives 1 very long beep with a very short delay in between. In this case battery needs to be replaced.

**Important:**

If you are using battery after a long time, then you have to charge and discharge it at least few times to bring the battery to its full storage capacity. To do this you can load any motion program from the “Experiments” folder which is located on the documentation CD and discharge the batteries after charging.

⚠ **Warning:**

Never ever attempt to charge the robot while its powered on. In case, if the robot is powered up first and if you insert the battery charging socket, it will not enter in charging mode. In case, when you insert battery charging socket first and start charging, and then power up the robot, the robot will be powered up and at the same time battery will get charged. This is a very dangerous scenario where robot's battery charging circuit may get confused because of noise from motors and both battery and robot may get permanently damaged.

### 3.2.4 Lithium Polymer Battery Pack and its Charger

Some of the variants of Fire Bird VI can also be powered by 11.1V, 5000mAh lithium polymer battery with 30C discharge rating. It can deliver continuous current up to 150Amps. When battery is fully charged its voltage reaches at 12.6V (4.2V per cell) and when it’s fully discharged its voltage drops to 9.9V (3.3V per cell). After battery is discharged to 9.9V, its voltage falls very rapidly. When battery voltage reaches below 3.3V per cell, battery becomes unsafe to charge. Never allow battery to go below 9.9V. If battery voltage goes below 9.9V, then battery charger will refuse to charge the battery. When Battery level reaches below 9.9V, robot starts giving continuous buzzer beeping. Once robot start giving continuous warning, immediately replace the battery.

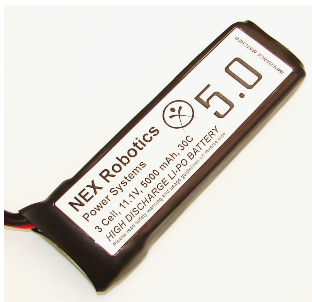



**Figure 3.25: Ni-MH battery Pack**

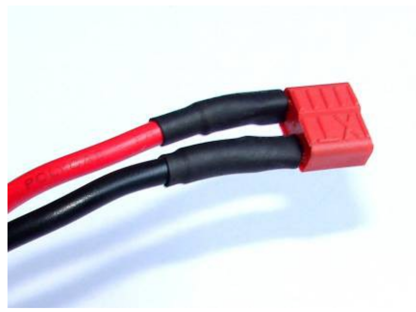


**Figure 3.26: Battery Connector**

To charge the battery, remove it from the robot and charge it in the open space. Robot comes with NR-BLIC-03 Battery charger. It will charge the battery in 10 to15 hours. B6AC universal battery charger is available as optional accessory which can charge battery in 3 to 5 hours. These smart battery chargers monitors individual cell voltages of the battery pack and adjust the rate of charge of the individual cell to perform balance charging. For more information on the chargers refer to respective user manuals located on the documentation CD. It is recommended to use only the battery charger provided by NEX Robotics.


**Figure 3.27: NR-BLIC-03 and B6AC battery charger from NEX Robotics**

### 3.2.5 Battery Connections

Robot's battery bay has place for 2 battery packs. One pack is used for the robot while other pack is used for an on-board computer. Both battery packs are to be strapped using Velcro straps. Before connecting batteries, ensure that Robot's and on-board computer's power switch is in off position and batteries are secured in their place. After batteries are mounted close the top lid.

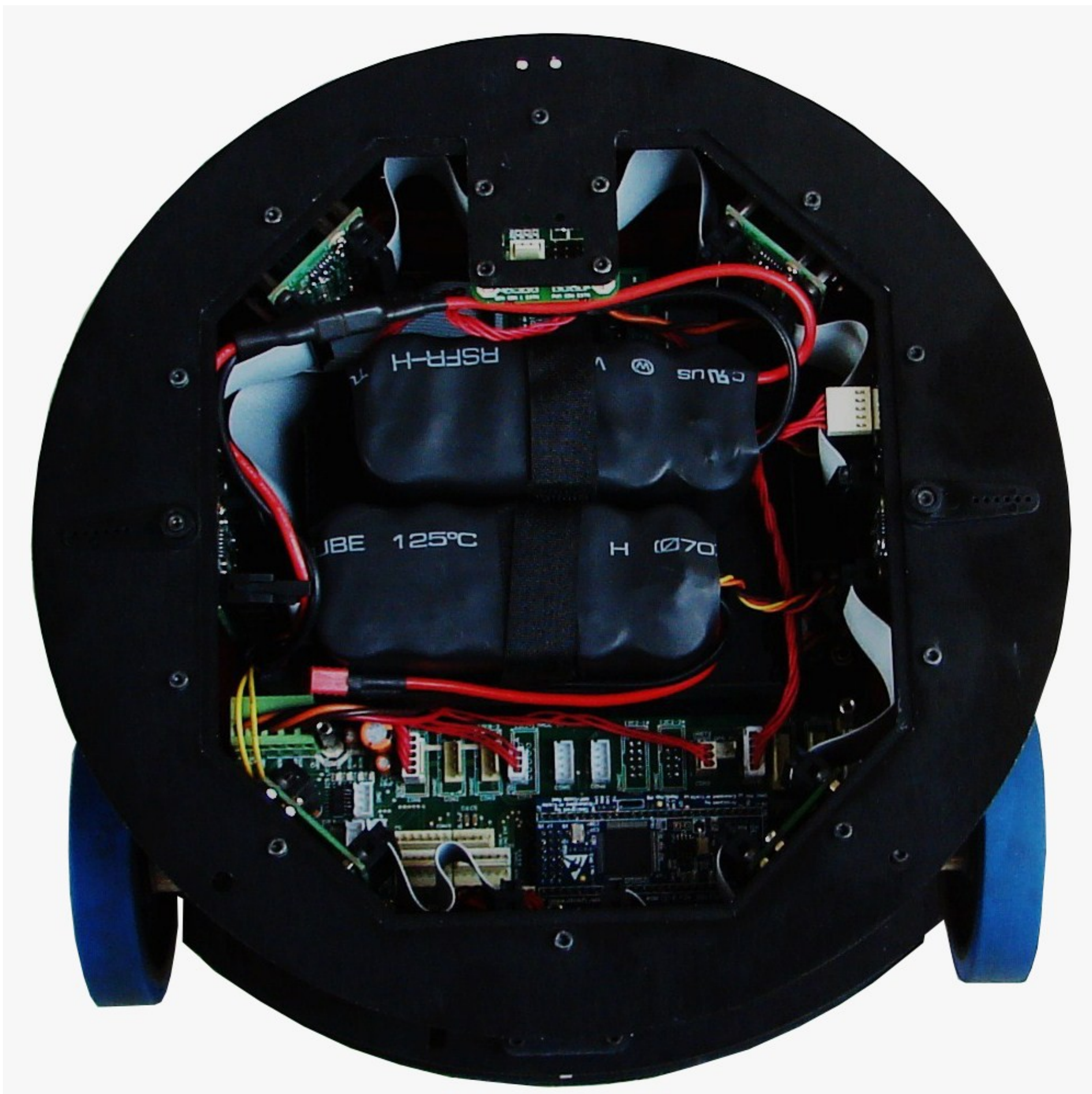


**Figure 3.28: Securing batteries inside Fire Bird VI**

### 3.2.6 System Power Board

System power board gets supply from the System supply power rail from the Power Management Board. It generates regulated stable supply for the most of the peripherals on the robot.

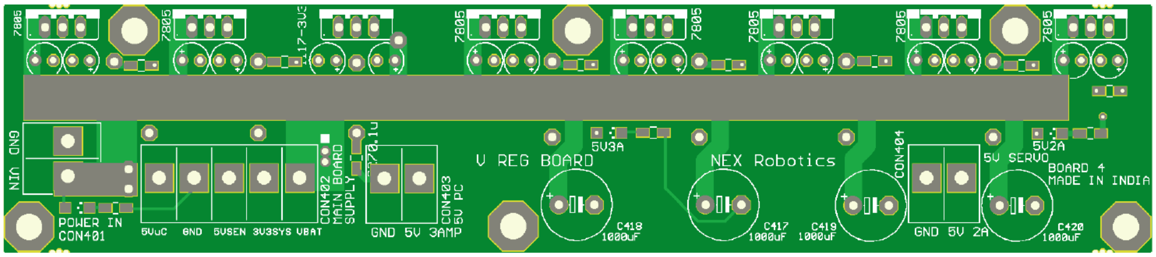


Figure 3.29: System Power Board

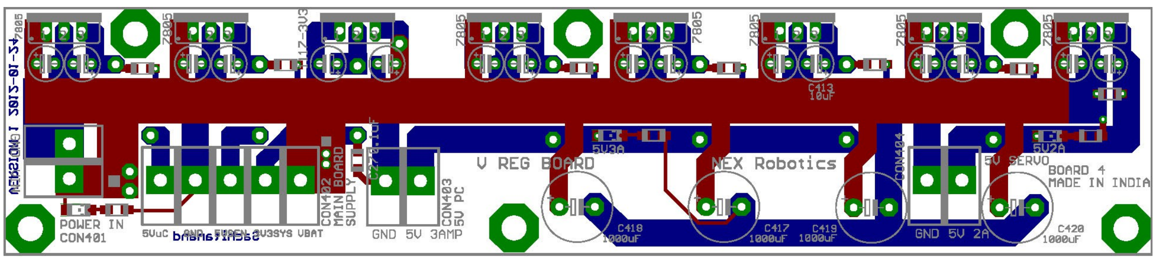


Figure 3.30: PCB Layout of System Power Board

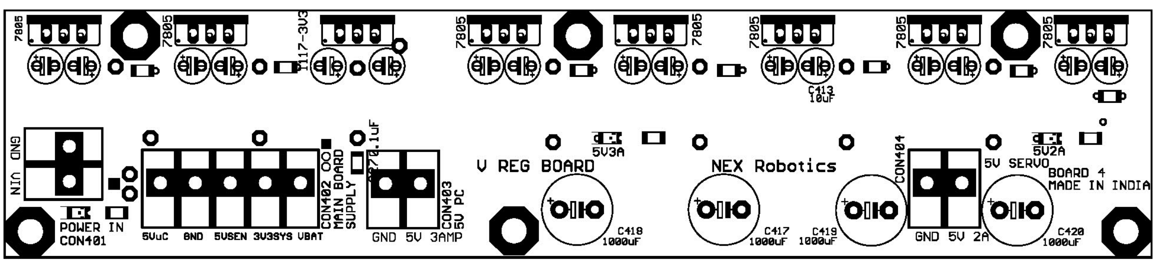


Figure 3.31: Silkscreen of System Power Board

**Power Board generates following supply rails:**

1. **5VuC:** 5V, 1A supply to the main board for powering peripherals
2. **5VSEN:** 5V, 1A supply for the sensors connected to the main board. Power is delivered directly by the respective connector
3. **3V3SYS:** 3.3V, 1A supply for the peripherals on the main board
4. **VBAT:** Battery voltage, 3A for powering up different peripherals via main board. Power is delivered directly by the respective connector
5. **5V PC:** 5V, 3A supply for powering small embedded computer, Beagle board, Friendly ARM board etc.
6. **5V Servo:** 5V, 2A supply for the camera / sensor servo pod of the robot

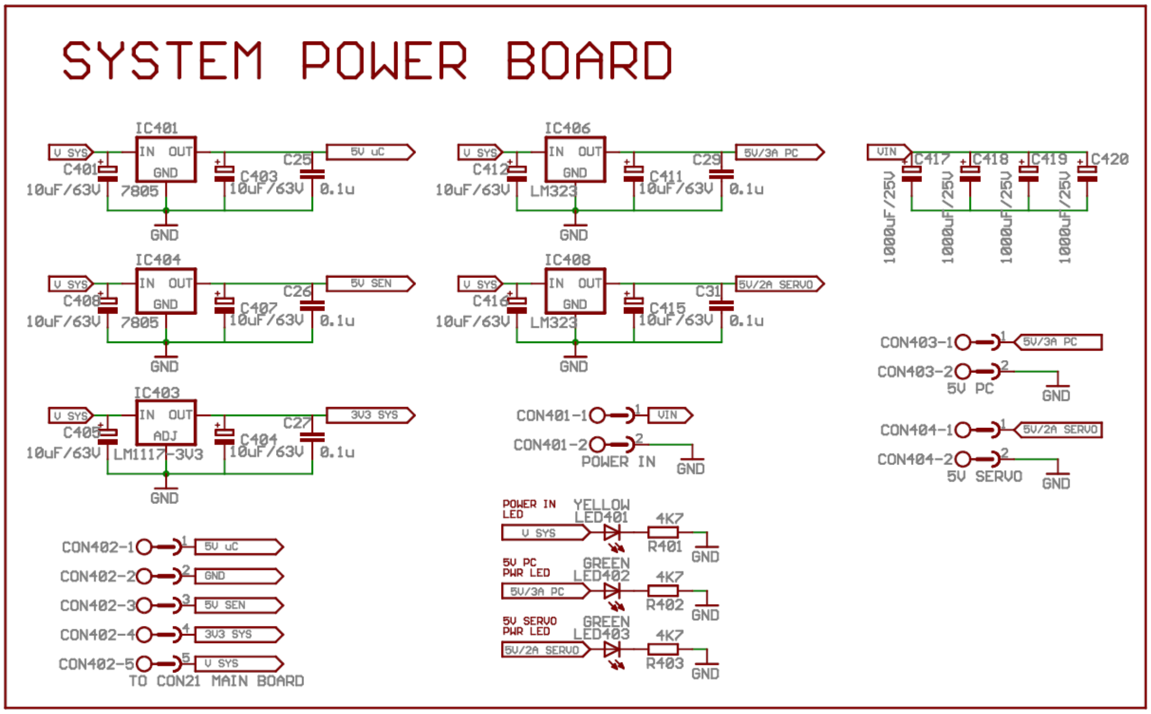



**Figure 3.32: Power Management Module schematics**

## 3.3 Sensor Module

Sensor module is connected to the main board via I2C0 bus using wire harness number 1 which has 5 pin 2510 relimate connectors at both ends.

Sensor module acquires data from 8 line sensors, 8 Ultrasonic range sensors and 8 IR Proximity sensors. It also generates PWM control signals for 3 servo motors. It can also turn individual sensor bank on or off in order to conserve power or to allow multiple robots to work in the same area by synchronizing each others sensors. By turning off IR proximity and line sensors, robot can save up to 600mA current.

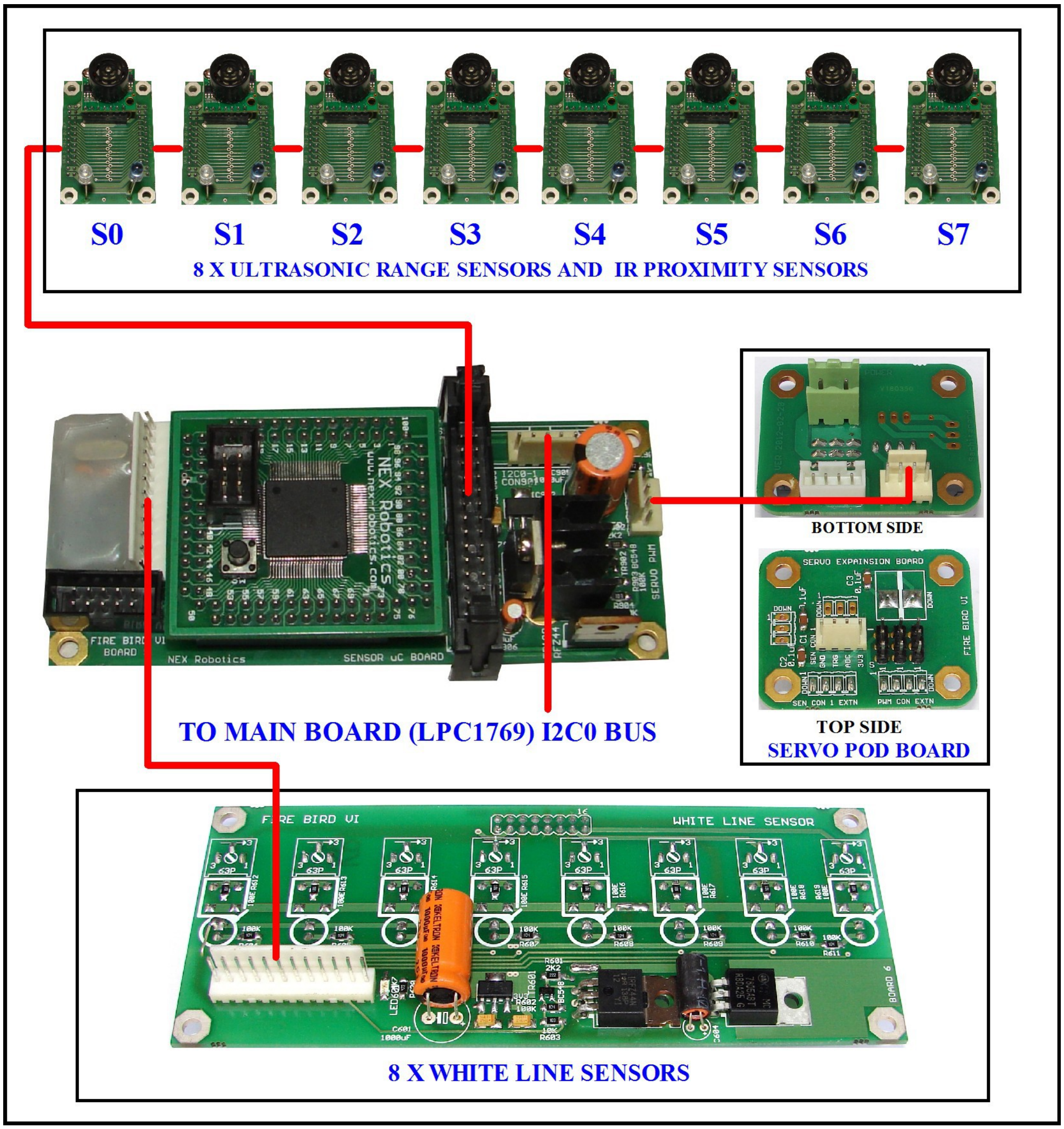



**Figure 3.33: Sensor module connection diagram**

### 3.3.1 Sensor microcontroller module

Sensor microcontroller module is at the heart of the sensor module of the Fire Bird VI robot. Communication protocol for sensor data acquisition and sensor power control is covered in the software manual of the robot.

**Main sensor microcontroller ATMEGA640:**

- Interfaced with the LPC1769 main controller over I2C0 bus.
- Acquires analog sensor data from 8 white line sensors and 8 ultrasonic range sensors using its 16 Analog to digital converters
- Acquires data from 8 IR proximity sensors from its slave ATMEGA8 microcontroller over its one of the serial port.
- Triggers ultrasonic range sensors periodically to take sensor data readings
- Controls power of IR proximity sensor's IR LEDs and white line sensor's red LED.
- Generates control signal for 3 servo motors which can be used for moving camera or servo pod.

**Slave sensor microcontroller ATMEGA8:**

- Acquires analog sensor data from 8 IR proximity sensors and sends it to the main sensor microcontroller.

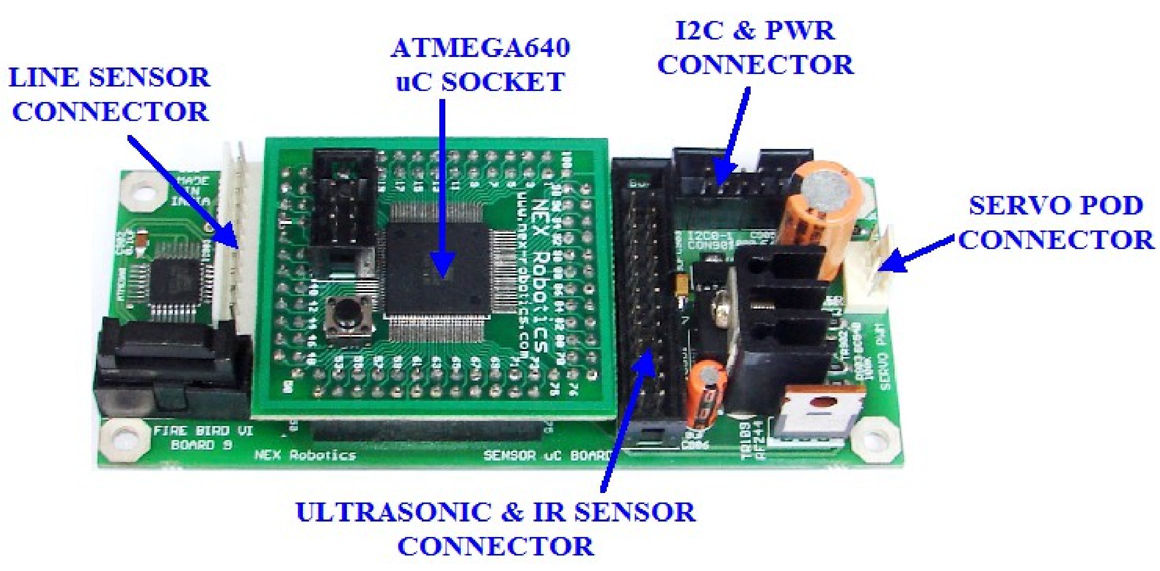
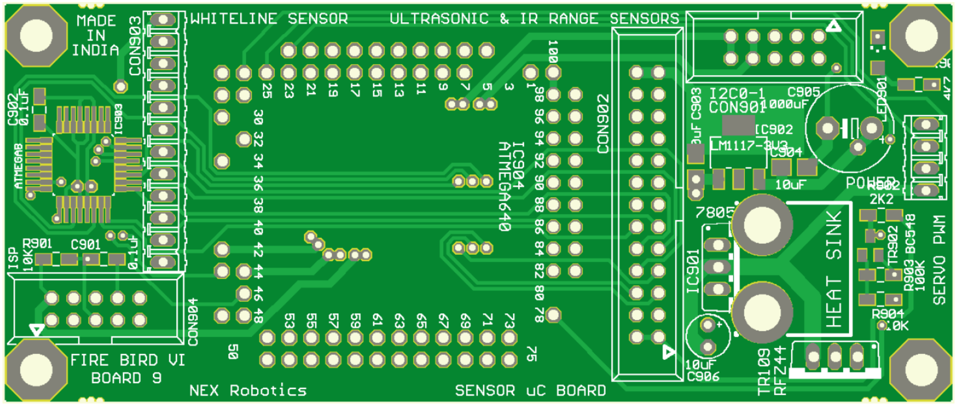



**Figure 3.34: Sensor Module uC Board**



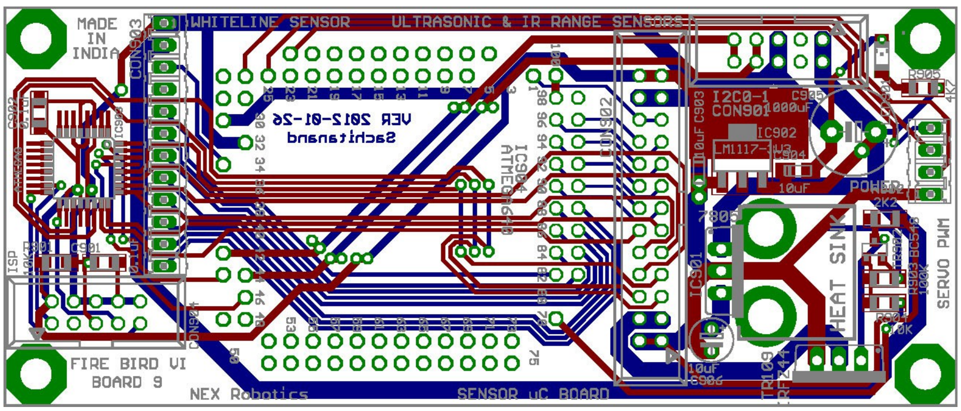




**Figure 3.35: PCB Layout of Sensor Module uC Board**

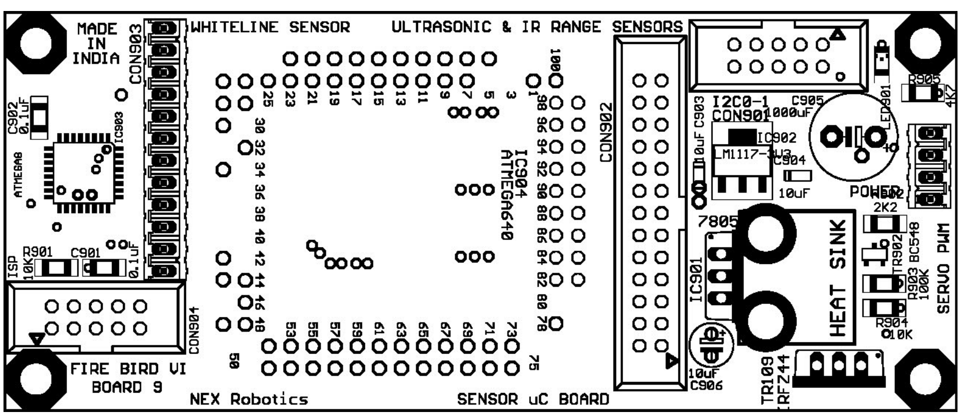



**Figure 3.36: Silkscreen of Sensor Module uC Board**

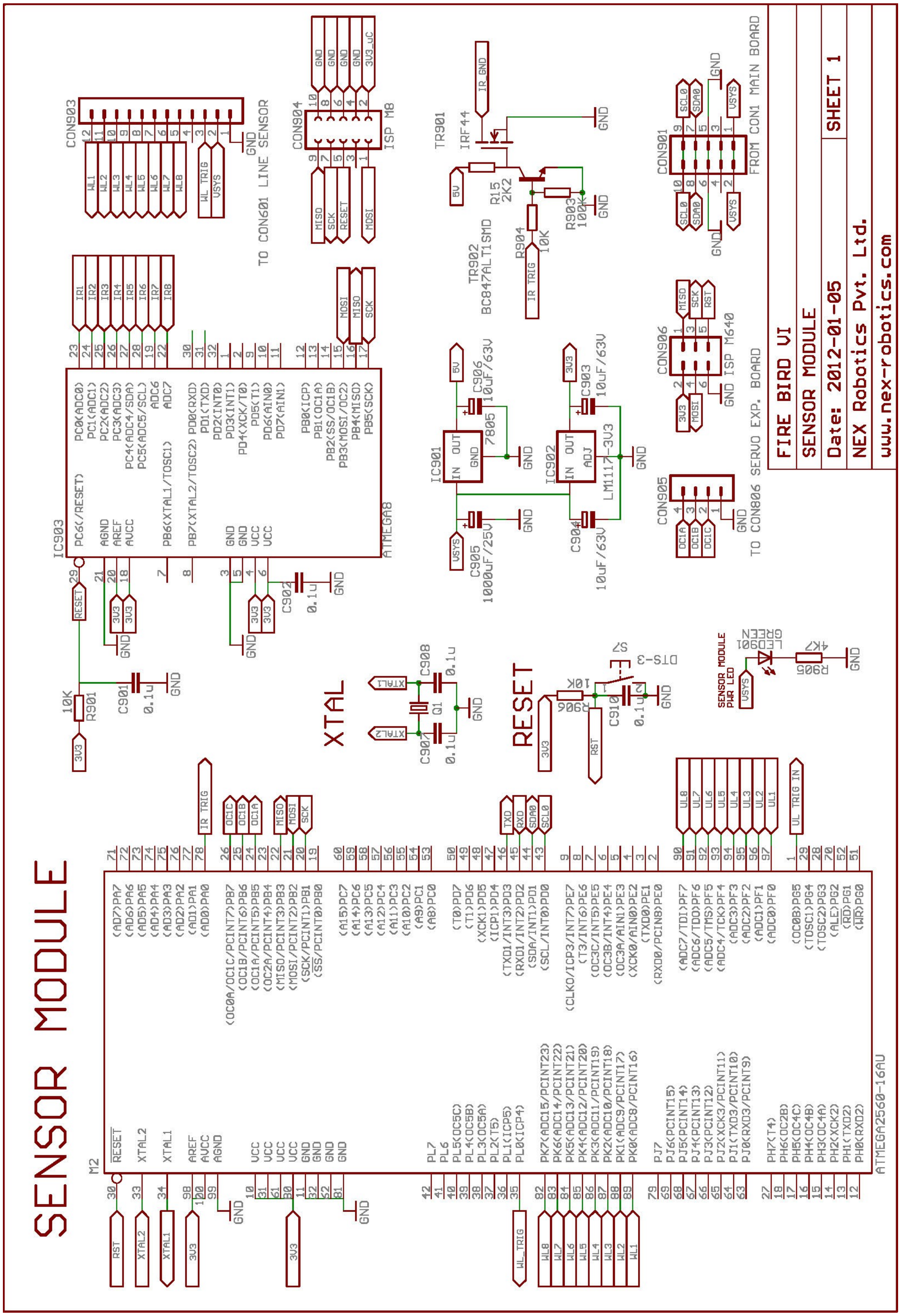



**Figure 3.37: Schematic of Sensor Module uC Board**

### 3.3.2 Line Sensor

Line sensor module is connected with the sensor microcontroller module using wire harness number 10 which has 12 pin 2510 relimate connectors on both ends. Line sensors are used for detecting white or black line on the ground surface. Lines are drawn on ground surface to give robot a sense of localization. It is possible to remove odometery errors introduced by the position encoders using a grid. The line sensor consists of a highly directional photo transistor for line sensing and bright red LED for illumination. Due to the directional nature of the photo transistor, it does not get affected with ambient light unless it is very bright.

When the line sensor is not on a white surface, amount of light reflected is less. Hence less leakage current flows through the photo transistor. In this case, the line sensor gives an output in the range of 1.5V to 3.3V. When the sensor is on a white surface, more light gets reflected resulting in considerable increase in the leakage current which causes voltage across the sensor to fall between 1.5 to 0.1V. Power to the red LED used for illumination is controlled by a MOSFET which can be turned off to extend robot’s battery life.

**Important:**

- Photo transistors are extremely sensitivity to the IR component of Sunlight and up to some extent IR component of filament based bulbs. Robot's line sensors will go in to hard saturation during daytime even if room has heavy curtains.
- In such case line detection performance can be improved by taking successive readings while red illumination LEDs are on and off and ambient IR light's component can be removed.
- Old choke and starter based fluorescent lights blink with 50-60Hz frequency. If room is brightly illuminated by such light then you may find fluctuation in the sensor's reading even though robot is not moving. This is because older fluorescent lights actually blink 50-60 times a second (50-60Hz). In such case, we strongly recommend to use new electronic chock based lights or CFL lights which run on 20KHz.

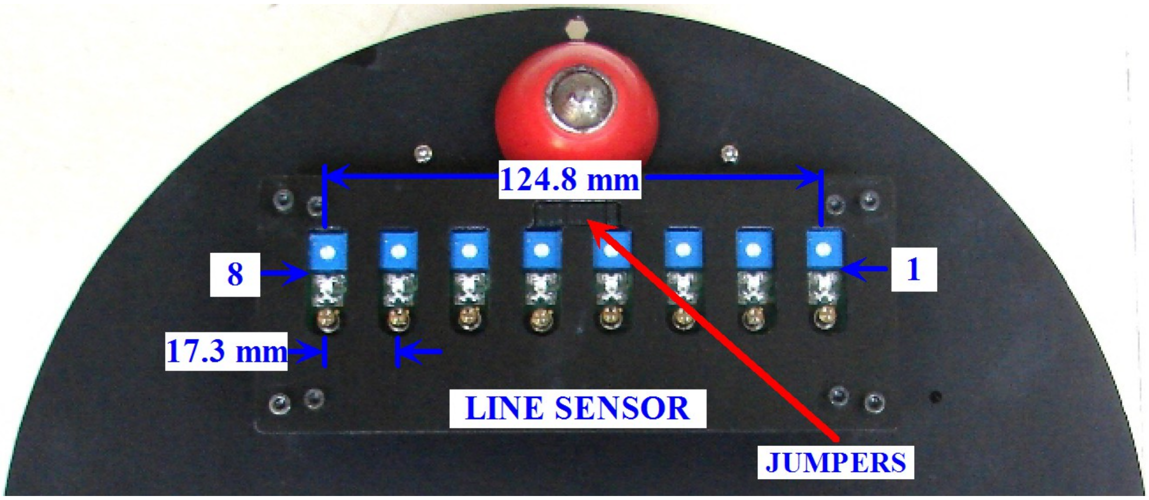



**Figure 3.38: Line Sensors on the Fire Bird VI**

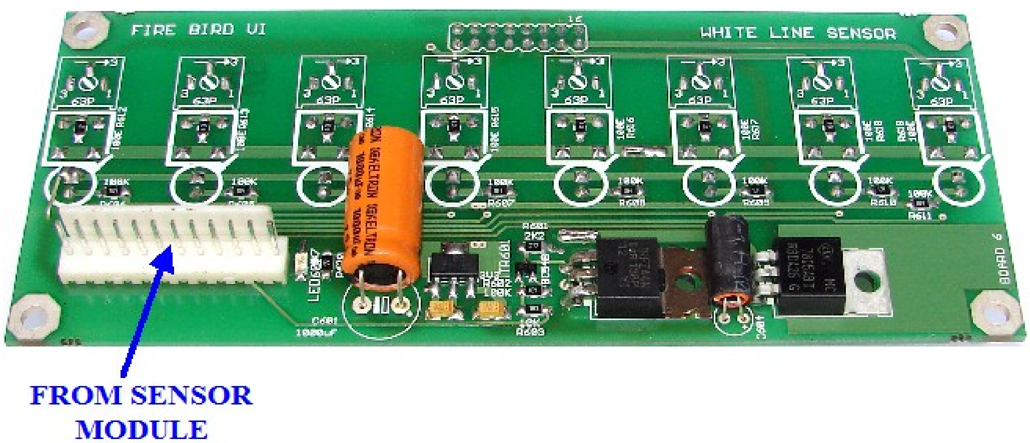



**Figure 3.39: Line Sensor Module Top Side**

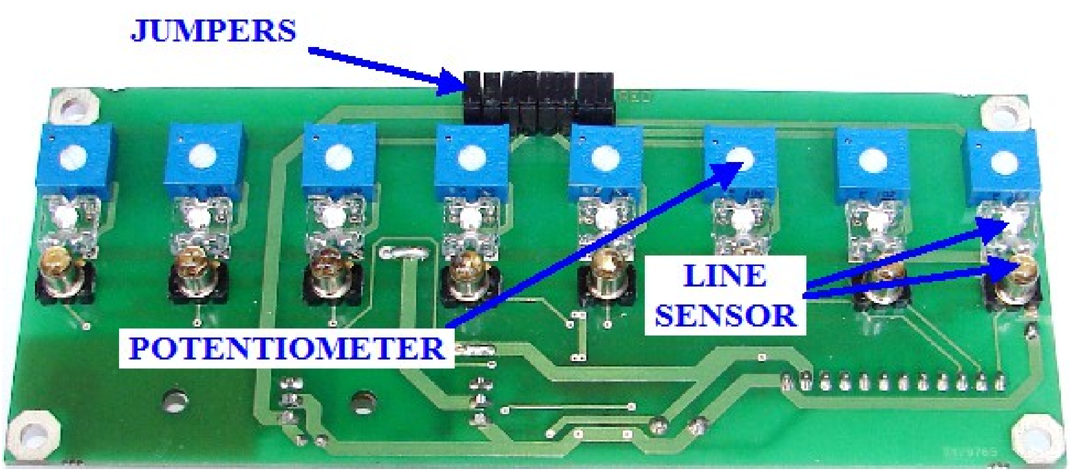



**Figure 3.40: Overview of Line Sensor Module Bottom Side**

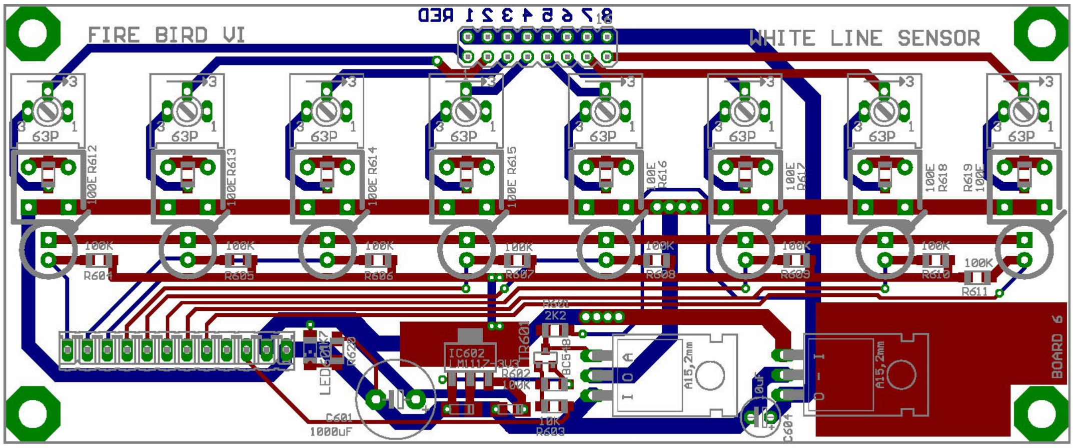



**Figure 3.41: PCB Layout of Line Sensor Module**

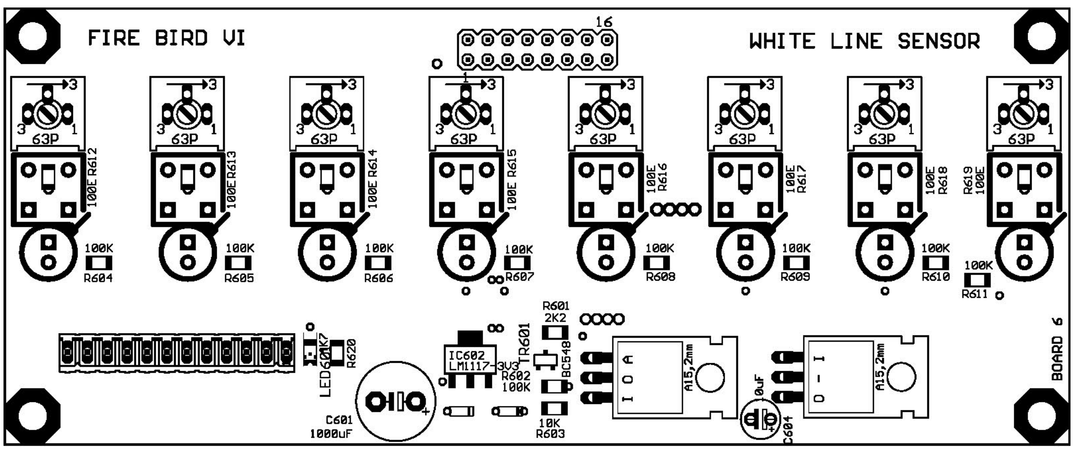



**Figure 3.42 Silkscreen of Line Sensor Module**

**Line Sensor numbering**
Line Sensors are numbered as left to right from 0 to 7 if you look at the robot from top view. Figure 3.38 shows the Line Sensors and its numbering.

**Power saving**
Fire Bird VI has 8 Line Sensors. Illumination LEDs consume about 200mA current. It is possible to turn ON or turn OFF these LEDs by sending specific commands to the sensor module. To save battery power, it is recommended to turn on LEDs 20mSec before taking the readings and turn Off LEDs after taking the readings.

**Interference with the ambient light**
Photo transistors used in the Line Sensor are highly directional in nature. Hence there is very less effect of the ambient light. In order to further nullify the effect of the ambient light you can take reading of the surface when Red LEDs are on and off and nullify the effect of the ambient light. You can also cover the sensors with card paper / metal plate from all side.

**Line sensor calibration**
Line Sensors can be calibrated for optimal performance by potentiometers which are connected in series with the red LEDs (shown in figure 3.26). Sensitivity adjustment is needed when color contrast between the white and non-white surface is not adequate. Figure 3.23 and 3.26 shows jumpers which are connected in series with LEDs and potentiometer. For most of the times it is sufficient to calibrate line sensors by visual means but advance users can also remove jumper corresponding to the particular white line and measure current flowing through LED for precision calibration of the LEDs.

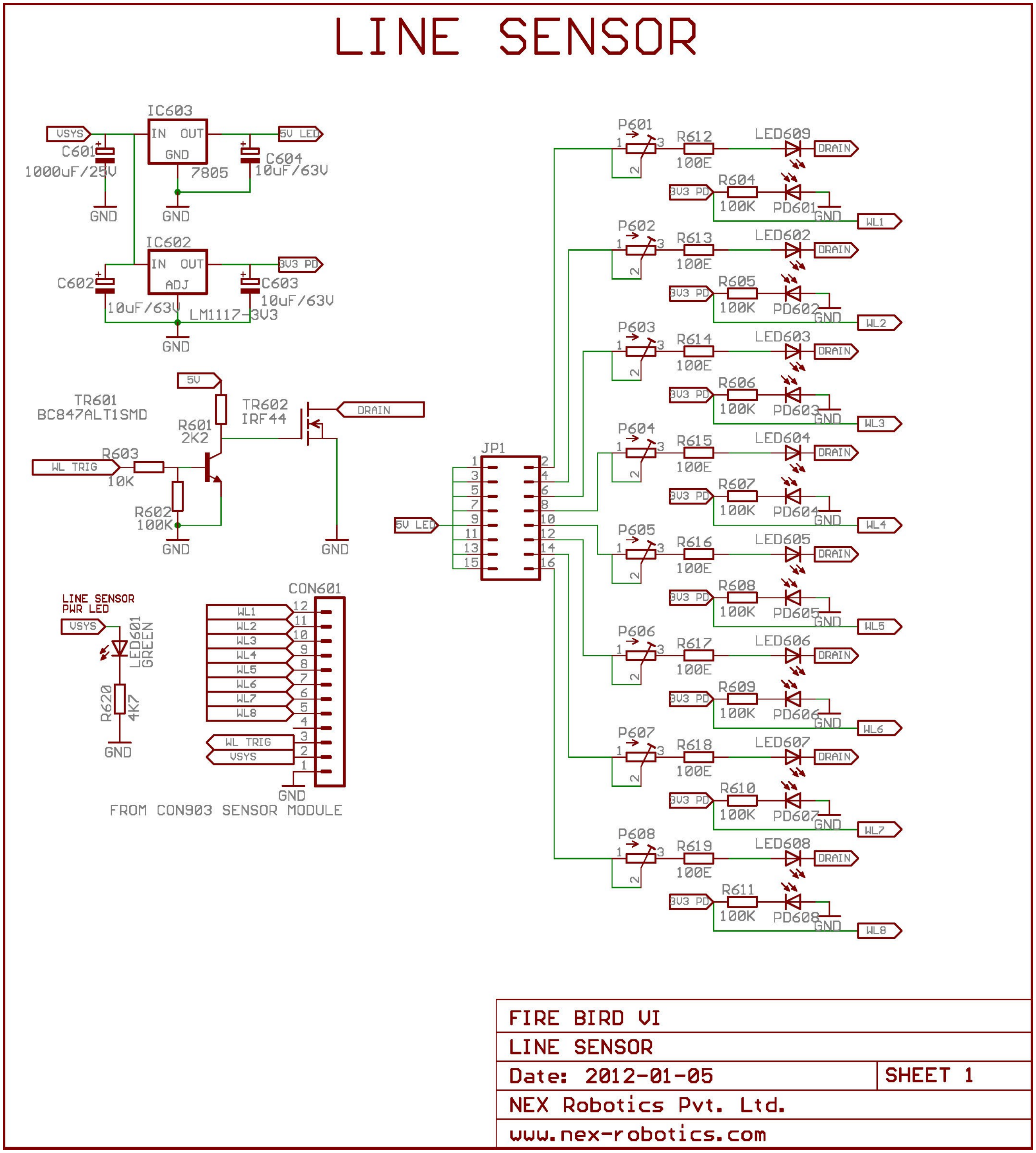



**Figure 3.43: Schematic of Line Sensor Module**

### 3.3.3 Ultrasonic and IR Proximity sensors

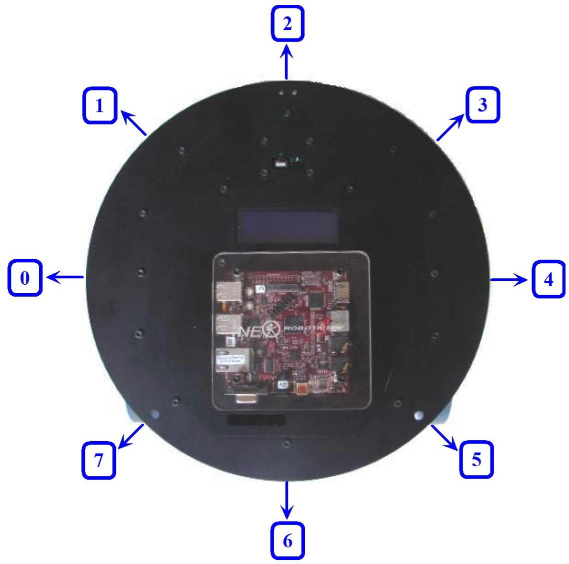



**Figure 3.44: Ultrasonic Range Sensors location and numbering**

Fire Bird VI uses eight EZ4 series ultrasonic range sensors from MaxBotix. These ultrasonic sensors are mounted at an angle of 45 degrees to cover 360 degrees.

Ultrasonic range sensor emits short pulse of 42 KHz frequency and measures time of echo. Based on the round trip time delay, it estimates the distance from an obstacle. EZ4 ultrasonic sensor has narrower beam width which makes it suitable for applications that involve directional ranging. EZ4 ultrasonic distance sensor provides distance in serial, PWM and analog format. For more information on the EZ4 ultrasonic sensor, refer to its manual provided in the documentation CD.

**Ultrasonic Sensor numbering**
Ultrasonic Sensors are numbered in clockwise direction as 0 to 7 if you look at the robot from top view. Figure 3.44 shows Ultrasonic sensor numbering.

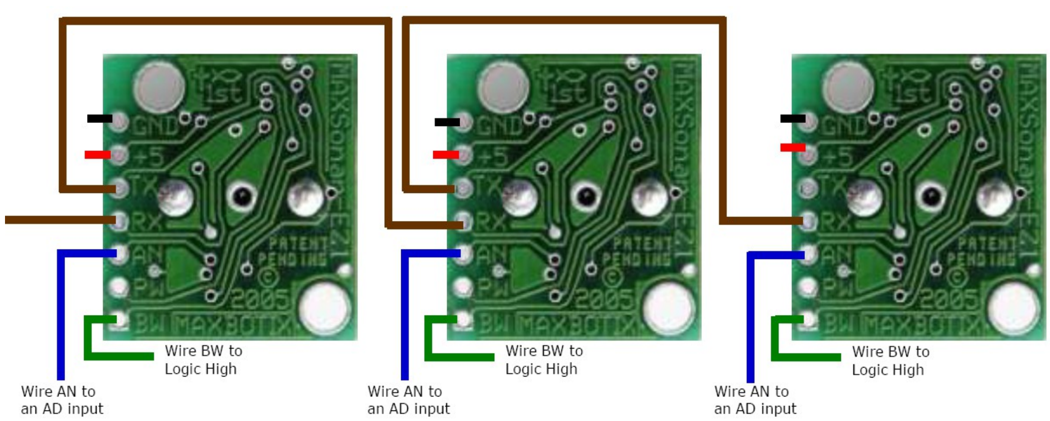



**Figure 3.45: Ultrasonic Range Sensors chaining (Courtesy MaxBotix Inc.)**

**Chaining of the Ultrasonic Sensors**

Ultrasonic range sensors are active sensors i.e. they transmit signal in ultrasonic frequency range to sense the surroundings. If multiple sensors emit signal at the same time then they may interfere with each other. In order to avoid this interference, we need to synchronize them so that at any given instant only one sensor emits ultrasonic pulse. This is achieved by chaining the sensors together. Figure 3.45 shows such chaining scheme. To achieve this, BW pin of all the sensor's is connected to Vcc and the TX of first sensor is connected to the RX of the next sensor. RX of the first sensor is connected to the microcontroller while TX of the last sensor is left unconnected.

**Ultrasonic Sensor Timing**

On power-up sensor takes 250mSec for the self calibration. After that each reading will take 49mSec. When a logic high pulse of more than 20uSec is applied to the RX pin of the first sensor, it takes range reading in 49mSec and then sends trigger pulse from its TX pin to the RX pin of the next sensor. In this way 8 sensors connected in chain completes their range sensing in 49mSec x 8 sensors = 392mSec.

**Interference with other robot's sensors**

If many robots are operating in the same environment then one robot's transmitted ultrasonic pulse may directly affect other robot's obstacle detection readings. In multi-robot environment you can also coordinate the use of sensors with other robots using robot's onboard WiFi / Bluetooth / ZigBee wireless module to insure that at any given instant only one is using its ultrasonic range sensors. For more information on commands to initiate ultrasonic sensor's to take readings, refer to the robot's software manual.

**General Power-Up Instructions (Courtesy MaxBotix Inc.)**

Every time after the LV-MaxSonar®-EZ4™ is powered up, it will calibrate during its first read cycle. The sensor uses this stored information to range a close object. It is important that objects not be close to the sensor during this calibration cycle. The best sensitivity is obtained when it is clear for fourteen inches, but good results are common when clear for at least seven inches. If an object is too close during the calibration cycle, the sensor may then ignore objects at that distance. The LV-MaxSonar®-EZ4™ does not use the calibration data to temperature compensate for range, but instead to compensate for the sensor ringdown pattern. If the temperature, humidity, or applied voltage changes during operation, the sensor may require recalibration to reacquire the ringdown pattern. Unless re-calibrated, if the temperature increases, the sensor is more likely to have false close readings. If the temperature decreases, the sensor is more likely to have reduced up close sensitivity. To recalibrate the LV-MaxSonar®-EZ4™, cycle power, then command a read cycle.

**Blind spot of the Ultrasonic Range Sensors**

MaxBotix EZ4 sensors have range up to 6 meters. However it shows obstacles in the range of 0 inch to 6 inch as 6 inch. It can not detect obstacles closer than 6 inches reliably. Hence to overcome this difficulty, simple reflective short range IR proximity sensors are used to detect presence of obstacles in the range less than 6 inches.

### 3.3.4 IR Proximity Sensors

Infrared proximity sensors are used to detect proximity of any obstacles in the short range. IR proximity sensors have about 15cm sensing range. These sensors sense the presence of the obstacles in the blind spot region of the Ultrasonic range sensors. These sensors can also be used as directional light intensity sensors by turning off IR LEDs. Fire Bird VI robot has 8 IR proximity sensors. Figure 3.32 shows the location of the 8 IR proximity sensors. Sensors are numbered as 1 to 8 from left to right in clockwise direction. In all the manuals this numbering convention will be used for addressing the particular IR sensor.

In the absence of the obstacle there is no reflected light hence no leakage current will flow through the photo diode and output voltage of the photo diode will be around 3.3V. As obstacle comes closer, more light gets reflected and falls on the photo diode and leakage current flowing through the photo diode starts to increase which causes voltage across the diode to fall.

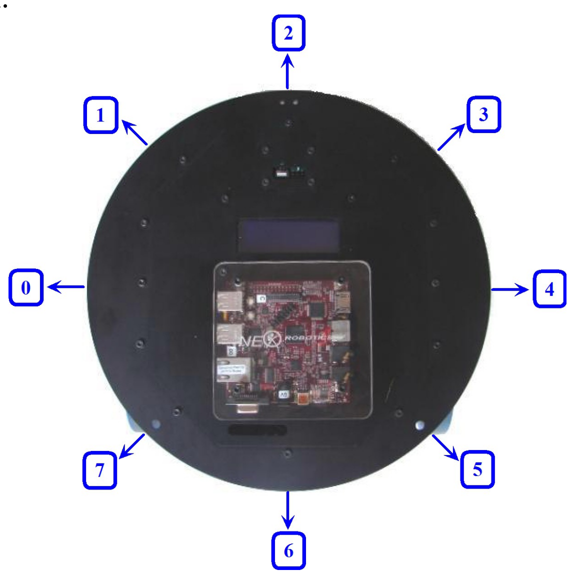



**Figure 3.46: IR Proximity Sensors**

**IR Proximity sensor numbering**
IR Proximity Sensors are numbered in clockwise direction as 0 to 7 if you look at the robot from top view. Figure 3.46 shows IR Proximity sensor numbering.

**Power saving**
Fire Bird VI has total 8 IR proximity sensors. IR LEDs of all these sensors consume about 0.3Amp current. It is possible to turn ON or turn OFF these IR LEDs by sending specific commands to the Sensor Module. For proximity sensing IR LEDs can be turned on 20mS before taking the reading. After all the readings are taken, the IR LEDs can be turned off. For command to turn on or off the sensors, refer to the software manual.

**Interference with the ambient light**

When robot is operated under cold light source such as fluorescent light or CFL then interference due to ambient light is negotiable. If source of ambient light is light bulb or sunlight (even coming from the window), it will saturate the IR receiver and may restrict its sensing range up to 5-6cm. If robot is operated on shiny surface then interference due to ambient light may increase depending upon the angle of the reflection of the light source with respect to the robot.

**Important:**

- Photo diodes are extremely sensitivity to the IR component of Sunlight and up to some extent IR component of filament based bulbs. Robot's IR proximity sensors will go in to hard saturation during daytime even if room has heavy curtains.
- In such case proximity range detection performance can be improved by taking successive readings while illumination LEDs are on and off and ambient IR light's component can be removed.
- Old choke and starter based fluorescent lights blink with 50-60Hz frequency. If room is brightly illuminated by such light then you may find fluctuation in the sensor's reading even though robot is not moving. This is because older fluorescent lights actually blink 50-60 times a second (50-60Hz). In such case, we strongly recommend to use new electronic chock based lights or CFL lights which run on 20KHz.

**Interference with other robot’s sensors**

If many robots are operating in the same environment then one robots transmitter will directly affect other robot’s receiver even from few feet of distance. You can switch off power to the IR LED by sending specific command to the sensor module. You can also coordinate with other robots using robot’s WiFi / Bluetooth / ZigBee wireless module to ensure that at any given instant only one robot’s IR LEDs remain active.

**Directional ambient light sensing**

If IR LEDs are switched off, then same photo diodes can be used for directional ambient light sensing. Shiny reflective surface may affect sensors directionality significantly.

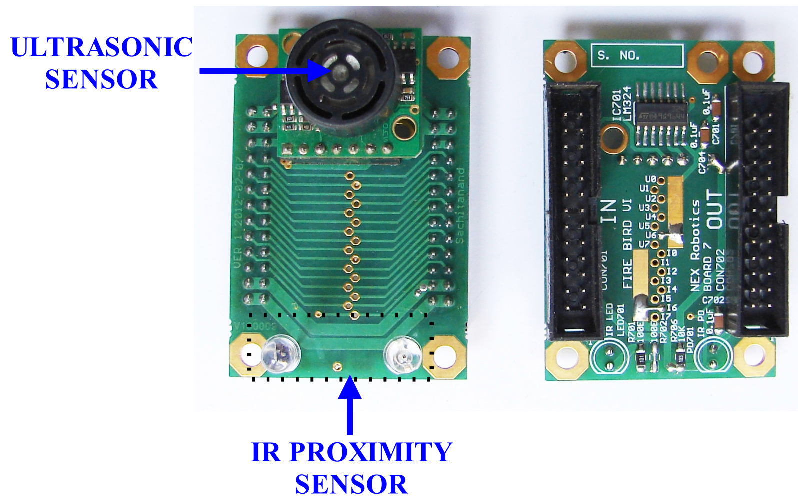



**Figure 3.47: Ultrasonic and IR Proximity Sensor board**

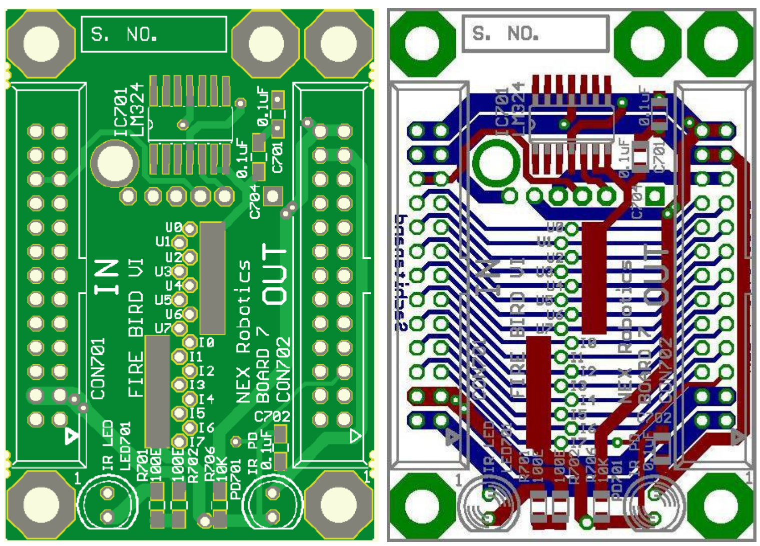


**Figure 3.48: PCB Layout of Ultrasonic and IR Proximity Sensor board**

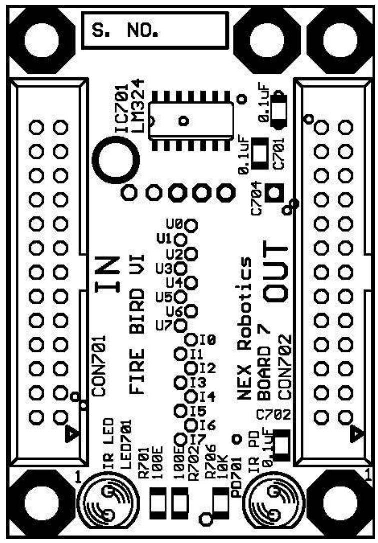



**Figure 3.49: Silkscreen of Ultrasonic and IR Proximity Sensor board**

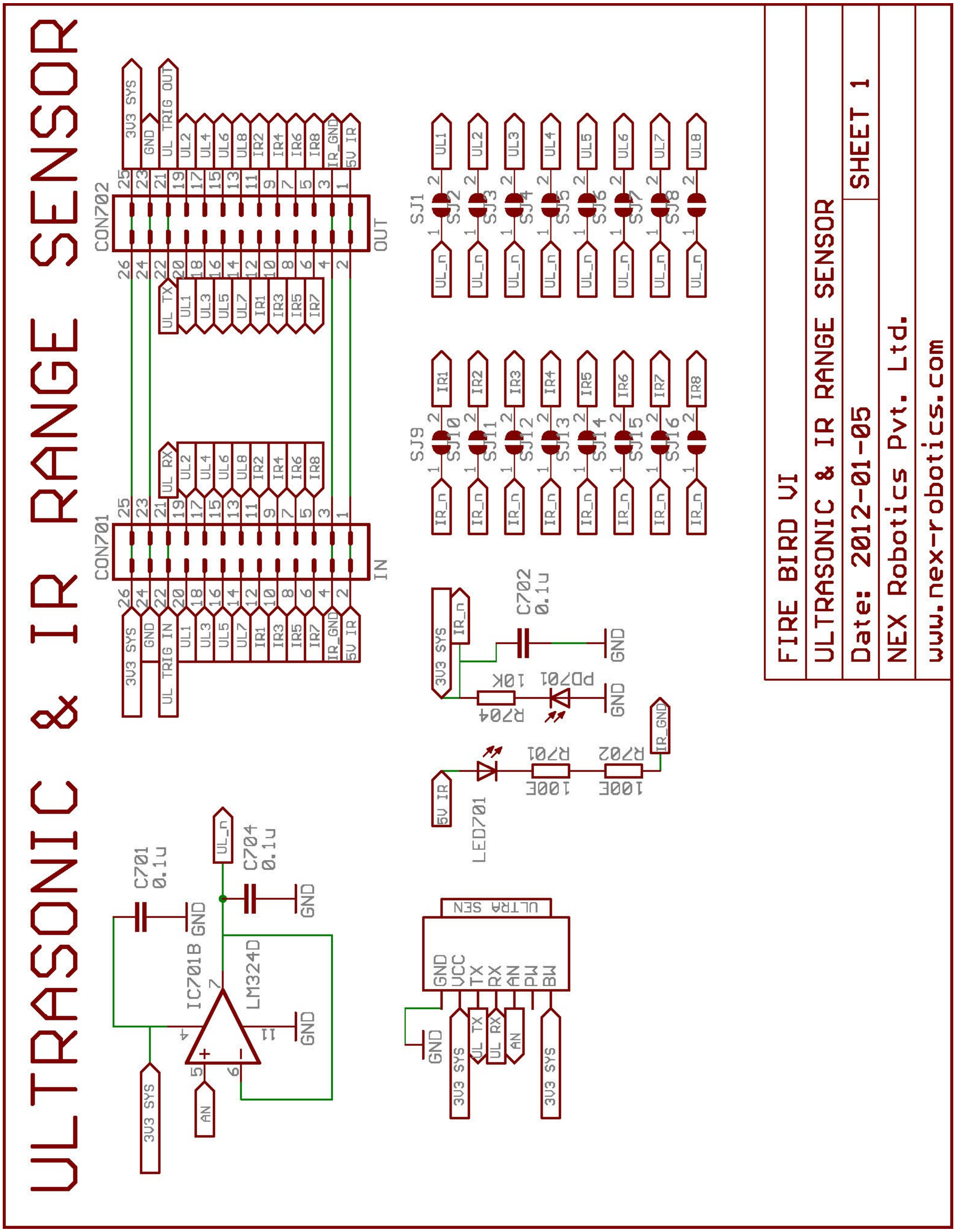



**Figure 3.50: Schematic of Ultrasonic and IR Proximity Sensor board**

## 3.4 Motion Control

Fire Bird VI robot uses two DC geared motors with magnetic hall effect position encoders and a dedicated motion control board. Motion controller is connected to the LPC1769 main controller over UART 2 via cable harness number 8 which has 3 pin relimate connector on one side and 4 pin 2510 relimate connector on other side. The axial distance between the left and the right wheel is 276 mm. The wheels are located on the rear side of the robot.

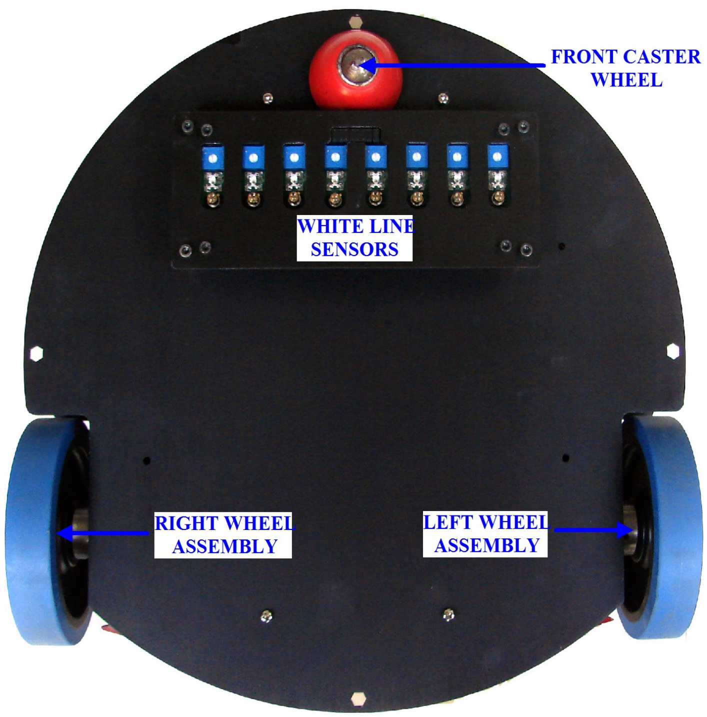



**Figure 3.51: Fire Bird VI bottom view**

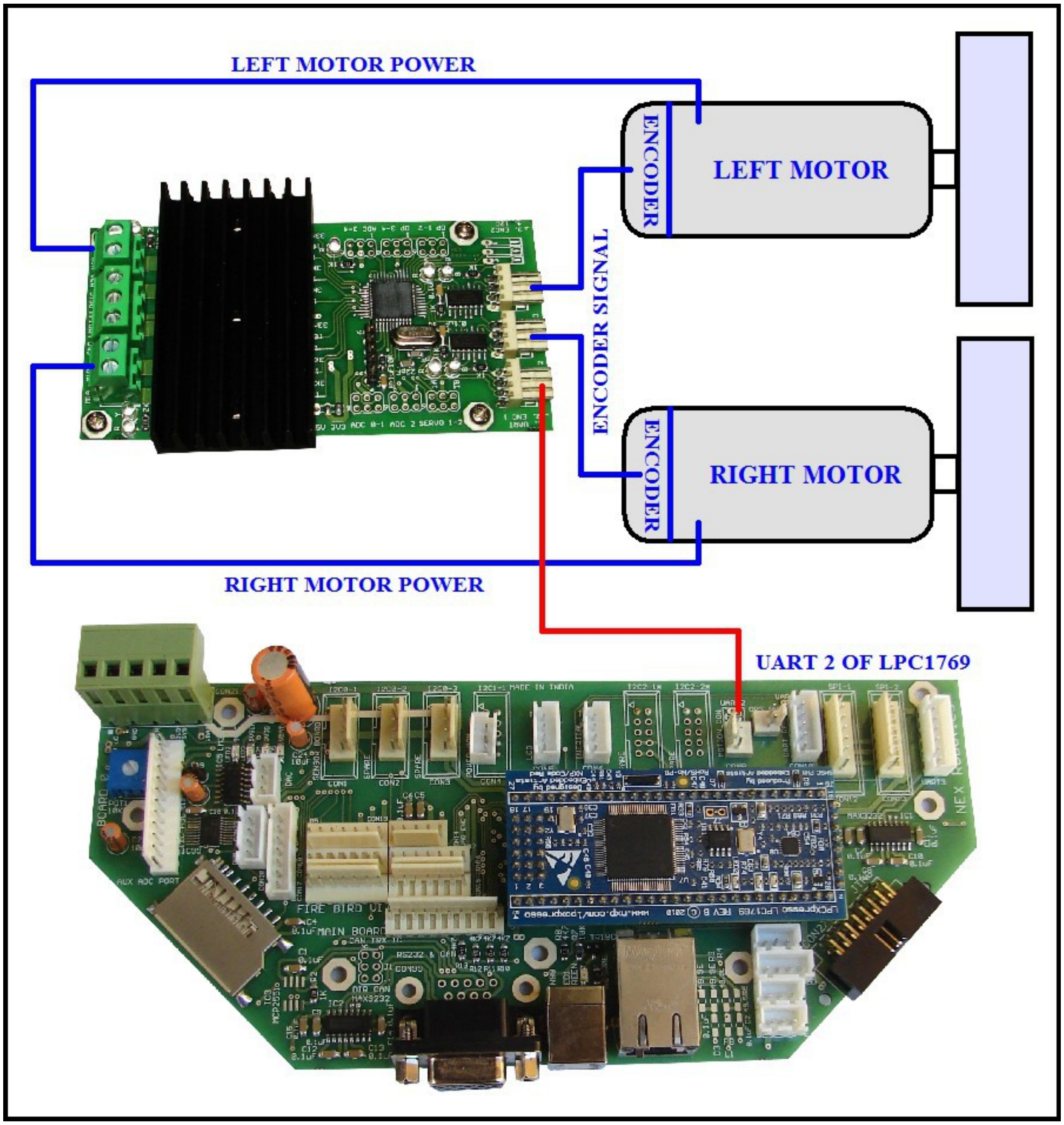



**Figure 3.52: Motion control module connections**

### 3.4.1 DC Motors

Fire Bird VI uses geared DC motors for locomotion. Motors have a top speed of 200RPM. The gearbox has gear ratio of 30:1. Each motor gives about 10Kg-cm stall torque. Each motor has hall effect quadrature position encoder which provides 360 pulses per revolution of the output shaft. Robot has two 98mm diameter wheels with special type of rubber for high grip. Each wheel has a 20mm wide rubber tread.

### 3.4.2 Motion Controller

Fire Bird VI has a dedicated motion controller for controlling motors in open loop, closed loop velocity and closed loop position control mode.

**Motion controller supports following modes:**

**Mode 0: Open loop velocity control**
This is the simplest mode of operation. In this mode, amount of power to be given to the motor can be specified. This is open loop control mode. In this mode robot has the quickest response but there is no velocity or position control.

**Mode 1: Closed loop velocity control**
This is closed loop velocity control mode. In this mode, robot follows exactly the specified velocity. Robot will go exactly straight and will maintain its velocity even while climbing and going down the slope. It is the most useful mode in the robot.

**Mode 2: Position control mode**
In this mode, robot goes from point A to Point B with specified distance. The distance is specified in terms of encoder counts for each motor. Robot's maximum velocity and acceleration for the position control can be set.

**Important:**

- Robot has top speed of 80 cm/second. If because of erroneous algorithm or erroneous command given by a user, the robot goes at the top velocity and collides with a wall, then it will damage itself and the wall as well. In order to prevent this, robot has safety mode which restricts it's top velocity. To run robot at top velocity user needs to give a specific command to turn off this safety mode.

- In all the three modes, robot's acceleration can be set between 0 to 9. 0 being slowest and 9 being fastest. For more information regarding the motion control commands, refer to the software manual.

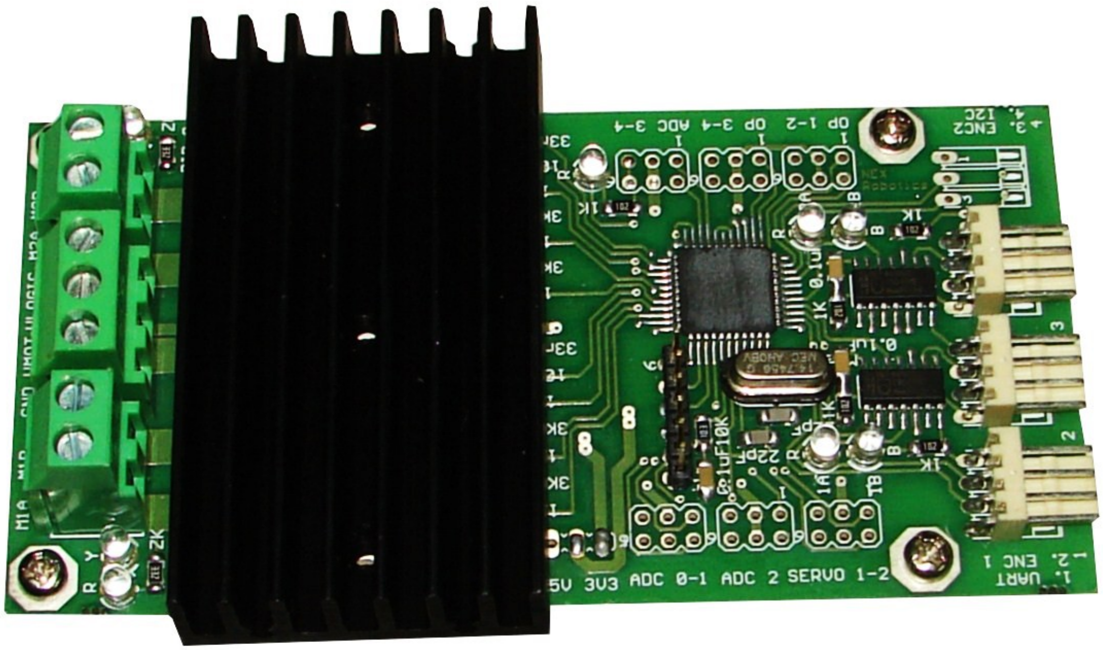


Figure 3.53: Motion controller

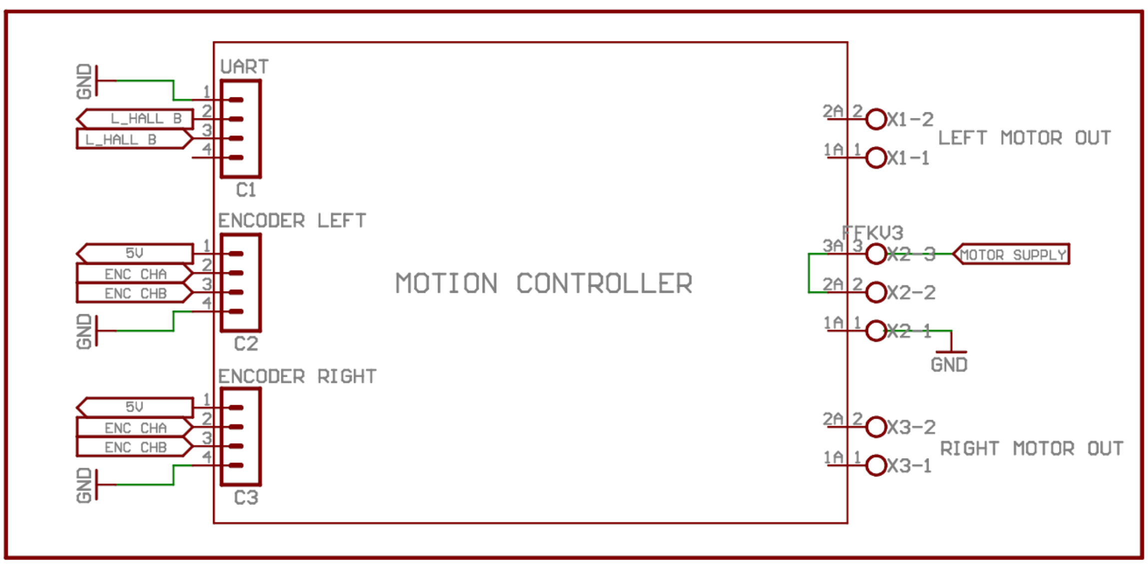



Figure 3.54: Motion controller schematic

### 3.4.3 Position calculation

Calculation of position encoder resolution:

**Case 1: Robot is moving forward or backward (encoder resolution is in mm)**

Wheel diameter: 98 mm
Wheel circumference: 98 mm * 3.14 = 307.72 mm
No. of counts in 1 rotation of output shaft: 360
Number of counts per 1 mm distance traveled = 360 / (3.14 x 98) =1.16
Or
Distance traveled per count = (3.14 x 98) / 360 = 0.8547mm = 854.7 microns.

**Case 2: Robot is turning with one wheel rotating clockwise while other wheel is rotating anti clockwise.**

Center of rotation is at the center of line passing through wheel axle and both the wheels are rotating in opposite direction (encoder resolution is in degrees)

Distance between Wheels = 276 mm

Radius of Circle formed in $360^0$ rotation of Robot = Distance between Wheels / 2
= 138 mm

Distance Covered by Robot in $360^0$ Rotation = Circumference of Circle traced
= 2 x 138 x 3.14
= 866.64 mm

Total pulses in $360^0$ Rotation of Robot
= Distance Covered by Robot in $360^0$ Rotation * Number of counts per 1 mm distance traveled
= 866.64 x 1.16
= 1005.30 (approximately 1005)

Position Encoder Resolution in counts = 1013 / 360
= 2.79 counts / degree

**Case 3: Robot is turning with one wheel stationary while other wheel is rotating clockwise or anti clockwise.**

Center of rotation is center of the stationary wheel (encoder resolution is in degrees)

In this case only one wheel is rotating and other wheel is stationary so robot will complete its $360^0$ rotation with stationary wheel as its center.
Radius of Circle formed in $360^0$ rotation of Robot = Distance between Wheels
= 276 mm

Distance Covered by Robot in $360^0$ Rotation = Circumference of Circle traced
= 2 x 276 x 3.14
= 1733.28 mm

Total pulses in $360^0$ Rotation of Robot
= Distance Covered by Robot in $360^0$ Rotation * Number of counts per 1 mm distance traveled
= 1733.28 mm x 1.16
= 2010.60 (approximately 2011)

Position Encoder Resolution in counts = 2011 / 360
= 5.58 counts / degree

## 3.5 Wireless Communication

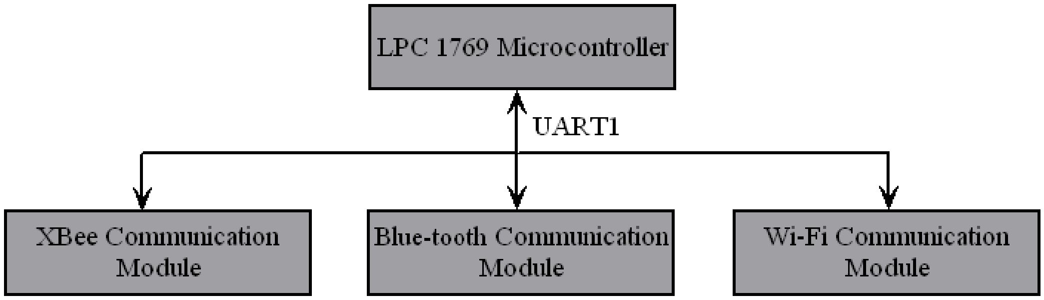



**Figure 3.55: Block Diagram of wireless communication modules on Fire Bird 6**

Fire Bird VI supports three different modes of wireless communication, viz. XBee, Bluetooth and Wi-Fi. Any one of these three modules can be used at a time. These wireless communication modules on Fire Bird VI are connected to the UART1 of the LPC1769. Depending on the configuration ordered, any of these modules will be present in the robot. For more information on each wireless module, refer to their product manual and the software manual.

Wireless module board is connected with the main board using wire harness 5 which has 5 pin JST connector on the one side and 5 pin 2510 relimate connector on the other side.

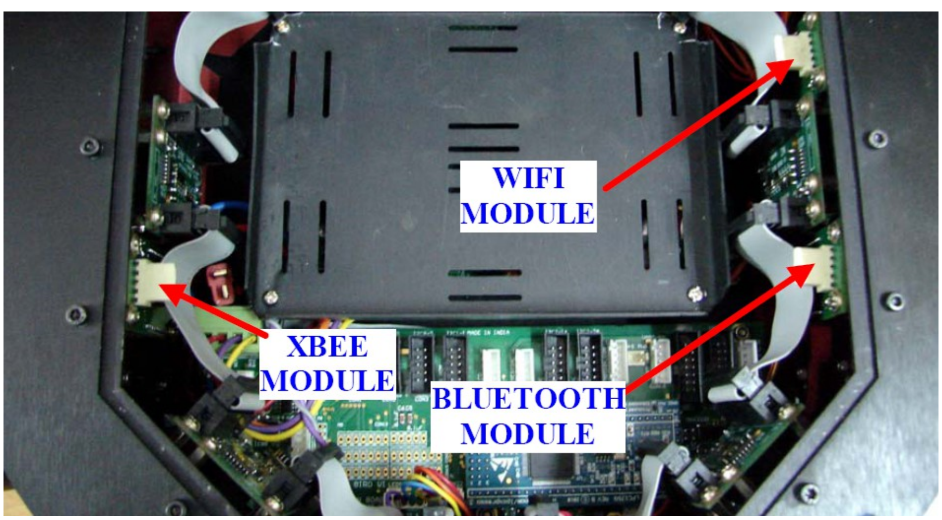



**Figure 3.56: Connectors for XBee, Wi-Fi and Bluetooth on Fire Bird VI**

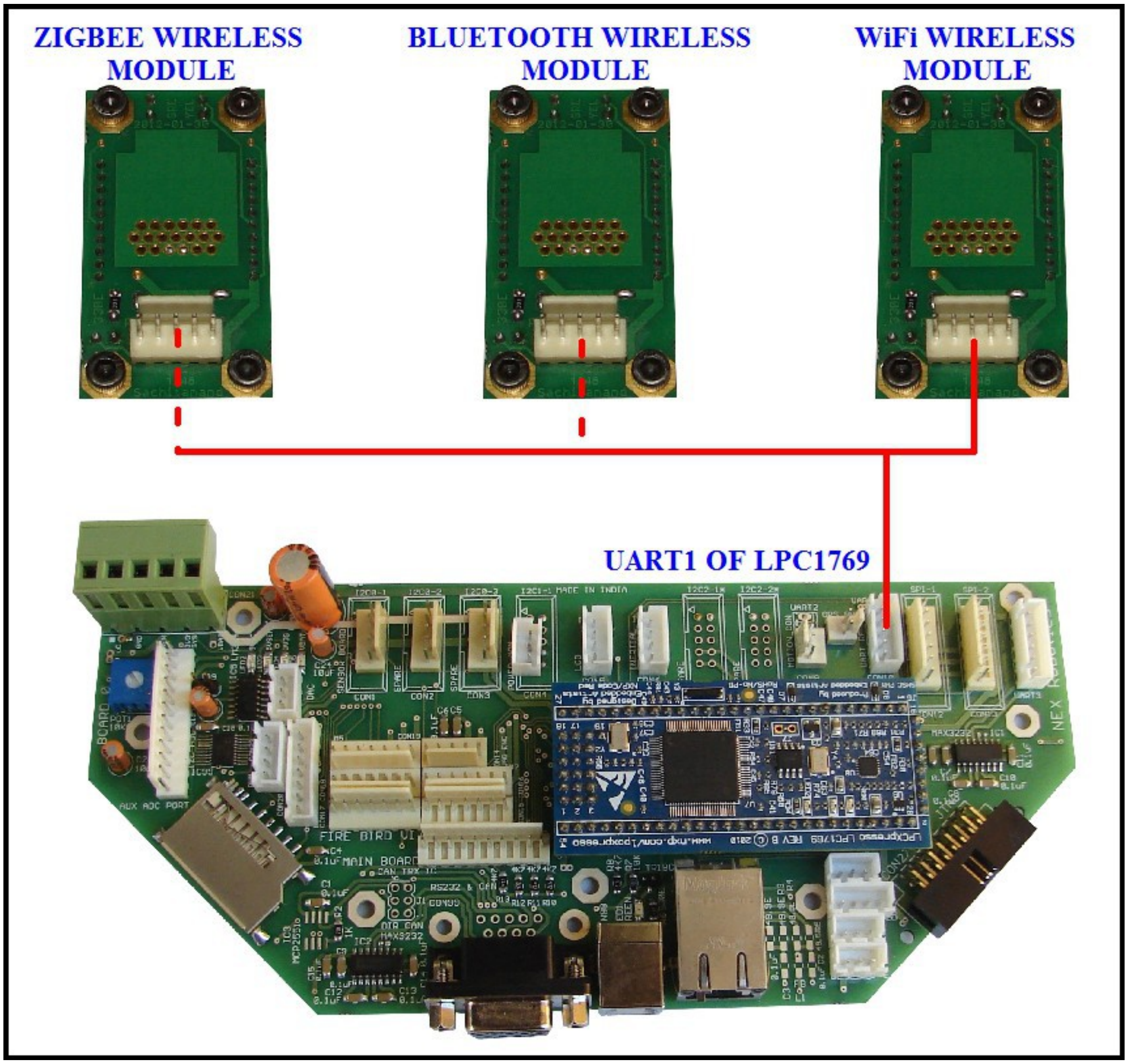



**Figure 3.57: Connecting wireless module on the robot**

**Important:**
Only one wireless module can be connected at a time to the UART1 of the LPC1769.

## 3.6 Serial LCD Interface

A 20x4 characters alphanumeric Serial LCD module is used for displaying various messages and data. LCD communicates with the main board using I2C1 on LPC1769 main controller using wire harness 11 having 4 pin JST connector on one end and 4 pin relimate connector on the other side. The 4-pin relimate connector from LCD module is connected to CON5 (LCD connector) on main board. Communication protocol is covered in the software manual and Serial LCD's product manual.

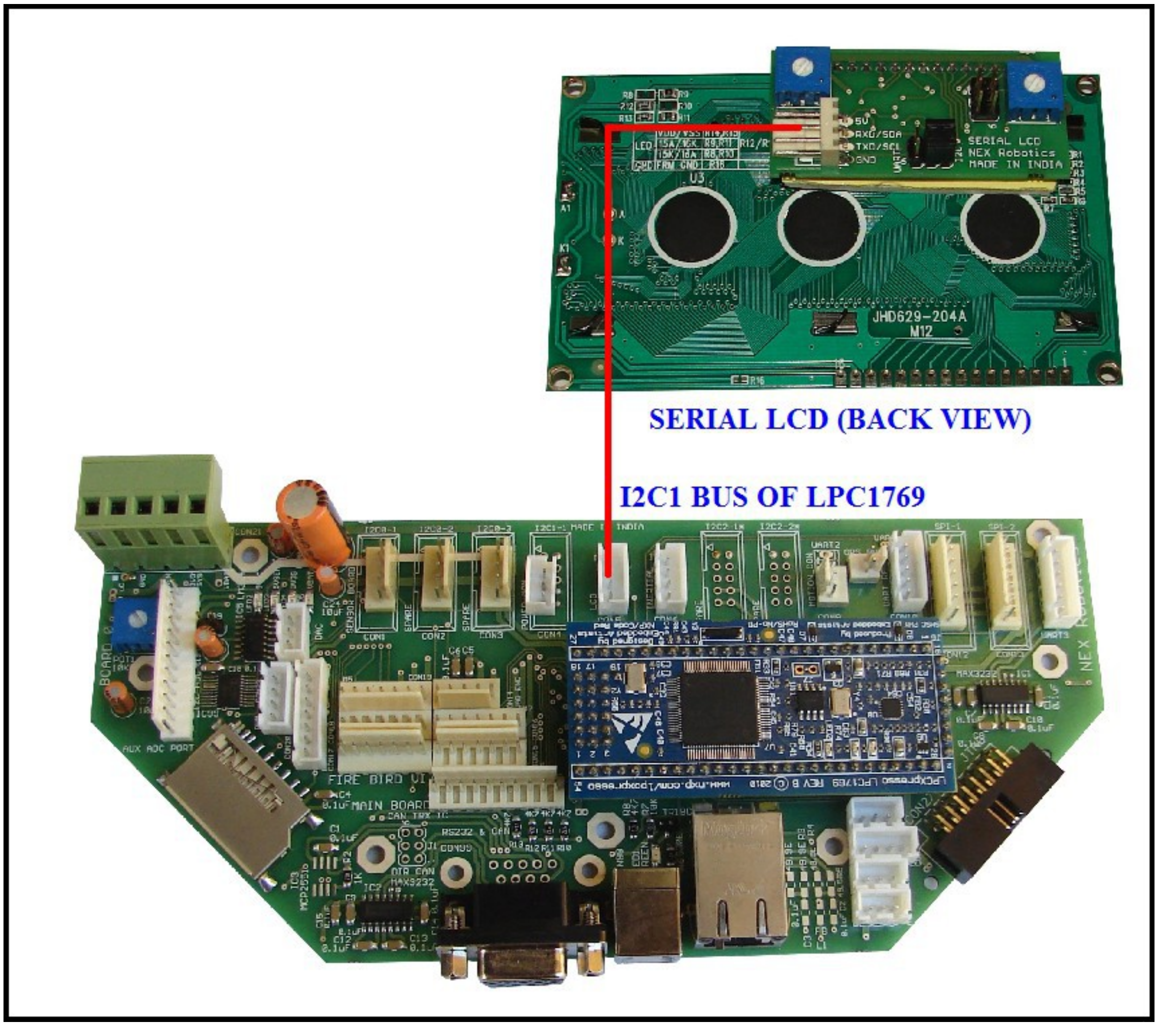



**Figure 3.58: Pin configurations of LCD module**

| Connector pin No. | Purpose |
|---|---|
| 1 | Ground |
| 2 | SCL/Rx |
| 3 | SDA/Tx |
| 4 | Vcc |

**Table 3.4A: LCD module Pin Configuration**

# 3.7 Servo Pod interfacing board

Servo pod interfacing board is used for moving Servo pod having wireless camera / Ultrasonic range sensor / Sharp IR Range sensor in pan and tilt direction. Servo pod's servo motors and sensors are connected to the Servo expansion board. Figure 3.59 shows the top and bottom view of the Servo expansion board. Servo motors are connected to the connectors S1, S2, S3. PWM control signal for the servo motors is generated by Sensor uC board. Cable harness number 2 is connected between Connector "PWM CON EXTN" on the servo expansion board and the "CON905" of the Sensor uC board. Power to the servo motors is provided by 2 pin XY connector from the system power board. For more information on the connections, refer to figure 3.65

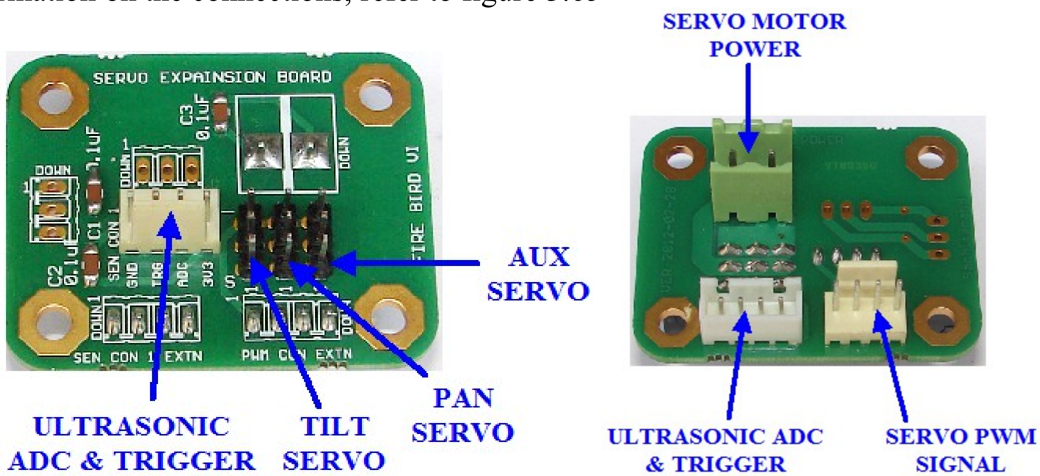



**Figure 3.59: Servo Expansion Board top view**

If Servo pod is mounted with the ultrasonic range sensor then it is connected to the "SEN CON 1" on the servo expainson board. Connector "SEN CON 1" is internally connected to the connector "SEN CON 1 EXTN" on the same board. Cable harness number 6 is connected between "SEN CON 1 EXTN" of the expainson board and "CON30" on the main board. Which is connected to the ADC0.1 of the LPC1769 microcontroller.

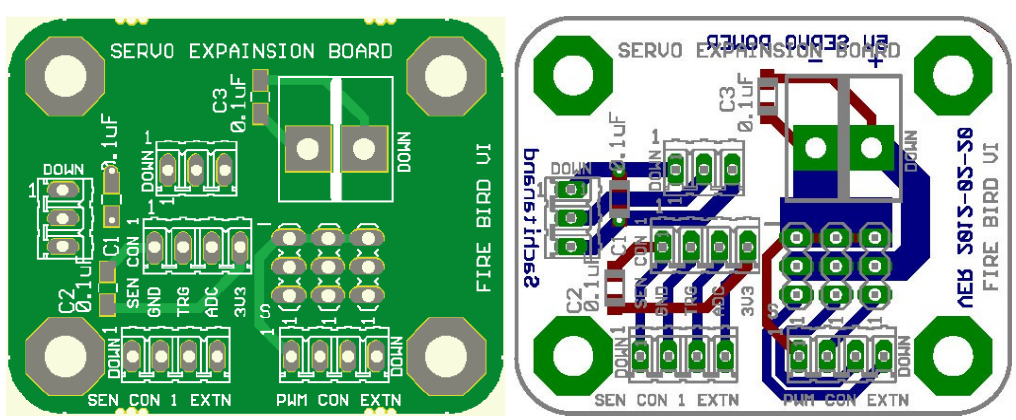



**Figure 3.60 PCB layout Servo Expansion Board**

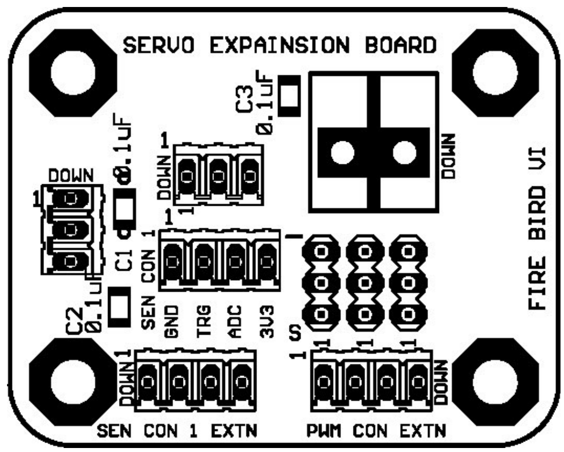


Figure 3.61: Silk screen Servo Expansion Board

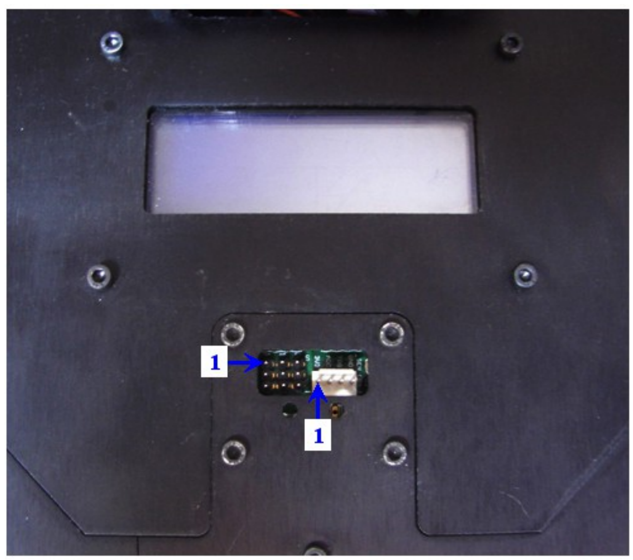



**Figure 3.62: Pin no. 1 of servo motor connector and sensor pod connector**

| Servo | Connector | Purpose |
|---|---|---|
| 1 | S1 | Pan Servo Motor |
| 2 | S2 | Tilt Servo Motor |
| 3 | S3 | Aux Servo Motor |

**Table 3.4: Servo Motor Connections**

| Connector pin No. | Purpose |
|---|---|
| 1 | PWM input signal |
| 2 | 5V DC |
| 3 | Ground |

**Table 3.5: Servo motor connector pin connections**

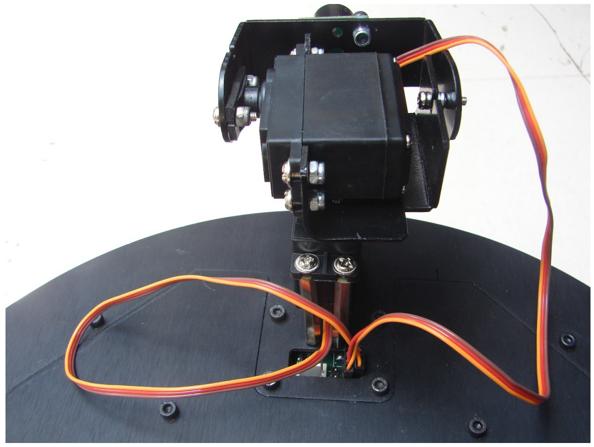


**Figure 3.63: Camera pod on Fire Bird 6**

**Sensor interface connector:**

The 4-pin relimate connector (CON804) of servo expansion board is used for Ultrasonic sensor interfacing. Table 3.6 shows the pin configuration for Ultrasonic ADC & Trigger connector.

| Connector pin No. | Purpose |
|---|---|
| 1 | 3V3 System |
| 2 | AD0.0(Analog signal) |
| 3 | P1.24(Trigger) |
| 4 | Ground |

**Table 3.6: Ultrasonic ADC & Trigger Connector Pin Configuration**

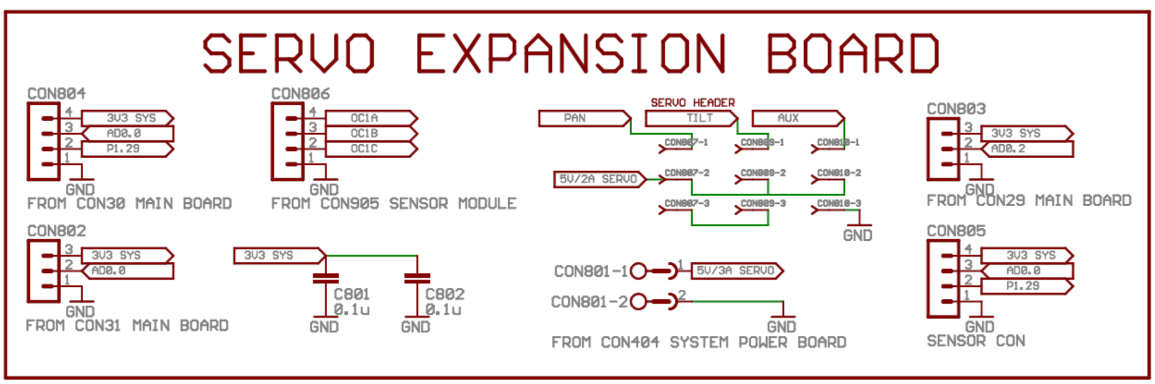



**Figure 3.64: Servo expansion board schematic**

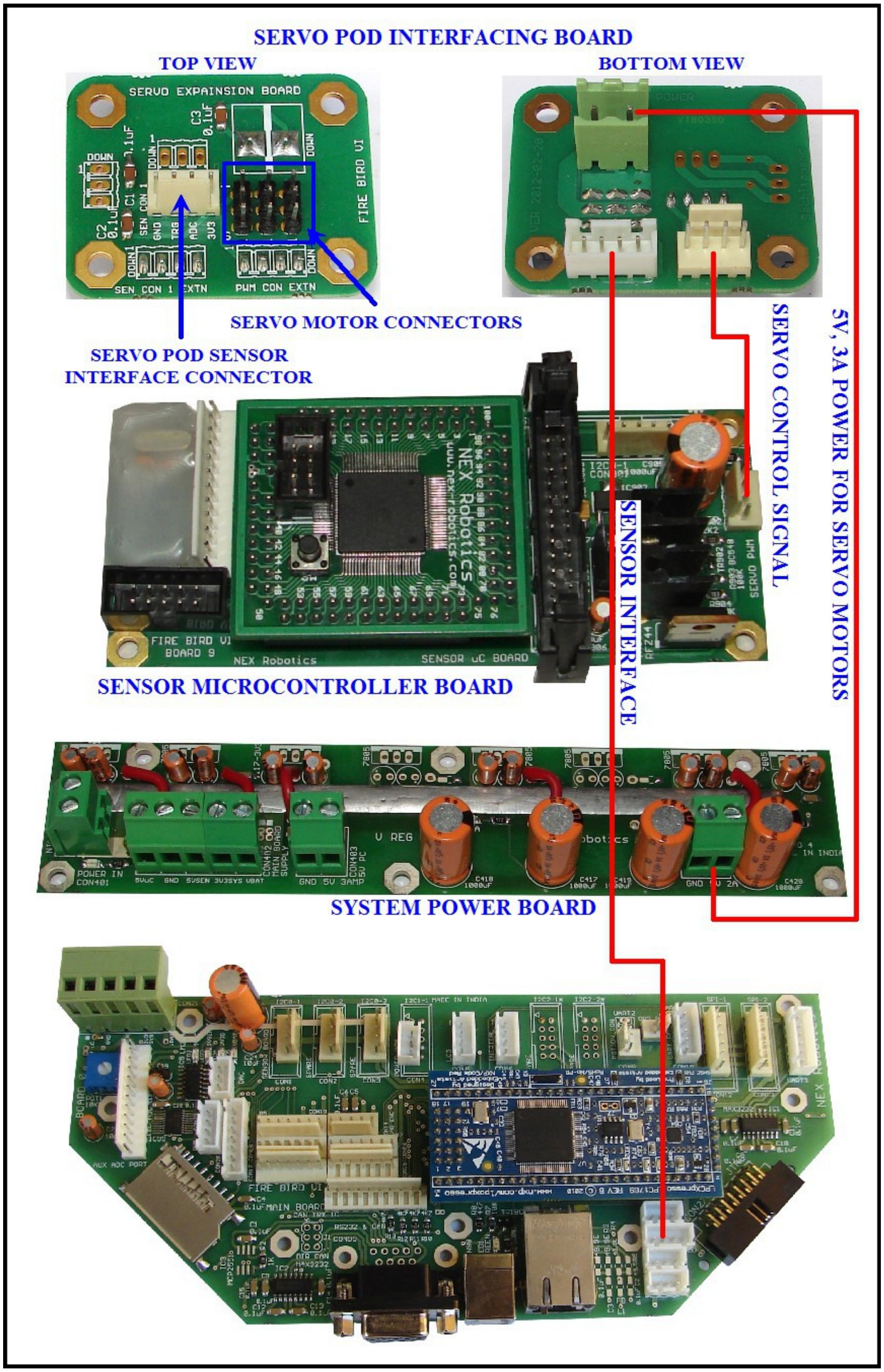



**Figure 3.65: Servo sensor pod interfacing**

## 3.8 GPIO Panel

GPIO panel is mounted on the rear side of the Fire Bird VI robot. The GPIO contains power status LED, reset switch, potentiometer, four general purpose switches and four LEDs for user applications. All the signals for GPIO board are connected to the LCP1769 microcontroller using CON24 (LED & SW connector) on GPIO Board and CON22 on Main Board. POT 2 is connected to the ADC0.5 of the LPC1769 microcontroller on CON28 of the main board using wire harness number 7AB having 3 pin JST connector on one end and 3 pin 2510 relimate connector on the other end.

Port pin allocation of LPC1769 microcontroller for GPIO board is given in table below.

| Port pin no. | Components |
|---|---|
| P1.25 | LED1 |
| P1.26 | LED2 |
| P1.27 | LED3 |
| P1.28 | LED4 |
| P2.10 | SW1 |
| P2.11 | SW2 |
| P2.12 | SW3 |
| P2.13 | SW4 |
| NC | POT1 |
| ADC0.5 | POT2 |

**Table 3.7: Ultrasonic ADC & Trigger Connector Pin Configuration**

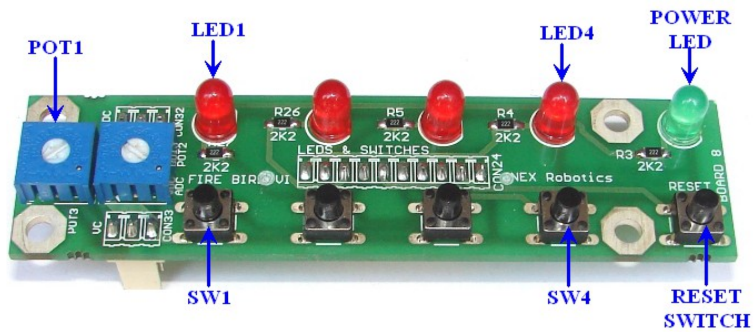



**Figure 3.66: GPIO board top view**

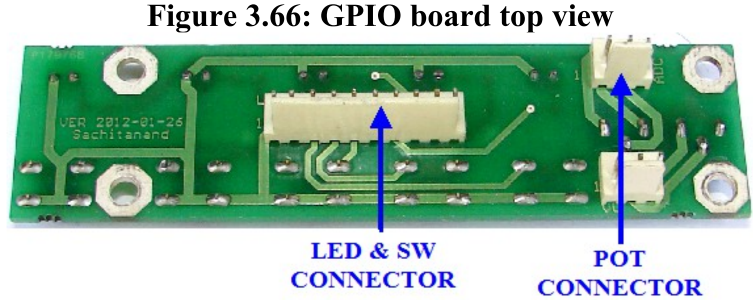



**Figure 3.67: GPIO board bottom view**

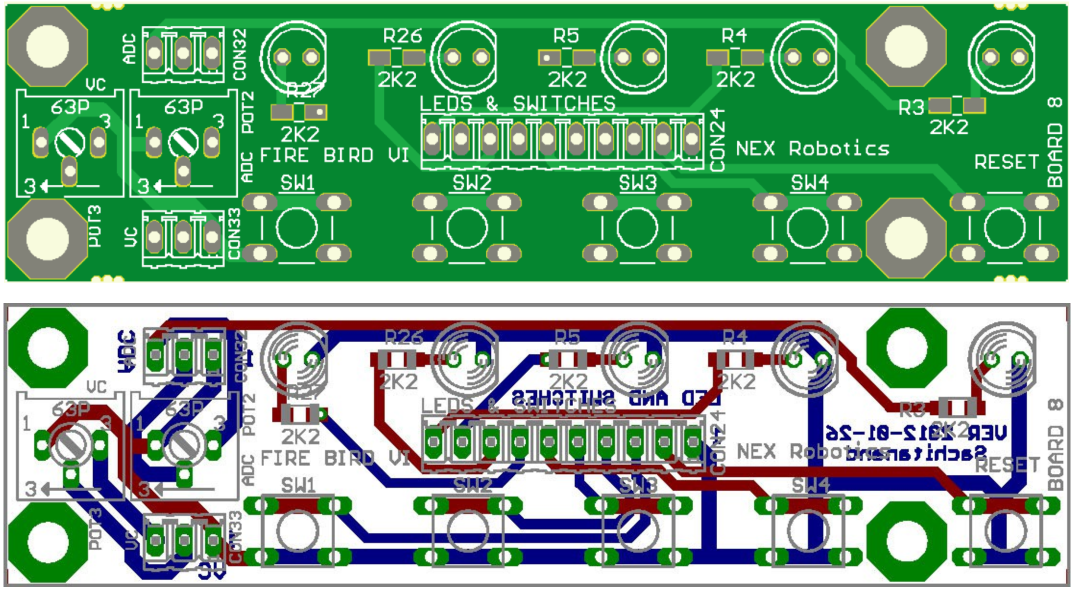



Figure 3.68: GPIO board PCB Layout

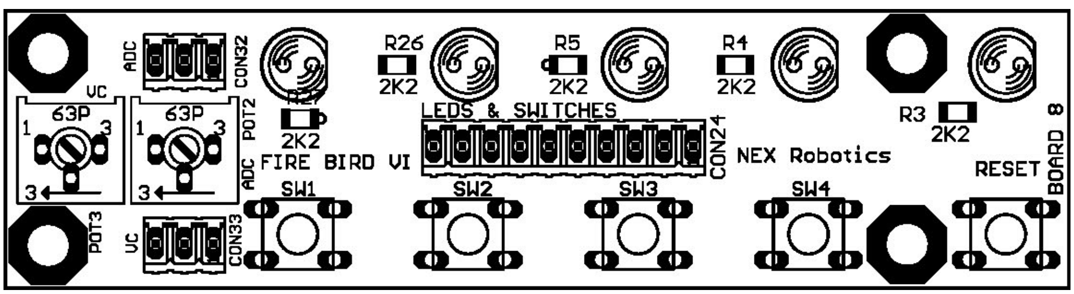



Figure 3.69: GPIO board Silk screen

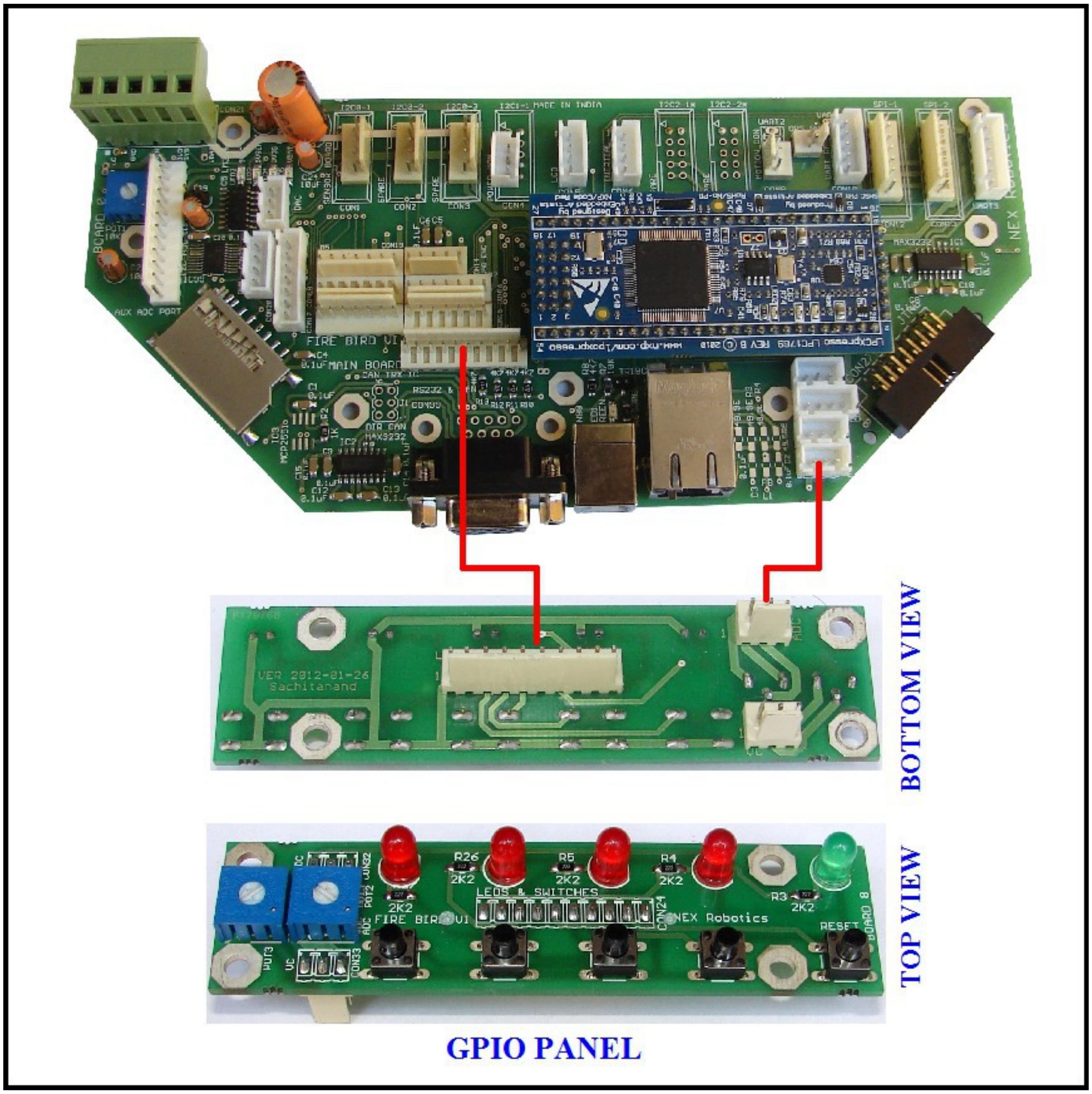



**Figure 3.70: GPIO panel interfacing**


**Figure 3.71: Back side switch and LED panel**

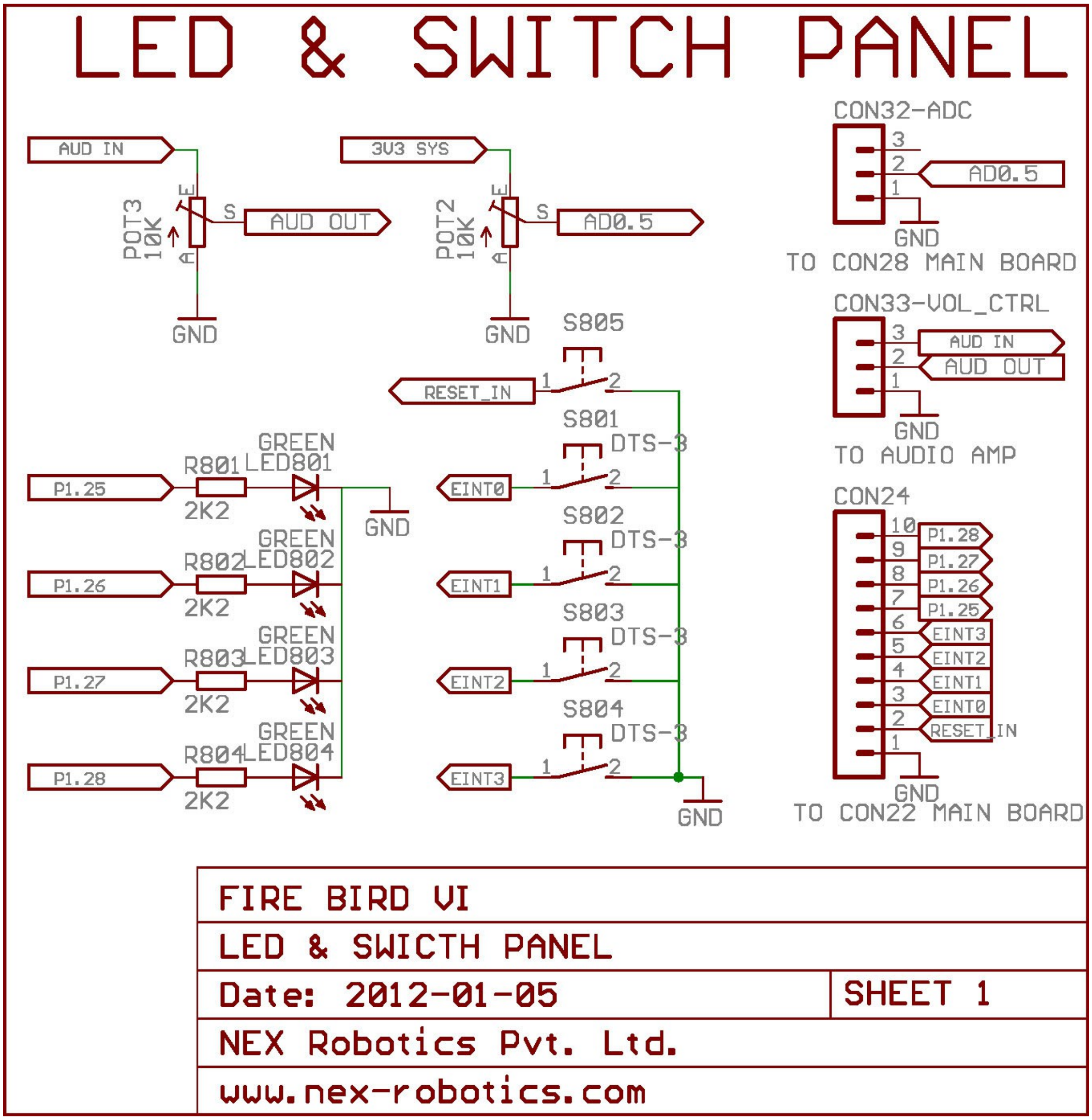



**Figure 3.72: GPIO board schematic**