0X DELTA

ROBOTIC RESEARCH PLATFORM

Hardware Manual

NEX ROBOTICS

Designed and Manufactured by: Nex Robotics Pvt. Ltd.

Disclaimer

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This document provides information about 0X Delta robot.

User may find few hardware changes in robot if it is integrated with add on accessories like on board computer, sensors, servo pods or camera interfacing.

Version 3.02
February 7, 2018

Read sentences carefully which are marked with ⚠caution symbol.

⚠Important:

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

⚠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 anti static environment and user is wearing anti static strap.
- ✔ 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 battery only with the charger provided with the robot.
- ✔ Charge the battery in the open area and on the concrete or ceramic flooring.
- ✔ Never allow battery to deep discharge. If it is 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.

⚠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.

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 Technical specifications

Figure 1.1: 0X Delta Robot

⚠ **Emergency stop button:**

When this button is pressed, the robot will immediately stop. Robot will be disconnected from power supply. This state can be reset by unlocking the emergency stop button by turning the switch clockwise.

Note: Figure 1.1 shows 0X Delta robot equipped with add on accessories. Based on users requirements robot may look different in case of absence or presence of on board accessories.

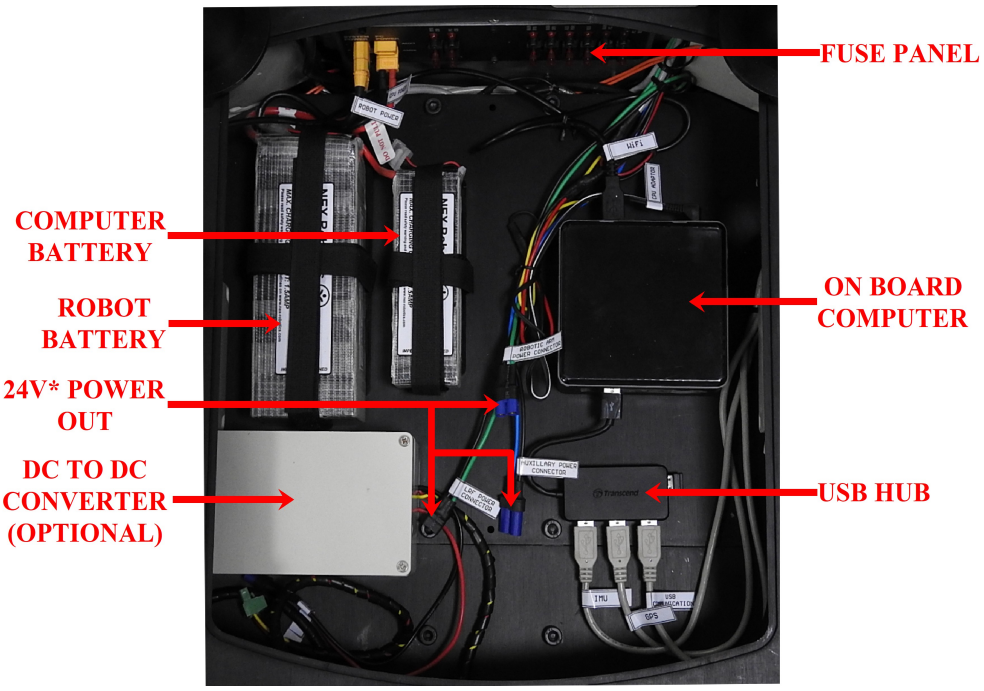

Figure 1.2a: Internal structure of 0X Delta robot (Version 1)

Note: Internal structure of robot will have few changes if robot is not integrated with on board computer.

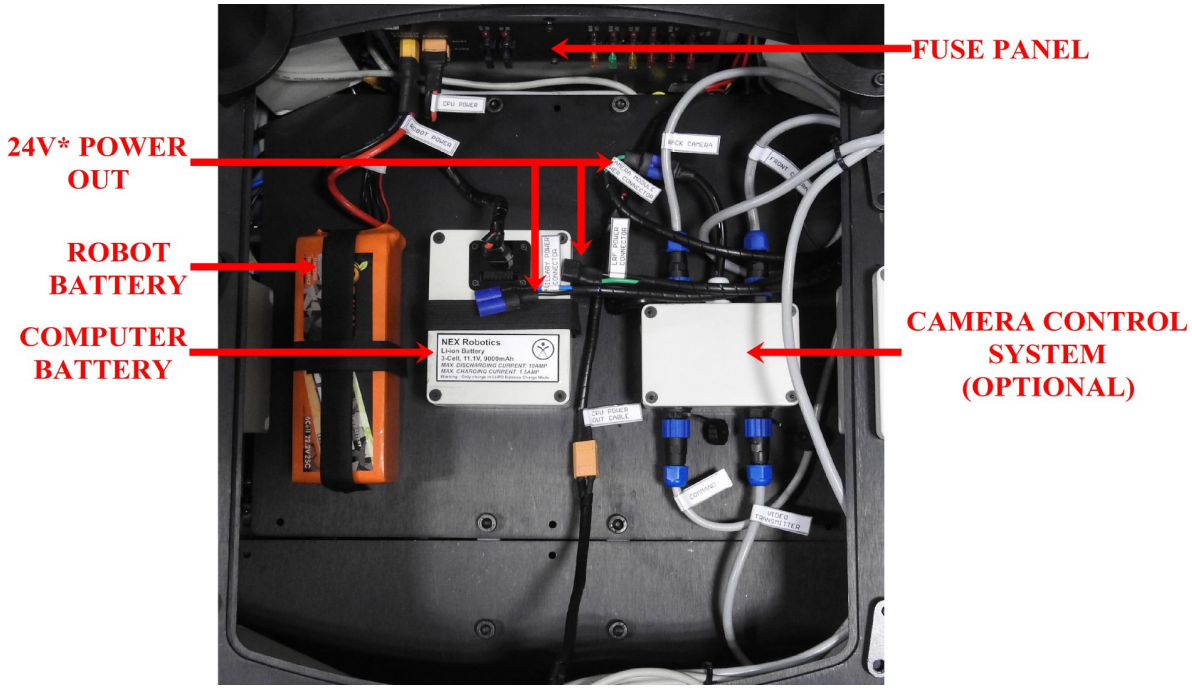

Figure 1.2b: Internal structure of 0X Delta robot (Version 2)

Sr. No.	Component	Specification
1	Drive	4 wheel Differential drive
2	Size	Length: 934mm Width: 670mm Height: 339mm (Without any payload)
3	Ground Clearance	90mm
4	Weight of the robot	30 Kg
5	Payload carrying capacity	30 Kg
6	Traversable slope	30 Degree
7	Maximum negotiable vertical obstacle (step) height	100 mm
8	Wheel Diameter	260mm
9	Axle Length	590mm
10	Terrain	Off-road (unpaved road), concrete, gravel, grass, soil, floor
11	Travel Speed	Max speed 2 m/sec with payload of 3 Kg
12	Operation time	>= 2 hours (when robot is fully operational with continues full velocity)
13	Operating Temperature	0 to 45 degree Celsius
14	Power	System Power: 6 Cell, 25.2V Lithium Polymer battery PC Power: 4 cell OR 3 Cell, Lithium-ion battery. (Depends on computer model)
15	User Power outputs	Robot Power out (24V) to power up any external devices with 24V robot battery supply.
16	Sensor Interfacing	1. 8 x Ultrasonic sonar sensors with 6 meter range (Optional) 2. 8 x Infrared distance range sensors. 3. 1 x 3 Axis Digital Gyroscope (Optional) 4. 1 x 3 Axis Digital Accelerometer (Optional) 5. 1 x 3 Axis Digital Magnetometer (Optional) 6. 1 x Indoor Navigation GPS Module (Optional) 7. 1 x USB powered outdoor navigation GPS module (Optional) 8. HD Webcam (Optional) 9. Wireless Network Camera (Optional) 10. Laser Range Finder (Optional)

17	Motion control	1. DC geared motors with 260mm diameter wheels and 80mm wide rubber tread on each wheel for excellent grip. 2. Position encoder with 2000 counts per output shaft rotation. 3. Accurate motion control with precise velocity and position control.
18	Communication	1. USB serial communication. 2. 2.4 GHz Wireless communication module. 3. WiFi communication (Optional) 4. Bluetooth communication (Optional) 5. WLAN Wireless USB Dongle (Optional) 6. Manual remote control (Optional)
19	Programming Support	C/C++, Scilab, Python

2 Overview of 0X Delta Robot

0X Delta robot comes with fully assembled and ready to use form. It has high precision DC gear motors with high resolution position encoder sensors. Motors are driven by motion control unit with velocity and acceleration control. Robot has ultrasonic range sensors, IR distance sensors and many more expandable interfaces as optional accessories of robot. As optional accessory, robot will also have on board computer to control the robot. In case of onboard computer, robot will also have separate battery pack to supply power to on board computer. Robot is powered by high capacity battery pack.

2.1 On board computer

⚠ **User can skip this section if robot is not integrated with on board computer.**

0X Delta robot have high performance on board computer as add on accessory of robot. Communication between robot and computer happens through serial USB cable labeled as “USB COMMUNICATION”. For connections please refer figure 7.1.

⚠ **On board computer model can vary from robot to robot.**

Features:
On board battery monitoring
Support battery hot swapping
Fuse protection: 10A

Note: On board computer power requirements varies from one model to another model. Based on power requirement of on board computer battery ratings of computer will also vary.

On board computer of 0X Delta robot can be powered by Li-ion battery pack as well as it can also be powered by external auxiliary adapter (supplied with robot). Fuse panel box has two XT-60 male connector slots i.e AUX1 and AUX2 for onboard computer’s power connection. To supply power to onboard computer, user will have to connect XT-60 female connector of Li-ion battery to any of these two slots. For more details on these connectors please refer section 2.4. Also refer section 6 for more details on how to power up on board computer via Li-ion battery as well as via external auxiliary adapter provided with robot.

⚠ **For safety purpose, only use adapter which is provided with this robot. Using any other adapter to power up on board computer may damage computer permanently.**

2.2 Back Panel

Back panel of 0X Delta is located at rear side of robot. This panel consist of illuminated push button switches. List of switches and purpose of each switch is mentioned in following table 2.1. For more details on back panel please refer figure 2.1

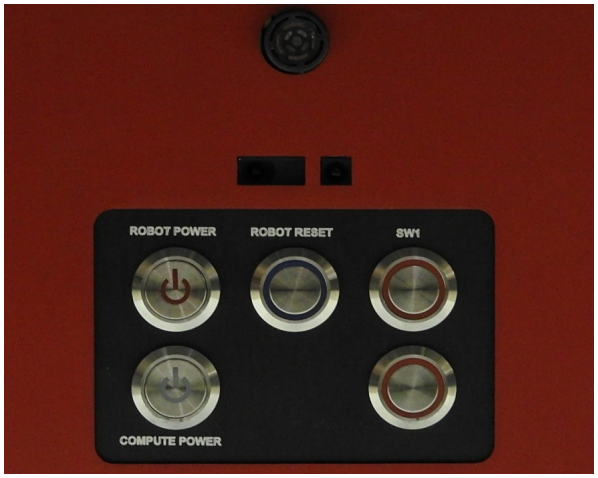

Figure 2.1: Back panel of 0X Delta robot

⚠ **If 0X Delta robot is not integrated with on board computer then COMPUTE POWER switch will be absent from back panel of robot.**

Sr. No.	Switch	Switch Type	Purpose
1	ROBOT POWER	Illuminated push to ON and push to OFF switch.	Engage and disengage supply to robot.
2	COMPUTE POWER	Illuminated push to ON and push to OFF switch.	Engage and disengage supply to robot's on board computer. This switch will be absent from back panel if robot does not integrated with on board computer.
3	SW1	Illuminated push button switch.	General purpose push button LED switch. Depending on version, robot may have more than one GPIO switches.
4	ROBOT RESET	Illuminated push button switch.	Robot reset switch.
5	BOOT	Illuminated push button switch.	Reserved.

Table 2.1: Back panel switches of robot

0X Delta robot has firmware upgrade port located on rear side of robot. While factory shipping robot will be upgraded with latest firmware. Before upgrading new firmware in robot user will have to contact Nex Robotics.

⚠ For proper functioning of your robot, do not try to override any firmware with existing robot firmware.

2.3 Power Management

Nominal supply voltage of 6 cell Li-PO robot battery is 22.2V. When battery is fully charged its voltage reaches 25.2V (4.2V per cell) and when it's fully discharged its voltage drops to 19.8V (3.3V per cell). Battery gives robot range of approximately 6km or standby battery life of about 10hours.

⚠ When battery voltage reaches below 3.3V per cell, battery becomes unsafe to charge. Never allow battery to go below 19.8V. If battery voltage goes below 19.8V, then battery charger will refuse to charge the battery. When battery voltage reaches below 19.8V, robot starts giving continues buzzer beep. Once robot start giving continues warning, immediately replace the battery.

Version 1(With NUC computer model):
Nominal supply voltage of 4 cell Li-ion on board computer's battery is 14.8V. When battery is fully charged its voltage reaches 16.8V (4.2V per cell) and when it is fully discharged its voltage drops to 13.2V (3.3V per cell).

Version 2 (With IPC2 computer model):
Nominal supply voltage of 3 cell Li-ion on board computer's battery is 11.1V. When battery is fully charged its voltage reaches 12.6V (4.2V per cell) and when it is fully discharged its voltage drops to 9.9V (3.3V per cell).

⚠ When battery voltage reaches below 3.3V per cell, battery becomes unsafe to charge. Never allow 4 cell and 3 cell battery to go below 13.2V and 9.9V respectively. If battery voltage goes below this threshold level, then battery charger will refuse to charge the battery. When battery voltage reaches below threshold level, robot starts giving continues buzzer beeping. Once robot start giving continues warning, immediately replace the battery.

2.3.1 Li-Po Battery Charging

To charge battery, remove it from the robot and charge it in the open space. Recommended charging current is 1.5A. Robot is supplied with B6AC battery charger. Usual battery charging time 3-5 hours. This smart battery chargers monitors individual cell voltages of the battery pack and adjust the rate of charge of the individual cells to perform balance charging. For more information on B6AC battery charger, refer to its manual which can be found in the battery charger's box.

Figure 2.2: B6AC battery charger from NEX Robotics

2.3.2 Battery charging procedure

Note: This section explains genuine battery charging procedure of Li-ion battery. User can refer this steps to charge on board computer's battery of robot. Based on the computer model, battery specifications (no of cells, voltage and current rating) will vary.

Robot battery charger includes,
1. Battery charger
2. Power cable
3. Battery charging connector
4. XT-60 male to XT-90 female converter

Figure 2.3: Battery charger accessories for Li-ion battery

To charge the Li-ion batteries refer following steps,

Step 1: connect battery charging cable between B6AC charger and battery as shown below. Based on the battery specification user may have to select 4 cell or 3 cell slot on battery charger to insert the battery charging cable.

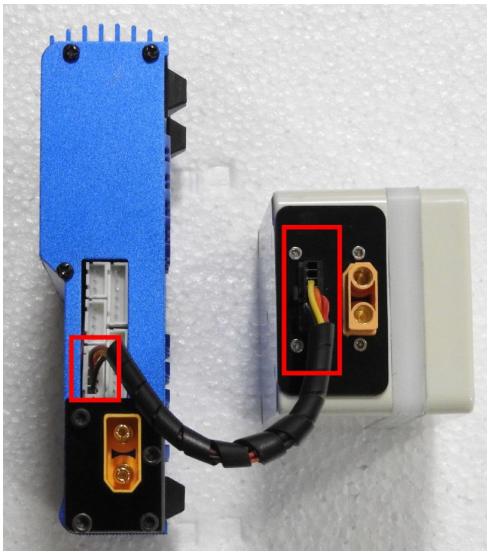

Figure 2.4

Step 2: connect male to female XT-90 or XT-60 connector between battery and charger as shown below.

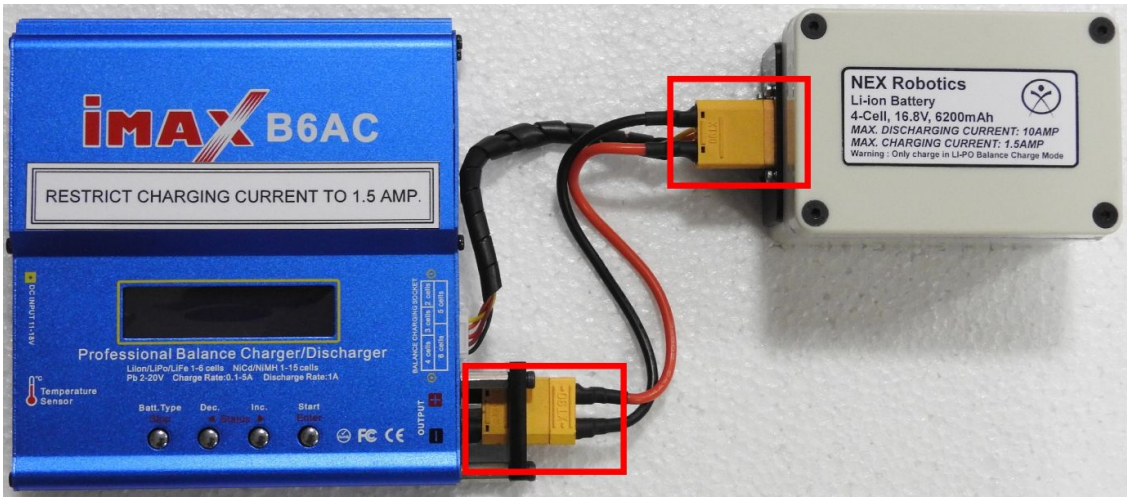

Figure 2.5

Step 3: plug the power cord into the socket on the left side of the B6AC charger and power it ON. Upon power up, user will see battery charging mode of charger.

Figure 2.6

Its recommended to charge the battery in balance charging mode. So, everytime on powering up the charger, user will always have to check present charging mode of charger.

On power up instance, 1st line of B6AC charger's LCD shows present charging mode of charger and 2nd line shows charging current in Amps (A) and battery charging voltage in cells i.e 3 cell (3S)/4 cell (4S)/6 cell (6S) etc.

Step 4: If charger is not showing "LiPo BALANCE" charging mode then keep pressing "Inc."(increment) button of charger till it shows "LiPo BALANCE" charging mode.

Figure 2.7

Step 5: To set the charging current after setting "LiPo BALANCE" charging mode, press "Enter/Start" button once. This will start blinking charging current parameter of battery in 2nd line of LCD. Now by pressing "Inc."(increment) and "Dec." (decrement) buttons, user can increase and decrease the battery charging current value respectively.

⚠For Li-ion battery charging, restrict the battery charging current to 1.5A

To set selected battery charging current press "Enter" one more time. That will set battery charging current and will start blinking battery charging voltage parameter of charger. Now depending upon battery cells mentioned on battery, press "Inc." or "Dec." buttons to select battery charging voltage value. To set selected battery voltage again press "Enter" button.

Figure 2.8

Step 6: after setting correct charging mode with charging current and voltage, press and hold the "Enter" button for 1 – 2 seconds. This will initiate battery charging process. Initially charger will quickly run a diagnostic test "BATTERY CHECK" on battery and then it will ask for final confirmation. After successful "BATTERY CHECK" test, LCD of battery charger should display following parameters.

Figure 2.9

Step 7: Press "Enter/start" button to start battery charging process. When battery becomes fully charge, charger will automatically stop charging process and battery charger will give audio indication for 4-5 seconds and charger's display will keep showing battery full indication.

Figure 2.10

Fore more details on battery charger manual please refer battery charging manual provided in B6AC battery charger box.

Note: User can also refer video of battery charging process provided in "Robot documentation CD\Videos\Robot Videos" folder. However the battery used for charging process demonstration may differ based on model of computer which you have on robot.

2.3.3 Battery Power Status Indication

Battery power status indication for robot battery and computer battery will be indicated by power symbol LED of respective illuminated push to ON/OFF switches. These switches are located on the back panel of robot. Robot battery voltage status will be indicated by power symbol LED of ROBOT POWER switch and computer battery voltage status will be indicated by LED of COMPUTE POWER switch. Please refer figure 2.1 for location of power switches.

For details on power LED pattern and its status please refer table 2.2.

Power LED indication pattern	Description
Solid ON	Battery status is good
Slow blinking with buzzer beep	Battery will soon need replacement
Fast blinking with buzzer beep	Battery is dangerously low. Replace battery immediately to protect battery from damage.

Table 2.2: Battery status indications

2.4 Fuse Panel Box

Fuse panel box has XT-90 male connector to connect 6 cell Li-Po battery to power up the robot. In case of on board computer, fuse panel will also have two XT-60 male connector slots AUX1 and AUX2. User can connect Li-ion battery of on board computer to any of these two slots. Fuse panel also contains different fuses with fuse blow indication LEDs. Refer following figure and table for more details on each fuse of fuse panel box.

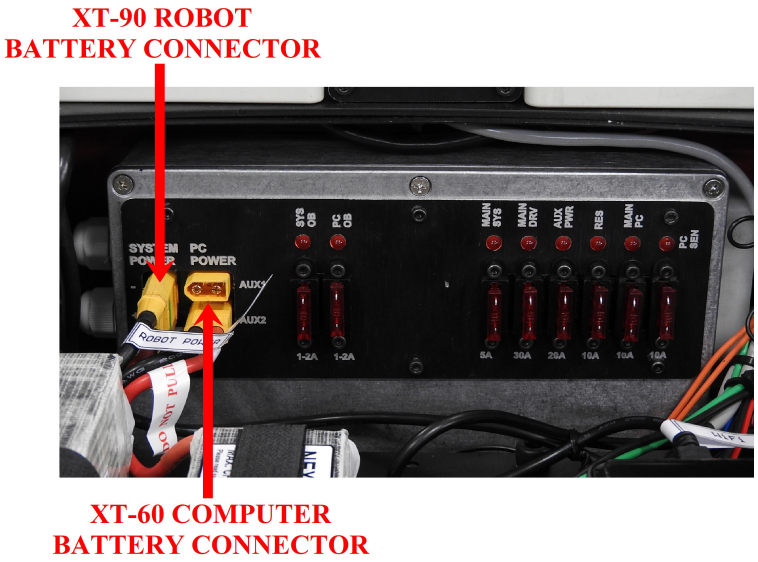

Figure 2.11: Fuse panel box

Fuse name on panel	Description
SYS OB	For internal use.
PC OB	For internal use.
MAIN SYS	5Amp fuse for robot's system power.
MAIN DRV	30Amp fuse for Motor circuit protection.
AUX PWR	20Amp fuse protection for any device powered with robot battery (24V) output voltage (AUXILIARY POWER CONNECTOR)
RES	10Amp fuse for any device powered with robot battery (24V) output voltage (RESERVED CONNECTOR)
MAIN PC	10Amp fuse for on board PC power.
PC SEN	10Amp fuse protection for any device powered with robot battery (24V) output voltage (LRF POWER CONNECTOR)

Table 2.3

⚠ **If fuse blows, replace it once and if it blows for the second time, contact NEX Robotics for repairs.**

Robot has 3 separate auxiliary robot battery out connectors which are reserved for powering any external devices by 24V robot battery voltage. These connectors are shown in figure 2.12.

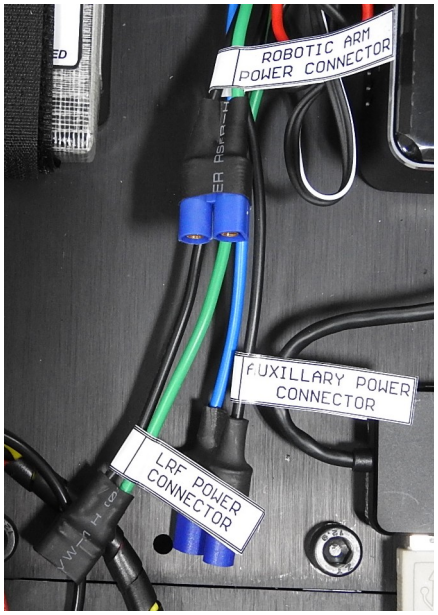

Figure 2.12: Robot power out connectors

Nominal supply voltage of robot battery is 24V. It can change from 19.8V to 25.2V depending on battery voltage status of robot battery.

⚠ **Depending upon user's requirement, number of power out connectors from robot can vary from robot to robot. Names given to these output power connectors may also vary from robot to robot depending on users requirements.**

3 Sensor Modules

⚠ **User can skip this section if robot is not integrated with any ultrasonic or IR distance range sensors.**

Sensor modules of 0X Delta robot is an optional accessory of robot. Based on user's requirement robot may include 8 ultrasonic sensor and IR distance range sensors. Robot 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.

3.1 Ultrasonic Range Sensors

⚠ **Based on users requirements, ultrasonic range sensors models can vary from robot to robot. This chapter provides information about standard ultrasonic range sensor(6 meters) supplied with 0X Delta robot.**

There are total 8 ultrasonic range sensors on robot. Sensors are numbered as 0 to 7. Where 0^{th} sensor will be on the left side of robot and counting of sensors from 0 to 7 will start in clockwise direction.

Ultrasonic Sensor Timing
On power-up sensor takes 250mSec for the self calibration. After that each ultrasonic sonar sensor reading will take 49mSec. That means all 8 sensors connected in chain complete 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 on board 2.4 GHz 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 Software manual of robot.

General Power-Up Instructions
Every time after the ultrasonic sensor 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 are not close to the sensor during this calibration cycle. The best sensitivity is obtained when nearest obstacle is away by fourteen inches, but good results are common when obstacles are away at least more than seven inches. If an object is too close during the calibration cycle, the sensor may then ignore objects at that distance.

Blind spot of the Ultrasonic Range Sensors
In standard robot configuration, ultrasonic sensors will 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. To cover the blind spot, IR distance range sensor is used. In standard configuration robot comes with IR distance sensor which has sensing range of 10 to 80cm. It is used to cover blind spot of the ultrasonic range sensor. For best performance use of a laser range finder is recommended.

Note: Blind spot of ultrasonic sensor differs from one sensor model to another sensor. If robot is integrated with 5 or 10 meters range sensors then blind spot of those sensor is 0cm to 30cm or 0 to 50cm respectively.

⚠ **Ultrasonic range sensor gives 6 meters range when incident angle of the beam on the surface is 90 degrees. If beam is incident on the surface with angle less than 80 degrees, depending on the beam angle with surface, sensor's range starts reducing.**

3.2 IR Distance Range Sensors

⚠ **Based on users requirements, IR distance sensors models can vary from robot to robot. This chapter provides information about standard IR distance sensor(10 to 80cm) supplied with 0X Delta robot.**

There are total 8 IR distance range sensors on robot. Sensors are numbered as 0 to 7. Where 0^{th} sensor will be on the left side of robot and counting of sensor from 0 to 7 will start in clockwise direction. In standard configuration robot uses 10cm to 80cm IR range sensor. It has blind spot for the distance less than 10cm.

Sensor gives out analog voltage corresponding to angle of reflection. Relationship between the angle of reflection and output voltage is not linear because of trigonometry involved. These sensors have blind spot in the range of 0 cm to some specific distance depending on the type of the sensor. In the blind spot region sensor gives incorrect readings. Robot uses 10cm to 80cm IR range sensor which has distance measurement range of 10cm to 80cm with blind spot of 10cm to 0cm.

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 the distance of few meters. You can switch off power to the IR range sensor by sending specific command to the sensor module. You can also coordinate with other robots using robot's 2.4GHz wireless module to ensure that at any given instant only one robot's IR range sensors remain active.

4 Servo Pod Interfacing Board

Servo pod interfacing board is used for moving servo pod having wireless camera / Ultrasonic range sensor / IR distance Range sensor in PAN and TILT direction. Servo pod's servo motors and sensors are connected to 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 controller board. ADC pot connected on servo pod interfacing board provides 12 bit Analog to Digital conversion.

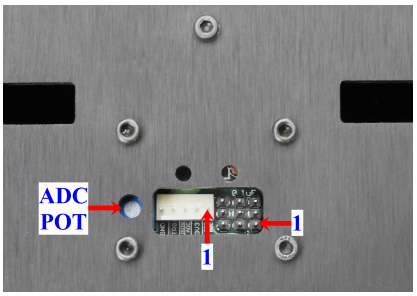

Figure 4.1: Pin no. 1 of servo motor connector and sensor pod connector

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

Table 4.1: Servo Motor Connections

Servo connector pin	Purpose
Yellow	PWM input signal
Red	5V DC
Brown	Ground

Table 4.2: Servo motor connector pin connections

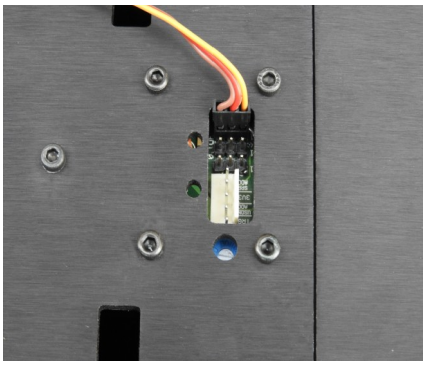

Figure 4.2: Servo connections on 0X Delta Robot

5 Powering 0X Delta Robot

Checklist before powering up 0X Delta robot

- ***Make sure all the power switches of robot are in OFF state.***
- ***"EMERGENCY STOP SWITCH" should be in released state.***
- ***Check the battery voltage of robot battery and computer battery. If battery voltage is lower than its critical voltage then before using batteries, please charge the them using B6-AC battery charger.***
- ***Place robot battery and computer battery to their respective slots and tie them properly using velcro straps.***
- ***Always close top lid of robot after connecting batteries.***

0X Delta robot runs on a high capacity 6 Cell 22.2V Lithium Polymer battery pack. Batteries are secured under protective top lid of robot using velcro straps. For safety measures, while shipping, battery connections are disconnected.

Please refer following steps to power up 0X Delta robot.

Step 1: To power up the robot using robot battery, open top lid of robot and place robot battery as shown in figure 5.1.

Figure 5.1: Robot battery slot

⚠ **Before connecting battery to robot ensure following things,**
1. Battery should be secured in it's place using velcro straps as shown in figure 5.1.
2. "ROBOT POWER" switch from back panel of robot should be in OFF position. Refer figure 5.3 for back panel of robot.

Step 2: Robot battery has XT-90 female connector labeled as "ROBOT POWER" sticker. Connect XT-90 female connector of battery to XT-90 male connector of fuse panel box. Refer fuse panel box from figure 5.2 for robot battery connections.

Do not forget to close the top lid of robot.

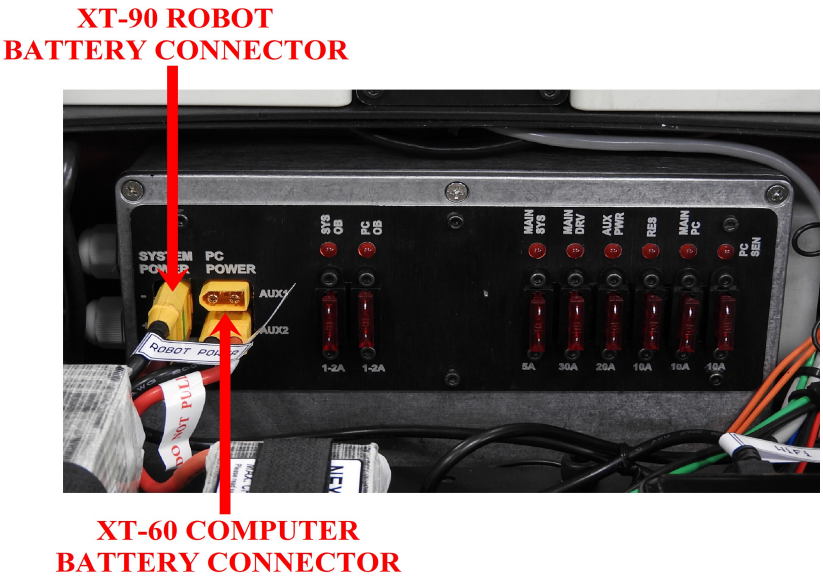

Figure 5.2: Fuse panel box

Step 3: Now press "ROBOT POWER" switch from back panel of robot. Refer figure 5.3 for location of switch from back panel. All the switches from back panel of robot are illuminated push button switches.

On power up instance, tower light of robot will blink once. Red LED of "ROBOT POWER" switch will lit and battery voltage indicator panel will start showing present voltage of robot battery.

Figure 5.3: 0X Delta Robot Back Panel

Note: Check following conditions if robot is not getting powered up.

⚠ **First check position of "EMERGENCY STOP SWITCH" of robot. If this switch is in pressed condition then rotate the switch in clockwise direction. Rotating will release the switch and robot should get powered up.**

⚠ **Emergency stop button:**

When this button is pressed, the robot will immediately stop. Robot will be disconnected from power supply. This state can be reset by unlocking the emergency stop button by turning the switch clockwise.

⚠ **If stop switch is in released state and still robot is not getting powered up then open top lid of robot and check fuse panel box for any fuse blow condition. Incase of any fuse blow condition, respective LEDs available on fuse panel box will lit. If any fuse is blown then replace the fuse with same ratings mentioned on the fuse and try to power up the robot. If fuse blows second time then please contact Nex Robotics for repairs. For more details on purpose of each fuse please refer Fuse Panel Box chapter.**

If robot is giving any battery low warning i.e buzzer beep audio indication OR LED blinking indication on “ROBOT POWER” switch of robot, then please shut down the robot and charge the battery using B6-AC battery charger.

Do not use battery if robot is giving battery low indication. For more details on battery low warnings please refer section 2.3.3.

To control the robot over GUI please refer section 8.

6 Powering 0X Delta On Board Computer

⚠ **User can skip this section if robot is not integrated with on board computer.**

On board computer of 0X Delta robot can be powered up by Li-ion battery pack or by using auxiliary power adapter of on board computer provides with robot as a part of accessories.

Powering on board computer using battery pack

On board computer of robot runs on a Lithium Ion battery pack. Batteries are secured inside box under protective top lid of robot using velcro straps. For safety measures, while shipping, battery connections are disconnected. Please refer following steps to power up on board computer of 0X Delta robot.

Step 1: To power up on board computer using computer battery, open top lid of robot and place robot battery as shown in figure 5.1.

⚠ **Before connecting battery to robot ensure following things,**
1. Battery should be secured in it's place using velcro straps as shown in figure 5.1.
2. "COMPUTE POWER" switch from back panel of robot should be in OFF position. Refer figure 5.3 for back panel of robot.

Step 2: Robot has XT-60 female cable named as "CPU POWER OUT CABLE" under top lid of robot. There will be one more cable provided in computer's accessories box named as "CPU POWER CONNECTOR". One end of this cable will have XT-60 male connector and another end will have DC connector. Connect XT-60 male of "CPU POWER CONNECTOR" to XT-60 female of CPU POWER OUT CABLE, and connect DC end of cable to DC jack of on board computer.

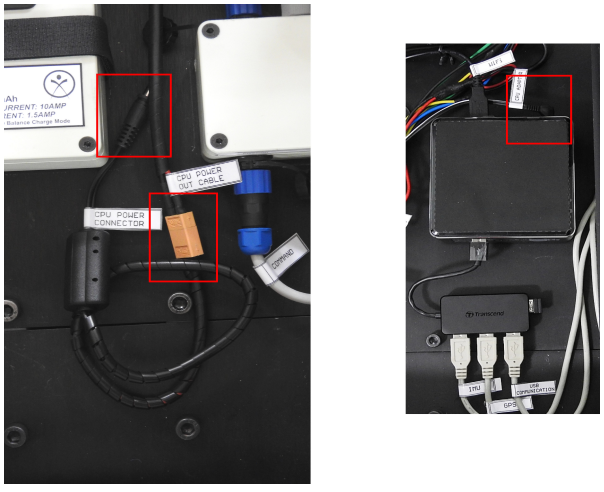

Figure 6.1: PC power connections (Version1)

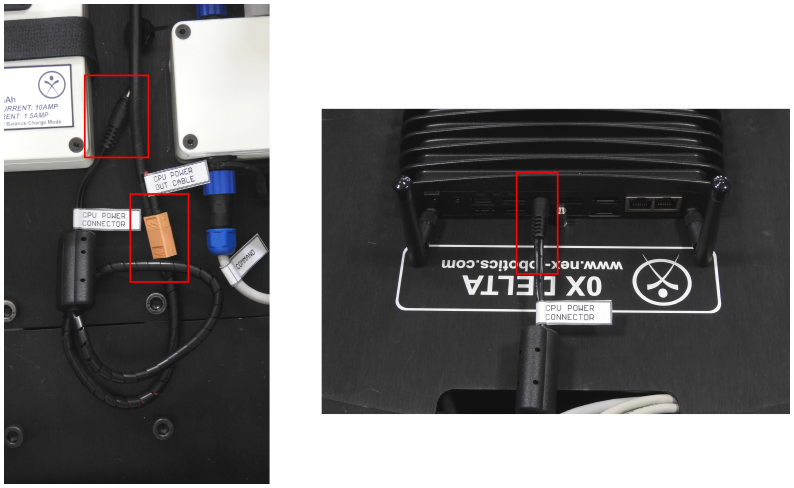

Figure 6.2: PC power connections (Version2)

Step 3: Computer battery has XT-60 female connector labeled as "CPU POWER" sticker. Connect XT-60 female connector of battery to XT-60 male connector of fuse panel box. Refer fuse panel box from figure 5.2 for computer battery connections.

Step 4: Now press "COMPUTE POWER" switch from back panel of robot. Refer figure 5.3 for location of switch from back panel.

On power up instance, Yellow LED of "COMPUTE POWER" switch will lit. Battery voltage indicators panel will start showing present voltage of computer battery.

Note: Check following condition if LED of "COMPUTE POWER" switch is not glowing.

⚠ **Check fuse panel box for any fuse blow condition. LEDs available on fuse panel box will lit incase of respective fuse blow condition. If any fuse is blown then replace the fuse with same ratings mentioned on the fuse and try to power up the robot. If fuse blows second time then please contact Nex Robotics for repairs. For more details on purpose of each fuse please refer Fuse Panel Box chapter.**

Powering on board computer using external auxiliary power supply

To power up on board computer using auxiliary power supply, connect external auxiliary power adapter (received with robot) directly to AUX1 or AUX2 connector of fuse panel box.

⚠ **For safety purpose, only use adapter which is provided with this robot. Using any other adapter to power up on board computer may damage the computer permanently.**

Battery hot swapping

Hot swappable power supplies for on board computer enables user to remove or replace low battery with fully charged battery without shutting down the computer.

To remove on board computer's battery without shutting down the computer, power up on board computer using auxiliary power supply as mentioned above. By doing this computer battery supply will automatically switch from battery power to auxiliary power and then user can easily remove or replace on board computer's battery.

7 0X Delta Robot Communication

Robot supports two different modes of communication, viz. USB (Serial) and 2.4GHz (wireless) module.

7.1 Serial Communication

USB serial communication is preferred for on board embedded PC or on board computer/ laptop. To establish a communication between robot and on board PC, connect USB cable of robot marked as “USB COMMUNICATION” to on board computer.

If 0X Delta robot is equipped with USB extension hub then user can also connect USB cable of robot to on board computer via USB extension hub.

Figure 7.1: USB cable of 0X Delta Robot

After connecting USB cable to on board PC/laptop, you may need to install USB drivers. Windows drivers for USB is available on documentation CD in /Softwares and Drivers folder.

⚠ If robot does not include on board computer then user can also connect “USB COMMUNICATION” cable to off board PC/Laptop.

7.2 Wireless Communication

⚠ To control 0X Delta robot over 2.4GHz wireless communication, make sure that "REMOTE CONTROL OVERRIDE" switch of robot is in release (OFF) state. This switch is illuminated push to ON/OFF switch. When switch is in OFF state, red LED of switch will remain OFF.

Figure 7.2: 0X Delta wireless mode selection switches

0X Delta robot is integrated with 2.4GHz wireless module with unique ID. While working on off-board computers/laptops, user can refer this communication mode. To communicates with robot using wireless module, you will need another wireless module with same unique ID that can be plugged into USB port of off-board PC/Laptop. Refer figure 7.3 for more details.

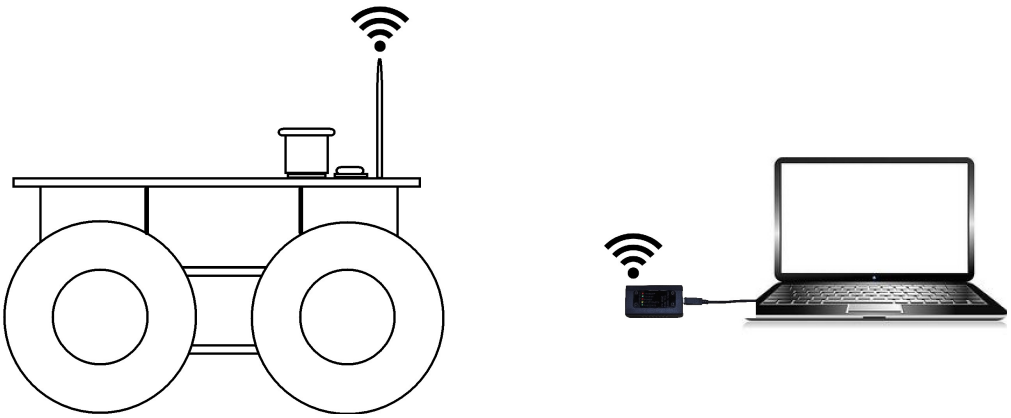

Figure 7.3: Wireless connection topology

After connecting 2.4GHz wireless module to USB port of computer, you will need to install USB drivers. Windows drivers for USB is available on documentation CD in /Softwares and Drivers folder.

Connecting wireless module to USB port of computer will create a COM port on that computer and communication between robot and computer will take place through that com port. As shown in figure 7.4, the wireless settings are printed on 2.4 GHz wireless module.

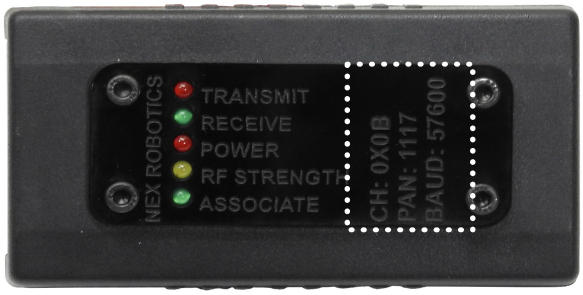

Figure 7.4: 2.4 GHz wireless module

⚠ To ensure successful communication, Always make sure that wireless setting information of 2.4 GHZ wireless module connected to USB port of PC/laptop should match with information of 0X Delta robot.

⚠ Information related to wireless module communication settings for each robot will be different.

⚠ Robot has separate communication channels for both USB and 2.4 GHz wireless module. However user can not access both communication modes simultaneously.

⚠ As a optional accessory, robot can be controlled over manual remote control. For more details please refer section 7.3.

7.3 Manual Remote Control Communication (Optional accessory)

⚠ 0X Delta robot shares same wireless link for 2.4GHz wireless communication mode and for manual remote control communication. Therefore at a given time, only one mode of wireless communication will be active, which is depend on ON/OFF status of "REMOTE CONTROL OVERRIDE" switch.

0X Delta robot can control its motions via manual remote control. On the top side, robot will have two illuminated switches named as "REMOTE CONTROL OVERRIDE" and "REMOTE CONTROL CALIBRATE". Please refer figure 7.2 for more details. Remote control override is illuminated push to ON/OFF switch. This switch takes care of manual remote control feature of robot.

Remote control override switch is press to ON and press to OFF switch, which will override 2.4GHz wireless communication (section 7.2) with manual remote control communication. Basically switching ON remote control override switch will transfer control of robot from 2.4GHz communication to wireless manual remote control communication. In this mode of communication, user can control all the motions of robot via multi channel remote control transmitter. Refer figure 7.5 for multi channel remote control transmitter.

Please go through following steps to switch ON the manual remote control mode.

Step 1: Press "REMOTE CONTROL OVERRIDE" switch.(Assuming that the robot is already in power up state)

Step 2: Now, power up remote control transmitter. On powering remote control transmitter, ideally robot should give following indications.

- Red LED of "REMOTE CONTROL OVERRIDE" switch will lit.
- Red LED of "REMOTE CONTROL CALIBRATE" will start blinking with approximate delay of 1 second.
- Red tower light of robot will start blinking with approximate delay of 1 seconds.
- Robot buzzer will beep after interval of every 4 seconds.

All above indications ensures that the robot controls are switched from 2.4GHz communication to remote control communication. To control robot motions via multi channel remote control, user must get all above indications from robot.

While switching from 2.4GHz communication mode to manual remote control mode, user may encounter with a problem that red LED of "REMOTE CONTROL OVERRIDE" switch is ON but LED of "REMOTE CONTROL CALIBRATION" switch remains in OFF state. This condition will occur when multi channel remote control transmitter is in OFF state. You need to turn it ON by sliding power switch of remote control in upward direction. Refer figure 7.5.

⚠ **To retain 2.4 GHz wireless communication, user will simply have to press and turn OFF the "REMOTE CONTROL OVERRIDE" switch.**

⚠ **Manual remote control mode will only control different motions of robot via remote control transmitter.**

⚠ **To avoid loss of communication between remote control transmitter and robot, please make sure that robot and remote control transmitter are in line of sight with each other.**

⚠ **If robot does not have manual remote control mode feature then "REMOTE CONTROL OVERRIDE" switch and "REMOTE CONTROL CALIBRATE" switches will be absent from robot.**

Controlling Fire Bird V robot via remote control transmitter

In standard package, 6 channel remote control transmitter will be supplied with robot.

Figure 7.5: Remote control configuration

Important: Do not touch the left switch and right switch, as these switches must be in down side for correct working of above remote.

Please refer table 7.1 to know functionality of each channel.

Sr. No.	Channel No	Functionality	
1	**Channel 1**	**Controls left and right motion of robot.**	
		Throttle left position = Left motion	Throttle right position = Right motion
2	**Channel 2**	**Controls forward and backward motion of robot**	
		Throttle up position = Forward motion	Throttle down position = Backward motion
3	**Channel 3**	**Controls velocity of robot.** Throttle down to up corresponds to 0 to max velocity.	
		Throttle extreme up position = Max velocity	Throttle extreme down position = Zero velocity
4	**Channel 4**	**Controls curved motions of robot.**	
5	**Channel 5**	Max position = kill power of robot motion control unit	Min position = Normal operation

Table 7.1

Note: Remote control transmitter model can vary from robot to robot. For any received modifications other than standard configuration please refer annexure section of manual.

8 0X Delta communication using GUI

⚠ 0X Delta robot is calibrated to work on Fire Bird VI GUI. Therefore same Fire Bird VI GUI can control Fire Bird VI as well as 0X Delta robot.

It is assumed that Fire Bird VI GUI is installed on your PC. If not, please refer Software manual of robot for GUI installation.

1. Start Fire Bird VI GUI from start menu or desktop shortcut and turn ON the robot.

2. Select baud rate as 57600 from the drop down box.

3. Select the COM port of USB to serial adapter board. Select “Serial/Wireless” as communication method.

4. Click connect to start the communication.

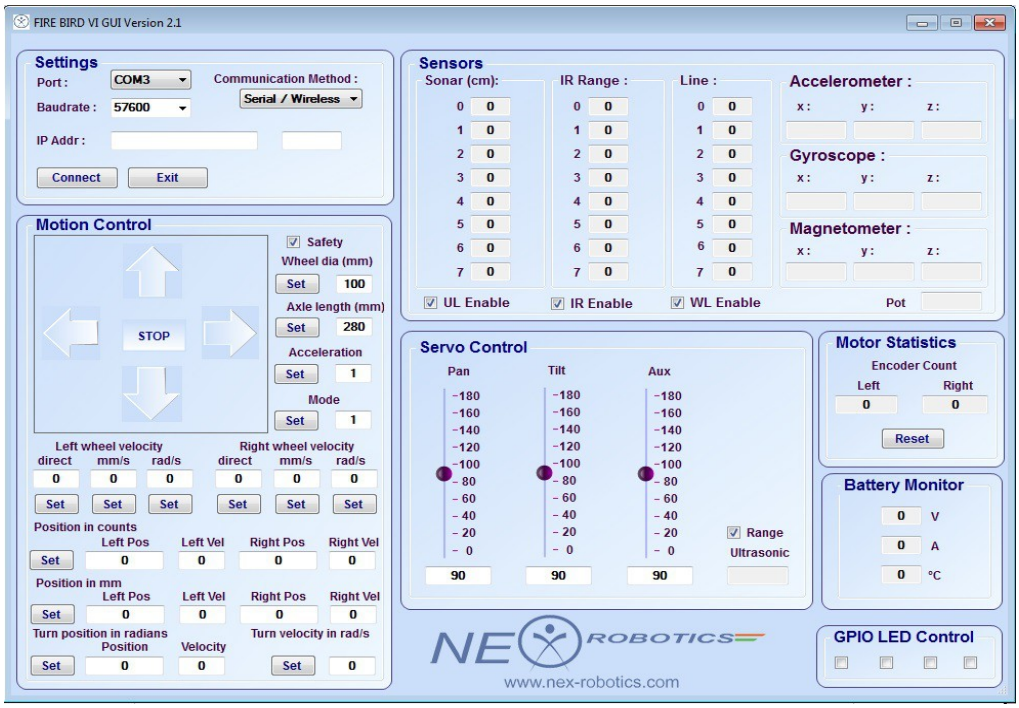

Figure 8.1: Robot communication with GUI over serial/wireless mode

⚠ 0X Delta Robot can be controlled over serial terminal. For more details please refer Robot communication using Real Term Serial Terminal manual.

9 Locomotion

0X Delta robot has solid rubber tires and a four wheel differential drive with high resolution position encoders. Robot has a dedicated motion control unit for controlling motors in open loop mode, closed loop velocity control mode and closed loop position control mode.

9.1 Motion controller 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.

⚠ **In all three motion control modes, Robot's acceleration can be set between 1 to 16. Where, 1 being slowest and 16 being fasted. For more information regarding all motion control commands please refer Software manual of robot.**

⚠ **In case of erroneous algorithm or erroneous command given by user, the robot can reach its top velocity and can collide with a wall, this will damage robot as well as the wall. In order to prevent this, robot has safety mode which will restrict robot's top velocity.**
To run robot at its top velocity user will have to turn off this safety mode. Please refer Software manual to turn ON/OFF safety mode of robot.

9.2 Position Calculation

Calculation of position encoder resolution:

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

Wheel diameter: **d** (mm)

Wheel circumference (**C**): **d** * Л

No. of counts in 1 rotation of output shaft: **N** = 2000

Number of counts per 1 mm distance traveled (**Y**) = **N** / **C**
Or
Distance traveled per count = **C** / **N** (mm)
OR
= (**C** / **N**) * 1000 (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 = **A** mm

Diameter of Circle formed in 360^0 rotation of Robot (**d**) = **A**

Distance Covered by Robot in 360^0 Rotation (C_1) = Circumference of Circle traced
= **d** x Л (mm)

Total pulses in 360^0 Rotation of Robot (Z_1)= C_1 * **Y**

Position Encoder Resolution in counts = Z_1 / 360 (counts per degree)

⚠ **For 4 wheel drive configuration user will have to calibrate axle length to some specific value where robot will follow case 2 and case 3 correctly and as per the user's requirement wheel diameter and axle length of robot can be set by user. To know more about commands to set and get wheel diameter as well as axle length consult Software manual.**

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.
Diameter of Circle formed in 360^0 rotation of Robot = **d** (mm)

Distance Covered by Robot in 360^0 Rotation (C_2) = Circumference of Circle traced
= **d** x Л (mm)

Total pulses in 360^0 Rotation of Robot (**Z2**) = C_2 * **Y**

Position Encoder Resolution in counts = **Z2** / 360 (counts per degree)

⚠**To get correct degree of rotation, user will always have to set axle length of robot to calibrated value on every reset condition.**

⚠**In case of 4 Wheel differential drive configuration, considering slippery behavior of robot wheels during angular positioning, user should always take angle feedback from inertial measurement sensor to achieve correct angular position.**

10 Annexure 1

⚠**This annexure contains modifications made in robot other than standard configuration.**

0X Delta Robot is equipped with HRXL-MaxSonar-WR (MB-7380) series ultrasonic sensors. This ultrasonic sensor had object detection range of 30cm to 500cm with 5mm resolution. However it shows obstacles in the range of 0 cm to 30 cm as 30 cm. It can not detect obstacles closer than 30cm reliably.

Figure 10.1: Ultrasonic sensor

To cover the blind spot, IR distance range sensor is used. Robot is integrated with IR distance sensor which has sensing range of 10 to 80cm. It is used to cover blind spot of the ultrasonic range sensor. For best performance use of a laser range finder is recommended.

0X Delta Robot has front and back surveillance camera interfaces with 5.8GHz video transmission link which sends realtime video footage of both cameras on wireless monitor. Wireless monitor is installed on Remote control transmitter of robot. User can switch surveillance camera footage using remote control transmitter. Robot had dedicated camera system control module under top lid of robot which provides power to both the cameras of robot. The same module is also responsible for switching between front camera and back camera live footage on wireless LCD monitor.

Figure 10.2: Front camera

Figure 10.3: Back camera

Connecting surveillance cameras to 0X Delta Robot

Note: Make sure robot is in power OFF state for conenctions.
Connect all the connectors as shown in figure 10.4. Connections are marked in red square.

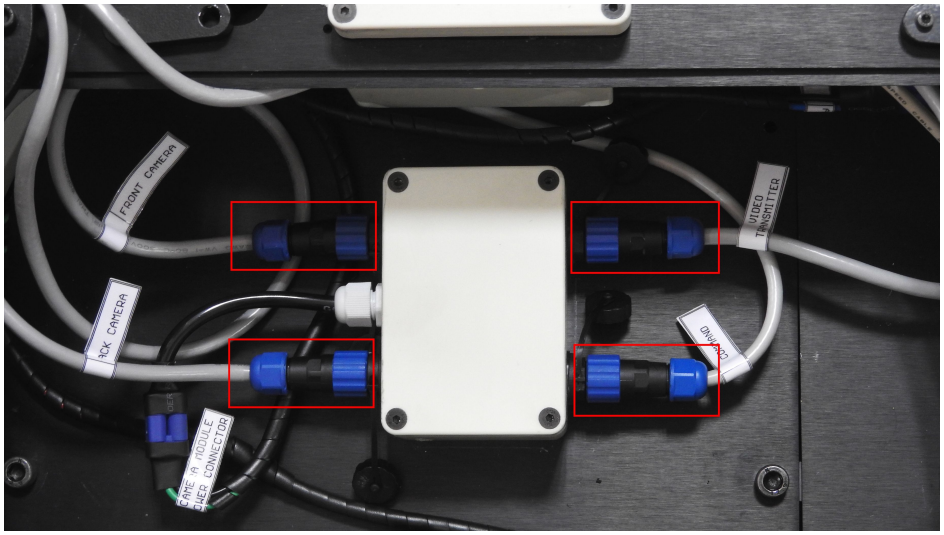

Figure 10.4

To power up camera system control module connect auxiliary supply of robot named as "CAMERA SYSTEM POWER CONNECTOR" with supply connector of camera system control module. Refer figure 10.5 for more details.

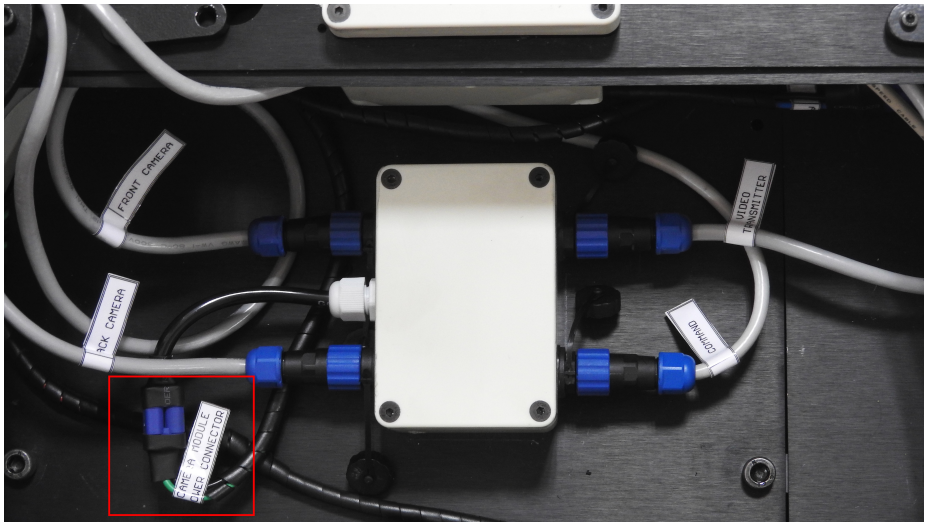

Figure 10.5

Controlling surveillance camera system

Surveillance camera control of 0X Delta robot is possible with Remote control transmitter of robot. Robot is equipped with two towers on the back side of robot. These tower has video transmission module and remote control receiver module attached on the top of towers. Remote control receiver will receive data send from remote control transmitter and video transmitter module will send data of each camera on LCD screen which is attached on remote control as shown in figure 10.6.

To control camera switching between front camera and back camera, remote control uses right switch named as "*GEAR*". Downward position of switch selects front camera and upward position selects back camera of robot. Remote control has one more dedicated pot named as "*PIT. TRIM*" which can connect as well disconnect power to motion control unit of robot. Extreme left side end of pot disconnects power of robot's motion control unit and extreme right end of pot again restores power of robot's motion control unit.

For more details on other channel 1 to 4 of remote control, please refer section 7.3.

Figure 10.6: Remote control transmitter with LCD