FIRE BIRD VI

LPC1769 ARM M3 CORTEX
AUTOMOTIVE DRIVE ROBOT
User Manual

Designed By:

ERTS Lab, CSE, IIT Bombay
www.it.iitb.ac.in/~erts

NEX ROBOTICS
www.nex-robotics.com

Manufactured By: NEX Robotics Pvt. Ltd.

FIRE BIRD VI

AUTOMOTIVE DRIVE ROBOT

Version 2
May 31, 2012

Documentation author
Dr. Anant Malewar, NEX Robotics Pvt. Ltd.
Sachitanand Malewar, NEX Robotics Pvt. Ltd.

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

⚠ **All the electronic components are static sensitive. Use robot in static free environment.**
⚠ **Read the manual completely before 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.

Important:

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

Important:

User must go through hardware and software manuals before using robot. Architecture wise Fire Bird VI Automotive Drive Robot is same as Fire Bird VI standard robot. Only difference being the Automotive Drive where rear wheels are driven by single motor. The rear wheels have differential gearbox in between the wheels. The robot can turn by steerable front wheels which are steered by a servo motor.

Use Fire Bird VI's standard Hardware and Software manual along with this manual. In this manual we will cover the parts of the robot which are different than the standard robot.

IMPORTANT: If front wheels are steered to maximum left or right position then servo motor will get stalled. Under stalled condition servo motor consumes about 2Amps and quickly gets heated up. If servo motor remains in stalled condition for more than 15 seconds then it may burn. Hence while operating the robot make sure that front wheels are always turned just less than maximum left or right position.

Table of Contents

1. Introduction

Thank you for choosing the Fire Bird VI mobile robot platform. The innovative architecture and adoption of the 'Open Source Philosophy' in its software and hardware design will enable you to create and contribute to complex applications that run on this platform, helping you acquire expertise as you spend more time with them.

Safety precautions:

- 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. If the battery 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 wet areas. Contact with water may 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 is 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. This is a fully programmable robot with onboard 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, etc. Robot is powered by high discharge, 11.1V, 5000mAH Lithium Polymer battery packs.

Figure 2.1 Fire Bird VI Automotive Drive 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 both side for 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 wheels

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 running robot in outdoor environment.

2.2 Block Diagram of Fire Bird VI

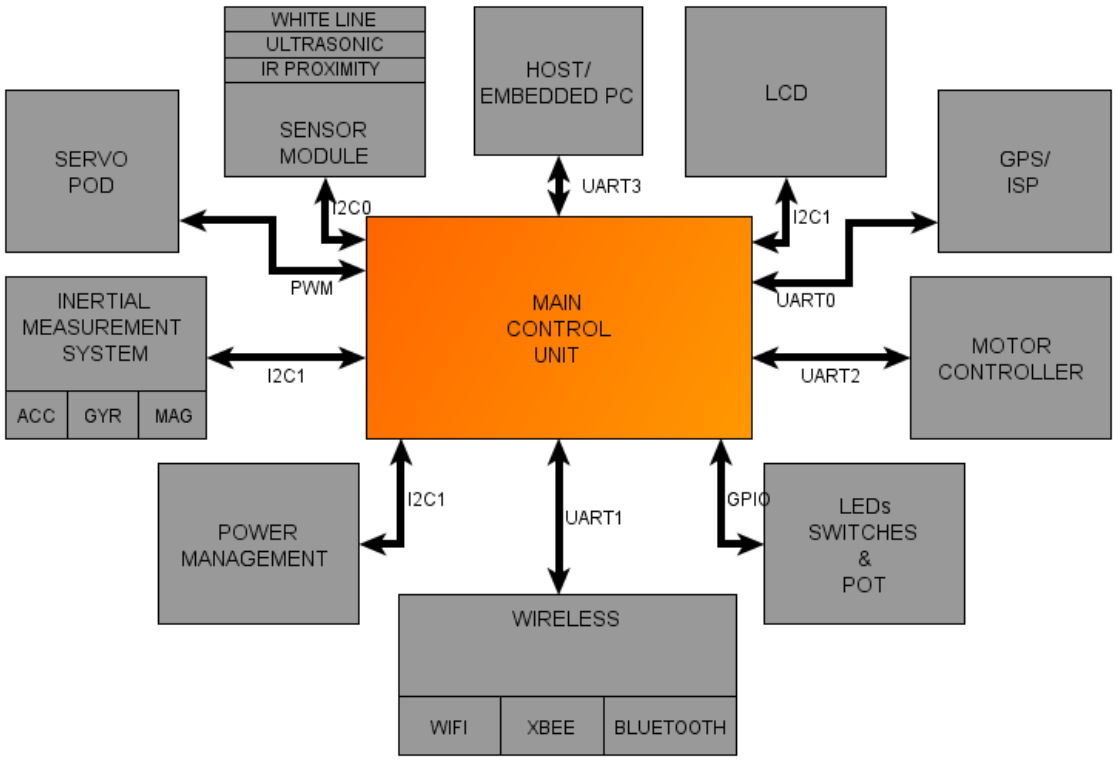

Figure 2.2 Block Diagram of Fire Bird VI Robot

Fire Bird VI uses ARM cortex-M3 based LPC1769 microcontroller running at 120 MHz as main microcontroller. Almost all the peripherals of the robot has their own microcontroller for doing mundane but 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.

2.3 Technical Specifications

Microcontroller: ARM Cortex-M3 based LPC1769

High level controller:

- TI's DM3730 (Beagle Board-xM)
- Embedded PC

Sensors:

- 8 x MaxBotix EZ4 Ultrasonic sensors with 6m range or Sharp IR range sensors with range up to 150cm
- 8 x IR Proximity Sensors
- 8 x White Line Sensors
- 1 x L3G4200D 3 axis Digital Gyroscope
- 1 x LSM303DLHC 3 axis accelerometer and 3 axis Magnetometer
- 1 x MT3310 GPS receiver module
- MaxBotix EZ4 ultrasonic range sensor with Pan & Tilt servo pod
- Sharp 100 to 500cm IR range sensor with Pan & Tilt servo pod

Motion control

- Back wheels are driven by single motor with differential gear box between back side wheels.
- Front wheels are steerable and are steered by servo motor.
- 300 count per output shaft rotation, high resolution position encoders
- 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

Power

- 11.1V, 5000mAh high discharge Lithium Polymer battery
- Smart battery monitoring circuit with voltage, current and battery temperature reading
- Intelligent battery charger with balance charging

Communication:

- 3 UART / RS232 serial ports
- USB
- 2.4GHz XBee wireless
- XBee USB module with XBee wireless module for robot to PC communication
- 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 (comes with robot)
- Serial R232 port based In System Programming

3. Fire Bird VI Automotive Drive: Hardware Description

Figure 2.1: Fire Bird VI Automotive Drive Robot

Important:
You can calibrate various parameters of the automotive drive train like steering settings, wheel balancing etc. For this information refer to the Drive trains manual. It is given as hard copy along with the robot.

3.1 Automotive Drive Train

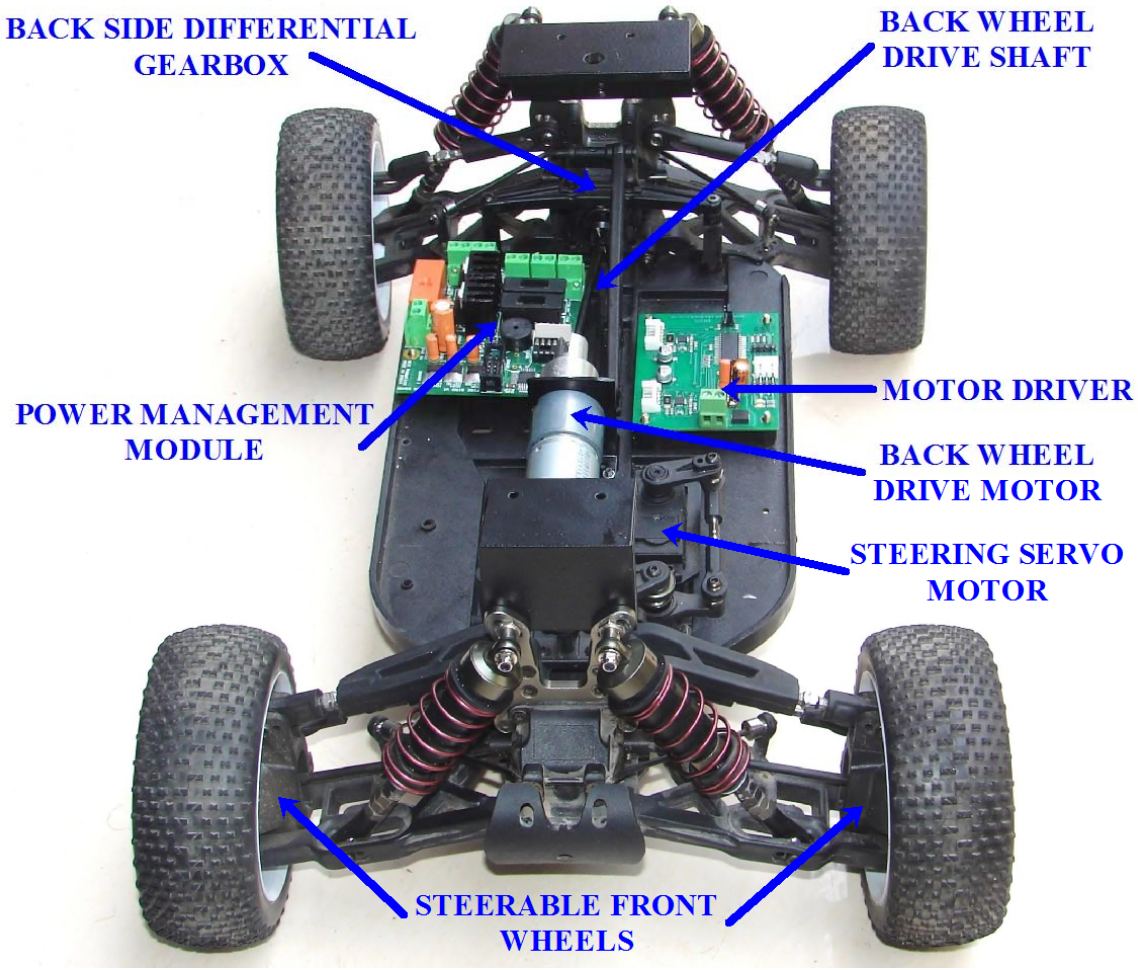

Figure 3.2: Automotive Drive Train of Fire Bird VI Robot

In Automotive Drive Train, the rear wheels have a differential gearbox similar to an actual automobile. This gearbox is driven by a single drive motor with the position encoder. Front wheels are made steerable by using a servo motor. Power management module and the Motor Driver are mounted on the Drive train itself.

3.2 Battery Status Indication

Power management module LED indicates presence of system power and motor power. The fuse blown indicator LEDs indicate if any of the fuses are blown due to abrupt current surges. Battery level status is indicated by 2 LEDs as shown in table 3.2.

Battery Voltage	LED and buzzer status indication
Above 11.1V	Battery 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 3.1: Battery status indication by battery monitoring circuit

Figure 3.3: Power status LED Location

3.3 Position Encoder Accuracy for locomotion

Differential gearbox assembly is located between robot's motor and the rear wheels. It is designed to distribute torque equally to both rear wheels rather than moving both wheels at same speed. Robot has accuracy of 0.294 mm per pulse count of the position encoder.

3.4 Steering angle

Robots front motors are steered using a servo motor. A spring loaded mechanism is present to protect servo from sudden shocks when front wheels are twisted because of sudden bumps. Because of this mechanism it is possible that wheels will not turn even if servo motor is turned by some degrees while robot is stationary on the ground. Wheels will take the new angle when robot starts to move forwards or backwards. User needs to calibrate steering wheels angle vs. radius of curvature of the path followed by the robot.
Steering servo motor can be rotated by +-40 degrees from the center position of 90 degrees (i.e. 50 to 130 degrees). Steering servo motor is connected to the Auxiliary servo motor connection. Figure 3.4 shows location of the servo motor connection.

Figure 3.4: Servo Motor connection of the Servo Pod Expansion PCB

Important:
If front wheels are steered to maximum left or right position then servo motor will get stalled. Under stalled condition servo motor consumes about 2Amps and quickly gets heated up. If servo motor is under stalled condition for more than 15 seconds then it may burn. Hence while operating the robot make sure that front wheels are always turned just less than maximum left or right position.