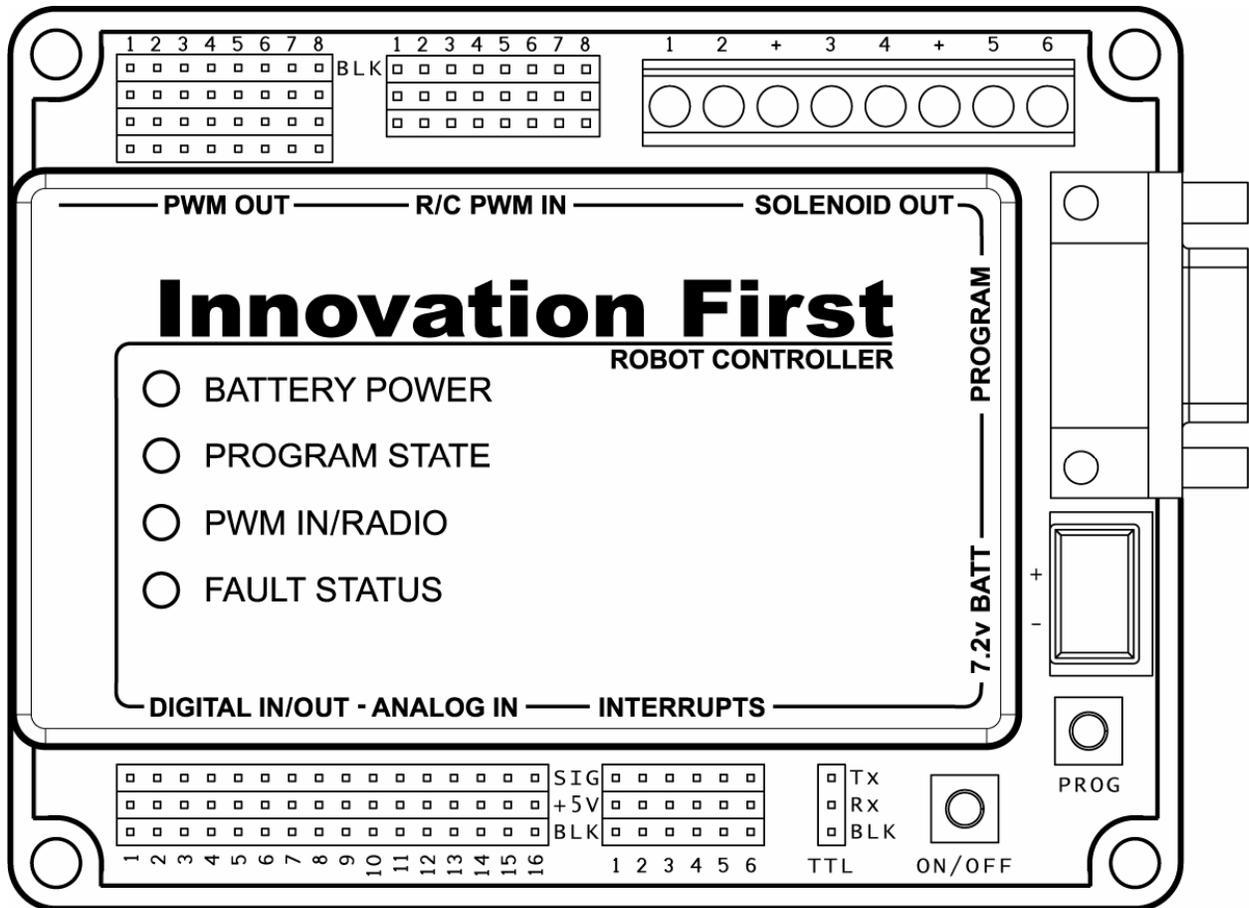


2004 EDU Robot Controller Reference Guide



FIRSTSM
EDUrobotics Kit

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1. Overview

The functionality of this smaller EDU Robot Controller is very similar to the full-size FRC Robot Controller and operates on the same basic principles. The basic differences on the EDU Robot Controller are: 1) smaller size and reduced weight, 2) fewer inputs and outputs, and 3) remote operation using the RS422 Radio has been replaced by control using a standard hobby radio control (R/C) transmitter/receiver set.

The EDU Robot Controller (RC) receives control signals from the remote user(s), gathers additional information from sensors on-board the robot, determines how the robot should function, and instructs the robot to perform the functions.

The EDU Robot Controller can be controlled remotely with hobby radio control (R/C) transmitters by interfacing it with one or two hobby R/C receivers.

The EDU Robot Controller collects signals from both the remote user and the on-board sensors and then processes them using a Microchip 18F8520 PICmicro microcontroller. The program being executed in this microcontroller takes the data, determines what to do with the outputs to make the robot behave as desired, and sets the PWM, digital, and solenoid outputs to the appropriate states. The EDU Robot Controller comes with a default program that will handle most robot control needs. If more sophisticated control of the robot is desired, then the default program can quickly be modified to provide the required functions of the robot.

For extensive details on creating custom programs for the Robot Controller, please refer to the [Programming Reference Guide](#) available from www.InnovationFirst.com. The default source code for the EDU Robot Controller is also available there. Links to additional programming software, manuals, and datasheets can also be found on the Innovation First web site.

The EDU Robot Controller has 8 PWM outputs, 6 special outputs to drive solenoids, 6 digital inputs, and 16 input/output pins which can be configured as either analog inputs, digital inputs, or digital outputs.

The PWM outputs can be used to drive EDU Multi Speed Motors, Victor 88x series speed controllers, or most standard hobby R/C servos. External digital circuitry and switches of various types may be connected to the digital inputs. Sensors that provide a 0-5V output, such as potentiometers and gyros (yaw rate sensors) may be connected to the analog inputs.

Other connectors on the EDU Robot Controller include a battery power plug, an RS-232 serial port for downloading custom programs from a PC, an auxiliary TTL-level serial port, and the connectors to interface with a hobby radio-control receiver.

The EDU Robot Controller also has the capability to operate autonomously. When powered on, the Robot Controller will continually execute whatever program is loaded into its memory. It does not require any signal from a hobby R/C transmitter/receiver pair for this to happen, so it can operate completely on its own if programmed to do so. All available inputs from on board the robot can be used for this purpose. These inputs are processed by the custom software to create the desired functions of the robot without any human operation.

EDU Robot Controller Specifications

Microcontroller	Microchip PIC18F8520
Processor speed	10 MIPS (million instructions per second)
Programming languages	C, Assembly
Variable space	1800 bytes + 1024 bytes EEPROM
Program space	32 kbytes FLASH
Hobby radio-control inputs	8 channels
PWM Outputs	8
Solenoid driver outputs	6
Digital I/O	22 max
Analog inputs	16 max
A/D resolution	10-bit
Remote communication	8 channels of hobby radio-control
Serial communication	2 serial ports (1 RS-232, 1 TTL-level)
Battery voltage	7.2V
Size (WxLxH)	3.4" x 4.6" x 0.75"

2. EDU Robot Controller Layout

Battery Connection: 7.2V Nominal
 EDU-RC Absolute Voltage Range: 5.2V to 9.0V (damage may occur above 9.0V)

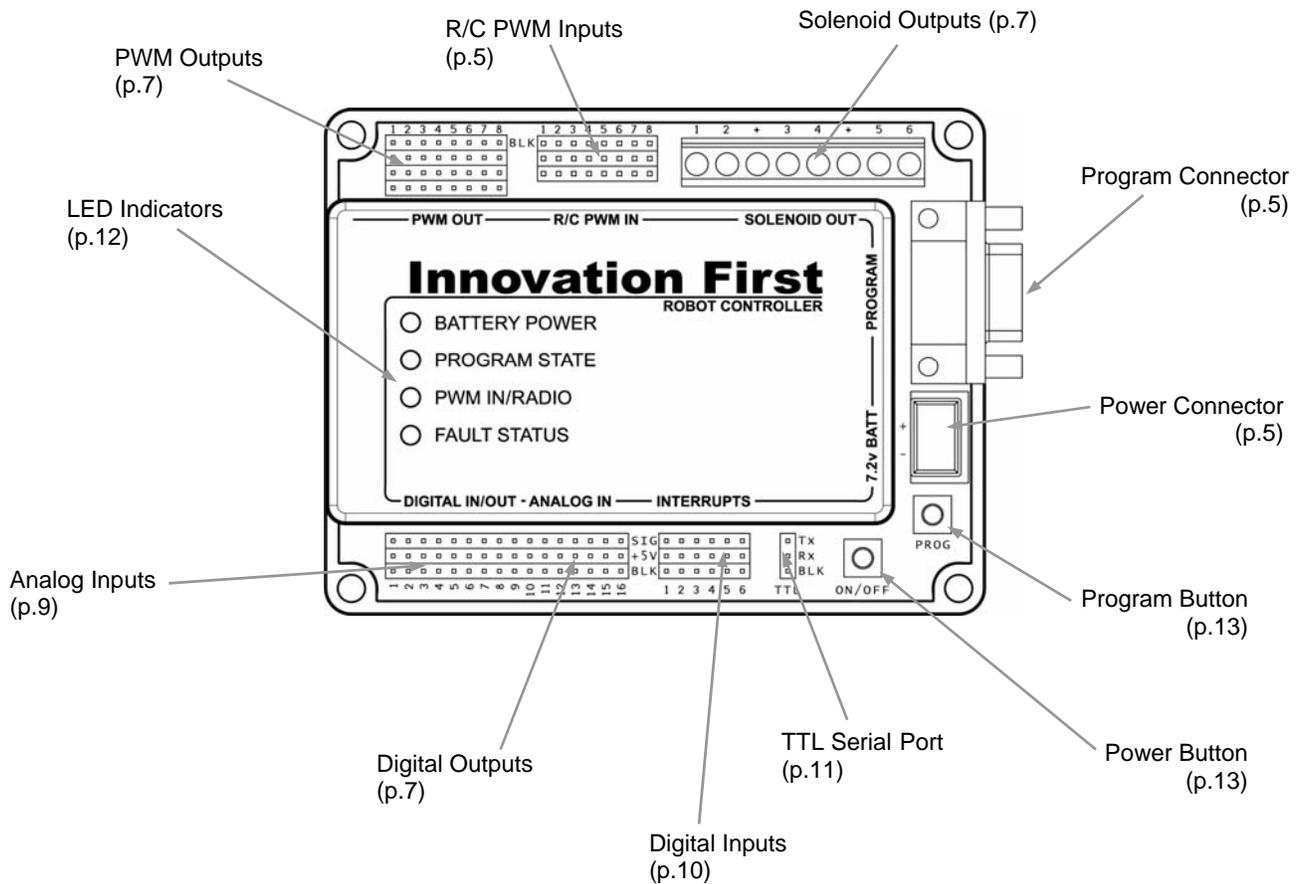


Table 1: Typical Connector Usage

Pin Header	Recommended Connection
PWM OUT	Multi-Speed Motors: four-wire cable with black wire at top Servos/Vector Speed Controllers: three-wire cable with black wire at top
R/C PWM IN	Hobby R/C Receiver: three-wire cable with black wire at top
SOLENOID OUT	Mini-Solenoids: all red wires to +, one black wire per number
DIGITAL IN/OUT – ANALOG IN	Analog Sensors: signal wire to top, 5V wire to center, ground wire to lower Digital Switches: connect between top pin and bottom pin Digital Outputs: top pin is output signal
INTERRUPTS	Digital Switches: connect between top pin and bottom pin External Circuitry: input signal to top pin, 5V to center, ground to lower
TTL	TTL-level Serial Communication: transmit line to top pin, receive line to center pin, ground line to lower pin

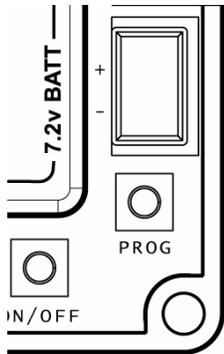
3. POWER Input

The Power connector on the EDU Robot Controller is intended to accept power from a 7.2V battery. The current draw for the EDU Robot Controller is typically between 0.12A to 3.0A. The maximum voltage allowable is 9.0V. Exceeding the 9.0V limit will damage voltage regulators in the EDU Robot Controller and will void the warranty. The minimum required voltage is 5.2V.

Caution: Exceeding 9.0V on the Input Power connection may permanently damage any EDU Multi-Speed Motor connected to the EDU Robot Controller.

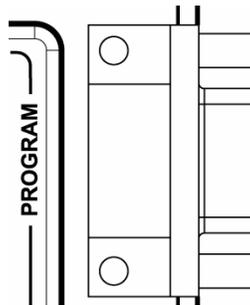
A 7.2V Battery with the proper mating connector is available from www.InnovationFirst.com. Replacement connectors are also available at www.InnovationFirst.com. Use a minimum of 16GA wire to minimize voltage drop to the Robot Controller. Fuses external to the EDU Robot Controller are not required.

Connect +Battery to the upper contact and Ground to the lower contact. The EDU Robot Controller is internally protected from reverse polarity.

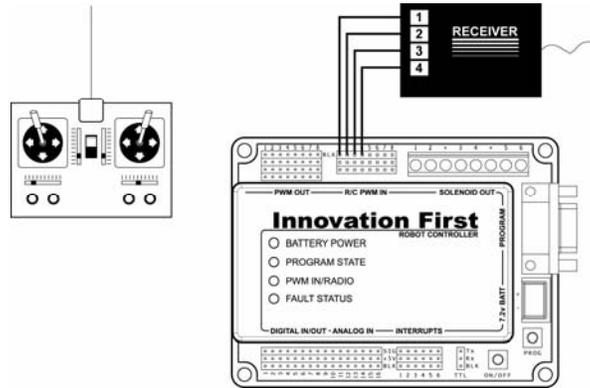


4. Serial Programming Port

The PROGRAM port on the Robot Controller is used to change the robot's program. The EDU Robot Controller uses the RS-232 serial port for connecting to a PC in order to download custom user programs. This port can also be used for debugging purposes by sending data back to the PC for display on the screen. Use a DB9 Male-Female Pin-to-Pin cable (maximum length 6 ft.) to connect the PROGRAM port on the Robot Controller to a PC serial port. For more information on using this port, refer to the [Programming Reference Guide](#) available from www.InnovationFirst.com.



5. Hobby R/C Receiver Interface



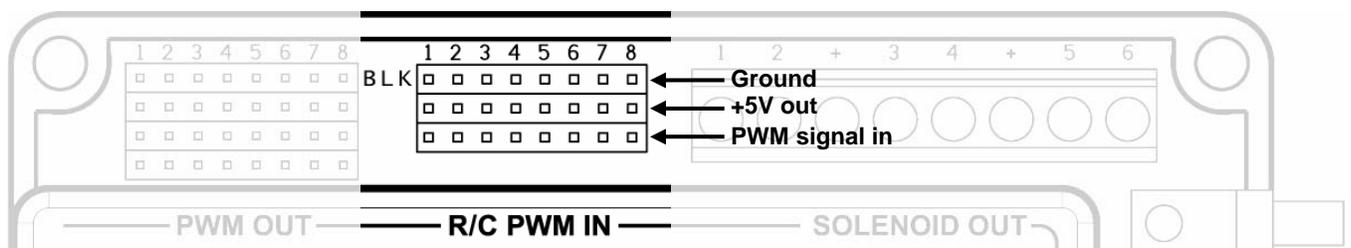
The EDU Robot Controller can use the signals from standard hobby radio-control (R/C) receivers for remote operation. In this manner a human operator can use the joysticks and switches on their standard hobby R/C transmitter to control the robot.

CAUTION: Do not connect the R/C PWM IN ports to anything other than a standard radio-control receiver. The voltage from the full-size FIRST Robot Controller PWM OUTPUTS is too high and will damage the EDU RC, voiding your warranty.

This control is accomplished by connecting the outputs from the hobby R/C receiver(s) to the “R/C PWM IN” connectors of the EDU Robot Controller with three-wire PWM cables. Servo extension cables will also work with some modification. The EDU-RC monitors these PWM signals and converts them to a value that can be used by the internal software to control the robot. Be sure to connect the PWM cables to the hobby R/C receiver with the black wires to the outside of the receiver.

A separate battery is not required for the hobby R/C receiver. Power will be supplied to the receiver through the PWM cables from the Robot Controller.

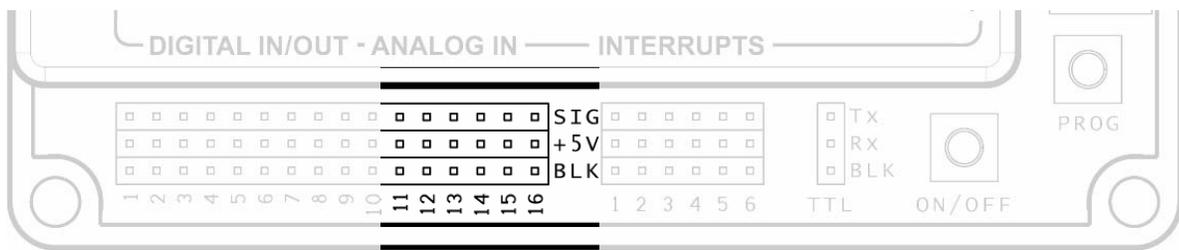
Since there are eight “R/C PWM IN” connectors, either one or two hobby R/C receivers can be connected to the EDU-RC. For example, one eight-channel receiver can be connected using one transmitter and filling all the inputs. In another case, two four-channel receivers can be connected, using two transmitters, and thus two human operators. If two receivers are used, care must be taken to keep their signals from being mixed up. One receiver should be plugged into outputs 1-4, and the other into 5-8. The order in which the signals are plugged in is not important, as long as the signals in 1-4 all came from the same receiver, and likewise for 5-8. Not all of the PWM inputs need to be used. As a final example, a three-channel receiver could be plugged into PWM inputs 1,2, and 4, while a separate two-channel receiver could be plugged into 5 and 8. No more than two receivers can be used in any case.



6. Standard Digital Outputs

The digital outputs on the EDU Robot Controller can be used to control external devices or circuitry. The pins that can be used as digital outputs are the 16 pins labeled “DIGITAL IN/OUT – ANALOG IN” on the lower edge of the Robot Controller. As an example, you could use only the last 6 “DIGITAL IN/OUT – ANALOG IN” pins as digital outputs, but all 16 could be configured as outputs if desired. For details on how to configure and use the digital outputs in software refer to the [Programming Reference Guide](#) available from www.InnovationFirst.com.

These digital outputs will put either 0V or 5V on the output pin, depending on whether the user program sets it to a 0 or a 1, respectively. These are TTL-level compatible signals.

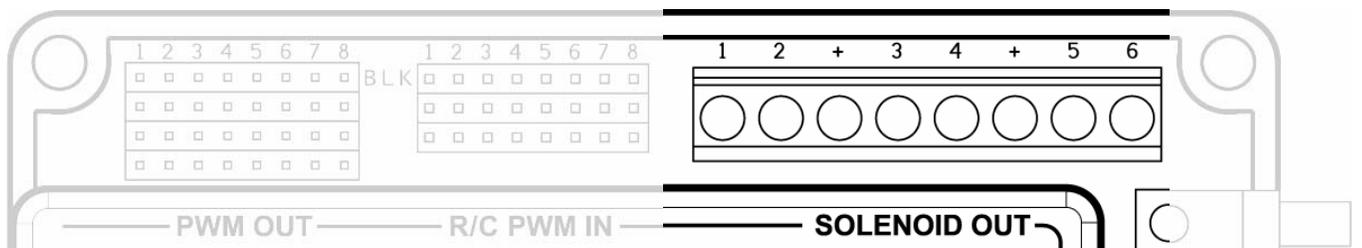


7. Solenoid Outputs

The EDU Robot Controller has six solenoid outputs which have enough drive capability to switch the mini-solenoids that are used with the pneumatic components of the EDU mechanical hardware. Typical current draw for an EDU solenoid switched on is 85 mA.

Connections are made by inserting the solenoid wires into the holes of the “SOLENOID OUT” connector strip and using a small Phillips-head screwdriver to tighten the screws until they firmly hold the wire. The red wires from the solenoids must all be connected to a + terminal. The black wires must connect to their corresponding numbered terminal.

In software, these outputs are similar to standard digital outputs because they can have a value of either 1 or 0. Their initialized value is 0, so that all solenoids will be off by default.



8. PWM Outputs

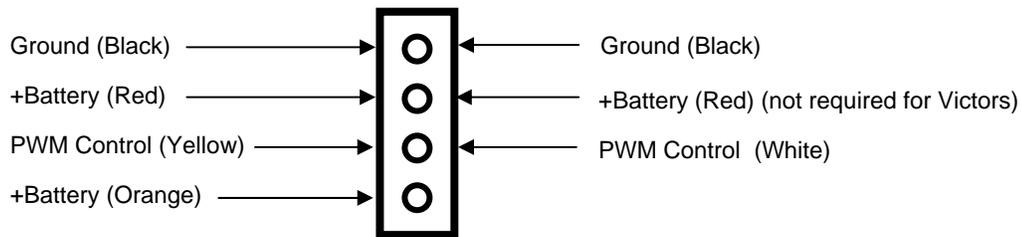
The EDU Robot Controller has eight 4-pin “PWM OUT” connectors. The PWM outputs are most commonly used to drive Multi-Speed Motors. These outputs can cause the speed to vary on the Multi-Speed Motors in a range from Full Forward, to Full Reverse, or Off. The Multi-Speed Motors can be connected directly to the PWM outputs. Be sure to connect the cable so the black wire is on the pin labeled “BLK” (on the top side of the connector).

The PWM outputs can also drive a Victor 88x Series Speed Controller or a servo. The Victor speed controller can be connected directly to the PWM outputs. Use a 3-wire PWM extension cable to connect a speed controller or servo to one of the PWM output ports. When connecting a servo or Victor speed controller, use the top (outside) 3 pins of a PWM port. Be sure to connect the cable so the black wire is on the pin labeled “BLK” (on the top side of the connector).

Caution: The center top pin and the bottom pin on the PWM connector are both connected to the Battery input voltage. Depending on your battery, this voltage may be too high for servos and some speed controllers. We recommend you disconnect the center wire on a 3-wire cable when connecting to other manufacturers’ speed controllers. You must then supply the required voltage, if needed, for that specific speed controller. Disconnecting the center wire is not necessary for the Victor. Most servos are rated at 4.8V to 6.0V.

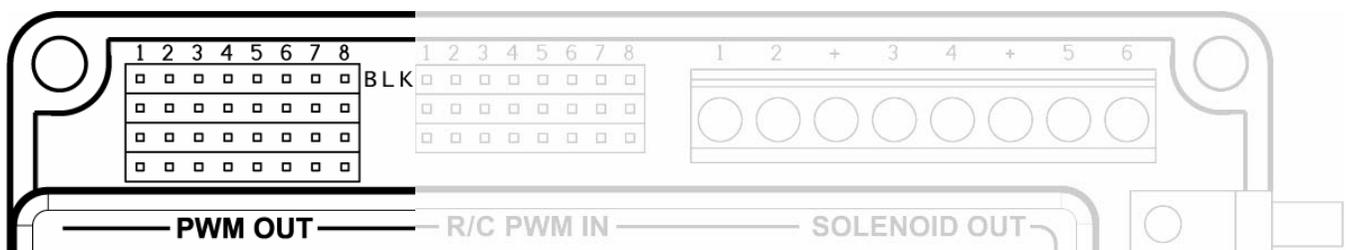
The internal circuit breaker connected to the PWM “+Battery” pins is guaranteed not to trip for any load up to 4 Amps.

Shown below is the PWM port pin-out to aid in the connection of a Multi-Speed Motor or a Victor 88x Series Speed Controller to a PWM output.



Multi-Speed Motor
Connection

Servo or Victor
88x Series Speed
Controller

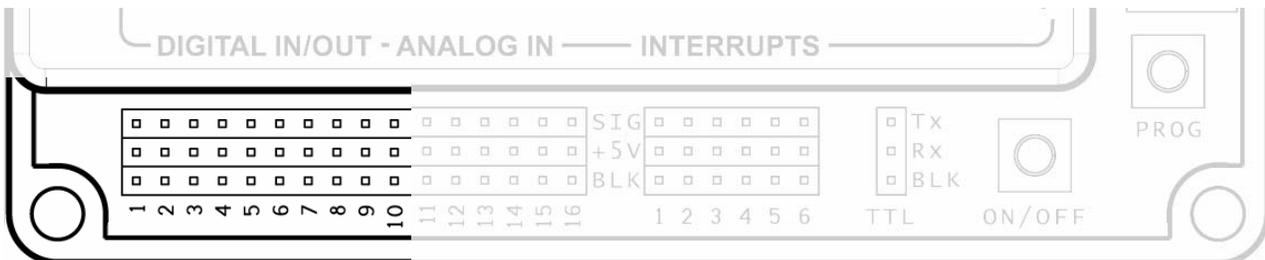
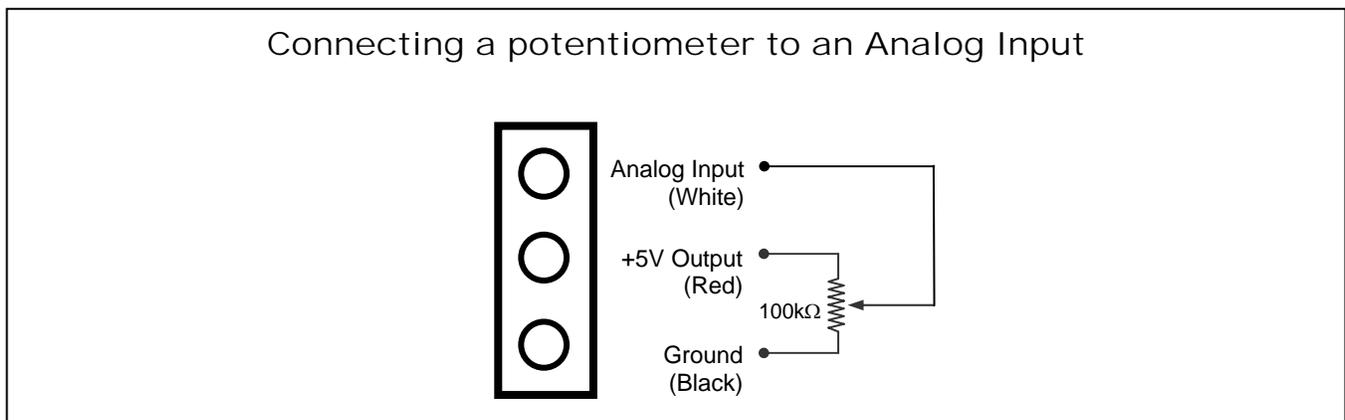


9. ANALOG Inputs

The “DIGITAL IN/OUT – ANALOG IN” connectors on the EDU Robot Controller can be configured as analog inputs, which can be used to measure various conditions on the robot and trigger automatic responses by the control program. As an example, you could set up the first 10 of these I/Os as analog inputs, but as many as all 16 can be used for this purpose. Note, however, that your analog inputs must be on consecutive pins, and must begin numbering at 1. For details on how to configure and use the analog inputs in software refer to the [Programming Reference Guide](#) available from www.InnovationFirst.com and the 18F8520 microcontroller datasheet from www.microchip.com.

Potentiometers and gyros (yaw rate sensors) may be connected to these analog inputs. For wiring 0-5V sensors such as gyros, refer to the sensor manufacturer’s data sheet. The I/O pin headers are typically wired using 3-wire PWM cables.

This diagram shows an example of how to wire a potentiometer to an analog input. The same pin-out can be used for any 0-5V analog sensor.



10. DIGITAL Inputs

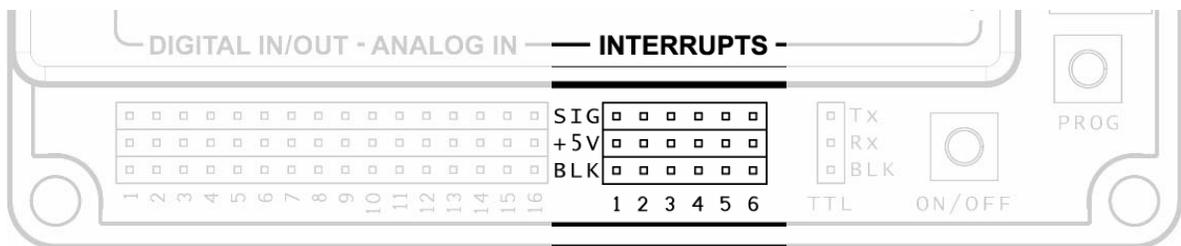
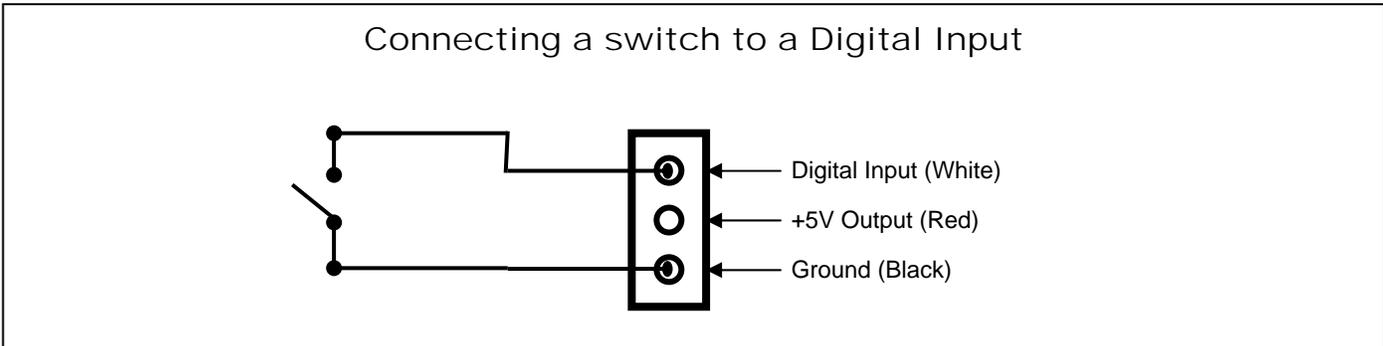
The digital inputs on the EDU Robot Controller can be used to monitor various conditions on the robot and trigger automatic responses by the control program. The pins which can be used as digital inputs are the six pins labeled “INTERRUPTS” and the 16 pins labeled “DIGITAL IN/OUT – ANALOG IN” on the lower edge of the Robot Controller. As an example, you could configure it to only use the 6 “INTERRUPTS” as digital inputs, but all 22 pins could be configured as digital inputs if desired. For details on how to use the digital inputs in software refer to the [Programming Reference Guide](#) available from www.InnovationFirst.com.

These digital inputs will pass either a 0 or a 1 to the control program. When a low voltage, or zero volts (ground), is applied to a digital input, the software inside the Robot Controller will receive a 0. When a high voltage, or five volts, is applied to the pin, a value of 1 is received by the software.

The digital inputs all have pull-ups, which means that if left unconnected they will be pulled high and therefore be read as 1 by the software.

A typical use of the digital inputs is to connect a switch which will pull the input to ground when it is closed. Switches are available from Innovation First for this purpose. Connect switches between the desired digital input signal pin and the ground pin only. Another option is to output a 0 on an adjacent output and connect the switch between that pin and the input. External circuitry that outputs a 5V or 0V signal may also be connected to the digital inputs in order to control the robot. These inputs are TTL-level compatible.

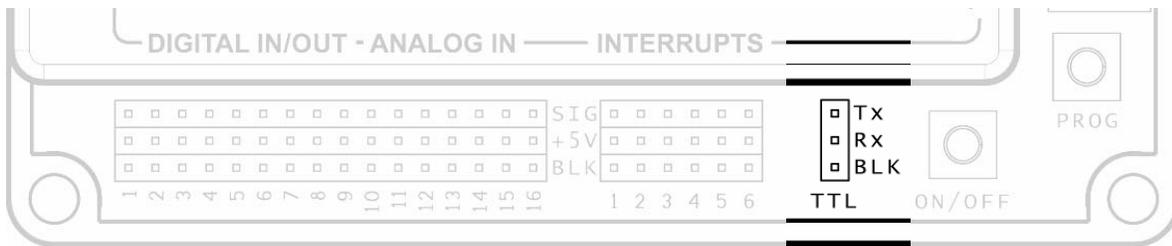
For advanced users, the 6 pins labeled “INTERRUPTS” can be configured to generate interrupt conditions if desired. While powerful, this feature can cause undesired operation if improperly used. Therefore Innovation First will not provide support for this feature. More details on using interrupts can be found by referring to the appropriate documentation from Microchip. Specifically, refer to the 18F8520 microcontroller datasheet and the appropriate programming manual.



11. TTL Serial Port

The three-pin header labeled “TTL” is an auxiliary serial port from the User processor inside the Robot Controller. The PROGRAM connector is actually the User processor’s Serial Port 1 (USART1), with circuitry to convert the TTL level signal to RS-232 levels so that it can be interfaced with a standard PC serial port or other RS-232 devices. The TTL connector is the User processor’s Serial Port 2 (USART2), but without any voltage level conversion. This enables the Robot Controller to use serial communications with other TTL-level digital circuitry. If it is necessary to use Serial Port 2 to communicate with RS-232 devices (such as a PC), various TTL to RS-232 adapters can be purchased from the internet, or plans to make one’s own are also available from the internet.

Both Serial Port 1 and Serial Port 2 are available to the user through custom programs. While Innovation First does not support this feature, general programming information can be found in the Programming Reference Guide from the Innovation First web site, and more specifics on the 18F8520 microcontroller, including pin-outs, can be found in the datasheet from Microchip’s web site. Note that no dedicated handshaking lines are provided for Serial Port 2, but any of the digital I/O lines could be used for this purpose in software, if necessary.



12. LED Indicators

The EDU Robot Controller has the following LED indicators.

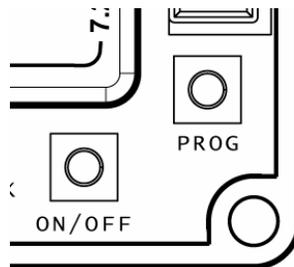
- BATTERY POWER
- PROGRAM STATE
- PWM IN/RADIO
- FAULT STATUS

Name	Status	Meaning
BATTERY POWER	Green Blinking	Input power is applied. Input Power is controlled from the ON / OFF button.
BATTERY POWER	Orange Blinking	Low battery voltage (below 6.2V) detected. Replace or recharge battery soon.
BATTERY POWER	Red Blinking	Battery voltage below 5V detected. Robot Controller is about to shut down.
BATTERY POWER	Red Solid	Hardware fault. Contact Innovation First.
PROGRAM STATE	Green Blinking	Robot Controller program executing normally.
PROGRAM STATE	Orange Solid	Waiting for new user program to be downloaded from PC.
PROGRAM STATE	Orange Blinking	Currently downloading new user program from PC.
PROGRAM STATE	Red Blinking	Continuous blinking – Program is in an infinite loop. Five blinks before turning solid – Invalid register accessed in user program.
PROGRAM STATE	Red Solid	No communication between User processor and Master processor.
PWM IN/RADIO	Green Blinking	Valid signals detected at “R/C PWM IN” inputs. Hobby R/C receiver is plugged in and operational.
PWM IN/RADIO	Red Solid	No valid signals detected at “R/C PWM IN” inputs. No hobby R/C receiver is plugged in.
FAULT STATUS	Green Blinking	Normal operation.
FAULT STATUS	Orange Blinking	High current condition exists on the DIGITAL I/O – ANALOG IN, INTERRUPTS, and R/C PWM IN power pins.
FAULT STATUS	Orange Solid	Over-current condition exists on the DIGITAL I/O – ANALOG IN, INTERRUPTS, and R/C PWM IN power pins.
FAULT STATUS	Red Blinking	High-current condition exists on the PWM OUT power pins.
FAULT STATUS	Red Solid	Hardware fault. Contact Innovation First.

13. ON/OFF Button (Reset)

To turn on the EDU Robot Controller, press the ON/OFF button for approximately one-half of one second, until the green light comes on. To turn it off, press it again for half a second until all lights go off.

The Power button can also be used to reset the EDU Robot Controller by “Power Cycling”. Power Cycling involves turning OFF the EDU Robot Controller and then turning it back ON after a few seconds. Power Cycling performs a complete hardware Reset of the Robot Controller, including the Master and User processors.



14. Program Button

The button labeled “PROG” is used to put the EDU Robot Controller into a state in which it is waiting to download a new program. When this button is pressed, whatever program is currently executing will be stopped and the “PROGRAM STATE” LED will turn a solid orange. Then a new user program can be downloaded from a PC. For complete details on how to download a new user program to the Robot Controller, refer to the [Programming Reference Guide](#) available from www.InnovationFirst.com.

If the “PROG” button is inadvertently pressed but you wish to continue running the currently loaded user program, simply power cycle the Robot Controller.

Also, if the PROG button is pressed at the same time as you turn on the unit, diagnostic mode will be entered and the LEDs will cycle through a distinctive pattern. This mode is not useful for users and the user program will not execute. Simply power cycle the unit to return to normal operation.

15. Circuit Breakers

The EDU Robot Controller has two internal auto resetting circuit breakers. One protects the bottom and center top PWM OUT pins from short circuits. This circuit breaker will trip when current exceeds 4 amps. The center top pin on the PWM connectors is typically used to power servos. The other circuit breaker protects the 5V power supply which goes to the DIGITAL IN/OUT – ANALOG IN, INTERRUPTS, and R/C PWM IN pins. This circuit breaker will trip when current exceeds 0.75 amps.

The status of these circuit breakers is indicated by the state of the FAULT LED on the Robot Controller. Refer to the table on page 12 for details. If a fault condition exists, as displayed by this LED, remove the connections to the corresponding pins one by one until the fault condition disappears.