Innovation First, Inc.
2004 Operator Interface
Reference Guide
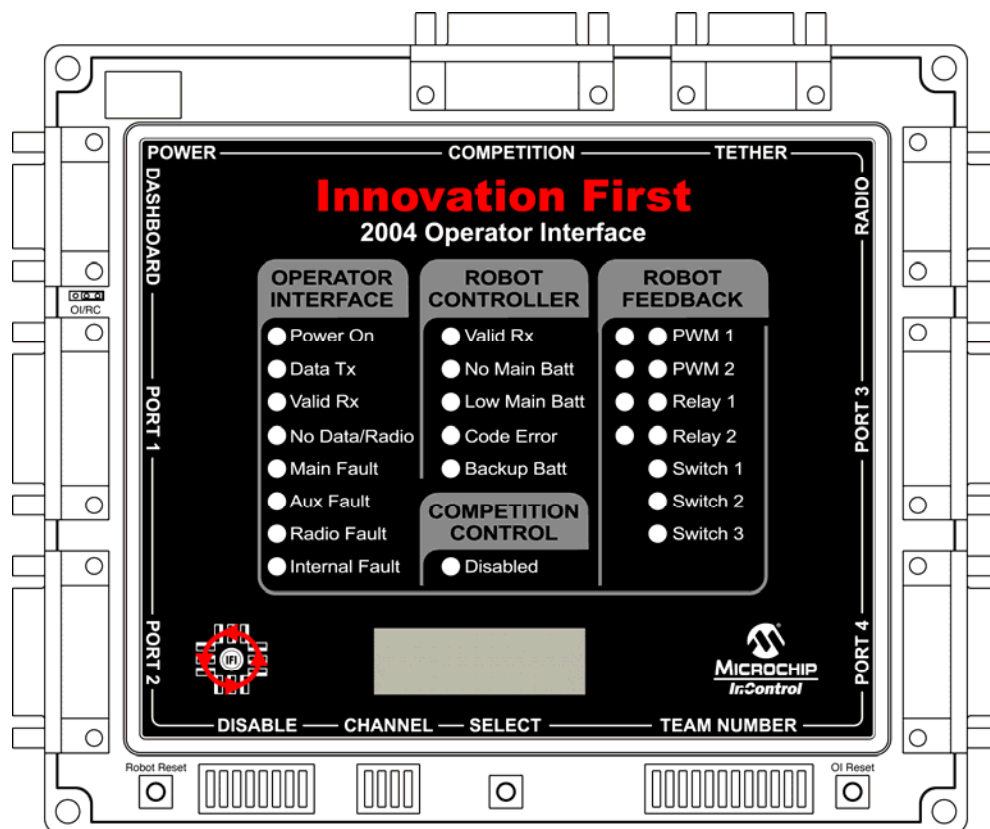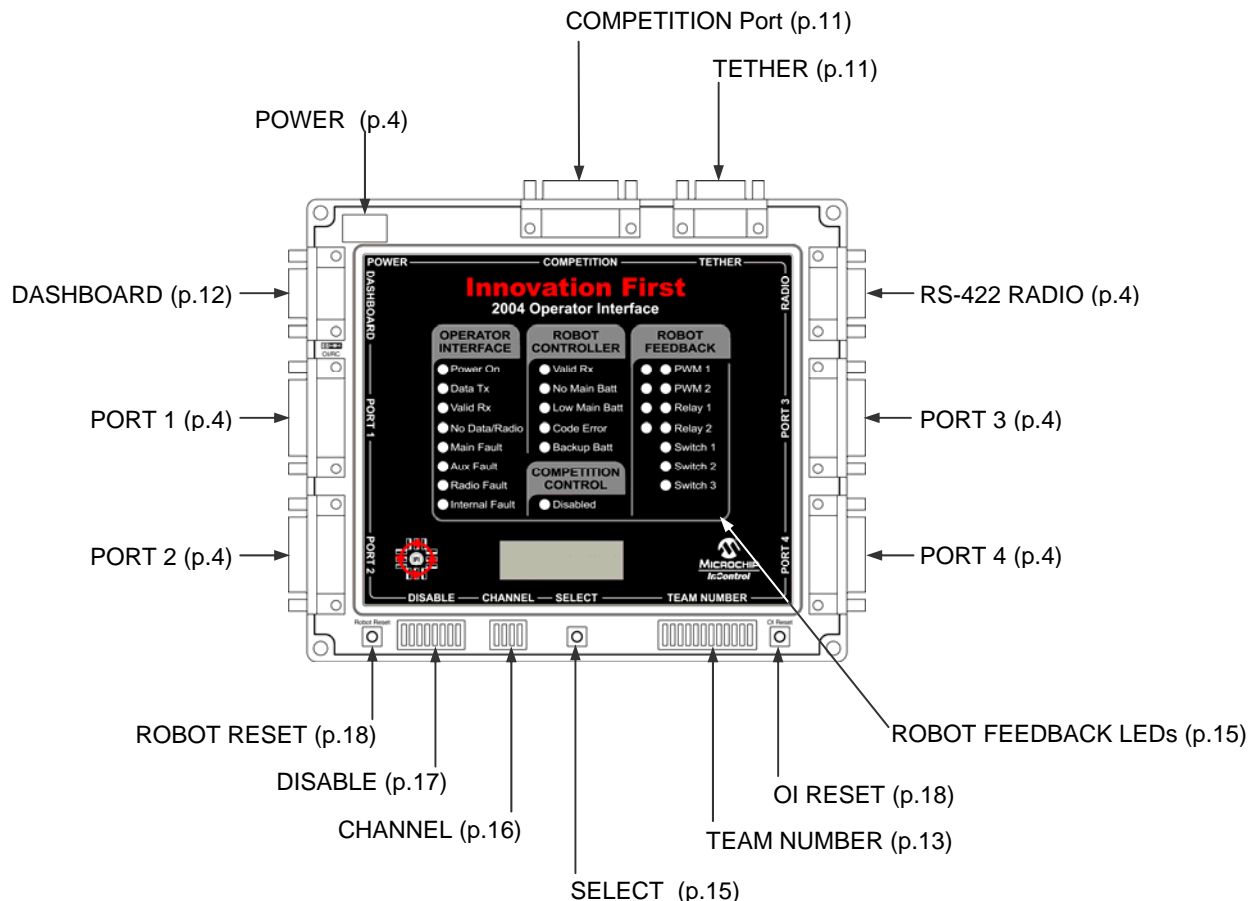
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1. Operator Interface Basics

The Operator Interface's basic function is to collect data from joysticks, buttons, and other input devices controlled by human operator(s). The data is transmitted through a Radio Modem or Tether cable to the Robot Controller. The Operator Interface also receives data transmitted from the Robot Controller, displays the data, and transmits the data out the DASHBOARD port, for display or manipulation on a PC, PDA, or other device. The data sent out the DASHBOARD port can be switched from Received data to Transmitted data using a jumper on the Operator Interface.

The Operator Interface inputs data via PORT 1, PORT 2, PORT 3, and/or PORT 4. These ports are CH Products FlightStick compatible. The ports can also be used with custom control boxes of your own design. The four input ports have a total of 16 digital inputs for switches, 16 analog inputs for potentiometers and sensors, and 8 LED drivers for controlling external indicators.

The 2004 Operator Interface can only be used with the 2004 Full-Size Robot Controller. Throughout this document all references to the Operator Interface and Robot Controller will be to the 2004 models only.

Three ways to Power the Operator Interface
There are three ways to power the Operator Interface:
- AC Adaptor
- Tether connection to the Robot Controller
- Competition port connection on the competition field

The AC Adaptor power can be used in conjunction with Tether power. Do not use Tether power at the same time as Competition power.

The most common method to power an Operator Interface is with an AC Adaptor. This adaptor converts standard 115V 60Hz wall power to the correct voltage and provides the necessary current. Only use the AC adaptor provided with the system. When the Operator Interface and the Robot Controller are connected via TETHER ports, the Operator Interface will be powered from the robot's 12V battery. Tether power provides a means to power the Operator Interface when 115V 60Hz power is not available. Tether power is useful before or after competition rounds to check your system or collapse your robot. The Operator Interface can also be powered via the COMPETITION port. Competition power will be used at regional and championship events, eliminating the need for an AC adaptor on the competition field.

Reference Documents (available at www.InnovationFirst.com)
Size, weight, and mounting information.......... Operator Interface Installation Info.pdf
Full-Size Quick Start Guide............................ Full-Size Control System Quick Start Guide.pdf
Dashboard port data specification.................... Dashboard Port Interface Guide.pdf

2. Input Power

The POWER connection on the Operator Interface is intended to accept DC power from an AC Adaptor. For information on other ways to power the Operator Interface, refer to page 3.

Warning: Only use the AC Adaptor AD48-0901500DU provided with the system. The use of any other AC Adaptor may damage the Operator Interface and will void the warranty. Additional AC Adaptors are available from Innovation First at www.InnovationFirst.com.

3. RS-422 Radio

The RS-422 RADIO port is intended to connect to the Innovation First RS-422 Radio Modem only. This port uses RS-422, instead of RS-232, to minimize noise interference in the communication link.

Caution: Do not connect any other equipment to this port.

There are two different Radio Modems provided with the system. Be sure to connect the Operator Interface to the Radio Modem that is marked "Operator Interface" by the chrome antenna. Use a DB9 Male-Female Pin-to-Pin cable (maximum length 6 ft.) to connect the Operator Interface to a RS-422 Radio.

The chrome antenna on the "Operator Interface" Radio Modem does not extend, but it does swivel and tilt. Try to keep it oriented parallel to the antenna on the Robot Controller. This ensures maximum range and optimal reception.

4. Operator Interface Ports 1, 2, 3, and 4

The Operator Interface Port's 1, 2, 3, and 4 are intended to provide user input. All four ports are designed to be analog joystick compatible. Each port can be split with a Y-Cable, allowing two joysticks to be connected to one port. Custom user input boxes can also be connected to one or more of these ports.

Joysticks PORTS
These ports are 100% CH Products FlightStick compatible. Other joysticks may be used (except during FIRST competitions), however, the joystick pinouts must be checked to ensure compatibility. The DISABLE dipswitch on the Operator Interface allows the joystick buttons to be disabled on PORT 1 and PORT 3.

Joystick Y-Cables
Y-Cables may be used to connect two joysticks to one port. This allows more functions on a custom user input box (see Figure 4.3.3). Refer to our web site (www.InnovationFirst.com) under White Papers for details on making a Joystick Y-Cable.

Analog Inputs (see pinouts on pages 7-10)
Each port provides four analog inputs. These inputs are typically connected to joysticks and potentiometers, providing an analog input ranging from 0 to 254 (in software) that is transmitted to the Robot Controller. In the event that an analog input is less than 0.05V, a value of 127 will be generated. This ensures that when a joystick is unplugged, the corresponding output on the Robot Controller will not go to a full reverse condition. Each port provides +5V Aux, used for wiring to potentiometers or other sensors. The wiring diagram for a potentiometer is shown below. Always use 100kΩ potentiometers.


```
+5V Aux     ●————————┐
                     ⌇
Analog Input ●——————▶⌇   100k Ω
                     ⌇
No connect  ●————————┘
```
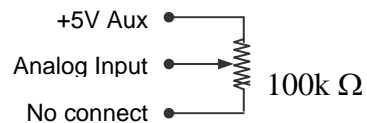
Digital Inputs (see pinouts on pages 7-10)
Each port provides four unique digital inputs. PORT 2 provides access to the same digital inputs as PORT 3, allowing access to 8 digital inputs from PORT 2. PORT 4 provides access to the same digital inputs as PORT 1, allowing access to 8 digital inputs from PORT 4. To utilize these inputs, wire buttons or switches between the desired digital input signal pin and any ground pin. A digital input senses a connection to ground to become active. Do not connect switches or digital inputs to 5V. Do not use lighted switches.

LED Drivers (see pinouts on pages 7-10)
PORT 1 and PORT 3 each provide four LED output drivers. These LED drivers allow the connection of external LEDs that duplicate the function of the top eight Robot Feedback LEDs on the Operator Interface. The LED drivers provide 5V that is current limited to 10mA. Connect the LED's anode to the desired LED drive pin. Connect the LED's cathode to any ground pins.

Figure 4.3.1: Operator Interface with Four Joysticks

Figure 4.3.2: Operator Interface with Two Joysticks and a User Box

**Figure 4.3.3:
Operator Interface with Two Y-Cable Joysticks and a User Box**

Table 4.3.1: Port 1 Pinout and Software Function

Pin	Function	Variable type	Variable Name	Disable Dipswitch
		C Code Information		
3	X-Axis	Analog (byte)	p1_x	
6	Y-Axis	Analog (byte)	p1_y	
13	Wheel	Analog (byte)	p1_wheel	
11	Aux Analog	Analog (byte)	p1_aux	
2	Joystick Trigger Switch	Digital (bit)	p1_sw_trig	SW01 [1]
7	Joystick Thumb Switch	Digital (bit)	p1_sw_top	SW02 [1]
10	Aux Switch1	Digital (bit)	p1_sw_aux1	SW03 [1]
14	Aux Switch2	Digital (bit)	p1_sw_aux2	SW04 [1]
15	Robot Feedback LED driver [2]	Output (bit)	pwm1_green	
8	Robot Feedback LED driver [2]	Output (bit)	pwm1_red	
9	Robot Feedback LED driver [2]	Output (bit)	pwm2_green	
5	Robot Feedback LED driver [2]	Output (bit)	pwm2_red	
1	+5V Aux (Fuse F2) [3,4]			
4	Ground			
12	Ground			

Notes:

[1]   The DISABLE dipswitch on the Operator Interface
[2]   LED drivers provide 5V at 10mA
[3]   +5V Aux is to be used for potentiometers in Joysticks and custom I/O boxes.
[4]   Do not use +5V Aux for lamps or LEDs.

Table 4.3.2: Port 2 Pinout and Software Function

Pin	Function	Variable type	Variable Name
		C Code Information	
3	X-Axis	Analog (byte)	p2_x
6	Y-Axis	Analog (byte)	p2_y
13	Wheel	Analog (byte)	p2_wheel
11	Aux Analog	Analog (byte)	p2_aux
2	Joystick Trigger Switch	Digital (bit)	p2_sw_trig
7	Joystick Thumb Switch	Digital (bit)	p2_sw_top
10	Aux Switch1	Digital (bit)	p2_sw_aux1
14	Aux Switch2	Digital (bit)	p2_sw_aux2
5	same as OI Port 3 Joystick Trigger Switch	Digital (bit)	p3_sw_trig
8	same as OI Port 3 Joystick Thumb Switch	Digital (bit)	p3_sw_top
9	same as OI Port 3 Aux Switch1	Digital (bit)	p3_sw_aux1
15	same as OI Port 3 Aux Switch2	Digital (bit)	p3_sw_aux2
1	+5V Aux (Fuse F2) [1,2]		
4	Ground		
12	Ground		

Notes:

OI refers to the Operator Interface

[1]   Do not use +5V Aux for lamps or LEDs.
[2]   +5V Aux is to be used for potentiometers in Joysticks and custom I/O boxes.

Table 4.3.3: Port 3 Pinout and Software Function

Pin	Function	C Code Information		Disable Dipswitch
		Variable type	Variable Name	
3	X-Axis	Analog (byte)	p3_x	
6	Y-Axis	Analog (byte)	p3_y	
13	Wheel	Analog (byte)	p3_wheel	
11	Aux Analog	Analog (byte)	p3_aux	
2	Joystick Trigger Switch	Digital (bit)	p3_sw_trig	SW05 [1]
7	Joystick Thumb Switch	Digital (bit)	p3_sw_top	SW06 [1]
10	Aux Switch1	Digital (bit)	p3_sw_aux1	SW07 [1]
14	Aux Switch2	Digital (bit)	p3_sw_aux2	SW08 [1]
15	Robot Feedback LED driver [2]	Output (bit)	pwm1_green	
8	Robot Feedback LED driver [2]	Output (bit)	pwm1_red	
9	Robot Feedback LED driver [2]	Output (bit)	pwm2_green	
5	Robot Feedback LED driver [2]	Output (bit)	pwm2_red	
1	+5V Aux (Fuse F2) [3,4]			
4	Ground			
12	Ground			

Notes:

[1]   The DISABLE dipswitch on the Operator Interface
[2]   LED drivers provide 5V at 10mA
[3]   +5V Aux is to be used for potentiometers in Joysticks and custom I/O boxes.
[4]   Do not use +5V Aux for lamps or LEDs.

Table 4.3.4: Port 4 Pinout and Software Function

		C Code Information	
Pin	**Function**	**Variable type**	**Variable Name**
3	X-Axis	Analog (byte)	p4_x
6	Y-Axis	Analog (byte)	p4_y
13	Wheel	Analog (byte)	p4_wheel
11	Aux Analog	Analog (byte)	p4_aux
2	Joystick Trigger Switch	Digital (bit)	p4_sw_trig
7	Joystick Thumb Switch	Digital (bit)	p4_sw_top
10	Aux Switch1	Digital (bit)	p4_sw_aux1
14	Aux Switch2	Digital (bit)	p4_sw_aux2
5	same as OI Port 1 Joystick Trigger Switch	Digital (bit)	p1_sw_trig
8	same as OI Port 1 Joystick Thumb Switch	Digital (bit)	p1_sw_top
9	same as OI Port 1 Aux Switch1	Digital (bit)	p1_sw_aux1
15	same as OI Port 1 Aux Switch2	Digital (bit)	p1_sw_aux2
1	+5V Aux (Fuse F2) [1,2]		
4	Ground		
12	Ground		

Notes:

  OI refers to the Operator Interface

  [1]   Do not use +5V Aux for lamps or LEDs.
  [2]   +5V Aux is to be used for potentiometers in Joysticks and custom I/O boxes.

5. Tether Port

The TETHER port is intended to connect the Operator Interface to the Robot Controller. The TETHER port passes the same data as the radios, allowing full functionality without the use of radios. A tether connection can be made with or without Radio Modems connected. The system will always use tether if it is available. When a tether connection is made, you will see the status indicators on the Radio Modems switch to Standby. Both the Operator Interface and the Robot Controller will automatically detect a tether connection and switch to tether without requiring power OFF or a reset.

A tether connection also provides power to the Operator Interface from the Robot Controller's battery. Tether power provides a means to power the Operator Interface when 115V 60Hz power is not available. Tether power is useful before or after competition rounds to check your system or collapse your robot.

Caution: This port is not intended to interface with a computer.

Use a DB9 Female-Female Pin-to-Pin cable (maximum length 6 ft.) to connect the Operator Interface to the Robot Controller.

6. Competition Port

The COMPETITION port is intended to allow control of your Operator Interface by competition organizers. Competition organizers can use the Competition port to access additional channels, provide power, and disable robot control for starting and stopping matches or for safety issues.

An adaptor cable can be connected to the Competition port allowing the 'disable robot' feature to be used anytime. This adaptor connector is not provided with the system. Details on making a disable adaptor cable are provided later in this section.

The COMPETITION port is also used to provide teams access to four additional radio channels. All Operator Interfaces default to channel 40. Access to channels 4, 13, 22, and 31 can be achieved by connecting a channel access adapter connector to the COMPETITION port. The adaptor connector is not provided with the system. Details on making a channel access adaptor connector are provided later in this section. Refer to page 16 for information on selecting additional channels once the channel access adaptor is installed.

Access to channels other than 40 will be restricted at events. Do not make the channel access jumper internal to the Operator Interface. This jumper connection is intended to be externally visible. Internal channel access jumper will be detected when you connect to the Arena Controller at FIRST Regional or Championship Events.

Competition Port Adapter

A Competition port adaptor can provide access to four additional channels and/or provide access to the Disable feature. To build this adaptor, you will need wire and the following:
  (1) DB15 Male solder pot connector
  (1) DB15 backshell
  (1) ON/OFF switch

Connect pin 12 to pin 8 to provide additional channel access. Connect pins 6 and pin 8 to the appropriate pins of an ON/OFF switch. Be sure that no other pins are shorted.

For more details, please refer to the Competition Port Pinout Guide on our web site at www.InnovationFirst.com/FIRSTRobotics/ under the Documents section.

Table 4.5: COMPETITION Port Pinout

Pin	Function
12	Channel access
6	Disable
8	Ground

WARNING: The COMPETITION port has pins that connect directly to the Operator Interface microprocessor. Incorrect wiring may damage the unit and will void the warranty. This damage may not be apparent until connecting to the field at competition. Use caution and double check your wiring prior to making a connection. Always use a backshell to protect the connector's pins from ESD discharge.

7. Dashboard Port

The DASHBOARD port is intended to allow the Operator Interface to transfer data to a computer for enhanced robot feedback. The DASHBOARD port is a transmit-only interface. The data transmitted out the DASHBOARD port can be selected by an OI/RC jumper located next to the DASHBOARD port. When the jumper is on the RC setting, the data transmitted out the port is the same data that is received by the Operator Interface from the Robot Controller. Likewise when the jumper is on the OI setting, the data transmitted out the port is the same data that is transmitted by the Operator Interface to the Robot Controller. Innovation First provides a Windows™ compatible Dashboard Viewer program for viewing the data on a PC. Innovation First does not provide support for the Dashboard Viewer software or release the source code. Custom programs may be written to make use of this data.

Connect the DASHBOARD port to the RS-232 serial port of a computer using a DB9 Male-Female Pin-to-Pin cable (maximum length 6 ft.).

Refer to the Dashboard Port Data Specification available at www.InnovationFirst.com.
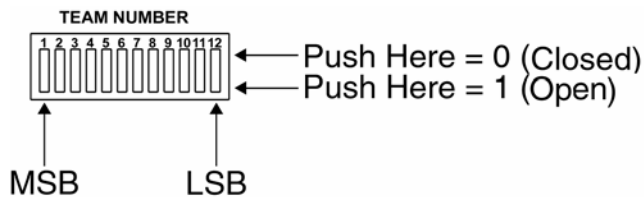
8. Setting the Team Number

A quick method of setting the Team Number without using binary is described in the Full-Size Control System Quick Start Guide.

Setting the Team Number on the Operator Interface requires changing the TEAM NUMBER dipswitch settings. The Team Number is set by changing the switches to match the binary equivalent of your Team Number. The Operator Interface will update the Team Number on your 4-digit display while you change the TEAM NUMBER dipswitch. You may have to press the SELECT button several times until the Team Number is shown. The Team Number is displayed as four numbers only, with no decimal place or letters. You can not use a team number of zero. A team number of zero is reserved for Autonomous Mode on the Robot Controller. For more information on Autonomous Mode, see the Programming Reference Guide.

Since the 2004 Robot Controller no longer has team number DIP switches, it must obtain its team number by being tethered to the OI. Once it has been tethered it will remember the team number that the OI was set to and will be able to connect by radio link from then on. The team number is stored in EEPROM and will be remembered even after power has been removed. If you need to change team numbers you must change it on the OI and then re-tether to change it on the RC.

The Operator Interface's 4-digit display can show any Team Number up to **4095.**

The diagram below shows the location of the Most Significant Bit (MSB) and the Least Significant Bit (LSB) on the Team Number dip switch.

The following diagram is an example of setting the Team Number to **34** . The black areas on the Team Number Switch indicate which half of the switch is in the down position.
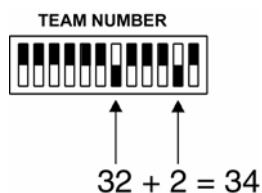
9. Operator Interface Indicators

Table 5.2.1: Operator Interface LEDs - Operator Interface Section

Power ON	Solid	Input power is ON from AC Adaptor, Tether, or Competition port.
Data Tx	Blink	Transmitting data packets to Radio Modem.
Valid Rx	Blink	Receiving data packets with correct Team Number and Channel Number.
No Data/Radio	Blink	No data packets received or bad data packets received.
No Data/Radio	Solid	Radio Modem not found. Check modem and cables.
Main Fault	Solid	Remove all connections to OI but Main Power. If problem continues, contact Innovation First.
Aux Fault	Solid	Remove all connections to OI but Main Power. If problem continues, contact Innovation First.
Radio Fault	Solid	Remove radio connection. If problem continues, contact Innovation First.
Internal Fault	Solid	Contact Innovation First.

Table 5.2.2: Operator Interface LEDs – Robot Controller Section

Indicator	Status	
Valid RX	Blink	The Robot Controller is receiving good data packets.
No Main Batt	Solid	The Robot Controller's main battery voltage is below 5V.
Low Main Batt	Blink	Main battery voltage below 9.0V detected. Replace or recharge battery soon.
Low Main Batt	Solid	Main battery voltage below 7.1V detected. Replace or recharge battery now. [1]
Code Error	Solid	The Robot Controller's User processor is held in reset by the Master processor due to invalid configuration or because it has not responded to the Master processor in a timely fashion. For example, it may be stuck in an infinite loop.
Backup Batt	Solid	Backup battery voltage is below 6V.

[1] Radio communication will begin to drop out when the battery voltage drops below 5.5V.

10. Competition Control LED

The COMPETITION CONTROL Disabled LED on the Operator Interface has 2 functions. It can indicate that the main outputs on the Robot Controller have been disabled via the Competition port (see page 11) leaving the robot "lifeless", or it can indicate Autonomous Mode of operation. Autonomous Mode can been turned ON by setting the team number to Zero on the Robot Controller or via the Competition port. For more details on the Competition port, refer to the Competition Port Pinout Guide. For more information on programming for Autonomous Mode, see the Programming Reference Guide. These guides are available from www.InnovationFirst.com/FIRSTRobotics in the Documents section.

When the Disabled LED is ON solid, the Robot Controller's PWM and RELAY outputs are disabled. The following functions are still active when the Disabled LED is solid ON:
- Operator Interface inputs (joystick, buttons, etc.) are transmitted to the Robot Controller.
- User code is executing.
- User code input, including Operator Interface inputs and local inputs (switches, pots, etc) are read in by the User processor.
- Robot Controller feedback is transmitted to the Operator Interface.

When the Disabled LED is blinking, the Robot Controller is in an Autonomous Mode. The following functions are still active when the Disable LED is blinking:

- Operator Interface inputs (joystick, buttons, etc.) are transmitted to the Robot Controller in their default state(analog inputs at neutral and digital inputs disabled).
- User code is executing.
- User code input, local inputs (switches, pots, etc), including Operator Interface default inputs are read in by the User processor.
- Robot Controller feedback is transmitted to the Operator Interface.
- For more information on programming Autonomous Mode, see the Programming Reference Guide.

Thus the Robot can move and function only from User code commands and will ignore any human input from the Operator Interface.

11. Robot Feedback LEDs

The ROBOT FEEDBACK lights on the Operator Interface represent data transmitted from the Robot Controller to the Operator Interface. All 11 lights are user definable in their custom C code. The Default Code provided with the Robot Controller utilizes these lights to display the status of PWM 1, PWM 2, Relay 1, Relay 2, and digital inputs 1, 2, and 3 respectively.

12. Select Button and the 4-Digit Display

The SELECT button is used to change the information presented on the 4-digit display. Pressing SELECT will cycle the display between Robot Voltage, User Mode, Team Number, and Channel. The data displayed can be distinguished by the format used.

	4 digit
Team Number display	0000
Channel display	c40
Robot Voltage display	12.0
User Mode	u000

The Operator Interface's 4-digit display can show any Team Number up to 4095. Refer to page 16 or the Programming Reference Guide for more info on the User Mode function.

13. User Mode

The User Mode can display any variable byte (8 bits) that is specified in the user's C program. The default code is configured to display value of Port1 Y axis. To change the variable that is displayed, you simply change the user code to specify which value you want to assigned to the User_Mode_byte variable. Also, through software, you can change the variable that is displayed with switches, buttons, knobs, etc. to provide the human operator with a variety of critical information feedback.

14. Channel Dipswitch

The CHANNEL dipswitch located on the Operator Interface is used to select a channel for both the Operator Interface and the Robot Controller. The Operator Interface reads the CHANNEL dipswitch on power-up or after pressing the OI RESET button. Access to channels 4, 13, 22, and 31 can be achieved by connecting a channel access adapter connector (see page 11) to the COMPETITION port and setting the CHANNEL dipswitch according to Table 5.4. The Operator Interface will default to channel 40 independent of the dipswitch setting if a competition port adapter is not detected.

The Robot Controller sets channels by scanning for the Operator Interface with the same Team Number. The Robot Controller will only scan channels on power-up or after pressing the RESET button located on the Robot Controller.

Table 5.4: CHANNEL Dipswitch Settings

1	2	3	4	Channel
X	ON	ON	ON	04
X	ON	ON	OFF	13
X	ON	OFF	ON	22
X	ON	OFF	OFF	31
X	OFF	X	X	40

ON -   The switch selector is in the Down position
OFF -   The switch selector is in the Up position
X -   Refers to a don't care condition. The switch can be ON or OFF in a don't care condition.

Steps for changing channels:
1. Make sure a COMPETITION port adapter with channel access is installed.
2. Make sure both units (RC and OI) are set to the same Team Number.
3. Set the CHANNEL dipswitch to the desired channel.
4. Press OI RESET on the Operator Interface.
5. Press RESET on the Robot Controller.
6. Note: ROBOT RESET on the Operator Interface will not work for this.
7. After a few seconds, the "Valid RX" LEDs should be flashing on both units, indicating each is transmitting and receiving good data with the correct team number and channel number.

15. DISABLE dipswitch

The DISABLE dipswitch is used to disable buttons on joysticks connected to PORT 1 and PORT 3. Only PORT 1 and PORT 3 have joystick digital inputs that are available on another port. This disable feature is useful when a custom button box uses the same digital input as a joystick. A button on a joystick can be disabled so only the button on the box is functional. The tables below list the buttons that can be disabled.
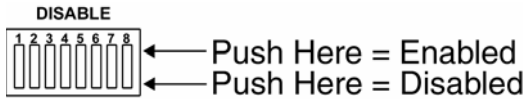
DISABLE

Push Here = Enabled
Push Here = Disabled

Table 5.5.1: Disable Switches for Port 1

Port 1		DISABLE switches for Port 1	Port 4	
Pin	Button		Pin	Button
2	Joystick Trigger Switch	SW01	5	same input as OI Port 1 Joystick Trigger Switch
7	Joystick Thumb Switch	SW02	8	same input as OI Port 1 Joystick Thumb Switch
10	Aux Switch1	SW03	9	same input as OI Port 1 Aux Switch1
14	Aux Switch2	SW04	15	same input as OI Port 1 Aux Switch2

Table 5.5.2: Disable Switches for Port 3

Port 3		DISABLE switches for Port 3	Port 2	
Pin	Button		Pin	Button
2	Joystick Trigger Switch	SW05	5	same input as OI Port 3 Joystick Trigger Switch
7	Joystick Thumb Switch	SW06	8	same input as OI Port 3 Joystick Thumb Switch
10	Aux Switch1	SW07	9	same input as OI Port 3 Aux Switch1
14	Aux Switch2	SW08	15	same input as OI Port 3 Aux Switch2

16. OI Reset

The OI RESET button performs a complete hardware reset of the Operator Interface. The following is the most common use for the OI RESET button:

- Pressing OI RESET after the CHANNEL dipswitch is changed will initiate a radio channel change. Note: If the RC was locked to the previous channel, the RC will need to be reset before a radio link can be re-established.

When in doubt, pressing OI RESET won't hurt.

17. Robot Reset

The ROBOT RESET button is intended to allow remote reset of the Robot Controller's User processor. The most common use for the ROBOT RESET button is to restart the User processor in case of a programming error. The ROBOT RESET button can also be used to reset the User processor after a new program has been downloaded if needed.

The ROBOT RESET button on the Operator Interface only resets the User processor and not the entire Robot Controller (including the Master processor). Using the RESET button on the Robot Controller or power cycling the Robot Controller are the only ways to reset the entire Robot Controller.