TABLE OF CONTENTS

This page intentionally left blank.

1. THE ROBOT

The Robot section of the 2002 FIRST Robotics Competition Manual provides information about the parts provided in the Kit of Parts at the Kickoff Workshop and information on additional parts that can be used to build the robot. It covers power distribution on the robot, gives some wiring examples, and lists the rules governing robot construction.

NOTE: Documentation for the robot control system is provided by the manufacturer, Innovation First, and can be found on their web site at www.innovationfirst.com/firstrobotics/.

Before embarking on the robot design process, it is important to understand that there are certain constraints on the robots that you must observe in order to compete. The reasons for the constraints are many and varied and include making sure that FIRST Robotics Competition events are safe, that all teams have access to the same materials, that teams follow certain good design practices in order to improve reliability and make problem solving and repair easier, or just to provide a design challenge.

1.1 Before You Start Building A Robot

The complete and detailed list of rules governing robot design and construction is included in *Appendix A.* Listed below are some important concepts from these rules:

1.1.1 Materials

The materials that you are allowed to use to build the robot are limited. There are three sources of materials:

Sources of Robot Materials	Reference Location
1. Parts found in the Kit of Parts	*Appendix B*
2. Parts from Additional Hardware List	*Appendix C*
3. Parts from **SMALL PARTS, INC.**	***SMALL PARTS, INC.*** *Website & Appendix D*

IMPORTANT: To keep the competition on a 'level playing field', any material used in the robot **must come** from the above sources and no other. *You may not use materials, which are not from the above sources.* The amount of materials from these sources may be limited by cost or quantity of material.

1.1.2 Rules Overview

It is very important to become familiar with the rules in Appendix A and read through the allowed materials lists in the appendices. Keep in mind the rules of game play listed in the Game section of the manual and the shipping deadlines listed in the appropriate event sections. By taking the time to read through the rules carefully, you will save time in the long run. You can waste major blocks of time because of the lack of knowledge about a certain rule at the onset of the design process. Pay special attention to the items listed below.

- The size of the robot when it starts a match is limited. Once a match starts, the robot may expand.
- The weight of the robot is limited.
- Certain uses of allowed materials are disallowed, primarily for safety reasons.
- All robots must pass inspection before being allowed to compete at each event.

1.1.3 Scheduling Overview

Plan your overall schedule to include simulated competition test runs. Give your robot operators as much practice as possible. If you have not built some sort of prototype (motors and wheels mounted on a board running around the floor, pick up mechanisms, etc.) by the end of the 3rd week, you are seriously behind schedule. If you have a question, consult this manual and the team updates. If you still don't see the answer to your questions, contact FIRST. Contact information can be found in the Administrative Section of the manual.

It is far better to find out 2 weeks or even 2 days before you ship your robot that something you wanted to do is against the rules than to find out at the event and have to scramble to re-engineer your robot.

1.1.4 Team Updates

As you progress in the design and build stage, assign several team members to carefully read the manual and any team updates, which will be made available on the FIRST web site. In addition to rules updates, corrections, and other important information, the team updates will contain answers to all questions asked by other teams. This helps to ensure that all teams have the same understanding of the rules. Assign several people to read, understand, and interpret the rules and updates for your team.

1.2 Robot Construction Tips

1.2.1 Drill Motors & Drive Assemblies

The drills motors and drive assemblies snap together for convenient handling during assembly of a drill. This motor-drive assembly cannot support normal (side) loads by itself. The gearshift lever on the drive assembly and the gears actuated by it cannot withstand large gear-shifting forces, especially while operating. FIRST recommends using the plastic drill shell to support the motor, drive assembly, and shift mechanism, providing ample speed reduction between the drill and its load.

The drill components were designed for drilling holes and driving screws, not for propelling a heavy robot. Please remember this when designing and operating your robot. Align mechanical power transmission components accurately. If you couple the spindle to another shaft, support the shaft with two bearings and use a suitable flexible coupling. If you mount a gear, pulley, or sprocket to the drive assembly spindle, use the largest pitch diameter possible to minimize side loads resulting from transmitting torque. Note the trade off between side loads and available gear ratio. A small pulley on the spindle allows a good gear ratio, but results in excessive side loads. Seriously consider the possible need for two stages of speed reduction between the drill and its load. If the drill shows signs of overloading, such as clutch disengagement, improve your design. When you get out on the playing field, failures will be far more likely than they were during practice. Refer to Appendix G for Motor Specifications. Small Parts, Inc. sells a special shaft coupling designed for the threaded output shaft of the drill gearbox. See Appendix D for ordering information.

If you plan to utilize both speeds of the gearbox, be sure that the drill motor is stopped before changing gears. Also, be sure to fully engage and hold the gear select level in each gear setting. Otherwise, damage to the gearbox is likely. If you plan to utilize a single speed, FIRST recommends using a secondary fastening method, such as pinning the gear select lever, to prevent the gearbox from slipping out of gear.

Many teams have discovered the hard way that the relatively gentle driving a robot did during prototyping and driver practice was not an accurate representation of what goes on during a match, and suddenly their robot keeps stopping out on the field. Often, this is because the 30 Amp auto-resetting circuit breakers protecting the speed controllers and drill motors are starting to trip. Please keep the following in mind when designing your robot drive system:

- Motor current is proportional to torque output, and the drill motors have a stall current of over 100 Amps. Power to the motors is provided through 30 Amp auto-resetting circuit breakers. Therefore, operating a drill motor at a high torque for more than a few seconds at a time will trip the circuit breaker, causing the robot to stop moving for a few seconds while the breaker cools off. Once the breaker has tripped, it is more sensitive (hot) for a while and thus you are likely to experience additional motor cutout. Please consider this when determining gear ratios for the robot.
- Sudden acceleration, pushing/pulling, climbing sloped surfaces, slamming the robot into reverse when moving forward, and vice versa all require high torque and can lead to tripping breakers if gear ratios are not appropriate.
- Most robots steer like a tank, requiring the wheels or treads to skid sideways in order to allow the robot to turn. This requires far more torque from each drill motor than when the motors are working in cooperation to move the robot forward or backward, and can lead to tripping breakers if gear ratios are not appropriate. Many teams opt to use low friction wheels or two-wheel drive plus caster wheels in order to allow gear ratios that support higher speeds without requiring high torque to turn.
- Some teams have discovered that using "brake" mode on the speed controllers will cause the breakers to trip more often. For more information about brake mode, refer to the Victor 883 documentation from Innovation First.
- Some teams have discovered that their robots drive system works perfectly when the robot is being tested on a bench but will flex and bind up when under load. Friction in the drive system increases the load on the motors and can lead to tripping the circuit breakers.
- A good rule of thumb when designing your drive system gear ratio: A robot that is so fast that it is difficult to steer has too high a gear ratio and is likely to experience breaker problems when competing.
- Sometimes what appears to be a breaker problem is really something else. Loose drive chains and belts, transmissions which disengage, shaft couplings that slip, and faulty electrical connections are just as detrimental as a tripping breaker and can lead to intermittent or total failure during a match.

1.2.2 Globe Motor with Drive Assembly

The drive assembly on the Globe Motor provides a 117 to 1 planetary gear redirection. *The output shaft of the drive assembly is not intended to support side loads.* It is highly recommended that your robot design incorporates a safe yield, to prevent damage to the drive assembly from side loads. Refer to Appendix G for Motor Specifications.

NOTE: *The output shaft of the drive assembly is not designed to support side loads. If the output shaft is not properly supported, it will damage the drive assembly.*

1.2.3 Seat, Window, and Van Door Motors

The seat, window, and van door motors contain one worm gear reduction stage and, in the case of the seat motor, a positive temperature coefficient (PTC) thermistor for overload protection. As the seat motor becomes warm from use, the resistance of the PTC device increases, thereby reducing the motor current and output torque. Operation at or near stall continuously will reduce the output torque to near zero until the motor has been allowed to cool. All motors, even those without a PTC device, will loose output power as they heat up.

To prevent overheating, take care to couple the output shaft in a manner that does not impose large side loads, use an appropriate gear ratio, and minimize the internal friction of the mechanism driven. Refer to Appendix G for Motor Specifications.

1.2.4 Mechanical Power Transmission

One of the most common problems teams have experienced in past competitions is mechanical power transmission failure. Typical torques at the final stage of your propulsion power transmission assembly are large enough to cause serious problems for most conventional means of fixing gears, pulleys, or sprockets to shafts.

Setscrews almost always fail. Pins offer better torque transmission, but can cost you valuable time if one breaks. Be careful not to use a pin so large that it occupies so much of the original shaft cross-section that the shaft breaks. Consider carefully the use of good clamping-type couplings, even though they may be expensive.

1.3 FIRST Policy on Replacement of Kit Parts

1.3.1 Design and Build Phase

FIRST has a limited supply of replacement parts available. If, during examination of components, a failure is determined due to misuse or incorrect wiring, in general, only one (1) additional unit will be supplied. *FIRST reserves the right to refuse to provide replacements to teams that break the same part over and over.*

FIRST will not provide replacement for parts that fail due to modification.

You **must** provide your Team number and daytime contact information when returning any broken part to FIRST for replacement.

- Unless otherwise specified, replacement parts shipped from FIRST will ship via 2nd day air within one business day of receipt of the non-functional part. Teams may opt for overnight shipment at their expense by requesting it, and providing their shipping company preference and account number, (UPS or FedEx, etc.) or by providing a credit card number. (Visa or MasterCard)
- FIRST does not provide "back up" spare parts to teams. When possible, FIRST will provide teams with information on who to contact to obtain extra kit parts. However, due to the nature of how the Kit of Parts is assembled, there will be some kit items for which spares are simply not available. Teams wishing to obtain extra parts for use in robot development or to have on hand as backup should utilize regular retail channels or consult the supplier contact information in *Appendix F*. If contact information for a particular part supplier is not listed in the supplier contact information, then they are not prepared to supply parts directly to teams.

NOTE: *Please do not contact parts suppliers if they are not listed in the supplier contact information.*

1.3.2 FIRST Policy on Replacement of Kit Parts at event sites.

Many kit parts are no longer available as spares at any of the events. This is due to the continued increase in the number of teams as well as the difficulty in obtaining extras.

The following items will not be available at event sites:

Crimping Tool	Casters
The Entire Rod Container	6" and 8" Wheelchair Wheels
CMT Bushings and Pulleys	

Batteries & chargers will NOT be available at any time at any event.

No more than 2 of each type of motor provided in the Kit of Parts will be given to any team at any event as a replacement. Please remember to use "Gracious Professionalism" when requesting new motors as FIRST does not have enough to provide for all teams at every event.

Loaner Control Systems at all events.

Teams are responsible for all Innovation First products required at events. If at any event a team needs to borrow any part of the Control System, a Credit Card number must be provided to ensure proper return of the items after the completion of the event.

If the part is not returned at the end of the event, FIRST retains the right to bill the credit card number provided for the items borrowed.

All "loaner" items are available on a first-come first-served basis.

1.3.3 Innovation First Products

The following kit parts are Innovation First products:

- Operator Interface
- Robot Controller
- Radio Modems
- AC Adapter for Operator Interface
- Speed Controllers (Victor 883)
- Relay Modules (Spike)
- PWM/relay cables
- 9-pin cables
- 15-pin cables

Do not contact FIRST for repair or replacement of Control system items as these units are covered by a product warranty. Please visit the Innovation First web site at www.innovationfirst.com/firstrobotics/ for product support and/or to obtain an RMA #.

This page intentionally left blank.

2. ROBOT ELECTRICAL SYSTEMS

This section covers power distribution and wiring rules for the robot and operator controls and gives examples of how to wire parts included in the kit to the Innovation First control systems. Please note that Innovation First provides control system documentation on their web site at www.innovationfirst.com/firstrobotics/.

WARNING

Please read this and the following sections carefully.

Failure to wire your robot properly could result in personal injury, damage to the control system, or damage to your robot. It could invalidate the control system warranty. FIRST and/or Innovation First will not provide free replacement of components damaged due to misuse or miswiring. Teams will be required to correct wiring that is not configured according to this section and the control system rules in Appendix A before being allowed to compete.

2.1 Wiring the Robot

2.1.1 Power Distribution

Item / Location	Power Source
Battery	Electric power from a 12 Vdc sealed-lead-acid (SLA) battery passes through a 60A main circuit breaker to fuse panels.
Robot Controller, Relay Modules, Fans, LEDs, Optical Sensors & Custom Circuit Board	Power is distributed from the fuse panels via 20A auto-resetting breakers.
Speed Controllers	Power is distributed from the fuse panels via 20 or 30A auto-resetting circuit breakers.
All other electrical devices	Sensors, motors, the rotating light, valves, and the pump receive power from either the Robot Controller, Relay Modules, or Speed Controllers as described below.

For safety reasons, the 60A circuit breaker supplied in the kit must be wired in series with the +12 Vdc output terminal on the battery. Insulate both battery terminals with electrical tape.

CAUTION

Do not connect anything other than the 60A main circuit breaker directly to the +12 Vdc battery output.

WARNING

Be very careful to avoid short circuits:

The 12 Vdc SLA battery can deliver current in excess of 200 Amps for a sustained period of time (minutes). This level of power can make wires turn red hot and melt through the insulation in a fraction of a second, which can result in serious burns, scars, and/or other injuries. Short circuits can also destroy control system components, cause a fire, and/or cause the battery to leak highly corrosive acid or explode. Always make sure the breaker is in series with the battery output. Please be careful!

Although unlikely, it is possible that the large impact forces sometimes experienced by robots in competition matches could cause the lever on the main circuit breaker to switch to the off position. FIRST recommends using a quick-release fastening mechanism to hold the switch in place during

matches. Holding the switch in the on position will not prevent the breaker from tripping in the event of an electrical overload.

Power from the battery must be distributed via the fuse panels included in the kit. Note that each fuse panel contains 12 fused (via the 20 or 30A circuit breakers) outputs connected to one input, and 12 non-fused outputs connected to a second input. The fused and non-fused sides are not connected, so that the panel can be used to distribute both 12 Vdc and Ground.

Figure 2.1 shows an example schematic for power distribution. For clarity, only the +12 Vdc distribution is shown. The non-fused portion of the fuse panel is used to distribute Ground.

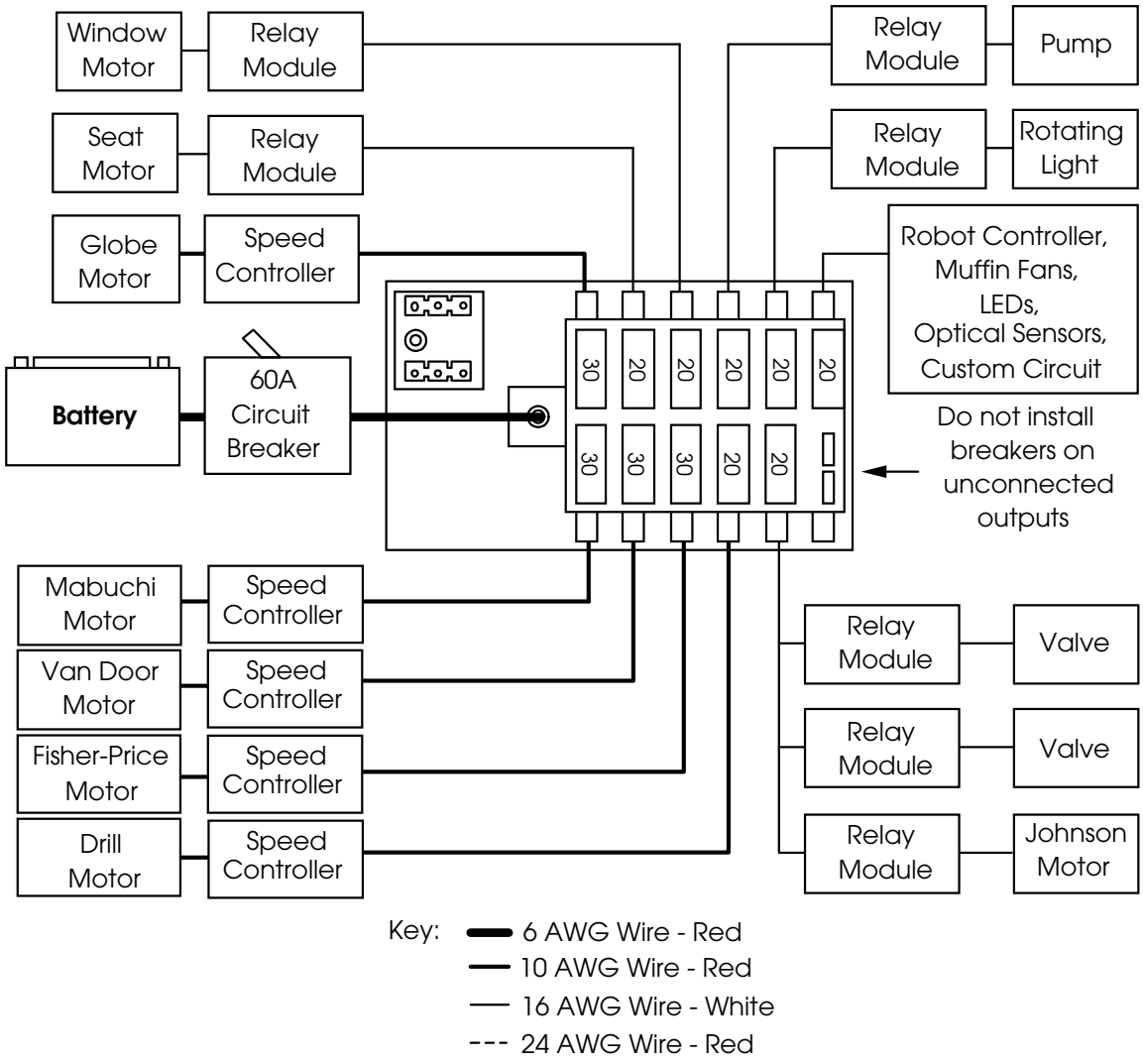

Figure 2.1: +12 Vdc power distribution

Note: Figure 2.1 shows seven relay modules in order to show how devices may be connected on your robot. Only four relay modules are provided in the kit. Additional relay modules and speed controllers may be obtained by purchasing them from Innovation First.

CAUTION

Check wiring periodically.

Be sure to check the wiring on a periodic basis to prevent failures which could harm the control system or cause a robot to stop dead in the middle of a match. Crimp-on connectors that are improperly crimped may work at first, but can fail easily due to the normal operating vibration of a robot. Also, be sure to avoid tension on the wires when components are installed on the robot and never remove a connector by pulling on the wire. Improper or abused connections can result in poor performance, intermittent failures, and/or short circuits.

In order to minimize mistakes and facilitate diagnosis of any problems, all wires distributing power with a constant polarity (i.e., not an output from a Relay Module, Speed Controller, or Sensor) must be color-coded as follows:

- Use Red or White wire for +12 Vdc and +5 Vdc.
- Use Black wire for Ground.

The wires and cables included in the Kit are intended for specific uses. Table 2.1 shows the minimum wire sizes allowed for hookup of the various control system devices.

Table 2.1: Minimum Wire Size by Device Type

Device	Wire Type
Power distribution from battery to fuse panels	6 AWG, red & black
Drill motors, Fisher-Price motors, van door motors, Mabuchi motor, Speed Controllers used with drill, van door, or Fisher-Price motors	10 AWG, red & black
Robot Controller power, Relay Modules, seat motors, window motors, Globe motors, Johnson motor, pump, valves, large muffin fan, Speed Controllers (if used with seat, window, or Globe motors)	16 AWG, 2 conductor
All switches, PWM cables, optical sensors, potentiometers, yaw rate sensor, LEDs, small muffin fans, custom circuit boards	24 AWG, 2 or 3 conductor

It is acceptable to shorten or lengthen control system cables containing 3 or less wires as needed as long as the following conditions are met:

- The connection is insulated.
- The proper wire type is used. (As specified above)

This means, for example, that you may use 24 AWG wire to lengthen a PWM/Relay cable, or use 16 AWG wire to lengthen a connector for a seat motor.

Due to their high current requirements, the drill motors, Mabuchi motor, Fisher-Price motors, Globe motors, and van door motors may only be powered by the Speed Controllers. The, seat, window, and Johnson motors may be powered by Speed Controllers or Relay Modules. Use only Relay Modules to drive the rotating light, pump, and valves.

CAUTION

Attempting to drive the drill motors, Mabuchi motor, van door motors, Globe motors, or Fisher-Price motors directly with the Relay Modules could damage the Relay Modules and is therefore prohibited.

Under certain circumstances, it is acceptable to power more than one device from a single Relay Module. A single Relay Module may power no more than one motor or Pump. A Relay Module may be used to power valves and/or fans in conjunction with a single seat motor, window motor, Johnson motor, pump, or rotating light. See section 2.1.3 for details on how to control more than one device with a single Relay Module.

Each Speed Controller must receive power via a dedicated 20 or 30A circuit breaker. Each Relay Module must receive power via a 20A circuit breaker. It is acceptable to distribute power from a single 20A circuit breaker to multiple Relay Modules if no more than one of the following devices is powered via the 20A breaker: pump, rotating light, window motor, or seat motor. Other devices which may be connected directly to the fuse panel (Robot Controller, Fans, etc.) must be connected via a 20A circuit breaker. The same breaker may power all these devices.

No devices other than the 60A main circuit breaker may be connected directly to the +12Vdc battery output. No devices other than the 20A and 30A circuit breakers in the fuse panels may be connected directly to the output of the 60A main circuit breaker.

The 12 Vdc panel mounted LEDs are intended to be used on the robot as indicator lamps and may be used on Speed Controller or Relay Modules outputs alone or in parallel with any other devices. You may also power the LEDs directly from an auto-resetting breaker.

2.1.2 Rotating Light

A Relay Module must be used to power the rotating light provided in the kit. The light must turn on when the robot is enabled and must turn off when the robot is disabled. The control system will provide this functionality automatically when a Relay Module is connected to relay output 8 on the Robot Controller and the default program is running. Wire the light such that the black power lead is connected to M- and the red power lead is connected to M+ on the Relay Module. The metal housing and mounting bolts on the light are electrically connected to the black power lead. In order to prevent short circuits, the light must be mounted on a non-conductive surface of the robot, such as wood or plastic.

2.1.3 Relay Modules

There are two types of Relay Modules in use in the 2002 FIRST Robotics Competition. Both provide identical power handling capacity, but there is an important difference. The different types of Relay Modules can be identified by the red or blue color of the “Spike” label.

The “red” Relay Modules connect the M+ and M- outputs to +12 Vdc when in the off state. The “blue” Relay Modules connect the M+ and M- outputs to Ground when in the off state. On both types, M+ is connected to +12 Vdc and M- is connected to Ground when the Relay Module is in “Forward” mode, and vice versa for “Reverse” mode. Normally, the Relay Modules are connected across both leads of a DC motor, which means that both types provide equivalent bi-directional motor control. However, in order to reduce the number of Relay Modules needed, it may be desirable to utilize the M+ and M- outputs to independently control simple on-off devices or motors which only need to run in a single direction. Therefore, if independent control of two devices is to be used, the wiring must be based on the type of Relay Module.

Figure 2.2 shows how to achieve independent control of two devices from a single Relay Module:

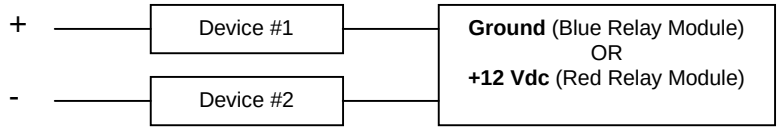

Figure 2.2: Controlling two devices with one Relay Module

Section 2.1.1 details what combinations of devices may be simultaneously powered by a Relay Module.

To achieve control of both solenoids on a double solenoid valve, use only one Relay Module, and avoid running separate power return leads, use two diodes (allowed per the Additional Hardware List in Appendix C) to route power to one solenoid at a time. Figure 2.3 shows the schematic for this arrangement.

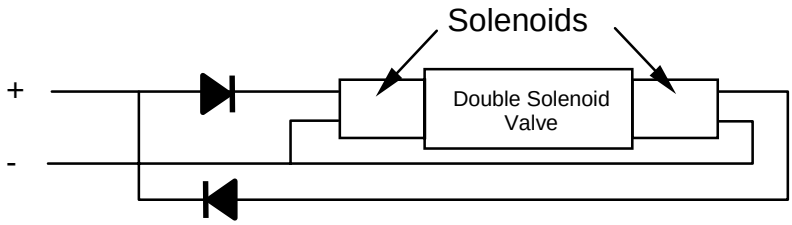

Figure 2.3: Use of Diodes with Double Solenoid Valve

CAUTION

The red Relay Modules will be damaged if reverse polarity is applied to the power inputs. Please be careful when wiring the relay modules.

For more information about the Relay Modules, refer to the documentation from Innovation First.

2.1.4 Speed Controllers

CAUTION

The Speed Controllers will be damaged if reverse polarity is applied to the power inputs. Please be careful when wiring the Speed Controllers.

For information about the Speed Controllers, refer to the documentation from Innovation First.

2.1.5 Muffin Fans

Several 12V muffin fans are included in the Kit primarily for added protection against motor overheating. FIRST recommends installing these fans to direct cooling air over the components that run the hottest. You may provide constant power to the fans via a 20A circuit breaker or use a Relay Module to switch power to the fans.

CAUTION

The muffin fans provided in the kit are not reversible. You can damage them if you apply reverse polarity. Please be careful when wiring the muffin fans.

2.1.6 Sensor Inputs on the Robot Controller

The exact wiring configuration for sensors connected to the Robot Controller is not specified. Teams may wire these devices, within the rules as described below, and according to the documentation supplied by Innovation First, in order to create a custom sensor system on the robot.

- Connect switches between Ground and the switch input pin of your choice.
- Connect potentiometers with +5 Vdc at one end and Ground at the other end. Connect the wiper to the analog input pin of your choice.

CAUTION

Do not connect switches to +5Vdc, it may damage the switches.

To connect the Yaw Rate Sensor to the Robot Controller, connect +5 Vdc (only use pin 1 - +5Vdc Aux. on the Analog Input port for power to this sensor) to the +5 Vdc input on the sensor, connect Ground to Ground, and connect the sensor output to the analog input pin of your choice. Output characteristics of the Yaw Rate Sensor are described in the manufacturers' specification sheets included in Appendix G.

CAUTION

Do not connect any voltages greater than +5Vdc to the analog inputs on the Robot Controller. It may damage the Robot Controller.

Figure 2.4 shows an example of the proper way to connect a pressure switch, potentiometer, yaw rate sensor, limit switch and optical sensor to the Robot Controller.

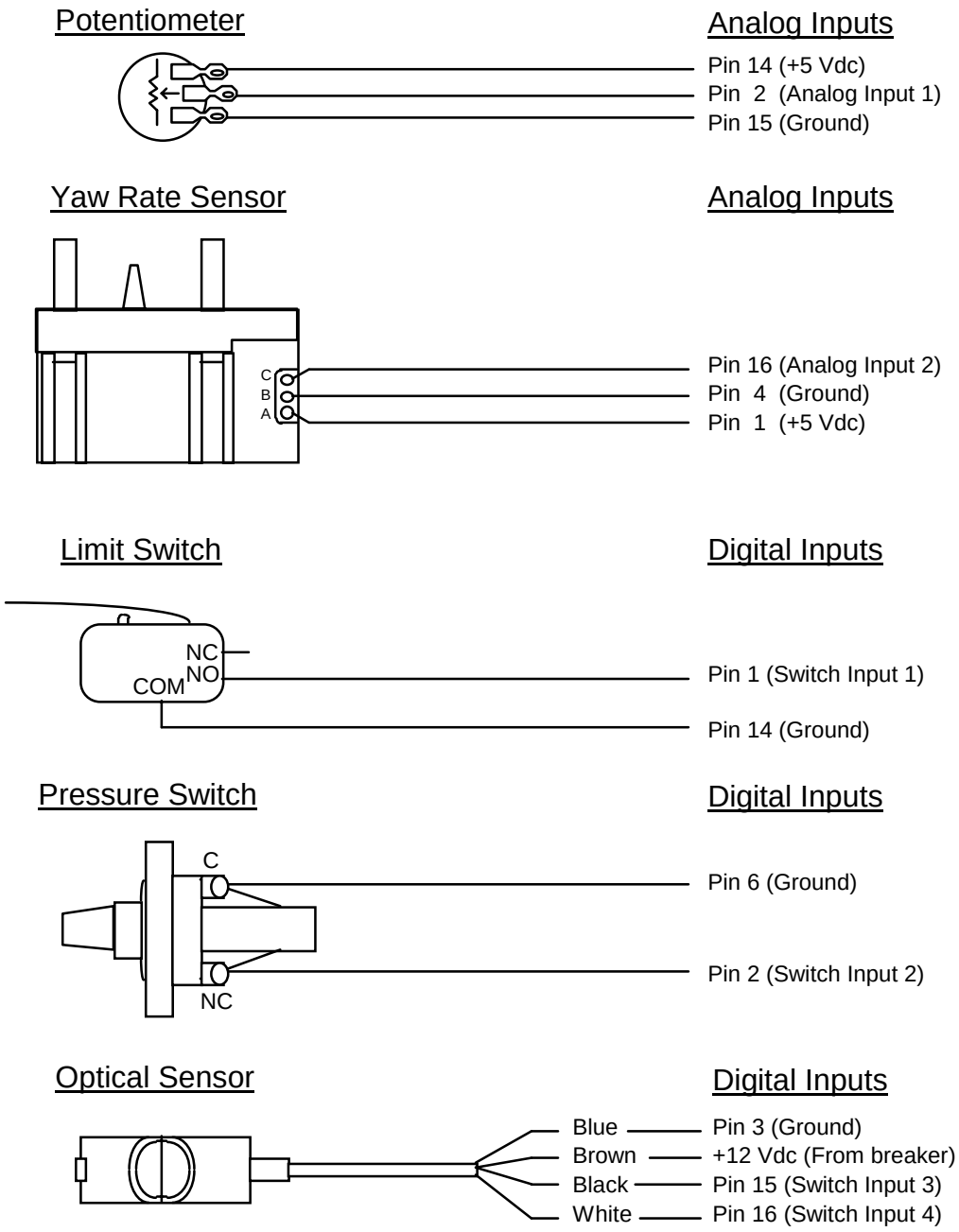

Figure 2.4: Connection Examples for Robot Controller

2.1.7 Custom Circuit Boards

Teams may construct a custom circuit board using allowed components from the Additional Hardware list. The circuit board must draw power from a 20A circuit breaker.

All outputs from the circuit board must be connected to the sensor inputs on the Robot Controller. Inputs to the circuit board may be connected to the following sources:

- 20A or 30A circuit breaker outputs
- Speed Controller or Relay module outputs
- PWM or Relay outputs on Robot Controller
- Switches, Potentiometers, the Yaw Rate Sensor, Optical Sensors, Motors and other sensors allowed in the Additional Hardware list.

The custom circuit board may be used to indirectly affect the robot outputs, by providing enhanced sensor feedback to the Robot Controller to allow it to more effectively decide how to control the robot outputs.

Custom Circuit boards may not:

- Interfere with the operation of other robots
- Directly affect any output devices on the robot, such as by providing power directly to a motor, supplying a PWM signal to a speed controller, or supplying a control signal to the relay module. (High impedance voltages monitoring inputs or low impedance current monitoring inputs on the custom circuit board connected to the robot outputs are acceptable, because the effect on the robot outputs should be inconsequential.)
- Be used for wireless communication, such as sending or receiving a signal to and/or from the alliance station
- Connect to the programming, radio, or tether ports on the robot controller.

It will be impossible for FIRST to test all custom circuits, so we are relying on all teams to use Gracious Professionalism when using custom circuits.

Teams assume all responsibility for custom circuit board failures or unexpected behavior.

Please read the control system documentation from Innovation First for information on the robot controller sensor inputs. Support by FIRST and Innovation First for the custom circuit boards is limited to documentation provided in your kit and on the Innovation First web site.

2.2 Wiring the Operator Controls

2.2.1 Power Distribution

Power may be supplied to the Operator Interface in 3 different ways.

1. The power supply for the Operator Interface can be plugged into the power jack.
2. The Robot Controller will provide power to the Operator Interface when the units are connected by the tether cable. This disables the radio modems, but is useful in situations where no AC power is available for the power supply.
3. During competition matches, a cable that plugs into the Competition port will supply power for the Operator Interface.

Due to the low current used by all devices that interface with the Operator Interface, 24 AWG or larger wire is sufficient for all wiring.

2.2.2 Sensor Inputs on the Operator Interface

The exact wiring configuration for the joysticks, switches, potentiometers, LEDs, and the yaw rate sensor connected to the Operator Interface is not specified. Teams may wire these devices, within the rules as described below and according to the documentation supplied by Innovation First, in order to create a custom interface for the robot operators.

Although not a requirement, it is suggested that teams use the project box as a housing for the switches, potentiometers, LEDs, and yaw rate sensor. When using the project box, wire all components to the 15 pin male connector(s), mount the connector(s) on the project box, and use the 15 pin molded cable(s) to make the connection(s) to the Operator Interface.

The +12 Vdc LEDs may be connected between +5Vdc and Ground or between an LED output and Ground to serve as a visual indicator to the robot operators. This can be helpful during a competition match when a robot operator may not have a good view of the Operator Interface. Connect switches between a switch input and Ground. *Do not use lighted switches with the Operator Interface unless the light is disabled.*

NOTE: Do not connect switches to +5Vdc.

The yaw rate sensor must be connected to +5 Vdc, Ground, and an analog input. Potentiometers must be connected to +5 Vdc and an analog input. Due to the special nature of the analog inputs on the Operator Interface, connecting potentiometers to Ground is optional but *not required.* See the Innovation First documentation for more information.

Figure 2.5 shows an example of the proper way to connect a switch, potentiometer, LED, and yaw rate sensor to the Operator Interface.

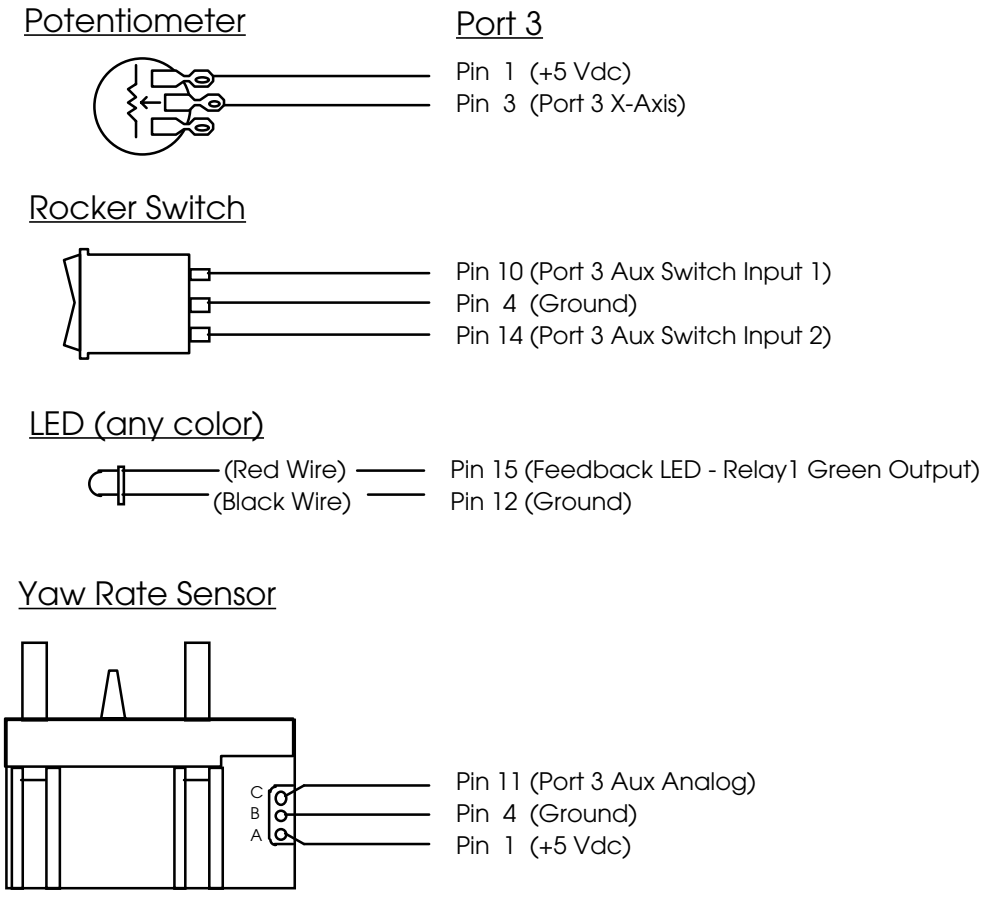

Figure 2.5: Connection Examples for Operator Interface

2.2.3 Dashboard Port

Teams are permitted to connect a portable computing device (Laptop computer, Palm Pilot, etc.) to the RS232 output of the Dashboard Port for the purpose of displaying feedback from the robot while competing in FIRST Robotics Competition matches. Portable computing devices may not be connected to inputs on the Operator Interface. *Please note that AC power will not be available at the playing field so these devices will have to run on internal batteries.*

Innovation First offers pre-written software for such a purpose on their web site. Teams assume all risk associated with use of this program and/or data collected from the Dashboard Port. For more information, consult the Innovation First web site at www.innovationfirst.com/firstrobotics/.

2.3 Batteries and Chargers

Teams are responsible for managing the power consumption of their robot and for ensuring that their batteries are sufficiently charged to compete in each two-minute match. This means that teams must charge their batteries at their pit stations at each FIRST Robotics Competition event.

For instructions on charging the batteries, please refer to the battery charger documentation included in the Kit.

WARNING

Allow a warm battery to cool before charging. Please do not attempt to cool a battery by immersing it in ice, water, or snow. A battery that has been left out in cold weather must be allowed to reach room temperature before charging. Failure to do so will cause serious damage to the battery, which may leak toxic liquid as a result. Be careful to avoid shorting the batteries. Short-circuit current exceeds 200A and can cause fire, serious injury, and leakage of toxic materials.

NOTE: If you have a battery that you know is damaged, please do not put it in the trash. Return the damaged battery to FIRST so that it can be recycled properly.

It is estimated that each battery can store sufficient energy to power a robot for at least 5 two-minute matches. Thus, it should not be necessary to swap batteries after each match.

Please adhere to the following:

- To connect the battery to the rest of the control system, FIRST recommends using ring terminal contacts and the red Anderson Power Products connectors. This allows for easy connection and disconnection of batteries in the robot.
- Although rare, the impact forces that robots sometimes experience during matches have been known to cause the Anderson Power Products connectors to disconnect. FIRST recommends utilizing a quick-release fastener, such as a Velcro strip, to hold the power connectors together during a match.
- When connecting the battery, be very careful to observe the proper polarity in order to prevent damage to control system components.
- During any match, only one of the 12 Vdc SLA batteries supplied by FIRST may be used to power the robot. You may charge the batteries through the normal operation of the battery charger that FIRST provides.

This Page intentionally left Blank

