Boosting Engineering, Science & Technology™

BEST Generic Kit Notes

GMKR00002 Revision 0; August 2005

1.0 Introduction

All Radio/Control equipment **must be returned** at the conclusion of the contest. This equipment will be used again next year; so **do not modify any of the equipment**. This includes the transmitter, receiver, servos, batteries, electronic speed controllers, and their associated connectors.

2.0 Batteries

You will have two 7.2 Volt NiCad batteries included with your kit. These are the source of electrical power for the functional components of your entire machine.

- Per the Generic Game Rules, only one battery may be on the machine at any time.
- Do not attempt to use the battery without using its mating connector. For example, do not attempt to test a motor by pushing the battery connector directly onto the motor power lugs. This can damage the connector and may cause your machine to fail during the competition (Ouch!). Instead, build a test connector using the supplied pigtails.

Inside the transmitter is a battery made of rechargeable NiCads. They have a use time of about 100 minutes before needing to be recharged. If your hub is **not** using the Tether system on contest day, **you need to manage your transmitter battery charge carefully;** that is part of the competition. Here are some hints:

1. Charge the transmitter batteries overnight before competition.
2. Keep your transmitter connected to the charger as much as possible (but not when using the transmitter).

3. Keep the transmitter and your machine off as much as possible.

2.1 How and when to use the battery discharger/conditioner (if one is included with your kit):

When batteries are stored and will not be used for several days, you should consider using the discharger/conditioner. Proper discharging lowers the battery's voltage to the proper level and prevents the development of a NiCad memory. You should refer to the instructions specific to the charger used at your hub. Some dischargers, like the Hobbico 905 AC/DC Multi-Charger, suggest that you monitor the discharge current and not let it drop below 1.5 Amps. Other dischargers, like the Gecko or SuperBug will not over discharge your batteries like an unattended resistor or light bulb (the use of these can permanently damage your battery). Just connect your discharger and leave it connected until the next time you are ready to fully charge and use the battery. The red LED indicates how quickly the battery is being discharged. The brighter the light the faster it is discharging. When the light is completely out (undetectable in a dark room) it has stopped discharging. This can take up to 5 days if the battery still has a good charge on it when you plug it into the discharger. Therefore, it is better to use the battery in your robot until it starts to slow down and then use the discharger.

Remember, the chargers and dischargers may differ from the examples described here, so be sure to read and understand the instructions provided with your hub-provided battery charger.

- Team-owned chargers are not allowed during any competition and will be removed from the pit area.

3.0 Speed Controller

The speed controller allows the R/C system to vary the speed and reverse the direction of a motor. The speed controller also contains a BEC (Battery Eliminator Circuit) that provides power to the receiver installed on-board your robot from the main drive battery (the 7.2 Volt NiCad). Since you may not use a receiver battery (didn't see one on the list did you?), you must have at least one speed controller on your robot so that your receiver will have power.

Two types of speed controllers are used in BEST kits: Hitec SP-520 PLUS (or 560 PLUS) and Hitec EZX-R. Although there are some differences in the controllers, they are functionally equivalent. Note that both types of speed controllers have a built in pause when switching from forward to reverse. This is to keep from damaging the speed controller and is normal.

The yellow/black/red wire, out of the speed controllers, plugs into the receiver (or Robot Box, if using the Tether system). It is not keyed in any way and can be plugged in backwards. You need to plug it in with the yellow wire facing the receiver and the black wire on the outside edge. Also, you will need to adjust both the NEUTRAL and FULL

POWER settings. Instructions, as well as the tool to do this with, are included in the box containing the R/C gear.

For the SP-520 PLUS, the speed controller is adjusted via trim pots as described in the yellow instruction sheet titled “SP-520 PLUS Electronic Speed Controller.” Please do not pry up the gold cover panel on the speed controller. The trim pots (what you turn to adjust the speed controller) are hard to get at, but please have patience when adjusting them so that the controllers are not damaged. When properly adjusted, the LED on the controller should be on when you are moving forward. It will be red at low speed turning to yellow and then to green as you move the joystick forward. If the LED comes on when you reverse, then you need to switch the wires going to the motor and invert the joystick control using the switches on the bottom of the transmitter.

For the EZX-R controller, the adjustment is made by turning on the ESC while holding the setup button and then following the sequence of joystick movements as described in the EZX-R Installation and Set-up Instructions. The LED for the EZX-R should show red when stopped or at low speed, and then will turn green when maximum speed has been reached. You may notice a high-pitch whine coming from the speed controller; this is normal.

- Do not drill, saw, or paint on your machine unless you first **remove or cover the speed controllers (and motors, Robot Box, receiver, etc.)**. Filings, dust, and paint can get inside and ruin the electronics.

4.0 Tether System for R/C Control

Teams competing at the regional BEST competitions (and at many local hubs) will use a special R/C system called the “Tether System.” This system was designed to overcome a limitation on the number of teams that can participate in a BEST contest. Without the use of this special R/C system, there is a 30 team limitation because there are only 30 ground vehicle Radio Control (R/C) frequencies allocated by the FCC. One solution to this problem is to assign dedicated R/C systems to the game field and have these systems be the only R/C systems active on game day. Teams connect their R/C transmitter (which must be turned off all day) to a field transmitter. For robot control off the game field (for instance in the pit area), the team's transmitter (still turned off) is connected to the robot through a tether (a cable). Since all the teams have their transmitters turned off at all times, it does not matter what frequency their transmitters use. There can now be an unlimited number of teams since we no longer have to worry about assigning each team a different frequency. For robot control during the building and testing phase, and because there are no other teams around, the transmitter is turned on and the system used as a normal R/C system. To see how all this works, let's have a look at the three modes this new system operates in.

Components of the tether system and its three modes are shown in **Figure 1**.

4.1 Tether System Mode 1

In mode 1, which is used during the six-week build and test time, the system works like a conventional Radio/Control (R/C) system. Your R/C transmitter broadcasts your control commands to the robot's receiver on its particular frequency. Inside the Team Receiver box is the matching R/C receiver for your transmitter. It receives the broadcast signal and translates it into servo commands. These commands travel through a flat ribbon cable to the Robot Box. Once in the Robot Box the signals are connected to the servos and speed controllers of the robot, making it do all the wonderful things your robot does under your control. **Figure 2** shows the channel assignments for the Robot Box and the orientation of the servo connectors.

To power your transmitter when you operate in tether mode, there is an inline power connector placed on the output side of the on/off switch assembly supplied in your kit. This power hookup is shown in **Figure 3**, and an alternate approach is shown in **Figure 4**. Since your transmitter power switch should remain in the off position when tethered to the robot, this power hookup allows your transmitter to draw power from your main drive battery.

4.2 Tether System Mode 3

Now let's skip to mode 3 in **Figure 1**. This is the mode used on Game Day when you are participating in a game. Here the Team Receiver box has been removed and has been replaced by a Field Receiver box. The box is attached to the robot using a hook and loop (Velcro) fastener. The hook side of the fastener will be on the box while the loop (fuzzy) side will be attached to the robot. When you enter the competition field for a match, you will be handed the Field Receiver box that you pop into place and connect to your robot. The field receiver is keyed to one of the four team areas on the field. When you reach your assigned driver's box, you must connect your transmitter to the buddy cable. The other end of this cable is connected to a field transmitter. Only the field transmitter is powered on; the power switch of the transmitter in your hand should be left in the off position since it will receive power from the field transmitter via the buddy cable. In this mode, controls from your transmitter will be transferred to the field transmitter and, using its frequency, broadcast to the field receiver on your robot. The field transmitter is basically the same as the radio in your hand except that it has been hard-wired into "Trainer" mode (take a look at your Futaba Manual). When your match is over and you leave the playing field, you unplug your transmitter from the field transmitter and remove the field receiver from your robot and hand it to a BEST staff member. By using Velcro and plug in connectors, this will only take a few seconds to do. **Note that the Velcro fastener used to mount the receiver or tether box cannot be used elsewhere on your machine.** Because the Receiver Box will be installed before and then removed after each match, the Receiver Box should be mounted so that it is easy to change.

Now you are back in the pit area and you need to be able to control your robot in case it needs a little adjusting.

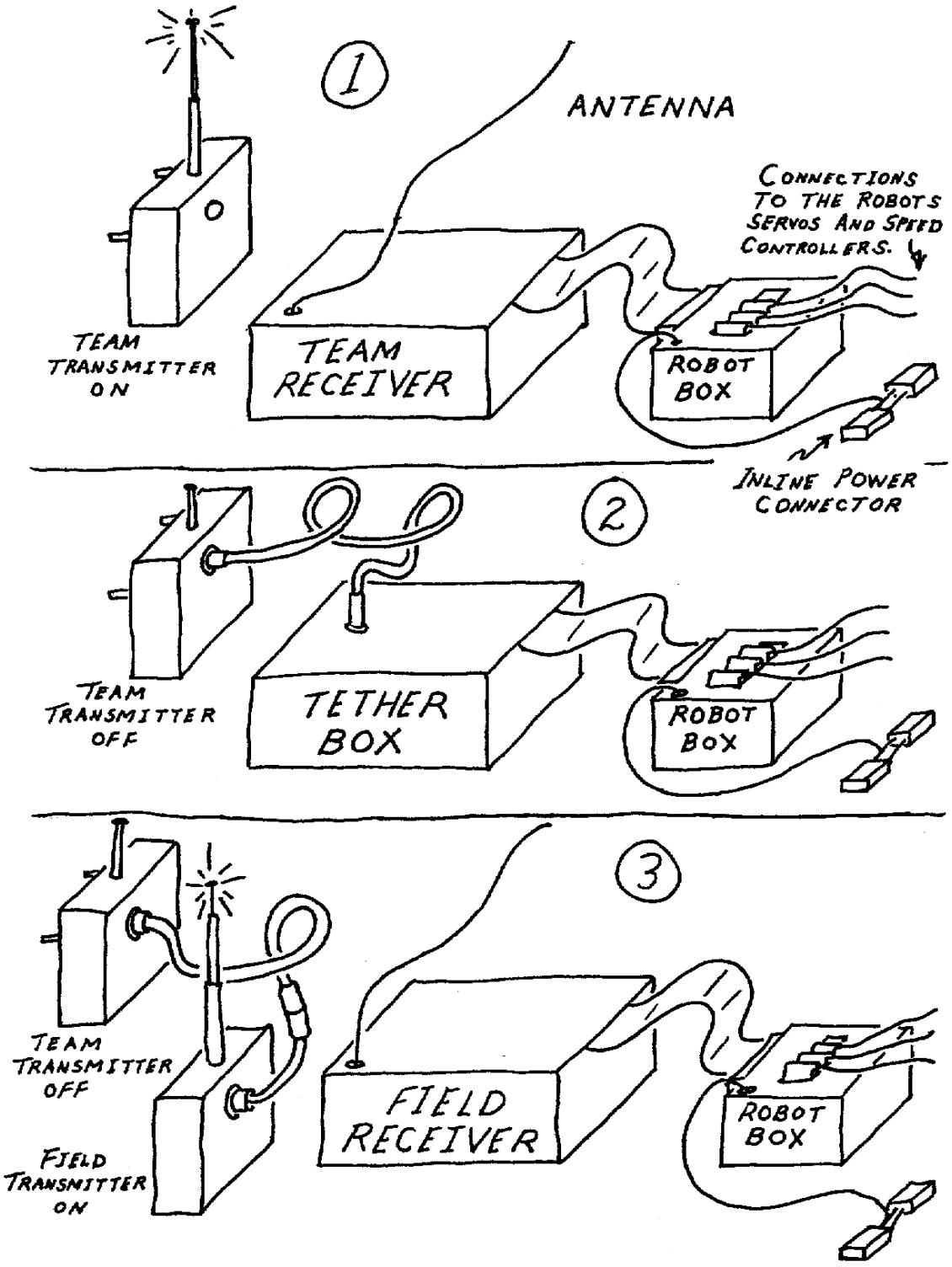

Figure 1: Three Modes of Tether System

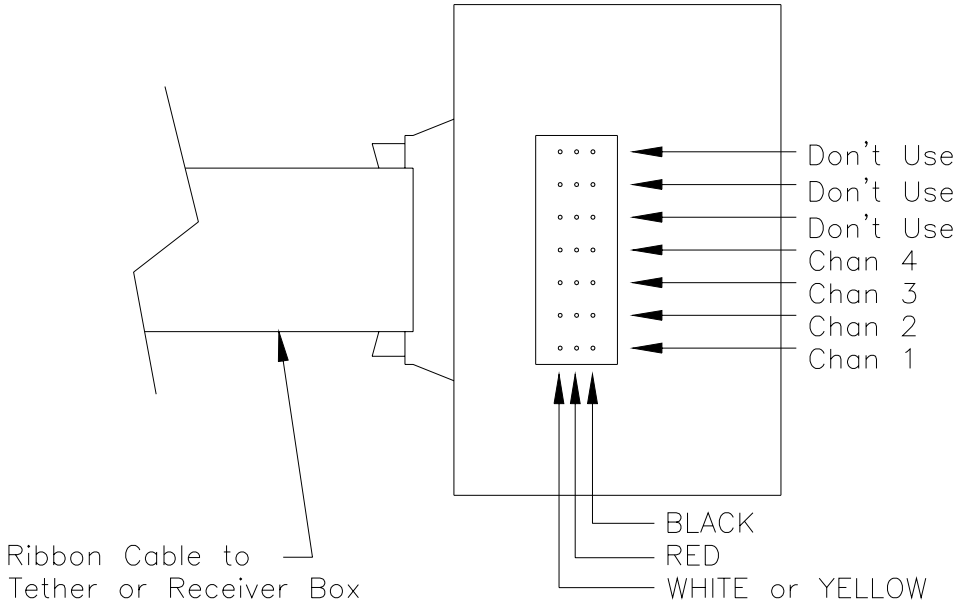

Figure 2 – Robot box connections.

4.3 Tether System Mode 2

Let's look at mode 2 of **Figure 1**. In the pit area you now connect a Tether Box where the Field Receiver box has been. In this mode, the buddy cable from the Tether Box is plugged directly into your transmitter. Although your transmitter is still turned off, the tether box will read its controls and send those control signals to the Robot Box without using a broadcast signal.

4.4 Tether System Summary

As you should now realize, the only broadcast signals used on Game Day are those from the field transmitters. This will eliminate the problem with interference between all the different R/C units. Since your transmitter is **never** turned on during Game Day, there will not be any problems with dead transmitter batteries. But the main benefit of this system is that it no longer matters what frequency a team is using, because that frequency is not used for broadcasting on Game Day. Only the field transmitters are broadcasting. An unlimited number of teams can now compete since each team no longer needs a unique frequency.

During Compliance Check-in on Game Day, each team must hand over their transmitter crystal. This will prevent accidental use of transmitters other than the field transmitters and will prevent interference. The level at which this Tether System is implemented at your local contest may vary from hub to hub. The hub may use the full system as previously described or may choose one of two variations on this system:

1. Hubs may choose to use the Tether System without implementing the field transmitters. Teams participating at these hubs will use their Team Receiver boxes during their matches, and should use the tether box while in the pit area. **Note**: this method still requires that each team be on a unique frequency during their local contest.

2. Hubs that do not implement the Team Receiver, Tether, and Robot boxes will use the standard R/C receivers mounted directly to the robot (rather than within the box). Teams that advance to a Regional competition from these hubs must allow space and weight for the receiver and robot boxes. The Tether and Receiver Boxes have dimensions of 4x3x1-5/8 inches and must be mounted within 2 inches of the Robot Box. The Robot Box has dimensions of 3x2x1 inch. The estimated weight of a set of boxes is 8 oz. The local BEST hub will provide boxes to the advancing teams. **Note**: this method still requires that each team be on a unique frequency during their local contest.

4.5 A WORD (or two) About R/C Interference

This section is primarily for teams from hubs that are not implementing the tether system, but it has some tips that can benefit all teams. Although each school has been assigned a unique R/C frequency, there may still be interference between transmitters. We will handle these on a case-by-case basis as the need arises. **Your vehicle needs to be designed so the receiver can be easily removed**. This will allow us to issue you a different transmitter and receiver on another frequency. Here are some hints to prevent interference:

1. When not in competition, keep your R/C equipment off as much as possible. We may have to impound transmitters in the pit area if there is an interference problem with machines in competition.

2. When using your R/C equipment, do not have your receiver on unless your transmitter is also on. When turned on, your transmitter is always transmitting, even when you are not moving the joysticks. Your receiver, meanwhile, is looking for the strongest transmitter signals on its frequency. All transmitters, in addition to putting out signals on their assigned frequency, transmit weaker signals on other frequencies called *harmonics*. If your receiver is on but your transmitter is off, the receiver will pick up these weak harmonics from other transmitters and use them to control your servos. Thus your machine will be responding to someone else's transmitter. They may be testing their forward motion and you may end up testing how your machine responds to being driven off the end of the table! If your transmitter is on, its strong signal will override these harmonics.

3. Be sure your transmitter antenna is extended (unless you are on tether or are using the field transmitter; in those cases extending your antenna does absolutely nothing). Note that many hubs place the receiver antenna inside the receiver box to keep it from being destroyed. This is normally not a problem since the radios were made to transmit and receive over much greater distances than needed for the BEST playing field. Do not open the receiver box to extend the receiver antenna without permission from your hub.

4. Be sure to keep a good charge on the transmitter battery. Note that the transmitter may not accept the charge if the transmitter is in the on position. Make sure the transmitter is turned off when you charge it.

In addition to mounting the receiver so that it can be changed easily, the servo and speed controller wires should be marked. It should take no more than 30 seconds to remove and replace the receiver, including unplugging and plugging in the wires.

5.0 Wiring Information

Figure 3 shows a suggested wiring diagram and includes the required "Y" connector on/off switch harness. This harness includes a fuse and provides an on/off switch for all of your robot's electrical power. Do not bypass the fuse. If you blow a fuse, determine why before replacing it. A replacement fuse may be included in your kit. Additional replacement fuses (only use the same rating fuse) can be found at auto-supply stores. The 25-cent fuse protects the $80 (or more) speed controllers!

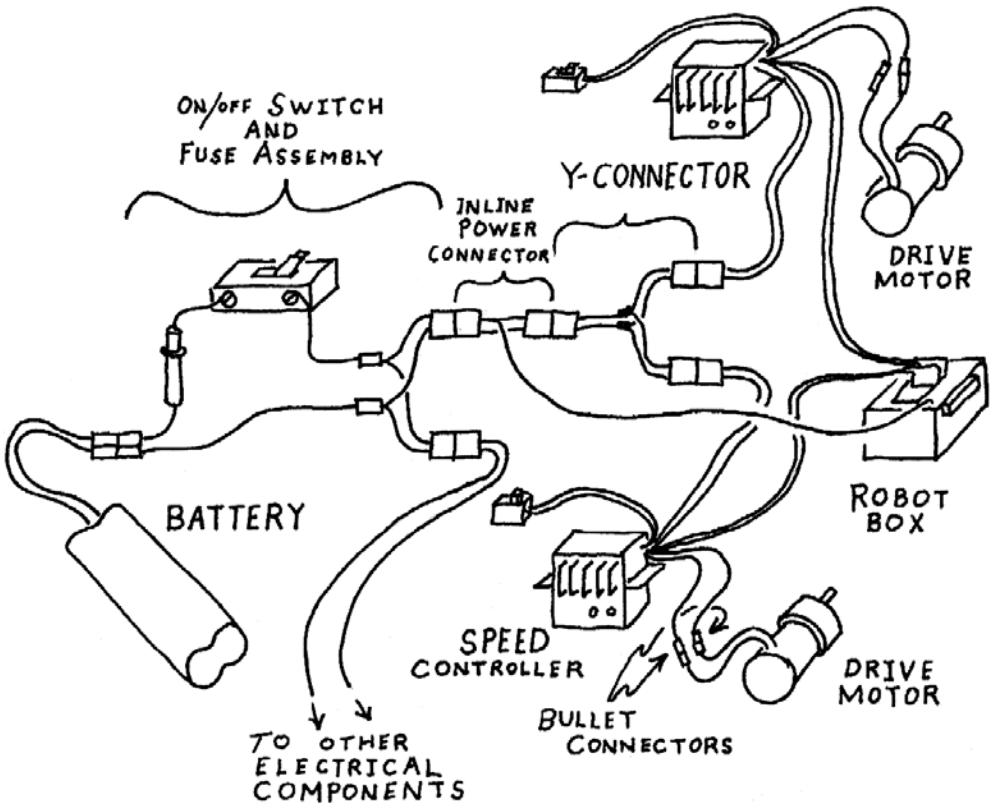

Figure 3 – Suggested wiring diagram (Note: the robot box is replaced by the R/C receiver for a non-tether system).

Figure 4 shows an alternative hookup that uses a bullet connector in place of the inline power connector to power the Robot Box directly from the switch-fuse assembly. Note that the robot box must be powered for the transmitter to function on tether with the transmitter power switch in the off position.

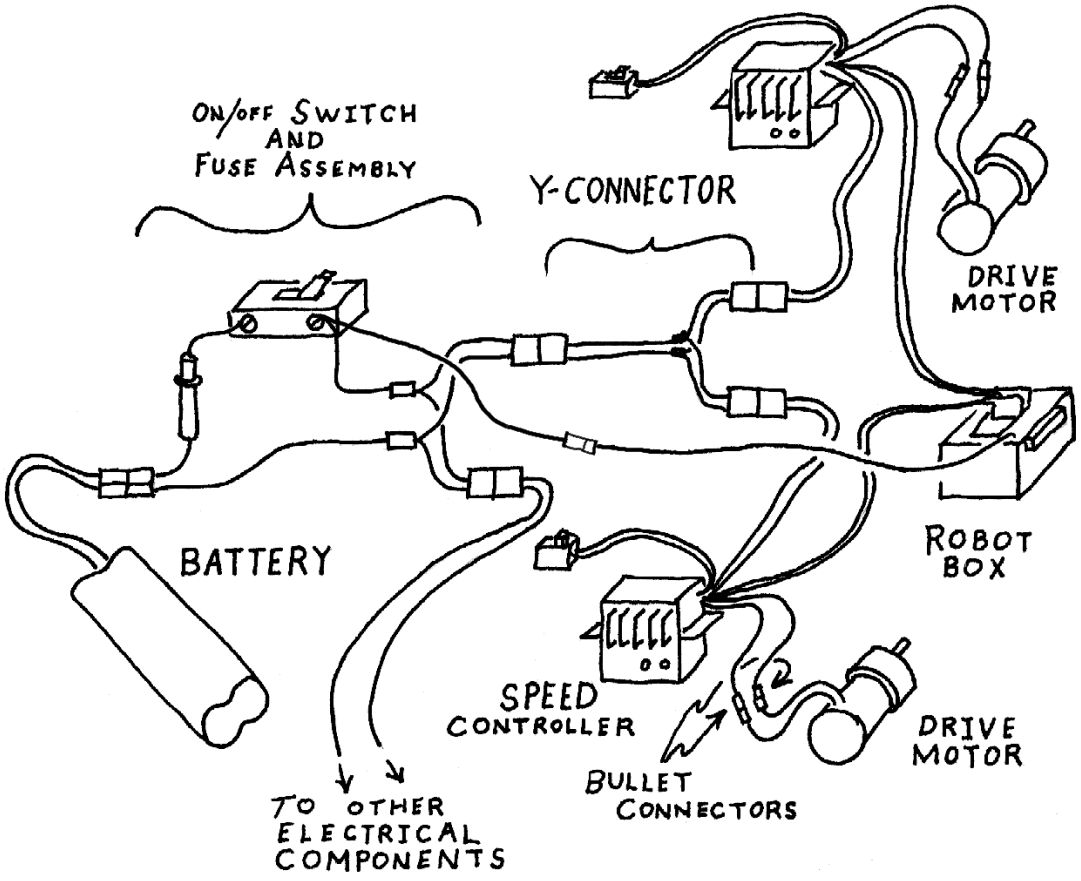

Figure 4 – Alternate wiring diagram (without inline power connector)

The on/off switch and fuse assembly is required and will be checked during kit Compliance Check-in. If it is not in place, you will need to add it. The on/off switch should be easy to access and labeled so that a referee can switch off your machine, should the need arise during a match.

You may also need to make your own motor connectors. Included in the kit are 6 "bullet" connectors. These should mate with the connectors coming from the speed controller. Attach these bullet connectors to a length of wire and then solder them to the motor tabs.

- **Do not cut the bullet connector sockets off of the speed controller wires!**
- **Do not crush the speed controller bullet connector sockets**.

6.0 Using the Microswitches

Included in the kit are four microswitches that can be used to control additional motors in the kit. **Figure 5** shows a method for using a servo to activate the switches. This setup will run a motor in either direction depending on joystick position. Since four microswitches are included in the kit, two of these setups can be constructed. Use the included double pigtail to supply power to your microswitch assembly(s). Check your wiring carefully before applying power to this assembly; mis-wired switches and wayward wire strands can cause electrical shorts that will consume your fuses quickly.

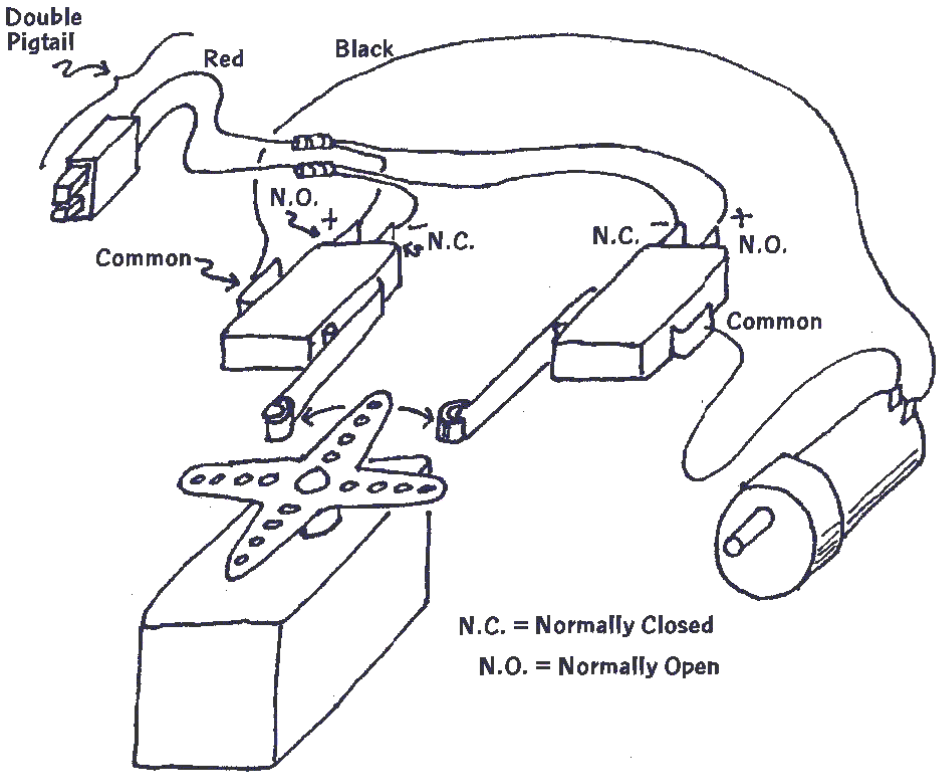

Figure 5 – Microswitch Setup for switching motor direction.

7.0 Servo Notes

If a servo is "humming," this indicates the load on the servo is more than it was designed to handle. This will cause the battery to drain quickly and may damage the servo. Readjust the servo travel and/or its linkage so the servo does not hum. **Do not open the servos.** If you suspect the servo is damaged, contact your hub's kit coordinator.

8.0 Wheel Attachment

Figure 6 shows two methods for wheel attachment that have been reliable in the past. These are not the only way to connect wheels, just suggestions.

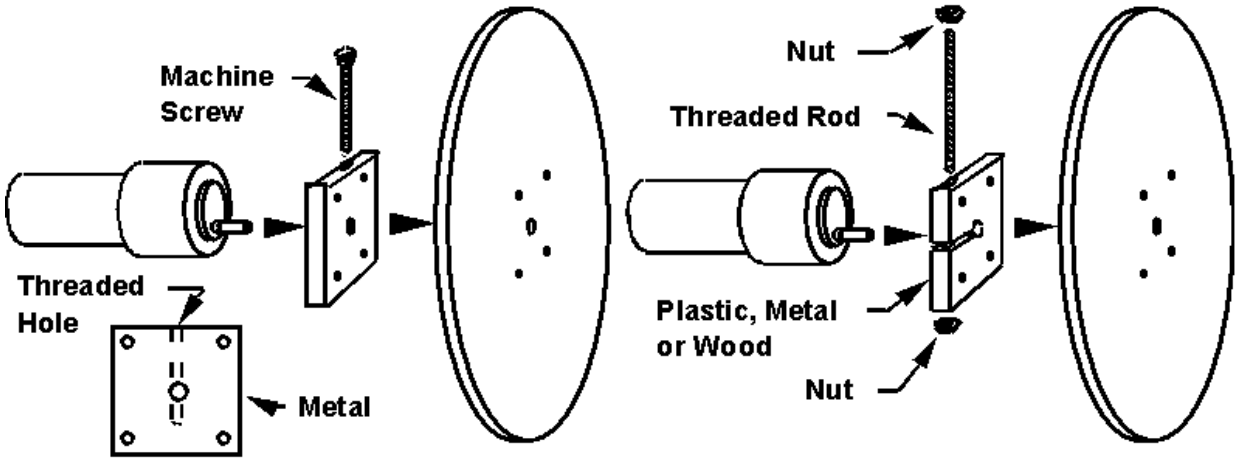

Figure 6 – Two suggestions for mounting wheels.

9.0 Motor Mounting

To prevent damaging the motors provided, mount them by one or both of the following methods:

1. Use the threaded mounting holes on the face of the motors (two on the large motors and three on the small motors).

2. Clamp on the large diameter of the motors.

To prevent damaging the gear drive of the motor, do not let the screws that go through the face of the motors penetrate into the motors more than three-eighths of an inch.

Do not clamp on the small diameter area of the motors as only two small screws attach that part of the motor to the large diameter part, and the screws will break easily.

10.0 Drive Component Usage

Recall that the drive components (other than the belts) cannot be modified since they are part of the Returnable Kit. This means, for example, that you are not allowed to drill holes into the large pulley to mount parts. It also means that you'll have to figure out a way to mount the bearings; a couple possibilities: ½ inch PVC stretches nicely when heated and does a good job of capturing a bearing without altering it, a piece of 1x4 with ¾ inch hole also should make a reasonable bearing mount.

The small all-plastic pulley has no setscrew or other legal means of fixing it to a shaft for drive purposes (remember, it is illegal to modify the part, or fix it with epoxy/adhesive). So you may ask, "What good is it?" Well, clever folks that we are, we've also included a shoulder screw in the kit that just happens to fit the small pulley. The combination of these two items can be used to make an idler pulley, a belt tensioner, or whatever other ingenious device you may come up with. One simple example mechanism is shown in **Figure 7** (it should a lot like the carriage mechanism in a printer).

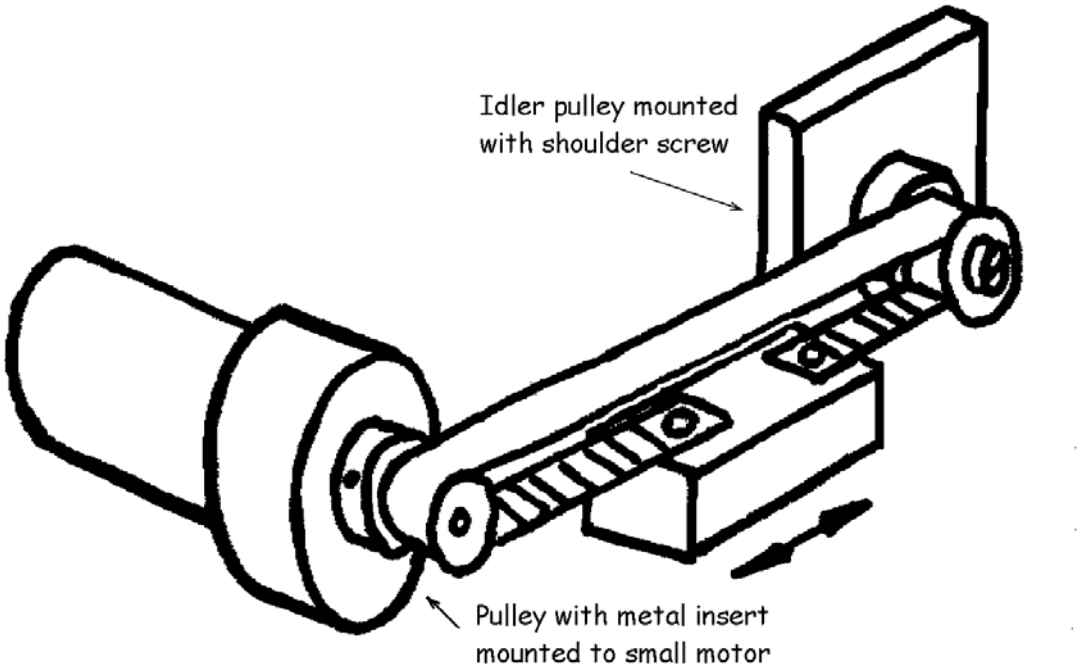

Figure 7 – One possible drive configuration.

Note that in the previous example, the 3-ft length of belt was used and we didn't even have to worry about joining the ends together to make a continuous belt. There are many other ways of using the length of belt without joining the ends together – usually for devices that don't have to rotate continuously.