BEST Generic Kit Notes

GMKR00002 Revision 1; July 2008

1.0 Introduction

All Returnable Kit items, including boxes and packing, **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, BRAIN controller, servos, batteries, motors, and their associated connectors/cables. See the *BEST Returnable Kit List* for a complete list of all returnable items.

Do not drill, saw, or paint on your machine unless you first **remove all Returnable Kit items**. Filings, dust, and paint can get inside and ruin the electronics. Do not allow paint to get on to any Returnable Kit items.

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 battery and may cause your machine to fail during the competition (Ouch!). Instead, use the pass-through power from the BRAIN (see Section 4.6) to test the motor; you'll have the benefit of having a switch and fuse to help you with your motor tests.

Inside the transmitter is a battery made of rechargeable NiCads. The battery pack has a use time of about 100 minutes before needing to be recharged. If your hub is **not** using

the Field Transmitter 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 the 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.

Please remember that (per the Generic Game Rules) team-owned chargers and batteries are not allowed during any competition and will be removed from the pit area.

2.1 Battery Discharger/Conditioner

Your return kit may include a battery discharger/conditioner; if so, the following guidelines cover how and when to use the discharger/conditioner.

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 helps you to avoid overcharging the battery. 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. Sometimes peak chargers fail to apply a full charge to the battery because the charger incorrectly senses that the battery is near capacity. You may need to solicit the advice of your hub to help you understand how best to use your specific charger.

3.0 Field Transmitter/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 that utilizes field transmitters for the competition. 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 transmitters 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 BRAIN through a tether 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 is used as a normal R/C system. To see how all this works, let's have a look at the three system operating modes.

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

3.1 Mode 1 – Standard Control

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 BRAIN controller. Once in the BRAIN, the signals are processed and connected to the robot’s servos and motors. The Team Receiver box is attached to the robot or the top of the BRAIN using a hook and loop (Velcro) fastener. The hook side of the fastener will be on the Team Receiver box while the loop (fuzzy) side will be attached to the robot or already be on the top of the BRAIN.

3.2 Mode 3 – Field Transmitter Control

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 Field Receiver box is attached to the robot or the top of the BRAIN using a hook and loop fastener. The hook side of the fastener will be on the Field Receiver box while the loop (fuzzy) side will be attached to the robot or already be on the top of the BRAIN.

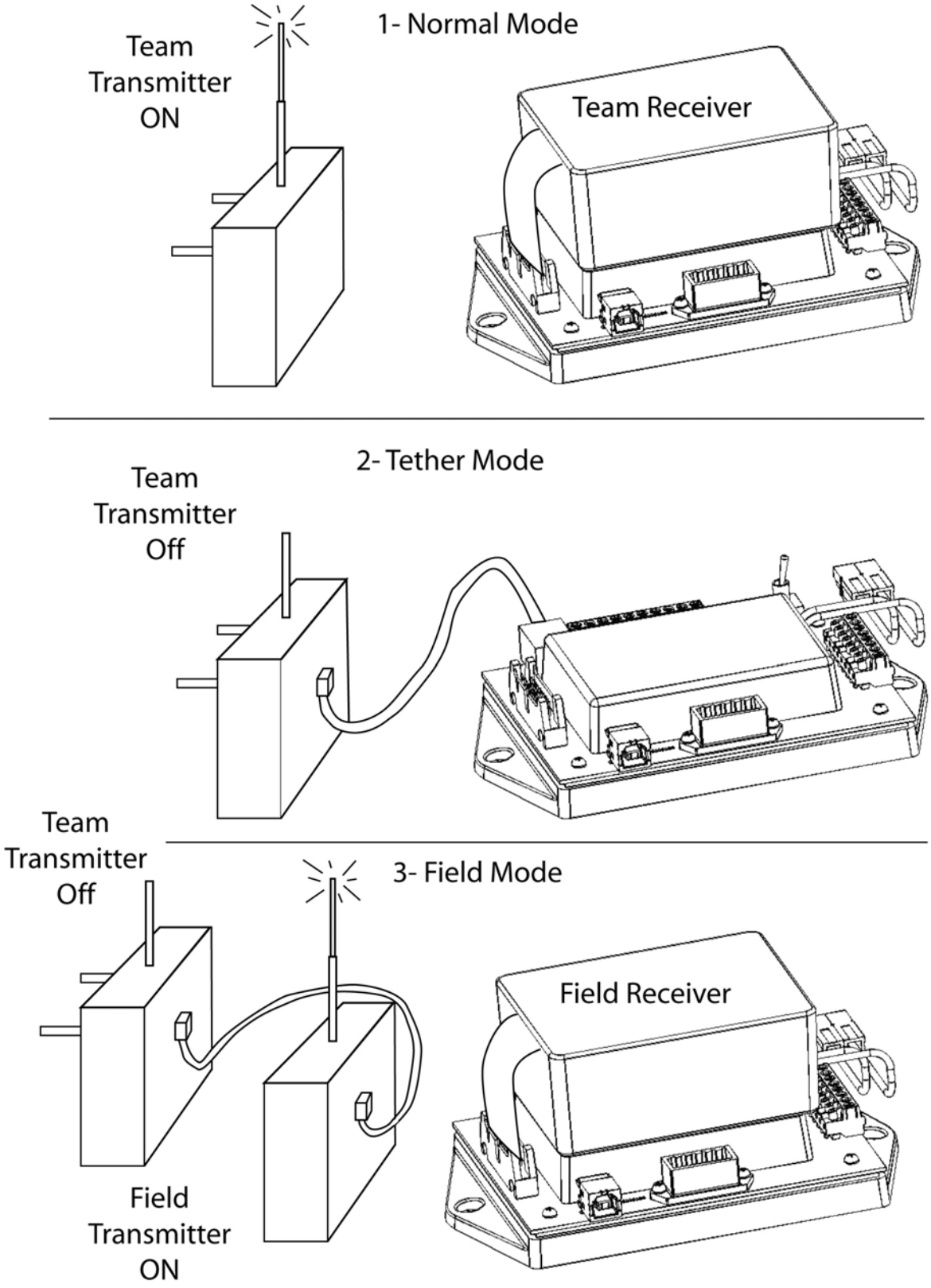

Figure 1. Three Modes of the Field Transmitter/Tether System

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's BRAIN. The field receiver is matched to one of the four team areas on the field. When you reach your assigned driver's area, you must connect your transmitter to the field buddy cable. The other end of this cable is connected to a field transmitter (that may be located inside a PVC pipe or some other container). 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.

3.3 Mode 2 – Tether Operation

Let's look at mode 2 of **Figure 1**. In the pit area you now connect a tether cable from your transmitter to the BRAIN. To power your transmitter when you operate in tether mode, the BRAIN has a special circuit that powers the transmitter using your main drive battery. Although your transmitter is still turned off, the tether cable provides power to the transmitter and connects the control signals from the transmitter to the BRAIN without ever using a wireless broadcast signal.

3.4 Field Receiver/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 to the compliance officials. This will prevent accidental use of transmitters other

than the field transmitters and will prevent interference.

Your hub 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 cable while in the pit area. However, this method requires that each team operate on a unique frequency during their local contest.

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

This section is primarily for teams from hubs that are not implementing the field transmitters, 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 robot needs to be designed so the receiver box 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 (robot) 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 which case 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. When operating your robot, hold your transmitter antenna at least three feet away from the Receiver Box, as holding it closer can sometimes cause servo and motor control interference.

5. Be sure to keep a good charge on the transmitter battery. Note that the transmitter

will not accept the charge if the transmitter is in the on position. Make sure the transmitter is turned off when you charge it.

4.0 BRAIN Connections

Figure 2 shows an example hookup of Return Kit components to the BRAIN controller. It shows an example of connections for motors, servos, receiver box and battery. Following are some tips to ensure problem-free use of the BRAIN.

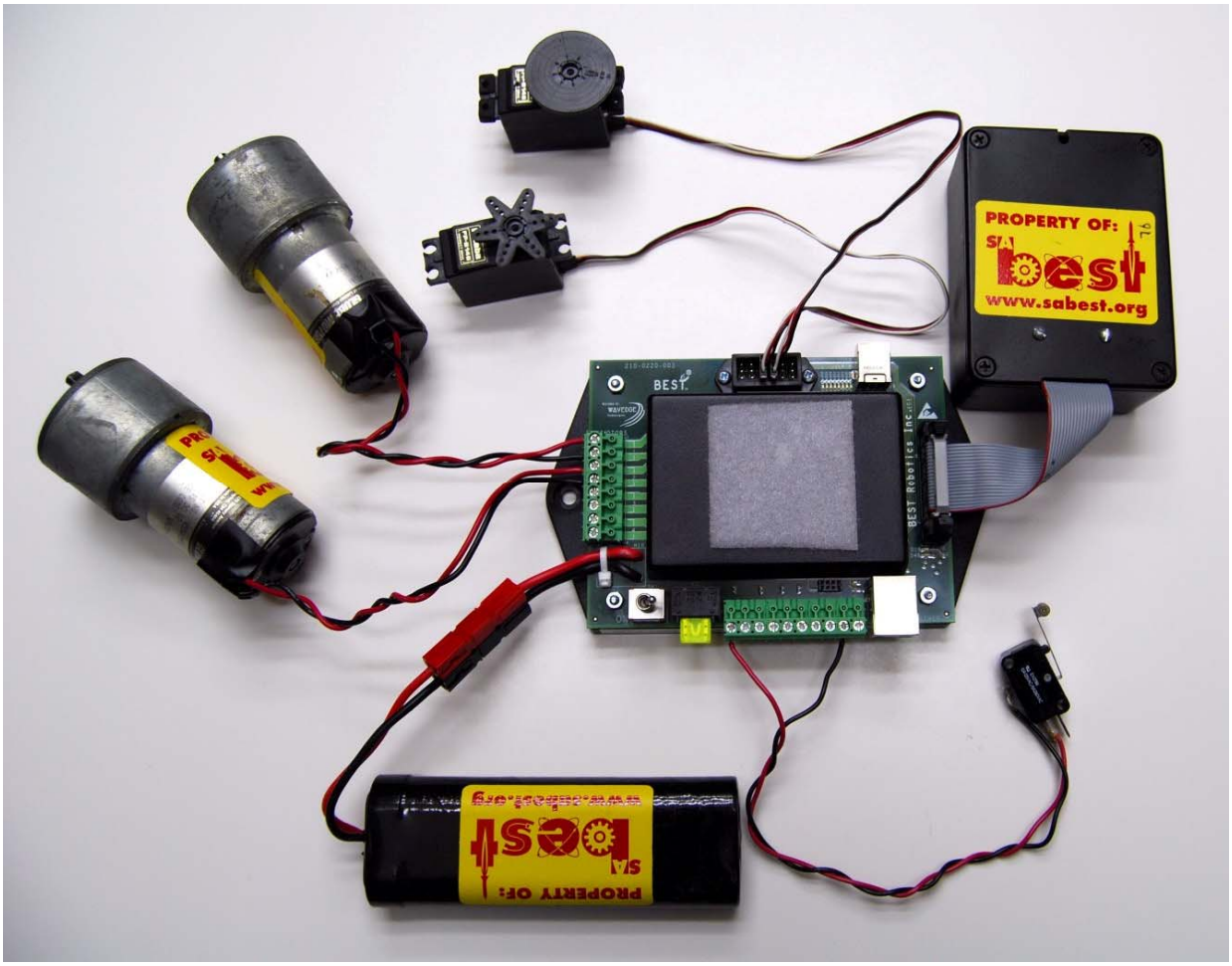

Figure 2. Example BRAIN Connections

Figure 3 provides an overview of all the BRAIN connector locations and features. Additional information on the BRAIN is contained in the *BRAIN Description* document. Refer to **Figure 3** for the locations of the connections described in this document.

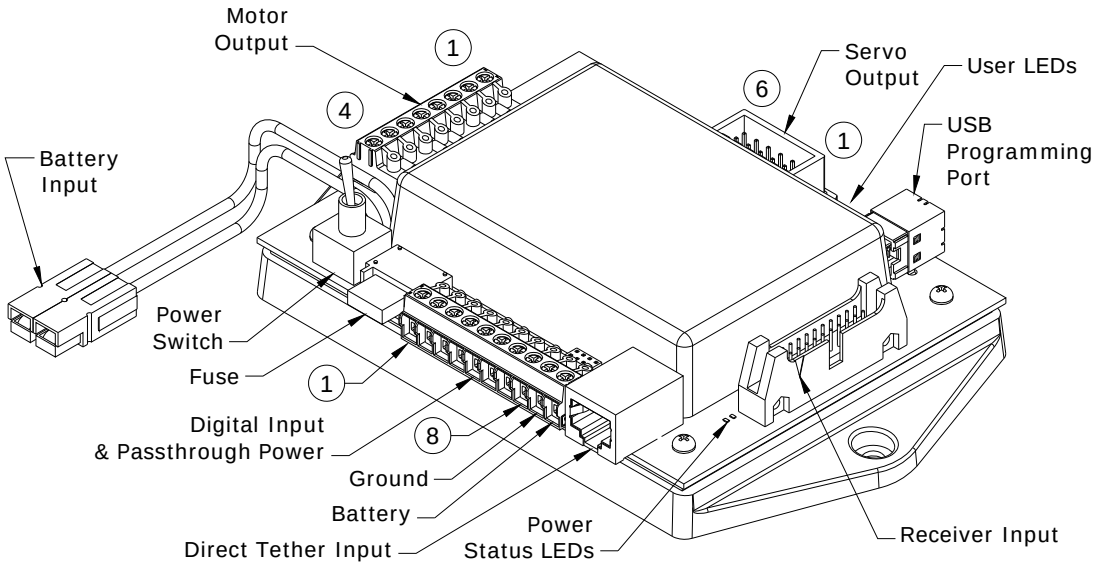

Figure 3. Brain Features

4.1 General

The BRAIN is powered by the 7.2 VDC, 1500 mAHr R/C battery included In your returnable kit. Do not attempt to attach the battery to any input other than the Red/Black power-pole connector.

The 20 Amp mini-blade fuse plugs into the fuse socket next to the BRAIN power switch (lower left in the picture). Do not bypass the fuse and do not use a fuse of an alternate rating. If you blow a fuse, determine why the fuse blew before replacing it. A replacement fuse should be included in your returnable kit. Additional replacement fuses (only use the same rating fuse) can be found at auto-supply stores. The 25-cent fuse protects the $100+ BRAIN and the equipment attached to it!

DO NOT solder wires to the BRAIN connectors! Servo connections are made using the standard 3-pin connector attached to the servo. Motor and digital input connections are made through bare wires inserted into the corresponding green Phoenix terminal strip and tightened with a small blade screwdriver. The Phoenix terminal strip may be removed from the BRAIN to make wiring connections, and then carefully re-inserted onto the BRAIN in either of two orientations: (1) wire insertion on top; (2) wire insertion on side. Removal of the terminal strips is for convenience only. All terminal strips should be properly installed on the BRAIN at the time of machine check-in and when you return your kit. No other connectors on the BRAIN are removable, so please don't try removing them or they will break!

The male/female bullet connectors provided in the consumable kit can be utilized to simplify your motor and digital input connections by providing a connection beyond the

terminal strips.

Mount the BRAIN to your robot using #10 (or #8) screws through the holes in the “ears”. Be careful not to over tighten the screws so that the mounting holes are not damaged.

Consider mounting the BRAIN on your robot in a place where it might be easily removed. Note that you will also need access to the BRAIN’s tether connector and to the USB programming port; a little planning can simplify access to these connectors.

The BRAIN’s on/off switch should be easy to access so that a referee can switch off your machine, should the need arise during or after a match.

4.2 Servo Connections

Servo wires are keyed to ensure the correct orientation for insertion. Insert and remove the servo wires carefully to avoid damaging the connectors and wires. Some hubs may use servos with non-keyed connectors. These do not have the small protruding tab at the top of the servo connector. If this is the case, be sure to insert these into the BRAIN in the proper orientation as shown in **Figure 4** or the servos will not function. The white servo wire should be oriented towards the notch in the servo connector shroud.

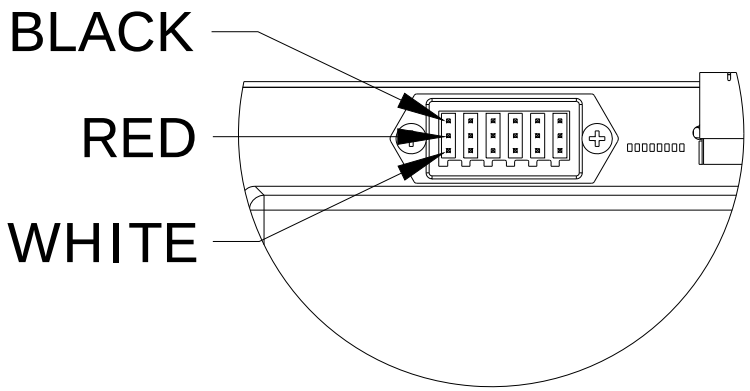

Figure 4. Servo Wire Orientation for the BRAIN

4.3 Motor Connections

Wires should be soldered to the Globe motor terminals leaving bare wire for connection to the BRAIN. These bare motor wires should be tinned with solder before attaching them to the BRAIN since frayed stranded wires could cause a short to other BRAIN terminals. Once inserted into the motor terminal strip on the BRAIN, tighten the screws with a small flat-blade screwdriver so that the wires are not loose and do not pull out. Each motor is connected to a pair of inputs (+ and -) on the terminal strip. The polarity that you choose will determine the relative direction of rotation of the motor for positive stick movement.

Note that two motors can be driven from one motor output pair. In addition, the voltage pass-through pins available on the Digital inputs terminal strip can be used for other motor drive functions.

4.4 Receiver Box and Tether Connection

When attaching the receiver box to the BRAIN, be sure to lock the ribbon cable connector completely after inserting. You should avoid hot insertion (power on) of the receiver box or old-style tether box into the Receiver Box connector. That is, ensure that the BRAIN power switch is turned OFF prior to making a connection to the Receiver. Unexpected operation may result if the BRAIN has not been turned off.

For tethered operation, insert the BRAIN tether cable into the RJ45 connector fully until locked. Insert the other end into the connector on the back of your transmitter. Carefully remove the tether cable when not using it and be careful not to break the tab on the RJ45 connector.

The BRAIN library routines are designed to take control signals from the tether cable input if a tether cable is connected, ignoring any input from the Receiver box connector.

4.5 Digital Inputs

Digital input (switch) connections are made through bare wire connections to a Phoenix terminal strip (similar to motor connections). Tin the ends of bare wire with solder before inserting into the Phoenix terminal strip. Be sure to tighten the screws on the terminal strip to that the wires are not loose and do not pull out.

4.6 Pass-Through Battery Power

The 7.2 volt battery power is also available as a fused and switched output on the same terminal strip as used for the Digital Inputs (see **Figure 3**). When the main power switch is on, battery voltage is present at the terminals labeled battery and ground. You can use this output to drive a motor directly, either continuously or with a servo-controlled microswitch, for example.

5.0 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. The power for this assembly should come from the pass-through power connection on the BRAIN. 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.

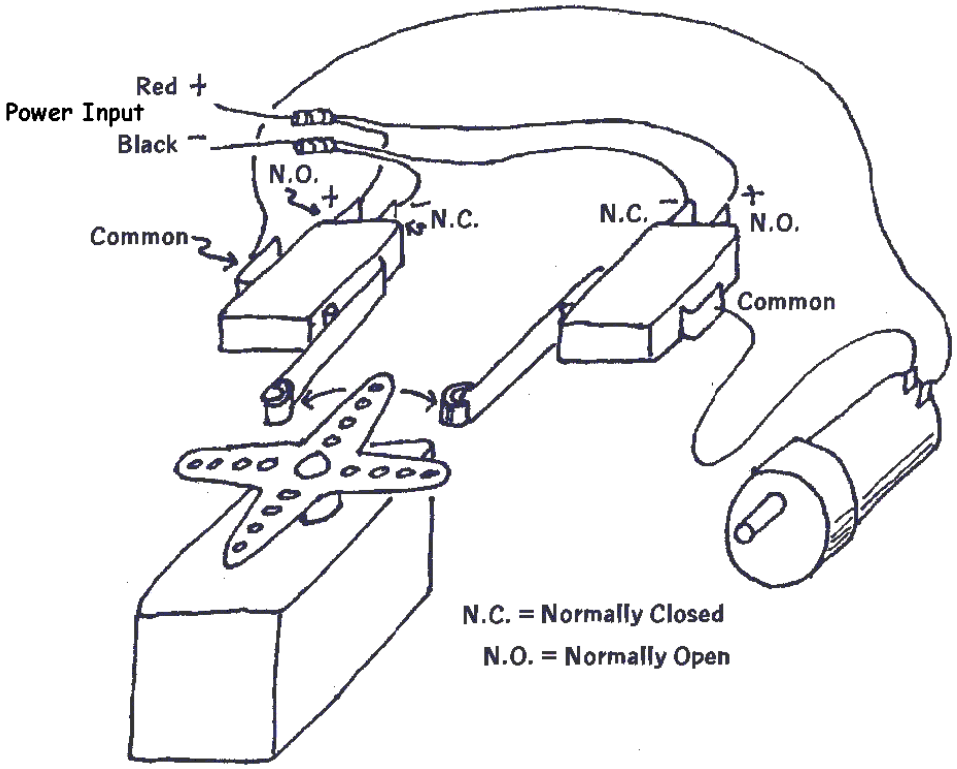

Figure 5. Microswitch Setup for switching motor direction.

6.0 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.

7.0 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, but only suggestions.

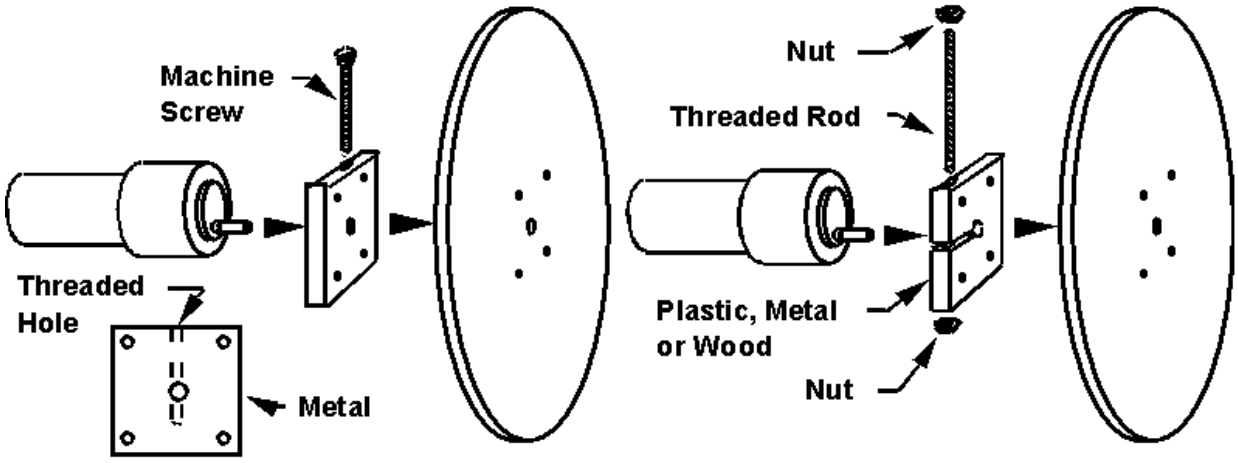

Figure 6. Two suggestions for mounting wheels.

8.0 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.

9.0 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 look a lot like the carriage mechanism in a printer).

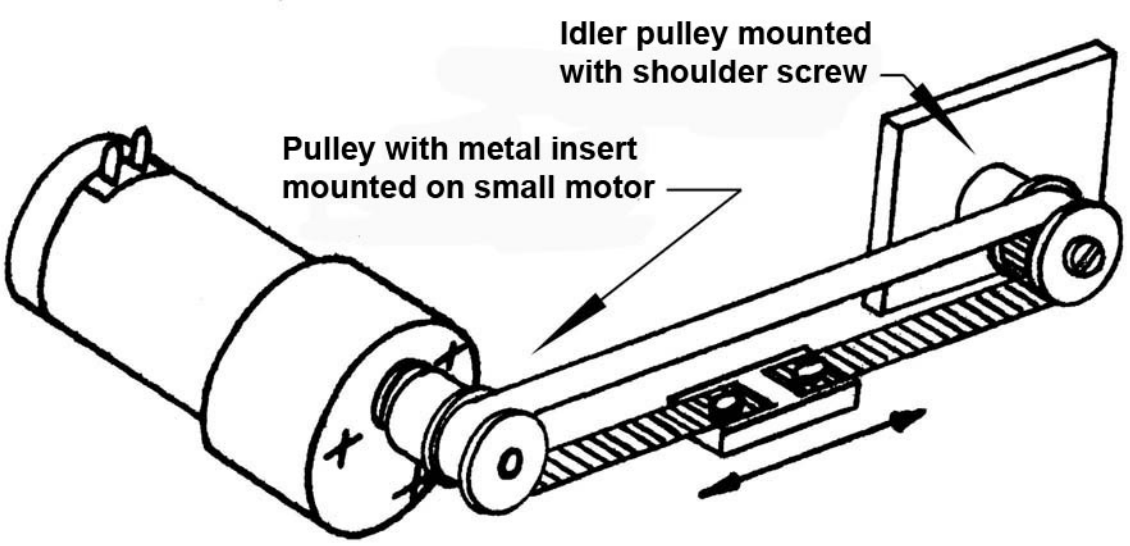

Figure 7. One possible drive configuration.

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.