Boosting Engineering, Science & Technology™

BEST Generic Kit Usage Guide

GMKR00002 Revision 10; August 2014

1.0 Introduction

This document is for information only. Although it is consistent with the rules, please see the Generic Game Rules document for the official rules.

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 VEXnet Joystick, VEXnet keys, VEX Cortex Microcontroller, 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 of the Returnable Kit items.

2.0 Batteries

You have two 7.2 Volt NiMH 3000maH 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.
- Connect and disconnect these batteries using the red and black connectors, not at the white connector. If the white connector is used, the contacts will become unreliable over time (you may lose power during a match).
- 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

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

directly onto the motor power lugs. This can damage the connector and battery and may cause your machine to fail during the competition (Ouch!).

Inside the Joystick are 6 'AAA' rechargeable Ni-MH batteries. These batteries have a use time of about 2 hours before needing to be fully recharged. **You need to manage your Joystick's battery charge carefully;** that is part of the competition. Here are some hints:

1. During the six-week period, you should **fully** discharge your Joystick AAA batteries and fully recharge them at least once. The charge time for fully discharged AAA batteries is about 2 hours.

2. Charge the Joystick batteries overnight before the competition to be safe.

3. Keep your Joystick turned off and connected to the VEX Cortex Microcontroller by substituting the VEXnet keys with the USB A-A cable as much as possible (when not using the wireless operation). During this tethered configuration, turn the VEX Cortex microcontroller ON and the Joystick OFF; the Joystick will receive power through the USB cable.

4. Keep the Joystick and your machine off as much as possible.

5. Have an extra 6-pack of regular non-rechargeable AAA batteries as backup (the Generic Game Rules allow these to be used during competition).

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

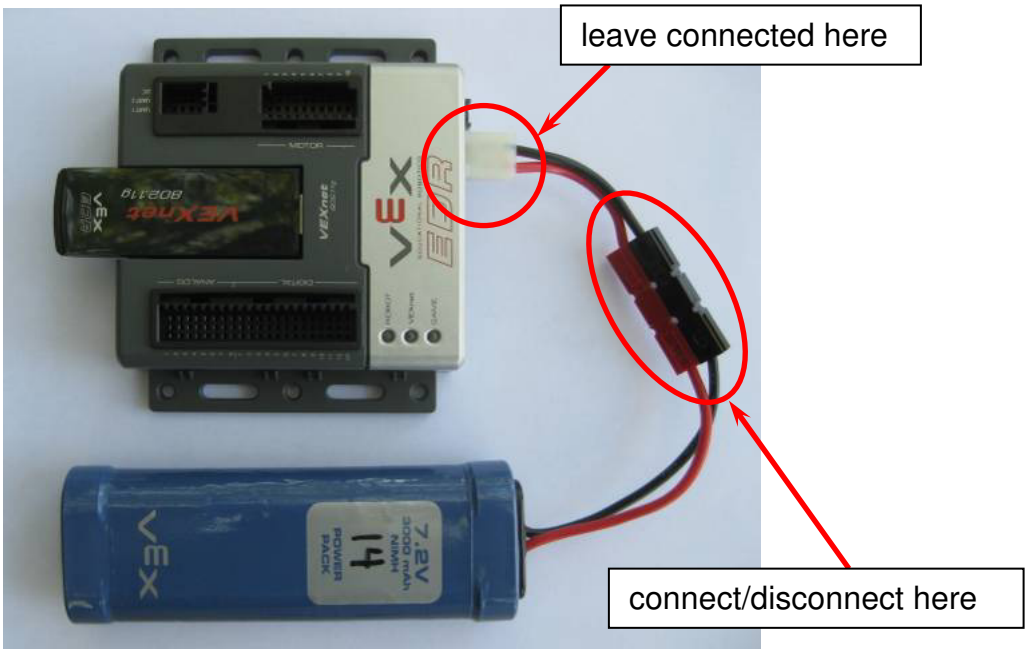
3.0 VEX Cortex Microcontroller Operation

The VEX Cortex Microcontroller uses an ad hoc network for communications through a proprietary VEXnet implementation. This implementation is designed to eliminate the need for any knowledge of IP addresses, MAC addresses, security settings, and IP protocols. Just turn it on and it automatically connects to the correct Joystick. To see how all this works, let's have a look at some information from the Cortex Microcontroller/Joystick User Guide (accessible at http://www.vexforum.com/wiki/index.php/VEX_Cortex_Microcontroller).

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

3.1 Basic Operation

The first step is to make some basic connections; batteries, Cortex microcontroller, Joysticks and (2) VEXnet keys. Attach 7.2v battery power and a VEXnet key to the VEX Cortex Microcontroller as shown.



Add AAA batteries to the Joystick by loosening the screw as shown. Remove the battery cover.

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

Install six identical batteries as shown. Use Alkaline, Ni-Cad or Ni-MH chemistries, but DO NOT mix different chemistry batteries. Charge rechargeable batteries only with a quality charger designed for your battery chemistry.

Reinstall the battery cover (insert the two tabs of the battery cover first along the back edge of the battery cover to aid in installation) and add the VEXnet key as shown.

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

For longest battery life, turn the units ON only when needed. Fresh batteries in the Joystick will provide about two hours of run time. If wireless operation is not required, substitute the VEXnet keys with a USB A-A cable. For this tether configuration, turn ON the Cortex Microcontroller but leave the Joystick OFF. The USB A-A cable will power the Joystick. Turn ON the Cortex Microcontroller and the Joystick (switches are shown in the ON position in the two pictures below).

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

A valid link is shown in the pictures below. The VEXnet light will be blinking a fast green on both units. It will take about 10 to 15 seconds for a link to be established after the units are turned ON. The Robot light will wink green (be mostly on) on both units and when using fully charged batteries. The Joystick light will be solid green when using fully charged batteries.

If the units fail to link up, turn them both OFF and then back ON. If they still fail to link up, tethering may be required. **Refer to Section 3.2 "Re-syncing the Controller and Joystick".**

When you enter the competition field for a match, you will first turn on your power switches for both the VEX Cortex Microcontroller and VEXnet Joystick to establish a wireless network connection (this could take 10-15 seconds) and then wait for the referee to begin the match. When the match is started, you can then operate your robot via the Joystick.

When your match is over, you can then power off both the VEX Cortex Microcontroller and VEXnet Joystick and leave the playing field.

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

3.2 Re-syncing the Controller and Joystick

If your Cortex microcontroller and Joystick fail to establish a link, you may need to re-sync the two devices. To do this: with both units powered off, remove the VEXnet USB keys and connect the Cortex microcontroller to the Joystick with the A-A USB cable. Power both on and wait for a slow blinking green Robot light and a solid green VEXnet light. The units are now paired and ready for normal operation. If this procedure fails to work, double check you that your batteries are charged and properly connected to the Cortex. Find additional debugging documentation in the Cortex Microcontroller/Joystick User Guide at http://www.vexforum.com/wiki/index.php/VEX_Cortex_Microcontroller (note that the "default program" referred to in the document is different than the BEST default program).

3.3 Tethered Operation

For tethered operation, first turn off your Cortex and Joystick. Remove the VEXnet USB keys from both the Cortex and the Joystick and store them in a safe place. Insert one end of the USB A-A cable into the USB connector on the Cortex and the other end into the USB connector on the Joystick. During tethered operation you only need to power-on the Cortex. The battery plugged into the Cortex will provide power (through the USB cable) to the Joystick. There is no need to power-on the Joystick, thus conserving its battery life.

It is recommended that you operate your robot in the tethered configuration when operating the robot in your PIT area.

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

3.4 VEXnet Keys

There are two different versions of the VEXkey, as shown and described below.

Version 2.0 key

Version 1.0 key
(obsolete)

The 1.0 version (the black key) operates by creating an ad hoc network using Wi-Fi communications channels and protocols; therefore it is subject to interference and bandwidth issues from other Wi-Fi sources. The 1.0 version key is not legal for use in BEST competitions and is no longer supported by VEX.

The 2.0 version (the white key) also operates by creating an ad hoc network, but it is not a Wi-Fi device; therefore it avoids the interference and bandwidth issues from other Wi-Fi sources. In addition, the 2.0 key has internal firmware that can be updated, this will allow for future functionality improvements.

The two different versions of the keys are not compatible with each other. A link cannot be established between a 1.0 key and a 2.0 key.

The firmware in the Cortex/Joystick must be at version 4.0 or later to use the 2.0 key. The v4.0 and later firmware is compatible with either version of the keys, but once a Cortex unit has been used with a particular version of the keys, stick with that version (swapping back and forth between the key versions would require additional steps to ensure that they will link up).

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

4.0 VEX Cortex Microcontroller Connections

Figure 1 below shows an example hookup of Return Kit components to the Cortex microcontroller. It shows connections for a motor, a servo and the battery. Following are some tips to ensure problem-free use of the Cortex.

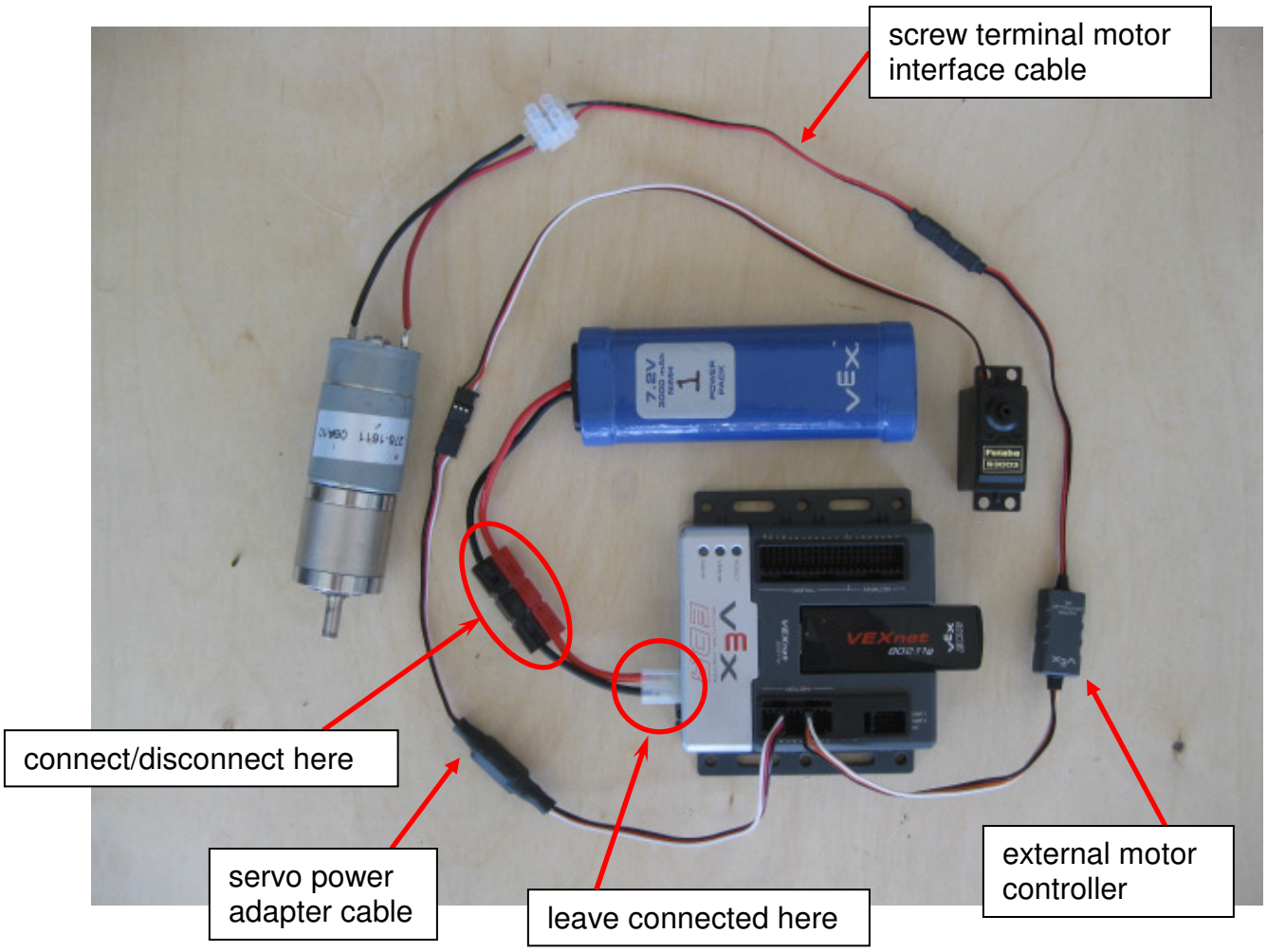


Figure 1: Example Cortex Connections

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

Figure 2 below provides an overview of all of the Cortex connector locations and features. Additional information on the Cortex is contained in the Cortex Microcontroller/Joystick User Guide.

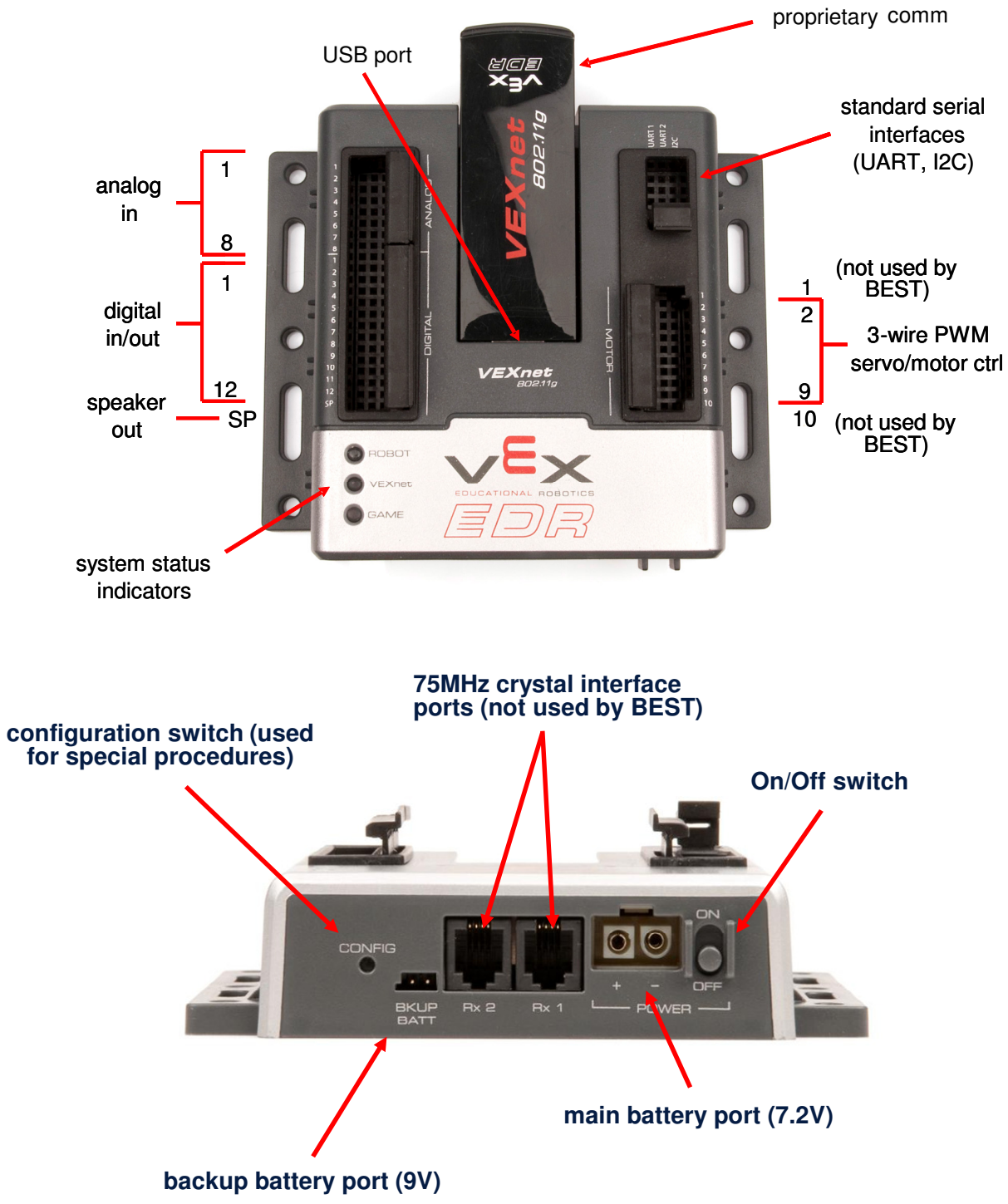


Figure 2: Cortex Microcontroller Features

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

4.1 General

The Cortex is powered by the 7.2 VDC, 3000 mAHr R/C battery included in your Returnable Kit. Use the battery adapter to connect your battery to the Cortex. Do not attempt to attach the battery to any input other than the Red/Black Powerpole connector.

DO NOT solder wires to the Cortex connectors! Servo connections are made using the standard servo power adapter cables. Motor connections are made using the screw terminal motor interface cables combined with an external motor controller. Only use motor ports 2 to 9 to connect a servo or a motor. **Do not** use the 2-pin screw terminal motor interface cable to plug directly into motor port 1 or 10 of the Cortex (this is to prevent damage to the Cortex if the motor wires short out).

The retaining clips on the Cortex connectors may be removed as needed for convenience. However, these clips must be properly installed on the Cortex when you return your kit.

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

Mount the Cortex to your robot using #8 screws through the holes provided on its base. Be careful not to over tighten the screws (to prevent damage to the mounting tabs).

Consider mounting the Cortex on your robot in a place where it might be easily removed. Note that you will also need access to the Cortex's USB Key connector; a little planning can simplify access to this connector.

The Cortex's on/off switch should be easy to access so that a referee can switch off your machine if needed.

4.2 Servo Connections

The servo power adapter cables are required to interface between the Futaba servos and the Cortex microcontroller. The servo power adapter cables are keyed to ensure the correct orientation for insertion into the Cortex. The white wire should be oriented towards the notch in the motor/servo port (as shown in **Figure 3)** or the servos will not function. The servo wire or a servo extension wire are then plugged into the servo power adapter cable. Make sure the white wires line up if the connector is not keyed. Always be careful when inserting and removing wires to avoid damaging the connectors and wires.

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

4.3 Motor Connections

Motor wires should be soldered (or attached with spade connectors) to the motor terminals at one end and attached to the terminal motor interface cable at the other end. The terminal motor interface cable end of the motor wires should be tinned with solder before securing them into the terminal motor interface cable since frayed stranded wires could cause a short to other components. Once inserted into the screw terminals tighten the screws with a small flat-blade screwdriver so that the wires are secure and do not pull out. The next step is to connect the 2-pin end of the screw terminal motor interface cable to the matching 2-pin female connector on the external motor controller. The polarity that you choose at this connection will determine the relative direction of motor rotation for positive stick movement (on the Joystick). Lastly, plug the 3-pin male connector end of the external motor controller in a Cortex motor port (2 – 9). The white wire should be oriented towards the notch in the motor/servo port (as shown in **Figure 3)** or the motor will not function.

Motor ports 2-5 and 6-9 are on separate banks (circuits) within the Cortex. The motors should balanced between these two banks to prevent overloading the Cortex (an overload will cause the circuit breaker to engage, preventing normal operation until the circuit cools off).

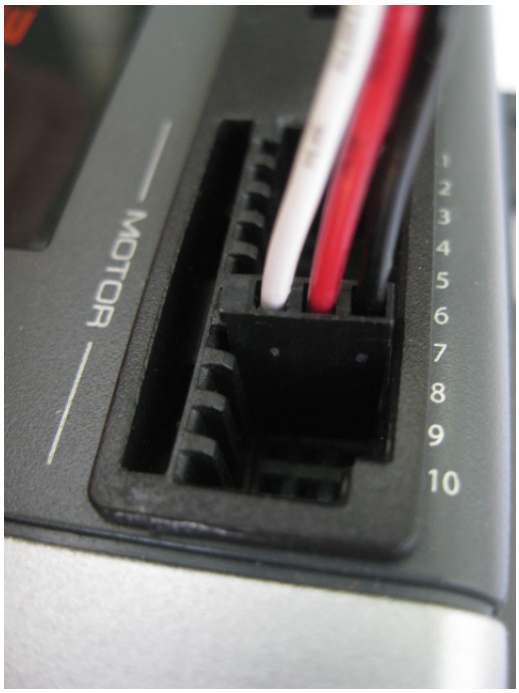


Figure 3: Servo and Motor Connections to Cortex

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

4.4 Analog and Digital Inputs

Analog input (a potentiometer for example) and digital input (a limit switch for example) connections are made through bare wire connections to a sensor screw terminal interface cable (similar to the motor connections). Tin the ends of wire (if the wire is stranded, not necessary for solid wire) with solder before inserting into the screw terminals. Be sure to tighten the screws on the terminal strip so that the wires are secure and do not pull out. Insert the pins of the sensor screw terminal interface cable into a Cortex input port (as shown in **Figure 4)**. Eight (8) sensor screw terminal interface cables have been provided in your kit, some have two pins (can be used with the limit switches) and some have 3 pins (can be used with the potentiometers).

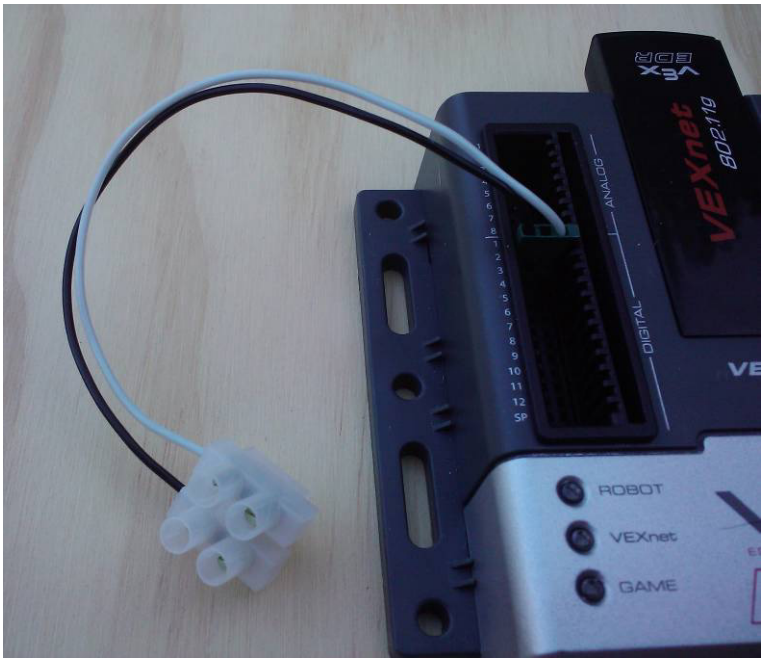


Figure 4: Digital Input Connection (with 2 pin cable)

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

An example showing how to connect a potentiometer to an analog input port is shown in **Figure 5**. IMPORTANT, the signal terminal of the potentiometer should be connected to the signal pin of the analog input port.

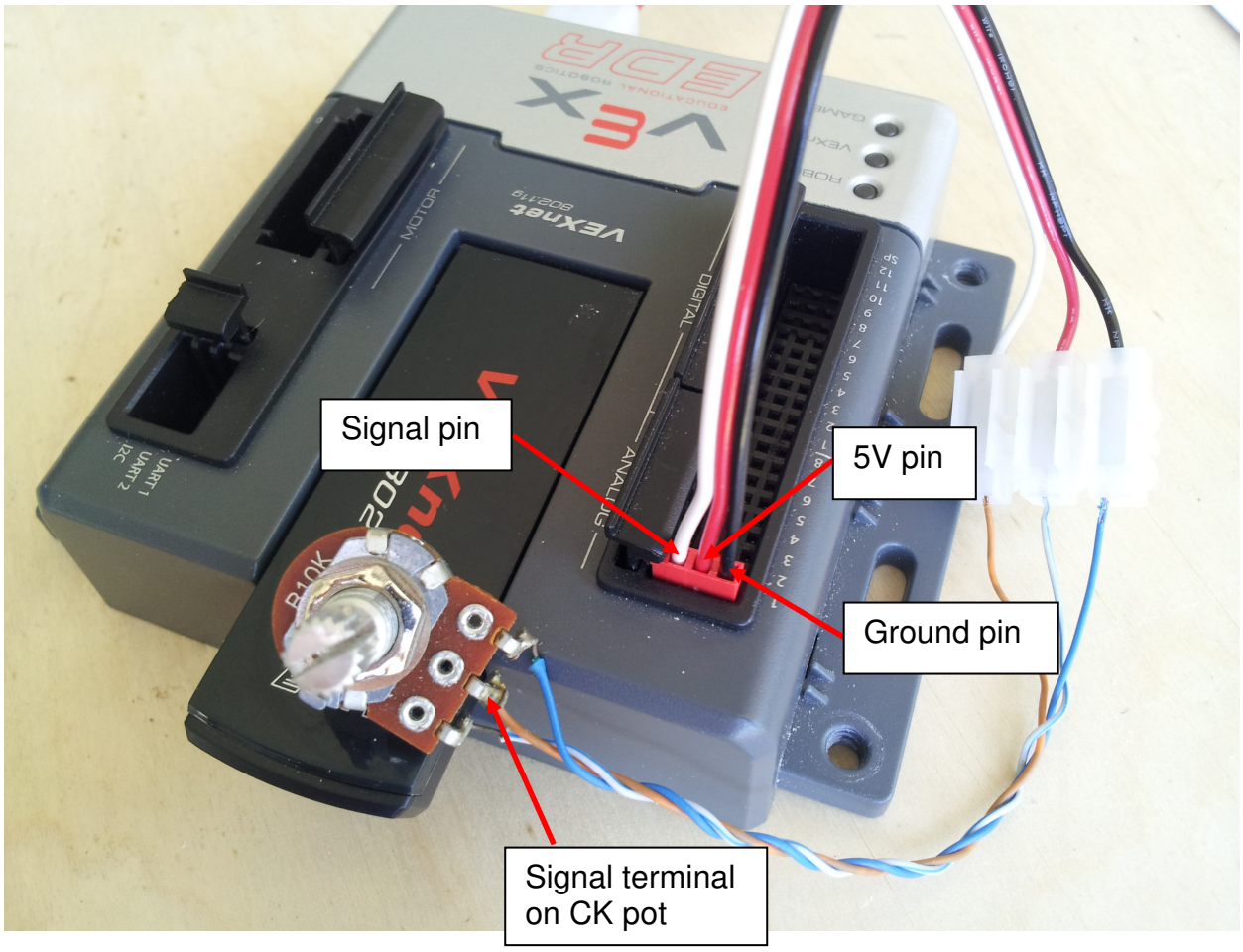


Figure 5: Potentiometer Connection (with 3 pin cable)

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

5.0 Using the Microswitches

Included in the kit are four microswitches that can be used to provide digital (on/off) information to your Cortex program about the robot's current status. These switches might be used for:

- bump sensing,
- motor limit detection,
- system interrupt,
- ect.

6.0 Servo Notes

If a servo is "humming," this indicates that the servo cannot move to the commanded position. 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.

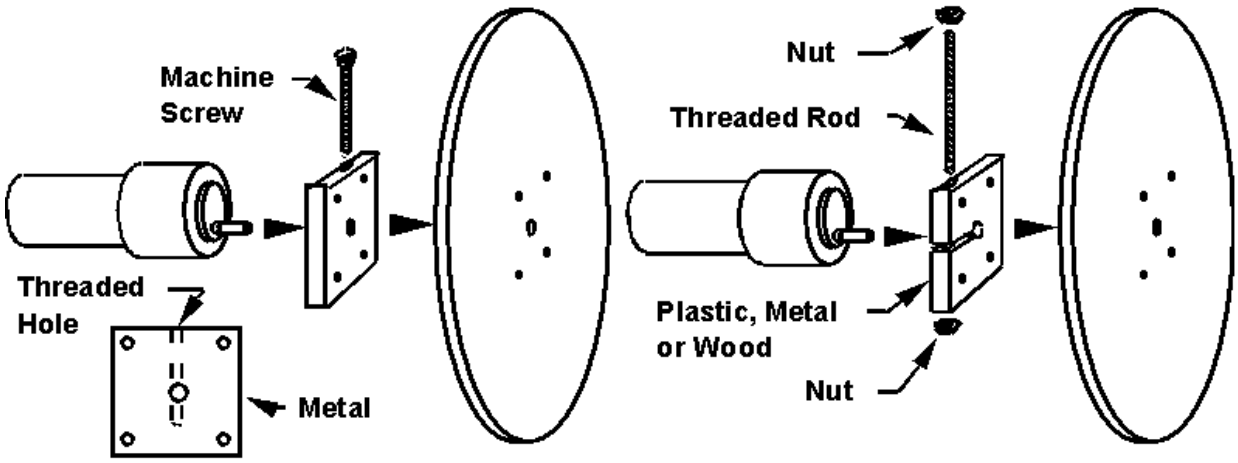


Figure 6: Two Suggestions for Mounting Wheels.

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

8.0 Motor Mounting

The motors may be mounted to the robot using the provided motor plates and screws from the consumables kit. The plate thickness and screw lengths are specifically matched to prevent damaging (the internal gear plates) the small motors. In addition, face-mounting of motors with these plates prevents the motors from spinning in their mounts and potentially shorting out the power wires.

The plates may be modified (may be bent or cut).

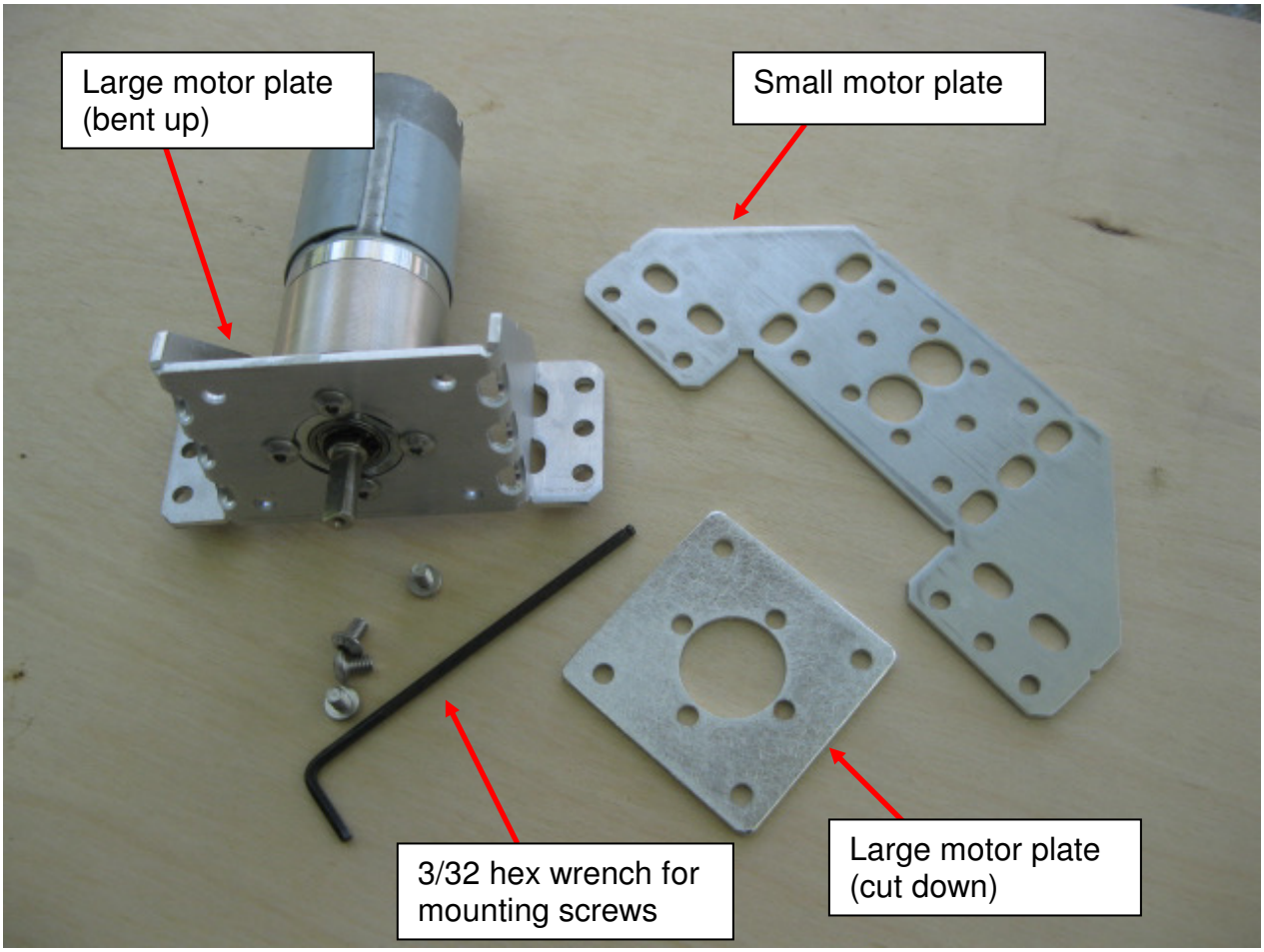


Figure 7: Motor Mounting Plates and Screws

If using an alternate face mounting method, make sure that the mounting screws do not extend to the small motor more than 0.200". This is to prevent internal damage to the motor.

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

If a clamping style motor mount is used, the motor should be clamped around the gearbox portion as opposed to the armature portion (see **Figure 8**) to prevent damage to the motor. Note that supporting the motor on the armature portion should be fine, just avoid clamping it here.

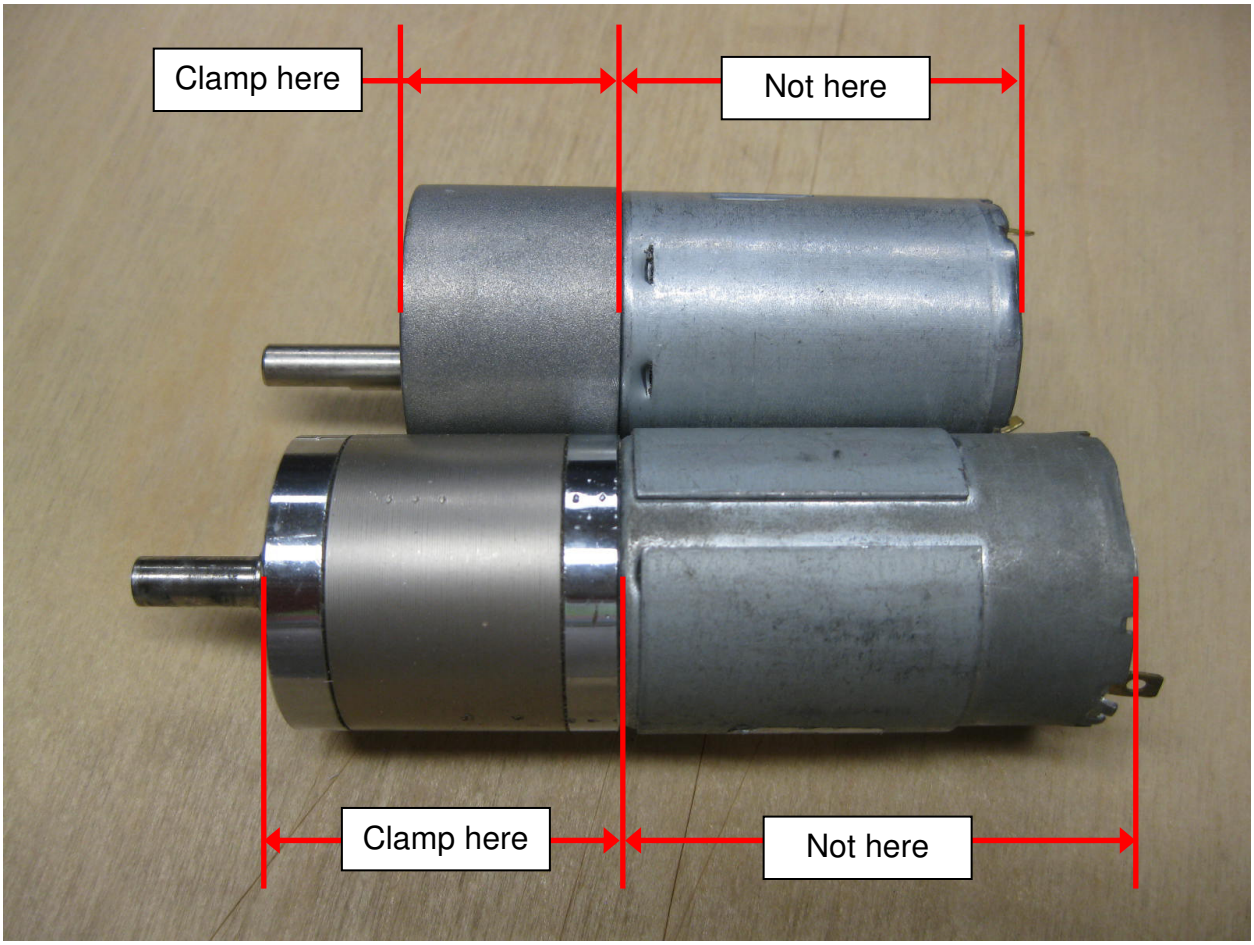


Figure 8: Motor Clamping Zones

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved

9.0 Drive Component Usage

Recall that the drive components (other than the 3-ft strip belt) 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 9** (it should look a lot like the carriage mechanism in a printer).

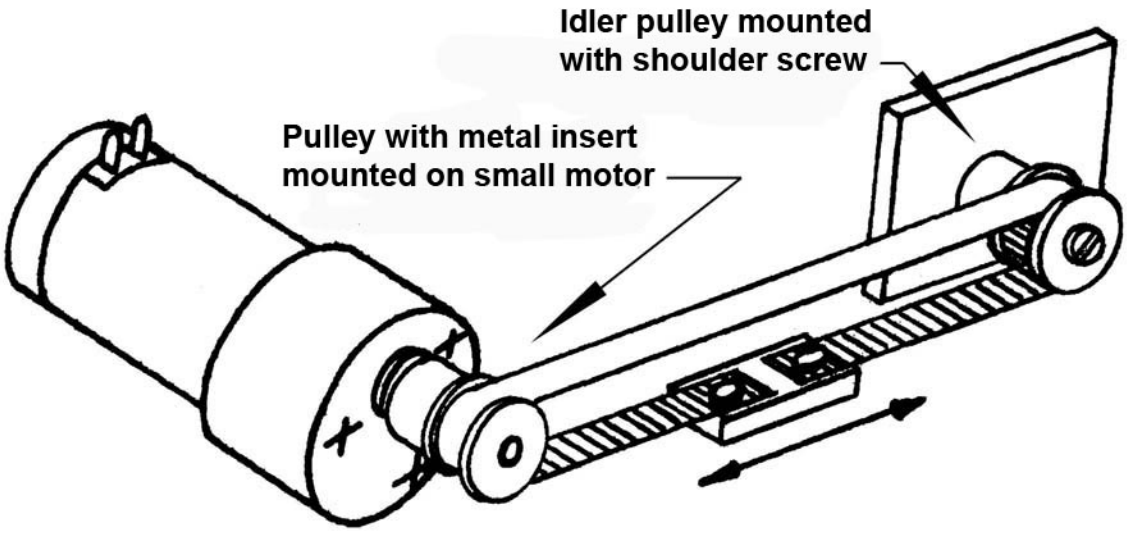


Figure 9: One possible drive configuration.

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.

Copyright © 2005 - 2014
BEST Robotics, Inc.
All rights reserved