1. Cortex Microcontroller and VEXnet Joystick Pairing Procedure:

a. The Joystick must first be paired to the Cortex Microcontroller before they will work using the VEXnet Keys. Pairing requires a USB A-A Cable and a VEX 7.2V Battery. This process must be completed each time you use a Joystick or Cortex with a new mate. A Joystick can only communicate with a Cortex that it has been paired with. During the Pairing Process, the ID from the Cortex is transferred to the Joystick; thus mating the two units together.

b. Start with the Cortex and Joystick turned OFF.
c. Connect the Cortex to the Joystick using a USB A-A Cable.
d. Connect the 7.2V VEX Battery to the Cortex.
e. Power up only the Cortex.
f. A successful tether is indicated by a Solid Green VEXnet LED on both the Joystick and the Cortex (See Figure Below).
   – The Solid Green VEXnet LED must remain ON both units at the same time for a minimum of 5 seconds.
   – Disregard the other LEDs as you are only interested in the VEXnet LED.
   – Pairing may take up to one minute to complete.

g. Once the units have finished pairing, turn OFF the Cortex.
h. Disconnect the USB A-A Cable from both units.

ROBOTICS DESIGN SYSTEM

2. Basic connections; batteries, microcontroller, Joysticks and (2) VEXnet keys.

a. Attach a 7.2v battery and a VEXnet 802.11g key to the VEX Cortex as shown.

b. 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.

c. 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 then tighten the cover screw. Then add the VEXnet 802.11g key as shown.

d. Turn on the Cortex and Joystick by setting the power switches to ON as shown in the two pictures below.

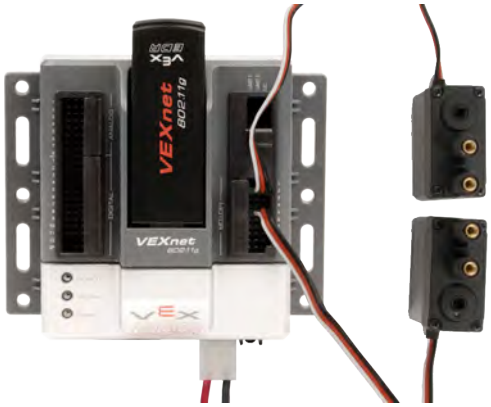
e. A valid link is shown below. The VEXnet LED will be blinking fast green on both the Cortex and Joystick. The VEXnet light is the only LED that determines a valid link. It usually takes 5 to 10 seconds to successfully establish a link. Once the units are linked, the Robot and Joystick LED Indicators will show the battery levels in their respective unit. A green Robot or Joystick LED indicates that their respective batteries are fully charged batteries. As the battery levels decrease, these LEDs will change to yellow and then red.

f. If the units fail to establish the VEXnet link, turn them both OFF and then back ON. If they still fail to link up, pairing may be required. Refer to the section 1 for pairing instructions.

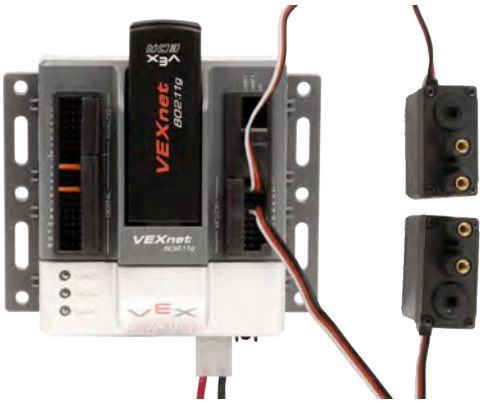
3. Basic Configuration

A few examples of the Default Code that is preloaded onto the Cortex Microcontroller are shown below. For complete details on the Default Code, refer to Section 4. **Please note: The default code for the Cortex Microcontroller varies from that of the PIC Microcontroller. Please review and follow the tables in this document to ensure your robot behaves in the manner you wish.**

a. Add motors and test. The following picture shows two VEX 3-Wire Motors plugged into Motor Port 2 and Motor Port 5. With the Default Code, pushing Joystick Channel 3 up will cause Motor 2 to turn clockwise. Pushing Joystick Channel 2 up will cause Motor 5 to turn counterclockwise.

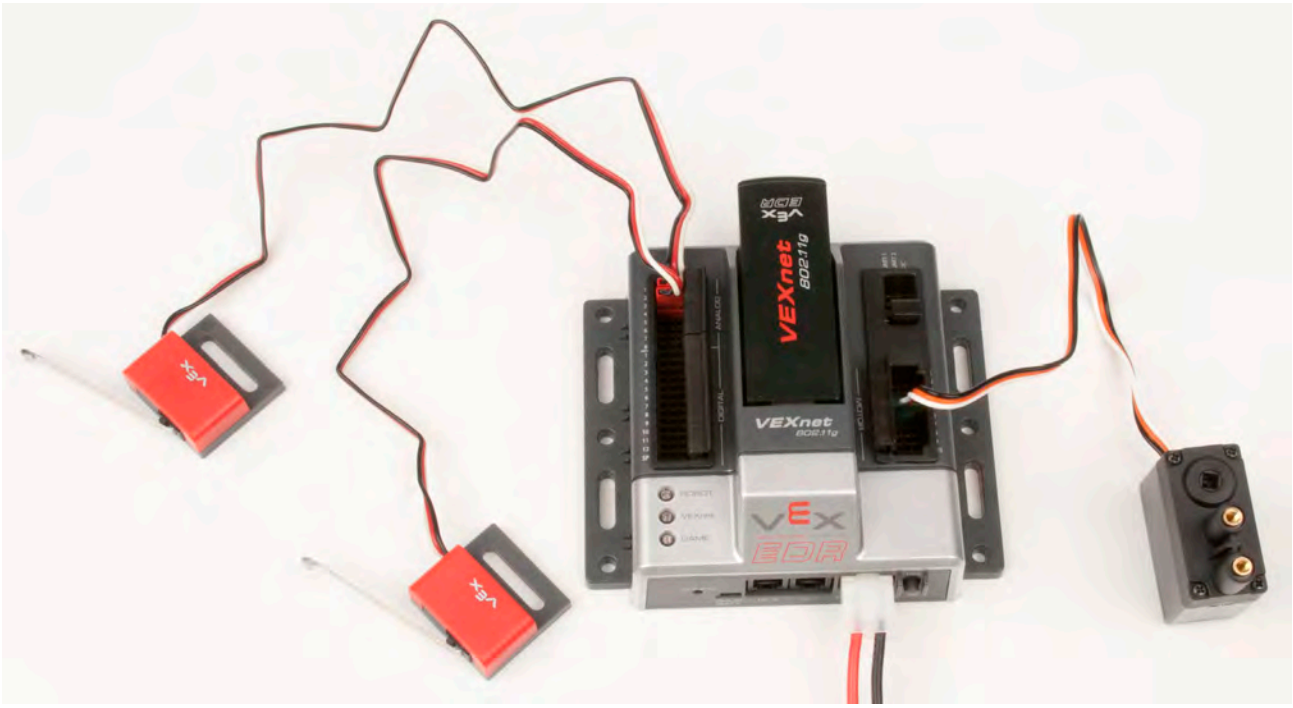


b. Motor Reversing: The Default Code allows jumpers or switches to be installed in the Digital Ports to invert the motor direction. This is useful to correct the direction of motors without changing code, or when using a switch to reverse a motor if the robot hits an object. The following picture shows motor reversing jumpers installed in Digital Ports 2 and 5 to reverse Motor Ports 2 and 5.



c. Two Joystick Operation: The Default Code allows two Joysticks to control motors when a jumper is installed in Digital Port 11. Connect the two Joysticks together using the PARTNER Ports with a coiled handset cord as shown below. Only one Joystick should have a VEXnet Key installed.

d. Limit Switch Inputs: The Default Code allows jumpers or switches to be installed in the Analog Ports to limit certain motor directions. These are useful for stopping a motor when an arm bottoms out. A limit switch plugged in to Analog 1 will stop Motor 6 from turning counterclockwise when activated. A limit switch plugged in to Analog 2 will stop Motor 6 from turning clockwise when activated.



4. **Default Operation: Refer to the attached figures for details and options of Joystick input to Motor response.**
These motor directions will make a Protobot robot go forward when the joysticks are pushed up. Robots that do not have an idler gear will go in the opposite direction until a reversing jumper is installed or custom code is created. Note the Jumper variations for each section.
Please note: The default code for the Cortex microcontroller varies from that of the PIC microcontroller. Please review and follow the tables in this document to ensure your robot behaves in the manner you wish.

NO Jumpers Installed - Single Driver Mode, Tank Drive

Motor 1	LEFT DRIVE	Primary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 2	LEFT DRIVE	Primary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 3	LEFT DRIVE	Primary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 4	RIGHT DRIVE	Primary Driver	Channel 2 (right stick, Y-axis)	Joystick Up = Motor CCW
Motor 5	RIGHT DRIVE	Primary Driver	Channel 2 (right stick, Y-axis)	Joystick Up = Motor CCW
Motor 6	MECH 1	Primary Driver	Channel 5 (left shoulder buttons)	U Button = Motor CW
Motor 7	MECH 2	Primary Driver	Channel 6 (right shoulder buttons)	U Button = Motor CW
Motor 8	MECH 3	Primary Driver	Channel 7 (left d-pad buttons, U/D)	U Button = Motor CW
Motor 9	MECH 4	Primary Driver	Channel 8 right d-pad buttons, U/D)	U Button = Motor CW
Motor 10	RIGHT DRIVE	Primary Driver	Channel 2 (right stick, Y-axis)	Joystick Up = Motor CCW

Jumper installed in Digital 11 - Dual Driver Mode, Tank Drive

Motor 1	LEFT DRIVE	Primary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 2	LEFT DRIVE	Primary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 3	LEFT DRIVE	Primary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 4	RIGHT DRIVE	Primary Driver	Channel 2 (right stick, Y-axis)	Joystick Up = Motor CCW
Motor 5	RIGHT DRIVE	Primary Driver	Channel 2 (right stick, Y-axis)	Joystick Up = Motor CCW
Motor 6	MECH 1	Secondary Driver	Channel 5 (left shoulder buttons)	U Button = Motor CW
Motor 7	MECH 2	Secondary Driver	Channel 6 (right shoulder buttons)	U Button = Motor CW
Motor 8	MECH 3	Secondary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 9	MECH 4	Secondary Driver	Channel 2 (right stick, Y-axis)	Joystick Up = Motor CW
Motor 10	RIGHT DRIVE	Primary Driver	Channel 2 (right stick, Y-axis)	Joystick Up = Motor CCW

Jumper installed in Digital 12 - Single Driver Mode, Arcade Drive

Motor 1	LEFT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 2	LEFT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 3	LEFT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 4	RIGHT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 5	RIGHT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 6	MECH 1	Primary Driver	Channel 5 (left shoulder buttons)	U Button = Motor CW
Motor 7	MECH 2	Primary Driver	Channel 6 (right shoulder buttons)	U Button = Motor CW
Motor 8	MECH 3	Primary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 9	MECH 4	Primary Driver	Channel 4 left stick, X-axis)	Joystick Right = Motor CCW
Motor 10	RIGHT DRIVE	Primary Driver	Arcade Drive (see separate chart)	

Jumper installed in Digital 11 & Digital 12 - Dual Driver Mode, Arcade Drive

Motor 1	LEFT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 2	LEFT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 3	LEFT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 4	RIGHT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 5	RIGHT DRIVE	Primary Driver	Arcade Drive (see separate chart)	
Motor 6	MECH 1	Secondary Driver	Channel 5 (left shoulder buttons)	U Button = Motor CW
Motor 7	MECH 2	Secondary Driver	Channel 6 (right shoulder buttons)	U Button = Motor CW
Motor 8	MECH 3	Secondary Driver	Channel 3 (left stick, Y-axis)	Joystick Up = Motor CW
Motor 9	MECH 4	Secondary Driver	Channel 2 (right stick, Y-axis)	Joystick Up = Motor CW
Motor 10	RIGHT DRIVE	Primary Driver	Arcade Drive (see separate chart)	

VEX ROBOTICS DESIGN SYSTEM

Arcade Mode - Channel 1 (right stick, X-axis) + Channel 2 (right stick, Y-axis)

Channel 1 (right stick, X-axis) **Robot Turn Rate**	Motor 1	LEFT DRIVE	Joystick Right = Motor CW
	Motor 2	LEFT DRIVE	Joystick Right = Motor CW
	Motor 3	LEFT DRIVE	Joystick Right = Motor CW
	Motor 4	RIGHT DRIVE	Joystick Right = Motor CW
	Motor 5	RIGHT DRIVE	Joystick Right = Motor CW
	Motor 10	RIGHT DRIVE	Joystick Right = Motor CW

Channel 2 (right stick, Y-axis) **Robot Forward Speed**	Motor 1	LEFT DRIVE	Joystick Up = Motor CW
	Motor 2	LEFT DRIVE	Joystick Up = Motor CW
	Motor 3	LEFT DRIVE	Joystick Up = Motor CW
	Motor 4	RIGHT DRIVE	Joystick Up = Motor CCW
	Motor 5	RIGHT DRIVE	Joystick Up = Motor CCW
	Motor 10	RIGHT DRIVE	Joystick Up = Motor CCW

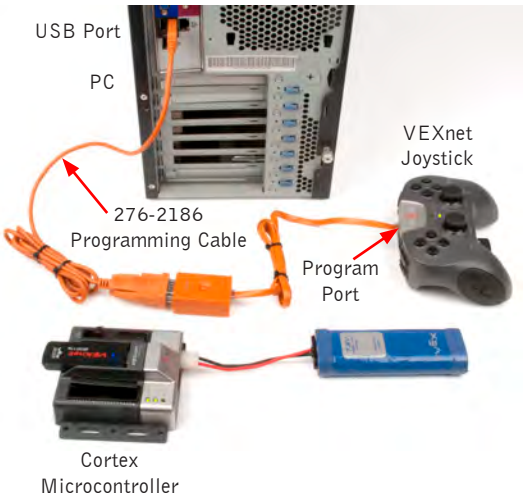
Reverse Motor Direction

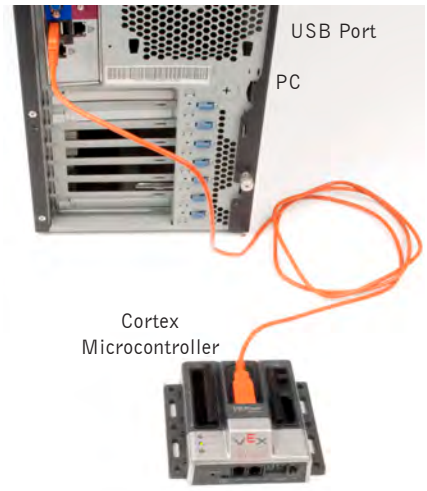
Reverse Motor 1	Jumper in Digital 1
Reverse Motor 2	Jumper in Digital 2
Reverse Motor 3	Jumper in Digital 3
Reverse Motor 4	Jumper in Digital 4
Reverse Motor 5	Jumper in Digital 5
Reverse Motor 6	Jumper in Digital 6
Reverse Motor 7	Jumper in Digital 7
Reverse Motor 8	Jumper in Digital 8
Reverse Motor 9	Jumper in Digital 9
Reverse Motor 10	Jumper in Digital 10

Limit Switch Inputs

Motor 6 ignores CCW	Jumper in Analog 1
Motor 6 ignores CW	Jumper in Analog 2
Motor 7 ignores CCW	Jumper in Analog 3
Motor 7 ignores CW	Jumper in Analog 4
Motor 8 ignores CCW	Jumper in Analog 5
Motor 8 ignores CW	Jumper in Analog 6
Motor 9 ignores CCW	Jumper in Analog 7
Motor 9 ignores CW	Jumper in Analog 8

a. The Cortex may be reprogrammed with user-created code. The hardware setup for wireless downloading is shown below. For non-wireless downloading, the VEXnet keys may be substituted with a USB A-A cable. You can also download code directly to the Cortex using the USB A-A cable.





VEX ROBOTICS DESIGN SYSTEM

5. Diagnostics Information: refer to the following chart for Joystick and Cortex LED patterns and meanings.

Joystick [5]	Robot	VEXnet	Game	
		Medium (yellow)		Initialize - Looking for PC or Tether Mate
		Blip (yellow)		Startup - Looking for USB Key
		Fast (yellow)		Linking - Searching for VEXnet Mate
		Fast (green)		Linked
		Slow (green / yellow)		Linked - Data quality reduced
		Slow (green / red)		Linked - Poor Data quality reduced
		Solid (green)		Tethered to Mate or PC
		Slow (red) single blink		Fault: Lost Link - Searching for VEXnet Mate
		Slow (green)		Downloading User Code [1]

Note 1: Does not apply to ROBOTC User Code Downloads

Joystick [5]	**Robot** [1]	VEXnet	Game	
	(red)			Main Battery = **Dead** (<5.5v) or CORTEX Off [2]
	(yellow)			Main Battery = **Low** (<6.5v) [2]
	(green)			Main Battery = **Good**
	Solid			All Good: Both Joysticks connected
	Solid + 1 Blink			All Good: Tx1 Joystick connected
	Fast			Autonomous only mode
	Fast (red) [3]			Fault: Low Backup Battery (0v-8v)
	Slow (red)			Fault: User Microprocessor Issue

Note 1: Robot LED only work when Linked

Note 2: Lowest CORTEX battery color latched at Joystick and CORTEX

Note 3: No Backup Battery only indicated if competition cable is connected.

Joystick [5]	Robot	VEXnet	**Game**	
			Off	No Competition connection
			Solid (green)	Driver [4]
			Fast (green)	Autonomous
			Fast (yellow)	Disabled

Note 4 : Game LED Driver Indicator is only used when the competition cable is connected.

Joystick [5]	Robot	VEXnet	Game	
(red)				Joystick Battery = **Dead** (<5.5v)
(yellow)				Joystick Battery = **Low** (<6.5v)
(green)				Joystick Battery = **Good**
Fast				Two Joysticks in use
Solid				One Joystick in use

Note 5 : Joystick LED only on Joystick.

Update Utility Tool Indicators

Joystick [5]	**Robot**	**VEXnet**	**Game**	
		Solid (green)		Tether to PC
	Slow (green)		Flickering (green)	Bootload Mode - Ready to update firmware
	Slow (green)	Slow (red)	Flickering (green)	Downloading Master Code

Other Indicators

Joystick [5]	**Robot**	**VEXnet**	**Game**	
(red)	(red)	(red)	(red)	Flash on all 3 indicates a Reset
		Slow (red) double blink		NO VEXnet Key detected
	Slow (red) double blink			Invaild ID in the CORTEX
Slow (red) double blink				Invaild ID in the Joystick

ROBOTICS DESIGN SYSTEM

6. VEXnet Joystick Calibration Procedure:

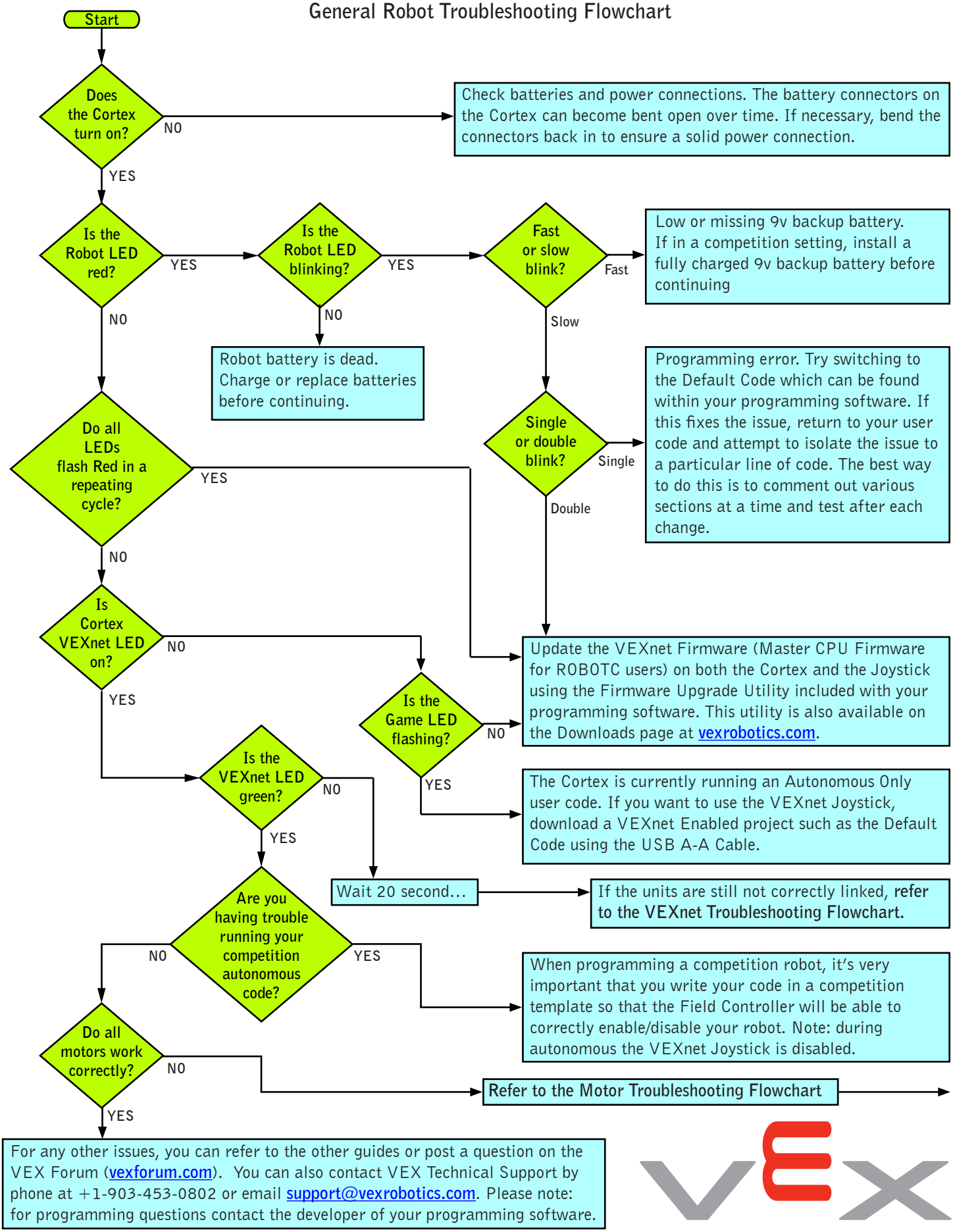
a. The Joystick must be linked to the Cortex Microcontroller using the VEXnet Keys.
b. Hold the "6U" Back Switch depressed.
c. While the "6U" Back Switch is depressed, use a small Allen Wrench (1/16" or smaller) or similar small straight tool to depress and hold the CONFIG Switch.
d. Hold both Switches depressed until you see the Joystick LED Flash red and green – you can now release both Switches.
   – There is a 10 second time limit to complete the following steps 5 and 6.
e. Move both Joystick Pots to the maximum position desired in all 4 directions – Up, Back, Left, and Right.
   –. If a movement is not detected in all 4 directions, a timeout will occur after about 10 seconds and the Calibration Mode will be discontinued and the VEXnet LED will briefly flash red.
   –. The Joystick LED will continue to flash red and green during the calibration process.
f. After movement is detected in all 4 directions, the Joystick LED will be ON and solid green.
   – To save the calibration, depress and release the "8U" top button.
   – If the calibration is accepted and saved, the Joystick LED will start flashing fast green for a few seconds.
   – If the calibration is not saved, a timeout will occur after about 10 seconds and the Calibration Mode will be discontinued and the VEXnet LED will briefly flash red.
   – To cancel the calibration, depress and release the "7U" top button. The Calibration Mode will be discontinued and the VEXnet LED will briefly flash red.
   – If the Calibration Mode is discontinued or saved, the Joystick LEDs will resume their normal function after the VEXnet LED briefly flashes.
g. If Joystick Master Firmware is downloaded into the Joystick, the Joystick will need to be recalibrated.

ROBOTICS DESIGN SYSTEM

7. Troubleshooting Flowcharts:

Start Here

General Robot Troubleshooting Flowchart



ROBOTICS DESIGN SYSTEM

VEXnet Troubleshooting Flowchart

Start

Do both units turn on?
- NO → Check batteries and power connections.
- YES →

Is the Joystick LED red?
- YES → Is the Joystick LED solid?
  - YES → Joystick batteries are dead. Replace batteries before continuing.
  - NO → Update the VEXnet Firmware (Master CPU Firmware for ROBOTC users) on both the Cortex and the Joystick using the Firmware Upgrade Utility included with your programming software. This utility is also available on the Downloads Page at vexrobotics.com.
- NO →

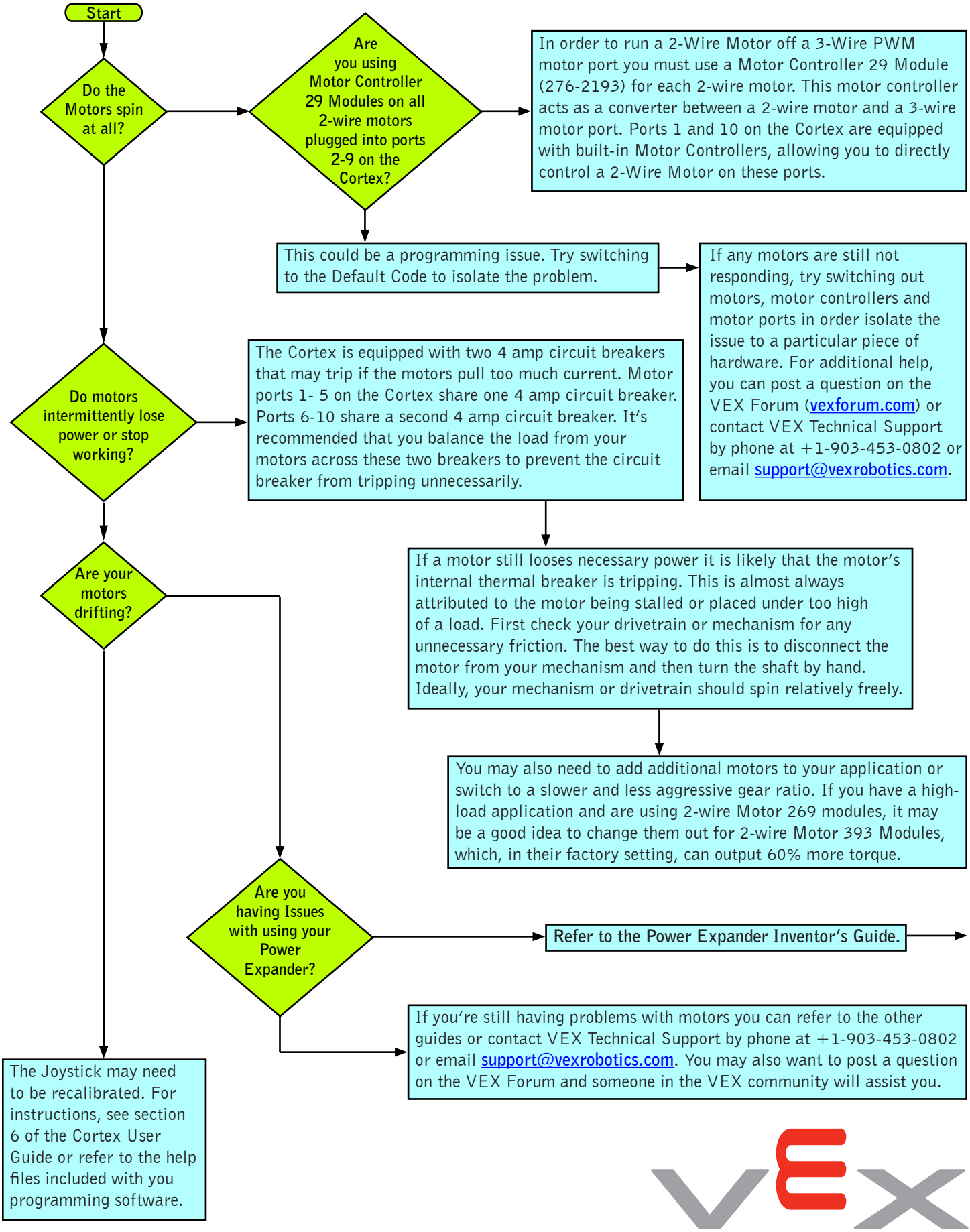
Are both VEXnet LEDs on?
- NO → Update the VEXnet Firmware (Master CPU Firmware for ROBOTC users) on both the Cortex and the Joystick using the Firmware Upgrade Utility included with your programming software. This utility is also available on the Downloads Page at vexrobotics.com.
- YES →

What color is the VEXnet LED?
- Flashing Yellow → For longer than 20 seconds?
  - YES → Pair Cortex and Joystick. For instructions, refer to **Section 1 of the Cortex User Guide.**
  - NO → Units are establishing VEXnet link. No action required.
- Red → Single or double blink?
  - Double → No VEXnet key detected. Check key connection and replace key if necessary. Powercycle unit when finished.
  - Single → Lost VEXnet link. → Signal may be blocked or units may be out of range. Consider moving key to a better location or consider moving the Cortex closer to the Joystick.
- Other → Is VEXnet LED flashing multiple colors?
  - NO → Units are correctly linked. If the problem persists, check user code or try using the Default Code which is available from within your programming software.
  - YES → Poor signal strength. → Signal may be blocked or units may be out of range. Consider moving key to a better location or consider moving the Cortex closer to the Joystick.

If the issue is still present after following this guide, update both the Cortex and Joystick with the most recent version of the VEXnet Firmware. If this does not resolve the problem, try using a different set of VEXnet keys. If you need further assistance you can post a question on the VEX Forum (vexforum.com) or contact VEX Technical Support by phone at +1-903-453-0802 or email support@vexrobotics.com.

ROBOTICS DESIGN SYSTEM

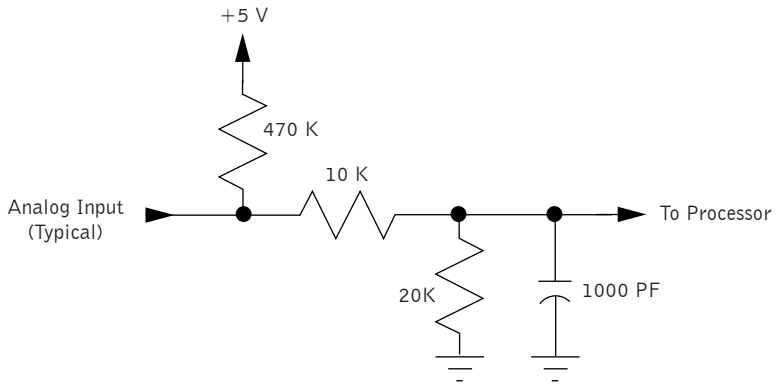
Motor Troubleshooting Flowchart



ROBOTICS DESIGN SYSTEM

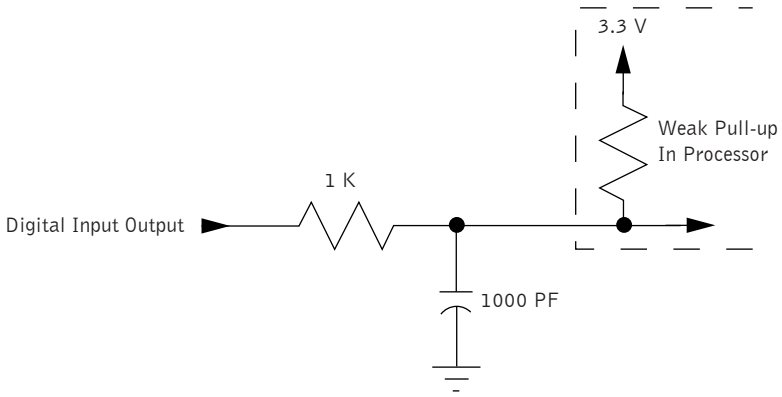
8. **Analog Information: Analog lines are input only and read about 62 (0.2 volts) when open.** When connected to a 0 to 5v source, such as the VEX Potentiometer, you will read from near 0 (0 volts) to near 1023 (5 volts). Circuit details are as follows:
   a. Analog input range is 0 to +5 volts.
   b. Analog circuit has a 470k pull-up to +5 volts, a series 10k resistor and a 20k resistor to ground.
   c. Analog inputs also have a 1000 pF capacitor to ground on the processor side of the 10k resistor.
   d. 3 dB bandwidth: 16 kHz.
   e. Circuit connections as shown.

Analog Port



9. **Digital Information: When configured as an input, digital lines have a weak pull-up.** When configured as an output, digital lines drive 0 volts for a low and 3.3 volts for a high. Circuit details are as follows:
   a. Digital input range is 0 to +5 volts.
   b. Digital drive is primarily limited by the 1k series resistor, so it can output a 2v high into 2k-ohms to ground or a 0.8v low into 7k-ohms to 3.3v.
   c. Digital inputs also have a 1000 pF capacitor to ground on the processor side of the 1k resistor.
   d. 3 dB input bandwidth: 16 kHz.
   e. Circuit connections as shown.

Digital Port



10. **Circuit details of the Digital-to-Analog Port, SP:**
    a. Circuit SP is connected to the Digital-to-Analog-Converter (DAC) output of the User Processor.
    b. Factory default Hex file does not support the DAC output. Check your compiler for availability and use.
    c. SP is an Analog Output when configured by compiler. Drive is primarily limited by a 5 kilo-ohm internal processor resistance and by the 100 ohm series resistor. Output swing of the processor into an open load is 0.2v to 3.1v, typical.

VEX ROBOTICS DESIGN SYSTEM

11. 2-Wire Motor Port outputs:

a. Motor Port 1 and Motor Port 10.
b. Maximum motor stall current: 3.0 amps at 8.5 volts.
c. Motor chop rate: determined by the compiler. Default code chop rate: 1 kHz.
d. Overcurrent protection: Motor Port 1 through Motor Port 5 shares one 4 amp circuit breaker. Motor Port 6 through Motor Port 10 shares a second 4 amp circuit breaker.

12. 3-Wire Motor Port outputs:

a. Motor Ports 2 through 9.
b. Maximum motor stall current: internally limited by motor assembly.
c. Motor PWM output: determined by the compiler. Default is 1 to 2 milliseconds high time and a 17 millisecond period.
d. Overcurrent protection: Motor Port 1 through Motor Port 5 shares one 4 amp circuit breaker. Motor Port 6 through Motor Port 10 shares a second 4 amp circuit breaker.

13. UART Connections:

a. Ground, Power (+5v), RX data in, TX data out. Data rate, byte width, (transmit) stop bits, parity, etc. are determined by the compiler.
b. Default for LCD data: 19,200 baud, 8 data bits, 1 stop bit, no parity and no flow control.

14. I2C Connections:

a. Ground, Power (+5v), Clock, Data. Data rate, byte width, (transmit) stop bits, parity, etc. are determined by the compiler.
b. The factory default Hex file does not support I2C.

15. Notes:

a. Do not use a USB Hub with the Cortex or Joystick. Always make a connection directly to a PC USB port when needed. USB Hub performance is not supported.