CORTEX Microcontroller and Joystick User Guide

This is a User Guide for using the VEX CORTEX Microcontroller and VEX Joystick. Refer to the VEX Wiki (http://www.vexforum.com/wiki/index.php/VEX_Cortex_Microcontroller) for updates to this document.

1. CORTEX Microcontroller and VEXnet Joystick Initial Tether
   a. The Joystick must first be Tethered to the CORTEX Microcontroller before they will work with the VEXnet Keys. Tethering requires a USB Male A-A Cable and a VEX 7.2V Battery. This process must be completed each time you pair a Joystick or CORTEX with a new "mate". A CORTEX can only communicate with a Joystick that it has been tethered with or a Joystick with the same ID as a CORTEX. During a Tether/Pairing process, the ID from the CORTEX is transferred to the Joystick; thus "pairing" the 2 units together.

   b. Start with the CORTEX and Joystick turned OFF.
   c. Connect the CORTEX to the Joystick with a USB A-male to A-male Cable.
   d. Connect the 7.2V VEX Battery to the CORTEX.
   e. Power up only 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 min of 5 seconds.
      – Disregard the other LEDs as you are only interested in the VEXnet light.
      – Tethering may take up to one minute to complete.

   g. When Tethering has completed, turn OFF the CORTEX.
   h. Disconnect the USB A-A Male Cable from both units.

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

a. Attach 7.2v battery power 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. Now add the VEXnet 802.11g key as shown.

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

e. A valid Link is as shown. The VEXnet light will be blinking a fast Green on both units. The VEXnet light is the only LED that determines a valid Link. It will take about 10 to 15 seconds for a Link to be established. Other LED Indicators that will be ON are the Robot and Joystick lights which will be Green on both units when using fully charged batteries. These lights will change to Yellow and then Red as the batteries become weaker.

f. If the units fail to "Link Up", turn them both Off and back On. If they still fail to Link Up, tethering may be required. Refer to the section 1 for tethering instructions.

3. Basic Configuration

A few examples of the Default Code that is pre-programmed into 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 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 CORTEX location Digital 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.

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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)	

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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

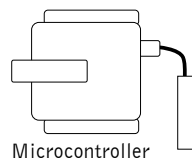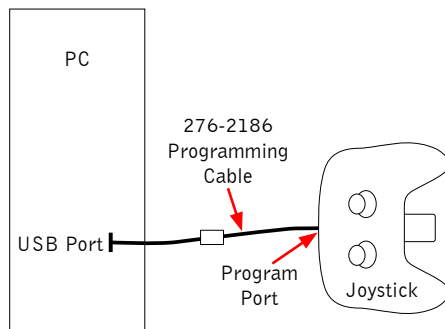| Motor 1	LEFT DRIVE	Joystick Up = Motor CW
Motor 2	LEFT DRIVE	Joystick Up = Motor CW
Motor 3	LEFT DRIVE	Joystick Up = Motor CW
Motor 4	RIGHT DRIVE	Joystick Up = Motor CCW
Motor 5	RIGHT DRIVE	Joystick Up = Motor CCW
Motor 10	RIGHT DRIVE	Joystick Up = Motor CCW

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. Shown is the interconnect sketch for wireless reprogramming. For non-wireless reprogramming, the VEXnet keys may be substituted with a USB A-male to A-male cable.

5. Diagnostics Information: refer to the following chart for Joystick and CORTEX light 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

Robot, VEXnet, and Game LED's
show the same data [2]

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6. Joystick Calibration: With the CORTEX linked to the Joystick using VEXnet keys, push and hold Joystick 6U Button. With the button depressed, push and hold the Config Switch. You can release both when the Joystick LED begins to flash Red and then Green. Now move both joysticks to the maximum position in all directions. When both joysticks have been detected, the Joystick LED goes Green. Now push any of the four "8" Buttons to save the cal. The Joystick LED will flash Green for a few seconds to indicate a good saved cal; otherwise the calibration was not successful. If you take too long to complete the calibration, it will time-out and will not be successful.
   Refer to the VEX Wiki (http://www.vexforum.com/wiki/index.php/VEXnet_Joystick).

7. Tethering: If the units fail to link up, tethering may be required. Please see item 1 of this document for instructions on how to tether your VEXnet Joystick to the CORTEX Microcontroller.

8. Debugging:
   a. Slow blinking green Robot light on CORTEX.
      Solution: Try VEXnet Upgrade Utility.
   b. Yellow or Red Robot light on the CORTEX. Solution: used fully charged Robot battery.
   c. Yellow or Red Robot light on the Joystick, even though the CORTEX is green. Solution: Joystick latches CORTEX's lowest battery level. Power cycle both Joystick and CORTEX.
   d. Fast Red blinking Robot light when plugged in to a competition field. Solution: Use a fully charged 9v back-up battery plugged in to the CORTEX.
   e. Robot does not shut off when turned OFF. Solution: At the end of the match, remove the Ethernet cable from the Competition Port of the Joystick. The CORTEX and Joystick will change to non-competition mode. Power off the Joystick and CORTEX. The CORTEX will shut off in about 5 seconds.
   f. Robot does not do what you want it to do. Solution: Download the default code and test to isolate hardware problems. Then make small program changes testing after each change.
   g. Robot still does not link up, even after tethering. Solution: Debug using a friends system to narrow down the problem, check the VEX Forum or contact VEX Robotics for assistance.
   h. Downloading Master Code to the Joystick will erase User Calibration and restore the Joystick to Factory Calibration. Please see item 6 of this document for instructions on how to recalibrate your Joystick.

9. 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
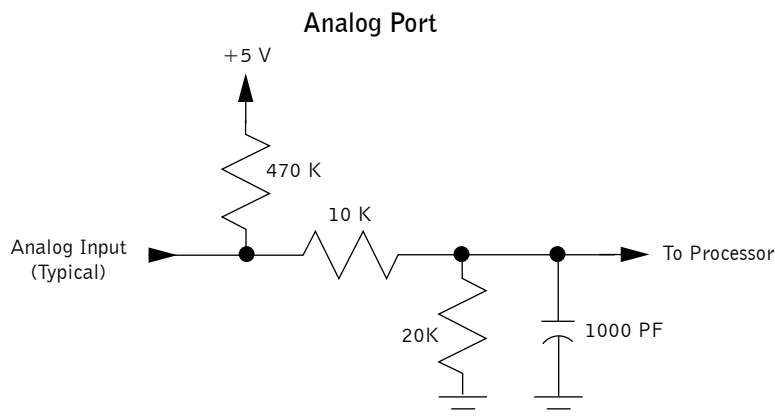
10. Digital Information: When configured as an input, digital lines have a weak pull-up. When configured as an output, digital lines drive 0 volts for a low and 3.3 volts for a high. Circuit details are as follows:
    a. Digital input range is 0 to +5 volts.
    b. Digital drive is primarily limited 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.
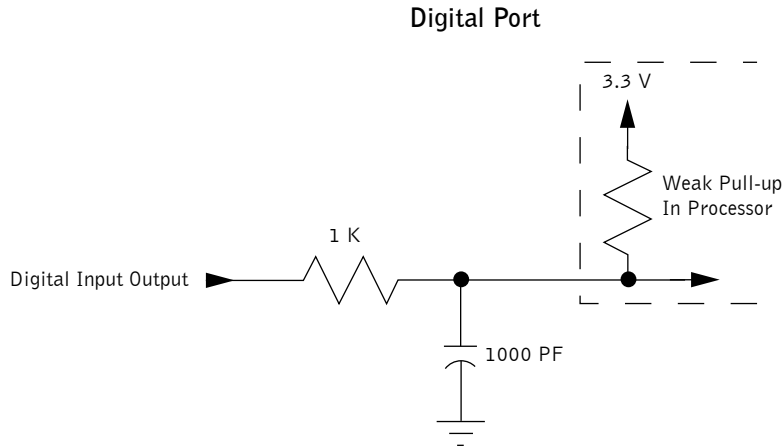
Digital Port

11. 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.

12. 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.

13. 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.

14. 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.

15. 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.

16. 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.