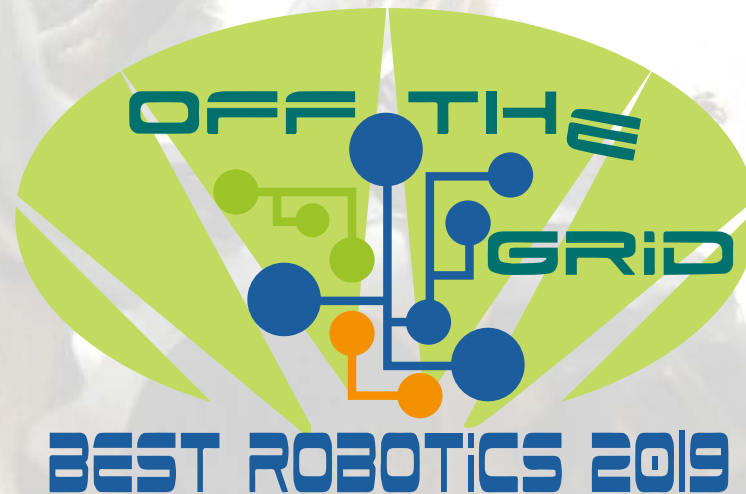


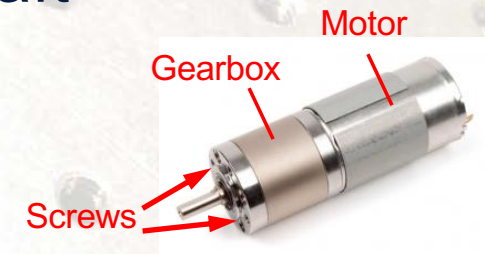


BEST Control System

BEST Robotic, Inc.



- ◆ New Cortex firmware
- ◆ VEXnet Key 2.0
 - White in color (**black** ones are **obsolete**)
 - VEXnet Key 2.0 keys and new firmware NOT COMPATIBLE with old keys and old firmware. **Can't mix and match!**
- ◆ Small motor has better gearbox, larger shaft
 - Small drive pulley now 1/4" instead of 3/16"
 - Again, **can't mix and match** with older kits
 - BE SURE GEARBOX SCREWS ARE TIGHT
- ◆ No 9-volt battery back-up battery connector





BEST™

~~Return Kit~~

Servos



Joystick

AAA Battery
Charger



WiFi key

USB/Tether

Serial

Analog

Digital
i/o

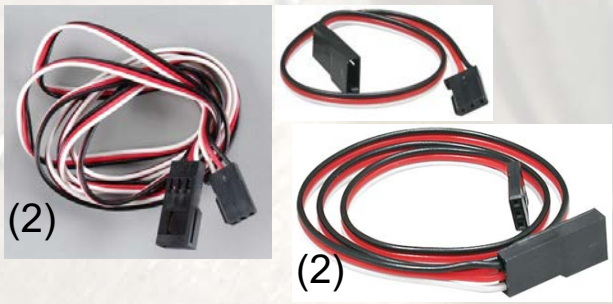
motors/
servos



Controller

battery

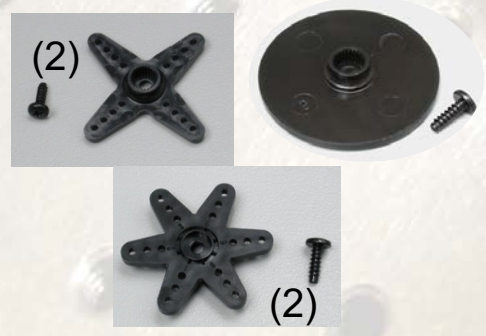
Servo Extensions



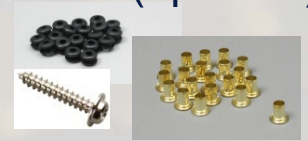
Servo Power Adaptor



Servo Horns



Servo Mounting
H/W (optional)



USB A-A cable



(16)



BEST™

~~Return Kit~~

Drive components

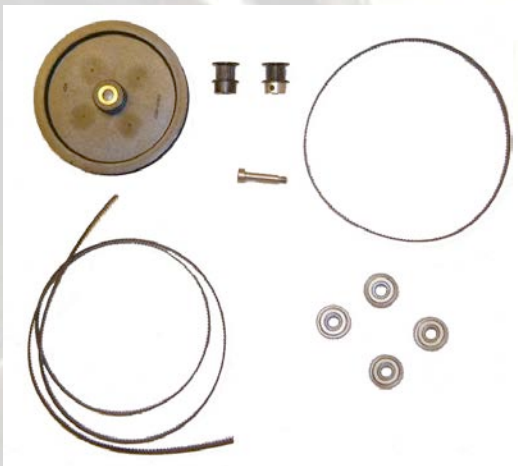


(2)

Motors



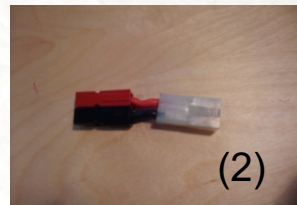
(2)



7.2V Battery charger



Battery adapter



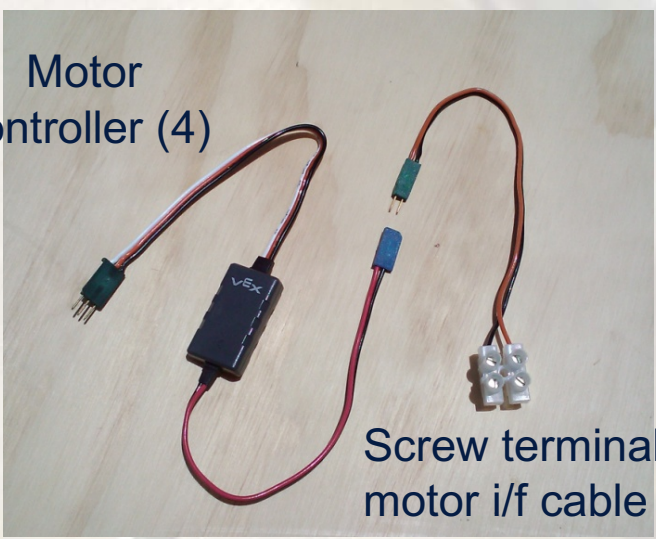
(2)

7.2V Battery



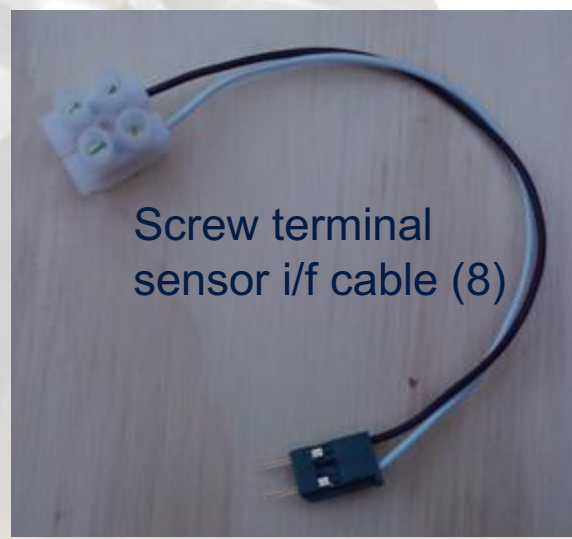
(2)

Motor controller (4)



Screw terminal motor i/f cable (4)

Screw terminal sensor i/f cable (8)



VEXnet Control System



- VEX Cortex microcontroller
- Dual ARM Cortex CPUs
- Programmable
- WiFi communications



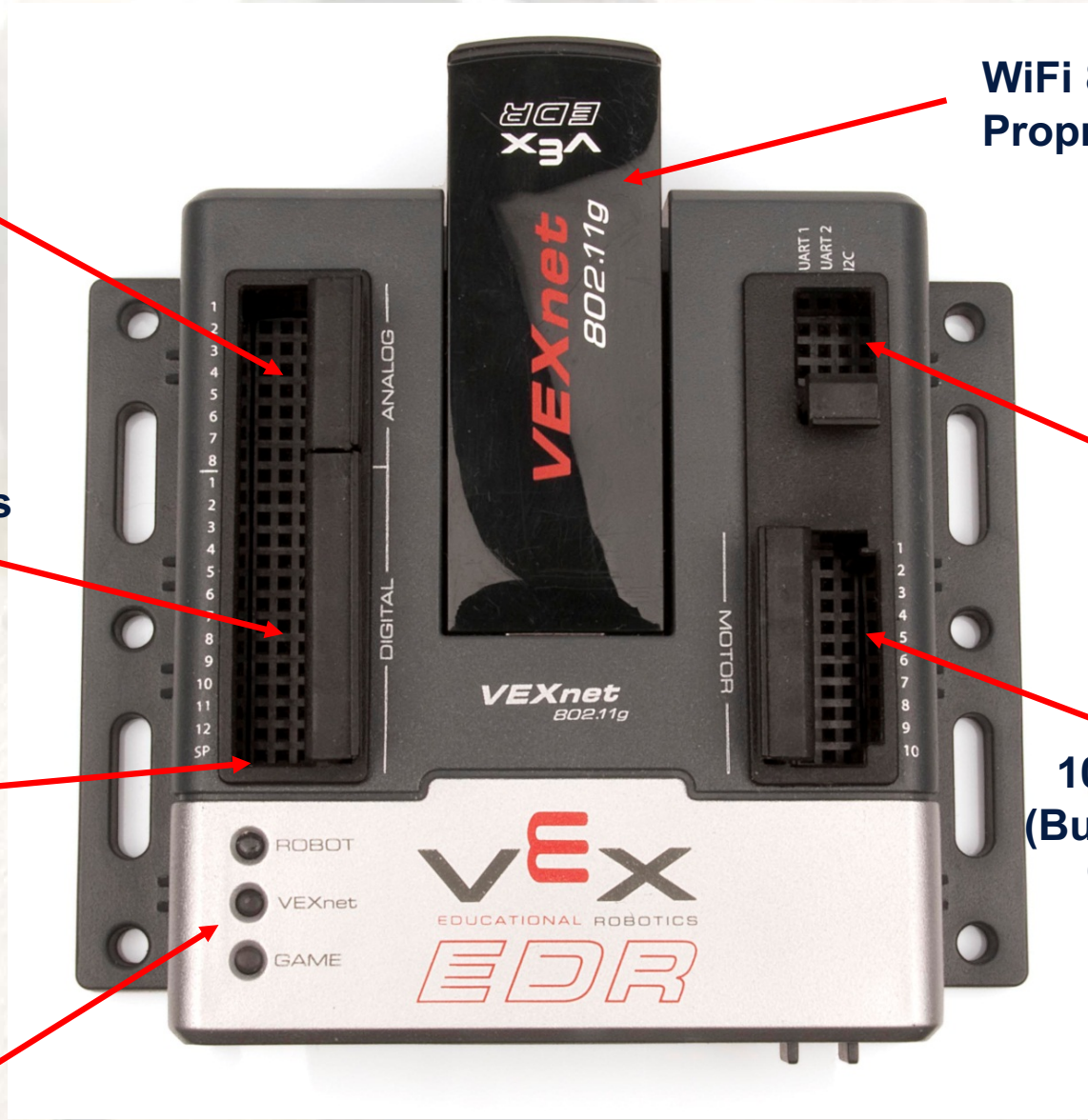
- Gaming style controller
- Joysticks, buttons, accelerometers



Remove screw to access batteries



VEXnet Cortex M3 Controller



8 Analog inputs

12 Digital inputs or outputs

Speaker Output

System Status Indicators

WiFi 802.11g
Proprietary Comm.

Standard Serial Interfaces
(UART, I2C)

10 Motor/Servo Ports
(Built-In ESC on 2 ports)
(Electronic Speed Control)



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VEXnet Joystick

◆ “Playstation” game-style controller



8 buttons on top

2 XY analog joysticks

Power switch

6 AAA
rechargeable
batteries

Plug-in USB/ WiFi Key

4 buttons on front-side

Programming Interface

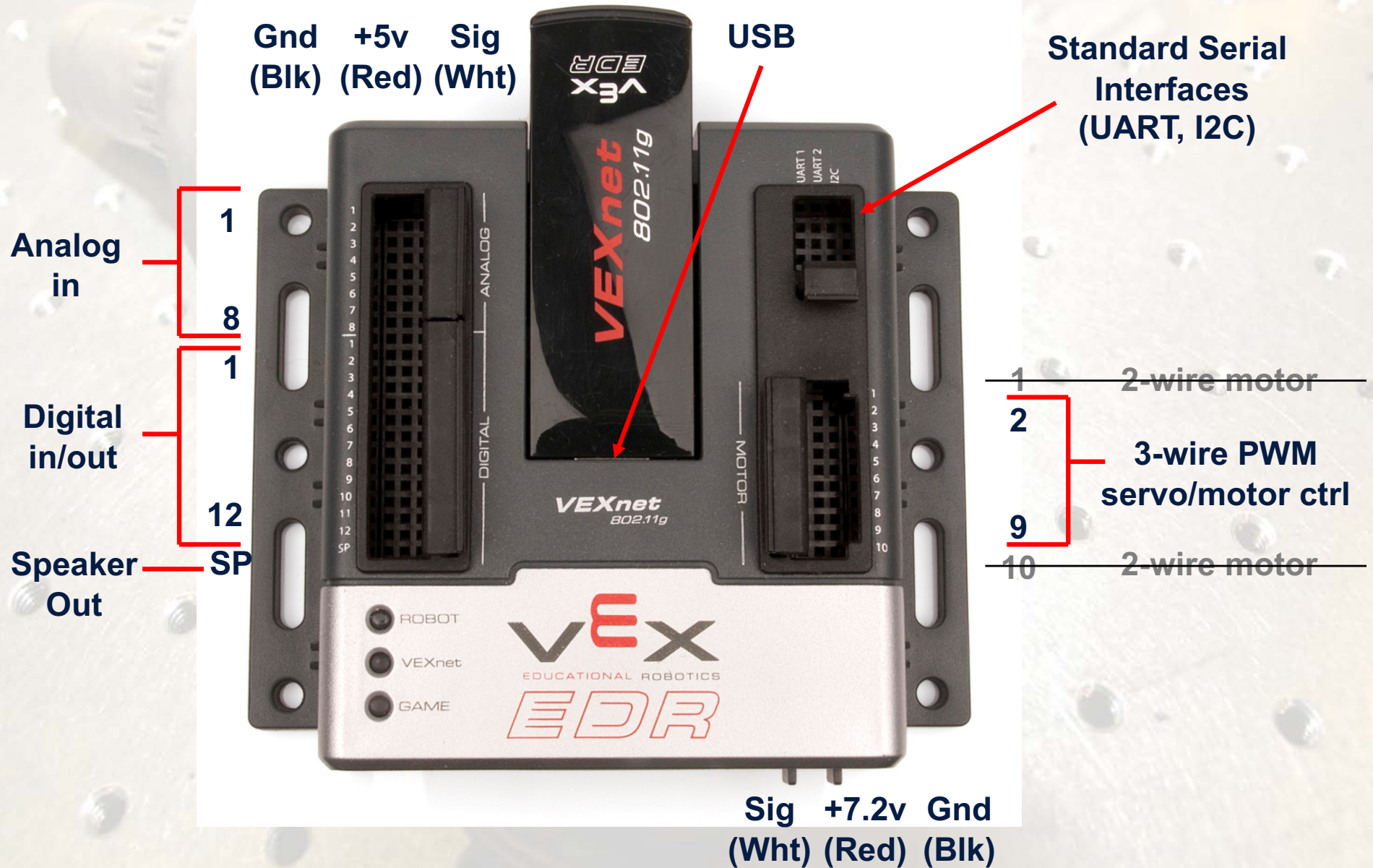


2 Axis Accelerometer
(X Tilt and Y Tilt)

System Features

- ◆ Wireless communication using 802.11g
- ◆ Two 2-wire proportional motor control outputs (**not used by BEST**)
- ◆ Eight 3-wire PWM servo/motor outputs
- ◆ 12 discrete digital inputs/outputs + 1 speaker
- ◆ Wireless or direct USB port for program download
- ◆ Onboard power switch
- ◆ Built-in resettable fuse for overcurrent situations
- ◆ Powered by a single 7.2 volt RC hobby battery
- ◆ 9-volt backup battery for WiFi

VEX Cortex Connectors



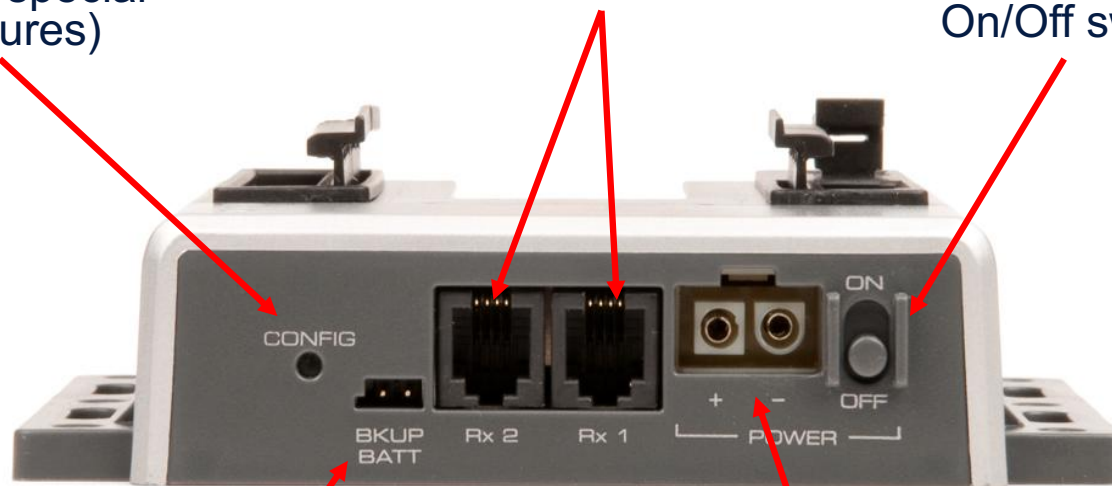
VEX Cortex Connectors



configuration switch
(used for special
procedures)

75MHz crystal interface
ports (**not used by BEST**)

On/Off switch



backup battery port for
WiFi communications
(9V)

main battery port (7.2V)

VEX Cortex Pinouts

- Ground
- + 5V
- Signal/Control
- + Battery Power

- + Battery Power
(for + control input)
- + Battery Power
(for – control input)

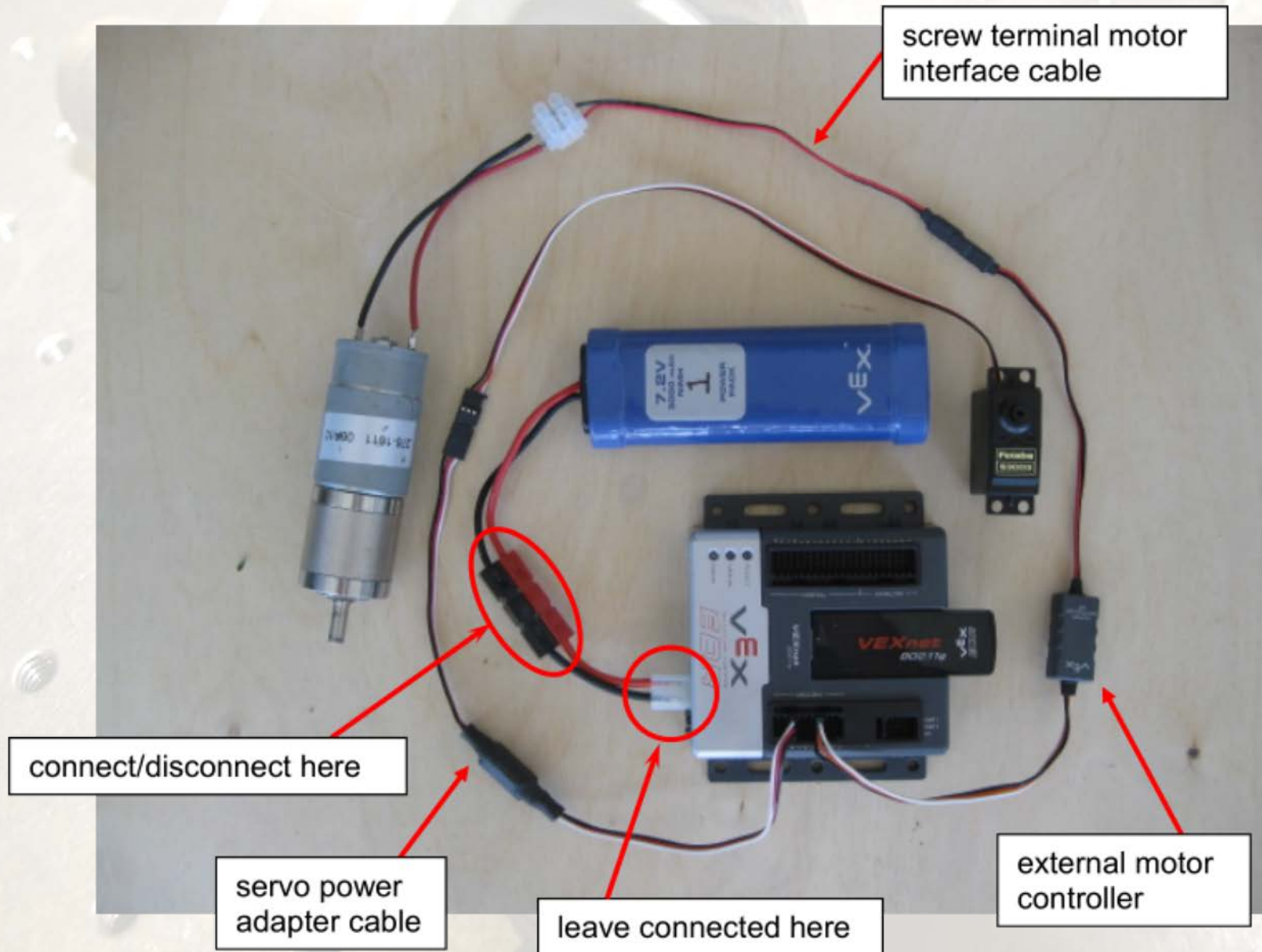


DC Motors



- ◆ Use of **internal motor controllers** (motor ports 1 and 10) is **not allowed**
- ◆ External motor controller(s)
 - ◆ connect via 3-wire external motor controller plus the 2-wire screw terminal cable
 - ◆ use motor ports **2 thru 9 only**

Example Hookup



DC Motors



- ◆ Servo/motor ports are divided into **two banks**
 - Bank1 = Ports 1-5 (2-5 for BEST)
 - Bank2 = Ports 6-10 (6-9 for BEST)
- ◆ Each bank can support a max of 4 Amps of current
 - BEST large motor stall current can reach 3.5 Amps.
- ◆ For power reasons, spread your motors so that
 - no more than 2 motors are plugged into ports 2-5, and
 - no more than 2 motors are plugged into ports 6-9.
- ◆ You risk **overcurrent/shutdown** of the processor
- ◆ Sheet metal shield around the large motors IS needed and **should not be removed**



DC Motors

- ◆ Solder wires to motor terminals or with the optional quick-disconnect (spade) terminals
- ◆ Polarity is **NOT** marked on motors: positive(+), negative(-)
- ◆ Wiring (and programming) will determine clockwise or counter clockwise rotation for positive stick movement



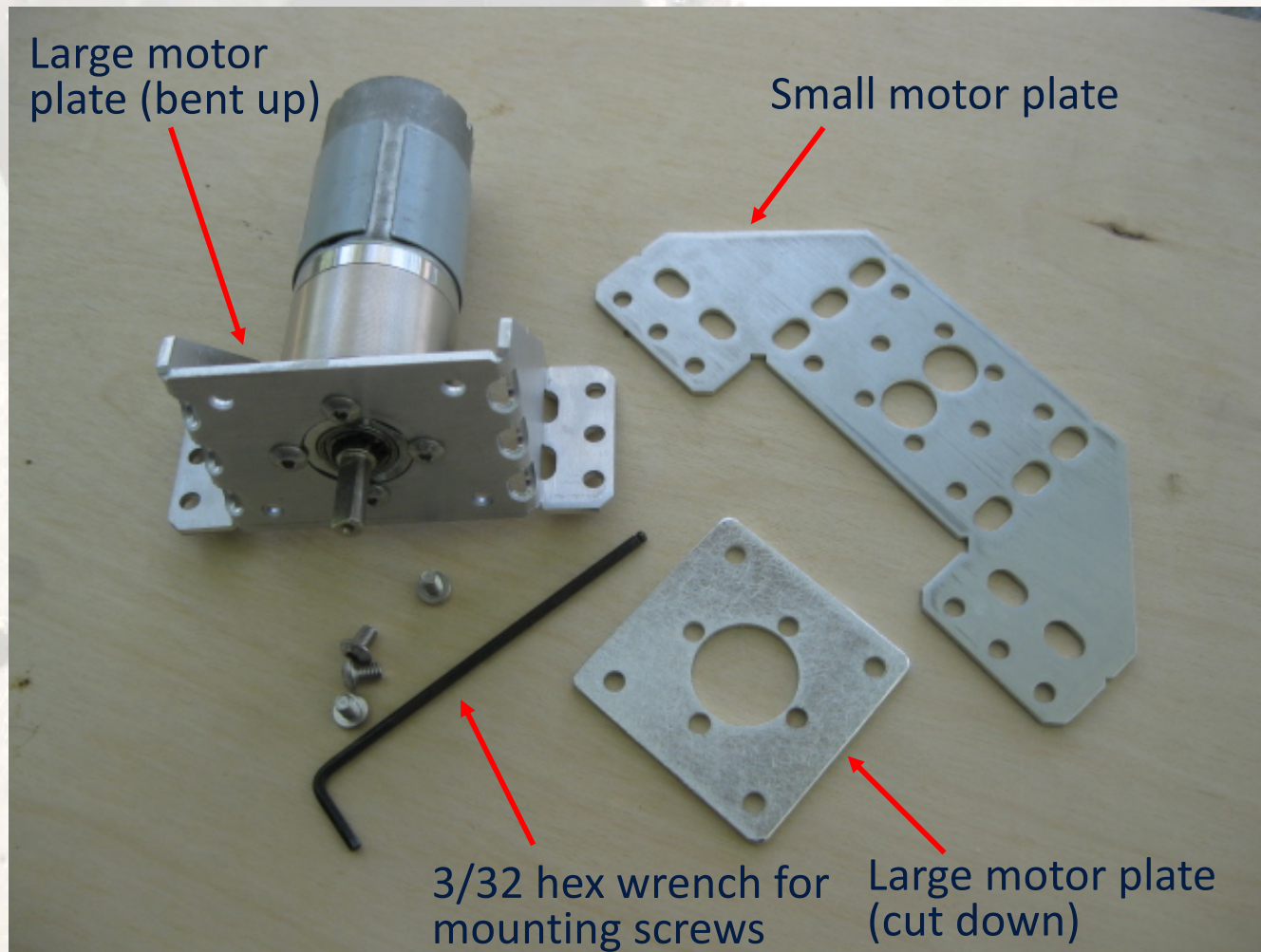
For Music City BEST, wires are pre-soldered and include bullet connectors



BEST™

DC Motors

- ◆ Motors can be mounted with VEX Motor Mounting Kit provided in the consumables kit





BEST™

3-Wire Motor Connection

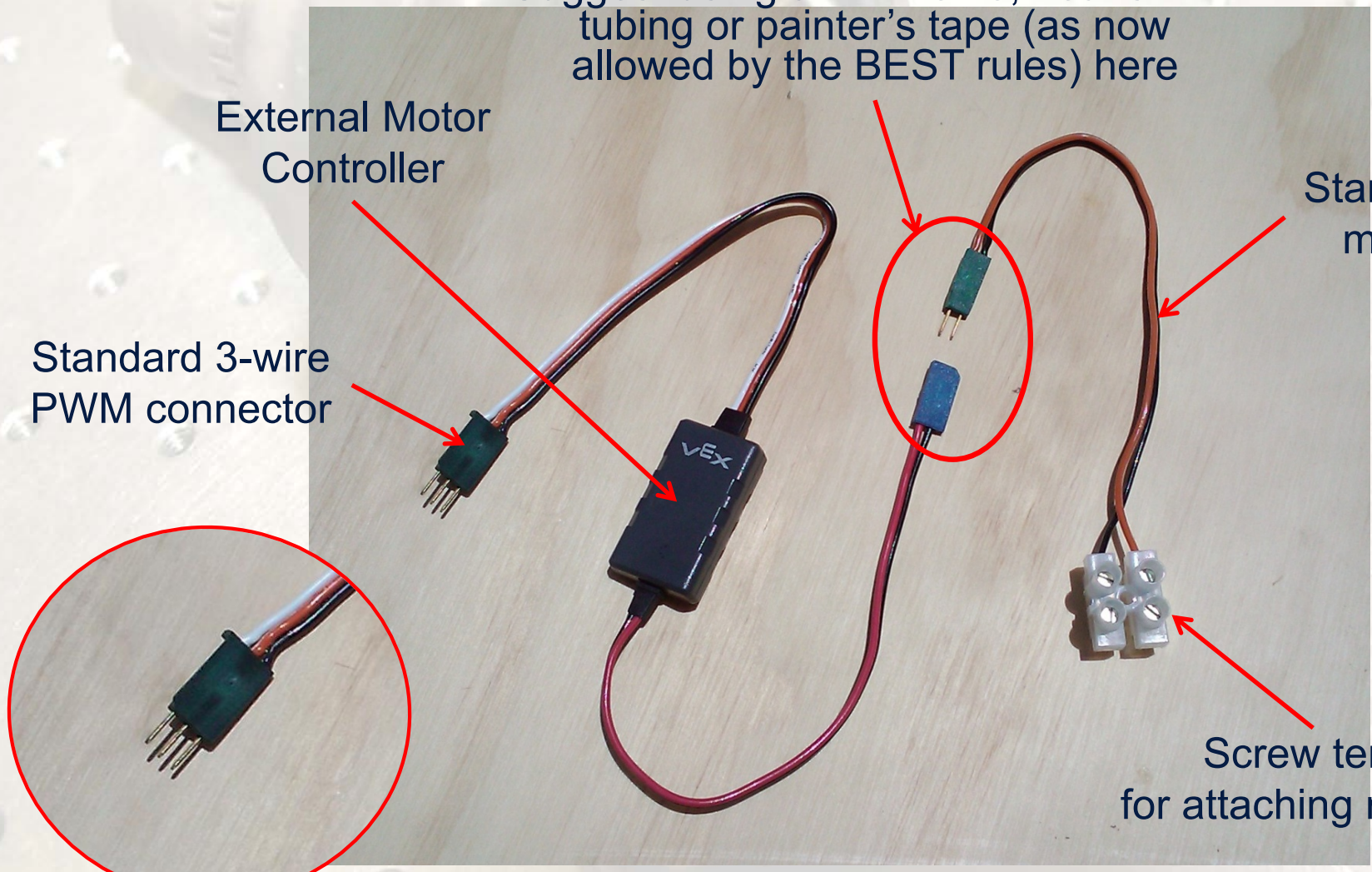
Suggest using a 4" wire tie, heat shrink tubing or painter's tape (as now allowed by the BEST rules) here

External Motor Controller

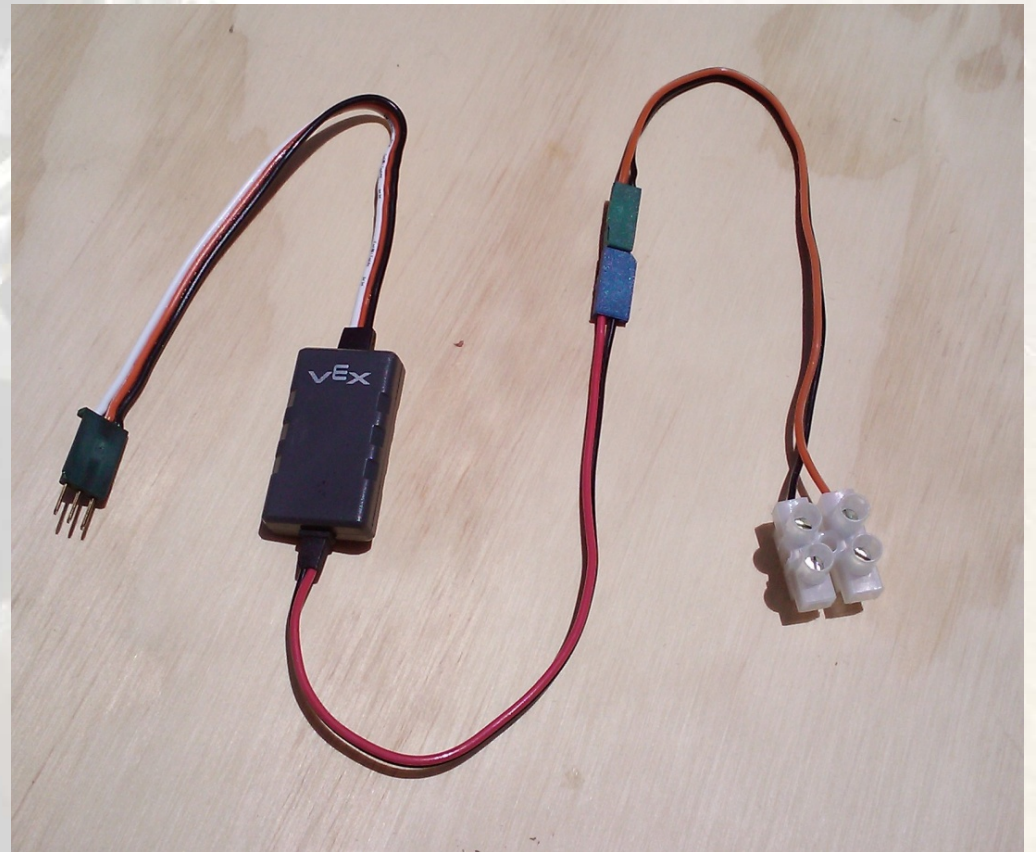
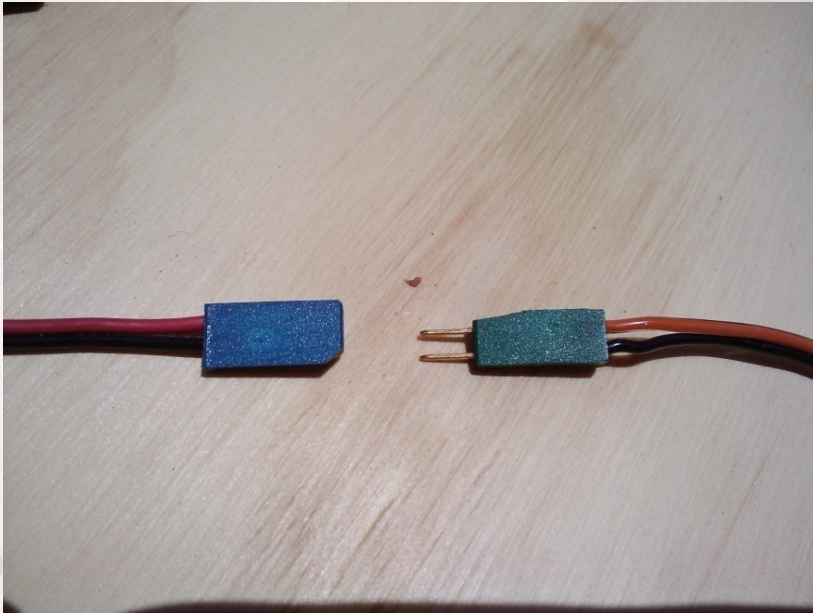
Standard 2-wire motor cable

Standard 3-wire PWM connector

Screw terminals for attaching motor leads



3-Wire Motor Connection



- ◆ Connectors are not keyed
- ◆ Connect red to red, black to black or reverse to change the motor response

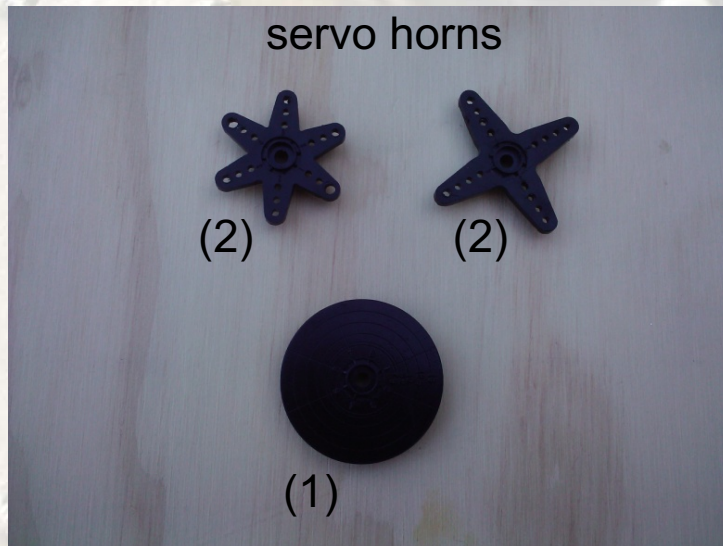


BEST™

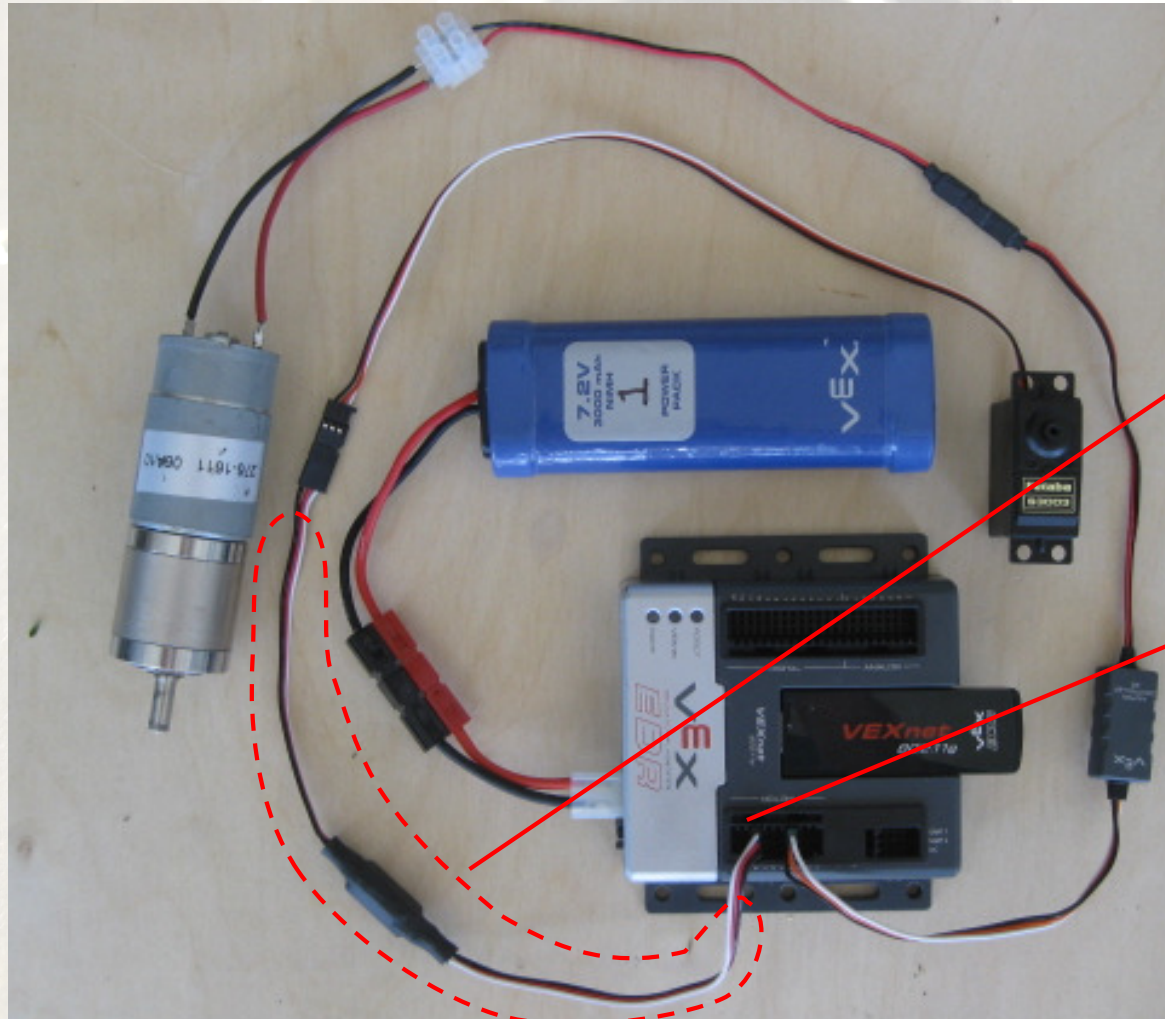
Servo Power Adaptors

Servos

- ◆ Futaba S3003 or S3004 series
- ◆ Maximum 120 degree rotation (+60, -60)
- ◆ Connection to Cortex controller
 - ◆ via 3-wire PWM + Servo Power Adaptor
 - ◆ use motor ports 2 thru 9 only
- ◆ Servo horns may be modified

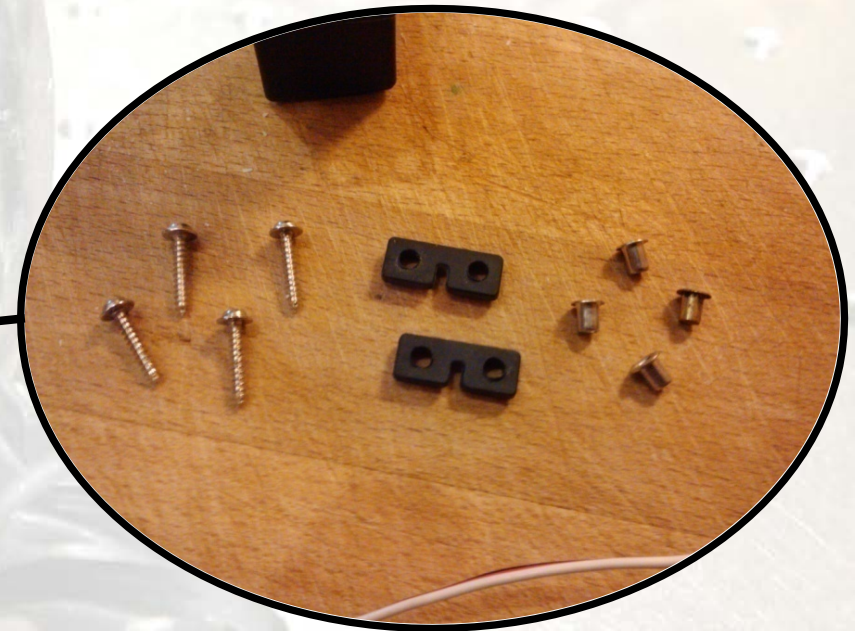
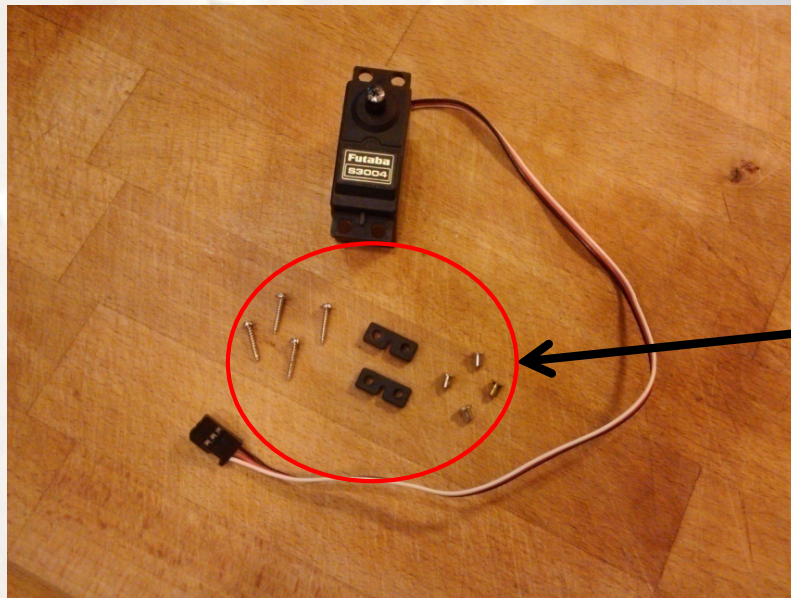


Connecting a Servo



- ◆ Connect a servo (or servo extension cable) to the **Servo Power Adaptor cable**
- ◆ Insert a Servo Power Adaptor cable into a **motor port** (2 through 9)

Servo Mounting with Optional Hardware



- ◆ Futaba 3003/3004 Servos
 - ◆ 4 per Kit
 - ◆ Mounting Hardware for each
 - ◆ To eliminate damage to mounting holes

- ◆ Servo Mounting Hardware
 - ◆ Rubber grommet (2)
 - ◆ Brass spacer (4)
 - ◆ Mounting screw (4)

Note: There are 16 of each screw, spacer, grommet in the Return Kit for BEST Hubs that provide servo mounting hardware.

Servo Mounting with Optional Hardware

1. No h/w attached



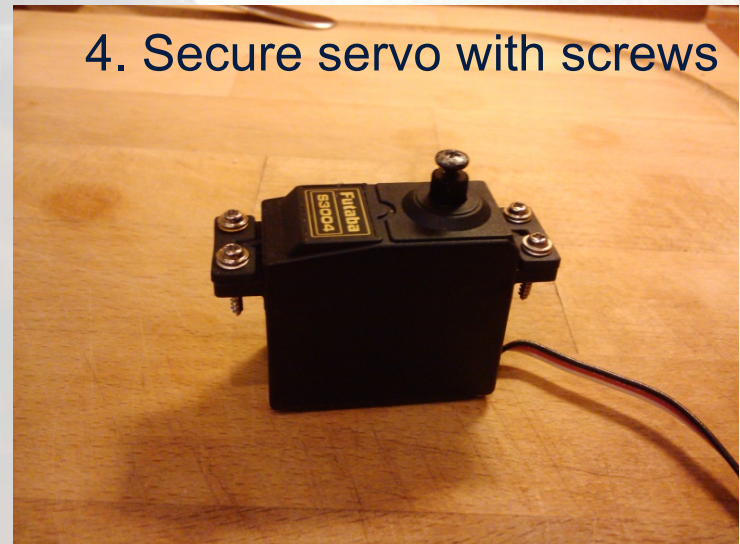
2. Attach rubber grommets



3. Insert brass spacers



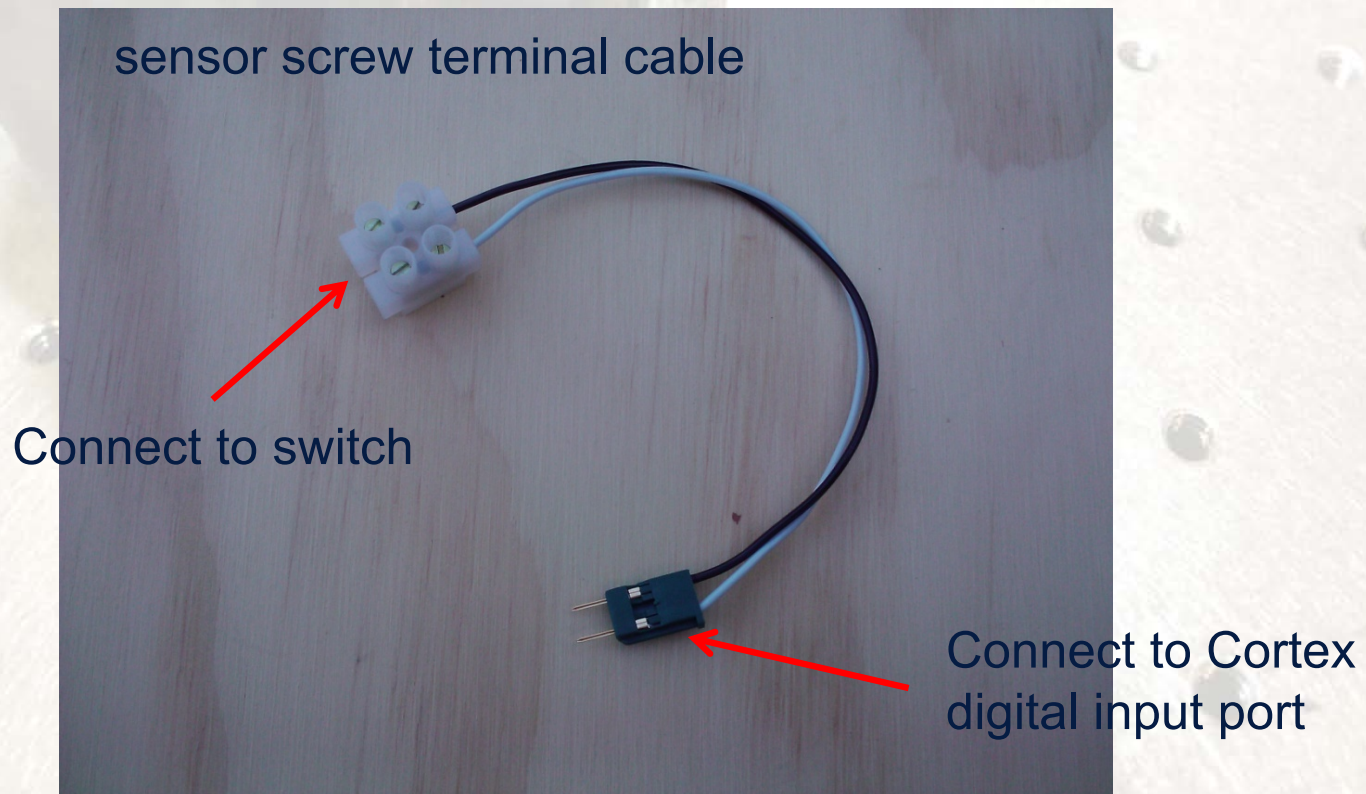
4. Secure servo with screws





Digital Input Connections

- ◆ Use for limit switches, microswitches
- ◆ Connect to Cortex digital inputs using 2-wire sensor screw terminal cables (white/black wires)

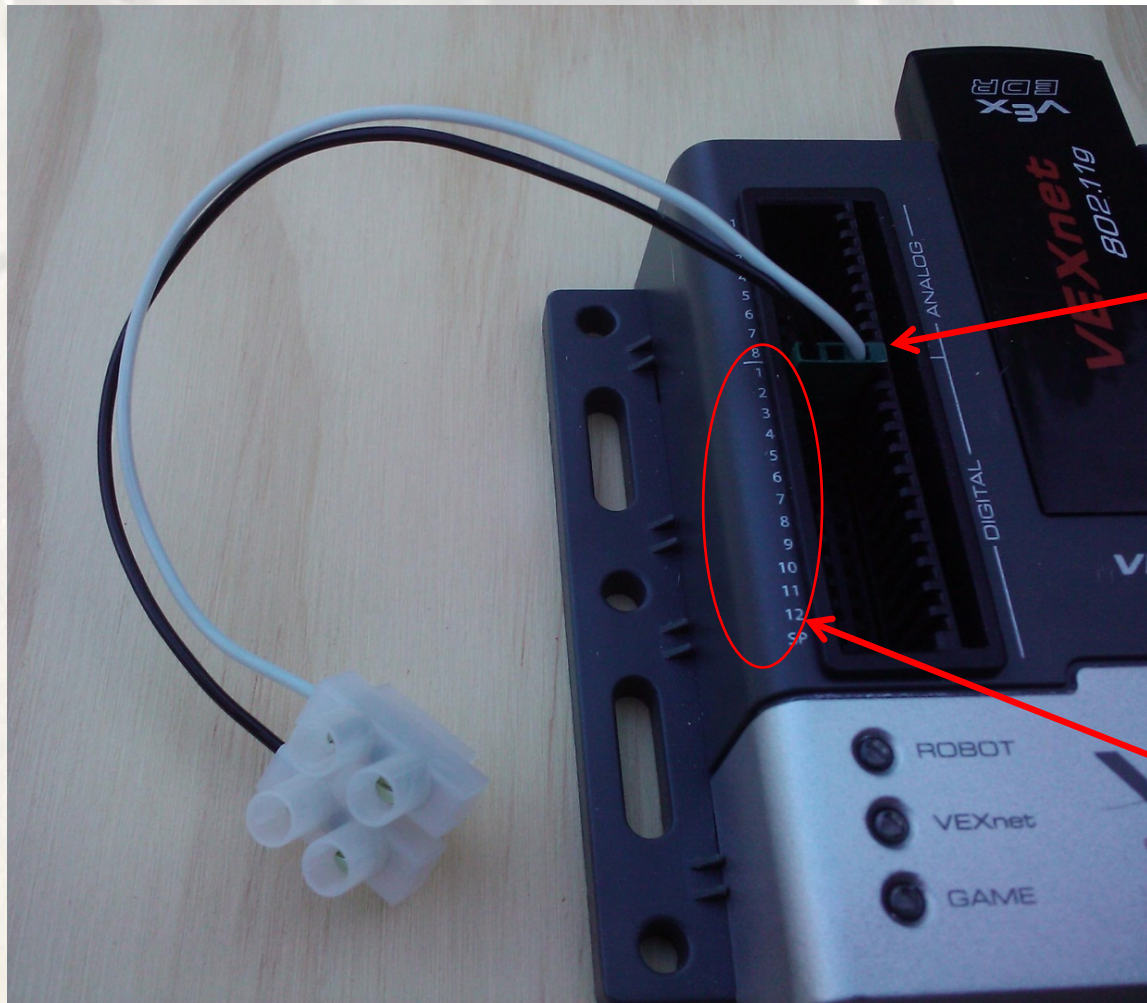




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Digital Input Connections

- ◆ must program digital port for proper direction (input)
- ◆ open = reads as '1' ; closed = reads as '0'

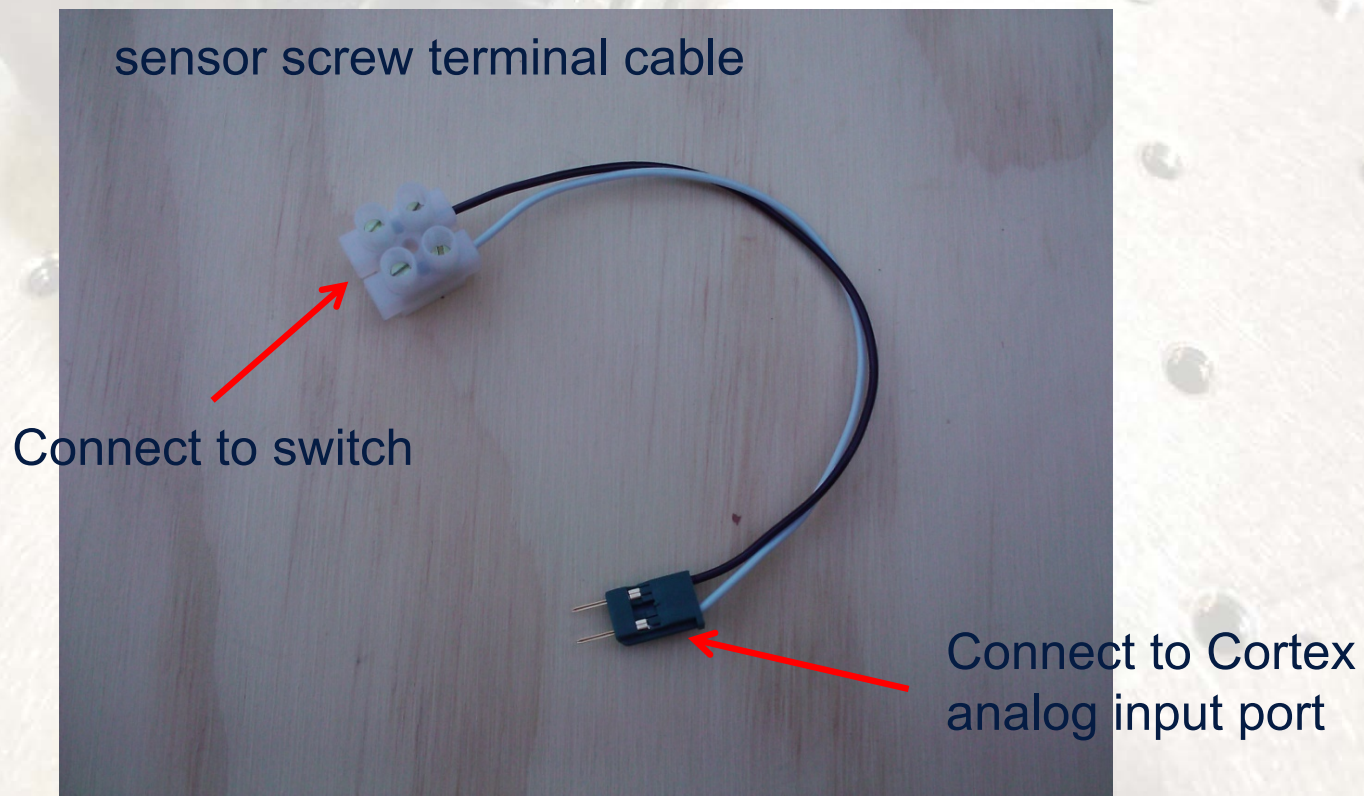


sensor cable
connector is **keyed**

use digital ports
1 thru 12

Analog Input Connections

- ◆ Use for potentiometers
- ◆ Connect to Cortex digital inputs using three of the 2-wire sensor screw terminal cables (white/black wires)
- ◆ Sensor cables must be plugged into the Cortex “sideways”

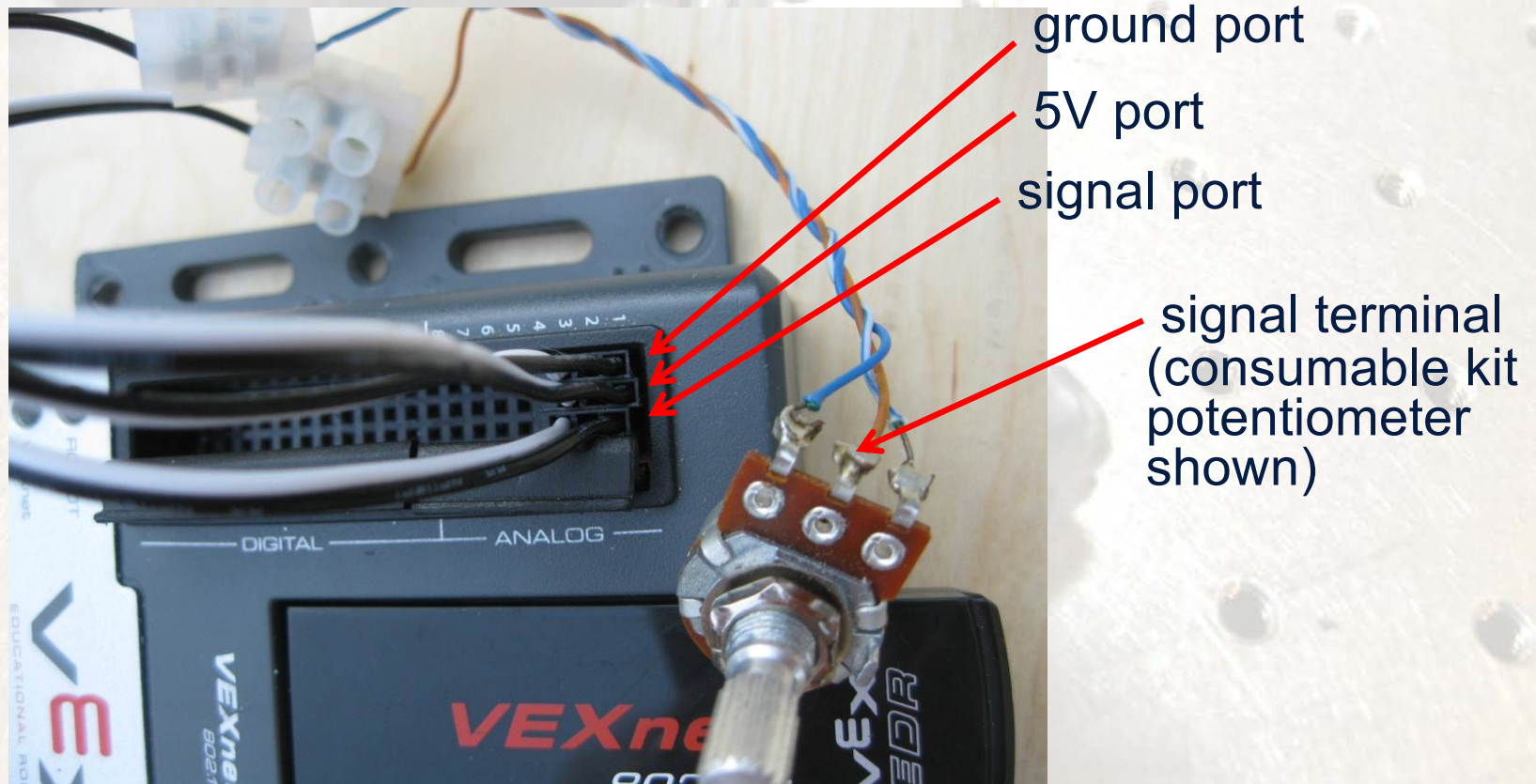




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Analog Input Connections

- ◆ signal terminal of the potentiometer must be connected to the analog input signal port
- ◆ program will read a value of about zero with 0V applied (grounded) at the signal port and the maximum value (program dependent) when 5V is applied at the signal port



Re-Syncing (Pairing) VEXnet



If VEXnet does not connect, you may need to re-sync the joystick/controller pair by simply connecting a USB cable and powering on both units.



Out of the Box Configuration

- ◆ Allows a team to hook up the Cortex and have it work without having to program it.
- ◆ Referred to as the “BEST default” program.
- ◆ This is **NOT the only configuration** for the Cortex!
- ◆ Good for initial checkout, but we want teams to load a unique configuration.



BEST Default Program



Motor/Servo Port	Joystick Channel	Motor Limits	
		Positive Direction	Negative Direction
Motor 2 (pair opposite of Motor 9)	Stick 3	None	None
Motor 3	Stick 4	None	None
Motor 4 (pair opposite of Motor 7)	Button 7 and 8 Up/Down/Left/Right	None	None
Motor 5	Stick 1	Digital Input 1	Digital Input 2
Motor 6	Stick 2	Analog Input 1	Analog Input 1
Motor 7 (pair opposite of Motor 4)	Button 7 and 8 Up/Down/Left/Right	None	None
Motor 8	Button 6 Up	None	None
Motor 9 (pair opposite of Motor 2)	Stick 3	None	None

Three BEST Programming Options



- **easyCv6:** <http://www.intelitekdownloads.com/easyCV6>
 - A block programming environment (drag-and-drop elements)
 - Use link above, then select “*Download easyCV6 Version 6.0.3.0*”
 - Install the SW, select “*Run as Administrator*” and enter license key (the hub will provide your team with a valid key, good for 150 days)
- **RobotC:** <https://www.vexrobotics.com/robotc-vexedr-vexiq.html>
 - Textual programming in C, with single-step debugging (great!)
 - Use link above to create an account and log in
 - Go to <https://www.vexrobotics.com/downloadable/customer/products/> and select “*ROBOTC for Vex Robotics 4.x download*” (license doesn’t expire)
- **MathWorks Simulink:** <http://www.mathworks.com/academia/best-robotics/>
 - ◆ A graphical programming/modeling environment with simulation capability (visualize what your program will do before you download it to the Cortex)
 - ◆ Simulink training video available on Auburn BEST website, too

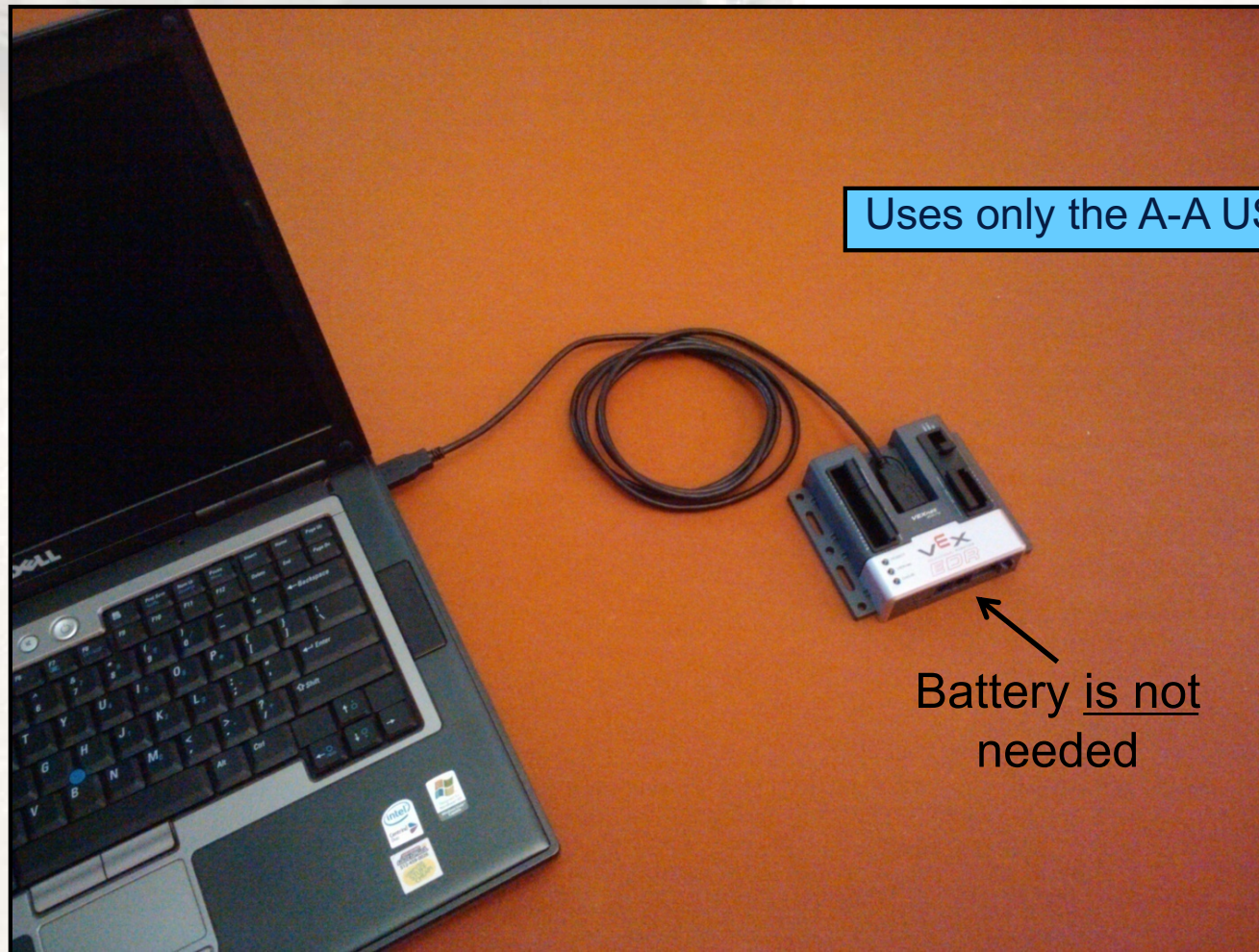
BEST Programming Options



- ◆ Three different programming environments available
 - easyCv6 <http://www.intelitekdownloads.com/easyCV6>
 - RobotC <http://www.robotc.net/download/cortex>
 - MathWorks Simulink <https://www.mathworks.com/academia/student-competitions/best-robotics.html>
(Simulink training video available on Auburn BEST website, too)
- ◆ **easyC** is a block programming environment (drag and drop programming elements)
- ◆ **RobotC** programs in C with a text editor, but it has runtime debugging (can step through program line by line and see what the results are)
- ◆ **Simulink** is graphical programming/modeling environment with simulation capability (see what your program will do before you download it to the Cortex)

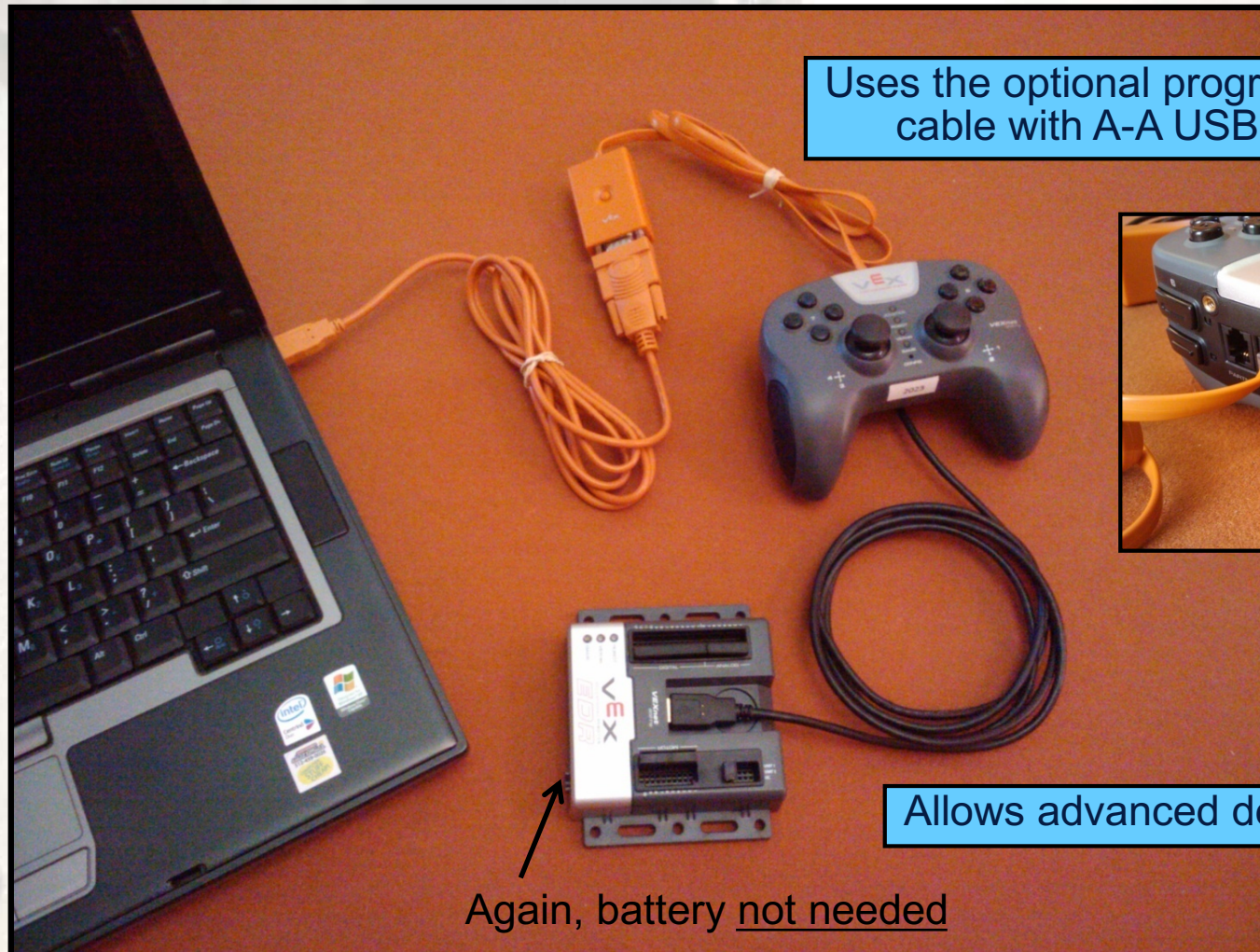
Downloading a Program

Option 1: Direct USB Download



Downloading a Program

Option 2: Tethered Download



Uses the optional programming cable with A-A USB tether.

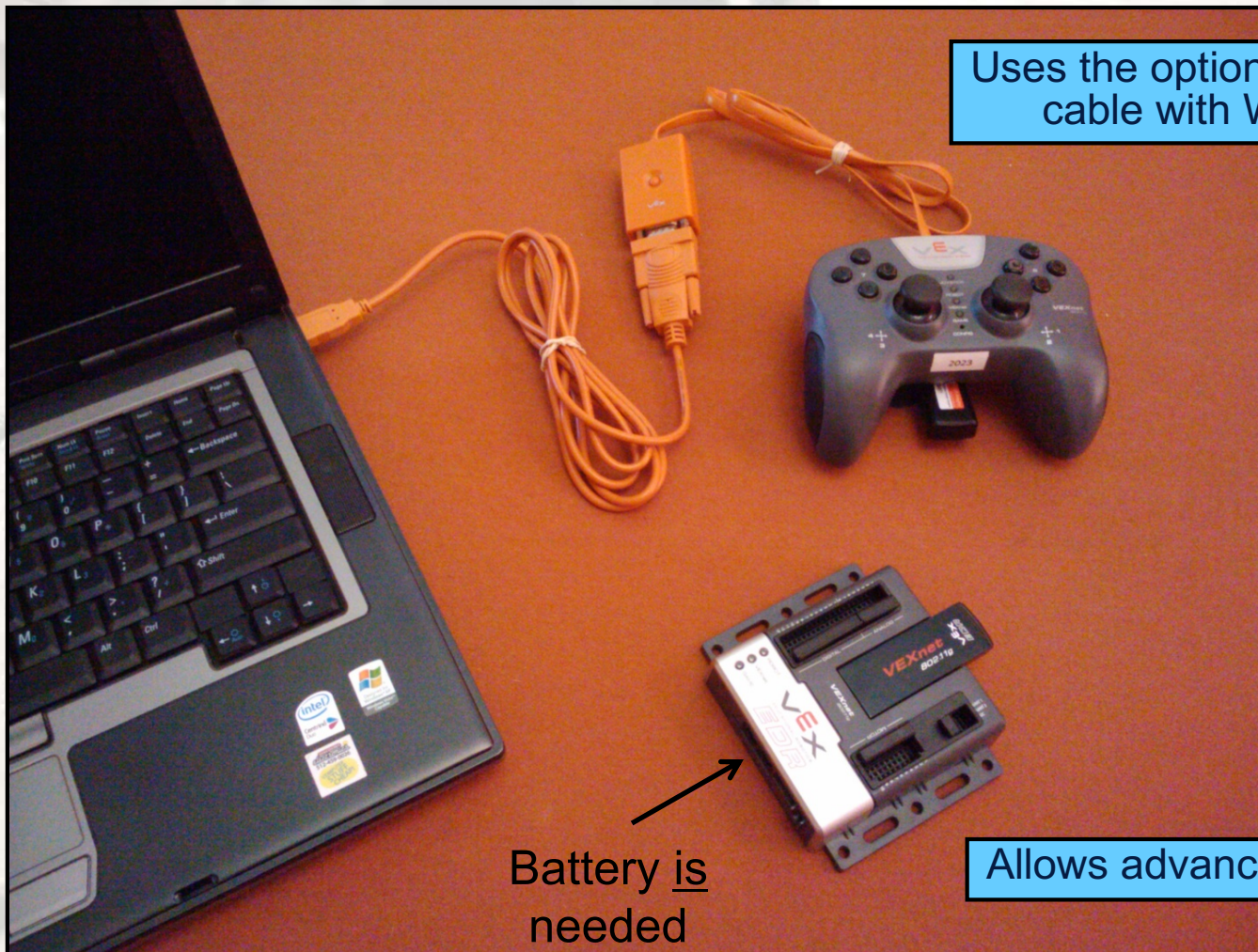


Allows advanced debugging.

Again, battery not needed

Downloading a Program

Option 3: Wireless Download



Uses the optional programming cable with WiFi USB Keys.

Allows advanced debugging.

Battery is
needed

Testing Tips

- ◆ Ensure your robot is 'safe' to operate:
 - Can't move or fall off table (use a jack-stand)
 - All team members clear of moving parts
- ◆ Connect either WiFi keys or tether cable between the joystick and the Cortex controller.
- ◆ Make sure Cortex switch is in OFF position.
- ◆ Attach a charged battery.
- ◆ Turn on joystick (if not using tether).
- ◆ Turn Cortex switch to on position.
- ◆ For WiFi comm, link should establish in ~10 sec
- ◆ Test robot operations with transmitter.

LED Status Lights



joystick battery status

robot battery status

comm. link status

Game status
(not used by
BEST)

- Green battery – good charge
- Yellow battery - dying
- Red battery – dead

- Green VEXnet – comm. established
- Yellow VEXnet – searching
- Lights on the controller and the joystick are the same

Team Tips



- ◆ Tin motor wires with solder before attaching to screw terminals since frayed stranded wires can cause a short or use the optional quick-disconnect (spade) terminals.
- ◆ Do NOT solder wires to Cortex connectors!
- ◆ Sensor cables, servo power adapter cables and external motor controllers are all keyed in correct orientation; insert and remove carefully to avoid destroying connectors.
- ◆ Tighten screws on motor and sensor connector cables so that wires are not loose and do not pull out.
- ◆ Mount Cortex to robot using #8 screws through holes provided; be careful not to over tighten.
- ◆ Avoid “hot insertion” of USB Keys.
- ◆ You may operate tethered by removing the USB WiFi key and connecting a USB A-A cable between joystick and Cortex.

Joystick Calibration



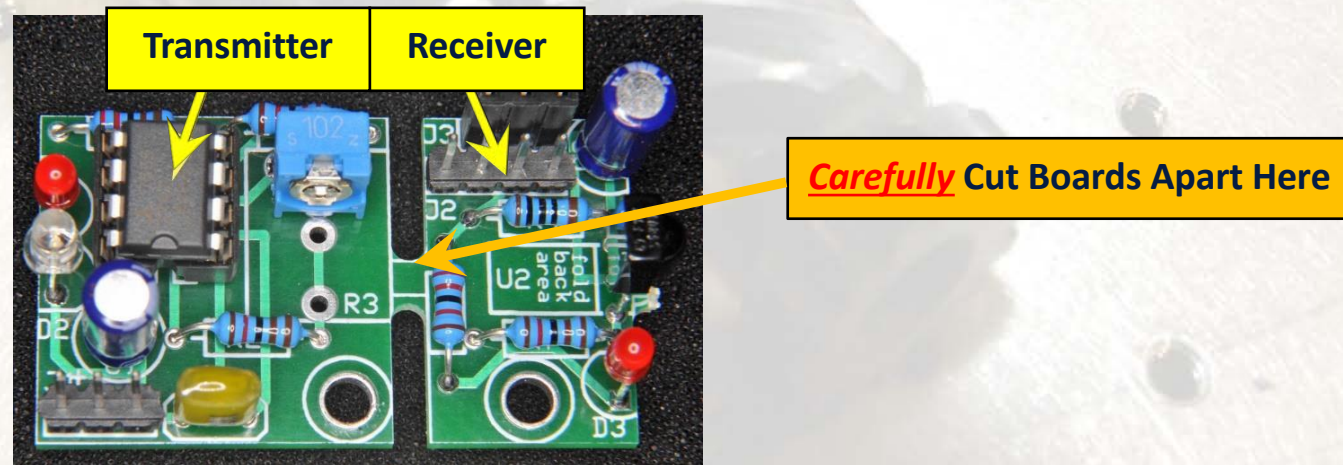
- ◆ If the motors hum or creep (sticks not returning to zero), the joystick may need to be recalibrated
- ◆ Calibration procedure (as extracted from the easyC help file)
 - 1) The Joystick must be "Linked" to the Cortex Microcontroller using the VEXnet Keys.
 - 2) Hold the "6U" Back Switch depressed.
 - 3) 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.
 - 4) Hold both Switches depressed until you see the Joystick LED Flash RED and GREEN - you can now release both Switches.
 - a. There is a 10 second time limit to complete the following steps 5 and 6.
 - 5) Now move both Joystick Pots to the maximum position desired in all 4 directions - Up, Back, Left, and Right.
 - a. If a movement is not detected in all 4 directions, a timeout will occur after about 10 seconds and the Cal Mode will be discontinued and the VEXnet LED will briefly Flash Red.
 - b. The Joystick LED will continue to Flash RED and GREEN during the calibration process.
 - 6) After movement is detected in all 4 directions, the Joystick LED will be ON and Solid GREEN.
 - a. To "Save" the Calibration, depress and release the "8U" Top Switch Button.
 - b. If the calibration is accepted and Saved, the Joystick LED will start Flashing Fast GREEN for a few seconds.
 - c. If the Calibration is not Saved, a timeout will occur after about 10 seconds and the Cal Mode will be discontinued and the VEXnet LED will briefly Flash Red.
 - d. To cancel a calibration, depress and release the "7U" Top Switch Button. The Cal Mode will be discontinued and the VEXnet LED will briefly Flash Red.
 - e. If the Cal Mode is discontinued or saved, the Joystick LEDs will resume their normal function after the VEXnet LED briefly Flashes.



BEST™

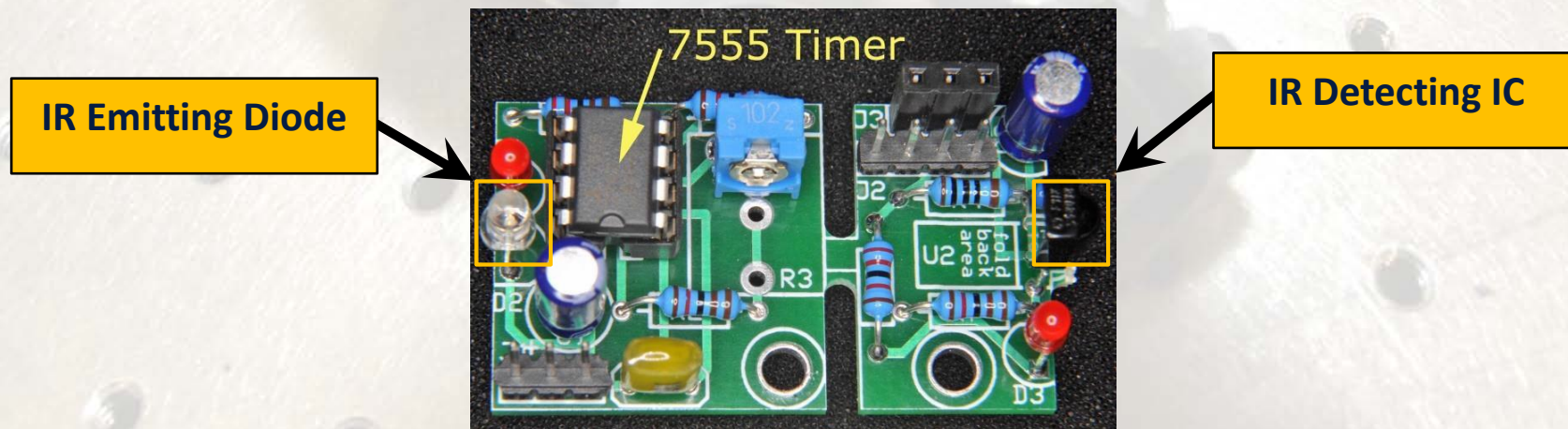
Using the IR Sensor w/ the Cortex

- ◆ Detects objects between transmitter and receiver
- ◆ Instruction sheet will show you how to:
 - Conduct simple sensitivity tests (including calibration)
 - Attach the BEST IR Sensor System to the Cortex Brain
- ◆ Full instruction sheet is part of your **documentation**



Using the IR Sensor w/ the Cortex

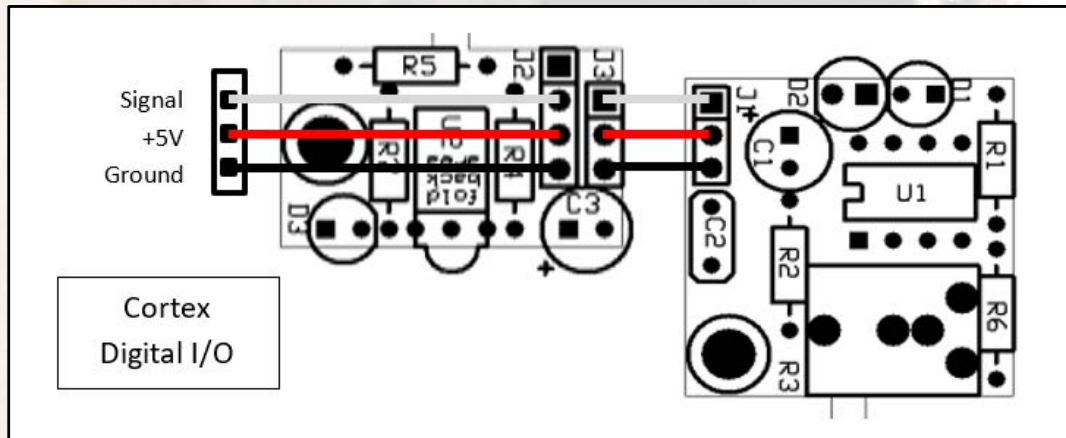
- ◆ Operates using **infrared light**
 - You can't see it but the detecting IC can!
 - On-board **RED LEDs** indicate transmission/reception
 - See “**Adjust the System's Sensitivity**” section to calibrate
- ◆ Careful when inserting or removing ICs
 - Leads are easily bent, **and even more easily broken!!**
- ◆ Use large holes for mounting (#4 screw size)





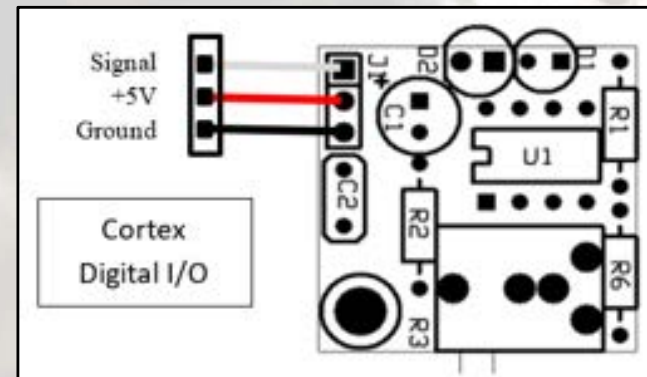
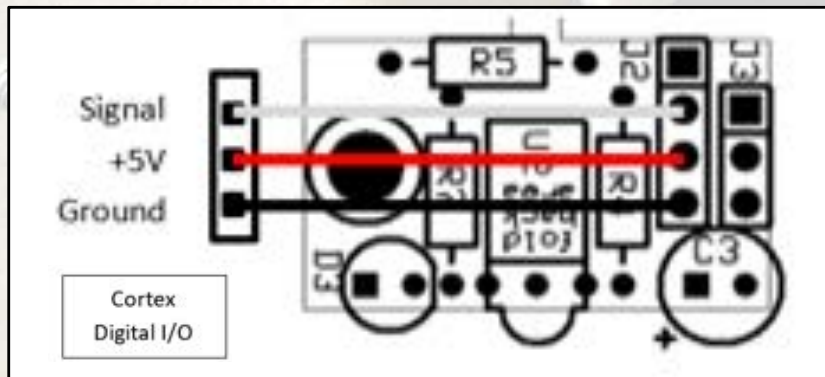
Using the IR Sensor w/ the Cortex

- ◆ Two options for attaching to Cortex
- ◆ Option 1: Daisy chain to a **single Cortex Digital I/O Port**



Emitter is always on. Read I/O port to **determine if beam is blocked or not.** ("High" means beam is blocked, and "Low" means beam is not blocked.)

- ◆ Option 2: Use two separate Cortex Digital I/O Ports



Emitter can be controlled, so can be used to send **messages** (in Binary of course!)

Where to find help?

- ◆ Music City Best game wiki (<https://cps-vo.org/group/MCBEST/wiki>)
 - Lots of relevant info! (will be live by kick-off day)
- ◆ Online resources/documentation (BRI Site)
 - https://www.bestrobotics.org/site/b_resources1.php
- ◆ BEST Public Message Board (<http://forums.bestinc.org>)
 - Must register for login account
 - Share ideas, resolve issues, ...
- ◆ Official Q&A “Control System” Category
 - <http://game.bestrobotics.org/qna/>
 - Use “Official Q&A” page during contest for “rules specific” questions
 - e.g. *“Is this legal?”*
- ◆ VEX Forum
 - <https://www.vexforum.com/>
 - Technical questions about VEX equipment
 - easyC and RobotC dedicated forums included here