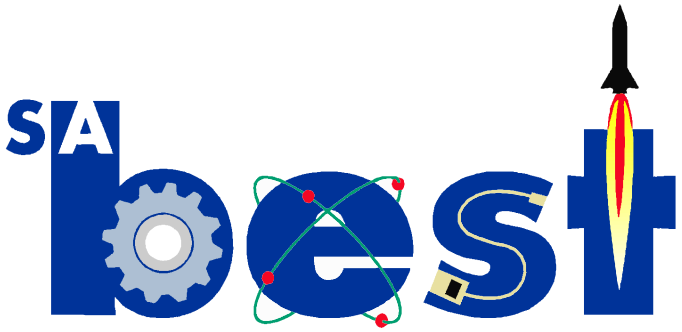


Care and Feeding of Your SA BEST Kit Parts

6 September 2025

www.sabest.org

What we will cover

- SA BEST Kit Hardware
- Basic control system wiring
- How NOT to destroy the parts we re-use each year
- (preloaded) BEST default code description

NOTE: *there is NO software or programming instruction in this presentation.*

What is in the Kit?

- **Return Kit (RK)**
  (parts we need back to use again next year)
  - Robot control system
  - Batteries & chargers
  - Cool drive components & sensors
- **Consumables Kit (CK)**
  (parts you can use up or otherwise destroy at your option)
  - Plywood, plastic sheet, metal sheet, PVC pipe & fittings
  - Hardwood, metal bar/rods, allthread
  - Metal brackets, screws, nuts, zip-ties, Velcro, glue, tape
  - Bicycle inner tube, string, rubber bands

Kit List in the Game Rules document is final authority on what you can use.

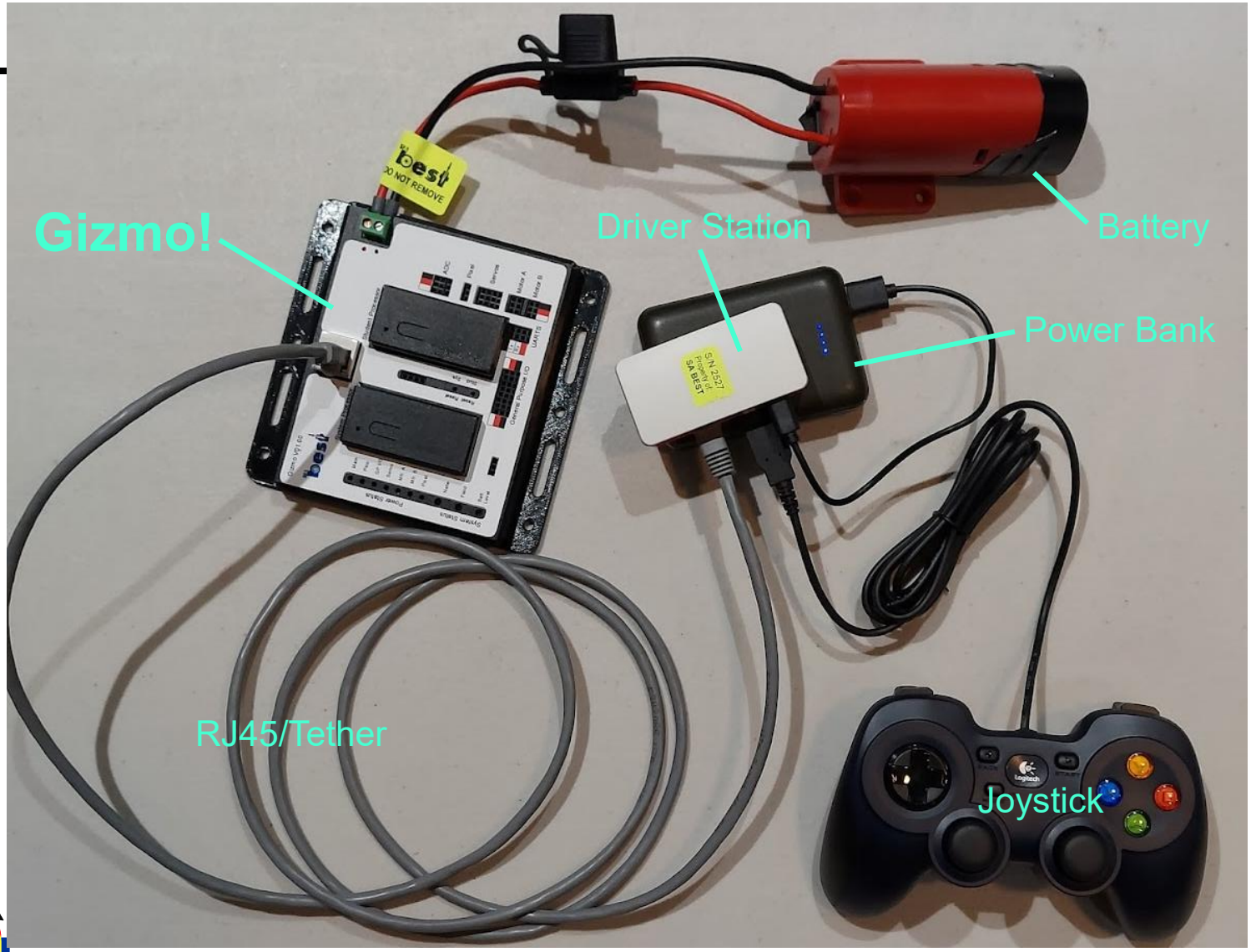
…and more!

Don’t Forget these CK parts!

- **Approved Optional Items (provided by team)**

Qty	Item Description
10 ea	wooden spring type clothes pins
3600 sq in	cardboard sheet, 1/4" maximum thickness (not preformed)
2 ea	empty food/beverage PETE container with screw on cap/lid (2 liter max.)
3 ea	wire coat hangers with or without plastic coating, 1/8" dia. max.
3 ea	solid core golf balls
1 ea	5 minute epoxy, 0.85 oz
3 ea	~10oz empty metal soup can with lid removed
24 lb	pennies (cannot be altered; bank wrappers allowed)
1 ea	8 oz. PVC primer
25 ea	deck or drywall screws; 2-1/2" maximum length
25 ea	wire management clips/ties/wraps (can only be used on wiring)
1 ea	Carpenters wood glue, 4 oz or 8 oz
4 ea	Team Custom Part

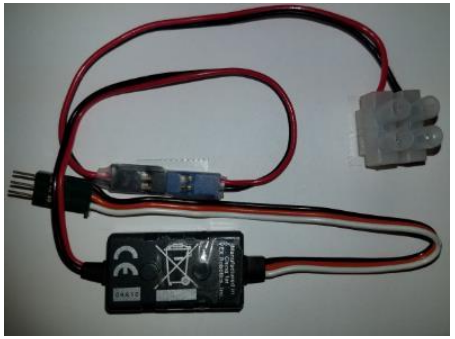
This is Your Gizmo Control System



Control System other parts

Motor (2 each size)

Motor Controller with
Motor Interface Cable (4)



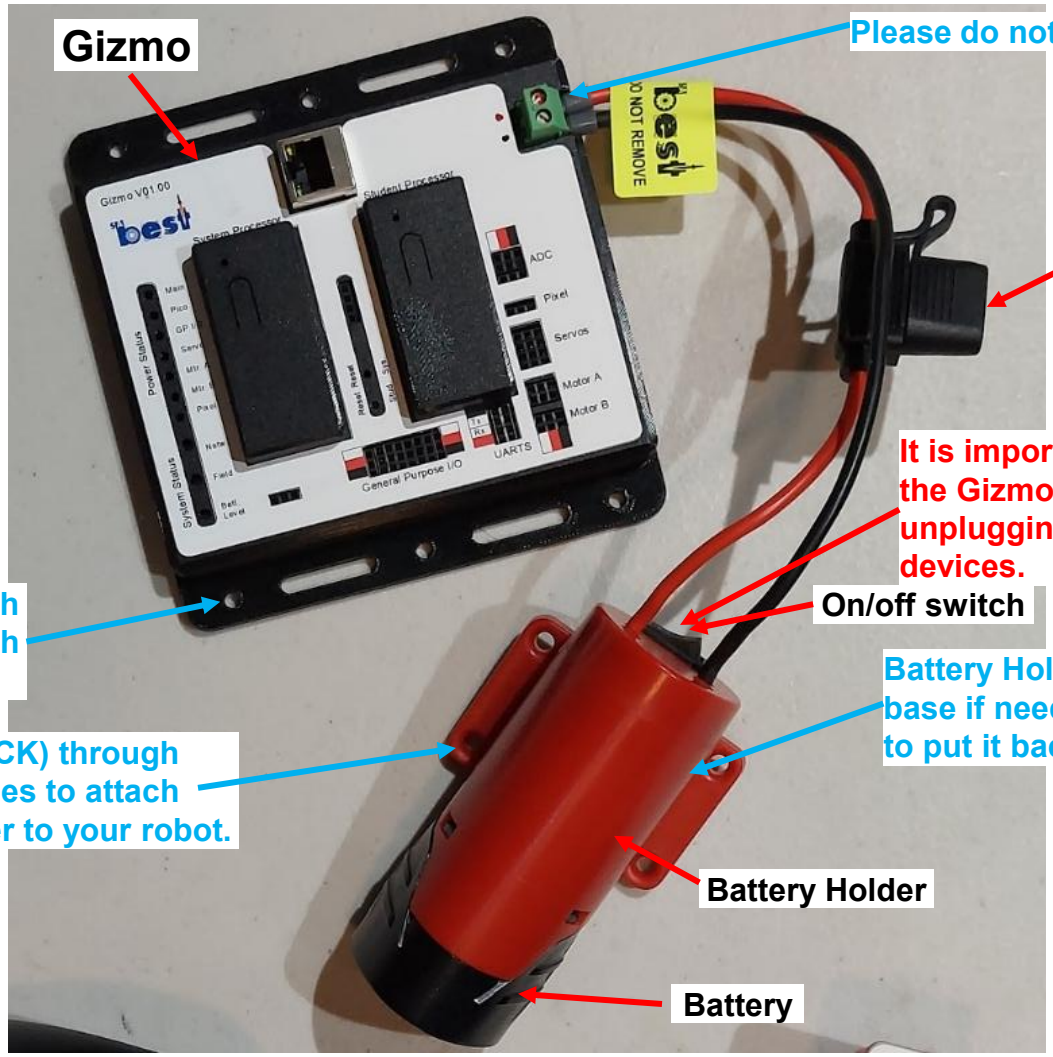
Sensor Input
(3 wire) Cable (4)

Servo (4) – we've added pins into the connector so it will plug into the Gizmo!

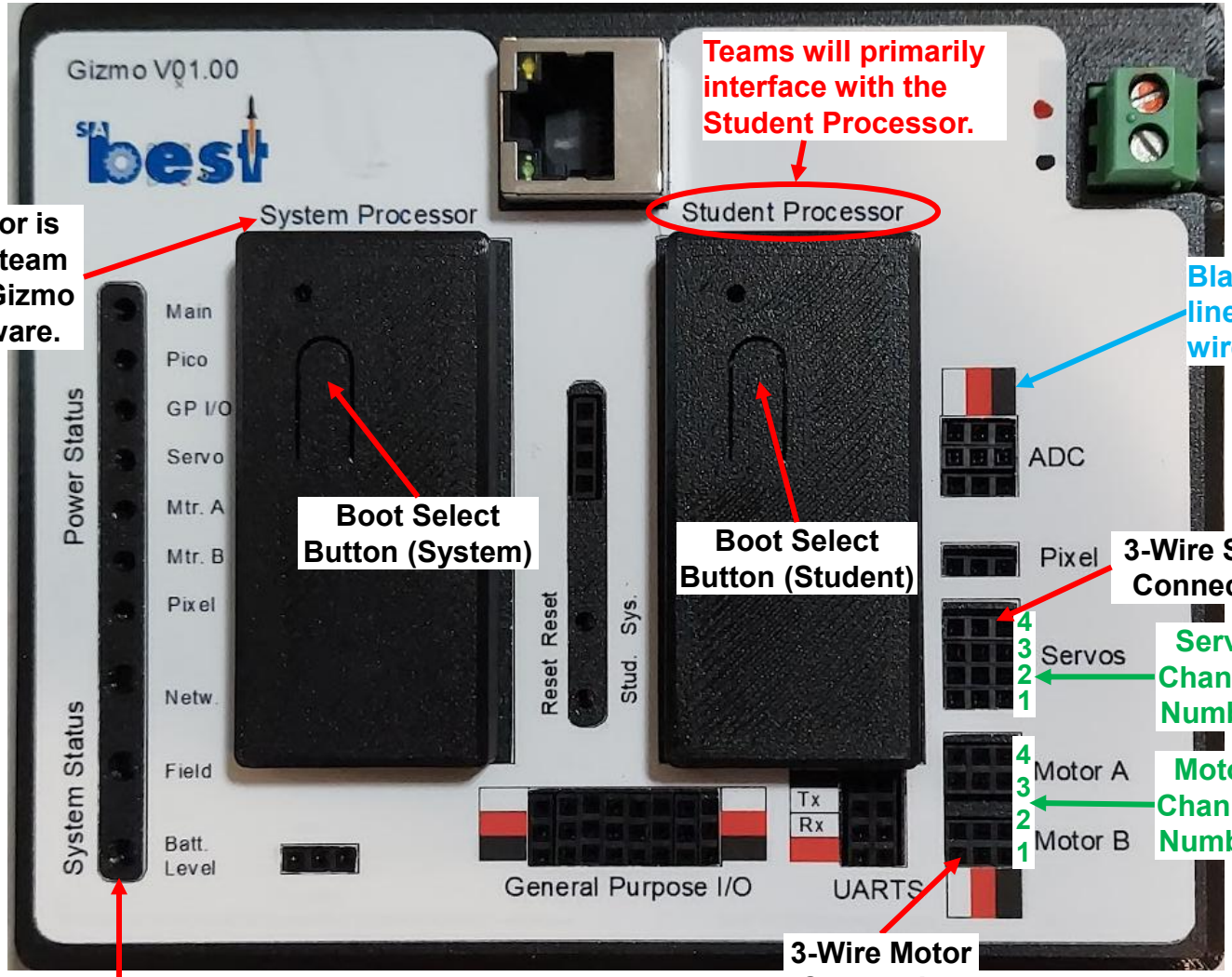
Sensor Input
(2 wire) Cable (4)

Programming able

Gizmo Details

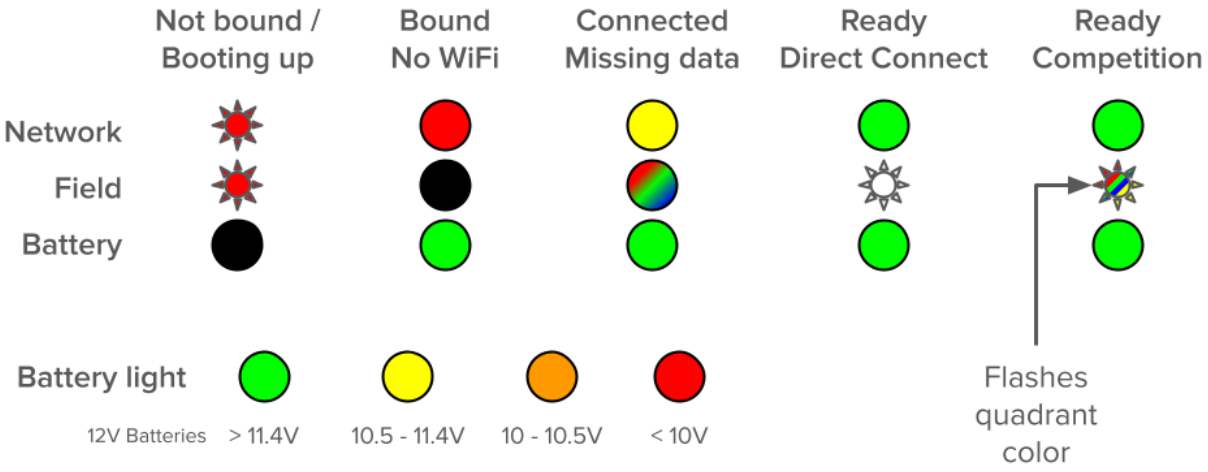


Gizmo Details



Status Light info

- **Power System Lights – on is normal, off means a problem with that system/component**
  - **Main Power (Orange)** **Pico Power (White)**
  - **GPIO Power (Blue)** **Servo Power (Green)**
  - **Motor Bank A (Yellow)** **Motor Bank B (Red)**
  - **Student NeoPixel Power (Red-Orange)**
- **System Status Lights**



Joystick / Driver Station

- The Gizmo Driver Station (DS) controls communication between the Joystick and the Gizmo.
- The DS is powered by a USB power bank. It is recommended to use the provided USB switch between the powerbank and the USB-micro power cable that plugs into the DS.
- The Joystick plugs into (and is powered by) the DS.
- Plug the Joystick into the USB below the USB-micro power input on the DS (as shown in figure).
- There are 3 different modes that may be used to control your robot.

Binding the DS to Gizmo

- In order for the DS to talk to the Gizmo, it first must be “bound” to it.
  - Binding was already done for the DS/Gizmo combinations in your SA BEST RKs.
  - If you need to repeat the binding for any reason, procedure is detailed in the “2025 SA BEST Visual Kit Reference” document, available in your Workflow.
  - Binding is the only time your team should have any reason to access the system processor.

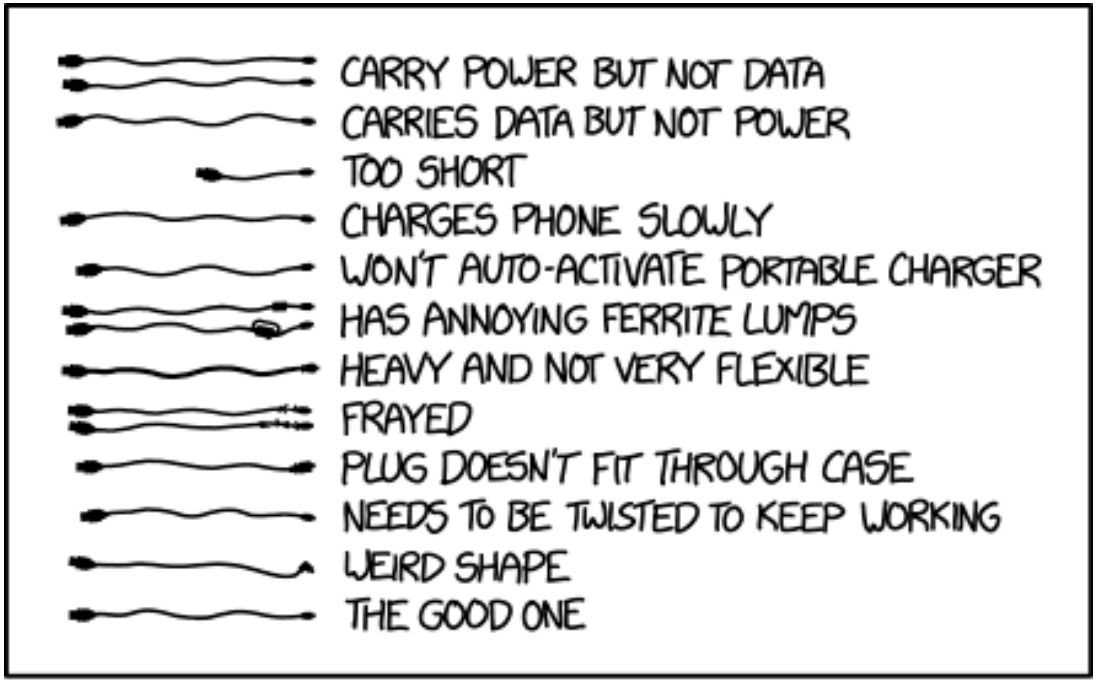
Not All USB-micro Cables were created equal!

(many thanks to Randall Munroe and his XKCD webcomic:)

Most USB-micro cables you may have laying around are power-only cables.

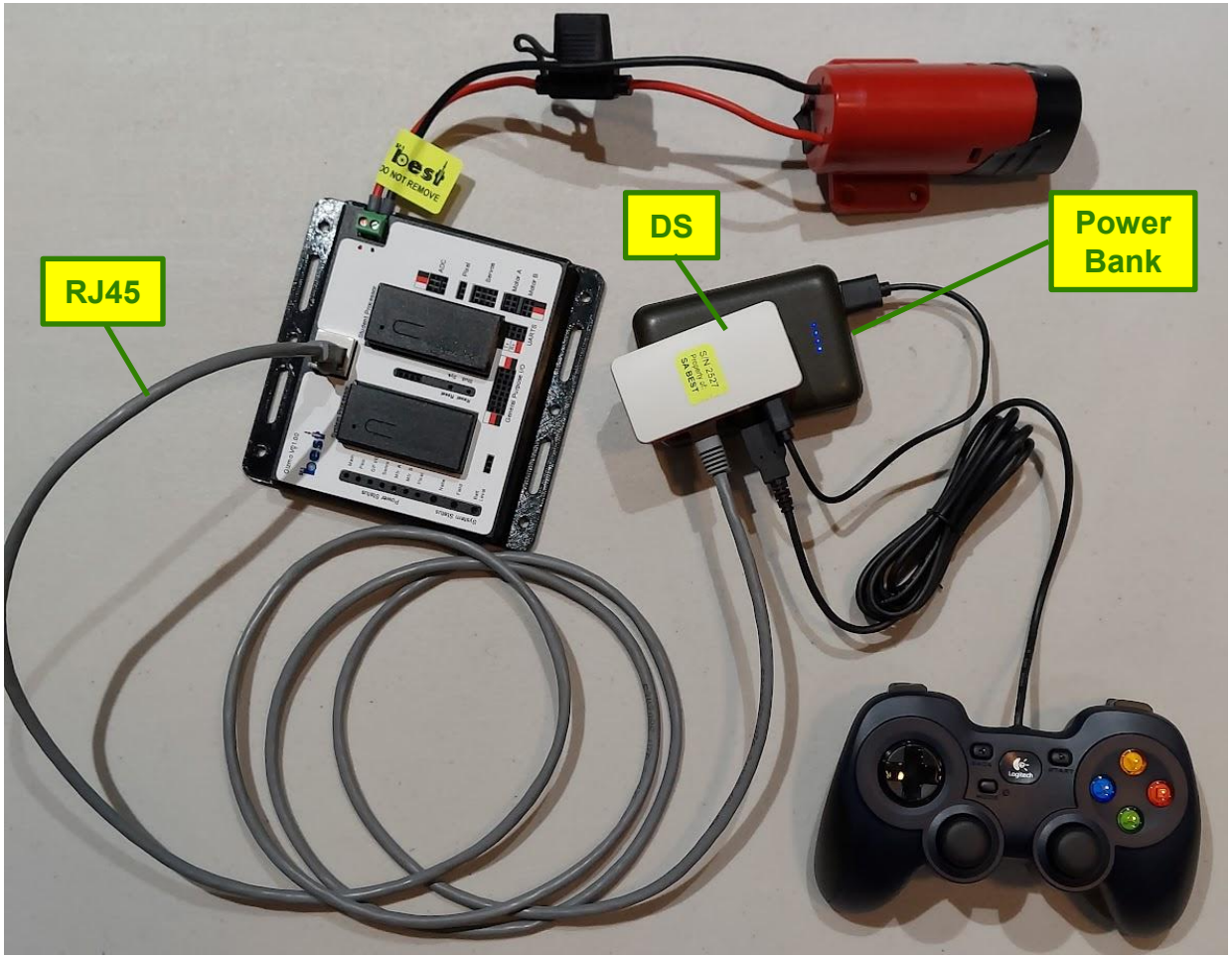
When connecting to the Gizmo, you must use a USB-micro cable capable of carrying DATA. The 6ft cable provided in your SA BEST RK is a DATA cable.

Attempting to use a power-only cable for data transfer can be a very frustrating experience…



THE LAW OF USB CABLES:
NO MATTER HOW MANY YOU GET,
YOU ONLY EVER HAVE ONE GOOD ONE.

Robot Control: Tethered



Robot Control: Wireless

Robot Control: Competition

- Looks just like the standard wireless mode, but the RJ45 cable is used to hook the DS up to the Field Management System (FMS).
- The FMS has a more powerful radio transmitter than what is in the DS, and the FMS controls which channels are used by all robots on the field.
- During Machine Check-in, your Gizmo will be bound to the FMS.
  - Once bound to the FMS, you can use only tethered mode when not on the field.
- You will bring Joystick, DS & powerbank to the field on game day.

Gizmo Resources

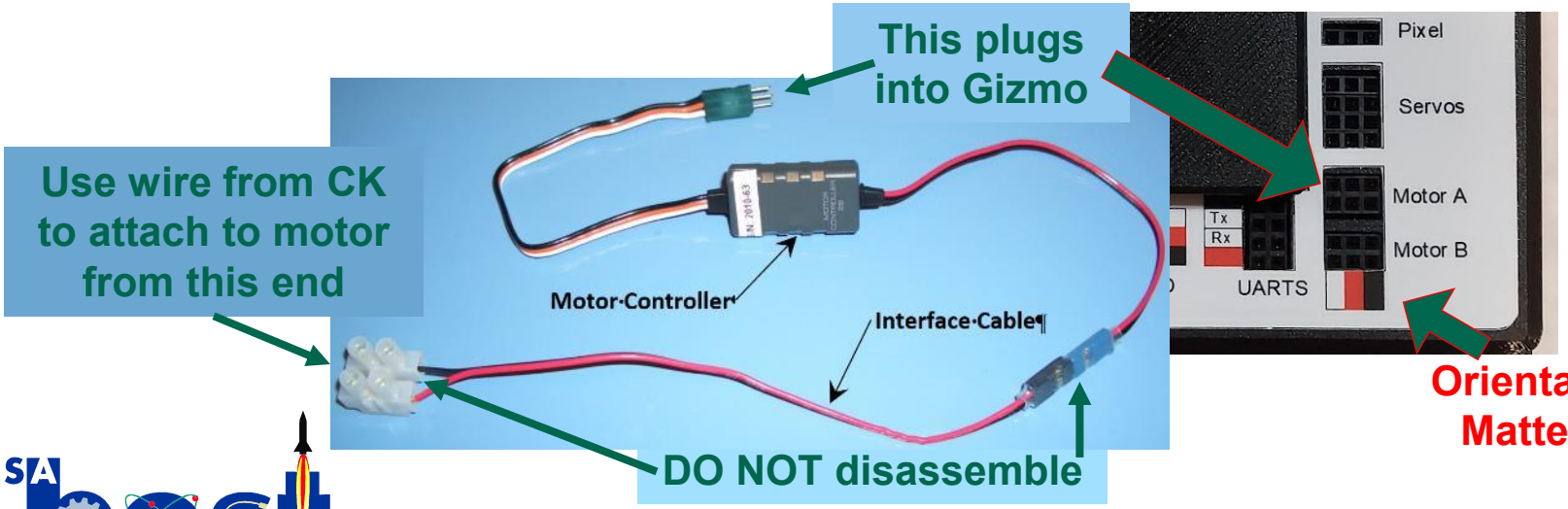
- ***BESTedu courses related to Gizmo***
  - ***Gizmo: Getting Started***
  - ***Gizmo: Programming with Arduino***
  - ***Gizmo: Python Programming***
- ***Additional resources at BESTedu***
  - ***Gizmo – The Team Experience***
  - ***Gizmo Troubleshooting Guide***
  - ***Raspberry Pi PICO Documentation***
- ***Gizmo website: https://gizmoplatform.org/***

Using Motors

- Gizmo motor connection
- Motor Controller Assy
- Motor Attachment
  - Wiring the Motor
  - Attaching to the Motor shaft
  - Attaching motor to the Robot

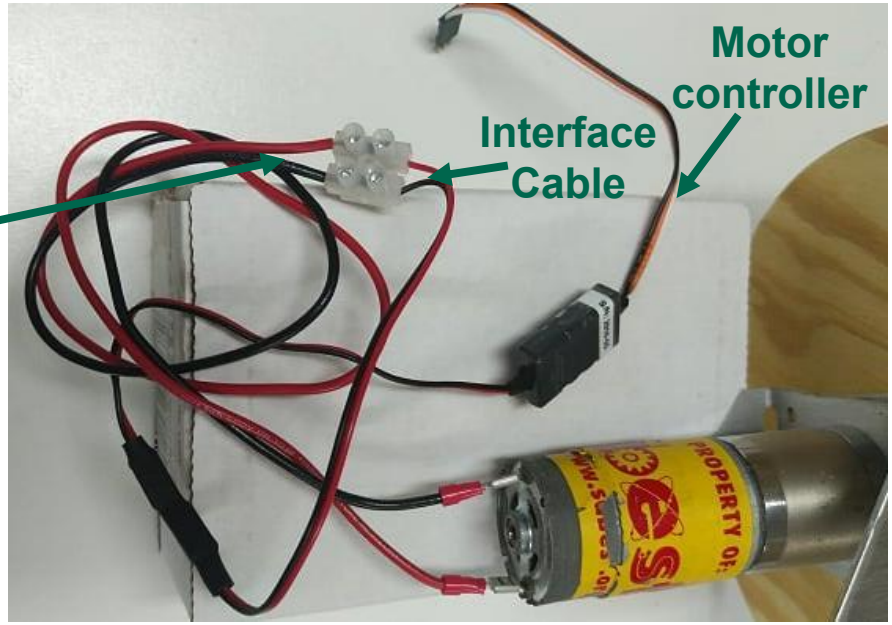
Gizmo Motor Connection

- Motor attaches to Gizmo through the external Motor Controller & Interface Cable.
- Motors can be installed to Gizmo motor channels 1 – 4 (Channel 1 is at the bottom).
- It is recommended to split up your drive motors between motor banks A and B (two different internal fuses).



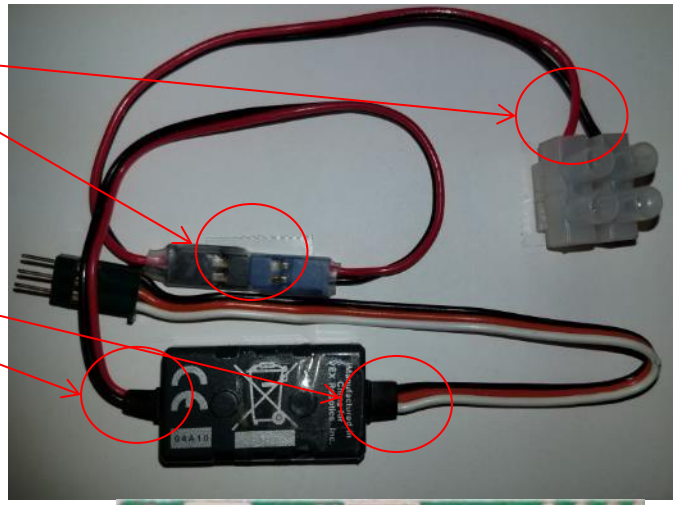
Motor Attach - Wiring

- Do not solder to the motor tabs!
- Use the Spade Connectors from the CK ("quick-disconnect terminal, insulated, female" on your kit list – look in "bag 3" in the small box in your CK).
- Other end of the wires go into the terminal block on the motor speed controller interface cable.



Care and feeding of your motor controller *assemblies*

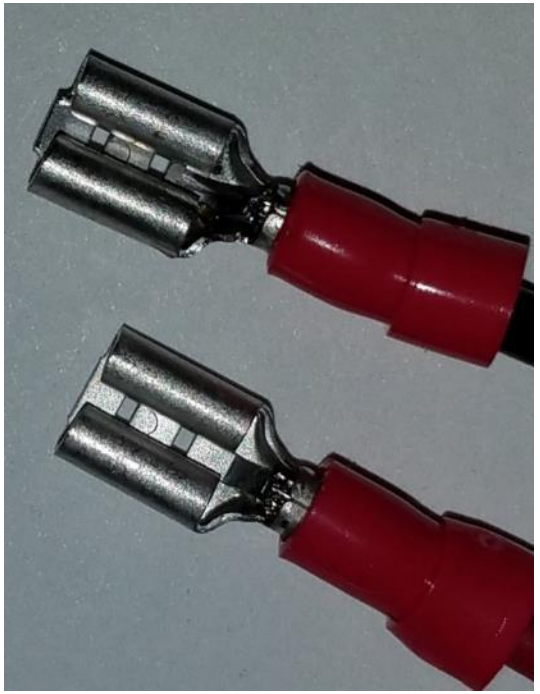
- **Leave these joints assembled, do not modify.**
- **Don't pull on the wires**
  - **Insulation can move**
  - **Wires can short (this is bad, overheats)**
  - **Too hot: melts, burns**
- **Don't pinch or cut wires**
- **Keep away from moving parts**



Hookup Tips

Crimp spade lugs to supplied wire

- You shouldn't be able to pull the wire out of the crimp
- Solder the wire to the spade lug if you can't get a good crimp.
  - Note: Plastic insulation on the lug may (i.e. will) shrink from the heat. This is OK.
- Keep solder out of the mating area
  - Top lug: OK, but solder shouldn't go any further
  - Bottom lug: Ideal, solder doesn't go past wire stop
- Heat Shrink or electrical tape (CK) may be used to insulate the exposed metal

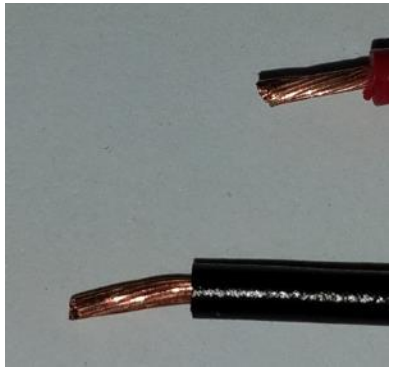


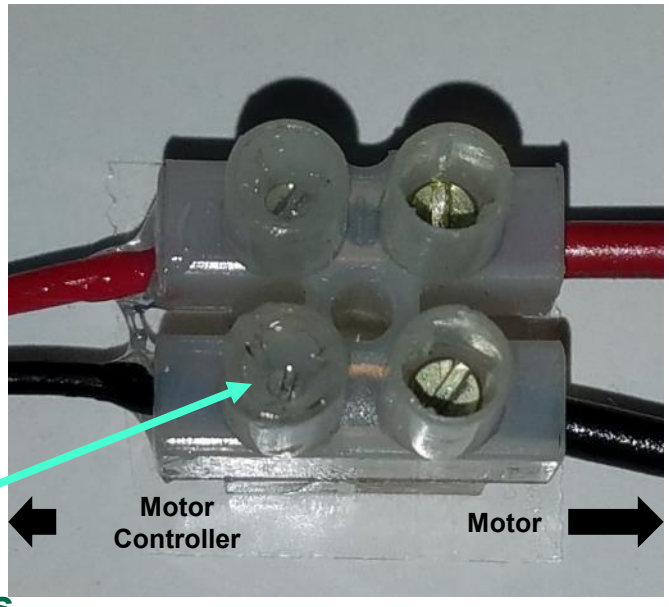
Hookup Tips (cont)

Connect Wires to EuroBlocks

- Motor Controllers
- Sensor Input Cables (2 or 3)

- Strip 6mm (1/4”) from each wire
  - For smaller wire, double the strip and fold in half
  - Don’t solder tin the bare wire, bare wire makes a better connection in the EuroBlocks
- Loosen Screws (counter clockwise) as needed
- Insert wire, bare wire must not be outside of the EuroBlock.
- Tighten Screws (clockwise) until tight (wire does come out with a light tug)





Note that some fasteners on your EuroBlocks have been covered with silicone. DO NOT remove these fasteners.

Hookup Tips (cont)

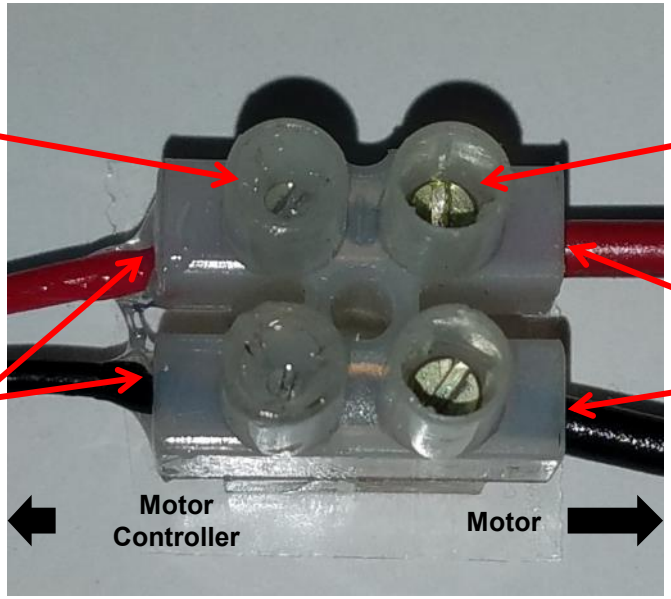
Connect Wires to EuroBlocks

- Motor Controllers
- Sensor Input Cables (2 or 3)

- **<u>DO NOT REMOVE</u>** EuroBlocks from RK parts!

These screws are covered in silicone, leave them alone.

These wires are already attached, do not remove.

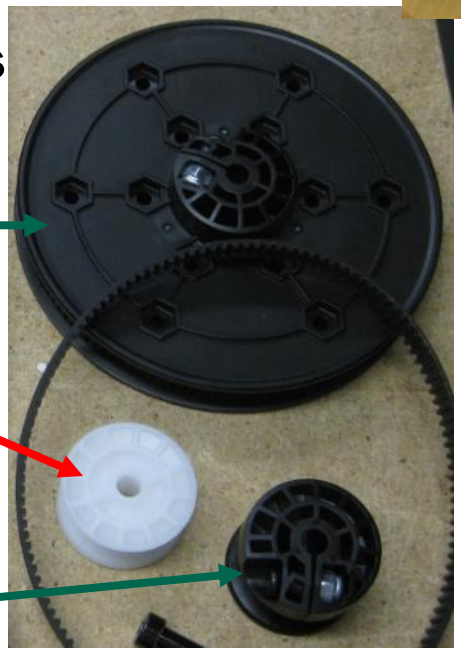


Loosen these screws to attach your wires.

Attach your wires here.

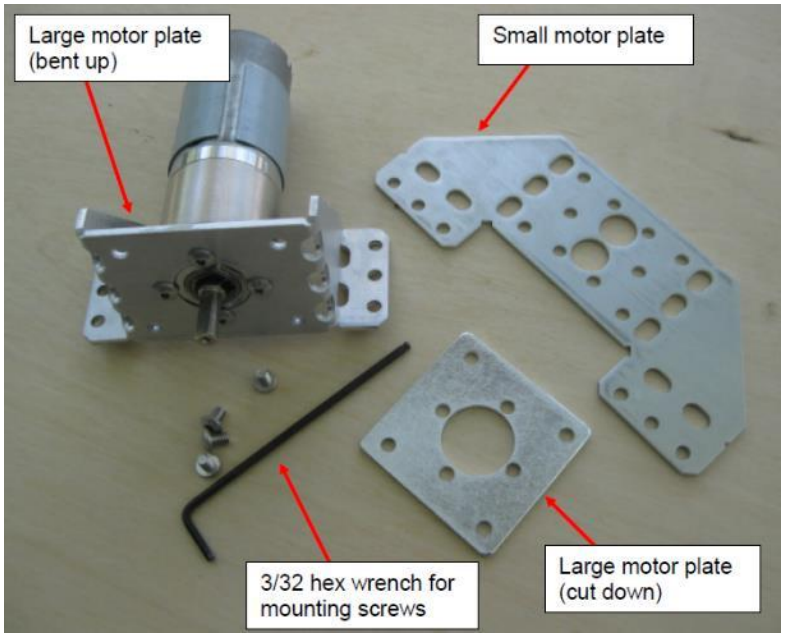
Motor Attach – Drive Shaft

- Do **not** use any glue/tape/epoxy on the motor.
- The BEST Kit Usage Guide shows a couple of methods of building hubs (similar to the one at right) to attach wheels to motors.
- Can also use drive parts provided in the RK:

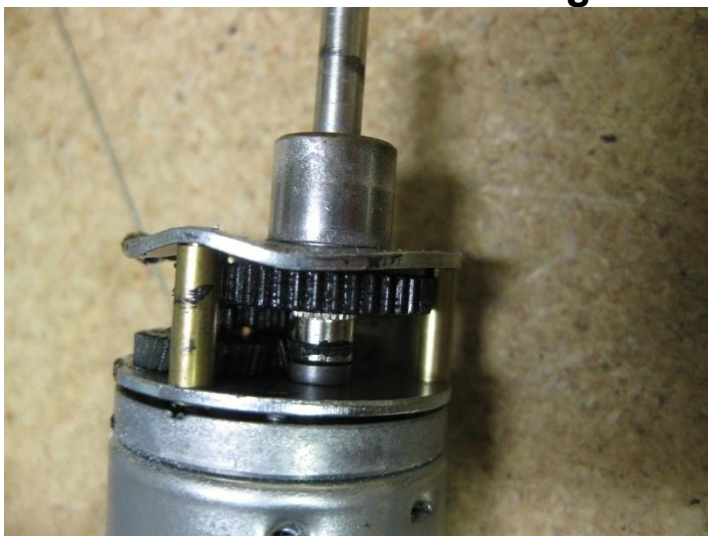


Motor Attach - Mounting

- **Motor mounting plates & screws are provided in the CK.**
  - **They are not required, but are convenient!**
  - **You have only one chance to bend the mounting plate – if you try to bend it back it will crack.**
- **If face mounting, use the short screws from the mounting bracket kit (or make certain that any other screw does not extend into the motor case more than 0.2”).**

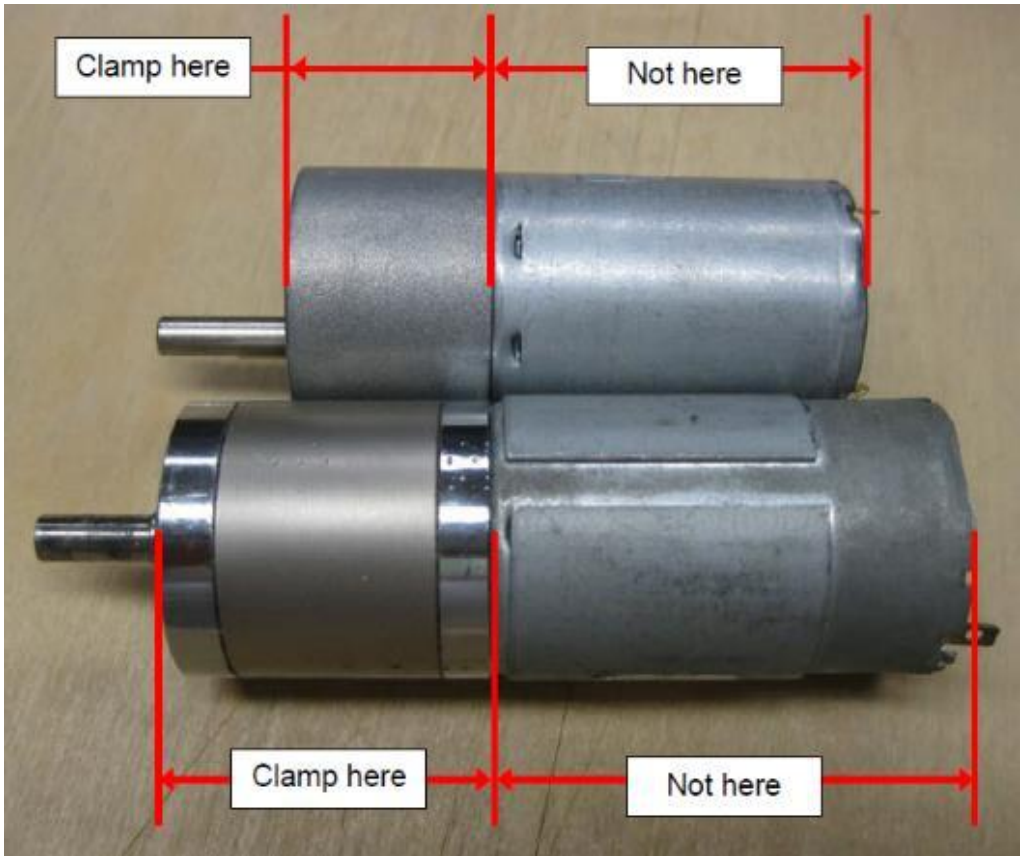


- **This is what happens when you use screws that are too long:**



Motor Attach - Mounting

- **If clamping around the motor case, only clamp around the gearbox (closest to shaft), not armature section (closest to wires).**



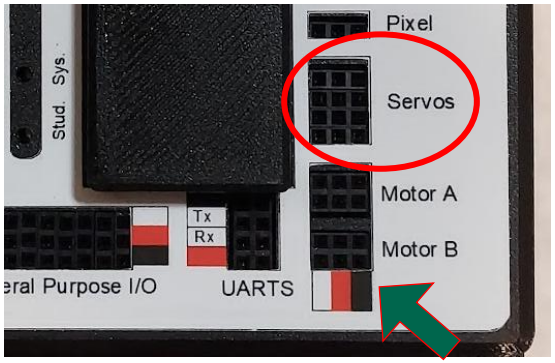
Motor Mounting

- Motor Brackets
  - Bend on oval holes
  - Start all 4 screws before tightening
  - Flanges can fold either way or even be broken off
  - Bend only once!
  - Brackets are optional
  - Use the supplied (short!) screws if you are mounting the motors using these brackets.
- Small Motor Bracket
  - Motor can mount in either hole

Using Servos

Connections:

- Servos plug into the Servo channels (numbered 1 – 4 starting at the bottom).
- Your Servos have been modified to add pins in the connectors, so they will directly plug in to your Gizmo.
- Connect the Servo to the Gizmo directly or via an extension cable
- Make sure the wire colors line up



Orientation Matters!

Use:

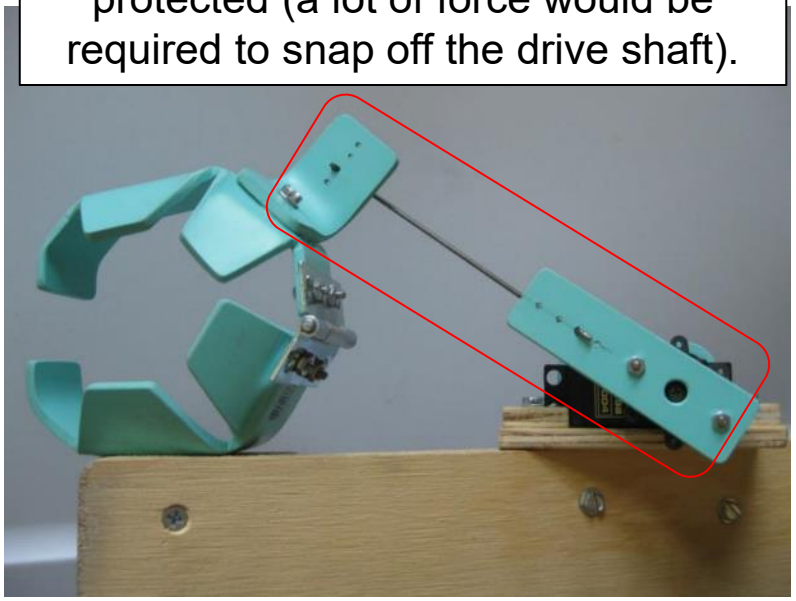
- Servos Rotate ±45° from center
- Do not manually move servo with power applied
- Do not overload the servo. If the servo ‘chatters’ or stalls, STOP: it is overloaded!
- If servo “hums” it is draining the battery. It needs to be adjusted (or your joystick calibrated).

Pins added (glued in). Do not remove them.

Servo Mounting

Running into something with this gripper open will strip the servo gears.

In the closed position, the servo is protected (a lot of force would be required to snap off the drive shaft).



There is hardware in the RK specifically for mounting the servos to the robot. If you use screws from the CK instead, be careful that you don't damage the mounting holes.

Thanks to David Kwast, Cowtown BEST

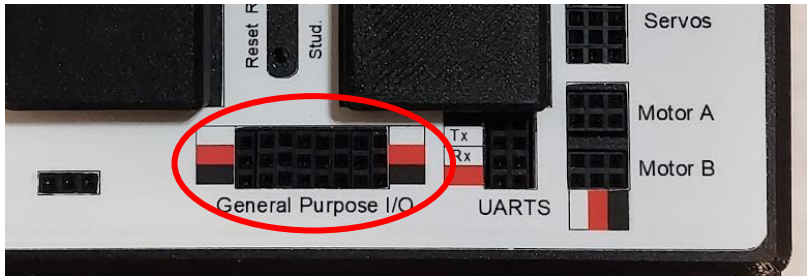
Sensor Input Connectors

Digital Input Connection

- 2 Wire Sensor Input Cable
  - Or
- 3 wire Sensor Input Cable
  - Center (red) connection not needed

Analog Input Connection

- 3 wire Sensor Input Cable
  - All three wires are used



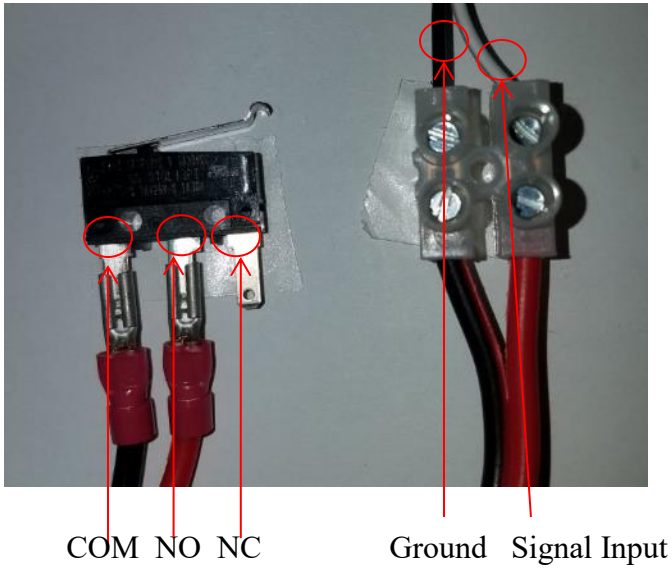
Real World Input

- **Analog Input**
  - **Continuously Variable**
  - **0 to +5V**
  - **0 to 1024 (EasyC – Analog Input)**
  - **Example: potentiometer (CK)**

- **Digital Input**
  - **Open/Close**
  - **Weak Pulled up to 5V**
  - **Open = 1**
  - **Closed = 0**
  - **Example: micro-switch (CK)**

Digital Connections (switch)

- Common (COM)
- Normally Open (NO)
  - Makes connection to COM when lever is pressed
- Normally Closed (NC)
  - Makes connection to COM until lever is pressed
  - Not normally needed
- Directly compatible with all Limit Functions
  - Closed to activate limit (logic 0)
- Use Electrical Tape or Heat Shrink Tubing to insulate terminals



Use for:

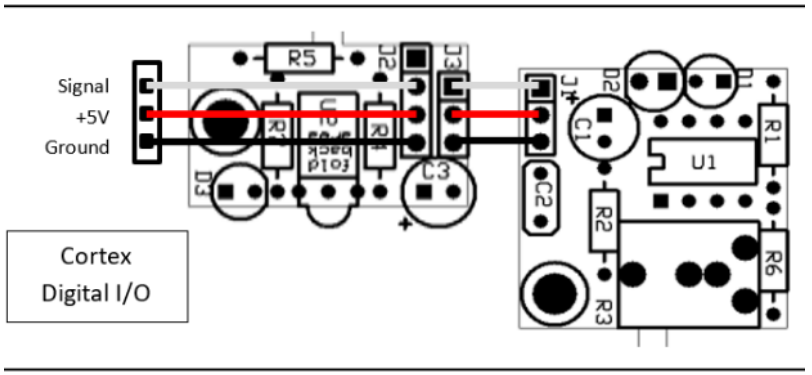
- Bump sensing
- Motor limit detection
- System interrupt, etc.

Digital Connect. (IR Sensor)

Option 1: Attach the System to a Single Cortex Port

- **IR emitter runs continuously. Works in a "beam break" application.**
- **Connect IR receiver to cortex digital I/O using one of the supplied Servo Extension Wires (SEWs).**

  Note: orientation matters at both ends!
- **Connect IR receiver to IR transmitter using another supplied SEW (*check orientation!*).**
- **Set Cortex digital I/O port as an input.**
- **The Cortex input will signal when IR (from any source) is detected.**

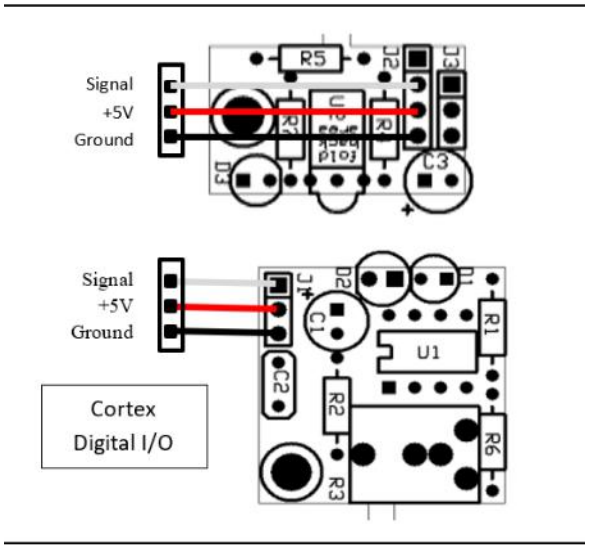


Reference BESTedu course "BEST Returnable Kit: IR Sensor" for more information.

Digital Connect. (IR Sensor)

Option 2: Attach the System to Separate Cortex Ports

- **IR emitter can be controlled. Works for simple signaling or "beam break".**
- **Connect IR receiver to cortex digital I/O using one of the supplied Servo Extension Wires (SEWs). *Note: orientation matters at both ends!***
- **Connect IR transmitter to cortex digital I/O using another supplied SEW (*check orientation!*).**
- **Set Cortex digital I/O port connected to receiver as an input, and port connected to transmitter as an output.**
- **IR emitter can now be controlled by the Cortex output, and the Cortex input will signal when IR (from any source) is detected.**



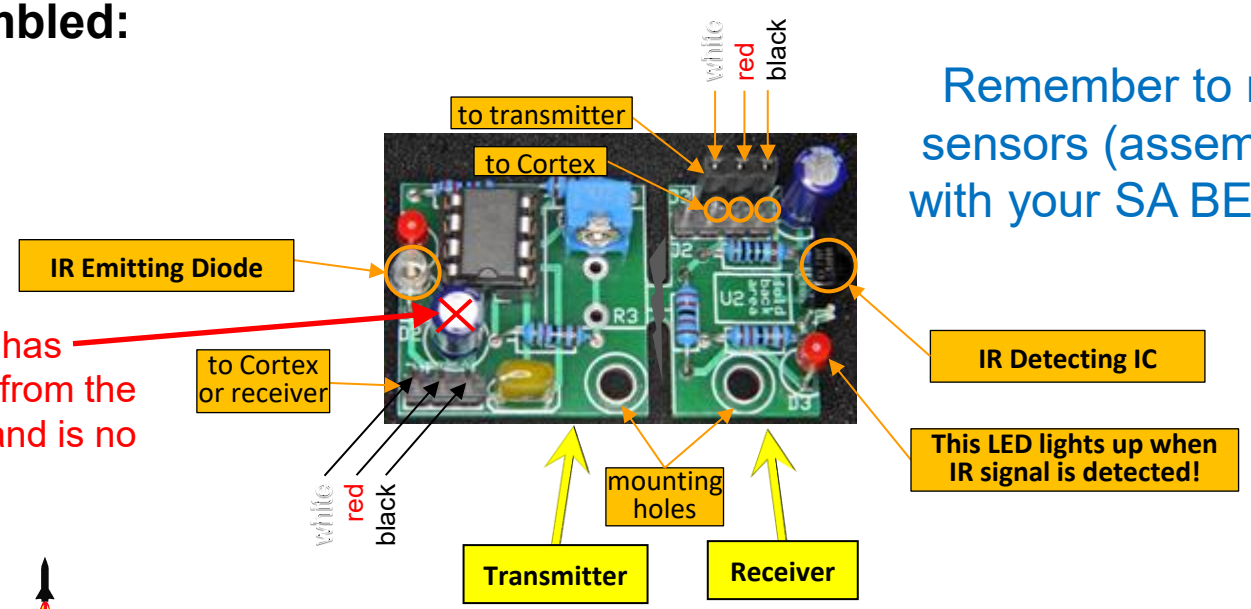
Reference BEST document "Using the IR Sensor System with the VEX Cortex" for more information.

IR Sensor Notes

- **Read through the entire *BEST Electronics Workshop Curriculum* prior to opening any IR Sensor Kit package.**

  These sensors are (relatively) expensive, so only open them if you have a plan to use and the skill/training to assemble.

- **Assembled:**



Remember to return all IR sensors (assembled or not!) with your SA BEST return kit.

Building & Using the IR Sensor

- From your team workflow (at registry.bestrobotics.org):
  - Click on BESTedu link
  - Select “Students”
  - Select “BEST Returnable Kit: IR Sensor”
- Much more detailed info here!
  - Using the BEST IR Sensor
  - Assembling the BEST IR Sensor

Analog Connect. (potentiometer)

- **Consumable Kit**
  - **10kΩ Potentiometer (2)**
  - **Rotates 300°**
- **Connections (CW Operation):**
  - **Pin 2 (Center) is the wiper**
  - **Wiper moves from 1 (CCW) to 3 (CW)**
    - 1 - Black (GND)
    - 2 - White (Signal)
    - 3 - Red (+5)
- ~~**Red or Black to PIN 2?**~~
  - **Pot becomes a Smoke Generator (illegal)**
  - **May damage cable or Cortex (also illegal)**

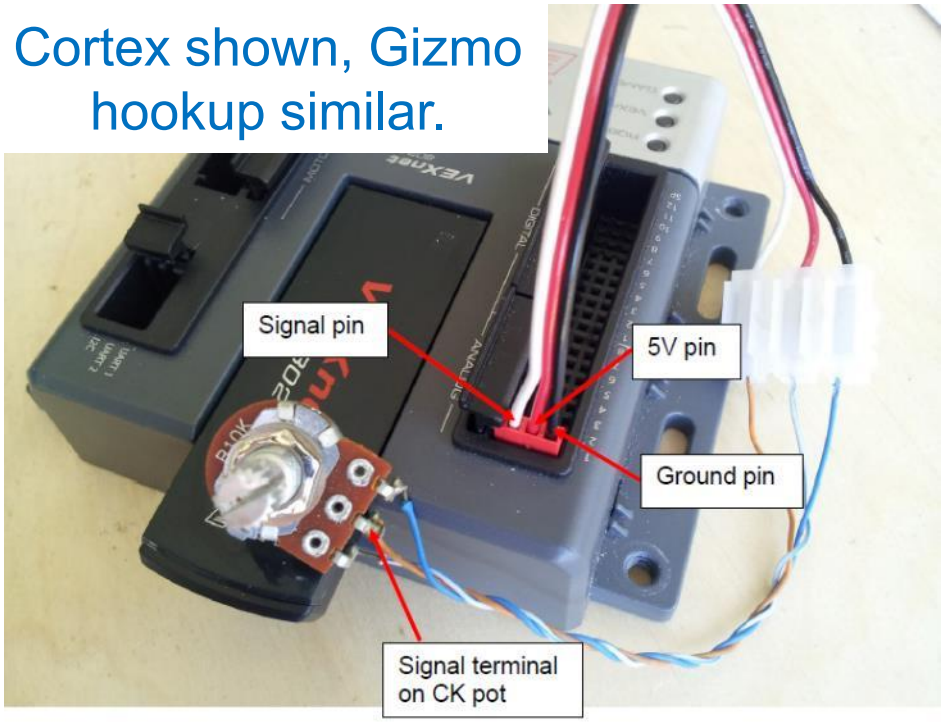
(reverse red & black for CCW operation)

Make sure the middle pin on potentiometer connects to the WHITE WIRE on the 3-wire sensor input cable (***not*** *to the middle wire!*)

Analog Connections (cont.)

- **Needs 3 wire Sensor Input Cables**
- **Do not connect +5V(red) or GND(black) to Wiper(middle) contact on Potentiometer**
  - **This can damage the control system(BAD!)**
- **Clockwise (CW) Operation**
  - **Input value increases with CW rotation**
  - **+5V to CW (3) terminal**
  - **GND to CCW (1) terminal**
- **Counterclockwise (CCW) Operation**
  - **Input value decreases with CW rotation**
  - **GND to CW (3) terminal**
  - **+5V to CCW (1) terminal**

Cortex shown, Gizmo hookup similar.



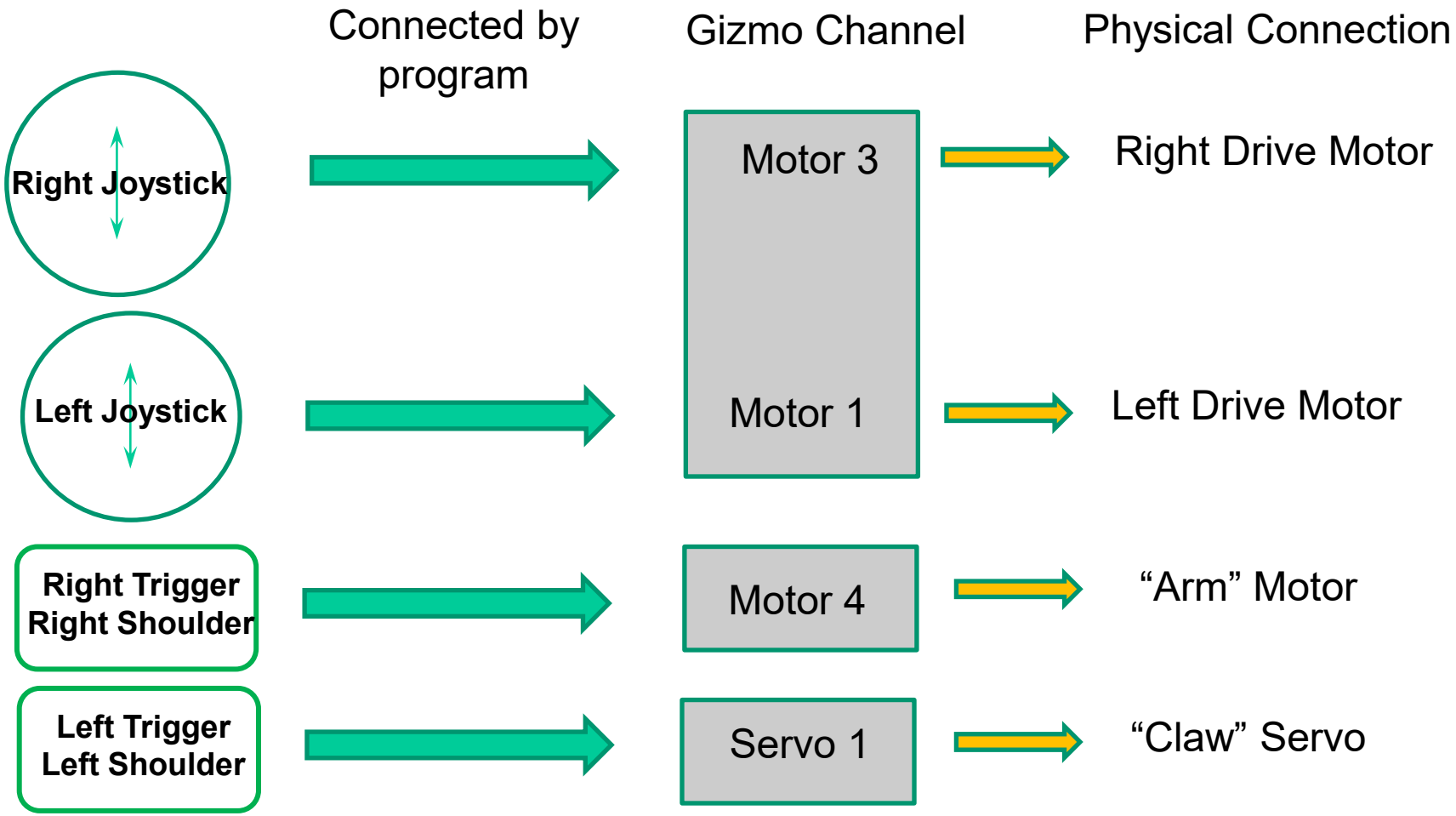
Robot Batteries

- **Always** monitor charging batteries
  - Batteries will be warm when charging, but…
  - If too hot to hold, something is wrong.
- When possible, deplete batteries using robot prior to recharging.
- A discharged battery may take a couple of hours to charge fully.

BEST Gizmo Default Program (Tank Mode)

Port & Function	Logitech F310 Controller	Description
Servo 4	Not Used	None
Servo 3	Not Used	None
Servo 2	Not Used	None
Servo 1	Left Trigger Left Shoulder None pressed	Move servo to 0 degrees Move servo to 90 degrees Servo defaults to 45 degrees
Motor 4	Right Trigger Right Shoulder	Move motor forwards Move motor backwards
Motor 3	Right Joystick (Fwd/Rev)	Move motor forwards or backwards
Motor 2	Not Used	None
Motor 1	Left Joystick (Fwd/Rev)	Move motor forwards or backwards
	Start Button	Toggle Tank vs. Arcade Mode

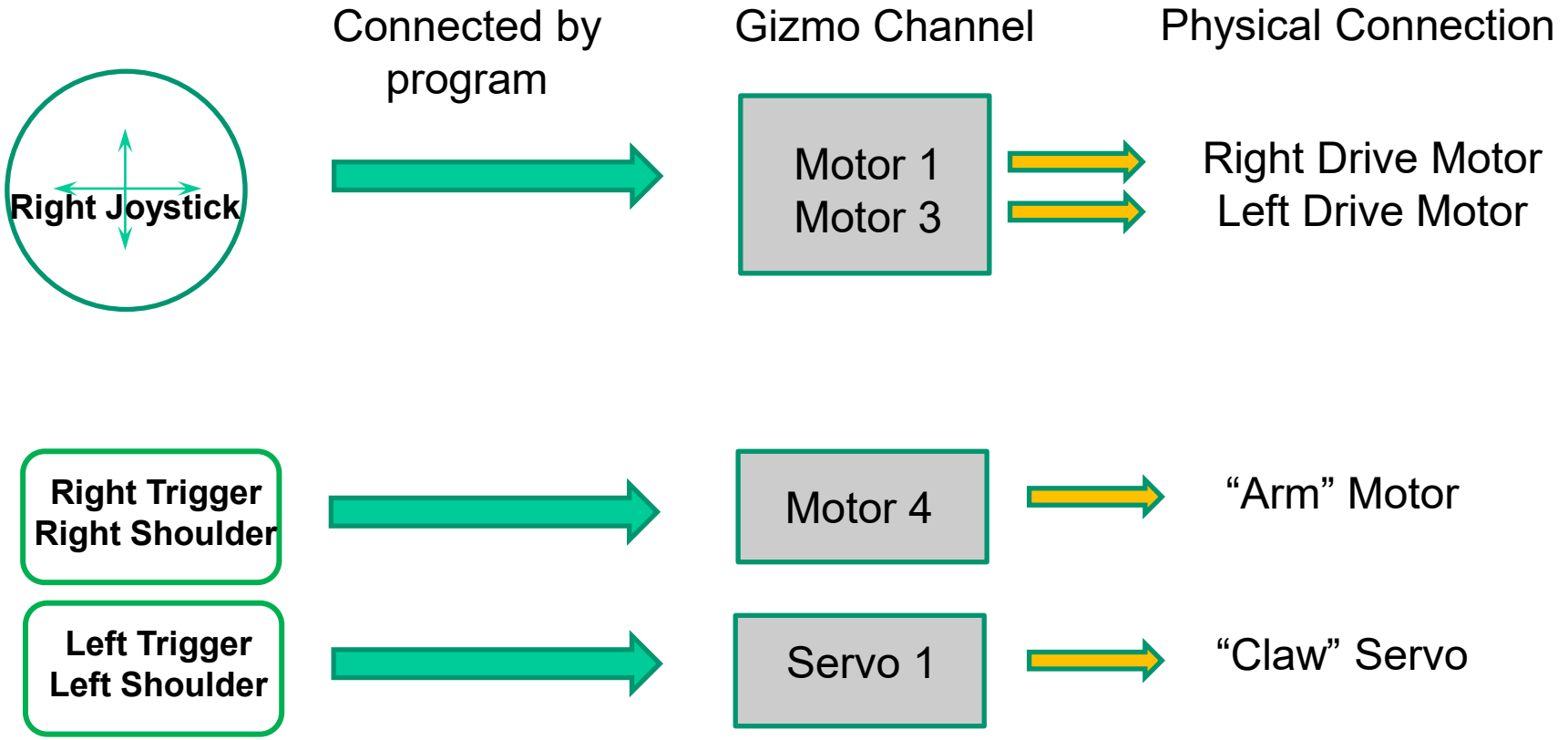
BEST Default Program (Tank Mode)



BEST Gizmo Default Program (Arcade Mode)

Port & Function	Logitech F310 Controller	Description
Servo 4	Not Used	None
Servo 3	Not Used	None
Servo 2	Not Used	None
Servo 1	Left Trigger Left Shoulder None pressed	Move servo to 0 degrees Move servo to 90 degrees Servo defaults to 45 degrees
Motor 4	Right Trigger Right Shoulder	Move motor forwards Move motor backwards
Motor 3 (mixed w/Motor 1)	Left Joystick (Fwd/Rev) Left Joystick (Left/Right)	Move forwards or backwards Turn left or right
Motor 2	Not Used	None
Motor 1 (mixed w/Motor 3)	Left Joystick (Fwd/Rev) Left Joystick (Left/Right)	Move forwards or backwards Turn left or right
	Start Button	Toggle Tank vs. Arcade Mode

BEST Default Program (Arcade Mode)



Keep your RK and Kit Team Happy

- **Do not Paint RK items.**
- **No Tape/Glue/Velcro/Screws(or holes!)/etc. in RK parts** *(except long belt & servo horns).*
- **Remove the Cortex before drilling, cutting, painting or other 'dirty' operations** *(don't want debris getting inside!)***.**
- **If you can't remove it, cover it.**
- **Do not cut, drill, glue or disassemble RK items, except:**
  - Belt stock (long piece, not the loop)
  - Servo horns can be sliced and diced as needed
- **Do not solder to motor terminals: use CK spade connectors.**
- ***If* you use (blue) painters tape to mark wires, remove it before returning kit.**

Repacking your RK

- *Remove any tape or extra CK wires from RK parts.*
- Put these items in the box as shown in picture.
- Pack the following labeled zip-lock bags with items listed on bag:
  - BEST CABLES
  - BEST Belts/Pulleys/etc
  - BEST Servos/Sensors/etc
- Put packed zip-lock bags in the box.
- Close the box. You may have to adjust position of bags to close the lid without binding.

Check inventory list on kit box lid to make sure you have everything!

box number on this end

If any part is non-working or damaged, please mark it clearly.

Handy Resources

- **Team workflow on the BEST registry (registry.bestrobotics.org)**
  - **"Files Shared With Your Team" area includes:**
    - this presentation
    - SA BEST Visual Kit Reference guide
    - some of the more useful Gizmo reference info
  - **"Team Software Licenses" area includes**
    - Software available to your team & licensing info
  - **"Annual Game Files & QnA" area includes:**
    - Link to ***QnA*** system
    - Link to ***Game Rules*** *and other Game Files (drawings, etc)*
    - Link to BEST Robotics "Public Resources"
    - Link to BEST Robotics "Public Training"
  - **You can also get to some of these items directly at:**
    www.bestrobotics.org
    - "Resources" | "File Manager" | "Public Resources"
    - "Resources" | "File Manager" | "Public Training"

Handy Resources

- **BESTedu !!!**
  - Direct link from “Resources” area of your workflow.
  - There is a lot of training available here, be sure to check it out.

- **www.sabest.org**
  - **“Kit” tab provides some basic info, and links to BEST robotics.**

- **E-mail: kitguy@sabest.org Telephone: 210-522-5556 (leave voice mail)**
  - **This email address forwards to several people, so it is usually your quickest method of getting an answer.**
  - **Be sure to include “sabest” in the subject line so the SPAM filter won’t eat your message.**
  - **Include your name, school name & team number in your e-mail or message.**
  - **E-mail: Include a detailed description of your problem.**
  - **VoiceMail: Include a basic description of your problem,**
    … and the best way to reach you.