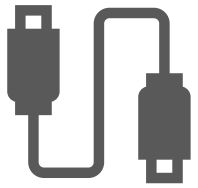

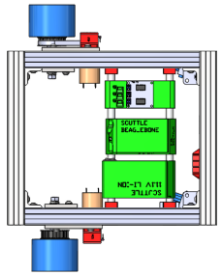

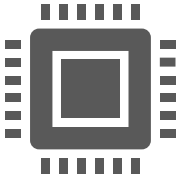

SCUTTLE Robot Wiring Guide

Revision 2022.12.12

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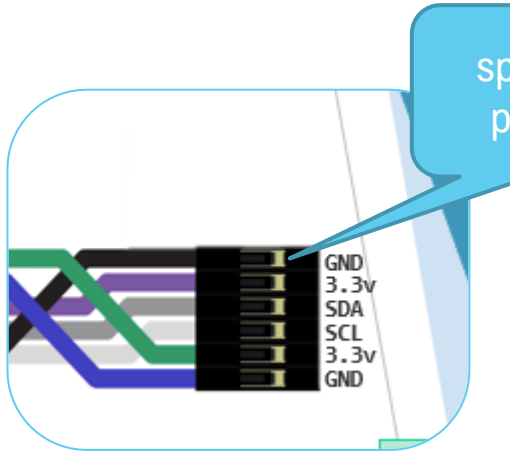
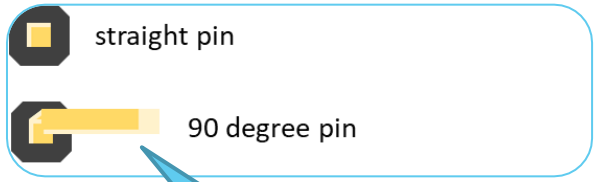
Good Practices

- Keep Wire sets bonded together.
- Use colors which are found in the common sequence
  - makes it easy for others to repeat your trials
  - makes it easy to document
- Eliminate individual pins
  - replace them with multi-position housings
- Use black colored wire for ground
  - whenever possible
- Dupont Housings: align the arrow to ground pin
  - whenever possible
- Use 90-degree headers where appropriate
- Hot glue backs of through-hole pins
  - reduce chance of short circuit
  - hot glue is removable if necessary

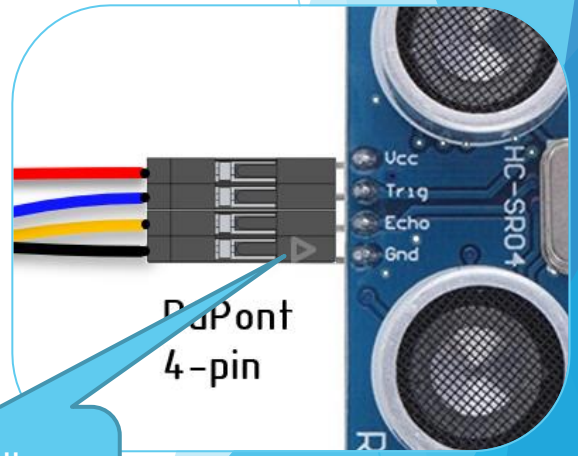


space for probing

cover pins with hot glue



choose appropriate male pins



Arrow aligns with ground

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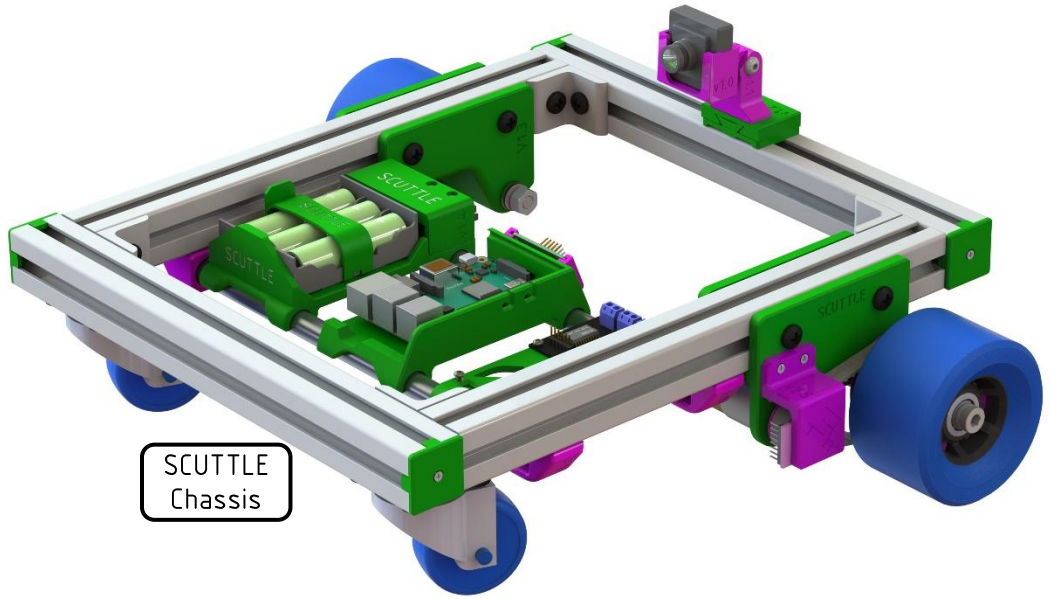
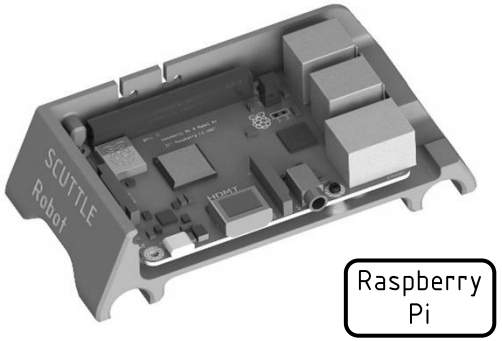
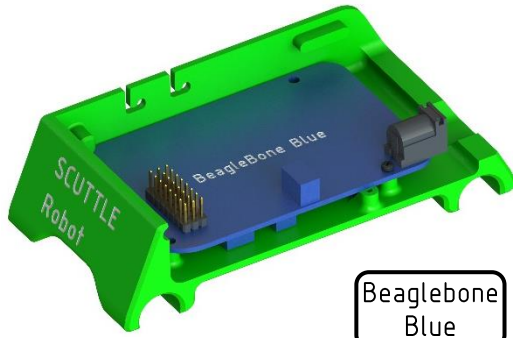
SCUTTLE Supports various CPUs

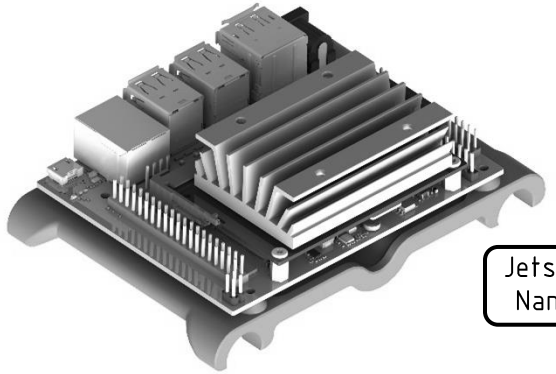




Raspberry Pi



Beaglebone Blue



Jetson Nano

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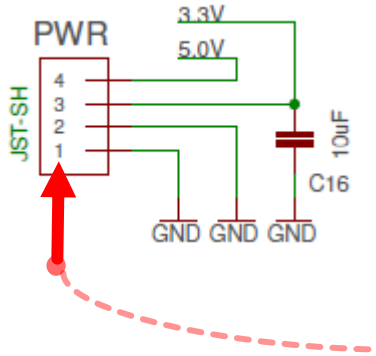
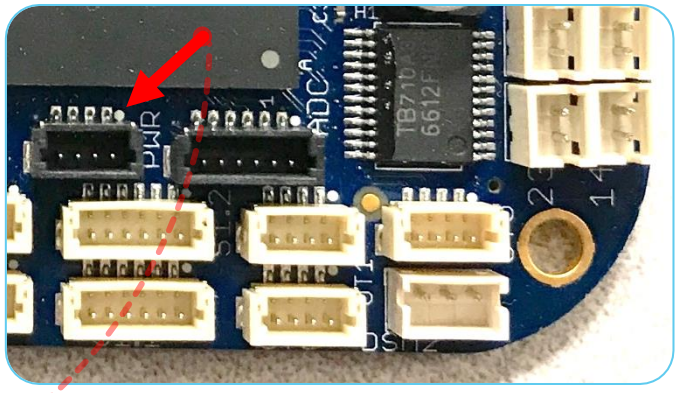
Before You Begin:

Important Info:
To match the beaglebone pins to the pin numbers on the diagram:
The tiny white circle on the silkscreen at each connector indicates “pin1”

images of this style are copied directly from the beaglebone schematic





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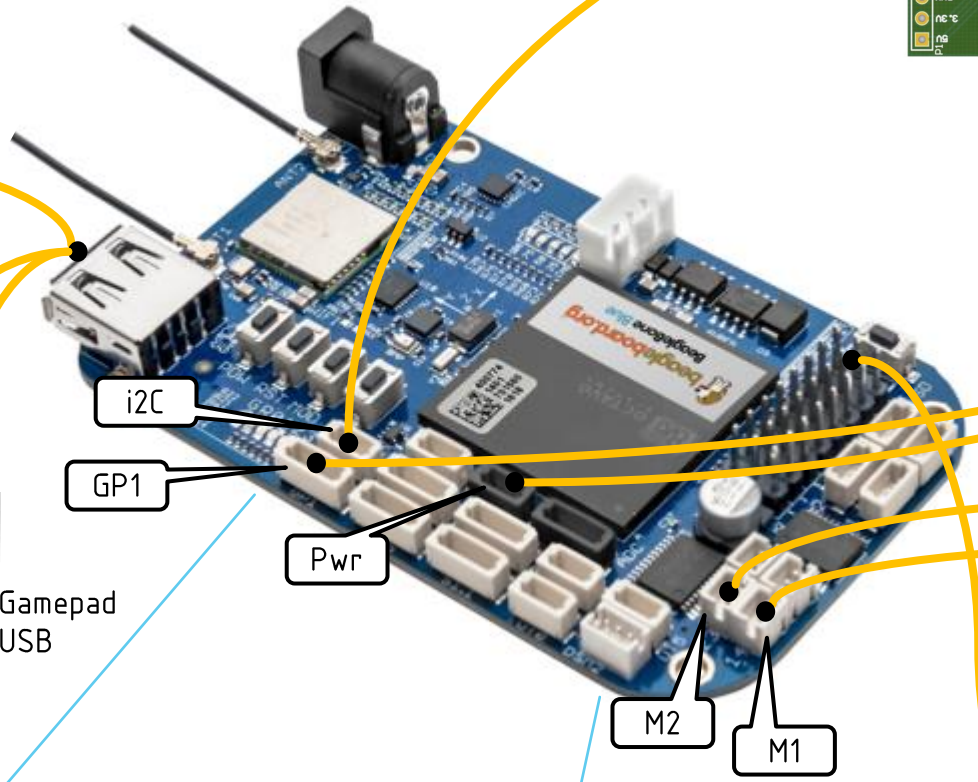
Validated Sensors & Actuators

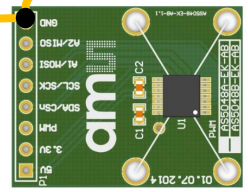
USB camera

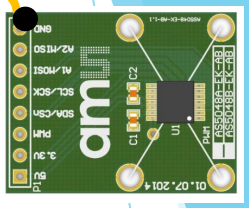
Audio Amplifier

Gamepad USB

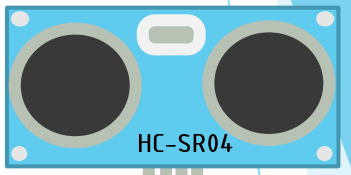
Gamepad Controller



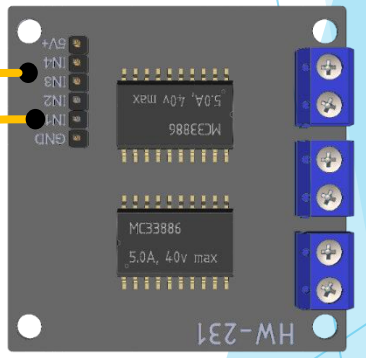




Encoders



Ultrasonic Sensor



Dual Motor Driver

Servos

Connection Map

I2C	4 GPIOs (GP0)	SPI (S1.2)	UART (UT1)	UART (UT5)
4 GPIOs (GP1)	UART (GPS)	SPI (S1.1)	UART (UT0)	UART (DSM)

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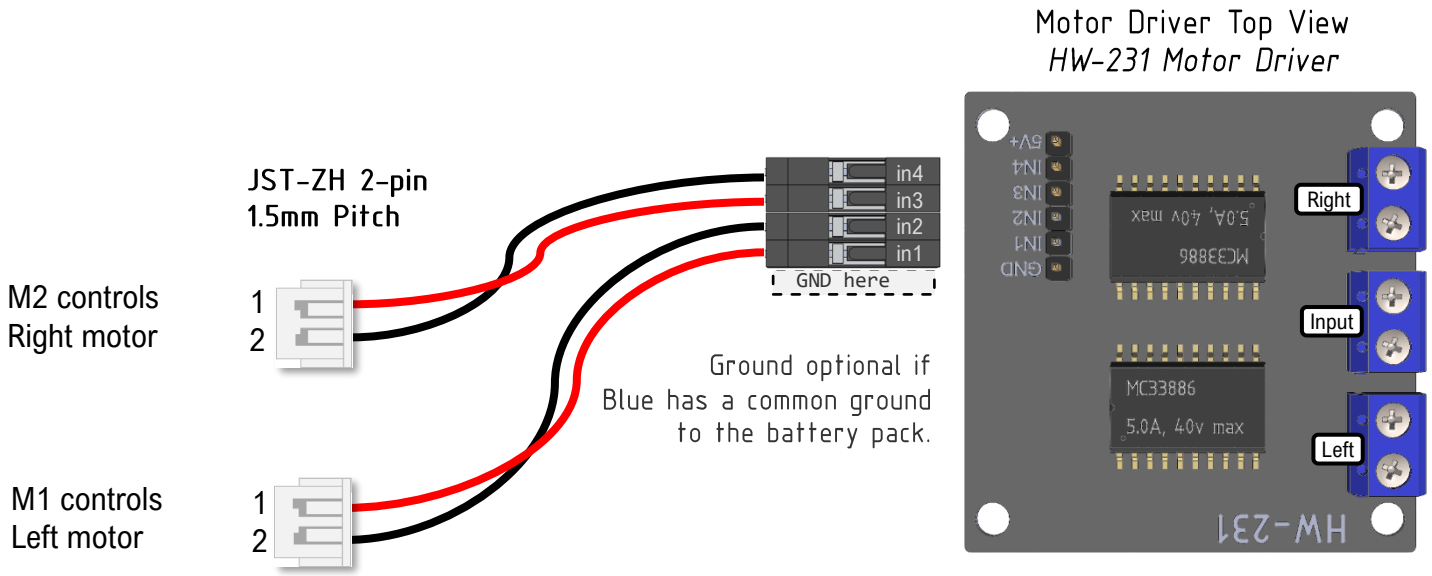
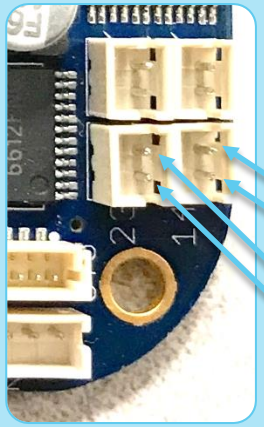
Motor Driver Signals



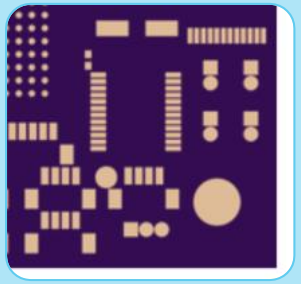


Pin 1 should be HIGH when motor is driven FORWARD

Motor1 Pin1
Motor1 Pin2

Motor2 Pin1
Motor2 Pin2

Hardware design convention:
Pin 1 uses the square solder pad.



Motor Direction:
Left-hand: Drives CCW on positive command.
Right-hand: Drives CW on positive command

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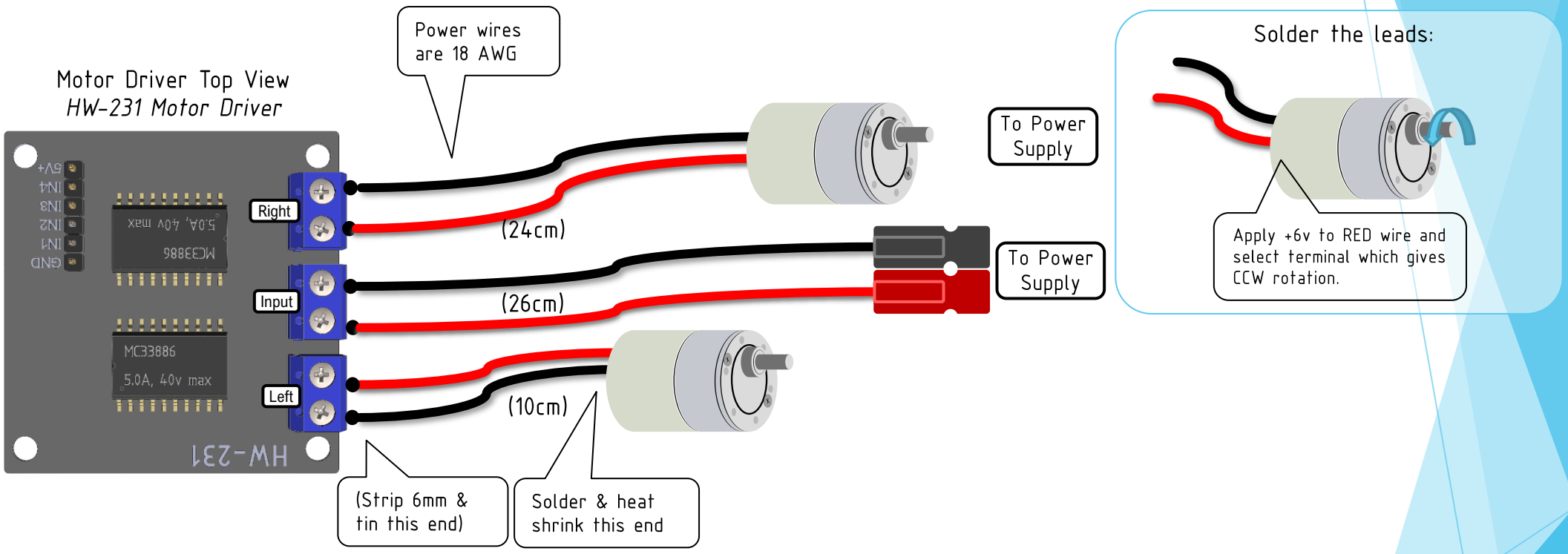
Motor Driver Power Wires



Motor Direction:
Left-hand: Drives CCW on positive command.
Right-hand: Drives CW on positive command

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H-Bridge L298N (optional)

A versatile and cheap device for delivering variable voltage to low-powered DC actuators.

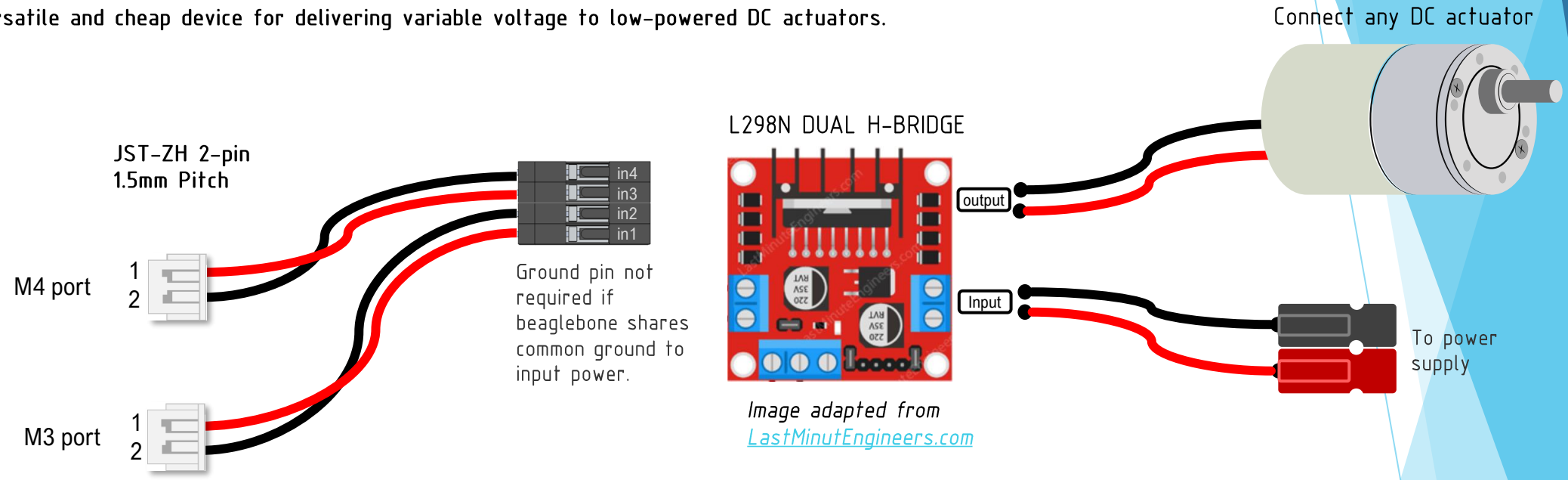
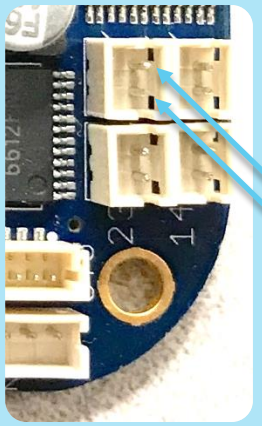


Image adapted from LastMinutEngineers.com



Pin 1 should be HIGH when motor is driven FORWARD

More information about the 5v regulator Found on the datasheet (L78M05)

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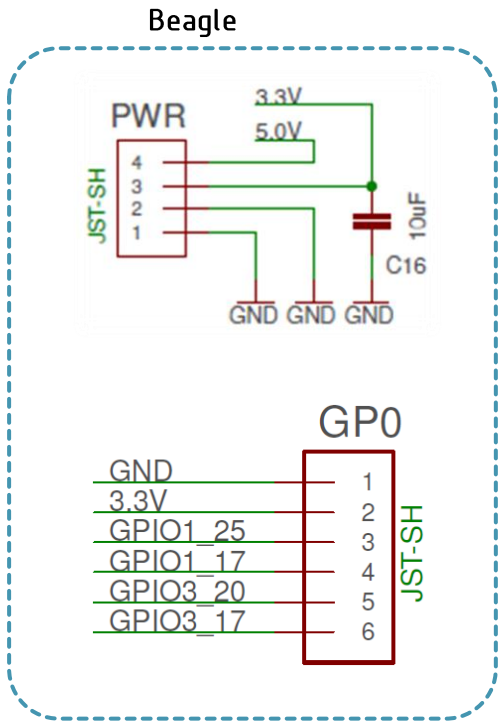
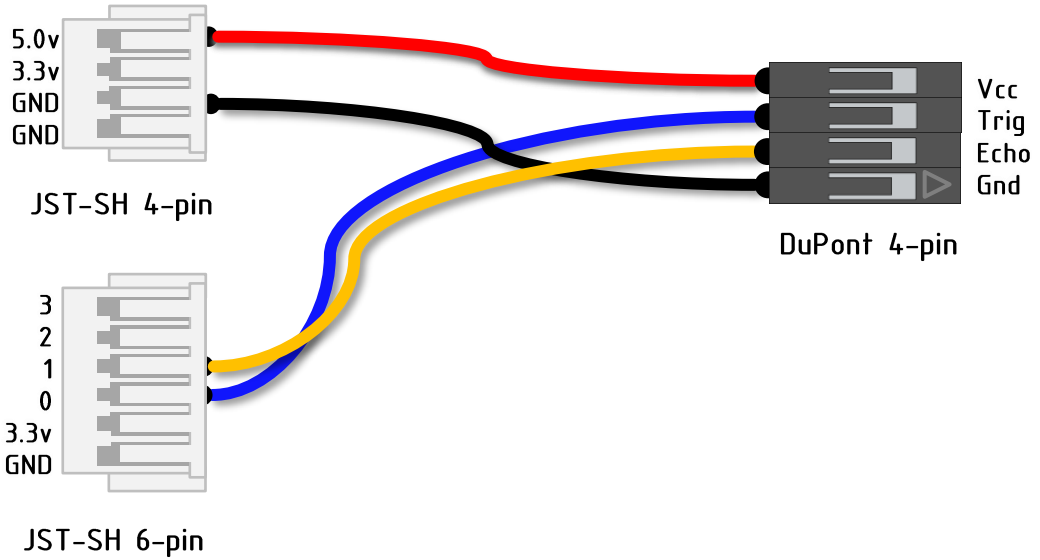
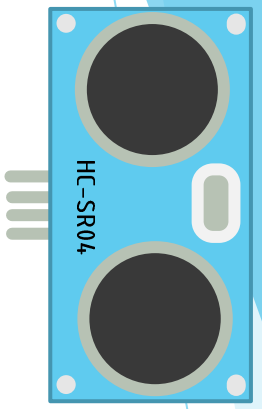
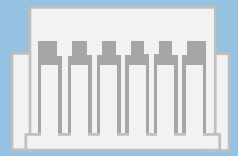
Ultrasonic Distance Sensor (GPIO)







NOTE: For JST connectors out-of-box, the colors are not in the correct order. You need to rearrange them.



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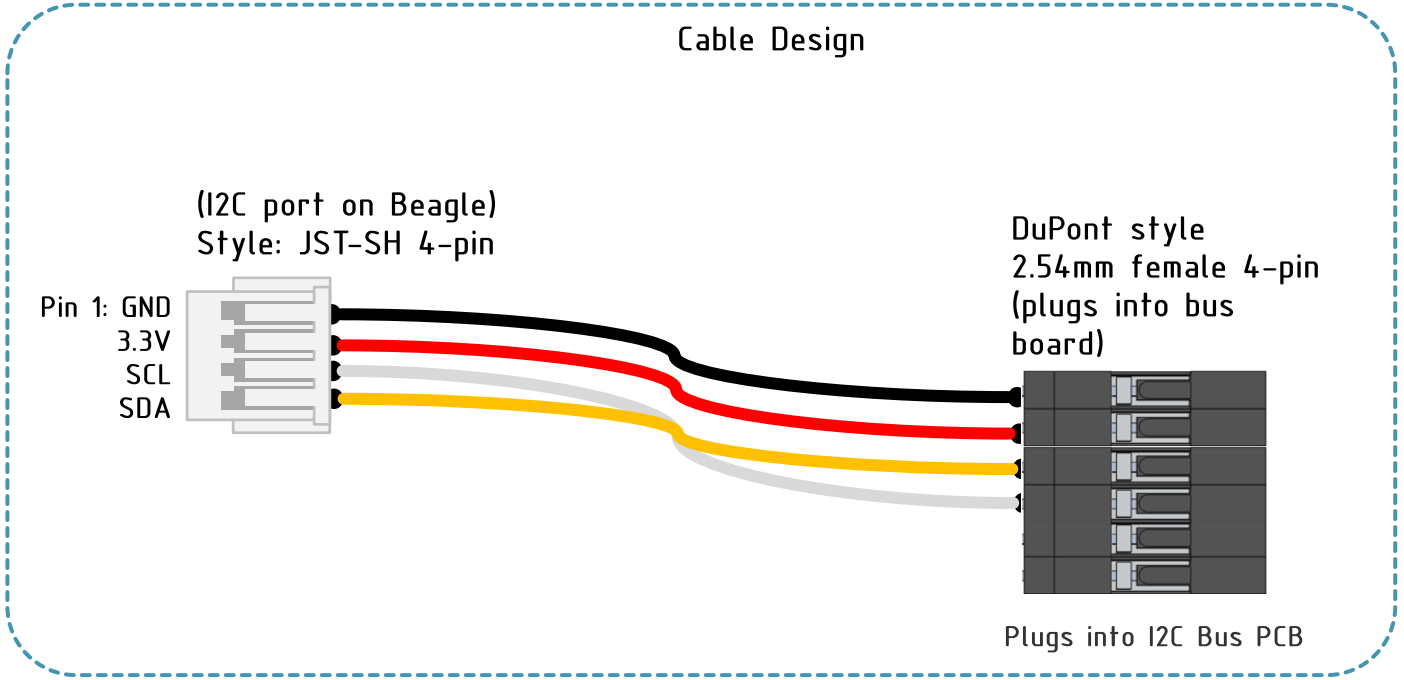
Beaglebone to I2C bus cable



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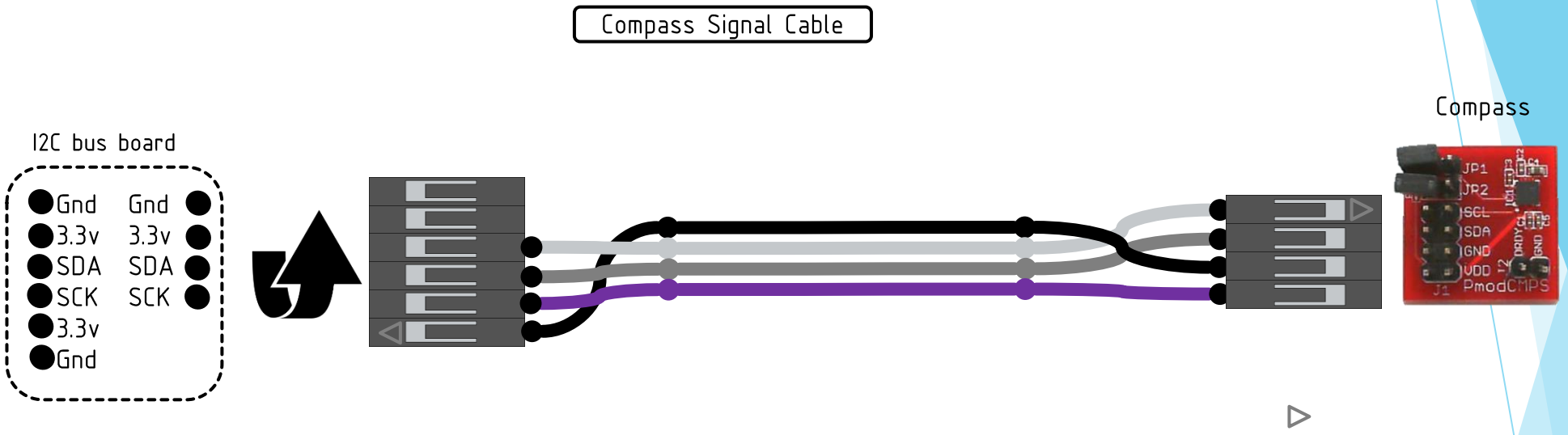
Compass CMPS or CMPS2 (I2C)



This compass is not necessary since you can access the compass on the beaglebone blue. Be sure to calibrate the compass on the blue since it lies within close proximity of magnetic hardware on the robot.

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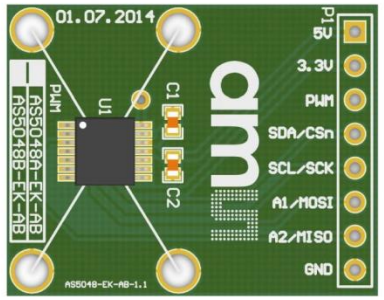
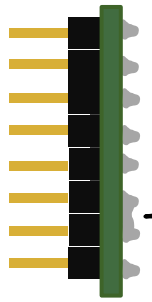
Encoder Details

Left Encoder



Front View



Side View

For the left-hand encoder, A1 AND A2 solder is bridged.

The i2c address is determined by the signals on A1 and A2 pins.

Left Hand Encoder A1 is pulled **down** to GND. I2C address is 0x40

Right Hand Encoder pin A1 is pulled **up** to 3.3v. I2C address is 0x41

	Pin A1	Pin A2	Resulting i2c address
Left Encoder	LOW	LOW	0x40
Right Encoder	LOW	HIGH	0x41

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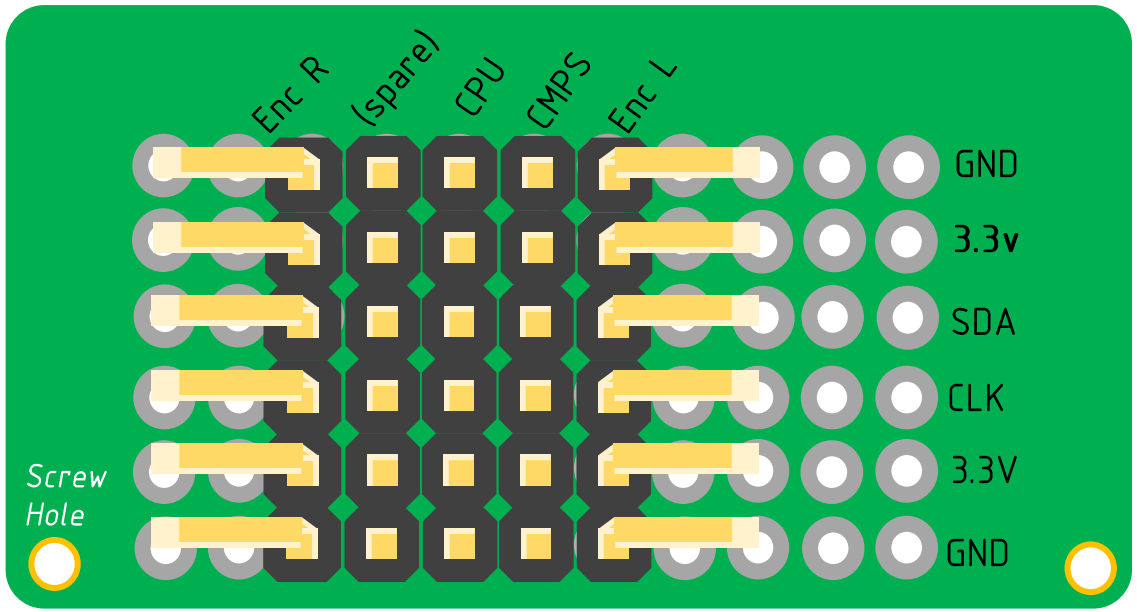
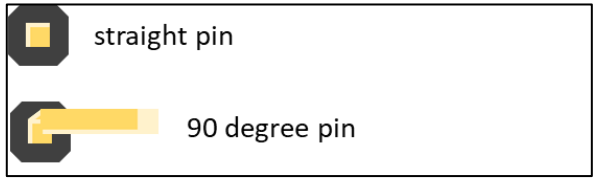
I2C Bus Board

Option A:
DIY using perfboard / breadboard

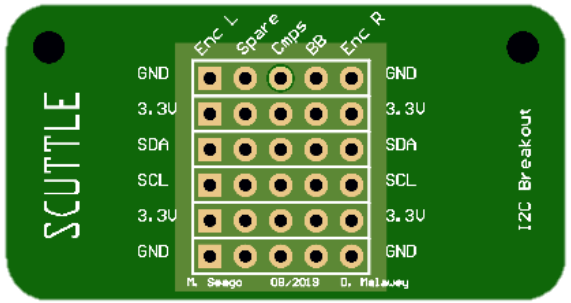
The board is made from a breadboard and soldered manually. The board can be cut between rows J & K. The solder bridges all pins from left to right.





Option B:
Order the custom PCB

You can order the custom PCB from JLCPCB.com or any other service. We have posted the design files on our github under electronics hardware.



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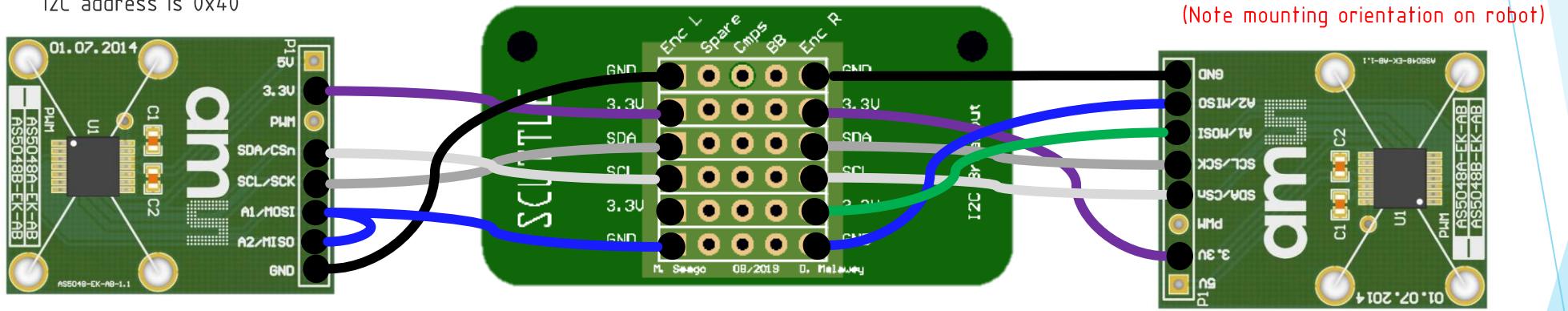
Encoder AMS AS5048 (I2C)

Also see: Encoder Details Slide

Left Hand Encoder
A1 is pulled **down** to GND
I2C address is 0x40

I2C bus board

Right Hand Encoder
A1 is pulled **up** to 3.3v
I2C address is 0x41
(Note mounting orientation on robot)



Left

Right

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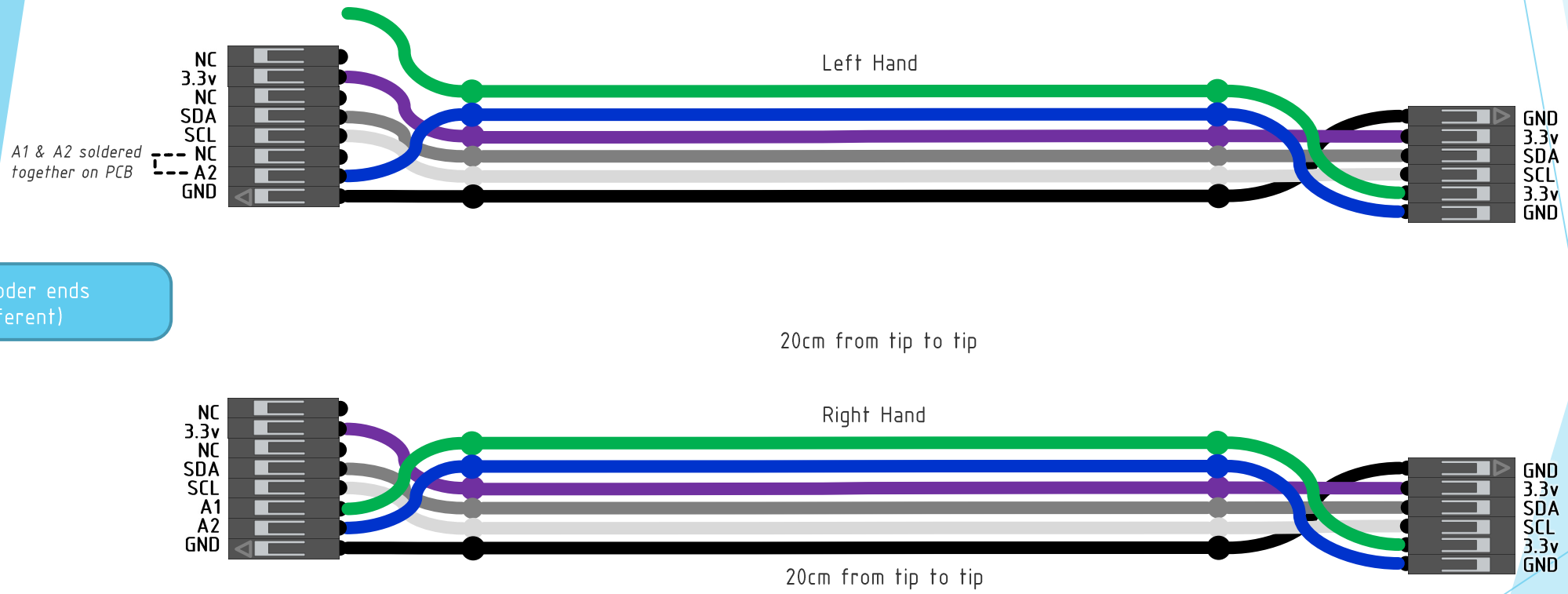
Encoder Cables

Cables modified as of 2020.12
SDA = GREY SCL= WHITE



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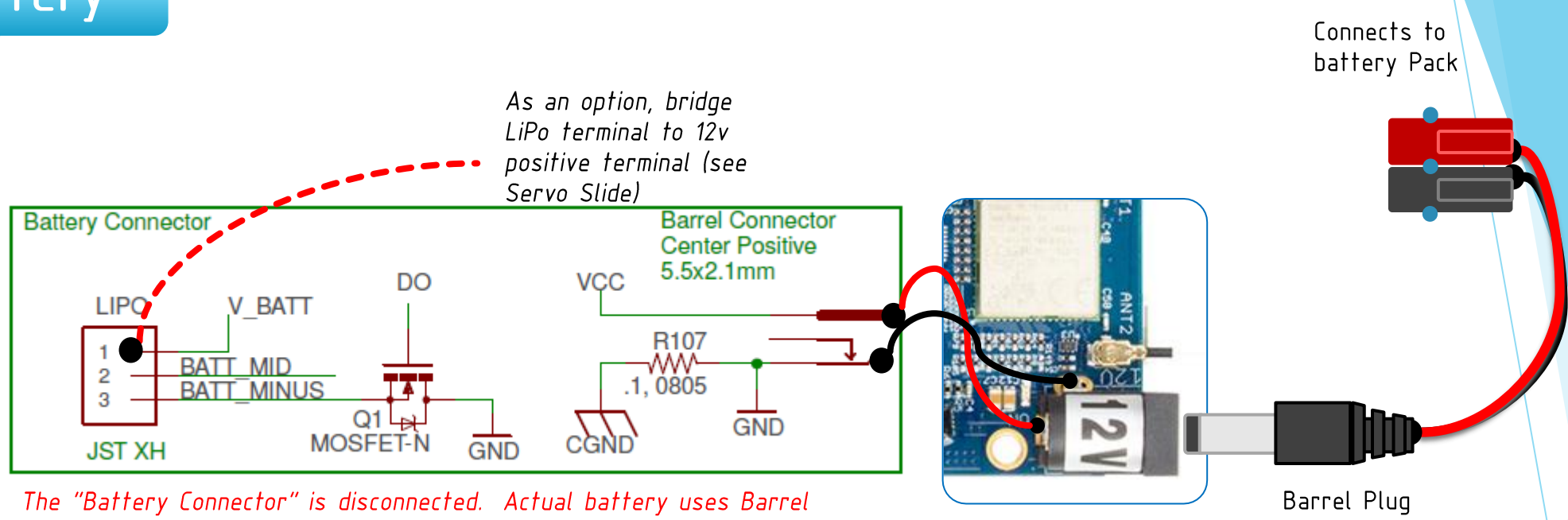
Battery



The "Battery Connector" is disconnected. Actual battery uses Barrel Connector.

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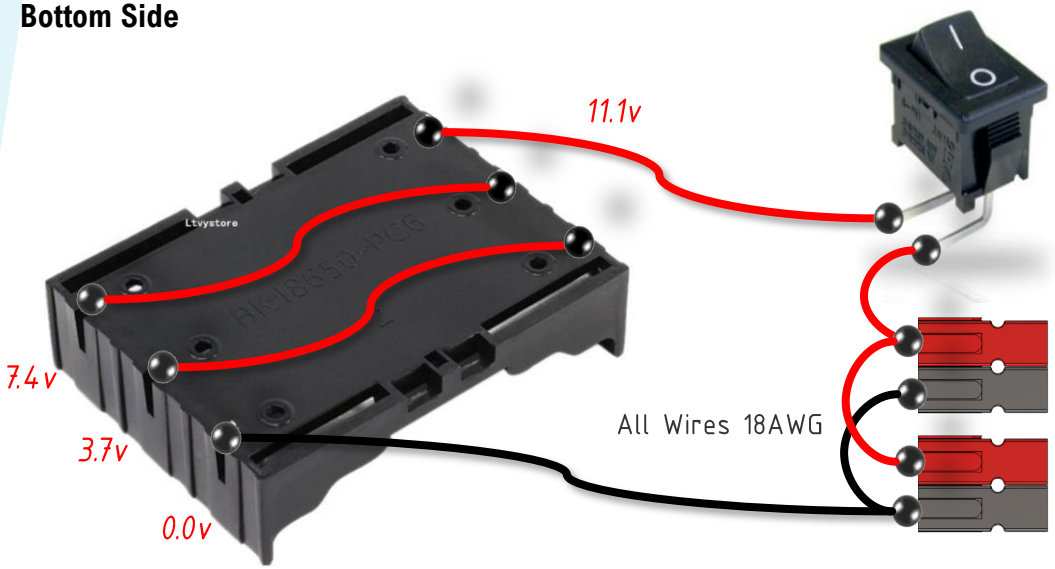
Battery Pack (version1 configuration)



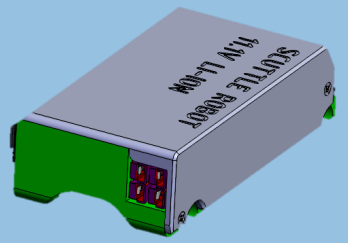
Switch PN:SRB22A2FBBNN
Carries 10A max

Two pairs of Anderson connectors are attached here.

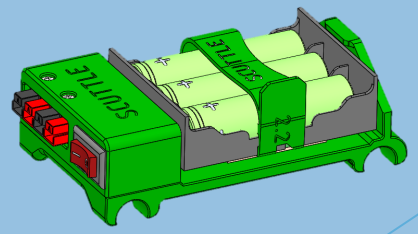
This battery pack was used through 2020.09. The wires are appropriate for the CAD designs posted prior to version 2.1.

You may build a battery pack without a Battery Management System (BMS) as shown here, or copy our latest design which includes BMS. See next slide.

Pack version 1
BMS: does not fit
Model on GrabCAD



Pack version 2
BMS: optional
Model on GrabCAD



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Battery Pack (v2, enhanced with BMS)

The BMS adds several functions to the battery pack. Charge overprotection, cell balancing, over-voltage protection, under-voltage protection, and more.

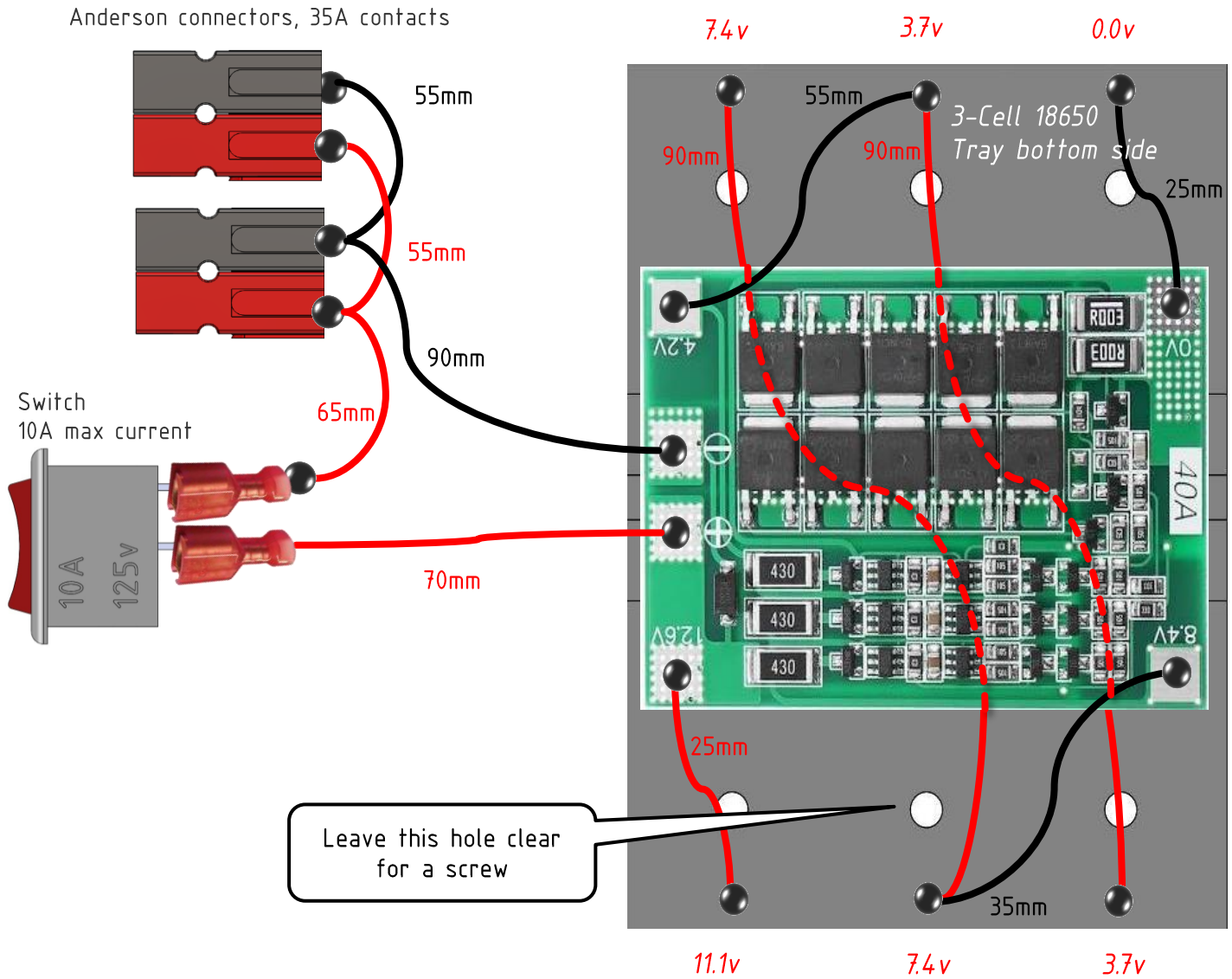

Table of wires to cut (11 total)

Length (mm)
25, 25
35, 35
55, 55
65
70
90, 90, 90

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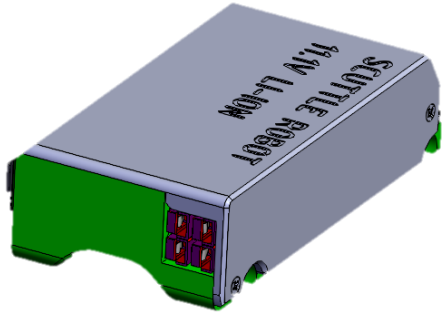
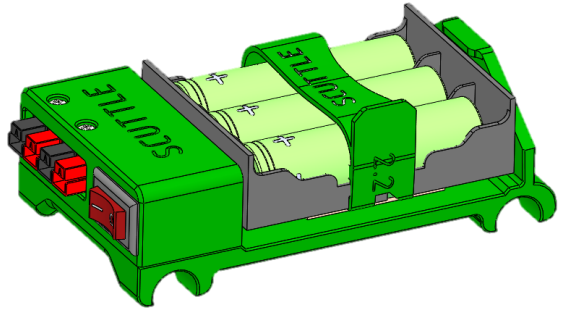
Battery Pack Styles

Pack version 1
- BMS: does not fit
- Model on GrabCAD
- Access CAD model from within SCUTTLE assembly



Pack version 2
- BMS: optional
- Model on GrabCAD
- Access the model as a standalone assembly



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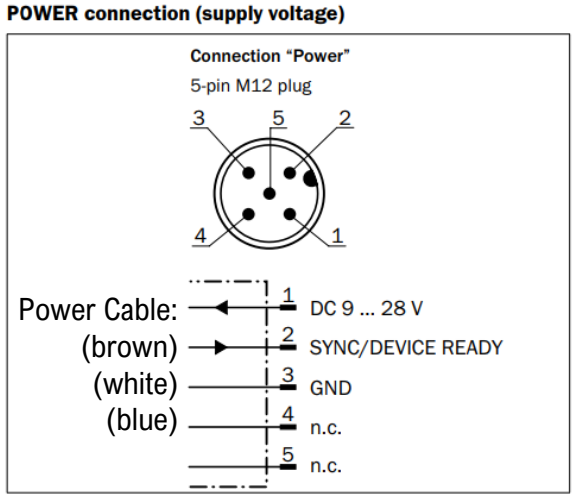
LIDAR

Lidar Device

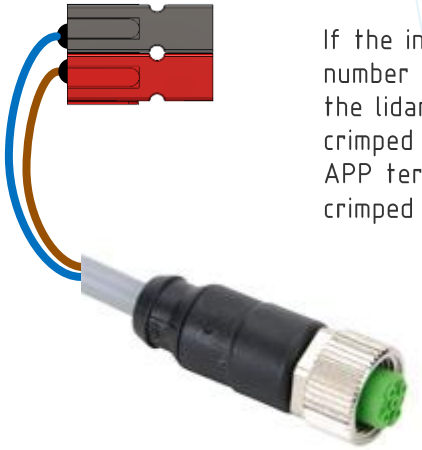
SICK TiM 561

Power Connector Diagram (lidar side)



LIDAR-side connector (male pins)

Power Cable Diagram (plugs into lidar)



If the indicated cable part number is used for power to the lidar, brown will be crimped into the 12v positive APP terminal and blue is crimped into the negative.

Cable: 7000-12241-2150300

Cable-side connector (female pins)

Typical Lidar power consumption: 2.1w

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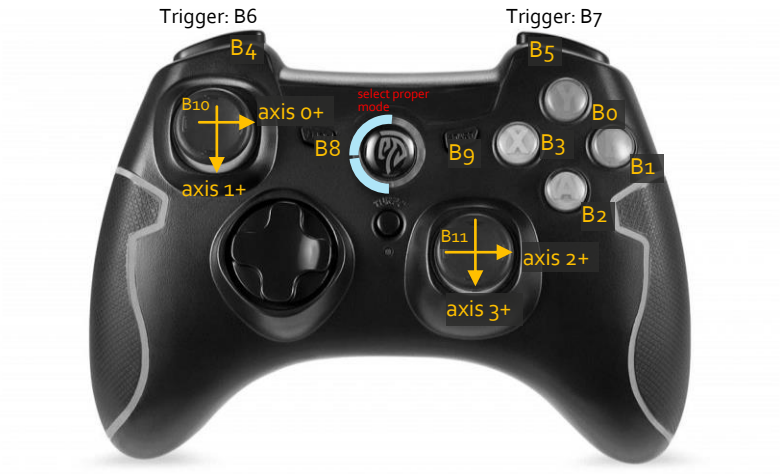
GamePad

Gamepad Controls Mapping



Button Behavior:

- not pressed: 0
- Pressed: 1

Axis behavior:

- Right returns positive values
- down returns positive values

- Outputs:
- Analog axes return values between -1 and 1
- These axes reach their limits before the hard-stop.
- To discover the behavior graphically, visit the html graphical test page here

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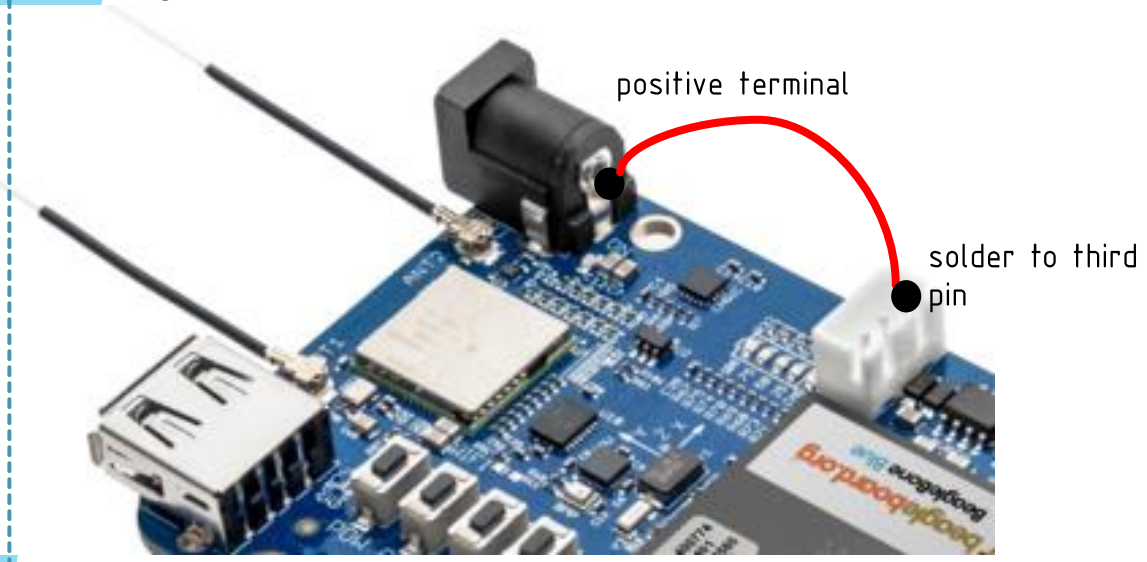
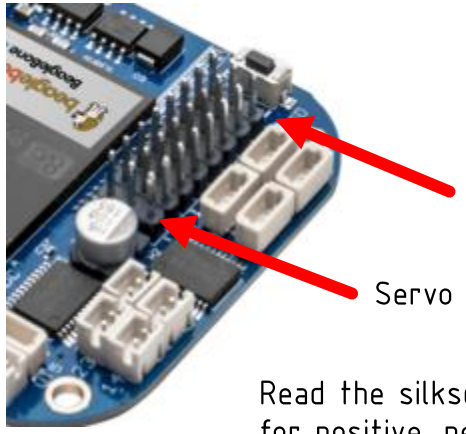
Servos

Bridge Power to the liPo connector



Without a power source available at the positive (third pin) input of the liPo connector, the board has insufficient current available to the servos to drive servos at full torque or to drive multiple servos.

A safe fix is to solder the positive terminal of the DC jack to the third pin of the connector shown. When a battery is connected, the pins correspond to 0.0v, 3.7v, and 7.2v terminals of a 2-cell lipo.



Read the silkscreen to see correct connector orientation for positive, negative, and signal.

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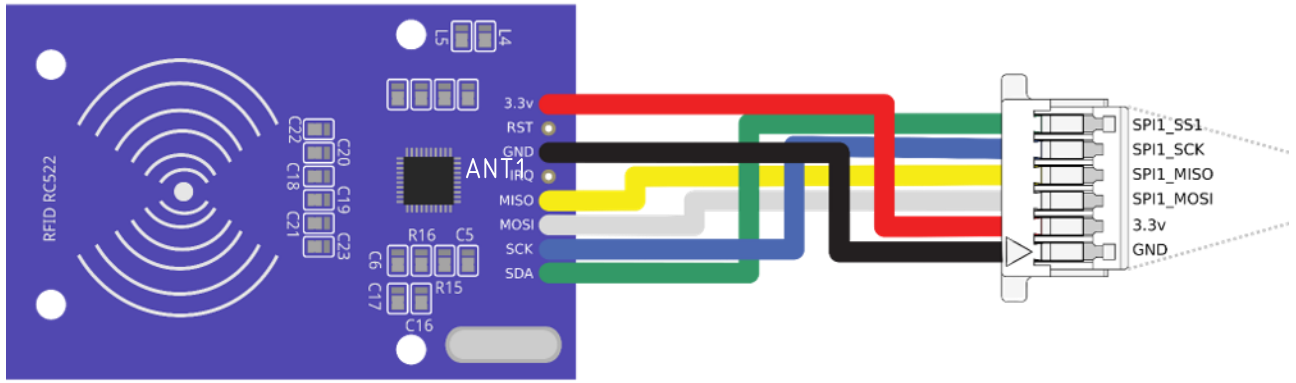
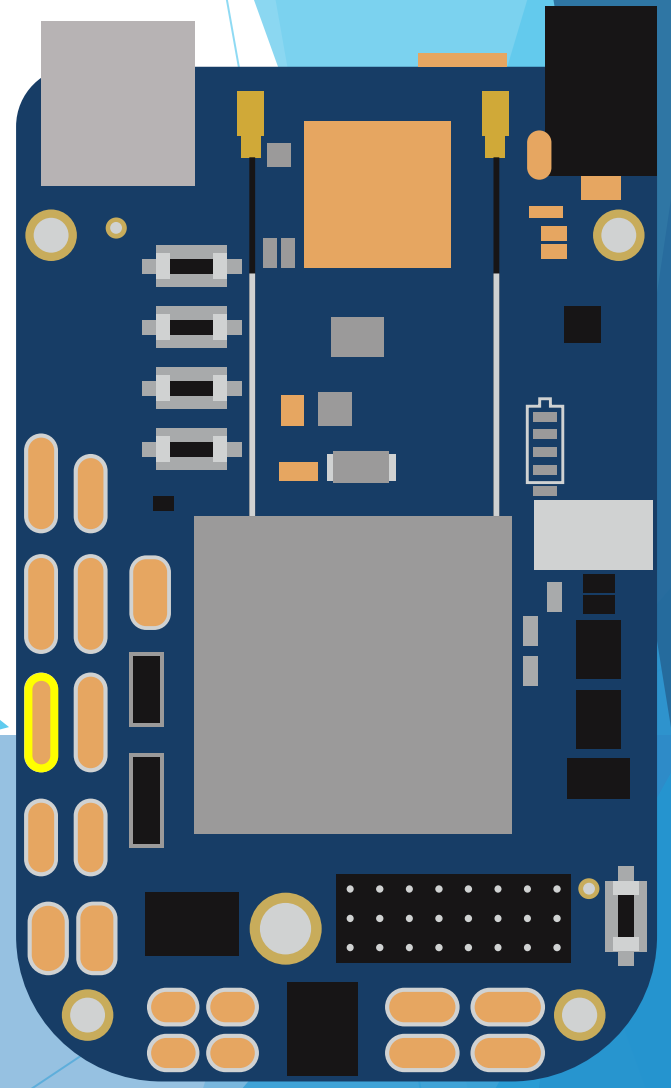
RFID reader

RC522 low-cost
RFID Scanner



Plug into 6-pin JST-SH
port on bbb.



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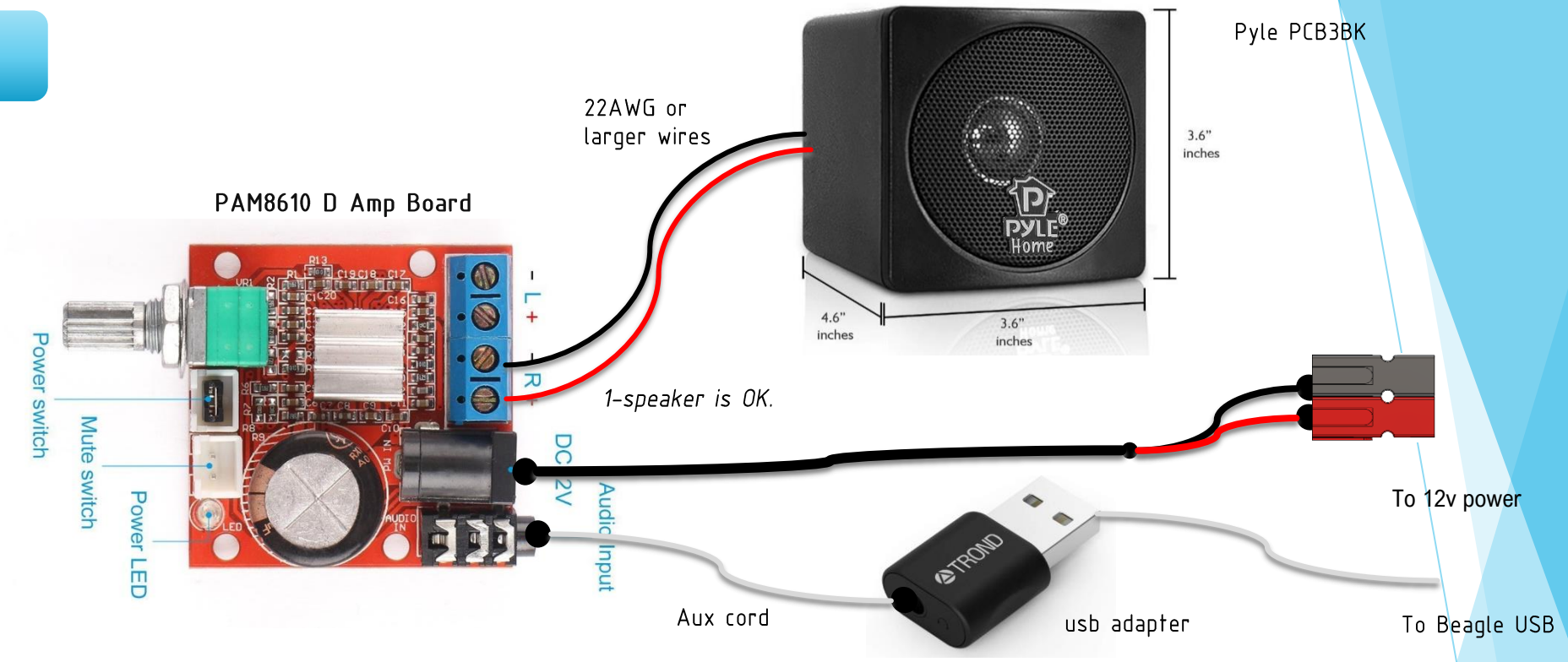
Audio Amp



Alternative:

The above setup will support at least 10 watts (this is actually quite loud – easy to hear in a crowded room).

It is also possible to find a speaker which receives BOTH power AND signal over USB. These will be more compact but less powerful. (The speaker shown is 3w max)

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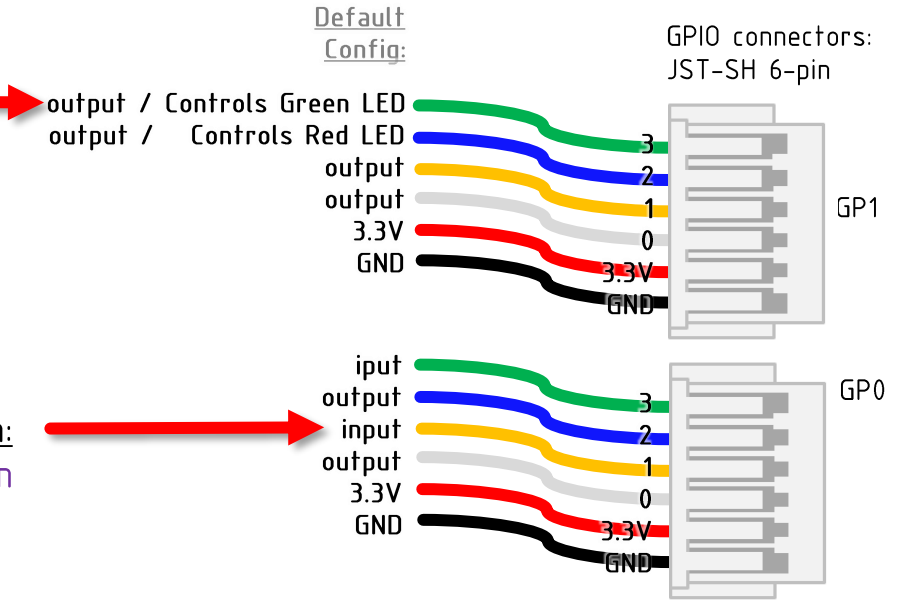
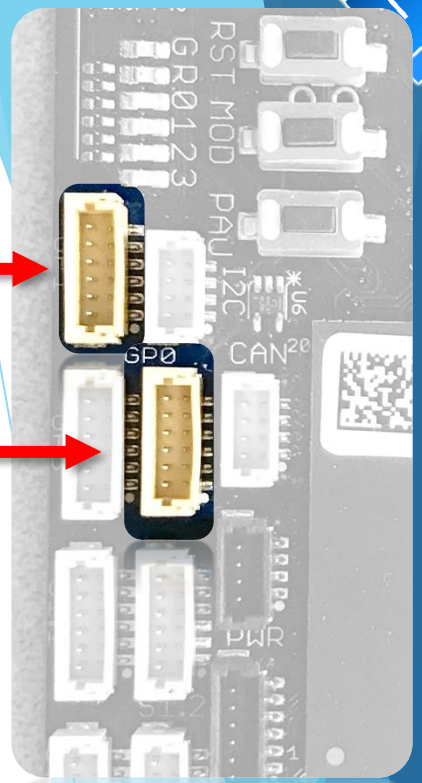
GPIO Connections

Example call for writing to this pin:
write(1,3,1) # arguments: port, pin, state

Example call for reading this pin:
read(0, 1) #arguments: port, pin



SCUTTLE naming convention (used in L1_gpio.py)



Note: JST wires don't come with the proper color sequence. They must be rearranged.

Connector vector image preserved for later use.

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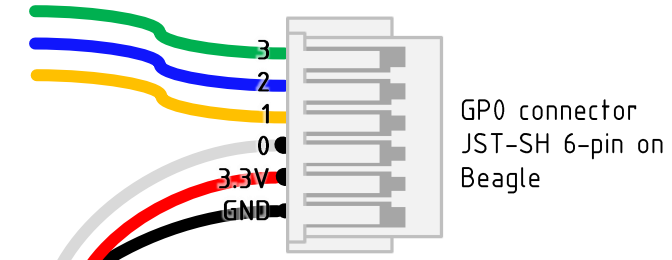
GPIO Example – Relay



GP0 connector
JST-SH 6-pin on
Beagle

Relays are appropriate for switching of high powered devices. For heavy pumps, motors, fans, or floodlights, it may be best to add a dedicated power source such as an ancilliary battery. Then, control the power to the device using logic-level signals and a relay or solid-state relay.

A great detailed writeup is here.

3v Relay with both Normally Open (NO) contact and Normally Closed (NC) contact.

This kind of board usually includes an opto-coupler and your powered device does NOT need to share a ground with your microcomputer. There are two circuits here, isolated from each other.

Heavy Duty Pump

Heavy Duty Power Supply

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Twin Relays (tested)

Successfully tested setup 2020.10.10

- Jumper pin is removed from Vcc pins
- Send GND and 5v to the device from Beaglebone PWR
- In our test, the 3.3v from Beagle was insufficient to drive the relays
- Our device was found to be active low although advertised as active high

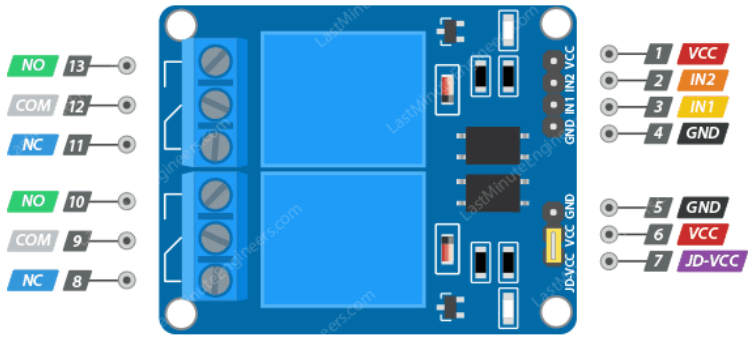
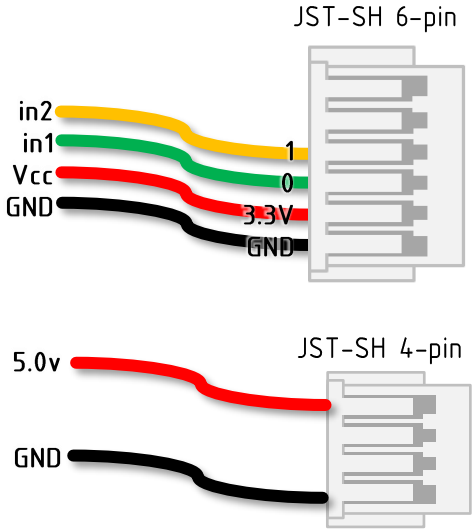
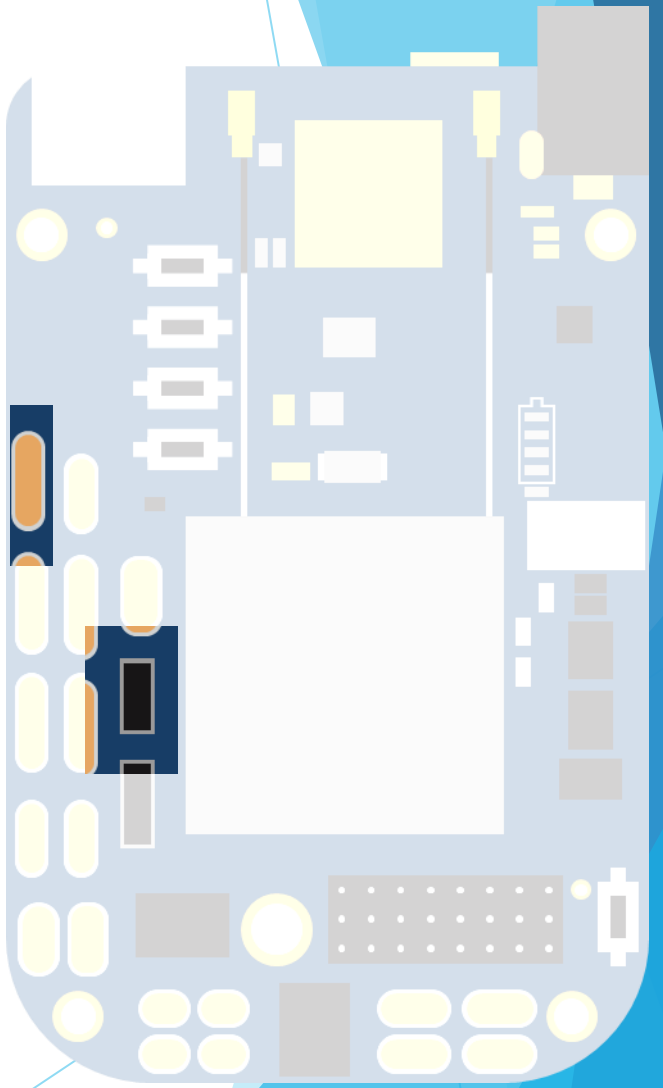


Image credit: Last Minute Engineers (visit)





The problem with active-low relays:
If you have an actuator which must not be actuated until the right moment, (such as a car horn we tested indoors) an active-low device may cause you trouble.

Unless the coil power is provided at the exact moment that the signal pin is driven high, there will be an actuation during startup. Consider this when you shop for a relay.

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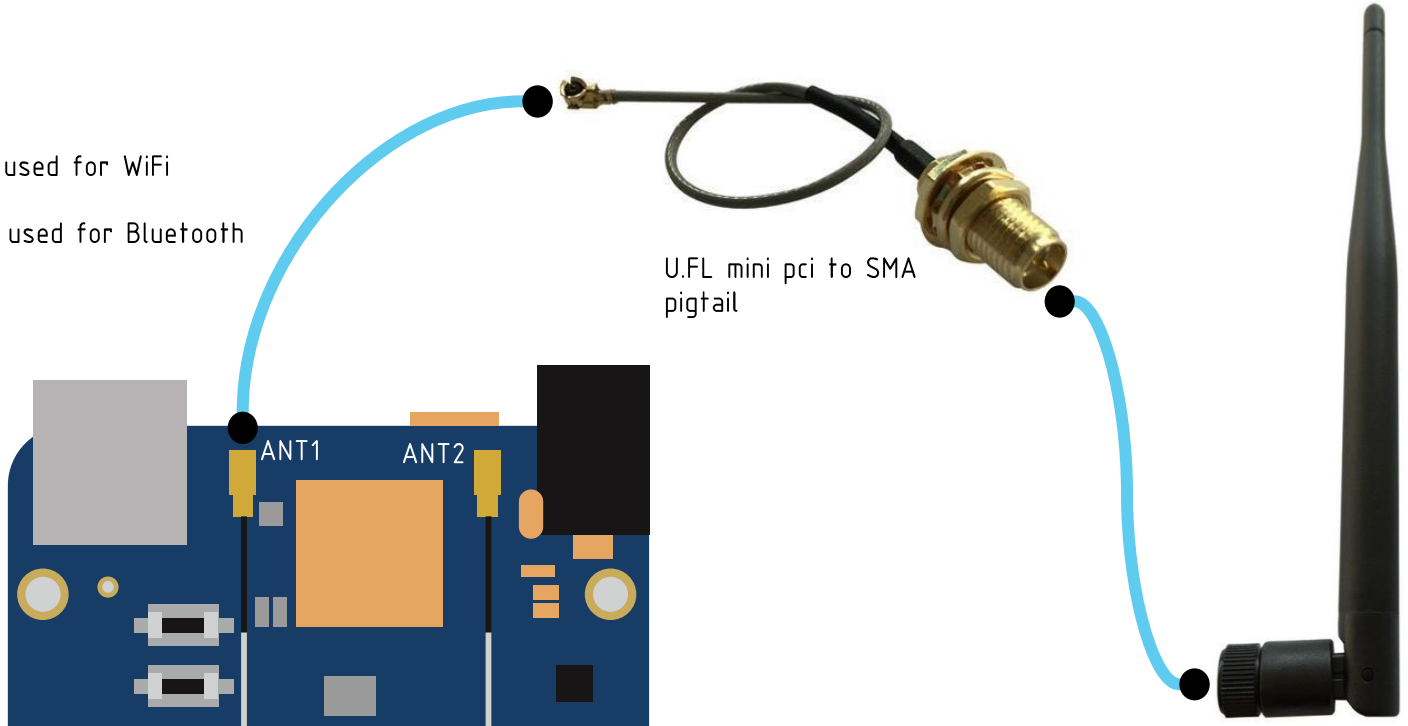
Wifi Antenna

Users can replace the small onboard antenna with their own selected antenna.

Antenna1 is used for WiFi

Antenna2 is used for Bluetooth



U.FL mini pci to SMA pigtail

6dBi antenna offers improved RSSI if pointed properly.

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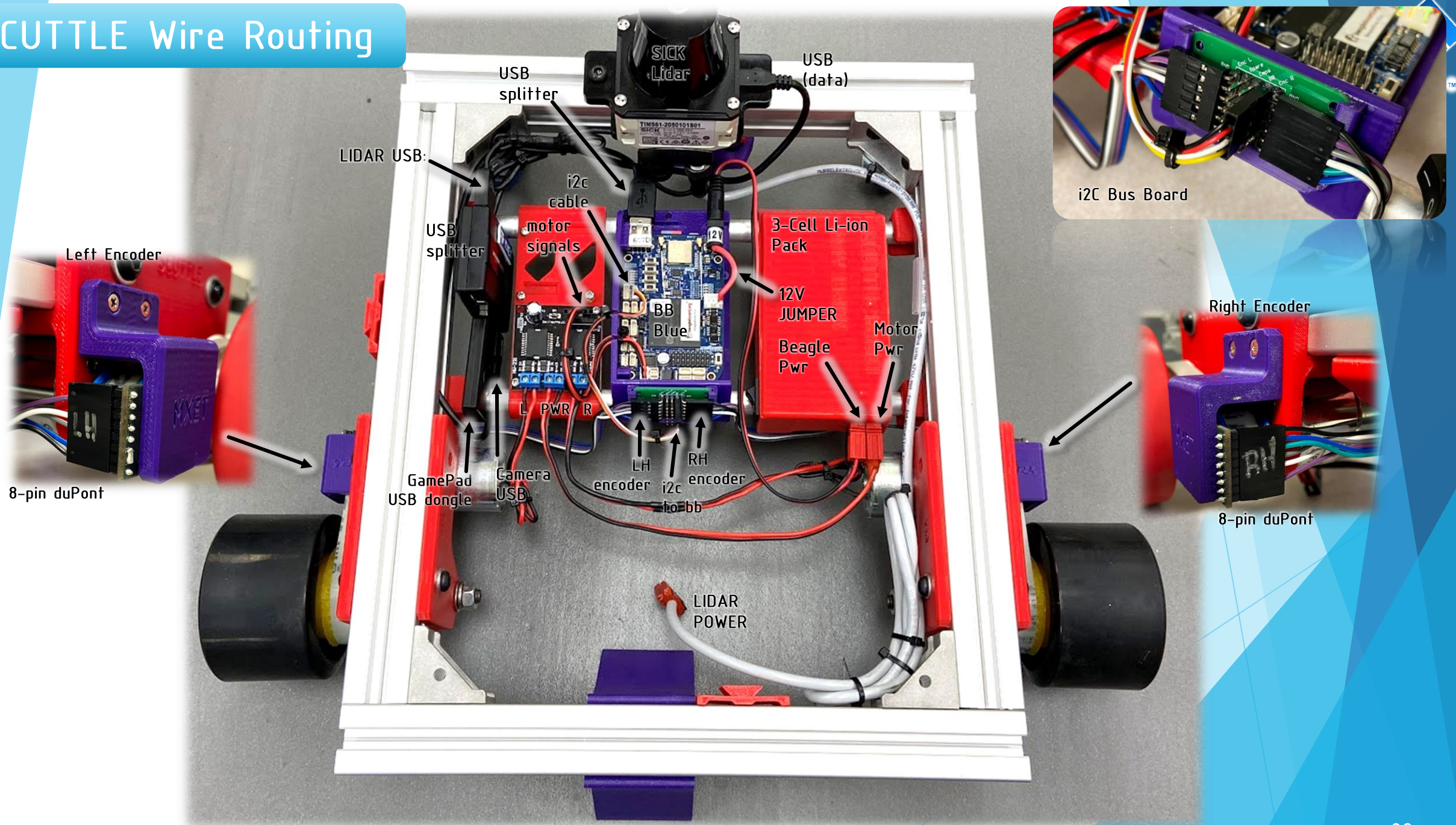
SCUTTLE Wire Routing



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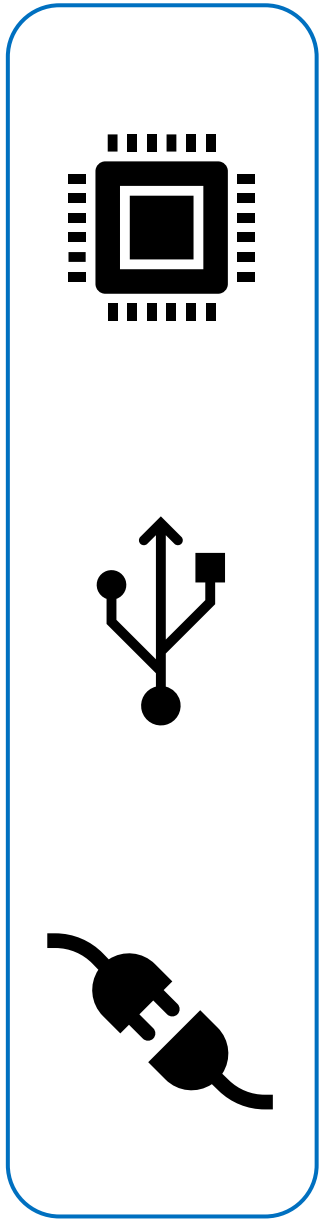

Wiring Guide Section 2

[Raspberry Pi] [Jetson Nano] [Edge AI]

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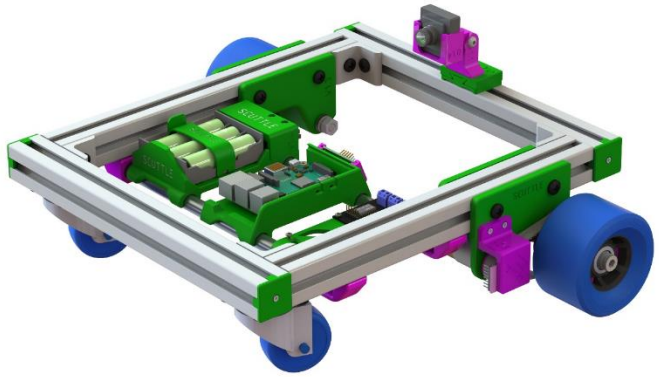
Pi Wiring Guide

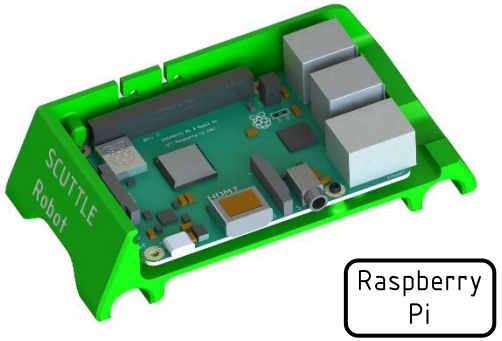
Contents:

This section covers single board computers (SBCs) that conform to the 40-pin header design from Raspberry Pi

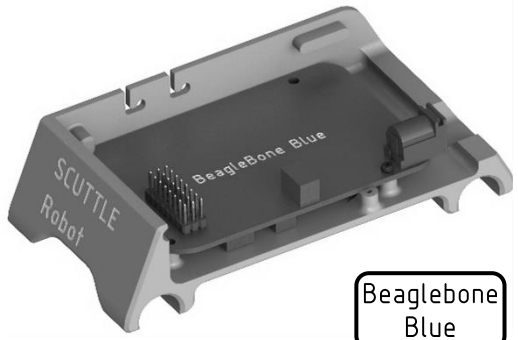
Note: Raspberry Pi was integrated after Beaglebone Blue. For wiring elements corresponding purely to the chassis, see Part 1.



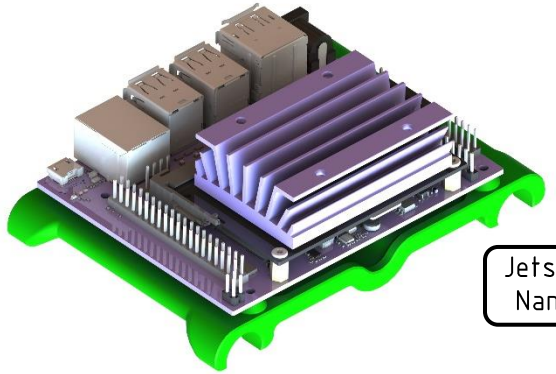
SCUTTLE Chassis



Raspberry Pi



Beaglebone Blue



Jetson Nano

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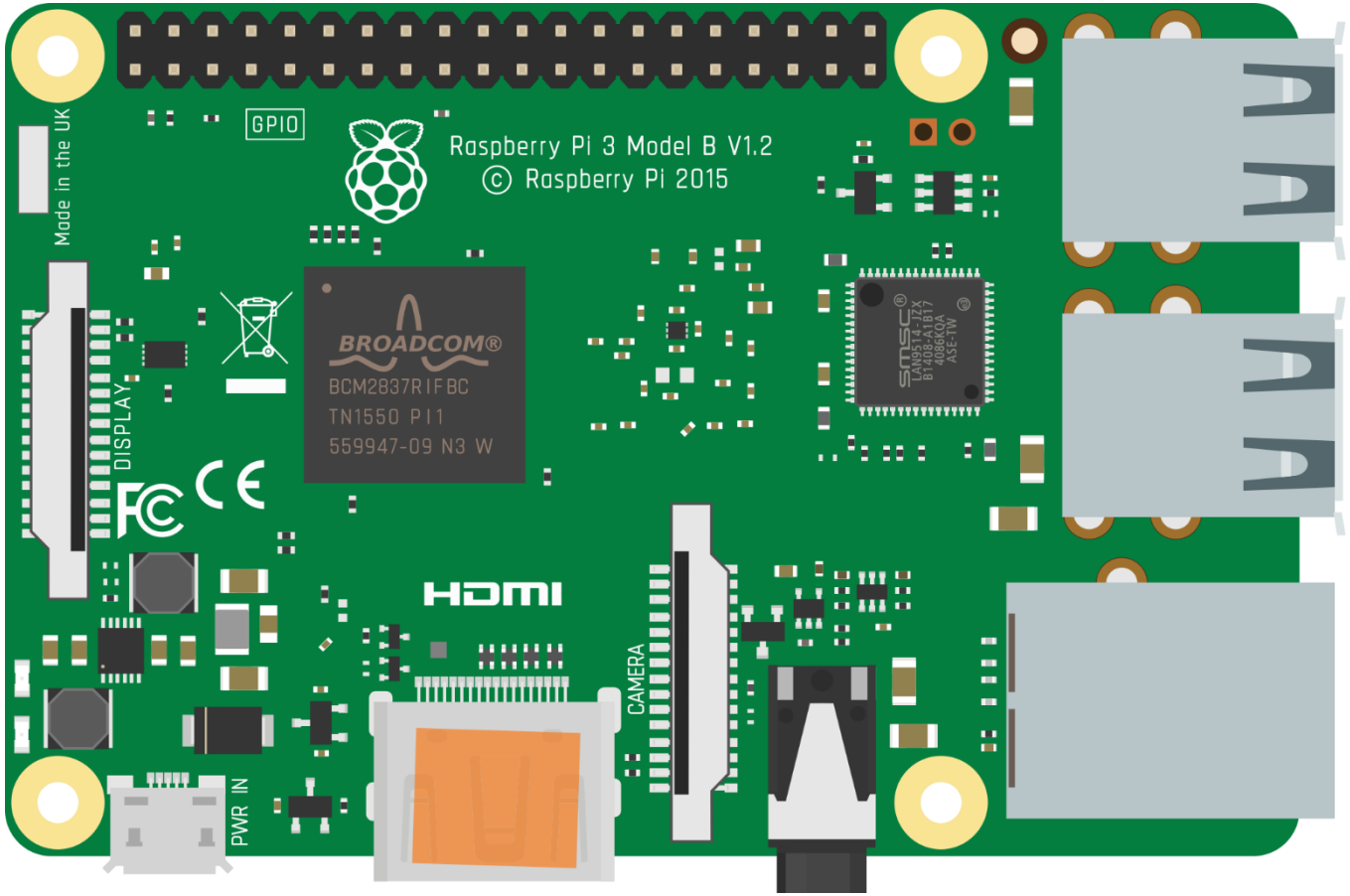
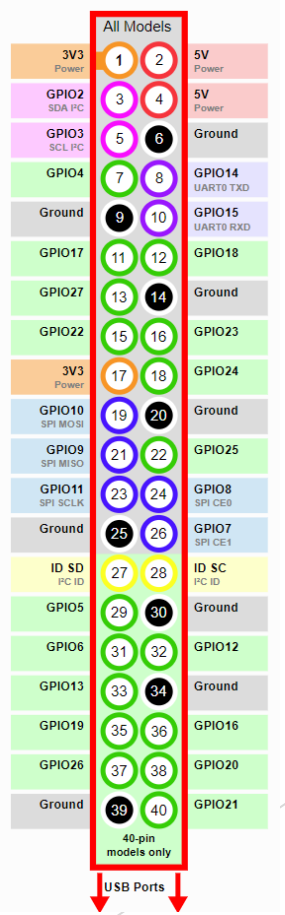
SCUTTLE Wiring Guide Pt2

Pi version 3B shown



Pin Number Convention



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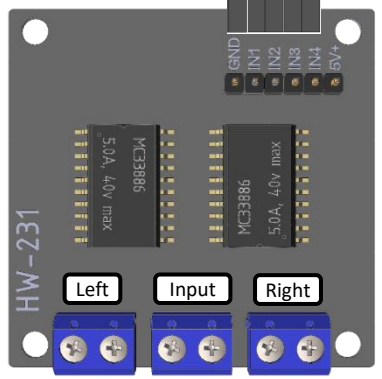
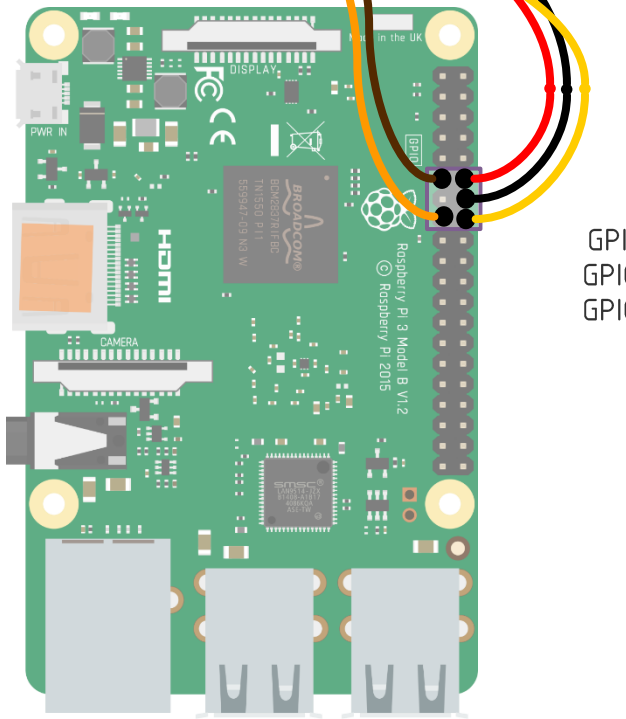
Pi – Motor Driver Signals

Keep the wires bonded together, if possible.

10cm cable

Top View
HW-231 Motor Driver





Pins on Pi

GPIO17	11	12	GPIO18
GPIO27	13	14	GND
GPIO22	15	16	GPIO23

See Motor Driver Power Wires slide for these connections.

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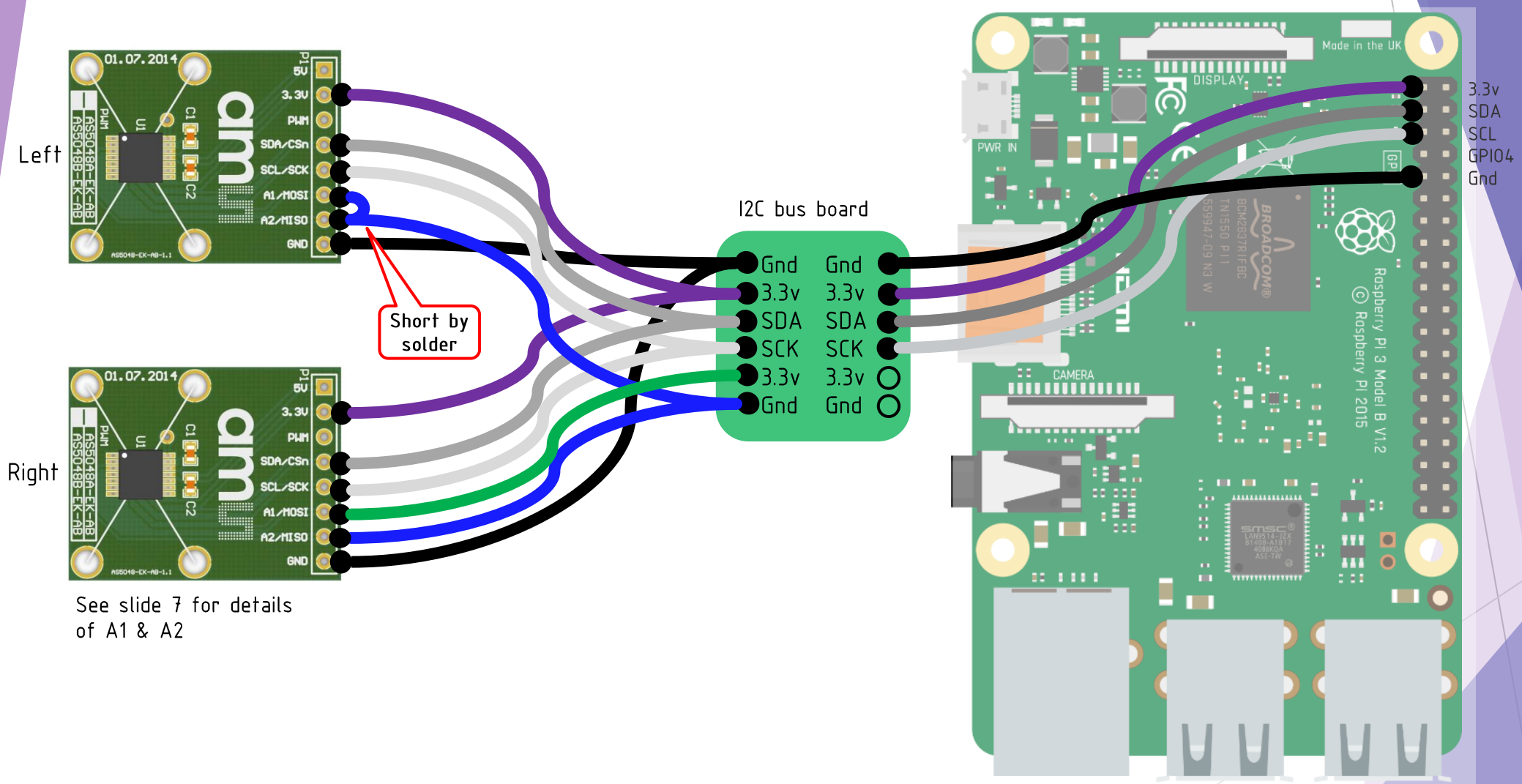
Pi - Encoder AMS AS5048 (I2C)



See slide 7 for details of A1 & A2

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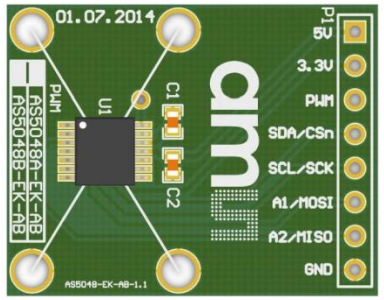
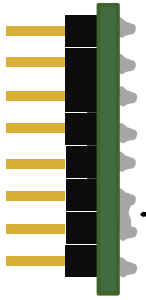
Encoder Details

Left Encoder



Front View



Side View

For the left-hand encoder, A1 AND A2 solder is bridged.

The i2c address is determined by the signals on A1 and A2 pins.

Left Hand Encoder A1 is pulled **down** to GND. I2C address is 0x40

Right Hand Encoder pin A1 is pulled **up** to 3.3v. I2C address is 0x41

	Pin A1	Pin A2	Resulting i2c address
Left Encoder	LOW	LOW	0x40
Right Encoder	LOW	HIGH	0x41

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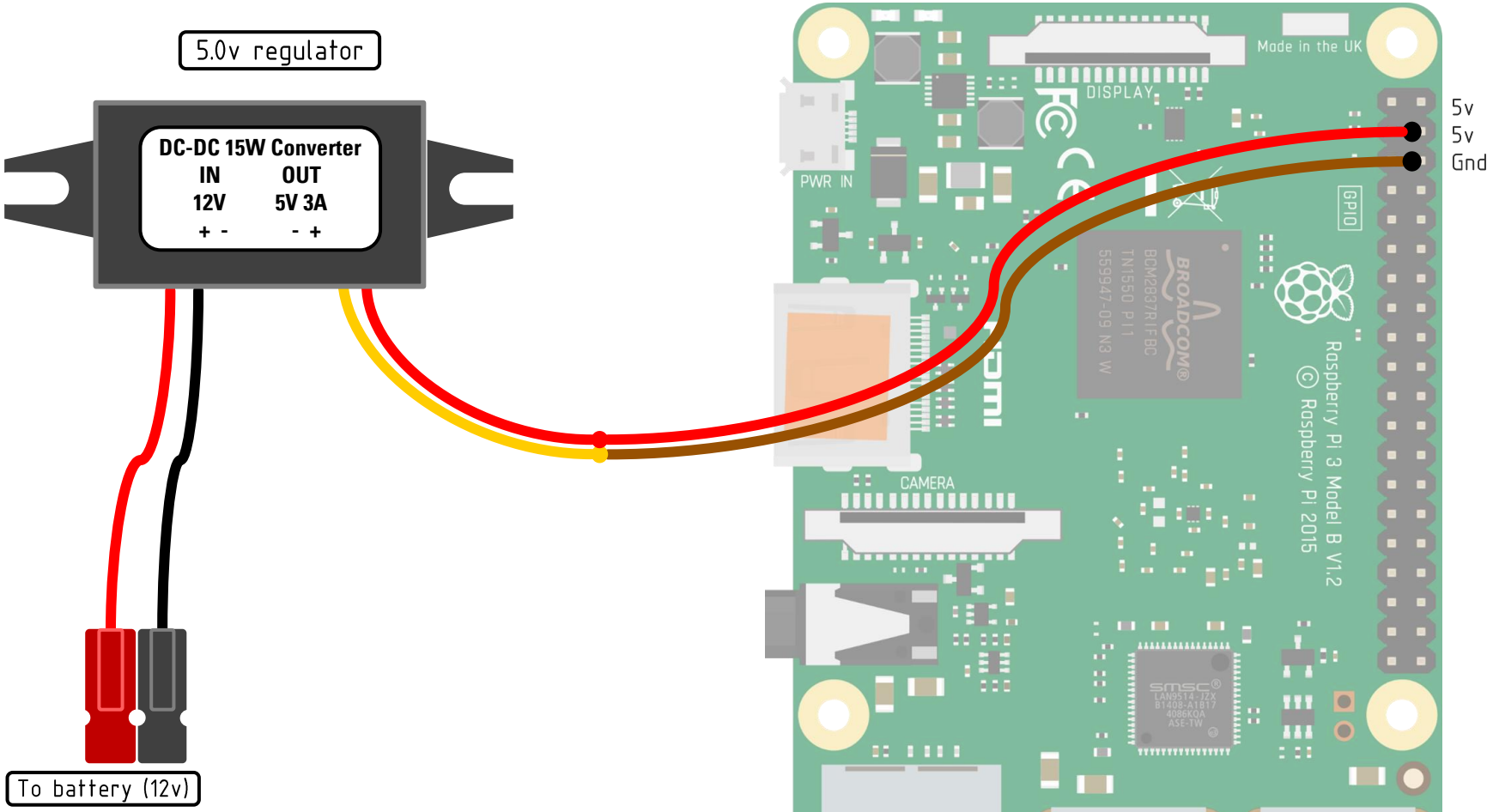
Pi - Power Supply



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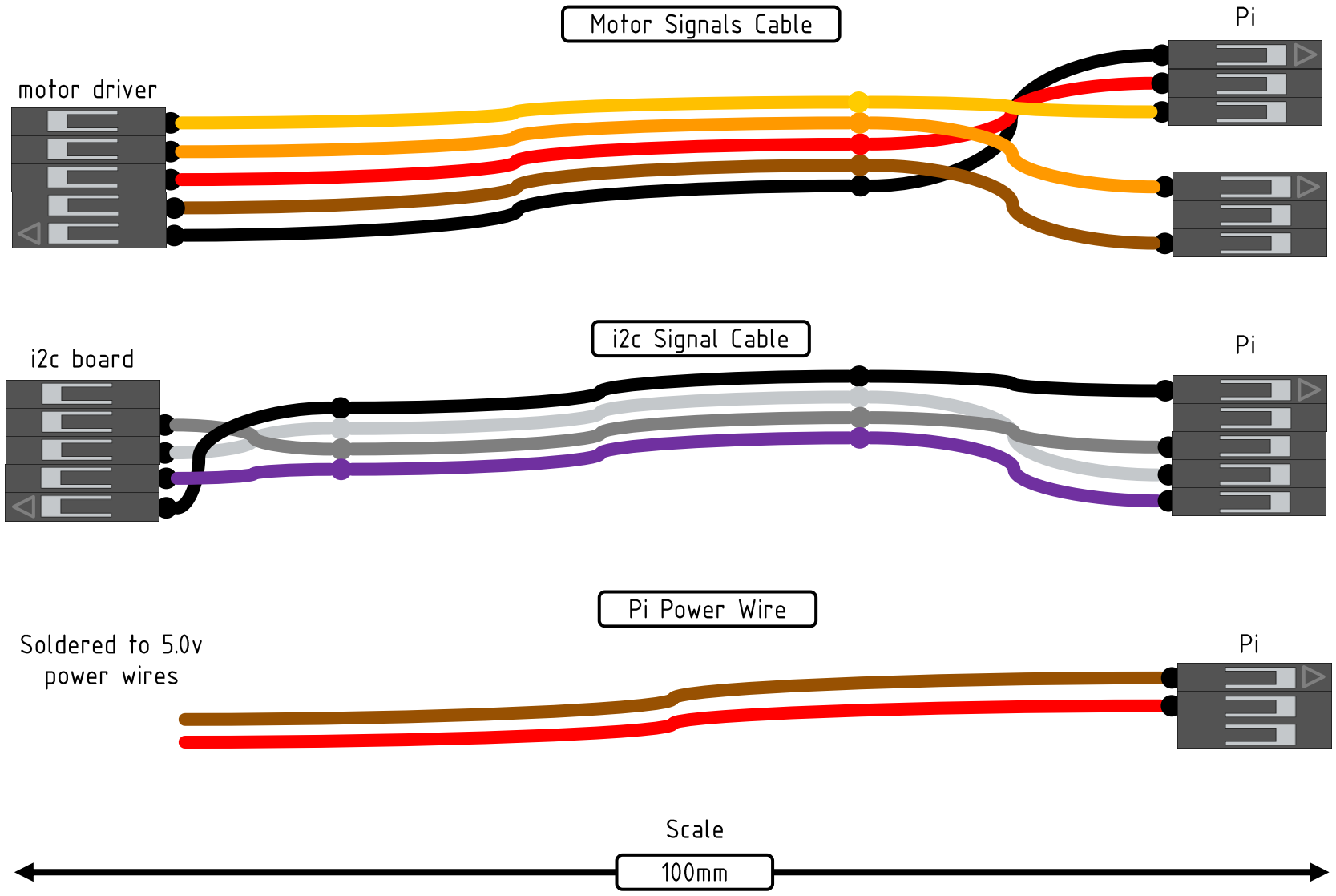
Dupont Cables



Guidelines:

Ground: When possible, insert the ground in the housing pin with the arrow.

Opening: Make the opening face the outside of the Pi headers when plugged in. This makes it easier to probe.

Bonding: Do not peel the wires apart unless you must. Keep wires bonded for strength

Pin Groups: Always use grouped housings instead of individuals. Then, the cable resists tugging, unplugging, and bending male pins.

Tug Test: After inserting pins into housings, lightly tug each pin to ensure it is locked in.

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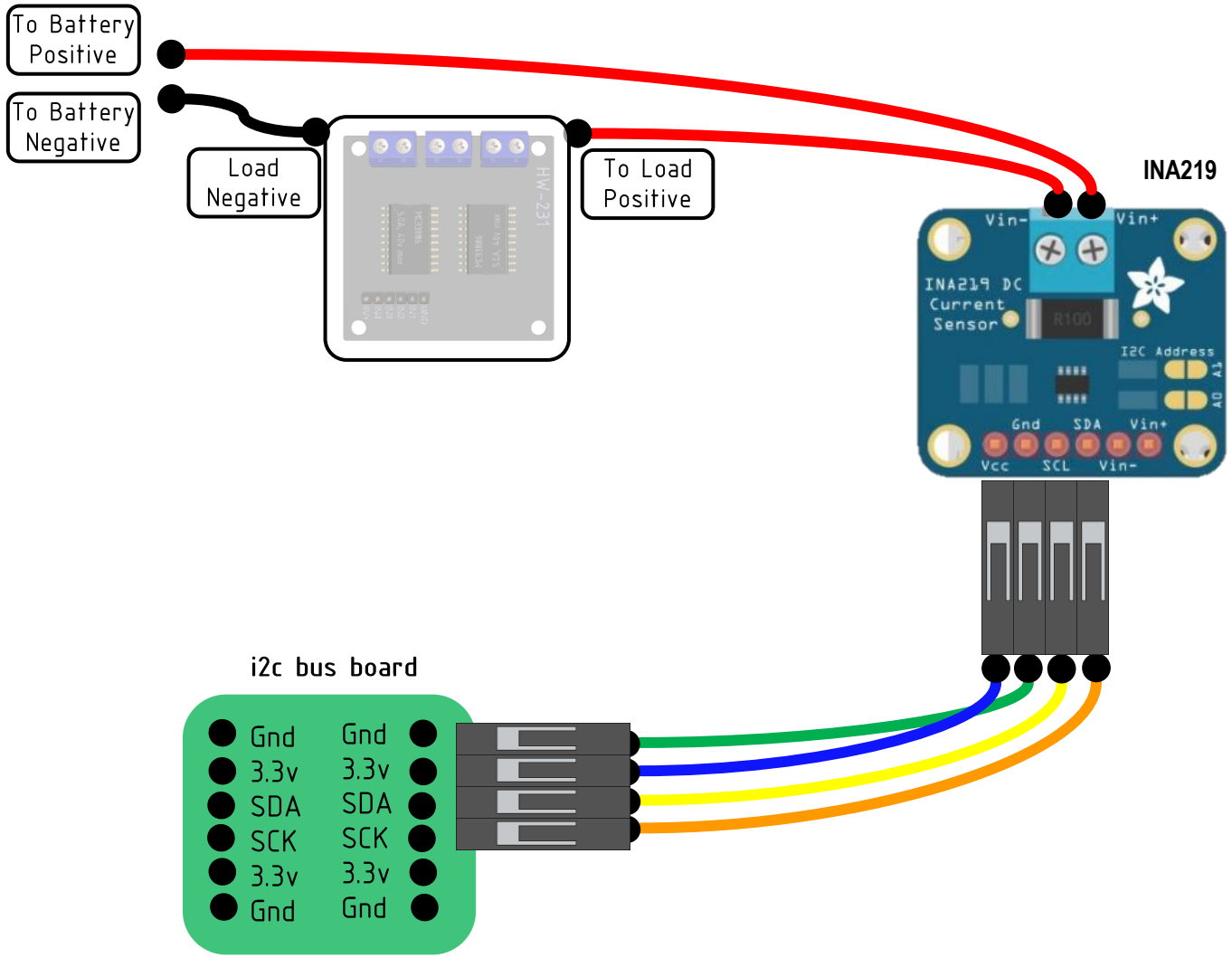
Voltage Meter – Adafruit INA219

This sensor can measure current and voltage.



Study an Example like this one if you plan to measure current.

Set the i2c address to 0x44 by bridging the A1 contact with solder. See this guide for details.

The default Address of 0x40 would interfere with the encoders.

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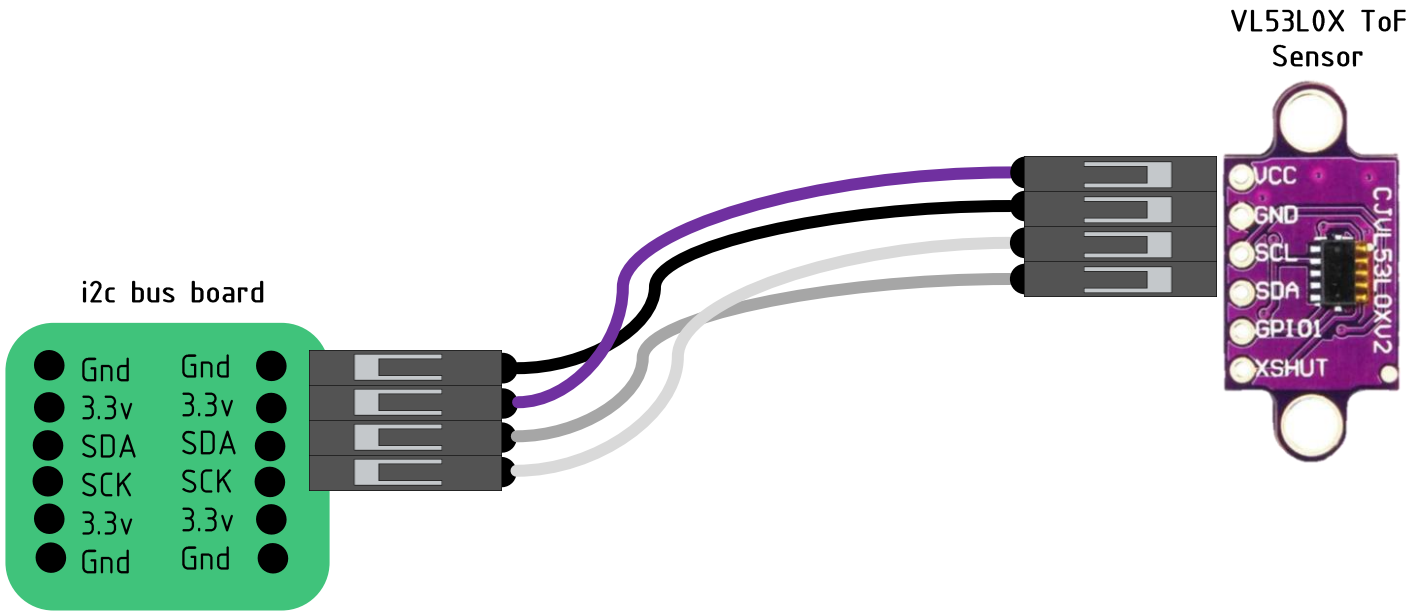
Distance Sensor – VL53L0X

This is a time-of-flight distance sensor.



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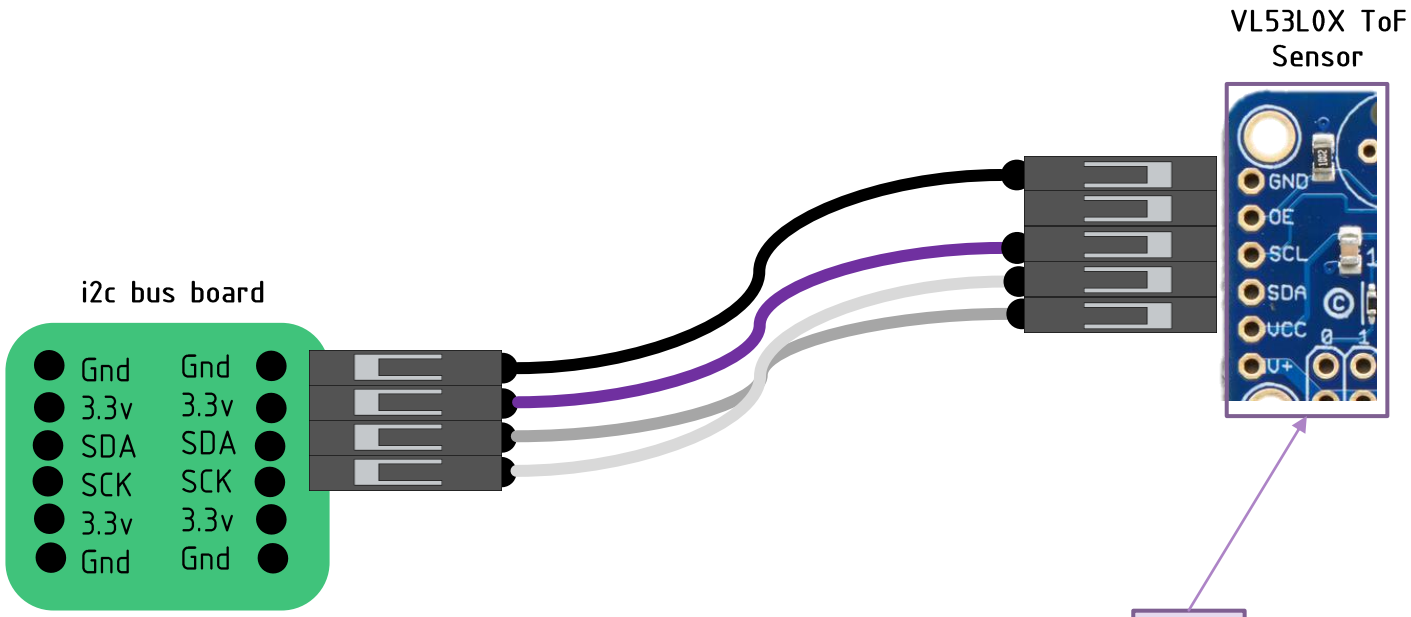
PWM Driver – PCA9685

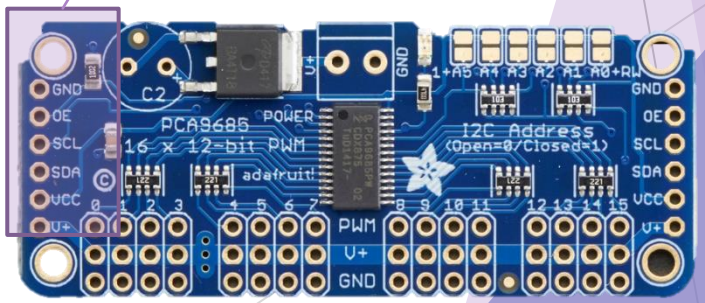
This is a driver for PWM signals (servos or other)



Learn more here on adafruit.

Set the i2c address to 0x44 found in the User Manual PDF.
Bridge A1 with solder to set address 0x42 (recommended).

The default Address of 0x40 would interfere with the encoders.



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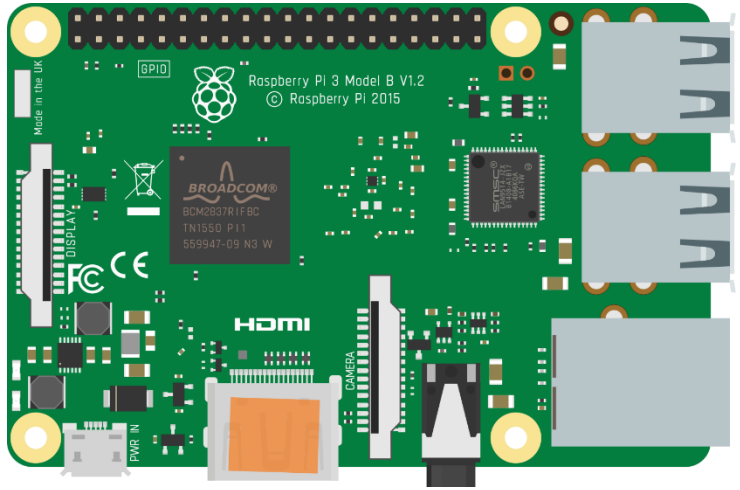
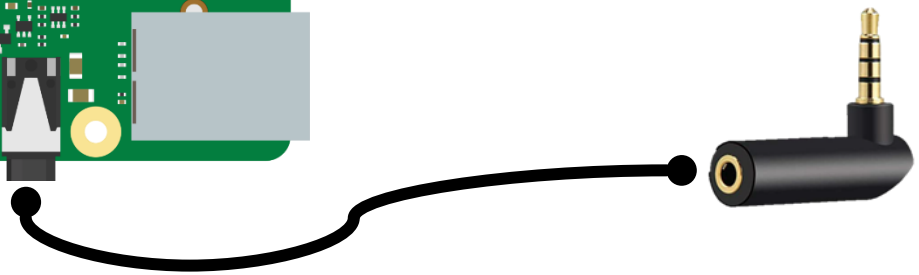
Pi - Configuration for remo.tv

Coming for this slide: configuration of hardware on RasPi B 3+, Linux default device numbers for branded speakers, and text-to-speech selection (ie, alsamixer).



We recommend a speaker that receives power AND signals from the USB port.



If you need to use an Aux cord, a right-angle adapter can keep your wires neat.

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Jetson Nano Wiring

Jetson Nano Pin Assignment Table

Sysfs GPIO	Name	Pin	Pin	Name	Sysfs GPIO
	3.3 VDC *Power*	1	2	**5.0 VDC** *Power*	
	I2C_2_SDA *I2C Bus 1*	3	4	**5.0 VDC** *Power*	
	I2C_2_SCL *I2C Bus 1*	5	6	**GND**	
gpio216	**AUDIO_MCLK**	7	8	**UART_2_TX** */dev/ttyTHS1*	
	GND	9	10	**UART_2_RX** */dev/ttyTHS1*	
gpio50	**UART_2_RTS**	11	12	**I2S_4_SCLK**	gpio79
gpio14	**SPI_2_SCK**	13	14	**GND**	
gpio194	**LCD_TE**	15	16	**SPI_2_CS1**	gpio232
	3.3 VDC *Power*	17	18	**SPI_2_CS0**	gpio15
gpio16	**SPI_1_MOSI**	19		**GND**	
gpio17	**SPI_1_MISO**	21	22	**SPI_2_MISO**	gpio13
gpio18	**SPI_1_SCK**	23	24	**SPI_1_CS0**	gpio19
	GND	25	26	**SPI_1_CS1**	gpio20
	I2C_1_SDA *I2C Bus 0*	27	28	**I2C_1_SCL** *I2C Bus 0*	
gpio149	**CAM_AF_EN**	29	30	**GND**	
gpio200	**GPIO_PZ0**	31	32	**LCD_BL_PWM**	gpio168
gpio38	**GPIO_PE6**	33	34	**GND**	
gpio76	**I2S_4_LRCK**	35	36	**UART_2_CTS**	gpio51
gpio12	**SPI_2_MOSI**	37	38	**I2S_4_SDIN**	gpio77
	GND	39	40	**I2S_4_SDOUT**	gpio78

40 Pin Array on Jetson Nano

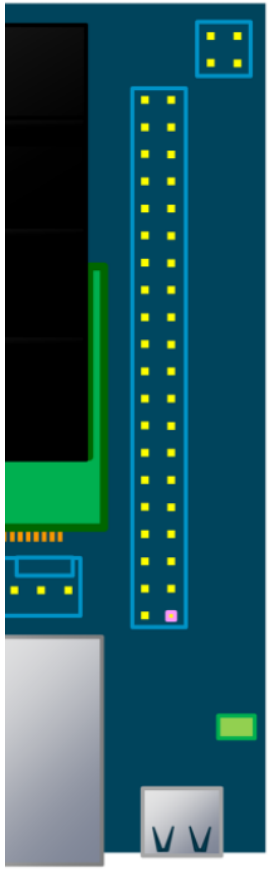

Diagram from Jetsonhacks.com

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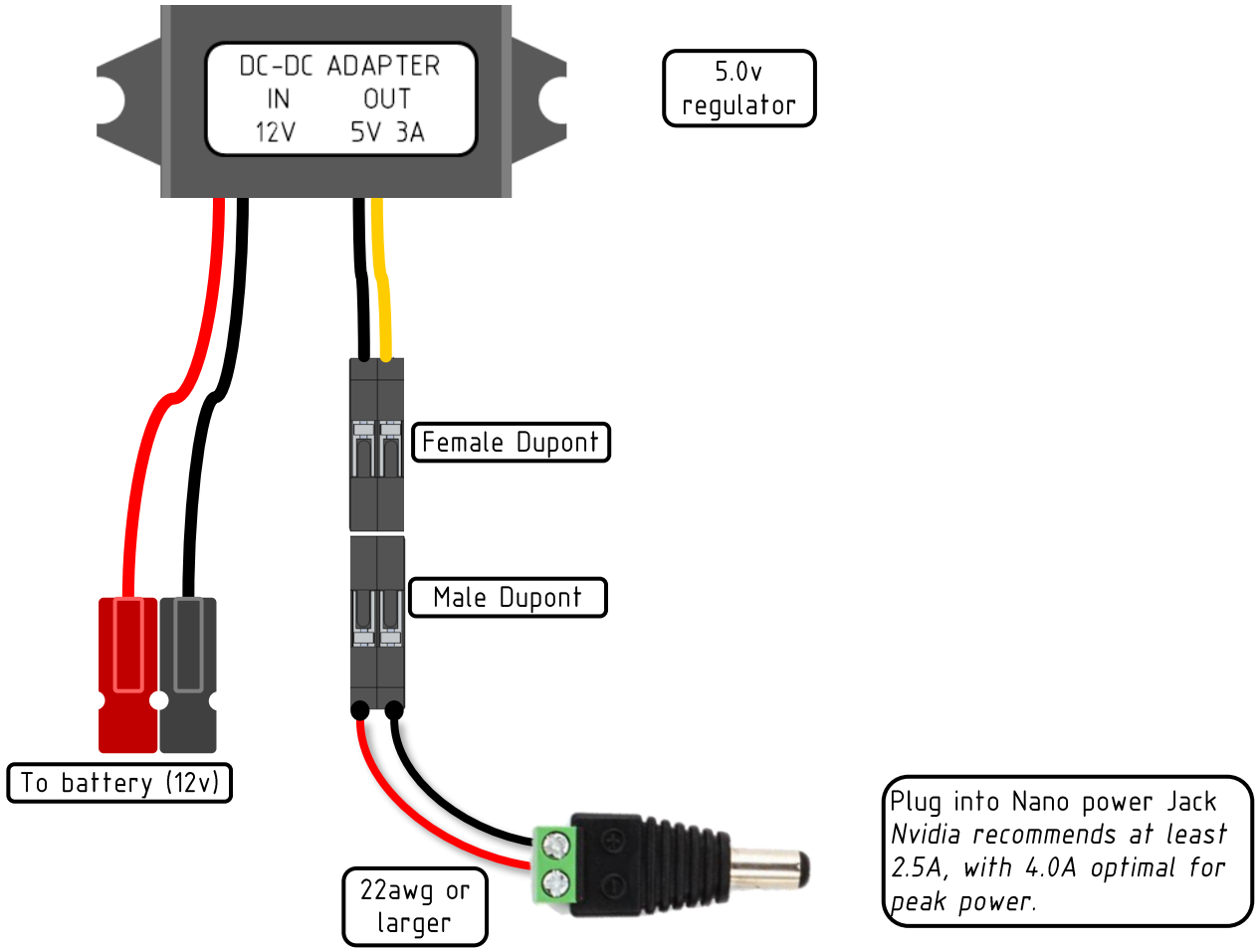
Jetson Nano - power

Diagram for powering Jetson Nano



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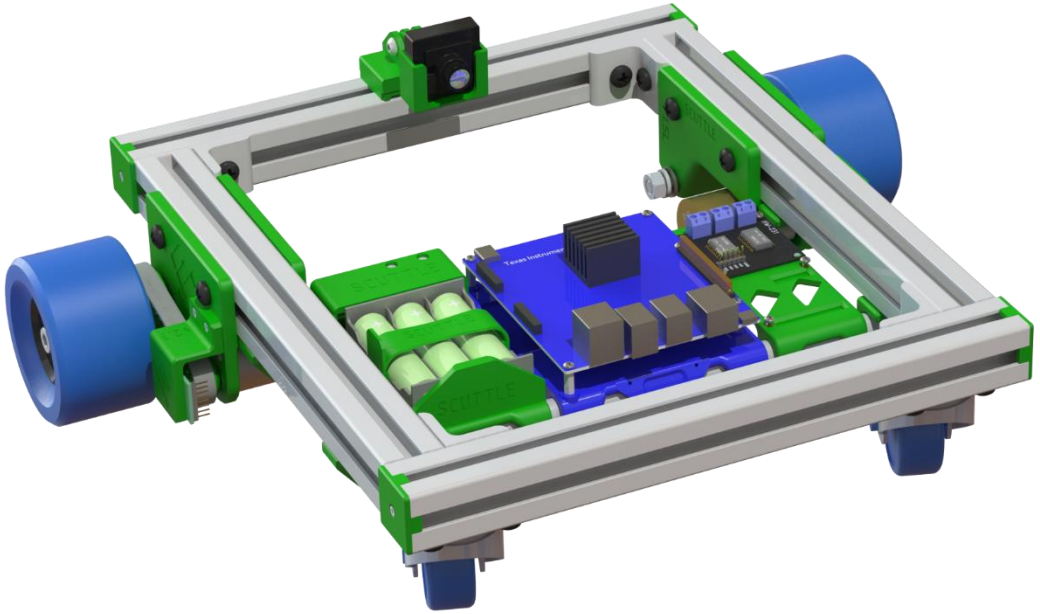
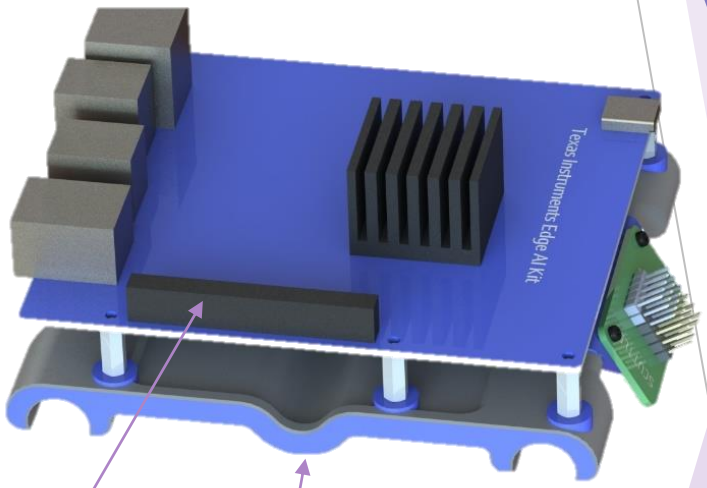
TDA4VM Edge AI Board

Jump to Main TDA4VM SCUTTLE Resources

SCUTTLE Equipped with TI TDA4VM kit





SCUTTLE i2c bus board

40-Pin Header (matching Pi)

Edge AI Bracket

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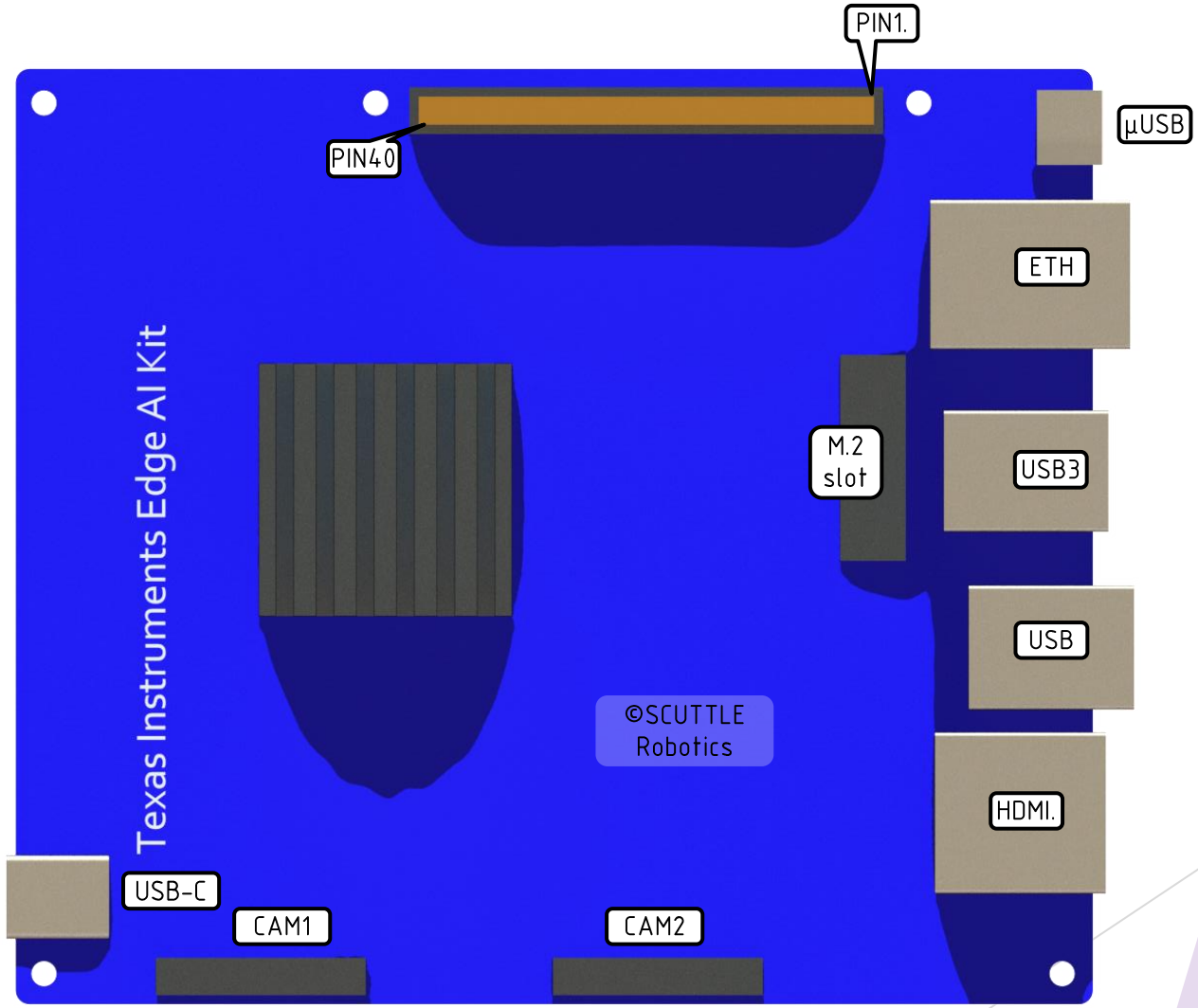
TDA4VM – Pinout

Main header pinout for TI board matches Raspberry Pi

	PIN		
Power_3.3	1	2	Power_5.0
I2C_SDA	3	4	Power
I2C_SCL	5	6	GND
GPIO	7	8	UART_TXD
GND	9	10	UART_RXD
GPIO	11	12	I2S_SCLK
GPIO	13	14	GND
GPIO	15	16	GPIO
Power_3.3	17	18	GPIO
SPI_MOSI	19	20	GND
SPI_MISO	21	22	GPIO
SPI_SCLK	23	24	SPI_CS0
GND	25	26	SPI_CS1
ID_SDA	27	28	ID_SCL
GPIO	29	30	GND
GPIO	31	32	PWM0
PWM1	33	34	GND
I2S_FS	35	36	GPIO
GPIO	37	38	I2S_DIN
GND	39	40	I2S_DOUT



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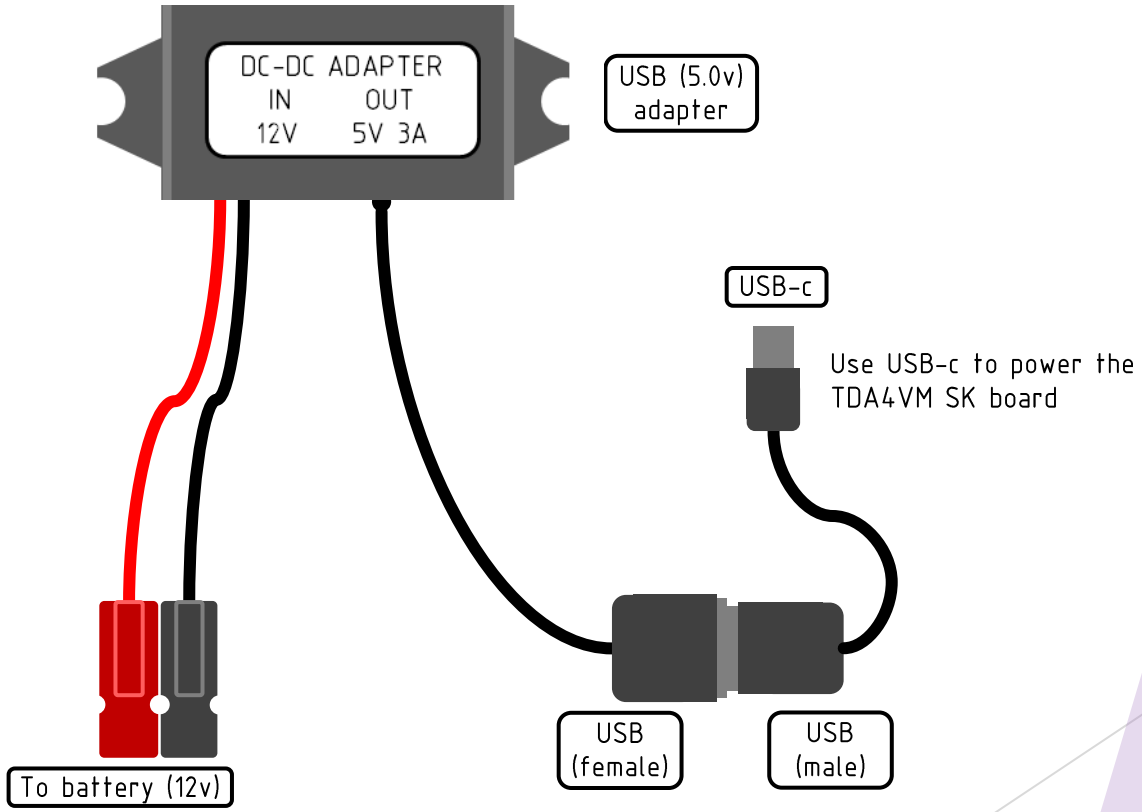
TDA4VM – Power

You can use the standard SCUTTLE battery pack and adapter to power the TI board, but power will be limited. The battery pack can generate up to 60 watts, but the standard adapter is limited to about 10watts effectively.

Note on usb-c: you can shop for USB-c power adapters that deliver 9 to 12v over usb-c for peak performance. The setup shown is limited to 5v output.

Example Power supply selected by TI engineering team on Amazon

Diagram for powering Edge AI Board



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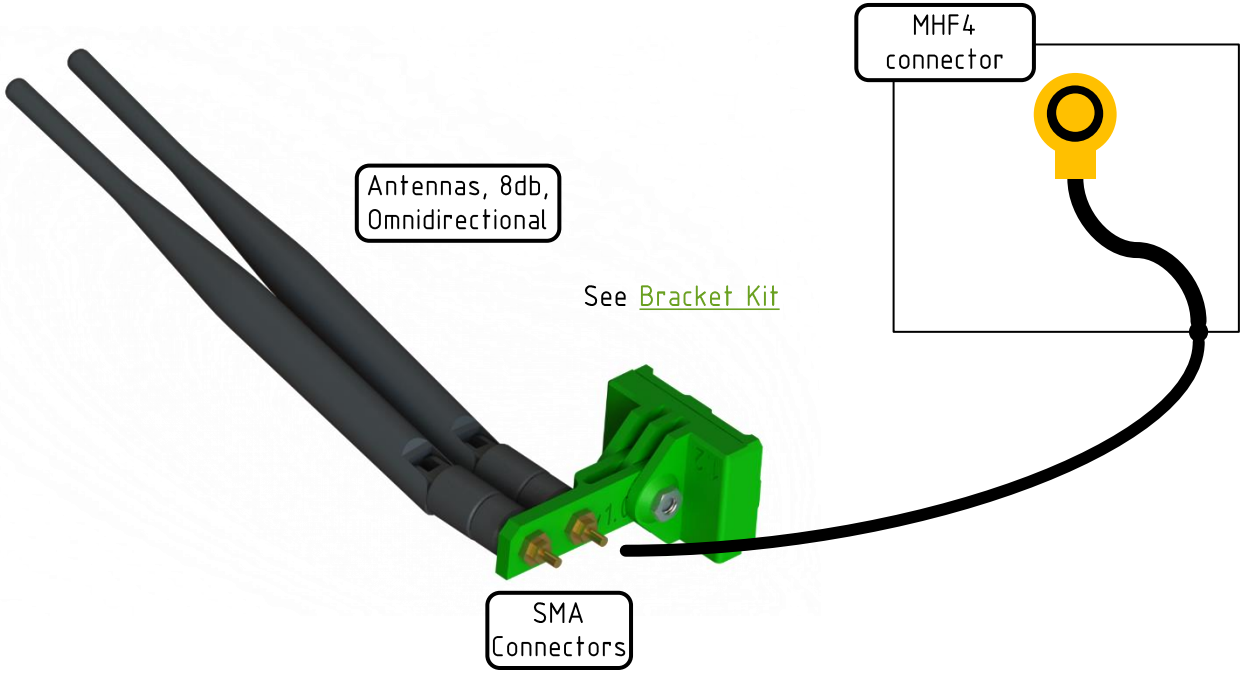
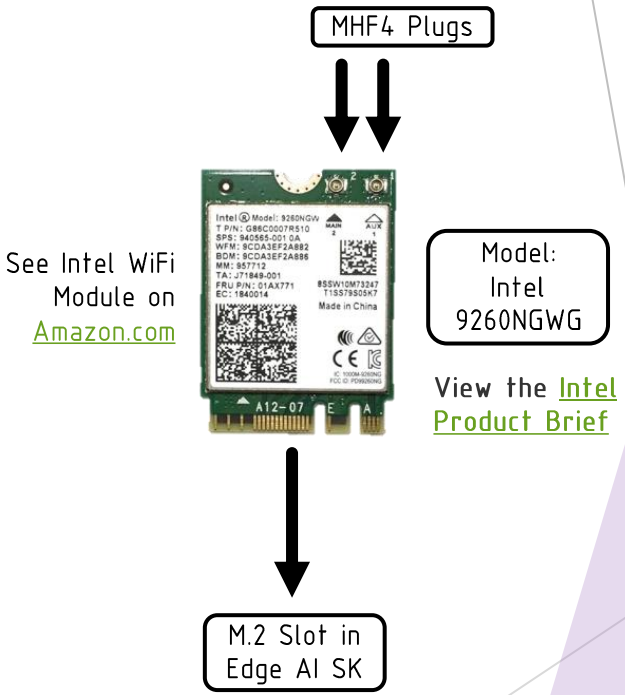
TDA4VM – WiFi

Diagram for recommended WiFi Setup

Essentially this setup uses M.2 slot from the TI board, an Intel dual-band wifi adapter, and omnidirectional antennas for long-range signal performance.





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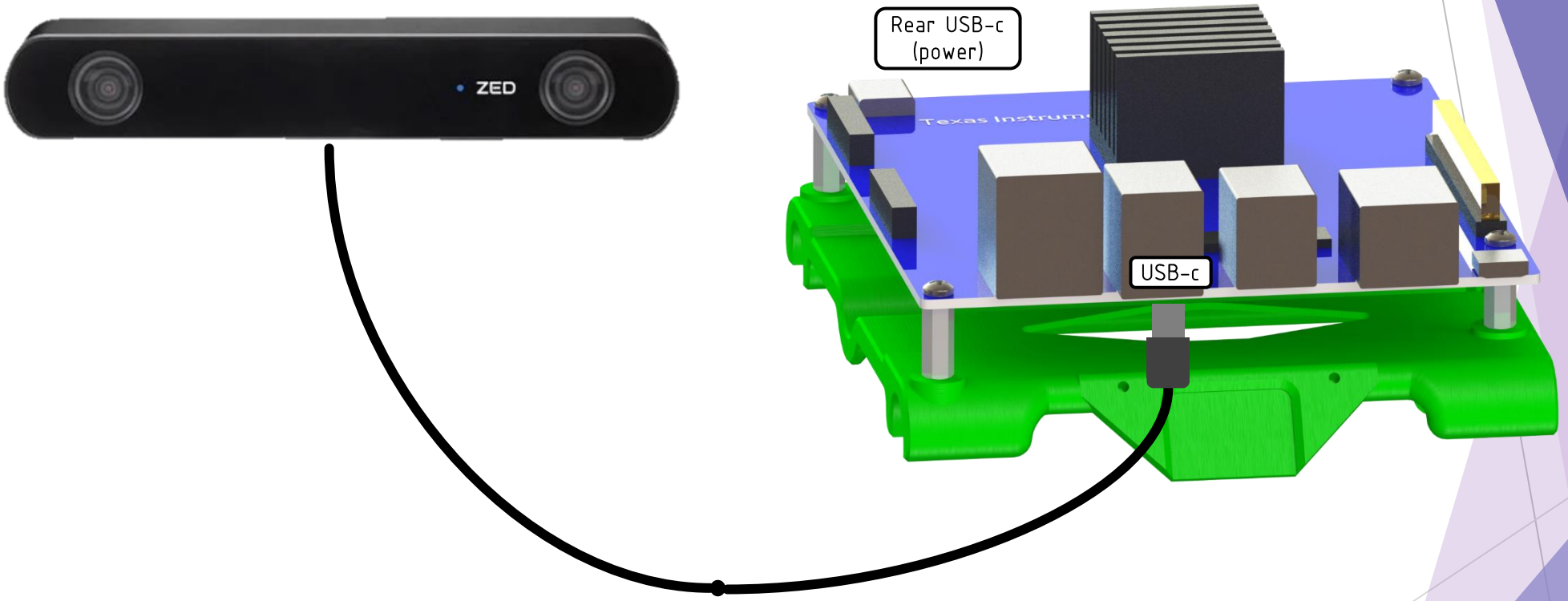
ZED2 Camera

Shop Here for ZED2 camera product that matches the selection by TI Engineers.



Power for camera + signal carries over USBC cable

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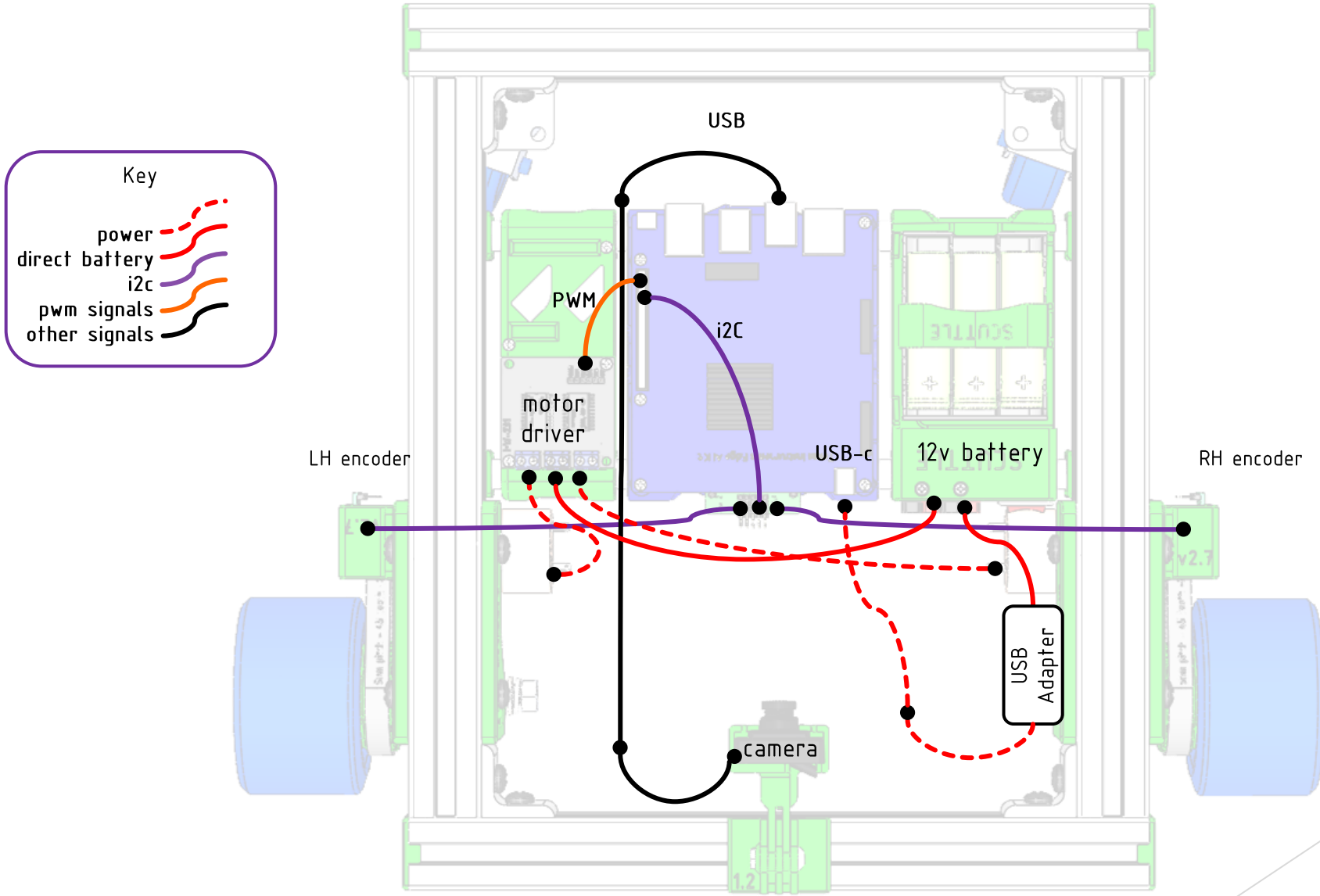
TDA4VM – SCUTTLE Wiring



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