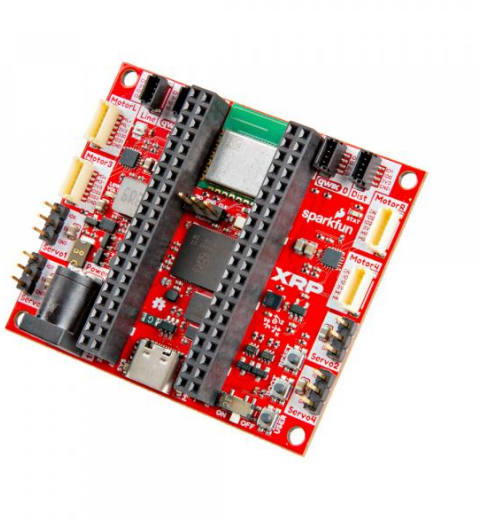
SparkFun XRP Controller Hardware

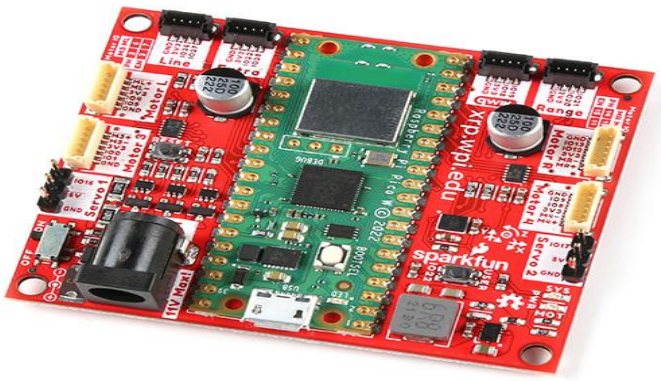
Part Number: 28009 & 28013

Introduction

Welcome to the SparkFun Experiential Robotics Platform (XRP) Controller Hardware Overview. This document provides detailed overviews of the hardware present on both versions of the XRP Controller; the XRP Controller and XRP Controller - Beta.

Each version of the XRP Controller has their own hardware overview section linked in the navigation menu to the left. If you're not sure which version to select, click on the image below matching the XRP Controller you have:



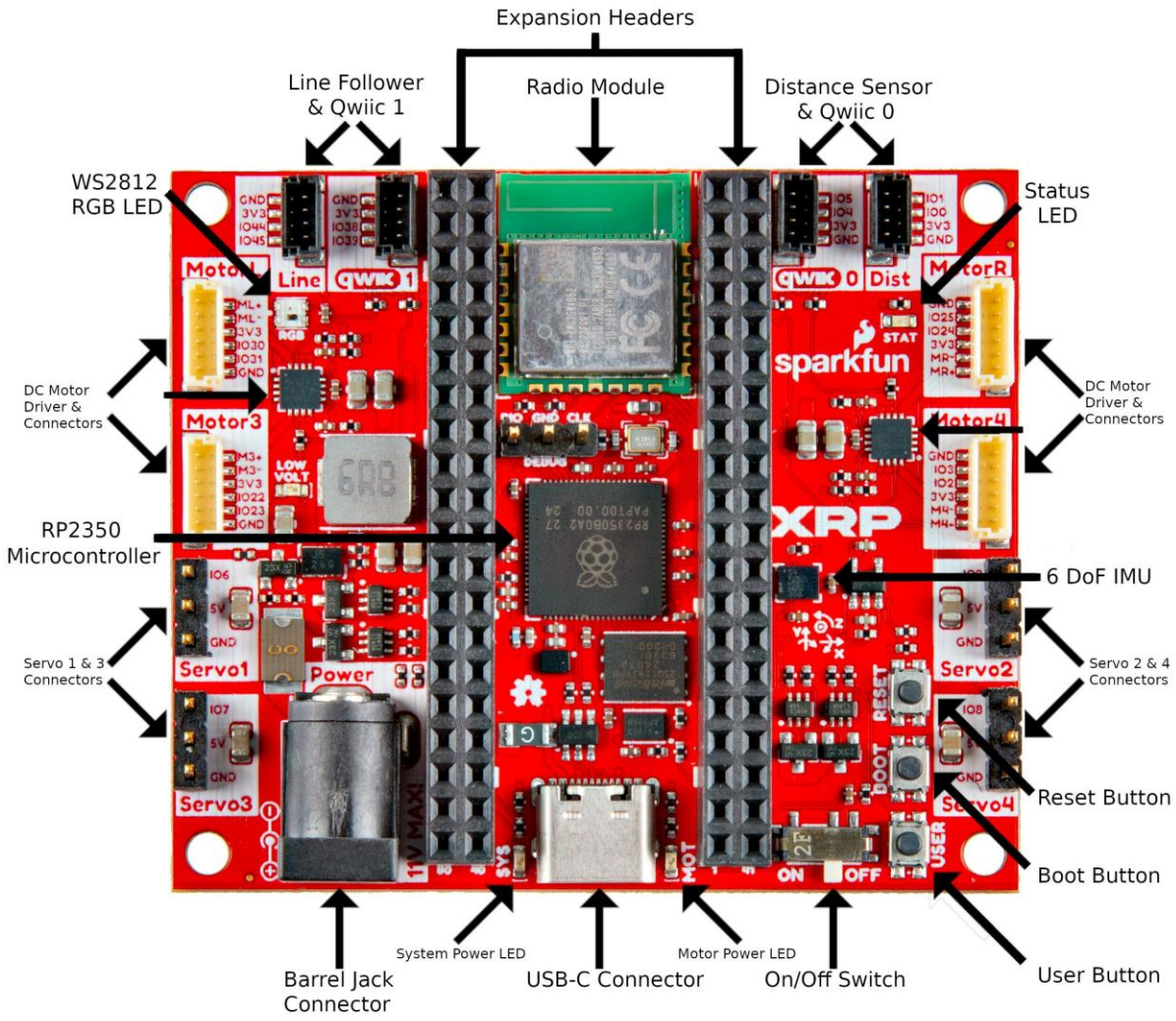


XRP Controller Overview

In this document, we'll take a close look at the heart of the Experiential Robotics Platform (XRP) Kit, the XRP Controller. This document outlines all of the parts on this board you'll interact with while building and using the XRP Kit.

Controller Board Overview

Let's take a broad look at the major components on the XRP Controller. The photo below points them out along with their names:

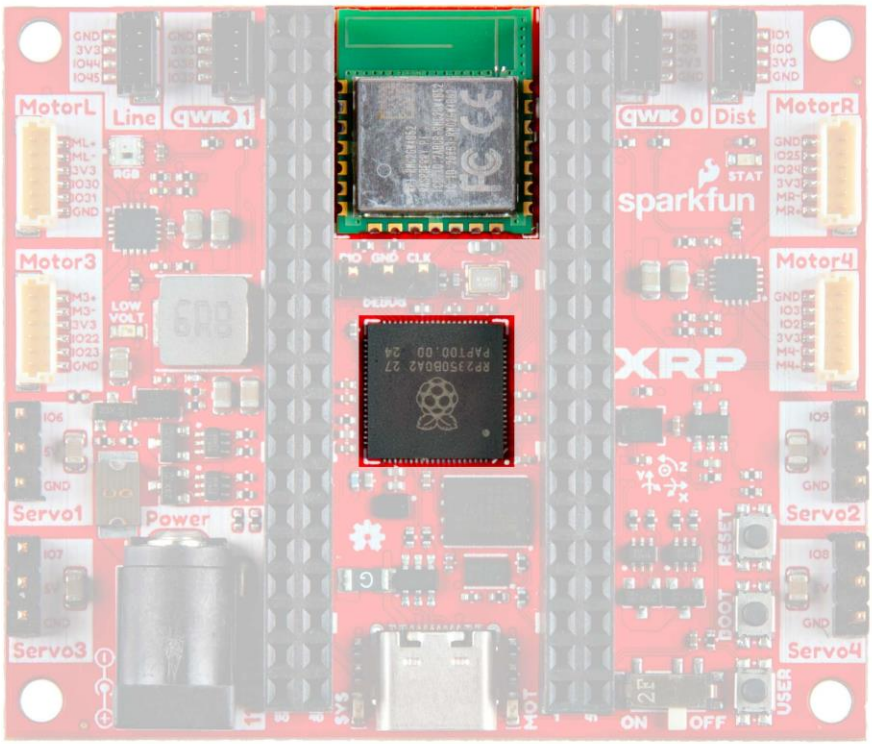


Having trouble seeing the detail in the image? Click on it for a larger view.

You'll notice that along with the arrows showing the name of some of the smaller components, the board uses what's called silkscreen to label all the connectors, buttons, LEDs and other parts you'll interact with while building and using the XRP Robotics Kit.

Raspberry Pi RP2350 & Radio Module 2

The Raspberry Pi RP2350 acts as the brain of this board. The RP2350 communicates with the motor controllers, IMU and other components to control the robotics kit's behavior. The Raspberry Pi Radio Module 2 (RM2) adds wireless connectivity to the XRP Controller over both WiFi and Bluetooth®. The photo below highlights the RP2350 and RM2 on the Controller Board:

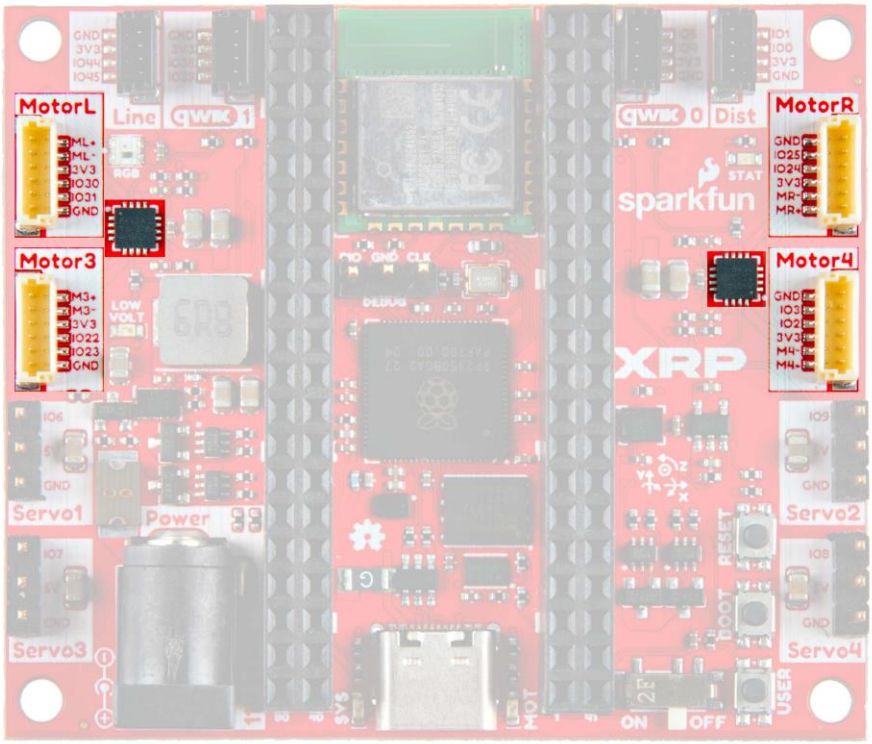


Think of the RP2350 as a brain sending signals to other parts of the "body" to tell them what to do. It has several General Purpose Input/Output (GPIO) pins that connect to the other major parts on this board so it can send and receive data from them and return it to you visually (such as seeing the motors move) or virtually (such as watching data on a computer monitor).

The Radio Module 2 connects to both WiFi networks and Bluetooth devices allowing wireless connectivity for the XRP Kit. It communicates with the RP2350 over its serial peripheral interface (SPI) and also has a few general purpose inputs and outputs (GPIO) that are connected to the two 2x20 expansion headers on the XRP Controller Board.

DRV8411A Motor Drivers

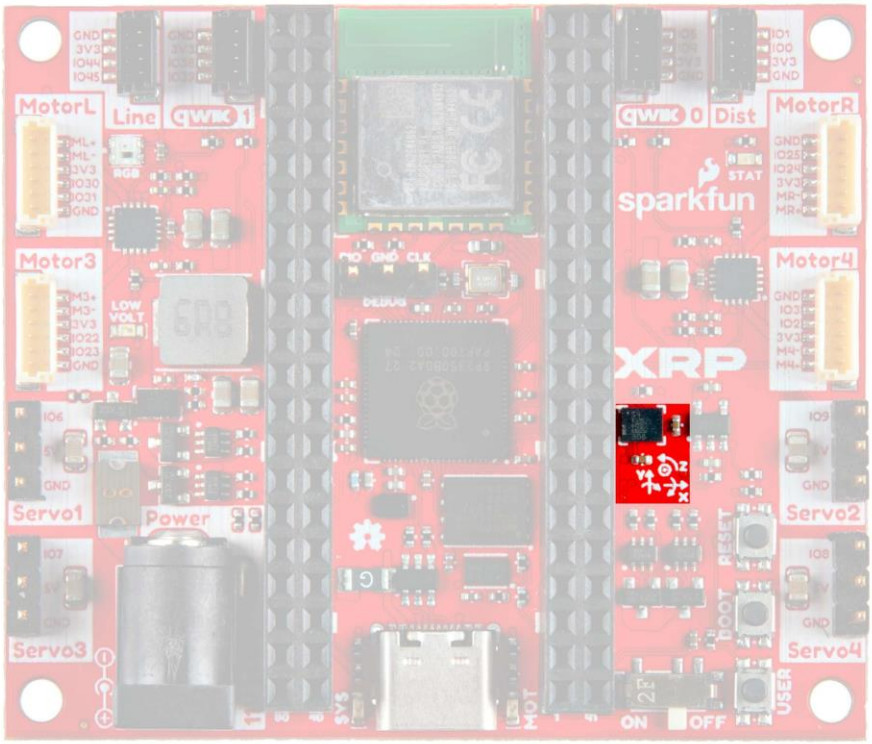
The pair of DRV8411A H-Bridge motor drivers from Texas Instruments™ on the XRP Controller Board control the direction and speed of the XRP Kit's motors.



The term H-bridge comes from how this circuit design looks on a schematic diagram. It has four internal switches that control whether the motor spins Clockwise (CW), Counter Clockwise (CCW), Coasts (no drive power), and Stops. When going through the XRP Kit curriculum you'll learn how to program the robot to tell the motor drivers to control the motors' speed and direction.

LSM6DSO 6-Dof IMU

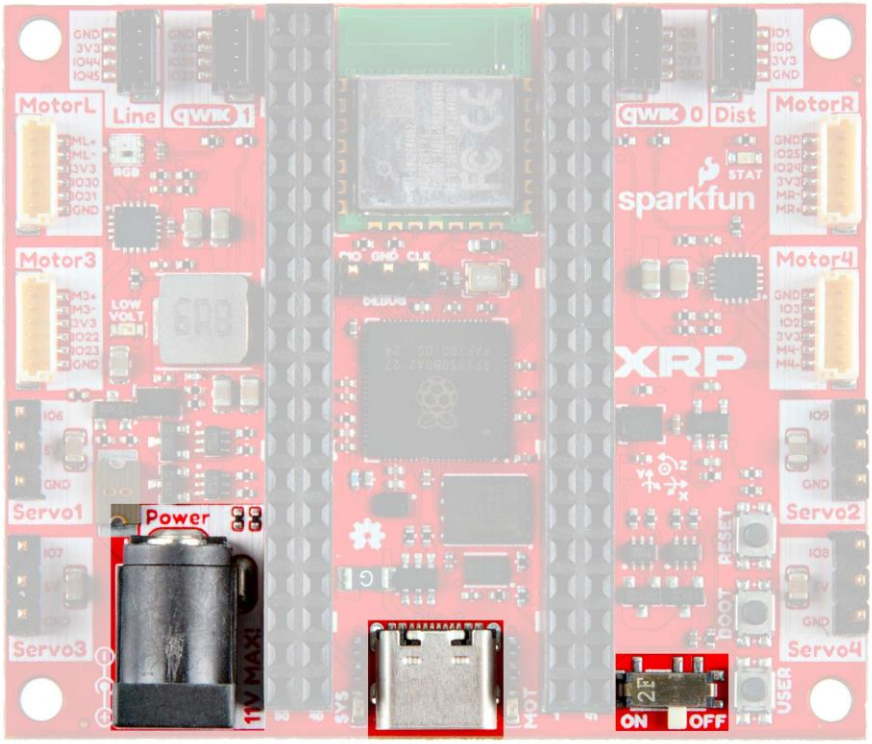
The LSM6DSO 6-DoF (Degrees of Freedom) IMU (Inertial Measurement Unit) from STMicroelectronics™ combines an accelerometer and gyroscope into a single IC (integrated circuit). This sensor lets you measure the robot's acceleration in three dimensions and also measure the orientation and angle of the robot.



The accelerometer in this chip has four measurement ranges of ±2/±4/±8/±16 g. These ranges allow you to customize the limits of the acceleration forces measured. The gyroscope has five selectable measurement ranges of ±125/±250/±500/±1000/±2000 DPS (degrees per second). Refer to the silk screen symbols on the XRP Controller for the directions of each axis.

Power Components

Now let's take a closer look at the parts on this board used for providing power to it.



Barrel Jack Connector

The barrel jack connector is the primary power input for the entire XRP Kit. This connector mates with the cable from the XRP Kit's battery pack for battery-powered operation. Take note that the maximum safe voltage that can be applied to this connector is **11V** and the minimum to run the system is **5V**. The 4-AA battery pack included with the kit supplies a maximum of **6V** so most users will have no issues exceeding the max voltage.

USB-C Connector

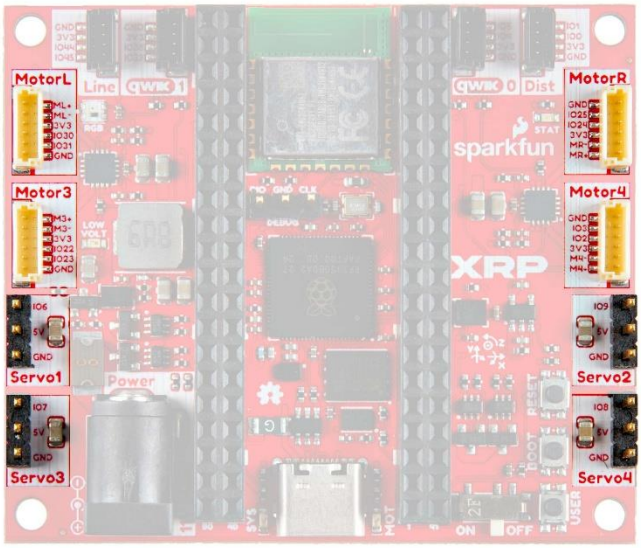
The USB-C connector provides power to the XRP Controller Board with **5V** from a USB cable. It also is the primary interface you'll use to initially set up the XRP Controller Board with a computer and program the RP2350 using a USB-C cable.

Power Switch

The power switch highlighted above controls the voltage input to the Controller Board. This two-way switch turns the kit's power on and off. You can use this to turn the robot off while keeping the battery pack plugged in. The switch does not affect the RP2350's power when a USB cable is plugged in.

Motor Connectors

The Controller Board has four six-pin connectors labeled **Motor L**, **Motor R**, **Motor 3** and **Motor 4** and four three-pin connectors labeled **Servo 1**, **Servo 2**, **Servo 3** and **Servo 4**.



DC Motor Connectors

The DC Motor connectors are where you'll plug in the left and right motors while assembling the kit. These connectors include the power connections for the motor as well as the encoders on the motors. The board routes these connections through the motor drivers to GPIO pins on

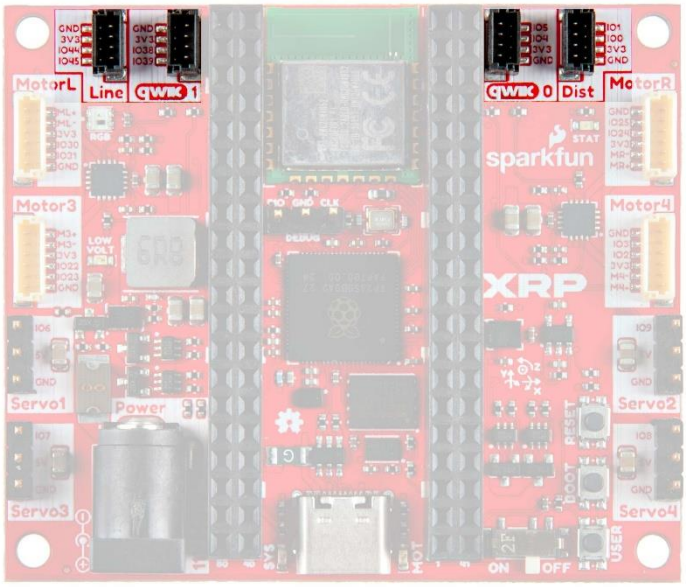
the RP2350. You'll use these pins to monitor how many rotations the motor completes and use that data to determine how far the robot has traveled. Refer to the Pinout table at the end of this document for the specific GPIO pins each motor connects to on the RP2350. The Controller Board has two extra motor connectors for expansion projects using more than two motors.

Servo Motor Connectors

The four three-pin connectors on either side of the board labeled Servo 1, Servo 2, Servo 3 and Servo 4 mate with servo motors. You'll use the Servo 2 connector to hook up the servo included in the XRP kit. The other three connectors are extra for expansion projects. These connectors have power pins (**5V** and Ground) and a signal pin to control the motion of the servo motor. Servo motors use a communication method called pulse width modulation (PWM) that tells the motor to move and with some motors, where to move to. If you're interested in learning more about how servo motors work, you may want to check out SparkFun's Servos Explained page for information and tutorials on how to use them.

Sensor & Qwiic Connectors

The Controller Board has four four-pin connectors labeled (from left to right when looking at the labels upright) **Line**, **Qwiic 1**, **Qwiic 0** and **DIST**. Their labels indicate their use as well as which GPIO pins they connect to on the RP2350. These connectors provide an easy plug-in connection for the line follower and distance sensor as well as two extra connectors for expansion projects. These connectors are polarized meaning they only work when connected properly but they are keyed and there is only one way to plug a cable into them.



Line Follower Connector

The Line connector is where you'll plug the cable for the line follower sensor into. This connects the sensor's two signal lines, Left and Right, to the RP2350's GPIO44 (Left) and GPIO45 (Right) pins. You'll use these pins to monitor whenever the sensor detects the robot has gone past the left or right threshold when performing line-following experiments. When connecting the Qwiic adapter cable that plugs into this connector, make the following connections to the Line Follower Sensor:

- **Red** - **3.3V**
- **Blue** - **S1**
- **Yellow** - **S2**
- **Black** - **GND**

Distance Sensor Connector

The Dist connector is where you'll plug the cable for the ultrasonic range sensor into. It connects the distance sensor's Echo and Trigger lines to the RP2350's GPIO0 (Trigger) and GPIO1 (Echo). You'll use these pins to receive distance data from the ultrasonic range sensor. When connecting the Qwiic adapter cable that plugs into this connector, make the following connections to the Distance Sensor:

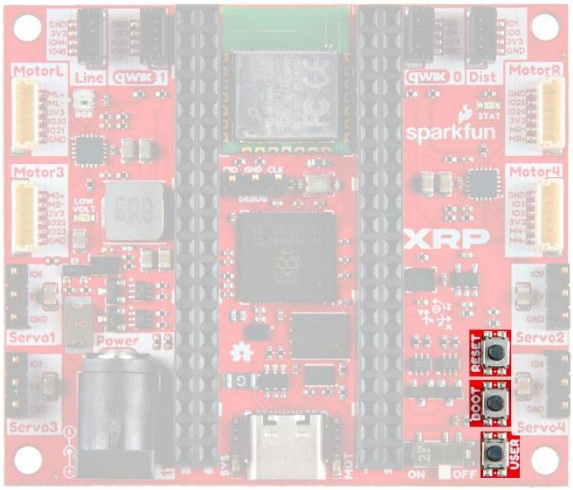
- **Red** - **VCC**
- **Blue** - **Trig**
- **Yellow** - **Echo**
- **Black** - **GND**

Qwiic Connectors

The Qwiic connectors work with SparkFun's Qwiic ecosystem of sensors that communicate over I^2C. This is a two-wire communication protocol that works with a large variety of sensors and other electronics. With this, you can customize the XRP Kit to add things like environmental sensing, OLED screens, data logging, and more!

Buttons

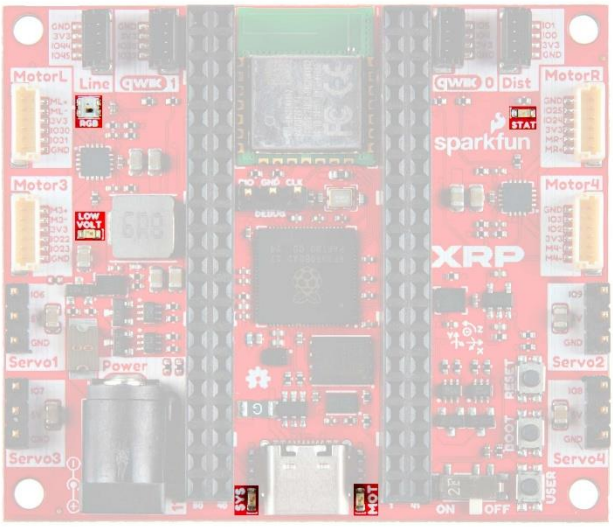
The Controller Board has three push buttons labeled **USER**, **RESET** and **BOOT** (on the RP2350).



The USER button connects to GPIO36 on the RP2350 which allows it to be programmed for various purposes. The RESET button does just what its name suggests and resets the entire board when pressed. This can help to reboot the robot or to restart a sequence you want the Robotics Kit to perform. Holding the BOOT button either when plugging in a USB cable or when pressing the RESET button sets the RP2350 to behave as a mass storage device when connected to a computer for uploading firmware.

LEDs

There are five LEDs on the XRP Controller Board labeled **MOT**, **SYS**, **LOW VOLT**, **STAT** and **RGB**.

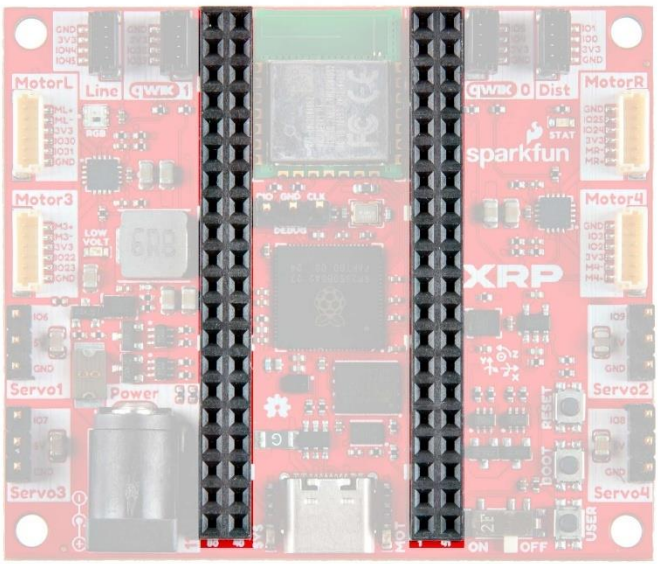


These LEDs are there to provide a visual indication to users. The LEDs labeled **MOT** and **SYS** turn on when their respective power rails are powered. The **MOT** LED turns on when the motors have power available. The **SYS** LED turns on when the **3.3V**/System circuit is powered. This circuit powers the RP2350, RM2, sensors, and the expansion connectors. The **LOW VOLT** LED connects to the 5V Buck regulator POWER_GOOD pin. It provides a quick visual indicator to notify users that the supply voltage has dropped below the operating threshold and the board is underpowered. This is **not** technically a low battery indicator but it coincidentally starts illuminating when 4xAA batterys are low, depending on the battery chemistry.

The other two LEDs labeled **STAT** and **RGB** are user-programmable status LEDs you can program for whatever behavior you prefer. The **STAT** LED connects to GPIO0 on the Radio Module and can be useful to indicate behavior from the radio such as connection status or data transmission. The **RGB** LED connects to GPIO37 on the RP2350 and can be programmed to change to any color based on whatever behavior you'd like. For example, you can have it turn from Green to Red when the distance sensor detects the robot is nearing an obstacle.

Expansion Headers

The XRP Controller Board now features a pair of 2x20 female headers that connect to nearly all the RP2350's and RM2's available pins to allow for more customization options for the XRP platform. Many of these pins are shared between the connectors and other components on the XRP Control Board so take care to ensure they are not being used by any peripherals (motors, sensors, etc.) before connecting and programming them for a different functionality.



The inner rows of this expansion header nearly matches the pinout of the Pico W 2 (minus the analog-to-digital conversion pins) and can be used with peripheral boards that work with the Pico 2 W. Please note this is **NOT** a socket for a Pico 2 W. The outer row contains available GPIO pins from the RM2, extra GPIO pins from the RP2350 along with voltage pins. The image below and following table offers a quick reference for the pinout and labels on the expansion headers as well as any other connectors (motors, sensors, etc.) or peripheral (button, LED, etc.) shared between them.

Color Code
Ground
Power
Control Signal
Status Signal
RP2350 GPIO
Radio GPIO
LED
Button/Switch
Motor
Servo
Sensor
I2C (Qwiic)
Free for User
Not Connected

XRP Usage	Header	Pin	Pin	Header	XRP Usage
MotorL/3 Current Limit	ML/3 VREF	61	21	GPIO16	Free
MotorL/3 Driver Fault	ML/3 Fault	62	22	GPIO17	Free
GND	GND	63	23	GND	GND
Encoder LA	GPIO30	64	24	GPIO18	Free
Encoder LB	GPIO31	65	25	GPIO19	Free
Motor L IN1	GPIO34	66	26	GPIO20	Motor 3 IN1
Motor L IN2	GPIO35	67	27	GPIO21	Motor 3 IN2
GND	GND	68	28	GND	GND
Encoder 3B	GPIO23	69	29	GPIO22	Encoder 3A
Power Good	PG	70	30	RUN	Reset Button
Motor L Current	GPIO40	71	31	GPIO44	Line L
Motor 3 Current	GPIO41	72	32	GPIO45	Line R
GND	GND	73	33	GND	GND
WS2812 RGB LED	RGB_OUT	74	34	GPIO46	VIN Measure
Servo Power	5V	75	35	VREF	Analog Reference
After Power Switch	VIN	76	36	3V3	System Power
Main Power Switch	VIN_EN	77	37	3V3_EN	3V3 Regulator Enable
GND	GND	78	38	GND	GND
Before Power Switch	VRAW	79	39	VSYS	Before 3.3V Regulator
Battery Power	VBATT	80	40	VBUS	USB Power

Radio Module

USB-C

XRP Usage	Header	Pin	Pin	Header	XRP Usage
Free	GPIO15	20	60	MR/4 Fault	MotorR/4 Driver Fault
Free	GPIO14	19	59	MR/4 VREF	MotorR/4 Current Limit
GND	GND	18	58	GND	GND
Free	GPIO13	17	57	GPIO33	Motor R IN2
Free	GPIO12	16	56	GPIO32	Motor R IN1
Motor 4 IN2	GPIO11	15	55	GPIO25	Encoder RB
Motor 4 IN1	GPIO10	14	54	GPIO24	Encoder RA
GND	GND	13	53	GND	GND
Servo 2	GPIO09	12	52	WL_IO2	Free
Servo 4	GPIO08	11	51	WL_IO1	Free
Servo 3	GPIO07	10	50	GPIO43	Motor R Current
Servo 1	GPIO06	9	49	GPIO42	Motor 4 Current
GND	GND	8	48	GND	GND
Qwiic0 SCL	GPIO05	7	47	GPIO39	Qwiic1 SCL (IMU)
Qwiic0 SDA	GPIO04	6	46	GPIO38	Qwiic1 SDA (IMU)
Encoder 4B	GPIO03	5	45	IMU INT1	IMU Interrupt 1
Encoder 4A	GPIO02	4	44	IMU INT2	IMU Interrupt 2
GND	GND	3	43	GND	GND
Distance Echo	GPIO01	2	42	BOOTSEL	Boot Button
Distance Trigger	GPIO00	1	41	GPIO36	User Button

Solder Jumpers

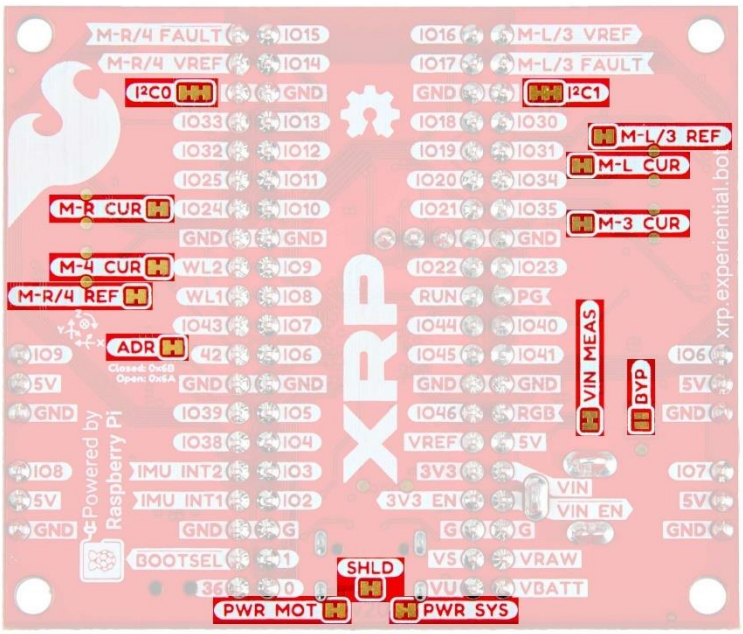
Warning

These solder jumpers can change the behavior of the board in a lasting way. Using these requires extra tools not included in the XRP Kit along with knowledge of how to use and interact with solder jumpers. We recommend that only advanced users adjust and change the solder jumpers. If you'd like to learn more about how to use solder jumpers, check out SparkFun's How to Work with Jumper Pads and PCB Traces tutorial.

The XRP Controller Board has fourteen solder jumpers. A solder jumper provides a customization option for advanced users to control the behavior of the pins and components they connect to. The solder jumpers on this board are labeled (from top-to-bottom reading left-to-right when looking at the photo below): **I²C0**, **I²C1**, **M-L/3 REF**, **M-L CUR**, **M-R CUR**, **M-3 CUR**, **M-4 CUR**, **M-R/4 REF ADR**, **VIN MEAS**, **BYPM**, **SHLD**, **PWR MOT** and **PWR SYS**.

Label	Default State	Function	Notes
I^2C0	CLOSED	Pulls SDA/SCL on I^2C 0 to **3.3V** through two **2.2kΩ** resistors.	Open completely to disable the pull up resistors on the I^2C 0 bus.
I^2C1	CLOSED	Pulls SDA/SCL on I^2C 0 to **3.3V** through two **2.2kΩ** resistors.	Open completely to disable the pull up resistors on the I^2C 1 bus.
M-L/3 REF	CLOSED	Sets the Left/3 DRV8411 motor driver's voltage reference to **3.3V**	Sets the DRV8411's reference voltage to match the system voltage. Open to set to a different voltage.
M-L CUR	CLOSED	Connects the Left Motor current sense output to IO40.	Lets users measure motor current draw using the ADC on IO40. Open to free up IO40 for other use.
M-R CUR	CLOSED	Connects the Right Motor current sense output to IO43.	Lets users measure motor current draw using the ADC on IO43. Open to free up IO43 for other use.
M-3 CUR	CLOSED	Connects the Motor Three current senss output to IO41.	Lets users measure motor current draw using the ADC on IO41. Open to free up IO41 for other use.
M-4 CUR	CLOSED	Connects the Motor Four current sense output to IO42.	Lets users measure motor current draw using the ADC on IO42. Open to free up IO42 for other use.

M-R/4 REF	CLOSED	Sets the Right/4 DRV8411 motor driver's voltage reference to **3.3V**	This sets the DRV8411's reference voltage to match the system voltage. Open to set to a different voltage.
ADR	CLOSED	Sets the LSM6DSO's I^2C address to **0x6B**.	Open to switch the I^2C address to **0x6A**.
VIN MEAS	CLOSED	Connects the VIN measurement circuit to IO46	Open to free up IO46 for alternate use
BYP	OPEN	Enables the fuse for the barrel jack input.	Close to bypass the fuse for the barrel jack.
SHLD	CLOSED	Connects the USB-C shield pin to the board's ground plane.	Open to isolate the USB-C shield pin
PWR MOT	CLOSED	Completes the Motor Power LED circuit.	Open to disable the Motor Power LED.
PWR SYS	CLOSED	Completes the System Power LED circuit.	Open to disable the System Power LED.



Pinout Reference Table

The table below gives a quick reference for the complete pinout of the XRP Controller and which pins they connect to on the RP2350.

RP2350 GPIO Pin	Connector/Peripheral Label	Expansion Header Pin Label	Pin Function
GPIO0	DIST	0	Distance Trigger Pin
GPIO1	DIST	1	Distance Echo Pin

GPIO2	Motor 4	IO2	Motor 4 Encoder A
GPIO3	Motor 4	IO3	Motor 4 Encoder B
GPIO4	Qwiic 0	IO4	I^2C 0 Data Signal
GPIO5	Qwiic 0	IO5	I^2C 0 Clock
GPIO6	Servo 1	IO6	Servo 1 Signal
GPIO7	Servo 3	IO7	Servo 3 Signal
GPIO8	Servo 4	IO8	Servo 4 Signal
GPIO9	Servo 2	IO9	Servo 2 Signal
GPIO10	Motor 4	IO10	Motor 4 Phase Pin
GPIO11	Motor 4	IO11	Motor 4 Enable Pin
GPIO12	None	IO12	Available I/O
GPIO13	None	IO13	Available I/O
GPIO14	None	IO14	Available I/O

GPIO15	None	IO15	Available I/O
GPIO16	None	IO16	Available I/O
GPIO17	None	IO17	Available I/O
GPIO18	None	IO18	Available I/O
GPIO19	None	IO19	Available I/O
GPIO20	Motor 3	IO20	Motor 3 Phase Pin
GPIO21	Motor 3	IO21	Motor 3 Enable Pin
GPIO22	Motor 3	IO22	Motor 3 Encoder A Pin
GPIO23	Motor 3	IO23	Motor 3 Encoder B Pin
GPIO24	Motor R	IO24	Motor R Encoder A Pin
GPIO25	Motor R	IO25	Motor R Encoder B Pin

GPIO26	None	None	RM2 Power On
GPIO27	None	None	RM2 Chip Select
GPIO28	None	None	RM2 SPI Clock
GPIO29	None	None	RM2 SPI Data
GPIO30	Motor L	IO30	Motor L Encoder A Pin
GPIO31	Motor L	IO31	Motor L Encoder B Pin
GPIO32	Motor R	IO32	Motor R Phase Pin
GPIO33	Motor R	IO33	Motor R Enable Pin
GPIO34	Motor L	IO34	Motor L Phase Pin
GPIO35	Motor L	IO35	Motor L Enable Pin
GPIO36	User Button	36	User button input
GPIO37	RGB	RGB	WS2812 Data In Pin

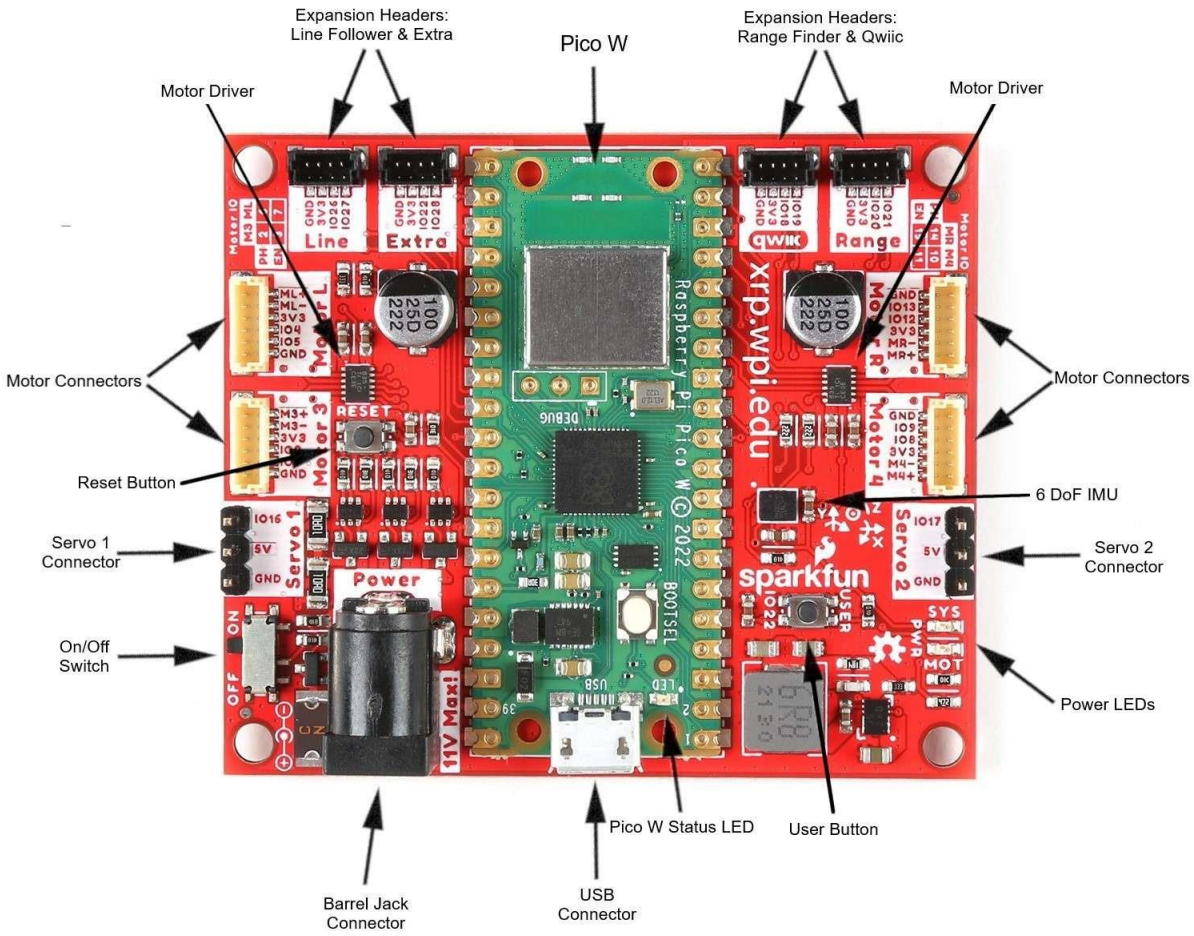
GPIO38	Qwiic 1	SDA1	I^2C 1 Data
GPIO39	Qwiic 1	SCL1	I^2C 1 Clock
GPIO40	None	IO40	Motor Left Current Measure
GPIO41	None	IO41	Motor 3 Current Measure
GPIO42	None	IO42	Motor 4 Current Measure
GPIO43	None	IO43	Motor Right Current Measure
GPIO44	Line	IO44	Line Follower Left Signal
GPIO45	Line	IO45	Line Follower Right Signal
GPIO46	None	IO46	Voltage Input Measure
GPIO47	None	None	PSRAM Chip Select

XRP Beta Controller Overview

In this document, we'll take a close look at the heart of the Experiential Robotics Platform (XRP) Kit - Beta, the XRP Controller - Beta. This document outlines all of the parts on this board you'll interact with while building and using the XRP Kit - Beta.

XRP Controller - Beta Overview

Let's take a broad look at the major components on the XRP Controller - Beta. The photo below points them out along with their names:

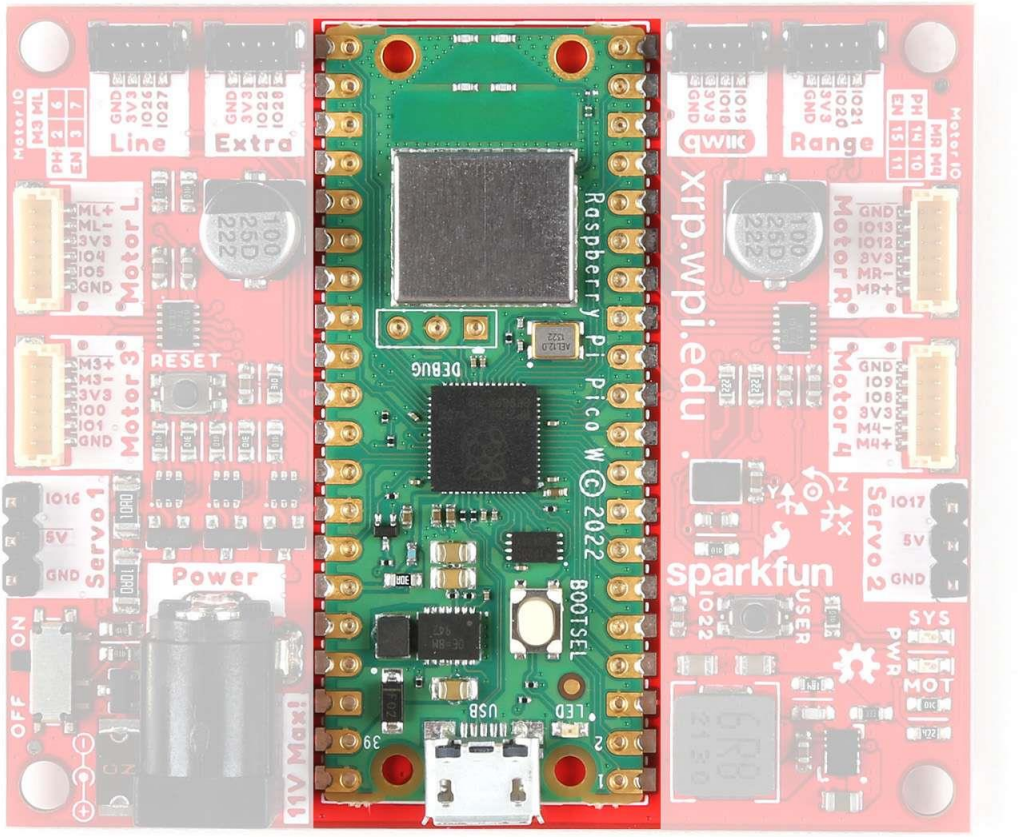


Having trouble seeing the detail in the image? Click on it for a larger view.

You'll notice that along with the arrows showing the name of some of the smaller components, the board uses what's called silkscreen to label all the connectors, buttons, LEDs and other parts you'll interact with while building and using the XRP Kit - Beta.

Raspberry Pi Pico W

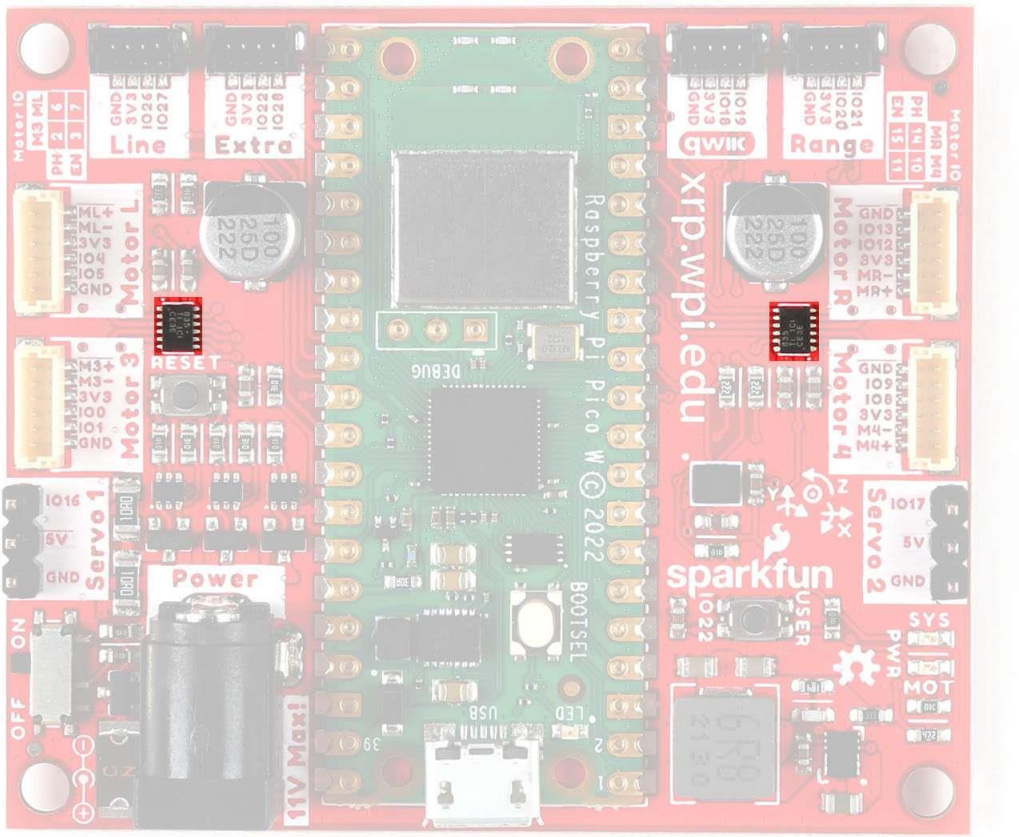
The Raspberry Pi Pico W microcontroller acts as the brain of this board. It combines a RP2040 processor with a wireless module for both 2.4GHz 802.11n wireless LAN and Bluetooth™ 5.2. The RP2040 communicates with the motor controllers, IMU and other components to control the robotics kit's behavior. The photo below highlights the Pico W on the Controller board:



Think of the Pico W as a brain sending signals to other parts of the "body" to tell them what to do. It has several General Purpose Input/Output (GPIO) pins that connect to the other major parts on this board so it can send and receive data from them and return it to you visually (such as seeing the motors move) or virtually (such as watching data on a computer monitor).

DRV8835 Motor Drivers

The pair of DRV8835 H-Bridge motor drivers from Texas Instruments™ on the XRP Controller - Beta control the direction and speed of the Robotics Kit's motors.

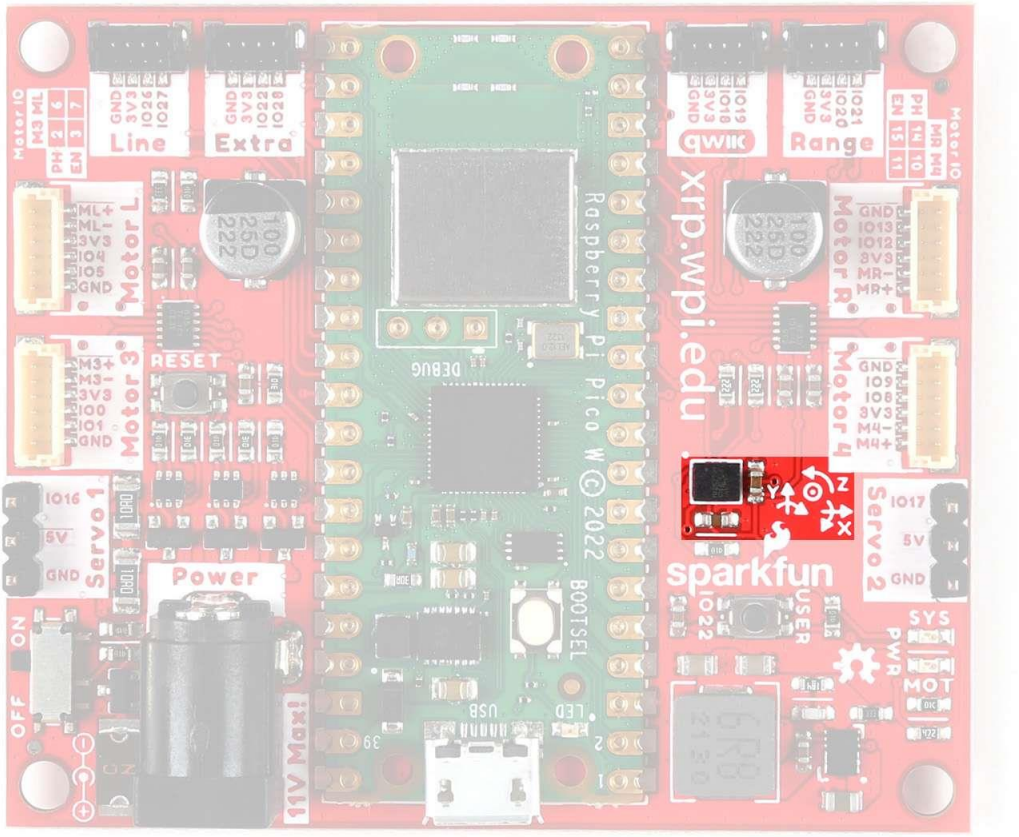


The term H-bridge comes from how this circuit design looks on a schematic diagram. It has four internal switches that control whether the motor spins Clockwise (CW), Counter Clockwise

(CCW), Coasts (no drive power), and Stops. When going through the XRP Kit - Beta curriculum you'll learn how to program the robot to tell the motor drivers to control the motors' speed and direction.

LSM6DSO 6-Dof IMU

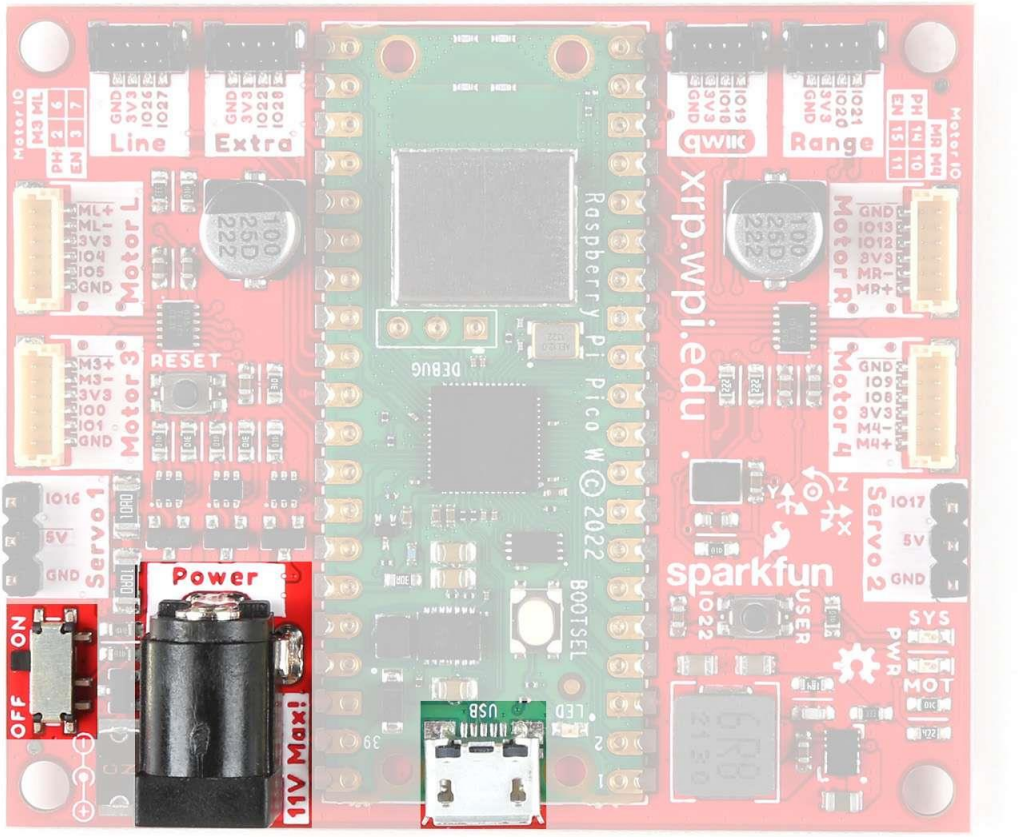
The LSM6DSO 6-DoF (Degrees of Freedom) IMU (Inertial Measurement Unit) from STMicroelectronics™ combines an accelerometer and gyroscope into a single IC (integrated circuit). This sensor lets you measure the robot's acceleration in three dimensions and also measure the orientation and angle of the robot.



The accelerometer in this chip has four measurement ranges of ±2/±4/±8/±16 g. These ranges allow you to customize the limits of the acceleration forces measured. The gyroscope has five selectable measurement ranges of ±125/±250/±500/±1000/±2000 DPS (degrees per second).

Power Components

Now let's take a closer look at the parts on this board used for providing power to it.



Barrel Jack Connector

The barrel jack connector is the primary power input for the entire XRP Kit - Beta. This connector mates with the cable from the XRP Kit - Beta's battery pack for battery-powered operation. Take note that the maximum safe voltage that can be applied to this connector

is **11V** and the minimum to run the system is **5V**. The 4-AA battery pack included with the kit supplies a maximum of **6V** so most users will have no issues exceeding the max voltage.

Pico W USB-Connector

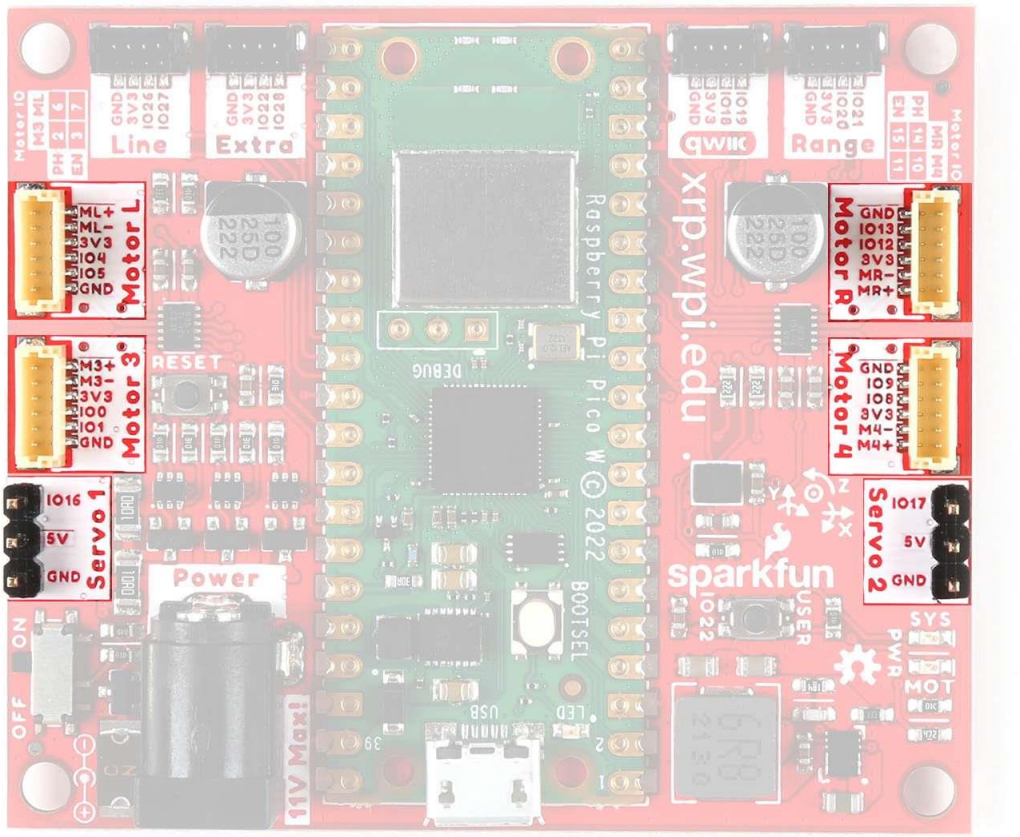
The Pico W has a Micro-USB connector that can be used to power the controller board with **5V** from a USB cable. It also is the primary interface you'll use to initially set up the Pico W with a computer and program the Pico W over a USB cable.

Power Switch

The power switch highlighted above controls the voltage input to the controller Board. This two-way switch turns the kit's power on and off. You can use this to turn the robot off while keeping the battery pack plugged in. The switch does not affect the Pico W's power when a USB cable is plugged in.

Motor Connectors

The controller board has four six-pin connectors labeled **Motor L**, **Motor R**, **Motor 3**, and **Motor 4** and two three-pin connectors labeled **Servo 1** and **Servo 2**.



DC Motor Connectors

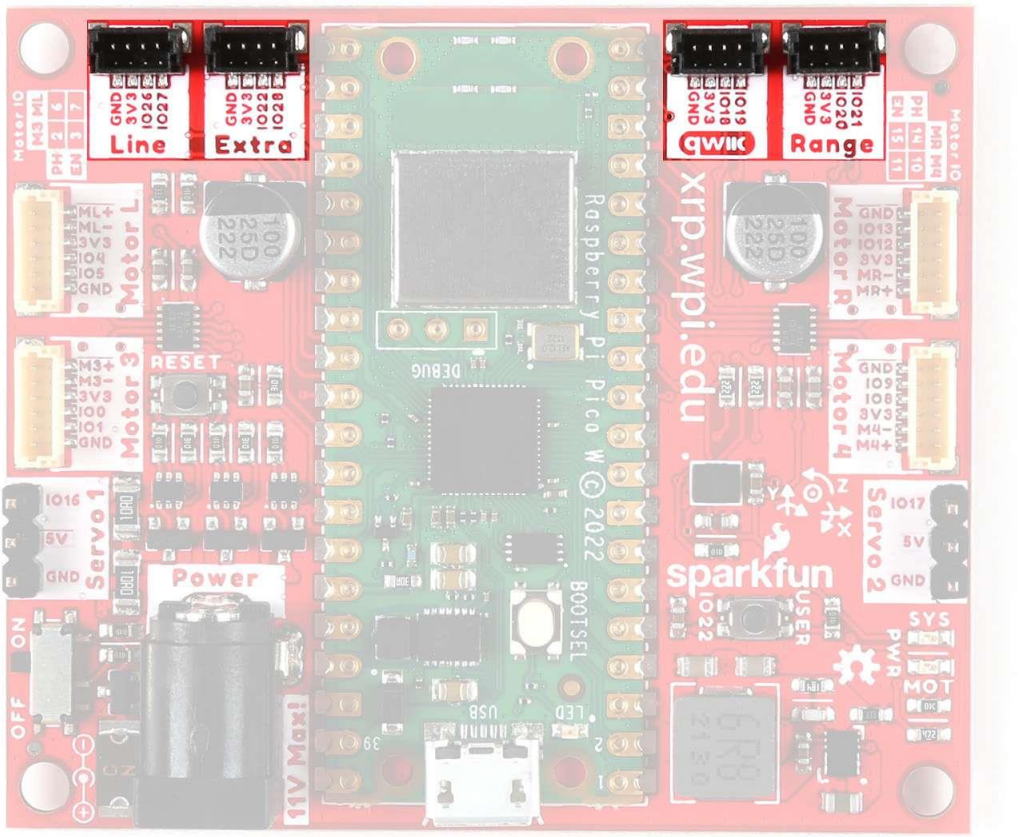
The DC Motor connectors are where you'll plug in the left and right motors while assembling the kit. These connectors include the power connections for the motor as well as the encoders on the motors. The board routes these connections through the motor drivers to GPIO pins on the Pico W. You'll use these pins to monitor how many rotations the motor completes and use that data to determine how far the robot has traveled. Refer to the Pinout table at the end of this document for the specific GPIO pins each motor connects to on the Pico W. The controller board has two extra motor connectors for expansion projects using more than two motors.

Servo Motor Connectors

The two three-pin connectors on either side of the board labeled Servo 1 and Servo 2 mate with servo motors. You'll use the Servo 2 connector to hook up the servo included in the XRP Kit - Beta. Servo 1 connector is an extra one for expansion projects. These connectors have power pins (**5V** and Ground) and a signal pin to control the motion of the servo motor. Servo motors use a communication method called pulse width modulation (PWM) that tells the motor to move and with some motors, where to move to. If you're interested in learning more about how servo motors work, you may want to check out SparkFun's Servos Explained page for information and tutorials on how to use them.

Expansion Connectors

The controller board has four four-pin connectors labeled (from left to right when looking at the labels upright) **Line**, **Extra**, **Qwiic**, and **Range**. Their labels indicate their use as well as which GPIO pins they connect to on the Pico W. These connectors provide an easy plug-in connection for the line follower and distance sensor as well as two extra connectors for expansion projects. These connectors are polarized meaning they only work when connected properly but they are keyed and there is only one way to plug a cable into them.



Line Follower Connector

The Line connector is where you'll plug the cable for the line follower sensor into. This connects the sensor's two signal lines, Left and Right, to the Pico W's GPIO27 (Right) and GPIO26 (Left) pins. You'll use these pins to monitor whenever the sensor detects the robot has gone past the left or right threshold when performing line-following experiments.

Range Sensor Connector

The Range connector is where you'll plug the cable for the ultrasonic range sensor into. It connects the distance sensor's Echo and Trigger lines to the Pico W's GPIO21 (Echo) and GPIO20 (Trig). You'll use these pins to receive distance data from the ultrasonic range sensor.

Qwiic Connector

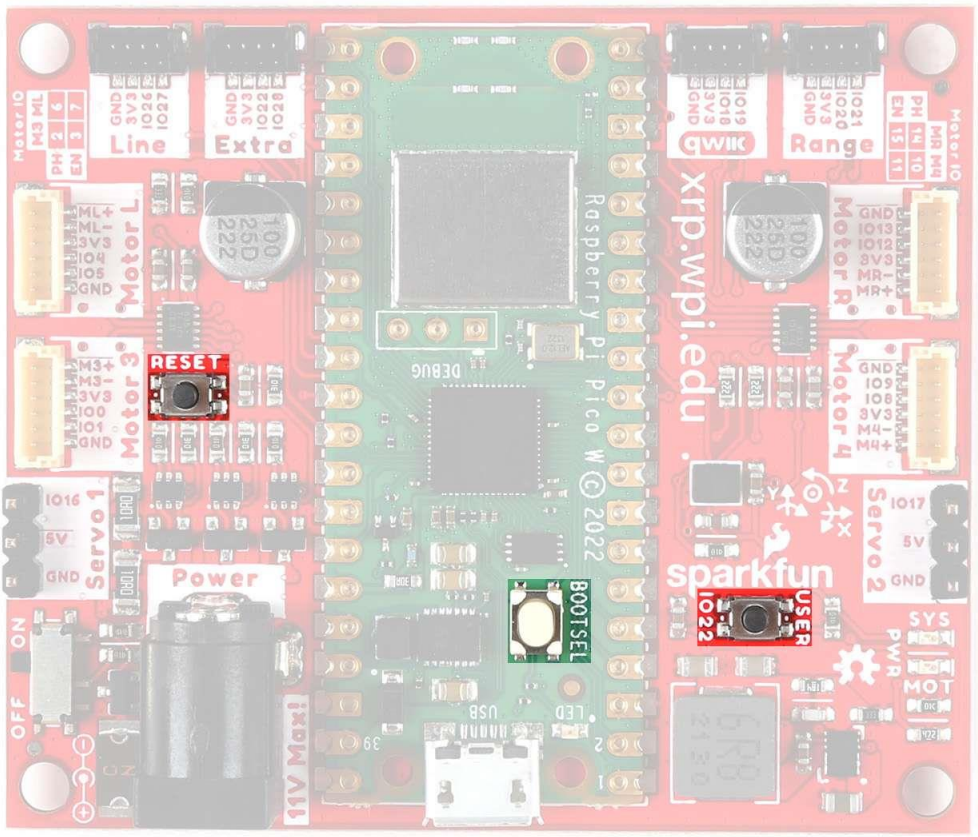
The Qwiic connector works with SparkFun's Qwiic ecosystem of sensors that communicate over I^2C. This is a two-wire communication protocol that works with a large variety of sensors and other electronics. With this, you can customize the XRP Kit - Beta to add things like environmental sensing, OLED screens, data logging, and more!

Extra Connector

The Extra connector has pins for both power and ground as well as pins that connect to the Pico W's GPIO28 and GPIO22. Note, these pins are *shared* with other functionality on the XRP Controller - Beta. GPIO28 is shared with the VIN Measure pin which lets you measure the voltage level on VIN so you can monitor the remaining battery charge. GPIO22 is shared with the User Button. Both pins' primary functions can be disabled with the solder jumpers, refer to the Solder Jumpers section below for more information.

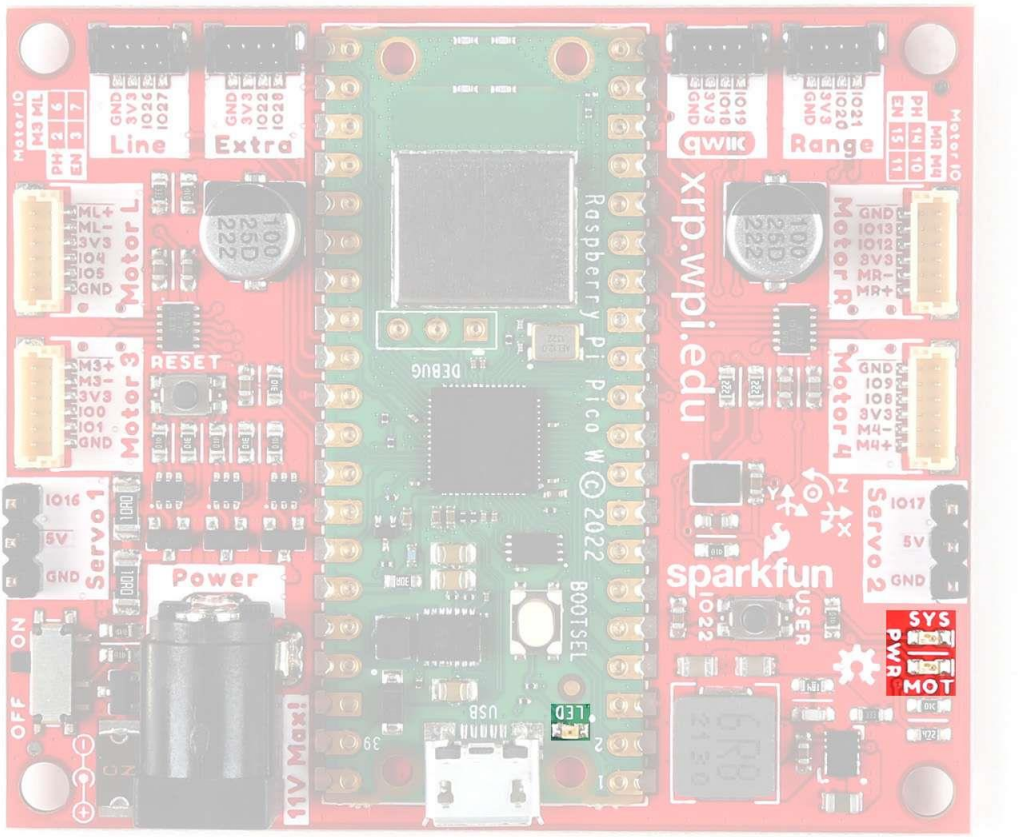
Buttons

The XRP Controller - Beta has three push buttons labeled **USER**, **RESET**, and **BOOTSEL** (on the Pico W). The USER button connects to GPIO22 on the Pico W which allows it to be programmed for various purposes. The RESET button does just what its name suggests and resets the entire board when pressed. This can help to reboot the robot or to restart a sequence you want the Robotics Kit to perform. Holding the BOOTSEL button either when plugging in a USB cable or when pressing the RESET button sets the Pico W to behave as a mass storage device when connected to a computer for uploading firmware.



LEDs

There are three LEDs on the XRP Controller - Beta labeled **MOT**, **SYS**, and **LED**.



These LEDs provide a visual indication to the user. The LEDs labeled **MOT** and **SYS** turn on when their respective power rails are powered. The **MOT** LED turns on when the motors have power available. The **SYS** LED turns on when the **3.3V**/System circuit is powered. This circuit powers the Pico W, sensors, and the expansion connectos. The LED on the Pico W labeled **LED** is a user-programmable status LED you can program for whatever behavior you prefer. For example, you can have it turn on when the distance sensor reports a certain distance.

Solder Jumpers

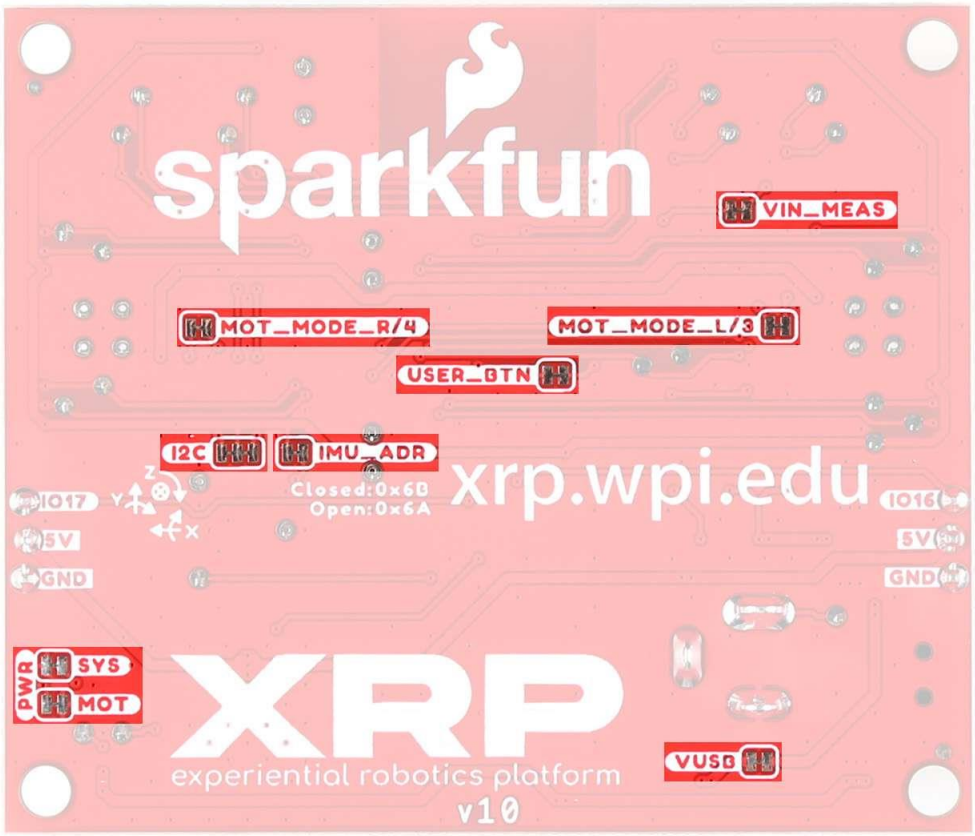
Warning

These solder jumpers can change the behavior of the board in a lasting way. Using these requires extra tools not included in the XRP Kit - Beta along with knowledge of how to use and interact with solder jumpers. We recommend that only advanced users adjust and change the solder jumpers. If you'd like to learn more about how to use solder jumpers, check out SparkFun's How to Work with Jumper Pads and PCB Traces tutorial.

Lastly, the XRP Controller - Beta has nine solder jumpers. A solder jumper provides a customization option for advanced users to control the behavior of the pins and components they connect to. The solder jumpers on this board are labeled (from top-to-bottom when looking at the photo
below): **VIN_MEAS**, **MOT_MODE_R/4**, **MOT_MODE_L/3**, **USER_BTN**, **I2C**, **IMU_ADR**, **SYS**, **MOT**, and **VUSB**.

Label	Default State	Function	Notes
VIN_MEAS	CLOSED	Completes the VIN circuit.	Open to disrupt the VIN circuit to measure voltage on VIN with a multimeter.
MOT_MODE_R/4	CLOSED	Pulls the Right DRV8835's MODE pin to **3.3V**.	This sets the DRV8835 to run in PH/EN mode by default. Open to switch the DRV8835 to operate in IN/IN mode.
MOT_MODE_L/3	CLOSED	Pulls the Left DRV8835's MODE pin to **3.3V**.	This sets the DRV8835 to run in PH/EN mode by default. Open to switch the DRV8835 to operate in IN/IN mode.
USER_BTN	CLOSED	Completes the User Button circuit to tie it to GPIO22.	Open to disconnect the button from GPIO22.
I2C	CLOSED	Pulls the SDA/SCL lines to **3.3V** through two **2.2kΩ**.	Open completely to disable the pull up resistors on the I^2C bus.
IMU_ADR	CLOSED	Sets the IMU's I^2C address to **0x6B**.	Open to switch the I^2C address to **0x6A**.
SYS	CLOSED	Completes the SYS Power LED circuit.	Open to disable the SYS Power LED.

MOT	CLOSED	Completes the MOT Power LED circuit.	Open to disable the MOT Power LED.
VUSB	CLOSED	Completes the V_USB circuit to provide **5V** and **3.3V** to the board from USB.	Open to prevent motors and servos from being powered by USB.



Pinout Reference Table

The table below offers a quick reference for the complete pinout on the XRP Controller - Beta and which pins they connect to on the Pico W.

Pico W GPIO Pin	Connector Label	Pin Function
GPIO0	Motor 3	Motor 3 Encoder A
GPIO1	Motor 3	Motor 3 Encoder B
GPIO2	Motor 3	Motor 3 Phase Pin
GPIO3	Motor 3	Motor 3 Enable Pin
GPIO4	Motor L	Left Motor Encoder A
GPIO5	Motor L	Left Motor Encoder B
GPIO6	Motor L	Left Motor Phase Pin
GPIO7	Motor L	Left Motor Enable Pin
GPIO8	Motor 4	Motor 4 Encoder A
GPIO9	Motor 4	Motor 4 Encoder B

GPIO10	Motor 4	Motor 4 Phase Pin
GPIO11	Motor 4	Motor 4 Enable Pin
GPIO12	Motor R	Right Motor Encoder A
GPIO13	Motor R	Right Motor Encoder B
GPIO14	Motor R	Right Motor Phase Pin
GPIO15	Motor R	Right Motor Enable Pin
GPIO16	Servo 1	Servo 1 Signal Pin
GPIO17	Servo 2	Servo 2 Signal Pin
GPIO18	Qwiic	Qwiic Data Signal for the IMU & Qwiic Connector
GPIO19	Qwiic	Qwiic Clock Signal for the IMU & Qwiic Connector
GPIO20	Range	Range Trigger Pin
GPIO21	Range	Range Echo Pin

GPIO22	Extra	User Button/Extra
GPIO26	Line	Line Follower Left Signal
GPIO27	Line	Line Follower Right Signal
GPIO28	Extra	VIN_Meas/Extra