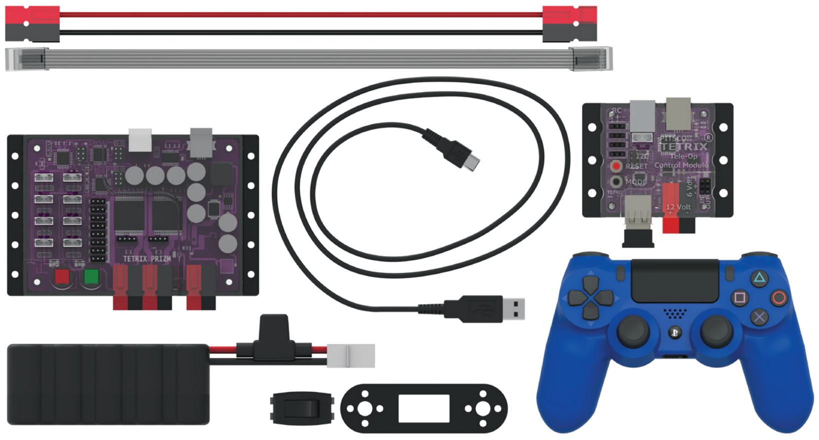
Tele-Op Module Activity 1 – Tele-Op Commands

Overview

This activity will introduce you to the TETRIX® Tele-Op Control Module and how it connects to the PRIZM® controller. It will also help you to become familiar with the functions and commands for using the Tele-Op module paired with a PS4 DUALSHOCK 4 gaming controller.

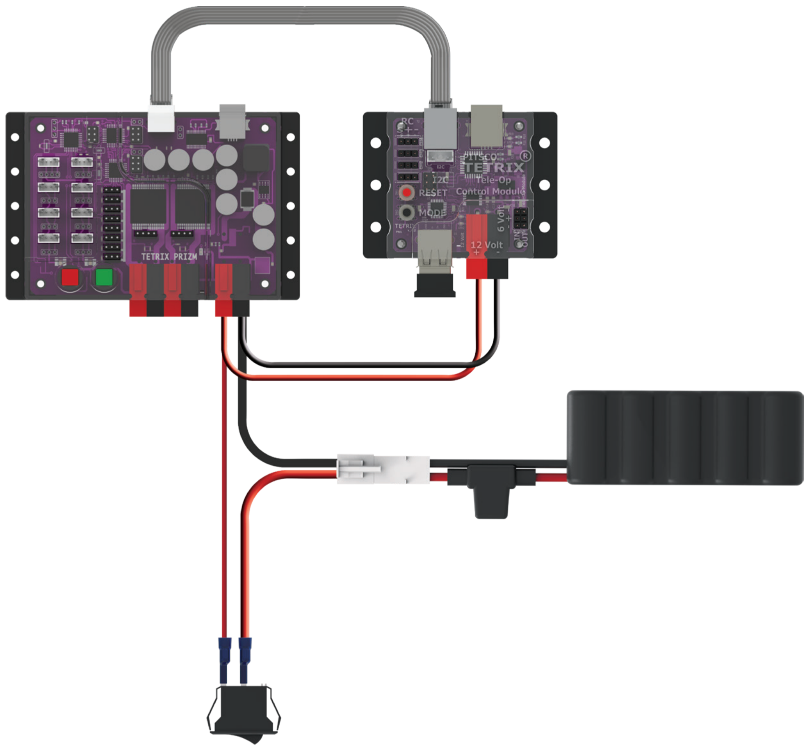
Parts Needed

- PRIZM controller
- Tele-Op module
- PS4 DUALSHOCK 4 gaming controller
- TETRIX MAX 12-volt battery
- PRIZM controller on/off switch
- Powerpole extension cable
- Daisy-chain data cable
- USB cable



Hardware Connections

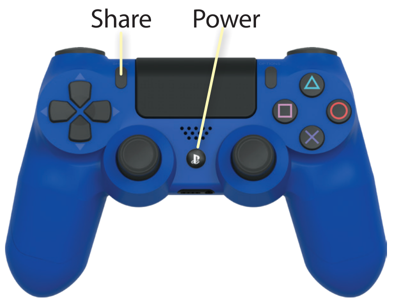
1. Connect the TETRIX MAX 12-volt battery to the PRIZM on/off switch.
2. Connect the PRIZM on/off switch to one of the battery connection ports on PRIZM.
3. Connect one end of the Powerpole extension cable to the other battery connection port on PRIZM. Connect the other end of the Powerpole extension cable to the battery connection port on the Tele-Op module.
4. Connect one end of the daisy-chain data cable to PRIZM's expansion port (labeled EXP). Connect the other end of the daisy-chain data cable to the I2C port on the Tele-Op module.



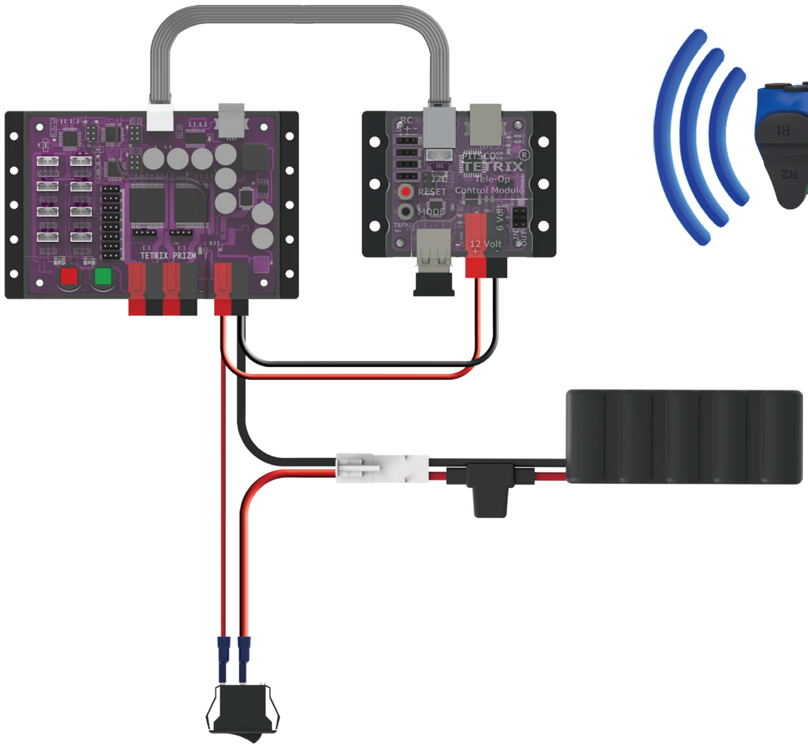
Bluetooth Connections

1. Make sure all devices that your PS4 controller has previously been paired with are off. This enables the PS4 controller to search for and connect to your Tele-Op module.
2. Make sure the PS4 controller is off.
3. Plug the Bluetooth dongle into Tele-Op module's USB port.
4. Turn on the PRIZM controller. The PRIZM controller and the Tele-Op module should both have a blue LED that lights up, indicating they have power. You should also notice a green flashing LED on the Tele-Op module, indicating that the Bluetooth dongle is compatible. If you do not see a green flashing light, then no Bluetooth dongle is connected or the dongle is not compatible with the Tele-Op module. Refer to the Tele-Op technical guide for more information on Bluetooth compatibility.
5. To pair the PS4 controller with the Bluetooth dongle, the controller must be put into discovery mode. On the PS4 controller, hold down the Share and the Power button at the same time for about five seconds until you see the controller's light bar flash white in a rapid pattern. The controller is now in discovery mode.
6. Press the black button on the Tele-Op module. The green LED on the Tele-Op module should remain on and stop flashing. Also, the light bar on the game controller should be a solid green color to indicate the controller is paired and ready to be used to control the Tele-Op module.
7. After the PS4 controller has been paired with the Bluetooth dongle in the Tele-Op module, you don't need to go through this process again unless you want to pair a different device or Bluetooth dongle. Simply turn on PRIZM and the Tele-Op module and then press the Power button on the PS4 controller. The controller will automatically connect to the Bluetooth dongle in the Tele-Op module.

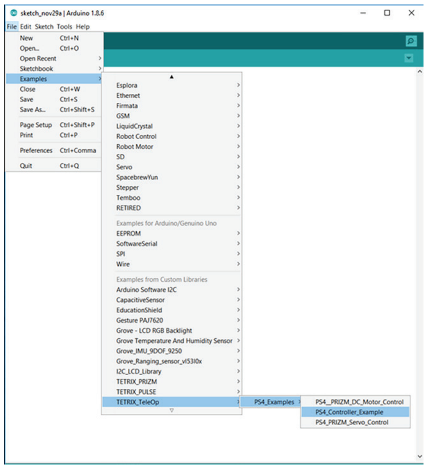
Note: When you connect the PS4 controller to the Tele-Op module, the game controller pairs with the Bluetooth dongle that is inserted into the Tele-Op module's USB port. If you remove the dongle from one Tele-Op module and plug it into another, the game controller can now be used to control the second Tele-Op module.



Note: When you turn off power to PRIZM and the Tele-Op module, the PS4 controller will automatically turn off after about 10 seconds.



Opening the Sketch



On your computer, open the Arduino Software (IDE). The sketch for this activity is stored with the examples that come with the Tele-Op library. To open the sketch, select **File** > **Examples** > **TETRIX_TeleOp** > **PS4_Examples** > **PS4_Controller_ Example**. A new sketch window will open with the example sketch.

This sketch has several sections. At the beginning, block comments are used to describe the example and how to pair the PS4 controller. Following this section is a listing of all the functions and commands that are included in the Tele-Op library along with descriptions of what they do and possible values that can be returned by the functions depending on the controller's status.

After the block comments at the beginning are the first lines of actual code. Notice that the Tele-Op module has its own library that must be included along with the PRIZM library. Following these initial lines of code is the **void setup()** section. This section sets up the serial monitor, initializes PRIZM, and sets the dead zones for the joysticks on the PS4 controller. We'll talk more about dead zones in the Hacking the Code section of this activity.

In the main loop, there is one active command. The **ps4.getPS4()** command gets the status of all the buttons and joysticks on the PS4 controller at one time as one data package. This command needs to be frequently repeated so that as the user uses the controller, the status of what buttons are pressed gets communicated to PRIZM.

Notice that the other commands in the main loop have been commented out. In other words, they have been turned into comments by adding "//" before each line. Each of these commented-out commands calls a function. The functions are listed after the main loop. Each function displays information in the serial monitor related to using certain Tele-Op commands. Because the function calls have been commented out, if you were to run the sketch as is, nothing would happen other than executing the command to get the button and joystick statuses of the PS4.

In order for the sketch to actually do something, one of the functions needs to be turned on by uncommenting it. In the main loop, find the command that calls the **Status()** function.

```
//  Status();
```

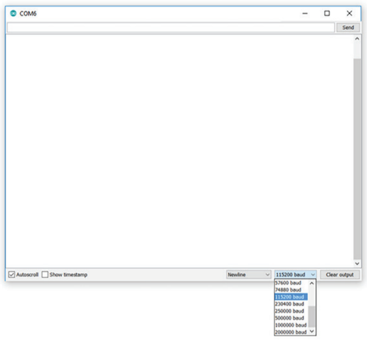
Remove the "//" at the beginning of the command to change the command from a comment to a function call. Notice how the text changes from gray to black. With this command uncommented, the main loop will continuously call the **Status()** function, which displays the PS4 connection status in the serial monitor.

Executing the Code

1. Connect the USB cable to a USB port on your computer or device. Connect the other end of the cable to the USB port on PRIZM.
2. Make sure PRIZM is turned on and the PS4 controller is paired with the Tele-Op Module. If it isn't, follow the steps in the Bluetooth Connections section.
3. In the Arduino Software (IDE), make sure the correct COM port is selected to communicate with PRIZM. Go to **Tools** > **Port** and then select the correct COM port.
4. In the software window, click the Upload button to upload the sketch. After the sketch has been uploaded, leave the USB cable connected so that you can use the serial monitor.
5. Open the serial monitor by selecting **Tools** > **Serial Monitor**. In the lower-right corner of the serial monitor window, make sure the baud rate is set to 115200 in the drop-down window.
6. Start the program by pressing the green Start button on PRIZM. Pay attention to the message displayed on the serial monitor. If the PS4 controller is not connected, the connection status will be 0. If the controller is connected, the status should be 1.
7. Try turning off the PRIZM controller. Wait for the PS4 controller to turn off (about 10 seconds). Close the serial monitor in the Arduino Software (IDE). Then turn PRIZM back on and wait for the green LED next to PRIZM's red Stop/Reset button to turn on. Reopen the serial monitor in the Arduino Software (IDE). Run the program again by pressing PRIZM's Start button. The serial monitor should display a connection status of 0. Now press the Power button on the PS4 controller. As soon as it connects to the Tele-Op module, the serial monitor should display a connection status of 1.
8. In the Arduino Software (IDE), find the **void Status()** function. Notice that the command that returns the connection status of the PS4 controller is **ps4.Connected**.
9. Return to the main loop and turn off the **Status()** function call by adding "//" back to the beginning of the command line.

```
//   Status();
```

Note: The Tele-Op module has a USB port that is used to flash its firmware. This USB port should not be used when uploading sketches. Make sure you use the USB port on PRIZM. Uploading a sketch to the Tele-Op module will overwrite its firmware, making it unusable until it can have its firmware flashed again.



Moving Forward

Explore the other functions by uncommenting each function, one at a time, and uploading the sketch to PRIZM. As the sketch runs, experiment with the PS4 controller while observing the output in the serial monitor.

Range()

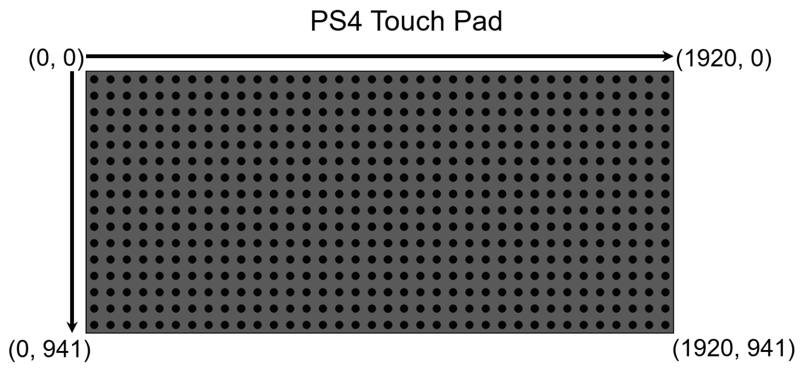
This function determines if the PS4 controller is in Bluetooth range of the Tele-Op module. The command **ps4.inRange** will return 1 if the controller is in range and 0 if the controller is out of range. In the main loop, uncomment the **Range()** function call to run this function.

TeleOpReset()

This function forces the Tele-Op module to reset itself. The command for resetting the Tele-Op module is **ps4.resetTeleOp()**. In this sketch, when this command is executed, the program enters a never-ending loop to keep from endlessly resetting the Tele-Op module. The **ps4.resetTeleOp()** command could be used to pass control from one PS4 controller to another without restarting the program on PRIZM. For example, if a robotics competition required two drivers each with his or her own controller, you'd pair both controllers but power on only one of them. When it was time to pass off control, you could do a remote reset of the Tele-Op module, power off the first controller, and power on the second controller to take control of the robot, all without ever having to restart the program.

TouchXY()

This function returns the *x*- and *y*-coordinates of the last touched area of the PS4's touch pad. As you drag your finger across the touch pad from left to right, you should see the *x*-coordinate increase from 0 to 1920 in the serial monitor. In the same way, as you drag your finger down from top to bottom, you should see the *y*-coordinate increase from 0 to 941. The commands for returning the *x*- and *y*-coordinates from the touch pad are **ps4.Touchpad(TOUCHX)** and **ps4.Touchpad(TOUCHY)**.



ControllerAngle()

The PS4 controller has a built-in gyroscope that it uses to measure the controller's tilt. The tilt measurements can be read by PRIZM and used to control elements such as servos and motors. In the **ControllerAngle()** function of the sketch, the PS4 controller's pitch (forward and back angle) and roll (side-to-side angle) is output to the serial monitor. The commands **ps4.Angle(PITCH)** and **ps4.Angle(ROLL)** each return a value of 0 to 360 degrees. When the controller is level on flat surface, the PITCH and ROLL of the controller should be about 180 degrees each. This value increases as you tilt the controller forward (pitch) or to the right (roll) and decreases as you tilt the controller back or to the left.

There are four other commands associated with the controller's pitch and roll measurements:

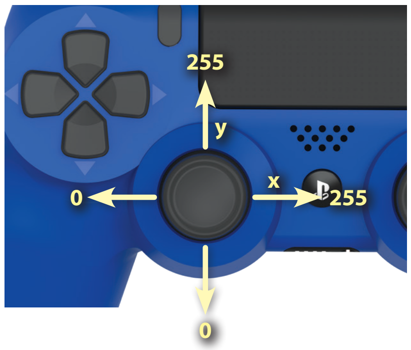
- **ps4.Motor(PITCH)** – Maps the controller's forward or back tilt to a motor's range of -100 to 100 percent power. When the controller is level, a value of 0 is returned.
- **ps4.Motor(ROLL)** – Maps the controller's side-to-side tilt to a motor's range of -100 to 100 percent power. When the controller is level, a value of 0 is returned.
- **ps4.Servo(PITCH)** – Maps the controller's forward or back tilt to a servo's range of 0 to 180 degrees. When the controller is level, a value of 90 degrees is returned.
- **ps4.Servo(ROLL)** – Maps the controller's side-to-side tilt to a servo's range of 0 to 180 degrees. When the controller is level, a value of 90 degrees is returned.

Sticks()

Each joystick on the PS4 controller has two analog values associated with it that range from 0 to 255. The *x* value indicates its horizontal position and the *y* value indicates its vertical position. The **Sticks()** function returns the *x* and *y* values of both joysticks. The command that returns the joystick position is **ps4.Stick(*CONTROL*)** where *CONTROL* can be any of the following:

- LX – left joystick *x* position (side to side)
- LY – left joystick *y* position (up and down)
- RX – right joystick *x* position (side to side)
- RY – right joystick *y* position (up and down)

For each joystick's horizontal position, a value of 0 is returned when the joystick is all the way to the left, and 255 is returned when the joystick is all the way to the right. For the vertical position, 0 is returned when the joystick is all the way down, and 255 is returned when the joystick is all the way up. When the joysticks are centered, the *x* and *y* positions should be about 128.



Note: Depending on your controller, you might notice that your joysticks do not naturally center at exactly 128 for their *x* and *y* positions. This is normal and is why the dead zone command can be very useful when using the sticks to control motors and servos.

Buttons()

This function shows the button press status of a single PS4 controller button. The command for determining the press status of a button is **ps4.Button(*CONTROL*)**. Two types of values can be returned from this command depending on how the function is used. All the buttons listed below return a digital Boolean value of either 0 (not pressed) or 1 (pressed) depending on whether the button is pressed or not.

- L1
- L2
- L3
- R1
- R2
- R3
- UP
- DOWN
- RIGHT
- LEFT
- TRIANGLE
- CROSS
- CIRCLE
- SQUARE
- SHARE
- OPTIONS
- POWER
- TOUCH

However, the L2 and R2 buttons can also be used as trigger buttons that return an analog value of 0 to 255 depending on how far the button is pressed. The same command is used to return analog values of the trigger buttons except that a T must be added to designate the buttons as analog: **ps4.Button(L2T)** or **ps4.Button(R2T)**. The L2 and R2 buttons are the only buttons that can return analog values. When you first open the example sketch, the function returns the status of the triangle button. You can change which button is output to the serial monitor by changing the word *TRIANGLE* in the command to any of the buttons in the list or by using *L2T* and *R2T* for the analog trigger buttons.

MoveMotor()

Although there are no motors connected to PRIZM for this activity, this function shows how a motor can be controlled using a PS4 controller. This function outputs a value of -100 to 100 to the serial monitor based on the left joystick's *y* value. When the left joystick is centered, a value of 0 is output to the serial monitor. This would indicate a motor power of 0 and the motor would not turn. If you push the left joystick up, the value increases to a maximum of 100 when the joystick is all the way up. This would indicate a motor power of 100 percent. If you pull the joystick all the way down, the value decreases until it reaches -100. The command for getting the joystick position and mapping it to the motor range (-100 to 100) is **ps4.Motor(*CONTROL*)** where *CONTROL* can be any of the following:

- LX – left joystick *x* position (side to side)
- LY – left joystick *y* position (up and down)
- RX – right joystick *x* position (side to side)
- RY – right joystick *y* position (up and down)
- L2T – L2 trigger button
- R2T – R2 trigger button
- PITCH – rotating the controller forward or back using the PS4 controller's internal gyroscope
- ROLL – rotating the controller side to side using the PS4's controller's internal gyroscope

These are the only controls that work for the **ps4.Motor(*CONTROL*)** command because these are the PS4 button and joystick controls that return analog values based on their position.

MoveServo()

Although there are no servos attached to PRIZM for this activity, this function shows how a servo could be controlled using the PS4 controller. This function outputs a value of 0 to 180 to the serial monitor depending on the *y* value of the right joystick. When the joystick is centered, a value of 90 is output to the serial monitor. If you push the right joystick up, the value increases until it reaches 180 when the joystick is all the way up. If you pull the joystick down, the output value decreases until it reaches 0. The command for getting the joystick position and mapping it to the servo range (0 to 180) is **ps4.Servo(*CONTROL*)** where *CONTROL* can be any of the following:

- LX – left joystick *x* position (side to side)
- LY – left joystick *y* position (up and down)
- RX – right joystick *x* position (side to side)
- RY – right joystick *y* position (up and down)
- L2T – L2 trigger button
- R2T – R2 trigger button
- PITCH – rotating the controller forward or back using the PS4 controller's internal gyroscope
- ROLL – rotating the controller side to side using the PS4's controller's internal gyroscope

These are the only controls that work for the **ps4.Servo(*CONTROL*)** command because these are the PS4 button and joystick controls that return analog values based on their position.

Rumble()

This function toggles on the rumble motors in the PS4 controller. When this function is called, the controller will vibrate at the slow speed for 1 second, then at the fast speed for 1 second, and then stops for 1 second. The command for changing the rumble motor's status is **ps4.setRumble(*STATUS*)** where *STATUS* can be SLOW, FAST, or STOP. One use of the rumble motors would be to have the controller vibrate when it is out of range of the Tele-Op module.

LEDcolor()

This function changes the LED color of the PS4 controller's light bar. The light bar will change from red to blue to yellow to green every 500 milliseconds. The command for changing the light bar color is **ps4.setLED(*COLOR*)** where *COLOR* can be RED, BLUE, YELLOW, or GREEN. Examples of when you might want to change the light bar color is to distinguish your controller from others, to indicate different modes of operation, to signal errors, and to represent different sensor data values.

buttonsGroup1()

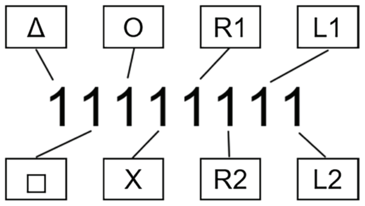
Button combos are common in the gaming world because they enable you to perform special moves or take certain actions when certain buttons are pressed at the same time. The Tele-Op module has some easy-to-use commands that can be programmed to do certain actions or tasks when different button combinations are pressed on the PS4 controller. The buttons on the PS4 controller are divided into two groups.

Note: A practical application of using button groups is shown in Tele-Op Activity 2. In this activity, button groups are used to change the speed of a robot from normal speed to either crawl or turbo speed.

Group 1	Group 2
• L1	• Up
• L2	• Down
• R1	• Left
• R2	• Right
• Cross	• L3
• Circle	• R3
• Triangle	• Share
• Square	• Options

The **ps4.buttons_1 command** will return a byte value that represents the Boolean states of the buttons in Group 1. In other words, this command returns an assigned value depending on which buttons are pressed from Group 1. Each combination of buttons has a unique assigned value.

In this sketch, the **buttonsGroup1()** function outputs the byte value for whatever button combination is pressed on the PS4 controller. It also outputs the byte value as a binary number where each digit represents the on/off status of a particular button. For example, if you press all the Group 1 buttons at the same time, the function will output a decimal value of 255 and a binary value of 11111111. In the binary number, each 1 represents a different button that is pressed. If you were to keep holding all the buttons down but release the L2 button, the function would output a decimal number of 254 and a binary value of 11111110, indicating that the L2 button is not pressed.

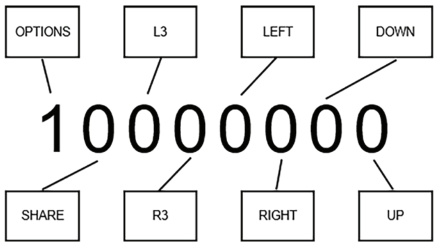


Binary value when all buttons in Group 1 are pressed.

There are too many button combinations to list them all here. However, you can use this sketch any time you are programming with the Tele-Op module to quickly identify the unique byte value of any button combination.

buttonsGroup2()

This function works exactly like the **buttonsGroup1()** function except that it returns the status of the buttons in Group 2 (Up, Down, Left, Right, L3, R3, Share, and Options). The command for returning the status of the Group 2 buttons is **ps4.buttons_2**.



Binary value when only the Options button is pressed.

Note: When the binary values of a button combination are displayed, the leading zeros are left off. This is why when the L1 button is pressed by itself, the function outputs 1 instead of 00000001. However, if you hold down the Triangle button, all eight digits will appear, and it is easier to see how each digit represents a different button. For Group 2, hold down the Options button to see all eight digits.

Notice that because of the way the direction buttons work, it is impossible to hold all four of them down at the same time.

Hacking the Code

Attach a standard servo and a motor to the PRIZM. Using the example sketch as reference, write a new sketch to control the servo using these PS4 controls:

- L2 trigger button
- Left joystick
- Touch pad's *x* position
- Roll from the PS4 controller's gyroscope

Add commands to control the motor using these controls:

- R2 trigger button
- Right joystick
- Touch pad's *y* position
- Pitch from the PS4 controller's gyroscope

In the **void setup()** section, include the commands:

```
ps4.setDeadZone(LEFT,10);
ps4.setDeadZone(RIGHT,10);
```

Experiment with changing the value of the dead zones from 10 to 0. How does this affect the servo or motor? Then change the value to 50. Do you notice a difference in how the servo and motor behave?

Dead Zones

Precisely controlling servos and motors using joysticks can be difficult sometimes because the joysticks don't always return to the exact center. This might cause your servo to not return to its center position or your motor to continue to slowly spin when the joysticks are released. By setting a dead zone, you identify the size of an area for the joystick's *x*- and *y*-axis that is considered neutral. When the joystick returns to this neutral dead zone area, the joystick is considered to be centered.

Setting a higher dead zone value gives you a bigger neutral area but reduces the sensitivity of the joystick outside the dead zone. On the other hand, a small dead zone gives you more precise sensitivity but reduces the neutral area of the joystick. You'll need to experiment with your controller to find the right balance of joystick sensitivity and dead zone.