

FTC Blocks Programming Training Manual

REV Robotics Expansion Hub Edition

Document Version 2.1

FIRST Tech Challenge



Revision History		
Revision	Date	Description
1.0	11/3/2016	Initial Release
2.0	06/09/2017	Updated with support for REV Expansion Hub. New tabular format.
2.1	06/16/2017	Some of the screenshots were missing negation operator.

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1 Introduction

This document shows how to set up, configure and program the control system used for the *FIRST* Tech Challenge competition. The basic examples in this document use the REV Robotics Expansion Hub as the primary input/output module. For detailed information about the REV Robotics Expansion Hub, refer to the *REV Robotics Expansion Hub Guide* which is available from the REV Robotics website (<http://www.revrobotics.com/>).

1.1 Point-to-Point Control System

Teams competing in the *FIRST* Tech Challenge use a *point-to-point* system to control their robots.



Figure 1 – The control system has a Driver Station connected wirelessly to a Robot Controller.

The *Robot Controller* acts as the “brains” of the robot and is mounted on the frame of the robot. The *Driver Station* lets humans interact with the Robot Controller through a wireless connection.

1.2 REV Robotics Expansion Hub

The REV Robotics Expansion Hub is the electronic *input/output* (or “I/O”) module that lets the Robot Controller talk to the robot’s motors, servos, and sensors. The Robot Controller communicates with the Expansion Hub through a USB connection.

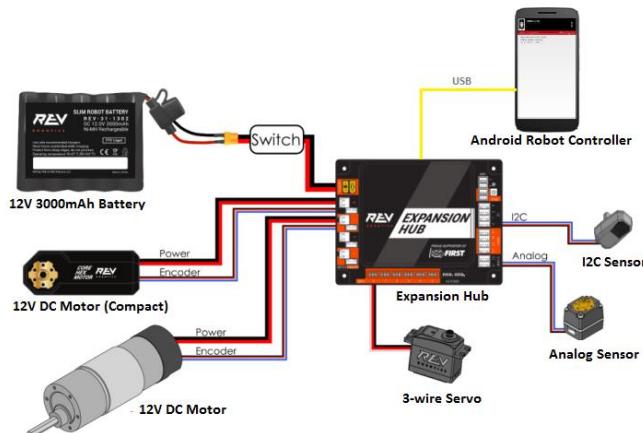


Figure 2 - The Expansion Hub lets the Robot Controller talk to the sensors, motors and servos.

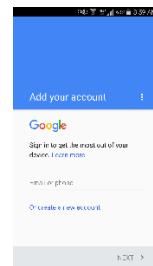
2 Required Materials

To follow along with the examples in this document, you will need the following items:

Two (2) *FIRST*-approved Android smartphones¹



A Google account (available for free from Google) to access the Google Play store



Wireless Internet access



Laptop with Microsoft Windows 7, 8 or 10 and Wi-Fi capability.

Note that your laptop should also have the most current service packs and system updates from Microsoft.



Javascript-enabled web browser (Google Chrome is the recommended browser).



¹ Consult the official *FIRST* Tech Challenge Game Manual, Part 1 for a list of approved devices.

REV Robotics Expansion Hub (REV-31-1153)



REV Robotics Switch, Cable, and Bracket
(REV-31-1387)



REV Robotics Tamiya to XT30 Adapter (REV-31-1382)



FIRST-approved 12V Battery (such as Tetrix W39057)



FIRST-approved 12V DC Motor (such as Tetrix W39530, with power cable W41352)²



² Note that for the examples listed in this document, it is recommended that the user builds a simple structure using a compatible build kit (such as TETRIX Max) to properly secure the DC motor and prevent it from rolling about uncontrollably while running the sample op modes.

REV Robotics Anderson to JST VH Cable
(REV-31-1381)



180-Degree Standard Scale Servo (such as
Hitec HS-485HB)



REV Robotics Color Sensor with 4-Pin JST PH
Cable (REV-31-1154)



REV Robotics Touch sensor with 4-Pin JST PH
Cable (REV-31-1425)



USB Type A male to type mini-B male cable



Two (2) micro USB OTG adapters



Logitech F310 USB Gamepad



3 Setting Up Your Smartphones

3.1 Renaming Your Smartphones

You will need to have two *FIRST*-approved Android smartphones for the control system. One phone will be used as the Robot Controller, the other will be used as the Driver Station.³

By establishing unique names for your phones, you can ensure that your phones will be communicating with each other rather than other teams' phones at meets and tournaments. The official rules of the *FIRST* Tech Challenge require that you change the Wi-Fi name of your smartphones to include your team number and “-RC” if the phone is a Robot Controller or “-DS” if it is a Driver Station. A team can insert an additional dash and a letter (“A”, “B”, “C”, etc.) if the team has more than one set of Android phones.

If, for example, a team has a team number of 9999 and the team has multiple sets of phones, the team might decide to name one phone “9999-C-RC” for the Robot Controller and the other phone “9999-C-DS” for the Driver Station. The “-C” indicates that these devices belong to the third set of phones for this team.

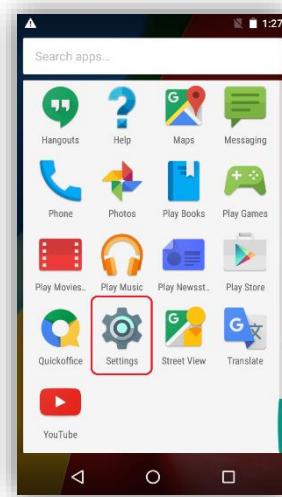
³ Note that the screen images for this document were made using a pair of Motorola Android smartphones. The actual screen images on your smartphones might differ slightly from the images depicted in this document.

Renaming Your Smartphones

(Time Needed to Complete Task: 5 Minutes per Phone)

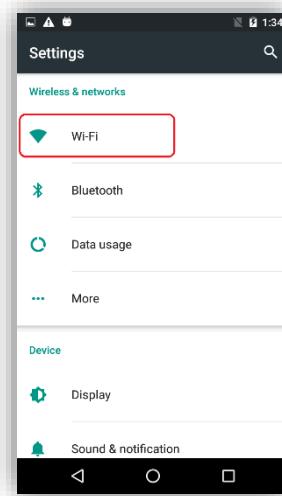
Step 1:

Click on **Settings** icon to display the Android Settings screen.



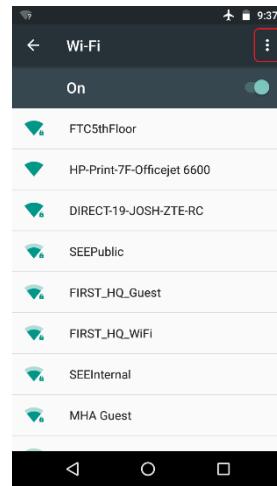
Step 2:

Click on **Wi-Fi** to launch the Wi-Fi screen.



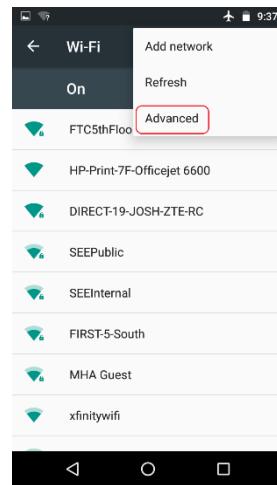
Step 3:

Touch the three vertical dots in upper right-hand corner to display a pop-up menu.



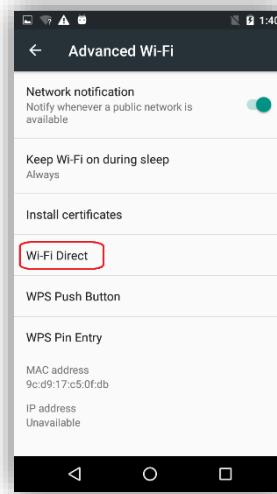
Step 4:

Select **Advanced** from the pop-up menu to display the Advanced Wi-Fi screen.



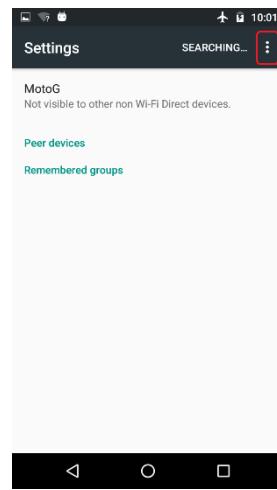
Step 5:

Select **Wi-Fi Direct** to display the Wi-Fi Direct menu.



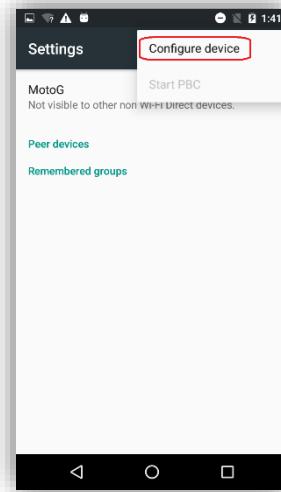
Step 6:

Touch the three vertical dots to display the pop-up menu.



Step 7:

Select **Configure Device** from the pop-up menu.



Step 8:

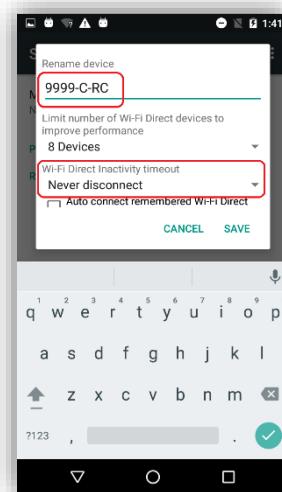
In the **Configure Device** screen, use the touch keypad to type in the new name of the device. If it is going to be a Robot Controller device, specify your team number and “-RC”. If it is going to be a Driver Station, specify your team number and “-DS”.

You can also set the Wi-Fi Direct Inactivity timeout to “Never disconnect” and then hit the **SAVE** button to save your changes.

Note that in the screenshot shown to the right, the team number is “9999”. The “-C” indicates that this is from the third pair of smartphones for this team. The “-RC” indicates that this phone will be a Robot Controller.

Step 9:

After you have renamed your phone, power cycle (i.e., restart) your smartphone.



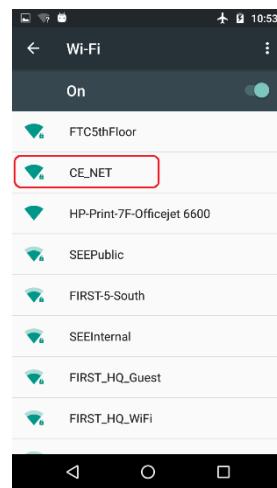
3.2 Installing the *FIRST* Tech Challenge Apps

The FTC apps are available to download for free from the Google Play store. You will need to have your Android phones connected to a Wi-Fi network that has Internet access before you can access the Google Play store. You will also need a Google account to be able to download the apps from the Google Play store.

Installing the *FIRST* Tech Challenge Apps (Time Needed to Complete Task: 7.5 Minutes per Phone)

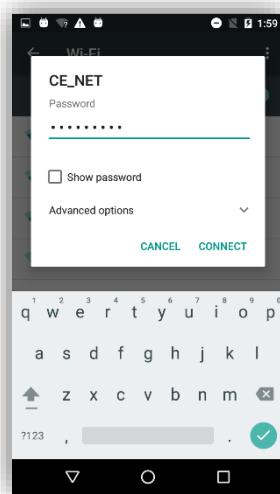
Step 1:

From the Android Wi-Fi screen look for the name of your wireless network (“CE_NET” in this example) and touch the wireless network name to login to the network.

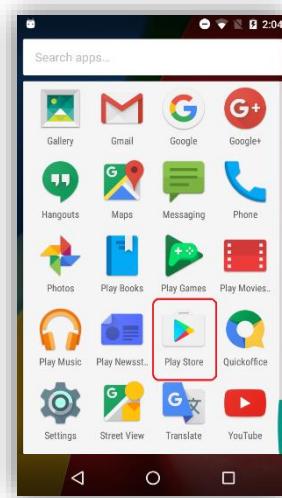


Step 2:

Specify the password using the touch keypad and hit **CONNECT** to connect to this wireless network.

**Step 3:**

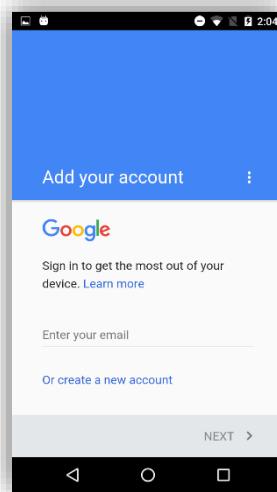
Find the Google Play Store icon on your phone and click it to launch the Google Play Store app.



Step 4:

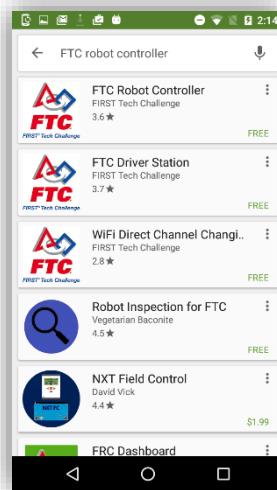
If you haven't signed into your Google account yet, follow the onscreen instructions to log into your Google account.

If you don't have a Google account, follow the onscreen instructions to create a new account.



Step 5:

In the search window of the Google Play app, type in the words "FTC Robot Controller" to find the Robot Controller or "FTC Driver Station" to find the appropriate FTC app for your phone.



Step 6:

Tap on the app in the Google Play listing to bring up the installation screen. Follow the onscreen instructions to install the appropriate app for your phone.

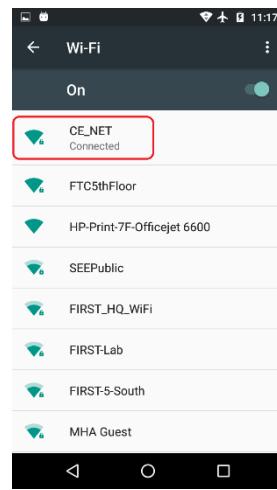
Important note: When you install the FTC apps, **only install one FTC app** (FTC Robot Controller or FTC Driver Station) **per phone**. You should avoid installing both apps onto the same phone. Doing so can cause Wi-Fi connection problems. You should only install the FTC Robot Controller app onto the phone that will be the Robot Controller and the FTC Driver Station app onto the phone that will be the Driver Station.



Step 7:

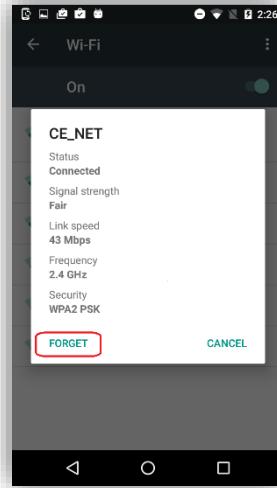
After you have successfully installed the app, you should forget the external wireless network on your phone.

Go to the Android Wi-Fi screen, find the name of the currently connected network, and tap on the network name to bring up a pop-up box with info about the network.



Step 8:

Click on **FORGET** button to forget the wireless network.



3.3 Placing Phones into Airplane Mode with Wi-Fi On

For the *FIRST* Tech Challenge competitions, it is important that you place your Robot Controller and Driver Station phones into Airplane mode but keep their Wi-Fi radios turned on. This is important because you do not want any of the cellular telephone functions to be enabled during a match. The cellular telephone functions could disrupt the function of the robot during a match.

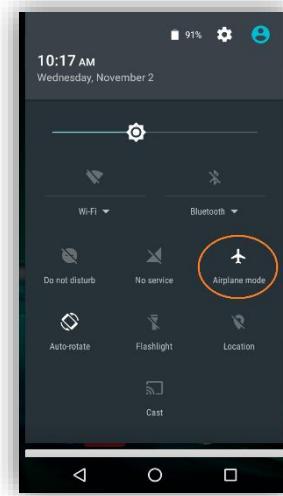
Placing Phones into Airplane Mode with Wi-Fi On (Time Needed to Complete Task: 2.5 Minutes per Phone)

Step 1:

On the main Android screen of each smartphone, use your finger to slide from the top of the screen down towards the bottom of the screen to display the quick configuration screen.

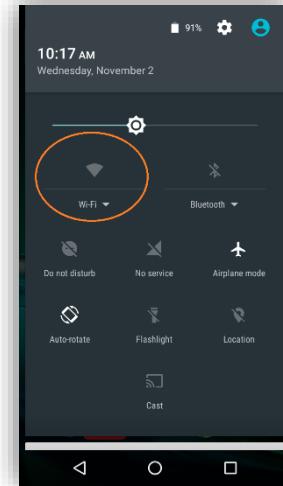
Note that for some smartphones you might have to swipe down more than once to display the quick configuration screen, particularly if there are messages or notifications displayed at the top of your screen.

Look for the Airplane mode icon (which is shaped like an airplane) and if the icon is not activated, touch the icon to put the phone into airplane mode.



Step 2:

Placing the phone into airplane mode will turn off the Wi-Fi radio. If the Wi-Fi icon has a diagonal line through it (see Step 1 above), then the Wi-Fi radio is disabled. You will need to touch the “Wi-Fi” icon on the quick configuration screen to turn the Wi-Fi radio back on.



3.4 Pairing the Driver Station to the Robot Controller

Once you have successfully installed the FTC apps onto your Android phones, you will want to establish a secure wireless connection between the two devices. This connection will allow your Driver Station phone to select op modes on your Robot Controller phone and send gamepad input to these programs. Likewise, it will allow your op modes running on your Robot Controller phone to send telemetry data to your Driver Station phone where it can be displayed for your drivers. The process to connect the two phones is known as “pairing.”

Pairing the Driver Station to the Robot Controller (Time Needed to Complete Task: 10 minutes)

Step 1:

On the main Robot Controller smartphone, look for the FTC Robot Controller icon. Tap on the icon to launch the Robot Controller app.



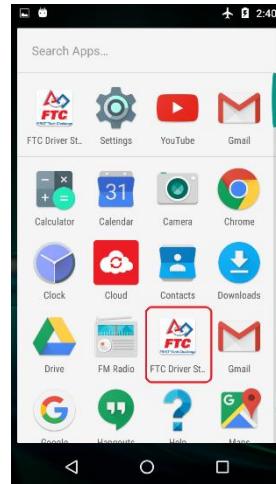
Step 2:

Verify that the Robot Controller app is running. The **Robot Status** field should read “running” if it is working properly.



Step 3:

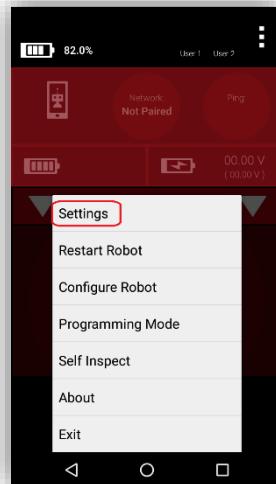
On your Driver Station phone, find the FTC Driver Station app icon. Tap on the icon to launch the Driver Station app.

**Step 4:**

Touch the three vertical dots on the upper right hand corner of the main screen of the FTC Driver Station app. This will launch a pop-up menu.

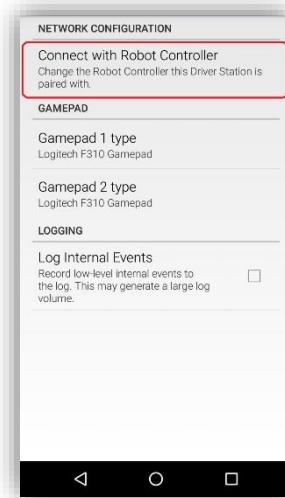
**Step 5:**

Select **Settings** from the pop-up menu.



Step 6:

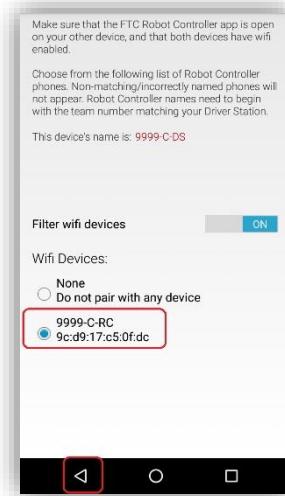
From the Settings screen, look for and select “Connect with Robot Controller” to launch the Connect with Robot Controller screen.

**Step 7:**

Find the name of your Robot Controller from the list and select it.

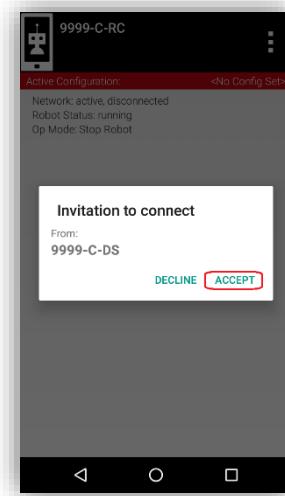
After you have made your selection, use the back-arrow key to return to the Settings screen.

Then press the back-arrow key one more time to return to the main Driver Station screen.

**Step 8:**

When the Driver Station returns to its main screen, the first time you attempt to connect to the Robot Controller a prompt should appear on the Robot Controller screen.

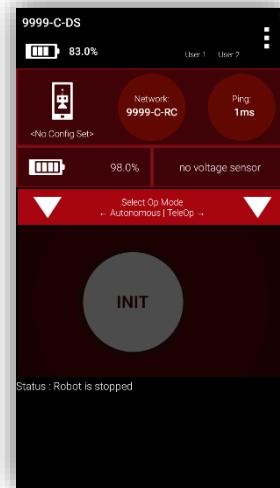
Click on the “ACCEPT” button to accept the connection request from the Driver Station.



Step 9:

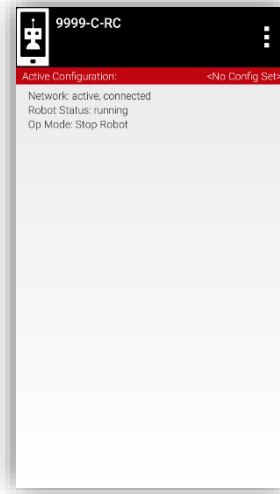
Verify that the Driver Station screen has changed and that it now indicates that it is connected to the Robot Controller.

The name of the Robot Controller's remote network ("9999-C-RC" in this example) should be displayed in the **Network** field on the Driver Station.

**Step 10:**

Verify that the Robot Controller screen has changed and that it now indicates that it is connected to the Driver Station.

The **Network** status should read "active, connected" on the Robot Controller's main screen.



4 Connecting Devices to an Expansion Hub

This section demonstrates how to connect and configure devices to your REV Robotics Expansion Hub. For the examples in this document, we will connect the Expansion Hub through a switch to a 12V battery. We will then connect a DC motor, a servo and some sensors to the Expansion Hub.

4.1 Connecting 12V Power to the Expansion Hub

The Expansion Hub draws power from a 12V rechargeable battery. For safety reasons, the battery has a 20A fuse built in. A mechanical switch is used to turn on/turn off the power.

Connecting 12V Power to the Expansion Hub (Time Needed to Complete Task: 5 minutes)

Step 1:

If your 12V battery has a Tamiya style connector, connect the Tamiya to XT30 adapter cable to the matching end of the switch cable.



Do not plug connect the 12V battery to the Tamiya adapter yet. We will connect the battery during a later step.

Step 2:

Connect the other end of the switch cable to a matching XT30 port on the Expansion Hub.



Step 3:

Verify that the switch is in the OFF position.

**Step 4:**

Connect the 12V battery to the Tamiya to XT30 cable.



Step 5:

Turn on the switch and verify that the Expansion Hub is drawing power from the battery. Note that the Expansion Hub's LED should be illuminated (notice blue LED in image below).

**Step 6:**

Turn off the switch and verify that the Expansion Hub is off. Note that the Expansion Hub's LED should not be illuminated.



4.2 Connecting a Motor to the Expansion Hub

The Expansion Hub can drive up to four (4) 12V DC motors per Expansion Hub. The Expansion Hub uses a type of electrical connector known as a 2-pin JST VH connector. At the time that this document was written, the *FIRST*-approved 12V DC motors were equipped with Anderson Powerpole connectors. An adapter cable is used to connect the Anderson Powerpole connectors to the Expansion Hub motor port.

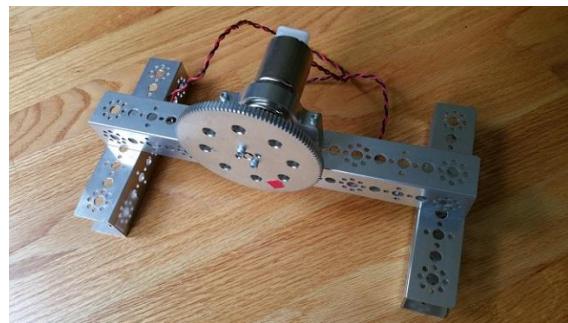


Figure 3 - Motor test rig made from Tetrix build components.

For the examples in this document, FIRST recommends that the user build a simple rig to secure the motor in place and prevent it from moving about during the test runs. The image above shows a Tetrix motor installed in a rig built with a Tetrix motor mount and some Tetrix C-channels. A gear was mounted on the motor shaft to make it easier for the user to see the rotation of the shaft.

Connecting a 12V DC Motor to the Expansion Hub (Time Needed to Complete Task: 2.5 minutes)

Step 1:

Connect the Anderson Powerpole end of the motor's power cable to the Powerpole end of the Anderson to JST VH adapter cable.



Step 2:

Connect the other end of the Anderson to JST VH adapter cable into the motor port labeled "0" on the Expansion Hub.



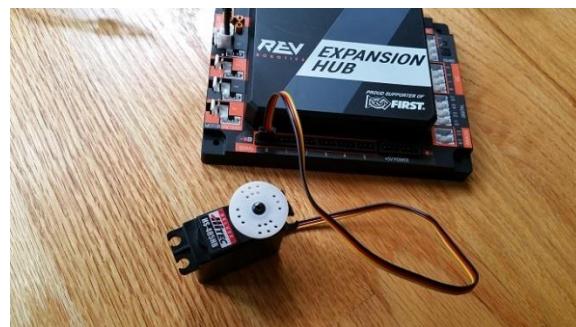
4.3 Connecting a Servo to the Expansion Hub

The REV Robotics Expansion Hub has 6 built-in servo ports. The servo ports accept the standard 3-wire header style connectors commonly found on servos. Note that ground pin is on the left side of the servo port.

Connecting a Servo to the Expansion Hub (Time Needed to Complete Task: 2.5 minutes)

Step 1:

Connect the servo cable to the servo port labeled “0” on the Expansion Hub. Note that the ground pin is on the left side of the servo port.



Step 2:

Verify that the black ground wire of the servo cable matches the ground pin of the servo port (which is aligned on the left side of the port).



4.4 Connecting a Color-Distance Sensor to the Expansion Hub

The Expansion Hub has 4 independent I2C buses. Each bus has its own port on the Hub. We will connect a REV Robotics Color-Distance sensor to the I2C bus #0 on the Expansion Hub.

Connecting a Color-Distance Sensor to the Expansion Hub (Time Needed to Complete Task: 2.5 minutes)
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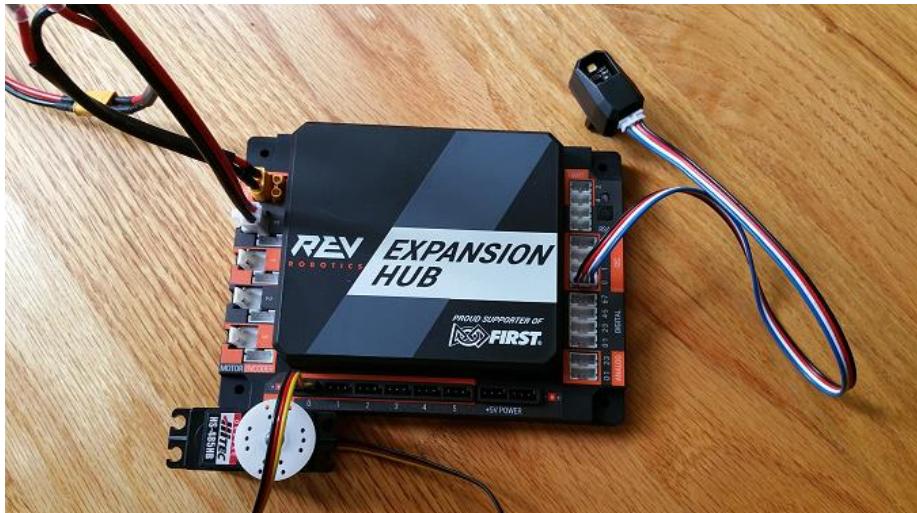
Step 1:

Connect the one end of the 4-pin JST PH cable to the REV Robotics Color-Distance sensor.



Step 2:

Plug the other end of the 4-pin JST PH cable to the I2C port labeled “0” on the Expansion Hub.



4.5 Connecting a Touch Sensor to the Expansion Hub

The Expansion Hub has 4 independent digital input/output (I/O) ports. Each port has two digital I/O pins for a total of 8 digital I/O pins on an Expansion Hub. You will connect a REV Robotics Touch sensor to one of the digital I/O ports.

Note that in the case of the REV Robotics Touch Sensor, the device has a connector port for a 4-pin sensor cable. However, the device only needs to connect to one of the two available digital I/O pins. For the REV Robotics Touch Sensor, the second digital I/O in the port is the one that gets connected when a standard REV Robotics 4-pin JST PH cable is used. For the “0-1” port, it is the pin labeled “1” that gets connected through the 4-pin cable. Similarly, for the “2-3” port, it is the pin labeled “3” that gets connected through the 4-pin cable.

Connecting a Touch Sensor to the Expansion Hub (Time Needed to Complete Task: 2.5 minutes)

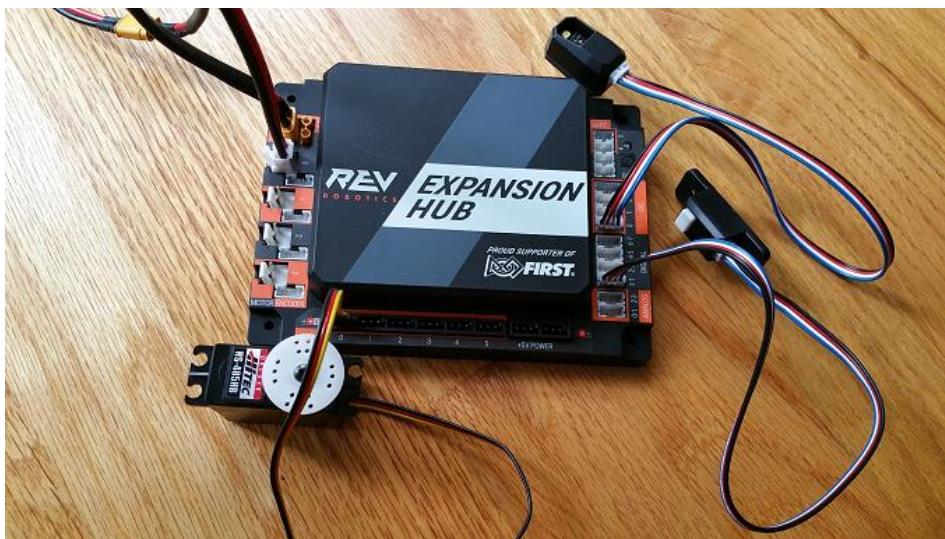
Step 1:

Connect the one end of the 4-pin JST PH cable to the REV Robotics Touch sensor.



Step 2:

Plug the other end of the 4-pin JST PH cable to digital I/O port labeled “0-1” on the Expansion Hub.



5 Configuring Your Hardware on the Robot Controller

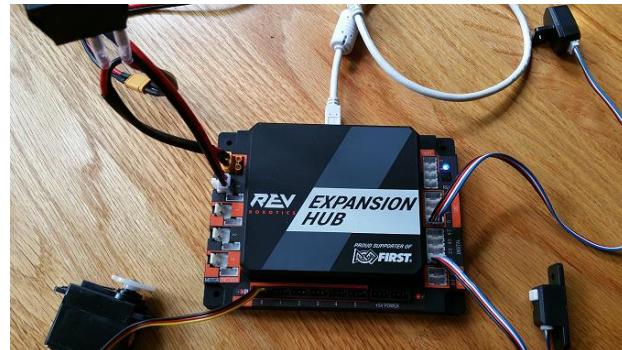
Before you can communicate with the motor, servo and sensors that are connected to the Expansion Hub, you first must create a configuration file on your Robot Controller smartphone, so that the Robot Controller will know what hardware is available on the Expansion Hub.

Creating a Configuration File on the Robot Controller (Time Needed to Complete Task: 20 minutes)

Connecting the Phone to the Expansion Hub

Step 1:

Power on the Expansion Hub by turning on the power switch.



Step 2:

Plug the Type B Mini end of the USB cable into the USB mini port on the Expansion Hub.



Step 3:

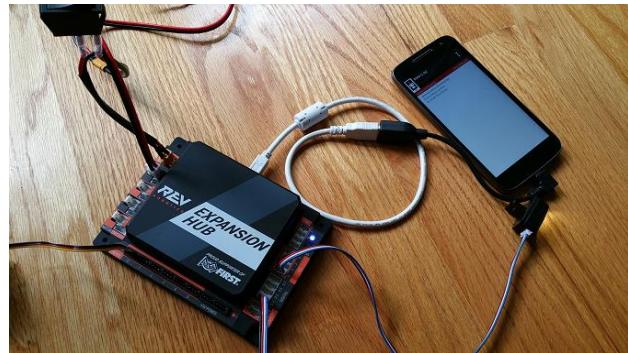
Plug the Type A end of the USB cable into the OTG adapter.



Step 4:

Verify that your Robot Controller smartphone is powered on and unlocked. Plug in the USB Micro OTG adapter into the OTG port of the Robot Controller phone.

Note that when the OTG adapter is plugged into the smartphone, the phone will detect the presence of the Expansion Hub and launch the Robot Controller app.



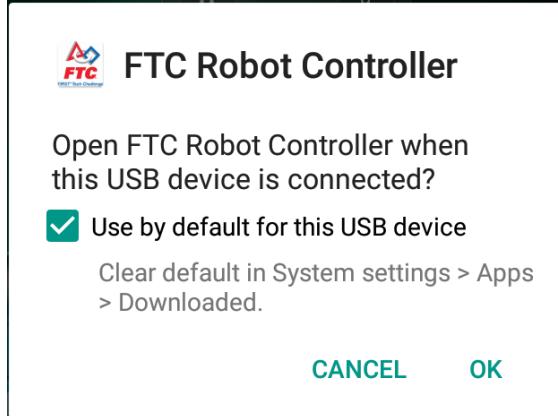
Step 5:

The first time you connect the Robot Controller smartphone to the Expansion Hub, the Android operating system should prompt you to ask if it is OK to associate the newly detected USB device (which is the Expansion Hub) with the FTC Robot Controller app.

Important Information!

You might be prompted multiple times to associate the USB hardware with the FTC Robot Controller. Whenever you are prompted by your phone with this message, you should **always** select the “Use by default for this USB device” option and hit the “OK” button to associate the USB device with the FTC Robot Controller app.

If you fail to make this association, then the Robot Controller app might not reliably connect to this Expansion Hub the next time you turn your system on.

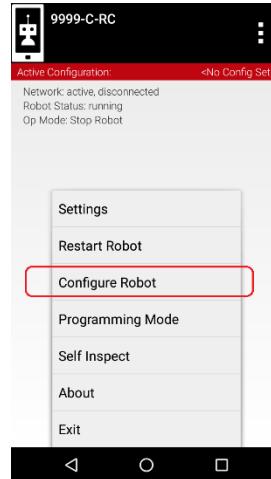


Step 6:

Touch the three vertical dots in the upper right hand corner of the Robot Controller. This will launch a pop-up menu.

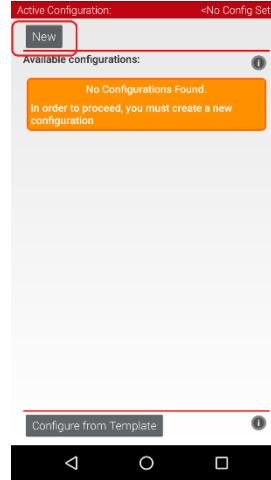
**Step 7:**

Select **Configure Robot** from the pop up menu to display the Configuration screen.

**Step 8:**

If your Robot Controller does not have any existing configuration files, the screen will display a message indicating that you need to create a file before proceeding.

Hit the “New” button to create a new configuration file for your Robot Controller



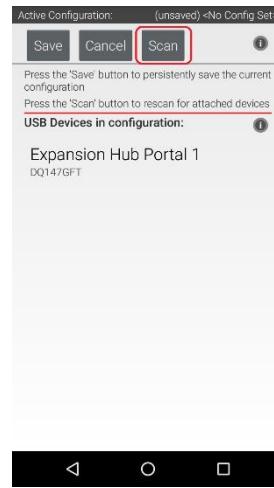
Step 9:

When the new configuration screen appears, the Robot Controller app will do a scan of the USB bus to see what devices are connected to the phone.

It will display the devices that it found in a list underneath the words “USB Devices in configuration.” You should see an entry that says something like “Expansion Hub Portal 1” in the list.

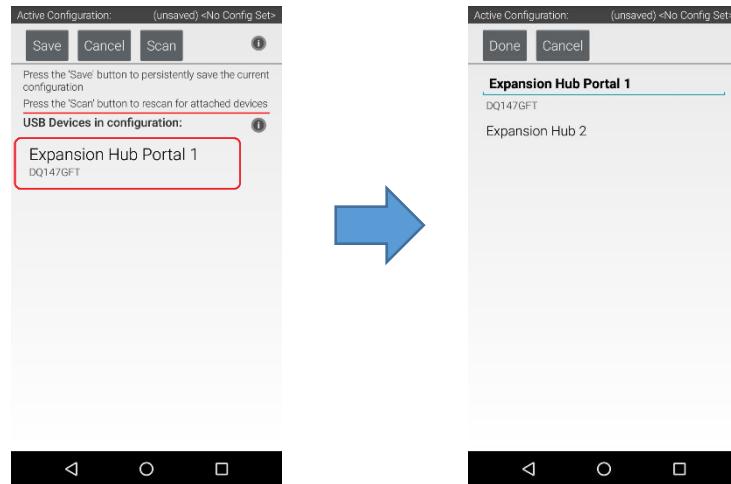
Your Expansion Hub is listed as a **Portal** because it is directly connected to the Robot Controller phone through the USB cable.

If you do not see your Expansion Hub Portal listed, check the wired connections and then press the **Scan** button one or two times to see if the phone detects the device on a re-scan of the USB bus.



Step 12:

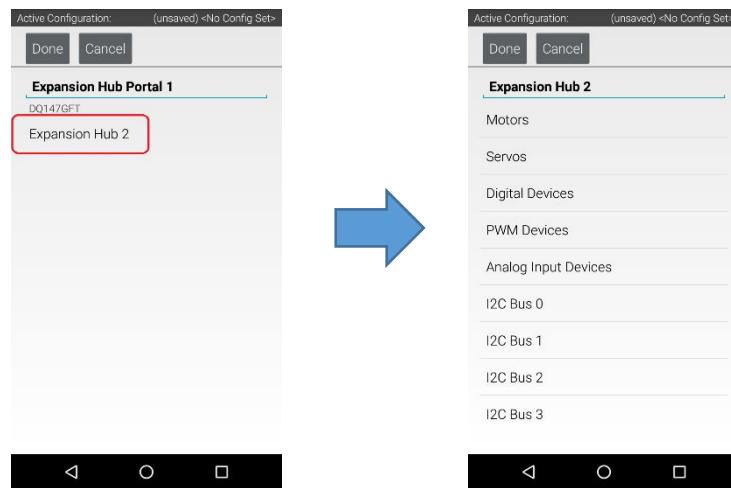
Touch the Portal listing (“Expansion Hub Portal 1” in this example) to display what Expansion Hubs are connected through this Portal.



Since we only have a single Expansion Hub connected, we should only see a single Expansion Hub configured (“Expansion Hub 2” in this example).

Step 13:

Touch the Expansion Hub listing (“Expansion Hub 2” in this example) to display the Input/Output ports for that device.

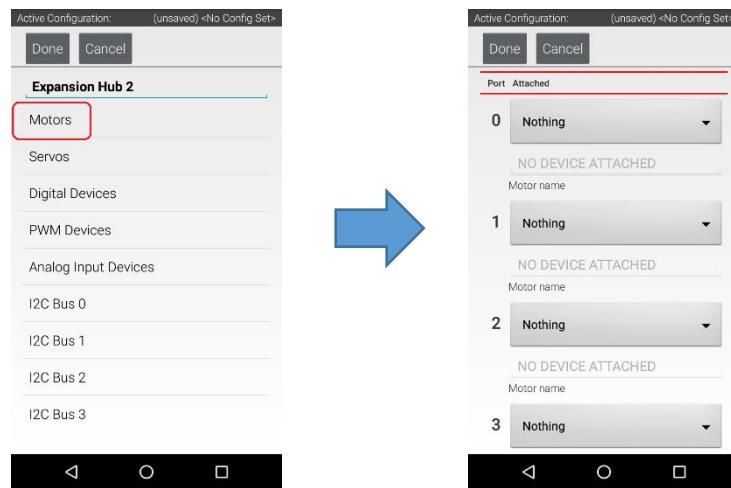


The screen should switch and list all the motor, servo and sensor ports that are available on the selected Expansion Hub.

Configuring the DC Motor

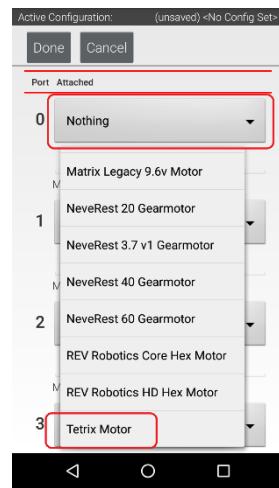
Step 14:

Touch the word **Motors** on the screen to display the Motor Configuration screen.

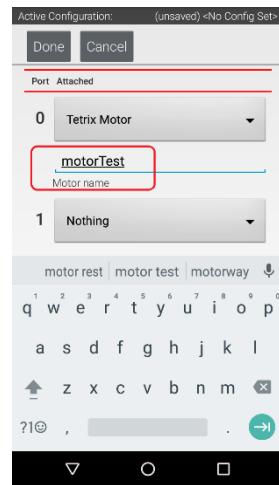


Step 15:

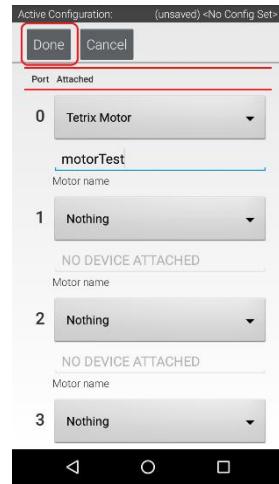
Since we installed our motor onto port #0 of the Expansion Hub, use the dropdown control for port 0 to select the motor type (Tetrix Motor for this example).

**Step 16:**

Use the touch screen keypad to specify a name for your motor ("motorTest" in this example).

**Step 17:**

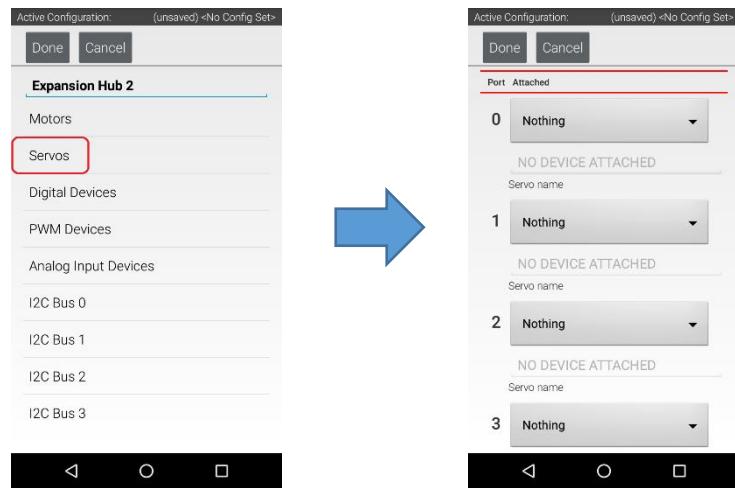
Press the **Done** button to complete the motor configuration. The app should return to the previous screen.



Configuring the Servo

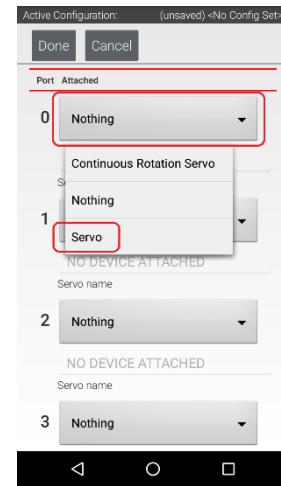
Step 18:

Touch on the word **Servos** on the screen to display the Servo Configuration screen.



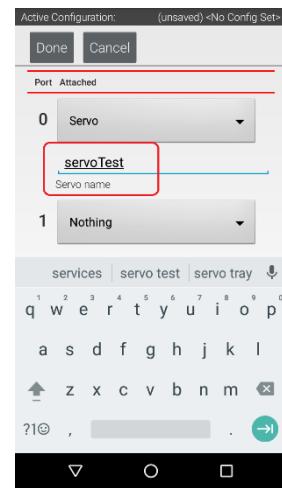
Step 19:

Use the dropdown control to select “Servo” as the servo type for port #0.

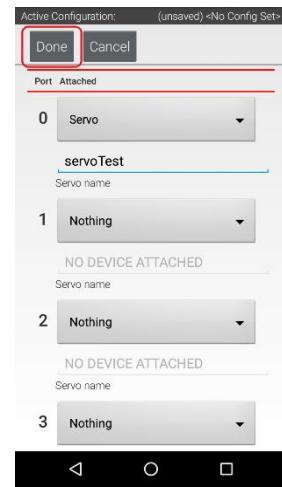


Step 20:

Use the touch pad to specify the name of the servo ("servoTest" for this example) for port #0.

**Step 21:**

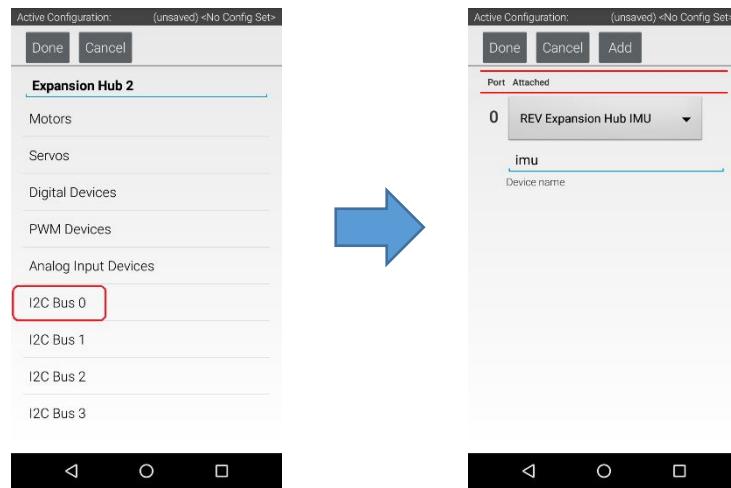
Press the **Done** button to complete the servo configuration. The app should return to the previous screen.



Configuring the Color Sensor

Step 22:

Touch the words **I2C Bus 0** on the screen to launch the I2C configuration screen for this I2C bus.



The Expansion Hub has four independent I2C buses, labeled “0” through “3”. In this example, since you connected the Color Sensor to the port labeled “0”, it resides on I2C Bus 0.

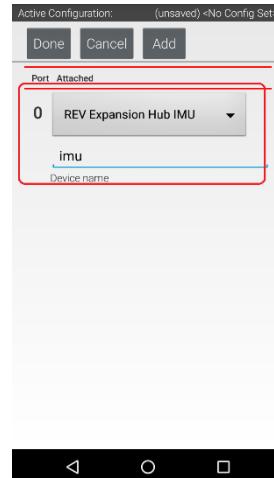
Step 23:

Look at the I2C Bus 0 screen. There should already be a sensor configured for this bus.

The Expansion Hub has its own built-in inertial measurement unit (IMU) sensor. This sensor can be used to determine the orientation of a robot, as well as measure the accelerations on a robot.

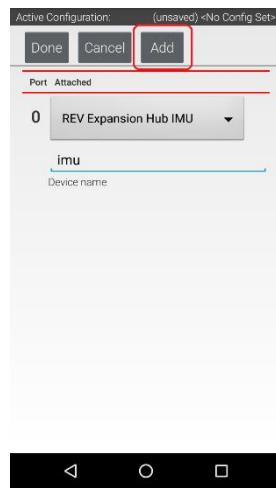
The built-in IMU is internally connected to I2C Bus 0 on each Expansion Hub. Whenever you configure an Expansion Hub using the Robot Controller, the app automatically configures the IMU for I2C Bus 0.

You will need to add another I2C device for this bus to be able to configure the color sensor.

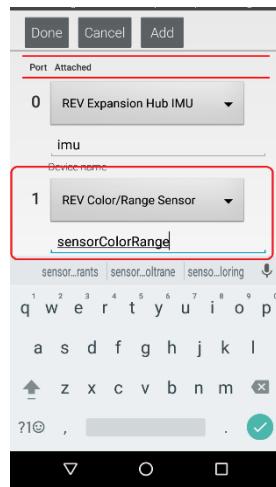


Step 24:

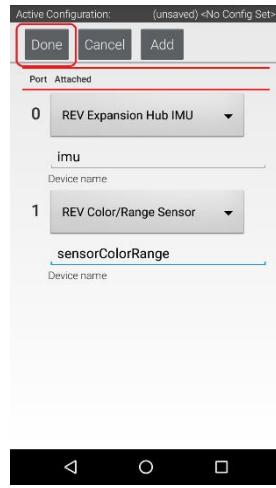
Press the **Add** button to add another I2C device to this bus.

**Step 25:**

Select “REV Color/Range Sensor” from the dropdown selector for this new device. Use the touchscreen keyboard to name this device “sensorColorRange”.

**Step 26:**

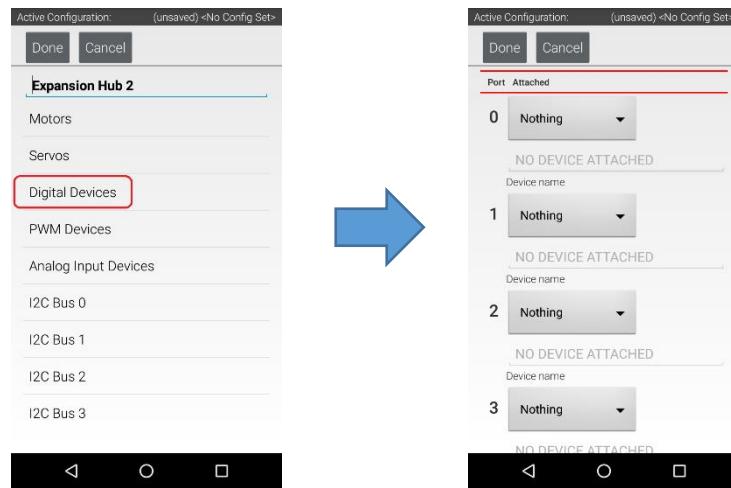
Press the **Done** button to complete the I2C sensor configuration. The app should return to the previous screen.



Configuring the Touch Sensor

Step 27:

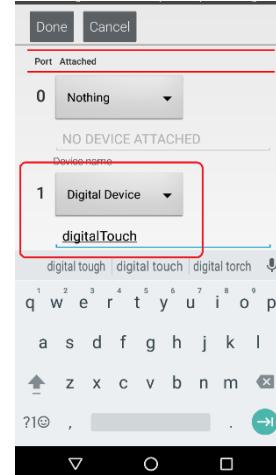
Touch the words **Digital Devices** on the screen to launch the Digital I/O configuration screen.



Step 28:

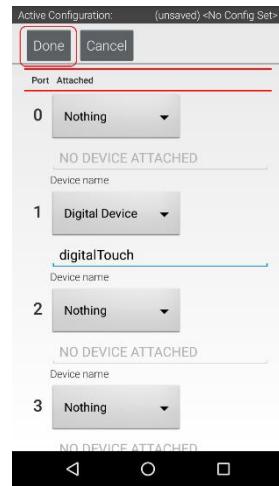
Use the touch screen to add a “Digital Device” for port #1 and name the device “digitalTouch”.

Notice that we are configuring the Touch Sensor on port #1 instead of port #0. This is because when the REV Robotics Touch Sensor is connected to a digital port using a standard 4-wire JST sensor cable, it is the second digital pin that is connected. The first pin remains disconnected.

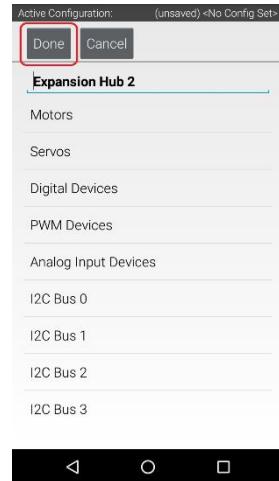


Step 29:

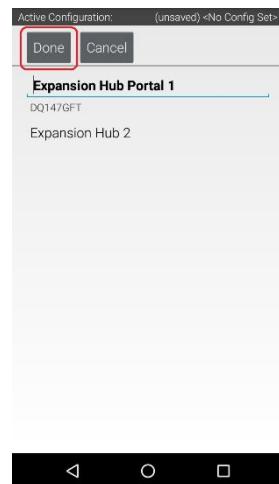
Press the **Done** button to return to the previous screen.

**Saving the Configuration Information****Step 30:**

Press the **Done** button to go up one level in the configuration screens.

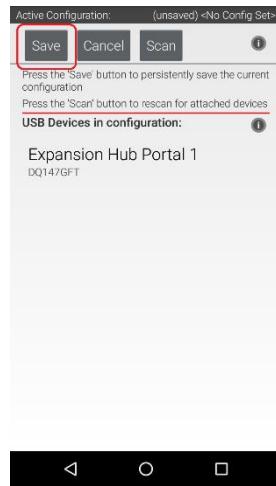
**Step 31:**

Press the **Done** button again to return to the highest level in the configuration screens.



Step 32:

Press the **Save** button.

**Step 33:**

When prompted, specify a configuration file name using the touchscreen's keypad (use "TestConfig" for this example).

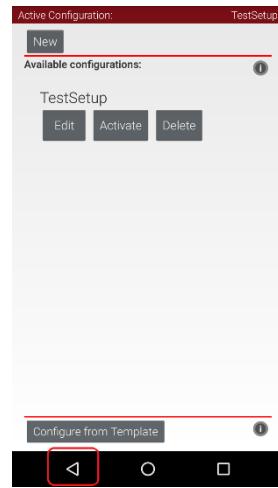
**Step 34:**

Press the **OK** button to save your configuration information using that file name.

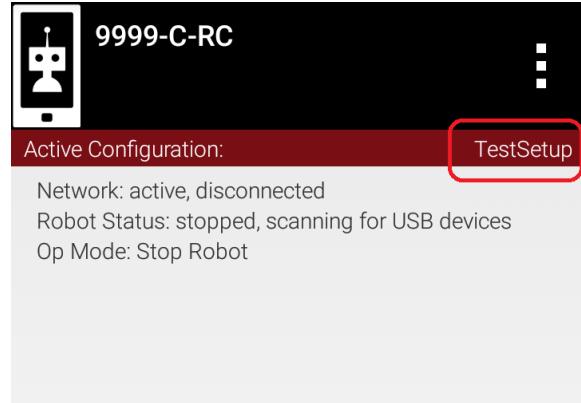


Step 35:

After the configuration file has been saved, touch the Android back-arrow button to return to the main screen of the app.

**Step 36:**

Verify that the configuration file is the active configuration file on the main Robot Controller screen.



6 Writing an Op Mode

6.1 What's an Op Mode?

During a typical *FIRST* Tech Challenge match, a team's robot must perform a variety of tasks to score points. For example, a team might want their robot to follow a white line on the competition floor and then score a game element into a goal autonomously during a match. Teams write programs called "op modes" (which stands for "operational modes") to specify the behavior for their robot. These op modes run on the Robot Controller phone after being selected on the Driver Station phone.

Teams who are participating in the *FIRST* Tech Challenge have a variety of programming tools that they can use to create their own op modes. This document explains how to use the blocks programming tool to write an op mode for an FTC robot.

6.2 The FTC Blocks Programming Tool

The *FTC Blocks Programming Tool* is a user-friendly programming tool that is served up by the Robot Controller phone. A user can create custom op modes for their robot using this tool and then save these op modes directly onto the Robot Controller.

Users drag and drop jigsaw-shaped programming blocks onto a design “canvas” and arrange these blocks to create the program logic for their op mode.

The FTC Blocks Programming Tool is powered by Google’s *Blockly* software and was developed with support from Google.

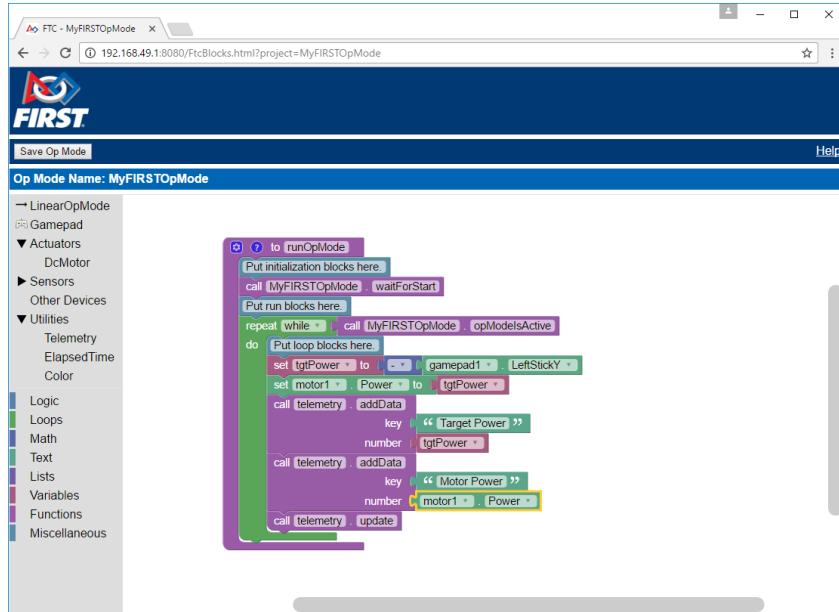


Figure 4 - Users arrange jigsaw-shaped programming blocks to create the logic for their op modes.

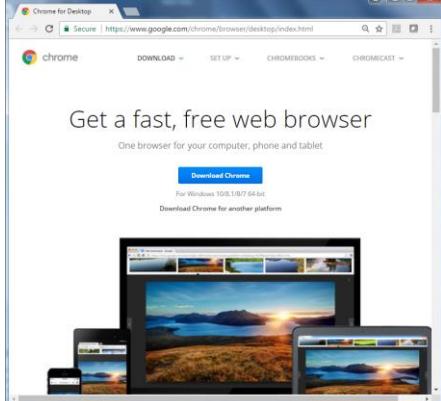
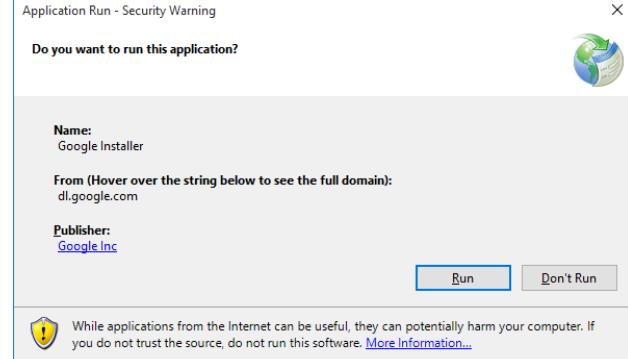
The examples in this document use a Windows laptop computer to connect to the Robot Controller. This Windows laptop computer has a Javascript-enabled web browser installed that is used to access the FTC Blocks Programming Tool.



Note that if you prefer, you can use an alternate device, such as an Apple Mac laptop, or a Chromebook, instead of a Windows computer to access the FTC Blocks Programming Tool. The instructions included in this document, however, assume that you are using a Windows laptop.

6.3 Installing a Javascript-Enabled Browser

To be able to program using the blocks programming mode server, your laptop will need a Javascript-enabled browser. FIRST recommends the use of Google Chrome as the Javascript-enabled browser for the FTC Blocks Programming Tool. The FTC Blocks Programming Tool has been thoroughly tested using Google Chrome.

Installing Javascript-Enabled Browser (Time Needed to Complete Task: 15 minutes)	
Step 1: Visit the Google Chrome website (using your computer's existing browser) and follow onscreen instructions to download and install Chrome.	https://www.google.com/chrome/browser/desktop/index.html 
Step 2: Note that your computer might prompt you with a security warning during the installation process. If you are prompted with this warning, click on the "Run" button to continue with the installation.	

6.4 Connecting Your Laptop to the FTC Blocks Programming Mode Server

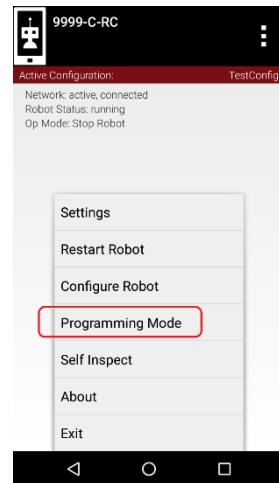
You will need to put your Robot Controller smartphone into FTC Blocks Programming Mode, which causes it to become a Programming Mode server, and then use your laptop to connect to this server so that you can start creating your op modes. Before you begin this exercise, please make sure that your Windows laptop has the most current service packs and system updates from Microsoft installed.⁴

Connecting Your Laptop to the FTC Blocks Programming Mode Server (Time Needed to Complete Task: 20 minutes)

Step 1:

On the Robot Controller, touch the three dots in the upper right hand corner of the screen to launch the pop-up menu.

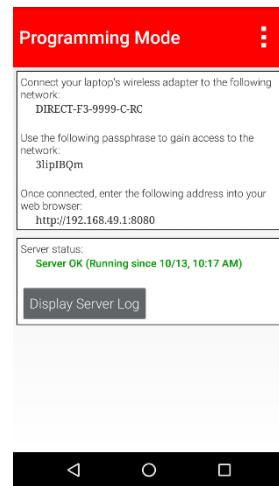
Select “Programming Mode” from the pop-up menu to place the Robot Controller into Programming Mode.



Step 2:

Verify that the Robot Controller is now in Programming Mode.

The Programming Mode screen displays important information that you can use to connect your laptop to the FTC Blocks Programming Mode server.



⁴ This example assumes the user has a Windows 10 laptop. If you are not using a Windows laptop, the procedure to connect to the Programming Mode server will differ. Refer to your device’s documentation for details on how to connect to a Wi-Fi network.

Step 3:

Verify the network name and pass phrase for the Programming Mode's wireless network.

Towards the top of the screen, the name of the blocks programming mode wireless network is displayed. In this example, the name of the Wi-Fi network is "DIRECT-F3-9999-C-RC" and the secure passphrase is "3lipIBQm".

Programming Mode

Connect your laptop's wireless adapter to the following network:

DIRECT-F3-9999-C-RC

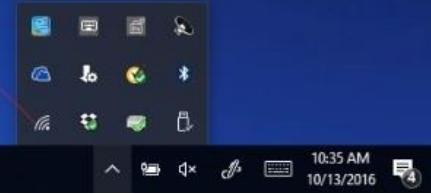
Use the following passphrase to gain access to the network:

3lipIBQm

Step 4:

On your Windows 10 computer, look in the lower right hand corner of your desktop for a Wi-Fi symbol. Click on the Wi-Fi symbol to display a list of available Wi-Fi Networks in your vicinity.

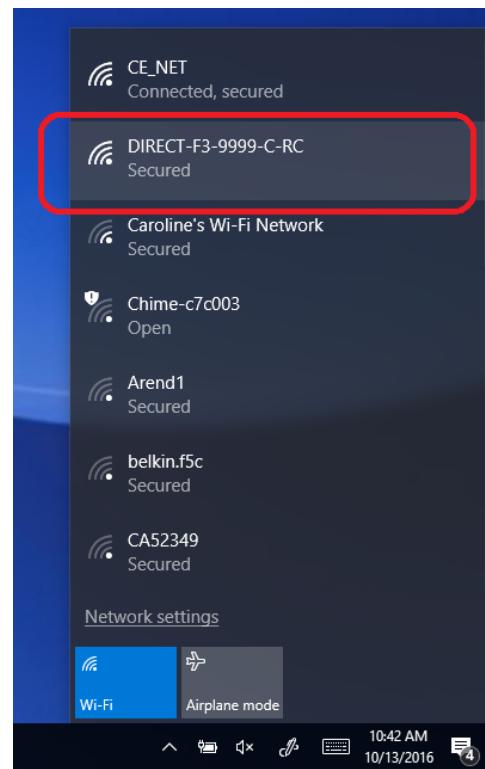
Click on Wi-Fi symbol to display
Wi-Fi settings for your
Windows 10 computer.



Step 5:

Look for the wireless network that matches the name displayed on the Robot Controller.

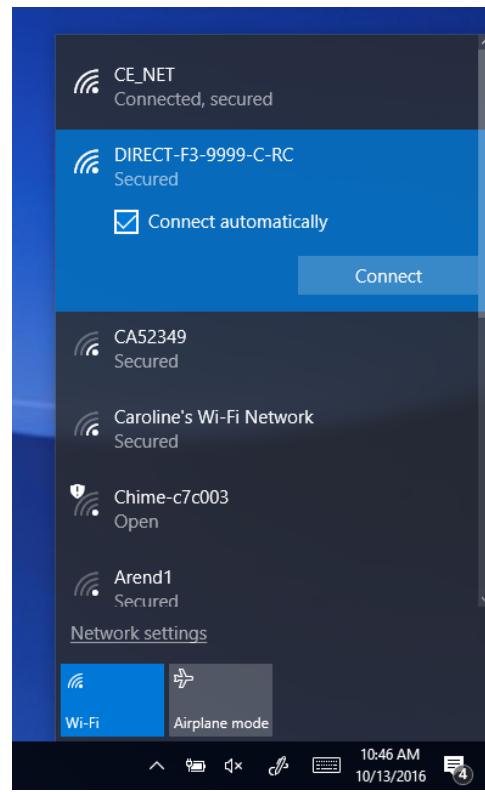
In this example, the name of the wireless network is “DIRECT-F3-9999-C-RC” and the network is visible in the list displayed on the Windows 10 computer.



Step 6:

Once you have found the target network in the list, click on it to select it.

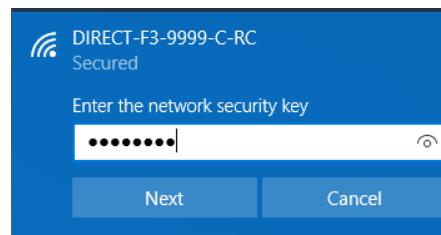
Press the **Connect** button to connect to the network.



Step 7:

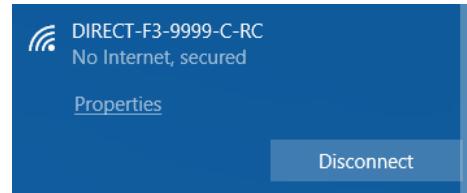
When prompted, provide the network passphrase (in this example “3lipIBQm”) and press “Next” to continue.

Note that the passphrase is *case sensitive*. Make sure that your spelling and capitalization matches the original spelling and capitalization shown on the Programming Mode screen.



Step 8:

Once you have successfully established a wireless connection between your Windows 10 laptop and your Robot Controller Android device, the status should be displayed in the wireless settings for your laptop.



If the display is not updated as shown after a few seconds, try clicking on Network Connections at the bottom of the blue box showing the Wi-Fi connections. This will bring up a Setting dialog box that includes a link to “Show available networks.”, which can be used to force the list of Wi-Fi connections to be updated.

Note that when you are connected to the blocks programming mode server on your Robot Controller phone, *your laptop will not have access to the Internet*. It only has direct access to the Robot Controller.

6.5 Troubleshooting Your Wireless Connection

If you cannot see your Programming Mode wireless network in the list of available networks, or, if you are having problems connecting your laptop to Programming Mode wireless network, make sure you answer the following questions:

1. Is the Robot Controller in Programming Mode?
2. Is your Windows laptop updated with the most current system updates and service packs?
Older versions of Windows 8 and 10, for example, had issues that could prevent the laptop from displaying the Programming Mode wireless network in the list of available networks.

If you are still having issues with connecting the laptop to the Robot Controller, visit section 10.1 of this document for instructions on how to manually connect to the Programming Mode wireless network with a Windows 10 laptop.

6.6 Creating Your First Op Mode

If you connected your laptop successfully to the Programming Mode wireless network of the Robot Controller, then you are ready to create your first op mode. In this section, you will use the FTC Blocks Development Tool to create the program logic for your first op mode.

Creating Your First Op Mode
(Time Needed to Complete Task: 10 minutes)

Step 1:

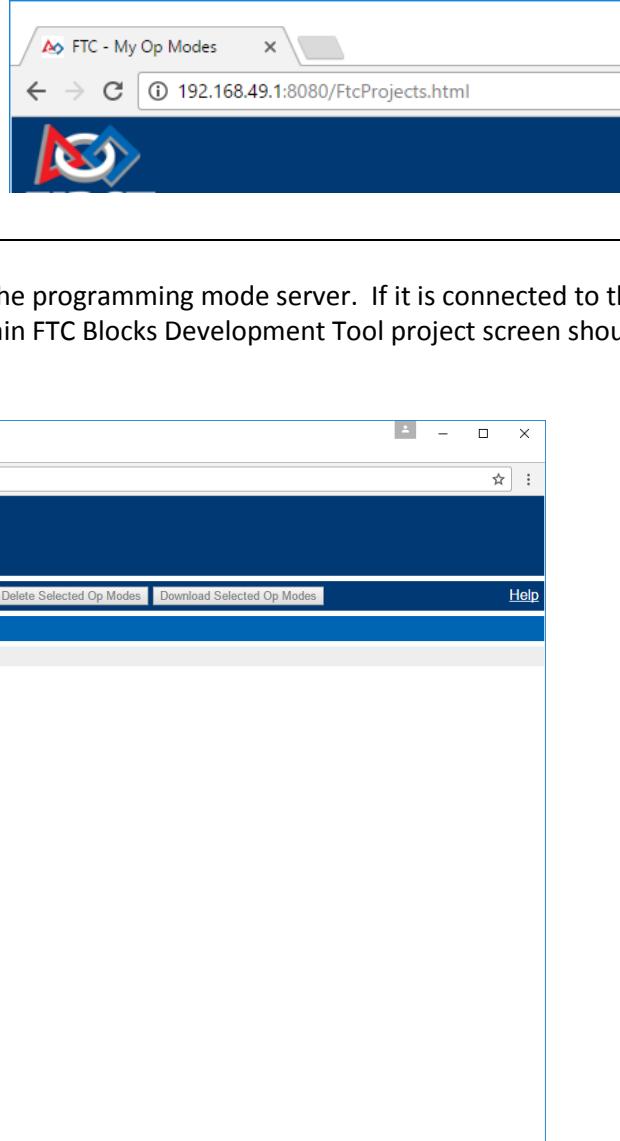
Launch the web browser on your laptop (FIRST recommends using Google Chrome).

Find the web address that is displayed on the Programming Mode screen of the Robot Controller. In our example, the web address is “192.168.49.1:8080”.

Type this web address into the address field of your browser to navigate to the Programming Mode web server.

Once connected, enter the following address into your web browser:
http://192.168.49.1:8080

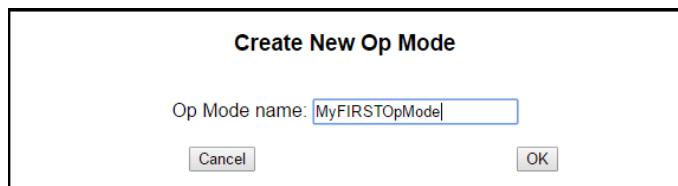
Server status:
Server OK (Running since 10/13, 10:17 AM)



Step 3:

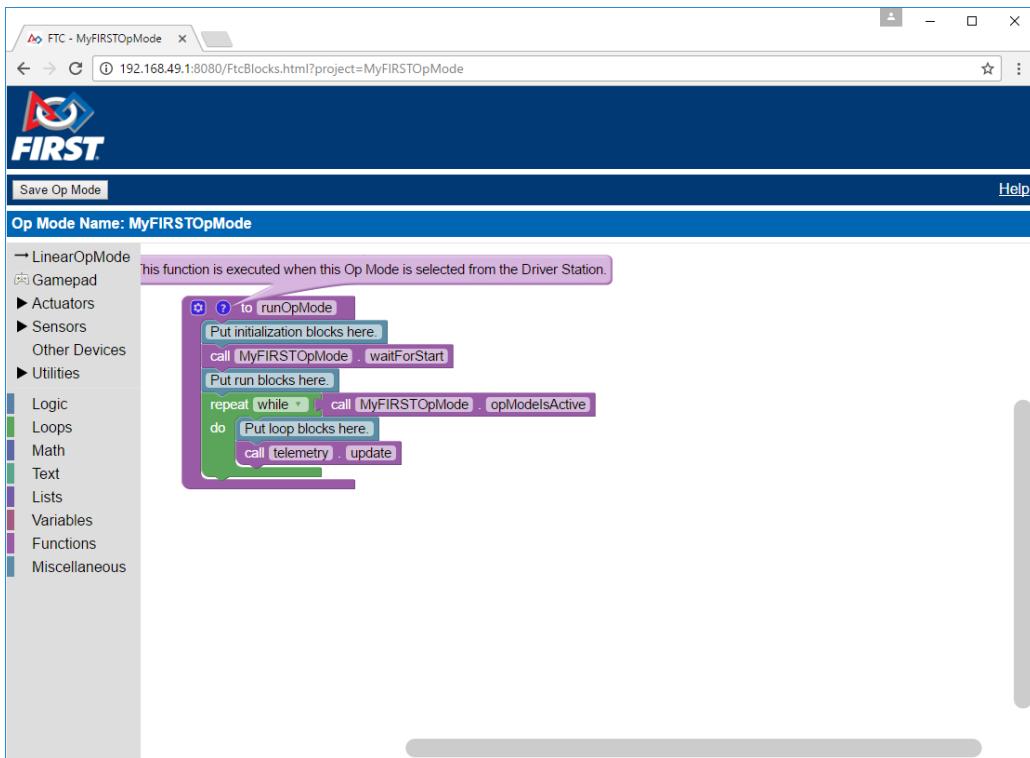
Press the “Create New Op Mode” button which should be visible towards the upper left hand corner of the browser window.

When prompted, specify a name for the op mode and hit “OK” to continue.



Step 4:

Verify that you created the new op mode. You should see your newly created op mode opened for editing in your web browser’s main screen.



Notice that the left-hand side of the browser’s screen contains a list of categorized programming blocks. If you click on a category, the browser will display a list of available related programming blocks.

The right-hand side of the screen is where you arrange your programming blocks to create the logic for your op mode.

6.7 Examining the Structure of Your Op Mode

When you create a new op mode, there should already be a set of programming blocks that are placed on the design canvas for your op mode. These blocks are automatically included with each new op mode that you create. They create the basic structure for your op mode.

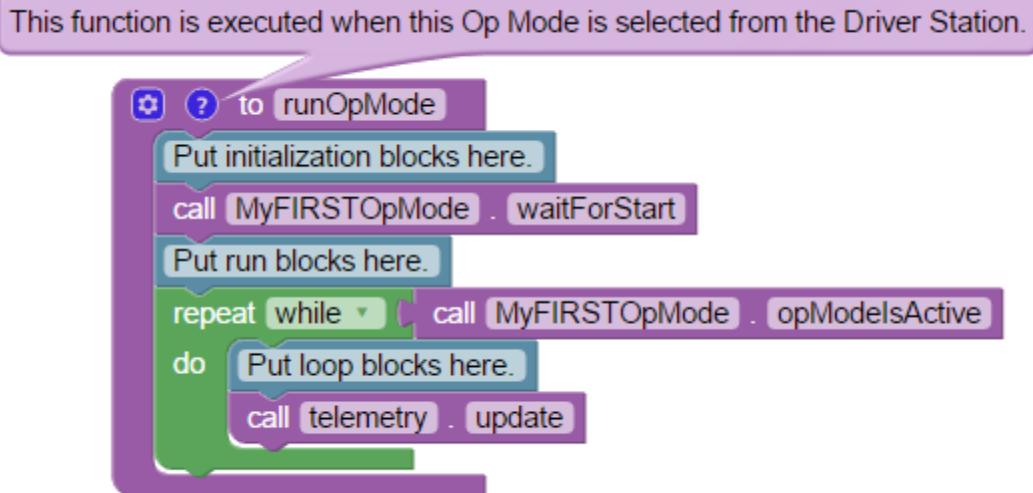


Figure 5 – Each new op mode includes a set of programming blocks that form the basic structure of the op mode.

In Figure 5 the main body of the op mode is defined by the outer purple bracket that has the words “to runOpMode” at the top. As the help tip indicates, this function is executed when this op mode (“MyFIRSTOpMode” in this example) is selected from the Driver Station.

It can be helpful to think of an op mode as a list of tasks for the Robot Controller to perform. The Robot Controller will process this list of tasks sequentially. Users can also use control loops (such as a *while* loop) to have the Robot Controller repeat (or iterate) certain tasks within an op mode.



Figure 6 - It can be helpful to think of an op mode as a task list for the Robot Controller.⁵

⁵ Clip art image was downloaded from ClipArtBest.com on 10/13/16.

If you think about an op mode as a list of instructions for the robot, this set of instructions will be executed by the robot whenever a team member selects the op mode called “MyFIRSTOpMode” from the list of available op modes for this Robot Controller.

You can hide the help text by clicking on the blue button with the question mark (“?”) on it. Let’s look at the flow of this basic op mode. The blue colored block with the words “Put initialization blocks here” is a comment. Comments are placed in an op mode for the benefit of the human user. The robot will ignore any comments in an op mode.

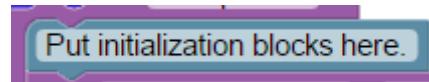


Figure 7 – Comments are blue-colored and are ignored by the robot.

Any programming blocks that are placed after the “Put initialization blocks here” comment (and before the “call MyFIRSTOpMode.waitForStart” block) will be executed when the op mode is first selected by a user at the Driver Station.

When the Robot Controller reaches the block labeled “call MyFIRSTOpMode.waitForStart” it will stop and wait until it receives a Start command from the Driver Station. A Start command will not be sent until the user pushes the Start button on the Driver Station. Any code after the “call MyFIRSTOpMode.waitForStart” block will get executed after the Start button has been pressed.

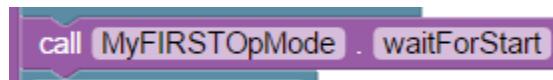


Figure 8 – The Robot Controller will stop and wait for a Start command when it reaches this programming block.

Any blocks that are placed after the “Put run blocks here” comment and before the green block labeled “repeat while call MyFirstOpMode.opModelsActive” will be executed sequentially by the Robot Controller after the Start button has been pressed.

The green block labeled “repeat while call MyFirstOpMode.opModelsActive” is an iterative or looping control structure.

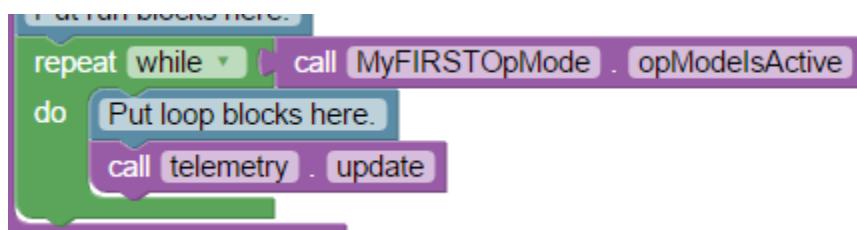


Figure 9 - The green programming block is a while loop control block.

This green control block will perform the steps listed under the “do” portion of the block as long as the condition “call MyFIRSTOpMode.opModelsActive” is true. What this means is that the statements included in the “do” portion of the block will repeatedly be executed as long as the op mode “MyFIRSTOpMode” is running. Once the user presses the Stop button, the “call MyFIRSTOpMode.opModelsActive” clause is no longer true and the “repeat while” loop will stop repeating itself.

6.8 Modifying the Op Mode to Control a DC Motor

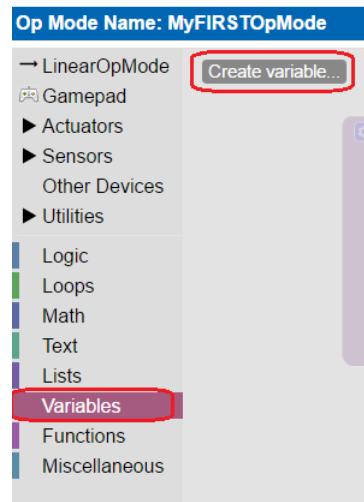
Let's modify our op mode to add some blocks that will allow us to control a DC motor with a gamepad.

Modifying the Op Mode to Control a DC Motor (Time Needed to Complete Task: 15 minutes)

Step 1:

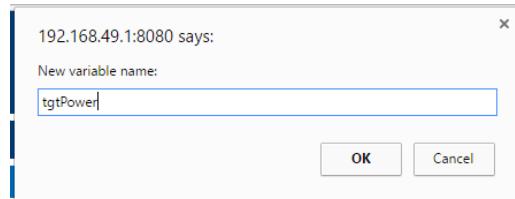
On the left-hand side of the screen click on the category called "Variables" to display the list of block commands that are used to create and modify variables within your op mode.

Click on "Create variable..." to create a new variable that will represent the target motor power for our op mode.



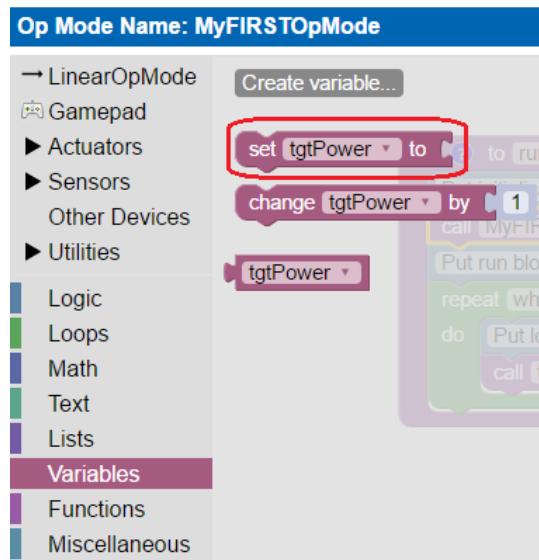
Step 2:

When prompted, type in a name ("tgtPower") for your new variable.



Step 3:

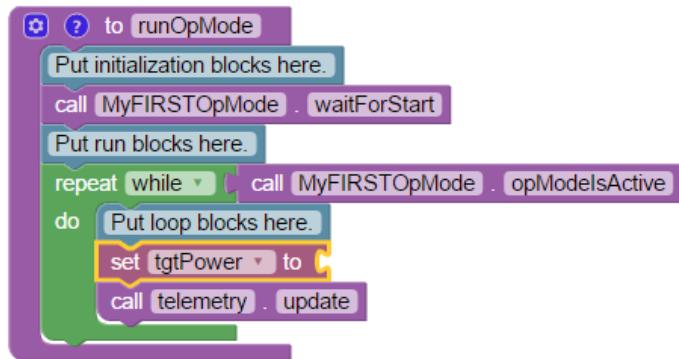
Once you have created your new variable, some additional programming blocks should appear under the "Variables" block category.



Step 4:

Click on the “set tgtPower to” programming block and then use the mouse to drag the block to the spot just after the “Put loop blocks here” comment block.

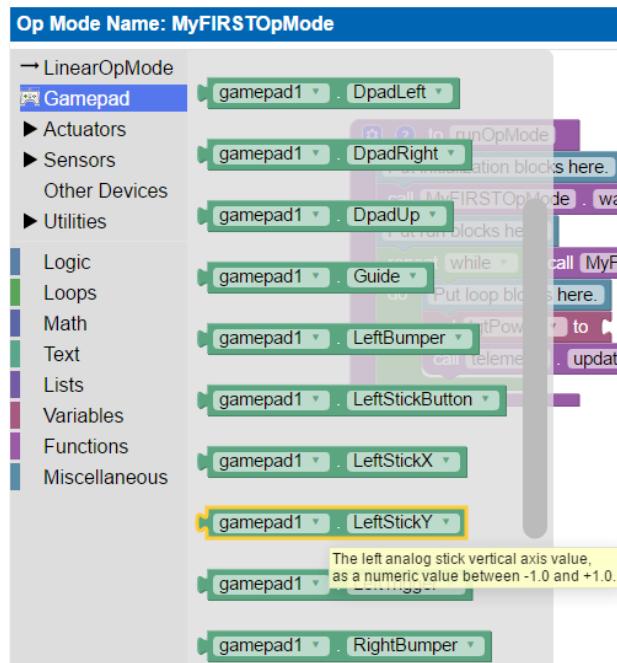
The “set tgtPower to” block should snap right into position.



Step 5:

Click on the “Gamepad” category of the programming blocks and select the “gamepad1.LeftStickY” block from the list of available blocks.

Note that the control system lets you have up to two gamepads controlling a robot. By selecting “gamepad1” you are telling the op mode to use the control input from the gamepad that is designated as driver #1.



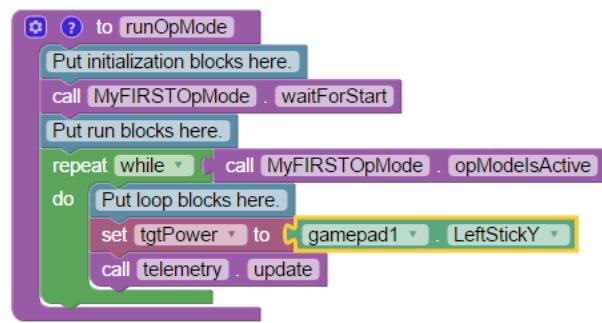
Step 6:

Drag the “gamepad1.LeftStickY” block so it snaps in place onto the right side of the “set tgtPower to” block.

This set of blocks will continually loop and read the value of gamepad #1’s left joystick (the y position) and set the variable tgtPower to the Y value of the left joystick.

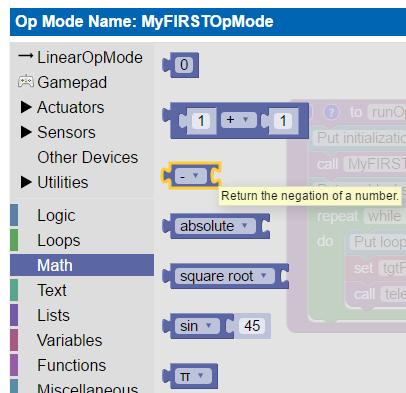
Note that for the F310 gamepads, the Y value of a joystick ranges from -1, when a joystick is in its topmost position, to +1, when a joystick is in its bottommost position.

This means that for the blocks shown in our example, if the left joystick is pushed to the top, the variable tgtPower will have a value of -1.



Step 7:

Click on the “Math” category for the programming blocks and select the negative symbol (“-”).

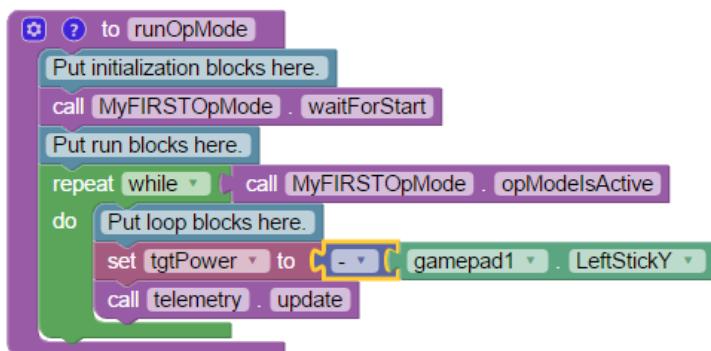


Step 8:

Drag the negative symbol (also known as a “negation operator”) to the left of the “gamepad1.LeftStickY” block.

It should click in place after the “set tgtPower to” block and before the “gamepad1.LeftStickY” block.

With this change, the variable tgtPower will be set to +1 if the left joystick is in its topmost position and



will be set to -1 if the joystick is in its bottommost position.

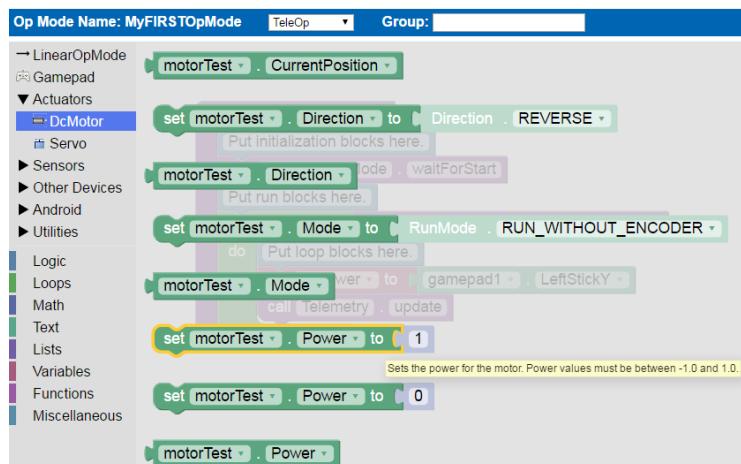
Step 9:

Click on the “Actuators” category of blocks.



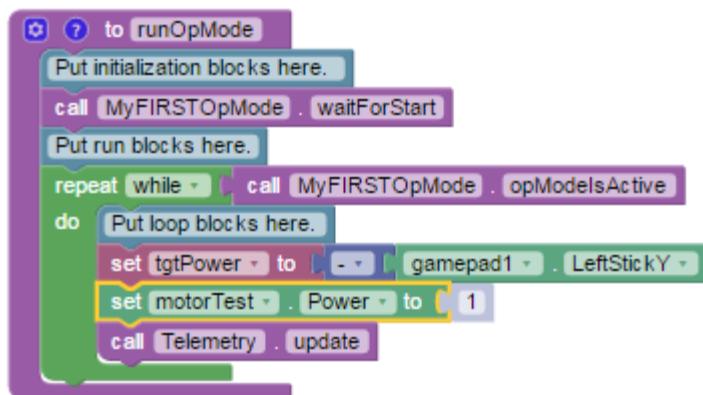
Step 10:

Select the “set motorTest.Power to 1” programming block.



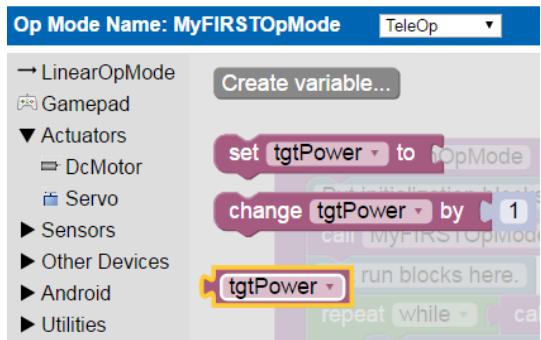
Step 11:

Drag and place the “set motorTest.Power to 1” block so that it snaps in place right below the “set tgtPower to” block.



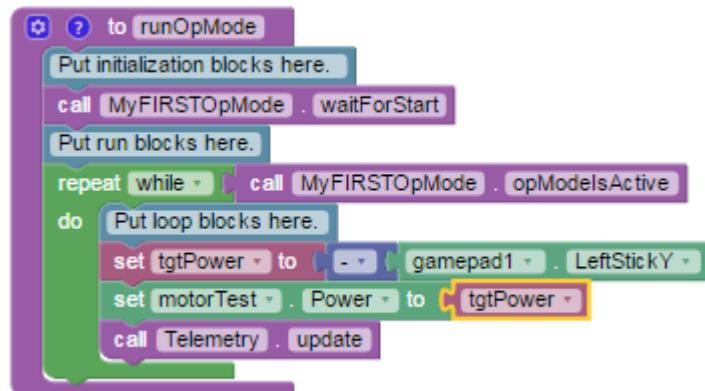
Step 12:

Click on the “Variables” block category and select the “tgtPower” block.

**Step 13:**

Drag the “tgtPower” block so it snaps in place just to the right of the “set motor1.Power to” block.

The “tgtPower” block should automatically replace the default value of “1” block.



6.9 Inserting Telemetry Statements

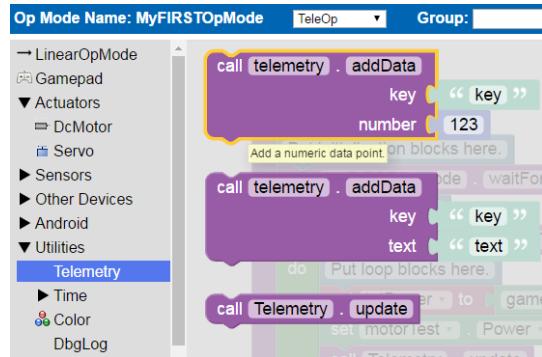
Your op mode is just about ready to run. However, before we continue, let’s add a couple of *telemetry statements* that will send information from the Robot Controller to the Driver Station for display on the Driver Station user interface. This *telemetry* mechanism is a useful way to display status information from the robot on the Driver Station. You can use this mechanism to display sensor data, motor status, gamepad state, etc. from the Robot Controller to the Driver Station.

Inserting Telemetry Statements

(Time Needed to Complete Task: 15 minutes)

Step 1:

Click on the “Utilities” category on the left-hand side of the browser window. Select the “Telemetry” subcategory and select the “call telemetry.addData(key, number)” block.

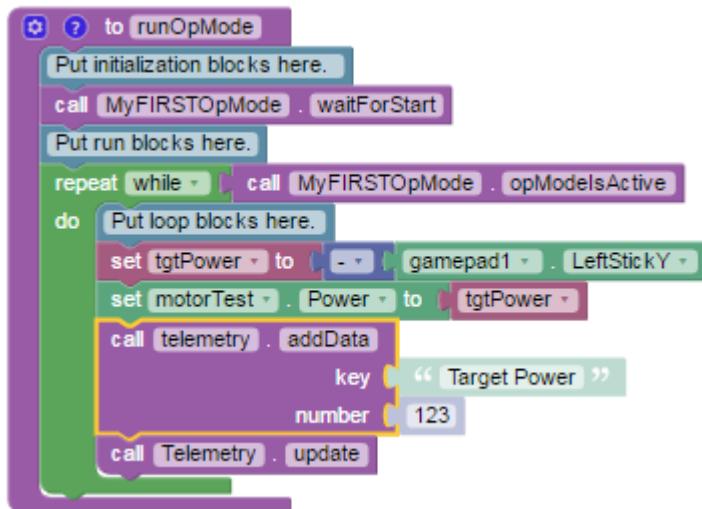


Step 2:

Drag the “call telemetry.addData(key, number)” block and place it below the “set motor1.Power to” block.

Click on the green text block “key” and highlight the text and change it to read “Target Power”.

Note that the “call telemetry.update” block is an important block. Data that is added to the telemetry buffer will not be sent to the Driver Station until the telemetry.update method is called.

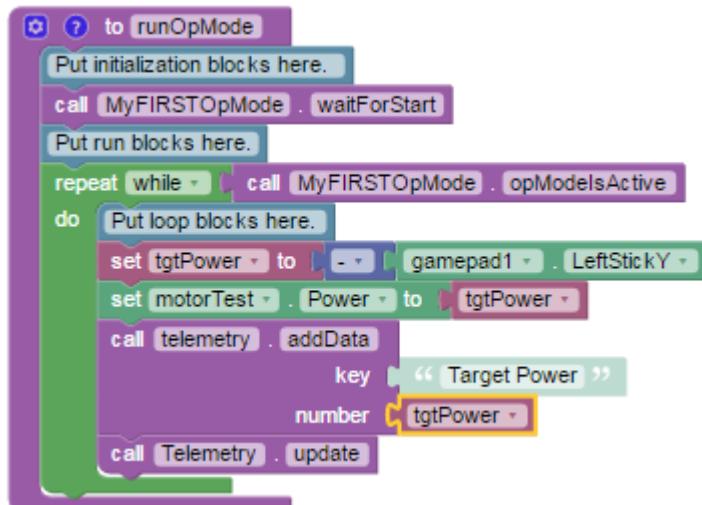


Step 3:

Click on the “Variables” block category and select the “tgtPower” block.

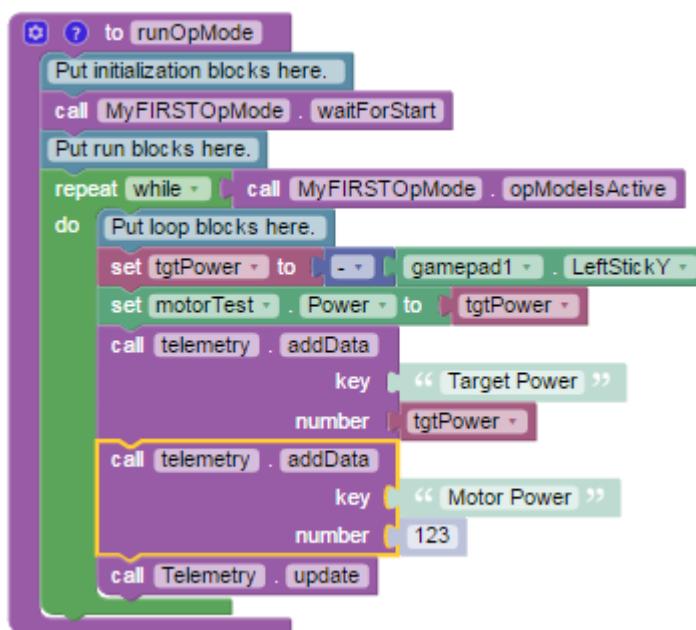
Drag the block so it clicks into place next to the “number” parameter on the telemetry programming block.

The Robot Controller will send the value of the variable tgtPower to the Driver Station with a key or label of “Target Power”. The key will be displayed to the left of the value on the Driver Station.



Step 4:

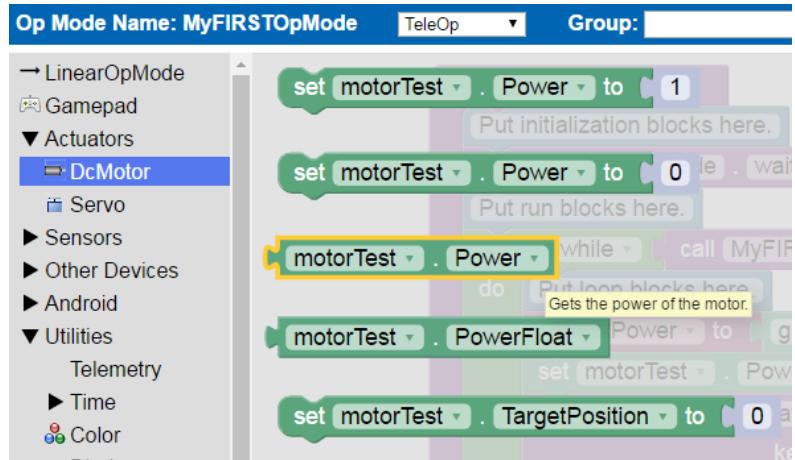
Repeat this process and name the new key “Motor Power”.



Step 5:

Find and click on the “DcMotor” subcategory.

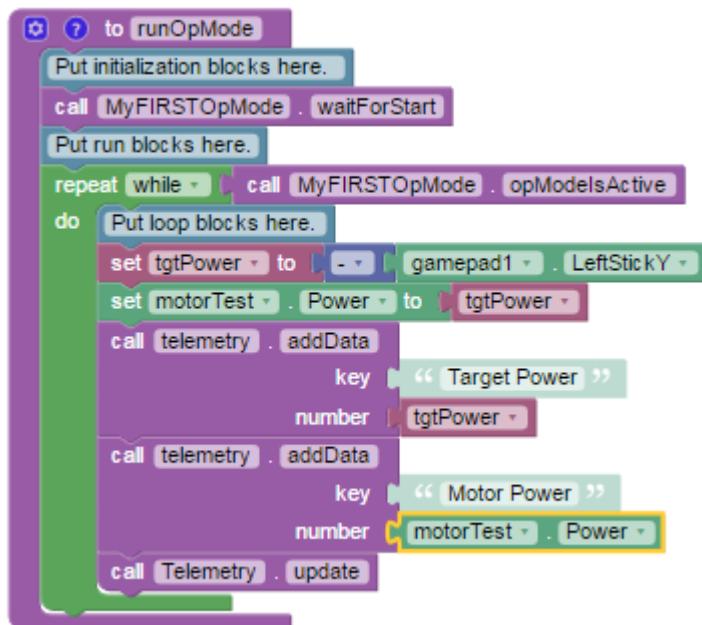
Look for the green programming block labeled “motorTest.Power”.



Step 6:

Drag the “motorTest.Power” block to the “number” parameter of the second telemetry block.

Your op mode will now also send the motor power information from the Robot Controller to be displayed on the Driver Station.



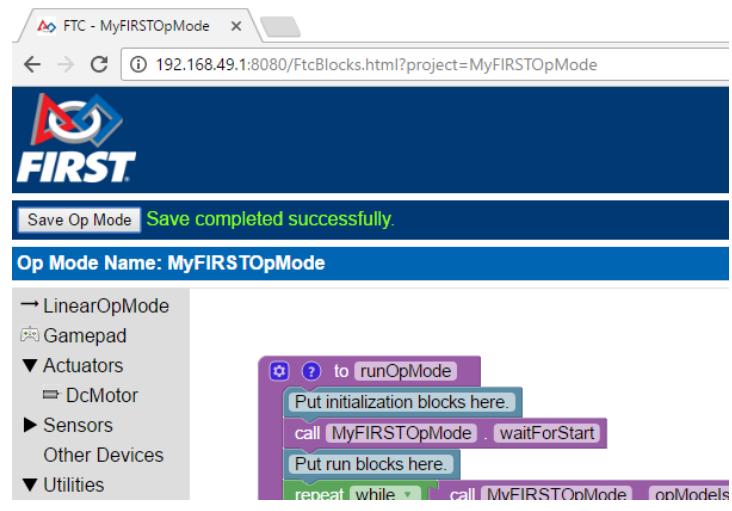
6.10 Saving Your Op Mode

After you have modified your op mode, it is important to save the op mode to the Robot Controller.

Saving Your Op Mode (Time Needed to Complete Task: 1 minutes)

Step 1:

Press the “Save Op Mode” button to save the op mode to the Robot Controller’s programming mode server. If your save was successful, you should see “Save completed successfully” in green letters next to the button.



6.11 Exiting Programming Mode

After you have modified and saved your op mode, you need to exit Programming Mode before you will be able to run your op mode.

Saving Your Op Mode

(Time Needed to Complete Task: 1 minutes)

Step 1:

Press the Android back arrow to exit Programming Mode. You need to exit Programming Mode before you can run your op mode.



7 Running Your Op Mode

Your op mode takes input from a gamepad and uses this input to control a DC motor. To run your op mode, you will need to connect a Logitech F310 gamepad to the Driver Station.

Running Your Op Mode

(Time Needed to Complete Task: 10 minutes)

Step 1:

Before you connect your gamepad to the phone, verify that the switch on the bottom of the gamepad is set to the “X” position.



Step 2:

Connect the gamepad to the Driver Station using the Micro USB OTG adapter cable.



Step 3:

Your example op mode is looking for input from the gamepad designated as the user or driver #1.

Press the **Start** button and the **A** button simultaneously on the Logitech F310 controller to designate your gamepad as user #1.

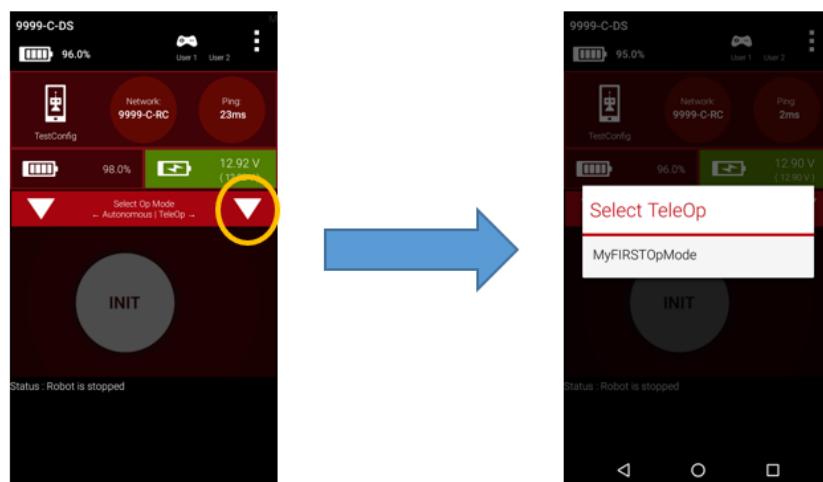


Note that pushing the **Start** button and the **B** button simultaneously would designate the gamepad as user #2.

Step 5:

On the Driver Station screen, touch the triangular-shaped, “TeleOp” dropdown list button to display a list available op modes.

You should see your recently saved op mode among the list of available op modes that reside on your Robot Controller.

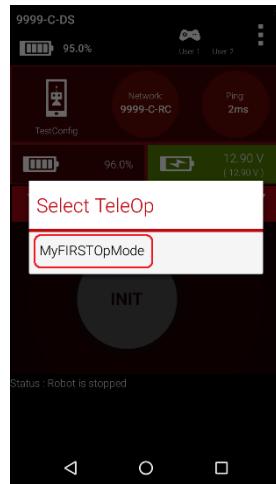


Note that the word “TeleOp” is short for “Tele-Operated” and it implies a driver controlled op mode (i.e., an op mode that gets input from a human driver).

Step 6:

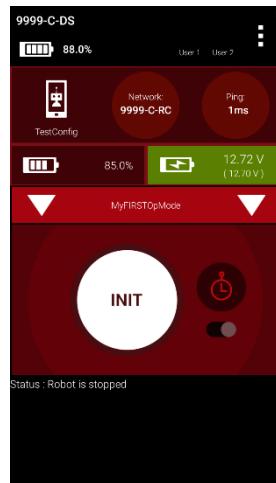
Select “MyFIRSTOpMode” to load your op mode on the Robot Controller.

Note that even though you are using the Driver Station to select the op mode, the actual op mode instructions will be executed on the Robot Controller phone.



Step 7:

Press the **INIT** button to initialize your op mode.



Step 8:

Push the Start button (designated by the triangular-shaped symbol) to start the op mode run.



Step 9:

Use the left joystick of the gamepad to control the operation of the DC motor.

As you manipulate the left joystick up and down, the target power and the motor power should be displayed in the lower left hand corner of the screen.

If you want to stop your op mode, press the square-shaped Stop button on the Driver Station.



8 Controlling a Servo Motor with an Op Mode

In this section, you will modify your op mode to control a servo motor with the buttons of the gamepad.

8.1 What is a Servo Motor?

A servo motor is a special type of motor. A servo motor is designed for precise motion. A typical servo motor has a limited range of motion.

In Figure 10 a “standard scale” 180-degree servo is shown. This type of servo is popular with hobbyists and with *FIRST* Tech Challenge teams. This servo motor can rotate its shaft through a range of 180 degrees. Using an electronic module known as a *servo controller* you can write an op mode that will move a servo motor to a specific position. Once the motor reaches this target position, it will hold the position, even if external forces are applied to the shaft of the servo.



Figure 10 – An example of a servo motor that is commonly used on *FIRST* Tech Challenge robots.⁶

Servo motors are useful when you want to do precise movements (for example, sweep an area with a sensor to look for a target or move the control surfaces on a remotely controlled airplane).

⁶ Image taken from the Pitsco website on 10/17/2016 (see https://c10645061.ssl.cf2.rackcdn.com/product/icongo/icg_39197_180deg servo.jpg).

8.2 Modifying Your Op Mode to Control a Servo

Let's modify your op mode to add the logic required to control a servo motor. For this example, you will use the buttons on the Logitech F310 gamepad to control the position of the servo motor.

With a typical servo, you can specify a target position for the servo. The servo will turn its motor shaft to move to the target position, and then maintain that position, even if moderate forces are applied to try and disturb its position.

For the blocks programming mode server, you can specify a target position that ranges from 0 to 1 for a servo. A target position of 0 corresponds to zero degrees of rotation and a target position of 1 corresponds to 180 degrees of rotation for a typical servo motor.



Figure 11 - A typical servo motor can rotate to and hold a position from 0 to 180 degrees.

In this example, you will use the colored buttons on the right side of the F310 controller to control the position of the servo. Initially, the op mode will move the servo to the midway position (90 degrees of its 180-degree range). Pushing the yellow "Y" button will move the servo to the zero-degree position. Pushing the blue "X" button or the red "B" button will move the servo to the 90-degree position. Pushing the green "A" button will move the servo to the 180-degree position.



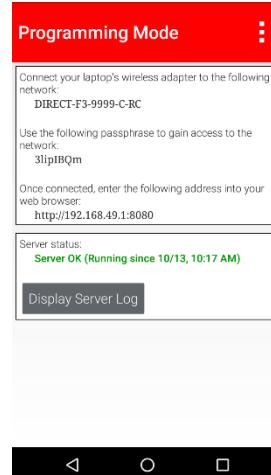
Figure 12 – The colored buttons on the right side of the gamepad will be used to control servo position.

Modifying the Op Mode to Control a Servo Motor

(Time Needed to Complete Task: 20 minutes)

Step 1:

Place the Robot Controller in Programming Mode.
Verify that your laptop is still connected to the Robot Controller's Programming Mode Wi-Fi network.

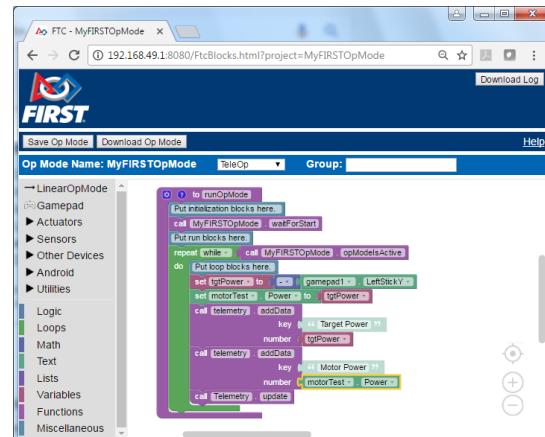


Step 2:

Verify that "MyFIRSTOpMode" is opened for editing.

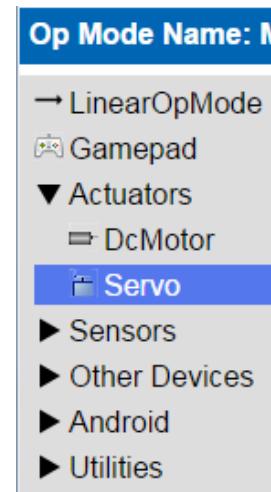
If it is not, you can click on the FIRST logo in the upper left-hand corner of the browser window on the laptop. This should take you to the main FTC Blocks Development Tool project screen.

Click on the "MyFIRSTOpMode" project to open it for editing if it is not already opened.



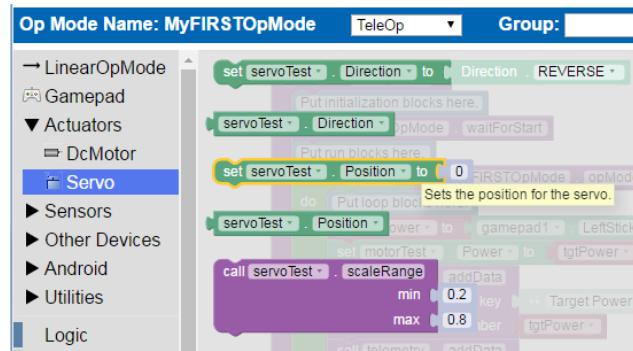
Step 3:

On the left-hand side of the screen click on the category called "Actuators" and look for the subcategory called "Servos".



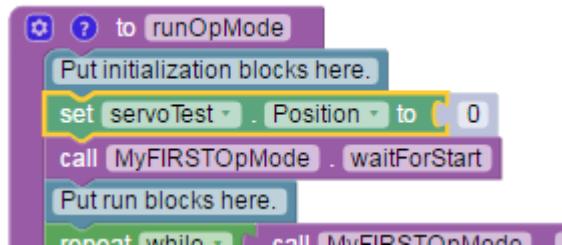
Step 4:

Select the “set servoTest.Position to” block from the list of available Servo blocks.

**Step 5:**

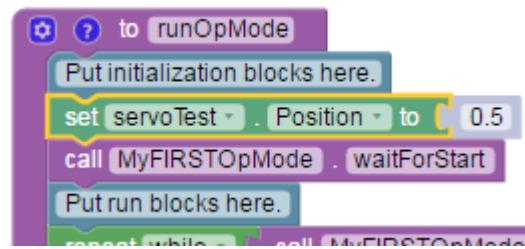
Drag the “set servoTest.Position to” block to the spot just under the comment block that reads “Put initialization blocks here.”

The block should click into place.

**Step 6:**

Click on the number block “0” and change the block’s value to “0.5”.

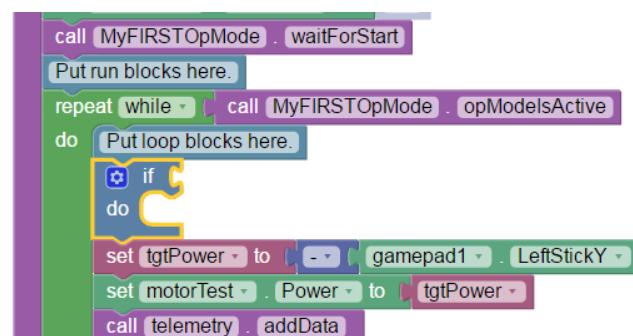
When a user selects this op mode, the servo position will initially be set to the midway point (90-degree position).

**Step 7:**

Click on the “Logic” category of the programming blocks and select the “if do” block from the list of available blocks.

Drag the block to the position immediately after the comment block that reads “Put loop blocks here.”

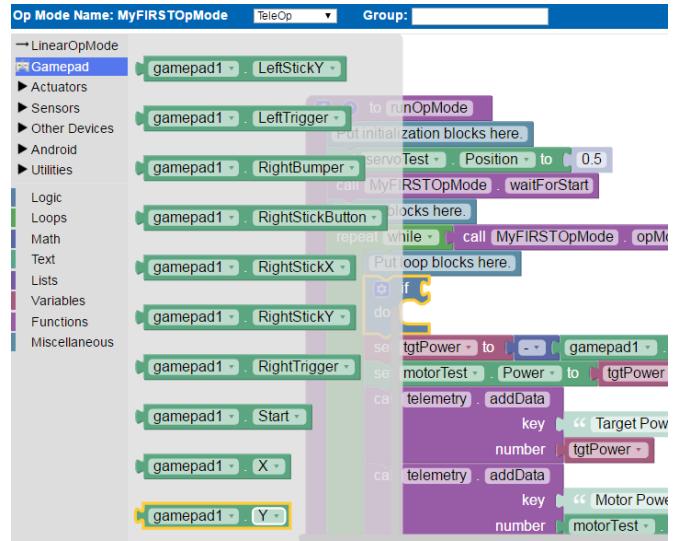
The block should click into place.



Step 8:

Click on the “Gamepad” category of the programming blocks and select the “gamepad1.Y” block from the list of available blocks.

Note that this block is towards the bottom of the list of blocks. You might have to scroll down to the bottom of the list before you can select this block.

**Step 9:**

Drag the “gamepad1.Y” block to the right side of the “if do” block.

The block should click into place.

The “if do” block will use the state of the gamepad1.Y value its test condition. If the “Y” button is pressed, the statements within the “do” portion of the block will be executed.

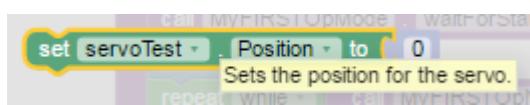


Step 10:

On the left-hand side of the screen click on the category called “Actuators” and look for the subcategory called “Servos”.

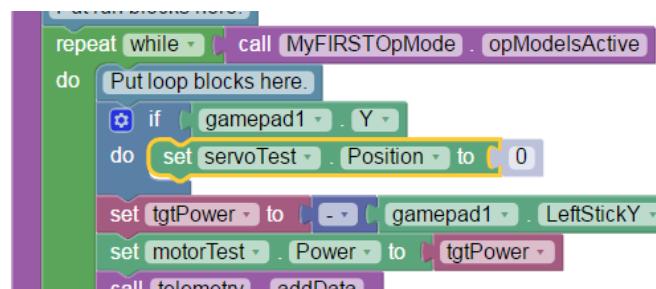
**Step 11:**

Select the “set servoTest.Position to” block from the list of available Servo blocks.

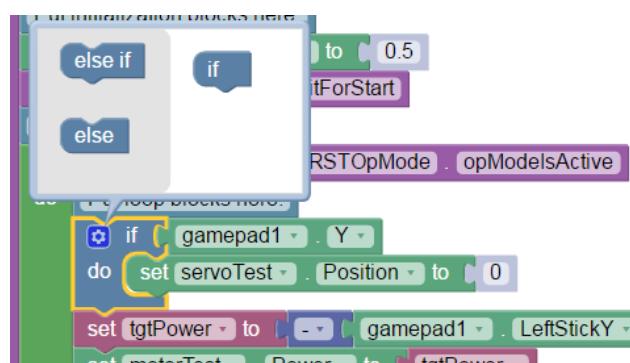
**Step 12:**

Drag the “set servoTest.Position to” block so that it snaps in place in the do portion of the “if do” block.

If the “Y” button is pressed on gamepad #1, the op mode will move the servo’s position to the 0-degree position.

**Step 13:**

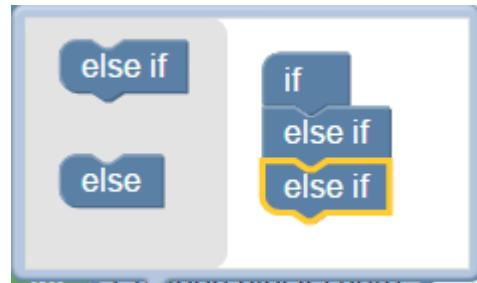
Click on the blue and white Settings icon for the “if do” block. This will display a pop-up menu that lets you modify the “if do” block.



Step 14:

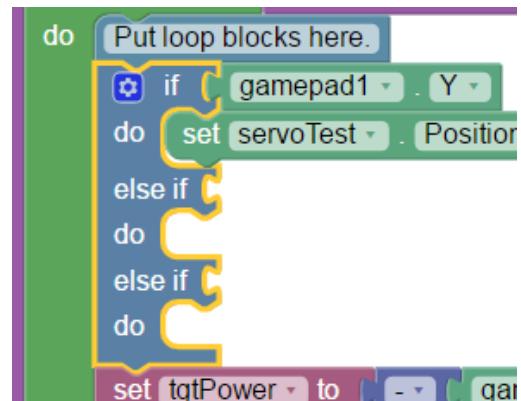
Drag an “else if” block from the left side of the pop-up menu and snap it into place under the “if” block.

Drag a second “else if” block from the left side and snap it into place on the right side under the first “else if” block.

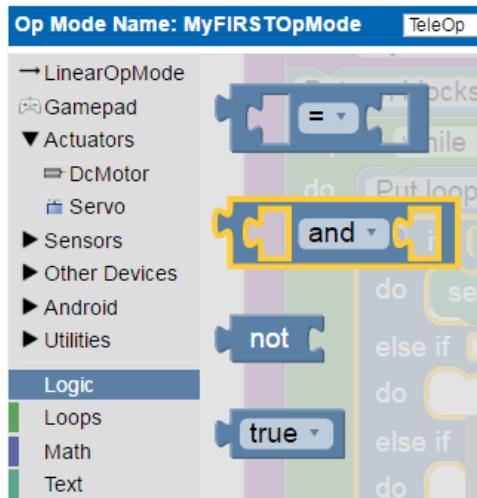
**Step 15:**

Click on the Settings icon to hide the pop-up menu for the “if do” block.

The “if do” block should now have two “else if” test conditions added.

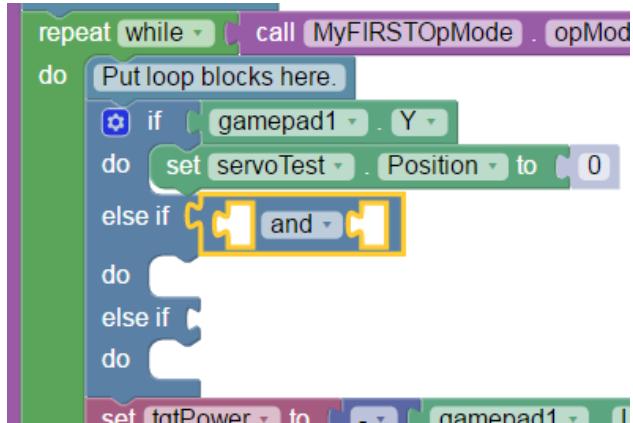
**Step 16:**

Click on the “Logic” category and select the logical “and” block.

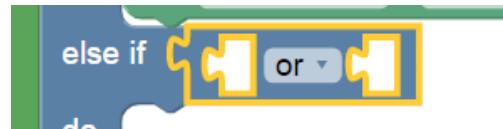


Step 17:

Drag the “and” block so it clicks in place as the test condition for the first “else if” block.

**Step 18:**

Click on the word “and” and select “or” from the pop-up menu to change the block to a logical “or” block.

**Step 19:**

Click on the “Gamepad” category and select the “gamepad1.X” block.



Drag the block so that it clicks in place as the first test condition of the logical “or” block.

Step 20:

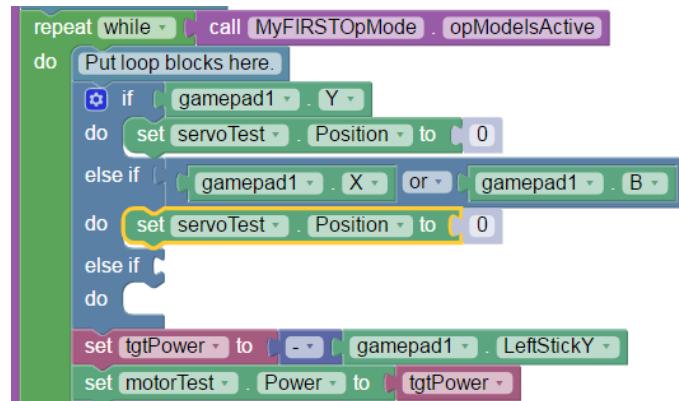
Click on the “Gamepad” category and select the “gamepad1.B” block.



Drag the block so that it clicks in place as the second test condition of the logical “or” block.

Step 21:

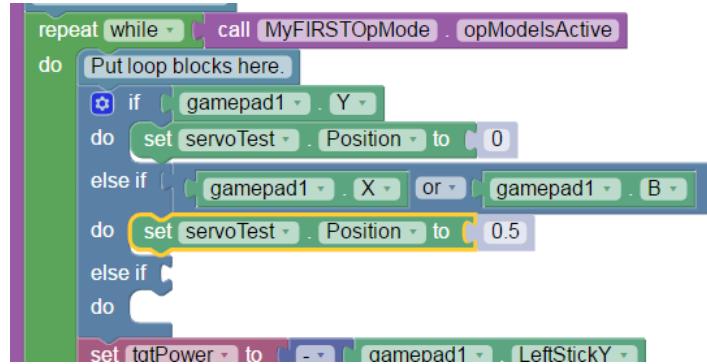
Select a “set servoTest.Position to” block and place it into “do” clause of the first else-if block.



Step 22:

Highlight the number “0” and change it to “0.5”.

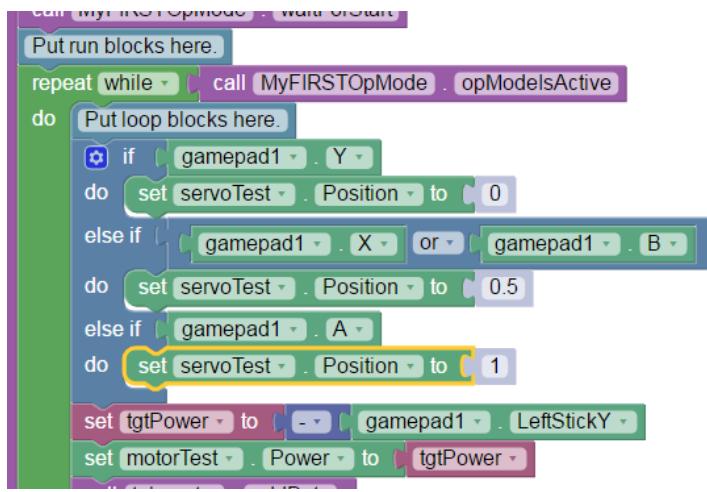
With this change, if the user presses the “X” button or “B” button on gamepad #1, the op mode will move the servo to the midway (90-degree) position.

**Step 23:**

Use a “gamepad1.A” block as the test condition for the second “else if” block.

Drag a “set servoTest.position to” block to the do clause of the second “else if” block and modify the numeric value so that the servo’s position will be set to a value of 1.

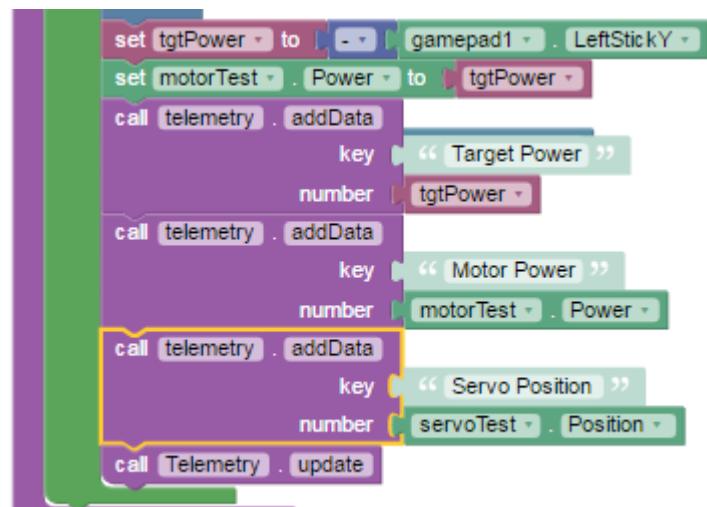
For this clause, if the “A” button is pressed on the #1 gamepad, the op mode will move the servo to the 180-degree position.

**Step 24:**

Insert a “call telemetry.addData” block (numeric) before the “call Telemetry.update” block.

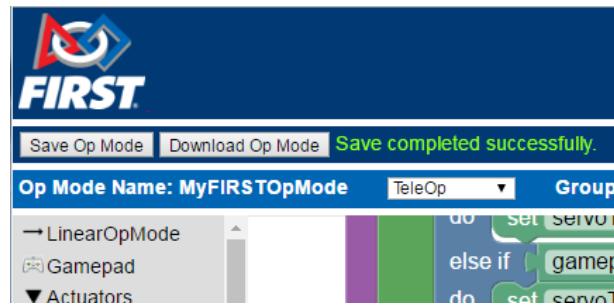
Rename the key field to “Servo Position” and insert a “servoTest.Position” block for the number field.

This set of blocks will send the current servo position value to the Driver Station while the op mode is running.



Step 25:

Save your op mode and verify that it was saved successfully to the Robot Controller.

**Step 26:**

Following the procedure outlined in Section 7 of this manual to run your updated op mode.

Don't forget to exit programming mode before selecting and running the op mode. Also, make sure that your gamepad is designated as User #1 before running your op mode.

You should now be able to control the servo position with the colored buttons. The servo position should be displayed on the Driver Station.



9 Using Sensors

9.1 Color-Distance Sensor

A *sensor* is a device that lets the Robot Controller get information about its environment. In this example, you will use a REV Robotics Color-Distance sensor to display range (distance from an object) info to the driver station.

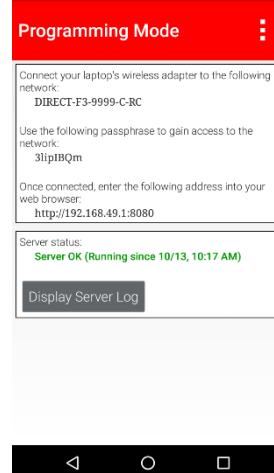
The Color-Range sensor uses reflected light to determine the distance from the sensor to the target object. It can be used to measure close distances (up 5" or more) with reasonable accuracy. Note that at the time this document was most recently edited, the REV Color-Range sensor saturates around 2" (5cm). This means that for distances less than or equal to 2", the sensor returns a measured distance equal to 2" or so.

Modifying the Op Mode to Display Distance

(Time Needed to Complete Task: 15 minutes)

Step 1:

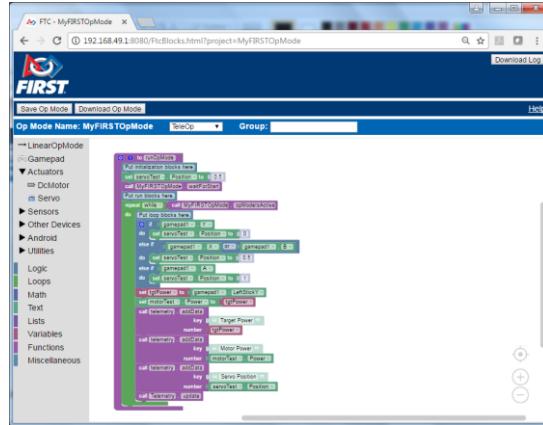
Place the Robot Controller in Programming Mode. Verify that your laptop is still connected to the Robot Controller's Programming Mode Wi-Fi network.



Step 2:

Verify that "MyFIRSTOpMode" is opened for editing.

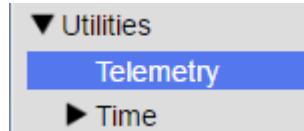
If it is not, you can click on the FIRST logo in the upper left hand corner of the browser window on the laptop. This should take you to the main FTC Blocks Development Tool project screen.



Click on the "MyFIRSTOpMode" project to open it for editing if it is not already opened.

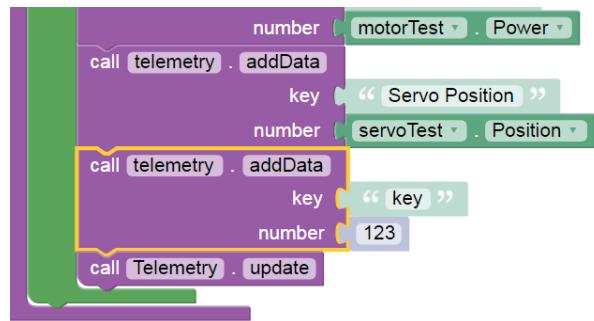
Step 3:

Click on the "Utilities" category on the left-hand side of your browser. Find and click on the "Telemetry" subcategory.

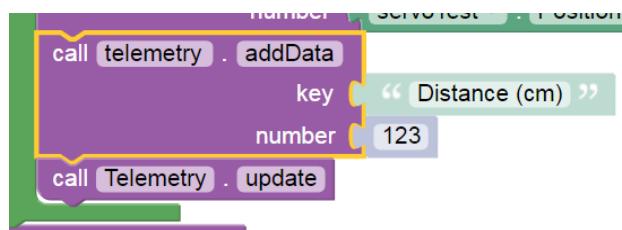


Step 4:

Select the “call telemetry.addData” block (the numeric version) and drag it to the spot in your “while” loop block immediately before the “telemetry.update” block.

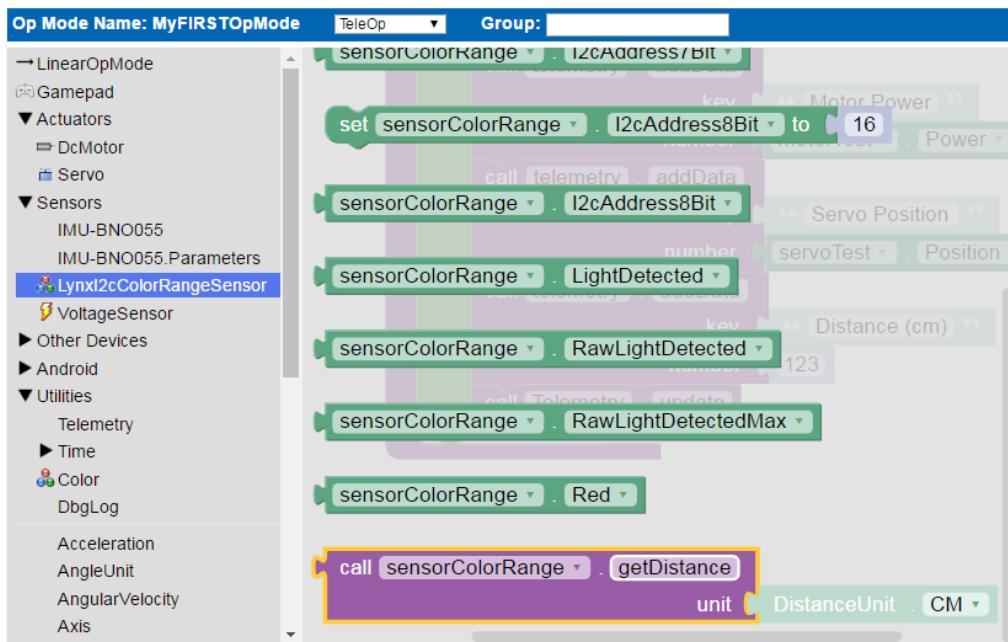
**Step 5:**

Click and highlight the “key” text and change the text so it reads “Distance (cm)”.

**Step 6:**

Click and expand the “Sensors” category. Click on the “LynxI2cColorRangeSensor” subcategory.

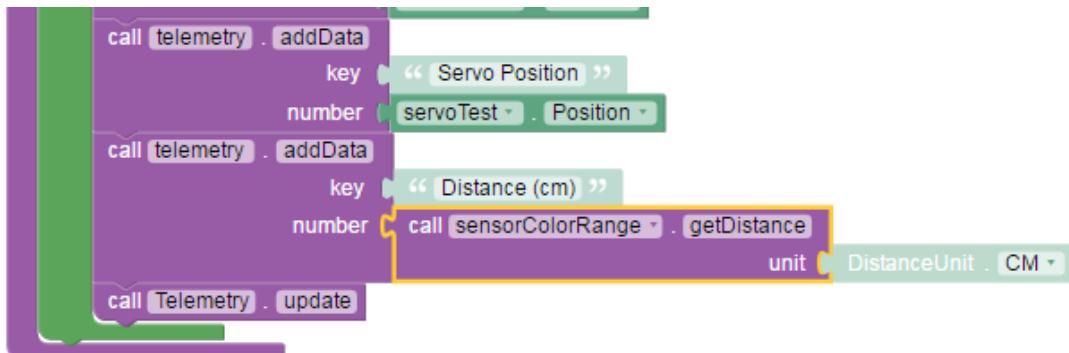
Click on and select the “call sensorColorRange.getDistance” programming block.



Note that the prefix “Lynx” is synonymous for “REV Expansion Hub”.

Step 7:

Drag the “call sensorColorRange.getDistance” programming block to the “number” field of the “call telemetry.addData” programming block.



This will send the measured distance to the target in centimeters back to the Driver Station.

Step 8:

Save your op mode and verify that it was saved successfully to the Robot Controller.

**Step 9:**

Following the procedure outlined in Section 7 of this manual to run your updated op mode.

As you run the op mode, if you move your hand above the color light sensor, you should see the measured distance change on the Driver Station screen. If the expression “NaN” (not a number) is displayed on the Driver Station, the target is most likely out of range (and the sensor does not detect any reflected light).



9.2 Touch Sensor

The REV Robotics Touch Sensor can be connected to a digital port on the Expansion Hub. The Touch Sensor is HIGH (returns TRUE) when it is not pressed. It is *pulled* LOW (returns FALSE) when it is pressed.



Figure 13 - REV Robotics Touch Sensor.

The Expansion Hub digital ports contain two digital pins per port. When you use a 4-wire JST cable to connect a REV Robotics Touch sensor to an Expansion Hub digital port, the Touch Sensor is wired to the second of the two digital pins within the port. The first digital pin of the 4-wire cable remains disconnected.

For example, if you connect a Touch Sensor to the “0,1” digital port of the Expansion Hub, the Touch Sensor will be connected to the second pin (labeled “1”) of the port. The first pin (labeled “0”) will stay disconnected.

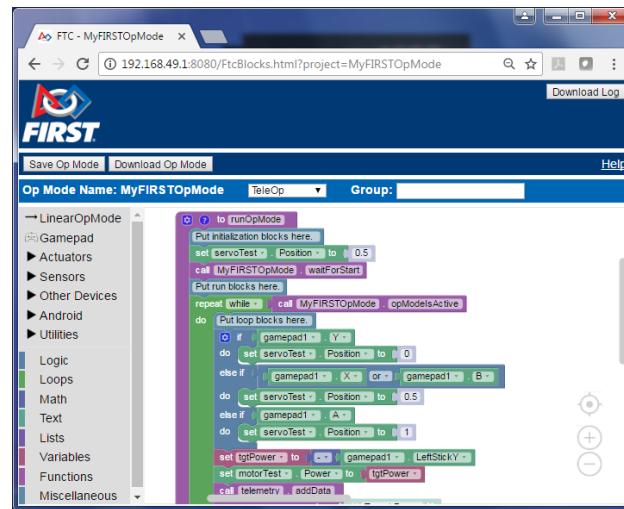
Modifying the Op Mode to Display Button State (Time Needed to Complete Task: 15 minutes)	
Step 1: Place the Robot Controller in Programming Mode. Verify that your laptop is still connected to the Robot Controller’s Programming Mode Wi-Fi network.	A screenshot of the Robot Controller's Programming Mode interface. The top bar is yellow with the title. Below it is a red header bar with the text "Programming Mode" and three vertical dots. The main content area has three sections: 1) Network connection info: "Connect your laptop's wireless adapter to the following network: DIRECT-F3-9999-C-RC" and "Use the following passphrase to gain access to the network: 3l1p1BQm". 2) Web browser info: "Once connected, enter the following address into your web browser: http://192.168.49.1:8080". 3) Server status: "Server status: Server OK (Running since 10/13, 10:17 AM)" with a "Display Server Log" button. At the bottom is a black navigation bar with arrows, a circle, and a square.

Step 2:

Verify that “MyFIRSTOpMode” is opened for editing.

If it is not, you can click on the FIRST logo in the upper left hand corner of the browser window on the laptop. This should take you to the main FTC Blocks Development Tool project screen.

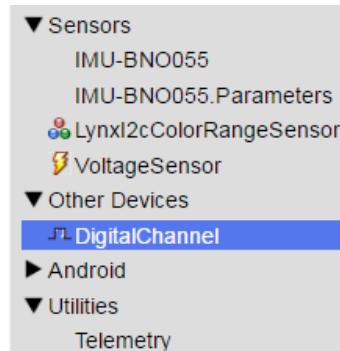
Click on the “MyFIRSTOpMode” project to open it for editing if it is not already opened.



Step 3:

Click on the “Other Devices” category to expand it. If you configured the touch sensor as a digital device, you should see the “Digital Channel” subcategory.

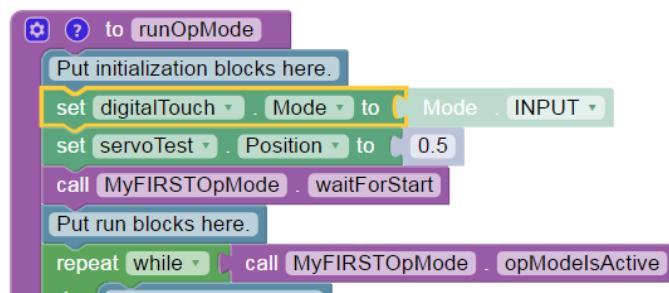
Click on “Digital Channel” to display the list of available programming blocks.



Step 4:

Select the “set digitalTouch.Mode to” block and drag it to the position after the “Put initialization blocks here” comment.

By default, this block will set the digital channel named “digitalTouch” to input mode.



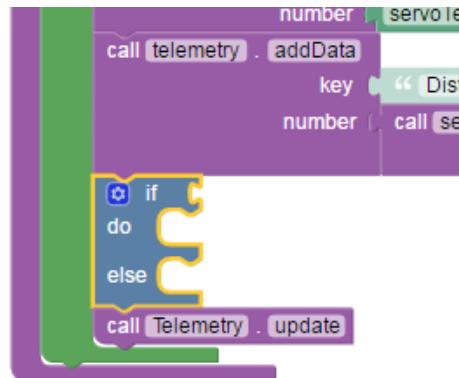
Step 5:

Click on the “Logic” category. Find and click on the “if do else” block.



Step 6:

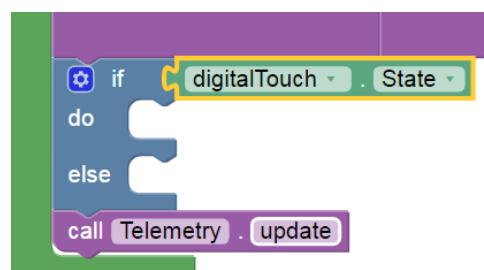
Drag the “if do else” block to the position before the “telemetry.update” block.

**Step 7:**

Click on the “Other Devices” category to expand it. Click on the “Digital Channel” subcategory, then find and select the “digitalTouch.State” block.

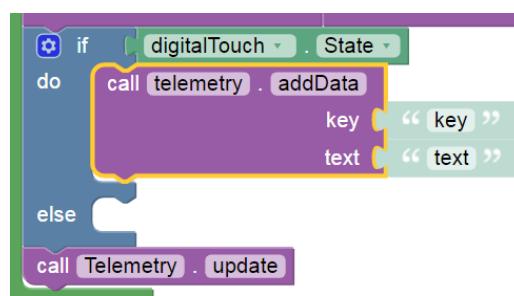
**Step 8:**

Drag the “digitalTouch.State” block to the test condition of the “if do else” programming block.

**Step 9:**

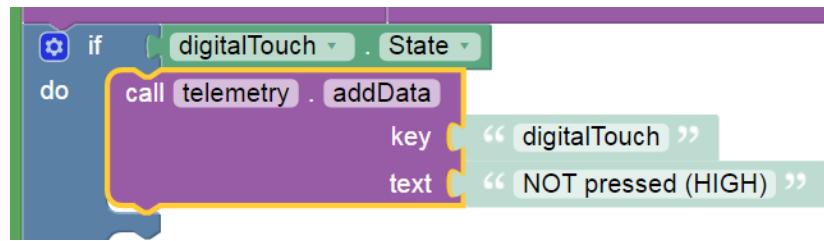
Click on the “Utilities” category on the left-hand side of your browser. Find and click on the “Telemetry” subcategory.

Select the “call telemetry.addData” block (the numeric version) and drag it to the “do” clause of the “if do else” block.



Step 10:

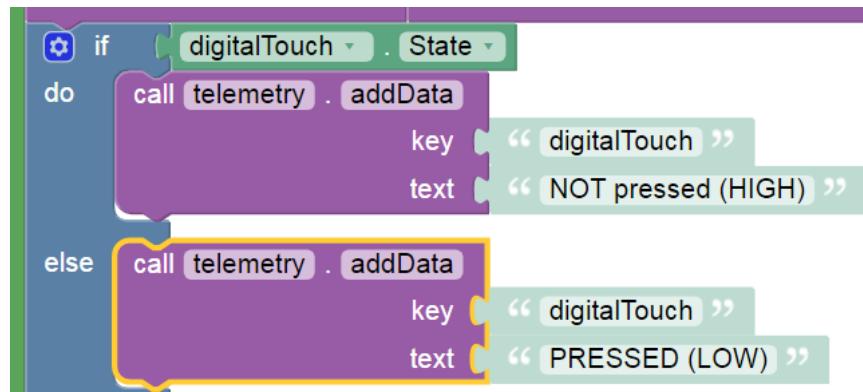
Change the “key” value to “digitalTouch” and the “text” value to “NOT pressed (HIGH)”.



If the op mode detects that the “digitalTouch” channel is HIGH, it will send a telemetry message indicating that the button is not pressed.

Step 11:

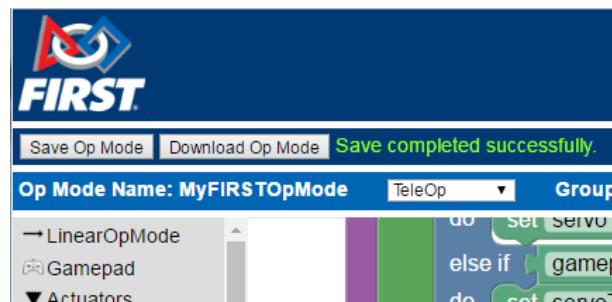
Select another “call telemetry.addData” block (the numeric version) and drag it to the “else” clause of the “if do else” block. Change the “key” value to “digitalTouch” and the “text” value to “PRESSED (LOW)”.



If the op mode detects that the “digitalTouch” channel is not HIGH, it will send a telemetry message indicating that the button is pressed.

Step 14:

Save your op mode and verify that it was saved successfully to the Robot Controller.



Step 15:

Following the procedure outlined in Section 7 of this manual to run your updated op mode.

As you run the op mode and push or release the button, the telemetry message on the Driver Station should update to reflect the current state of the digital Touch Sensor.



10 Troubleshooting

10.1 Manually Connecting to the Blocks Programming Mode Wi-Fi Network

Section 6.4 describes how to search for the blocks programming mode Wi-Fi network from a list of available networks and then connect to it with a Windows laptop. For some Windows devices, the laptop might not display your blocks programming mode Wi-Fi network in its list of available networks. This problem can occur with some Windows 10 machines (and possibly with some Windows 8 machines), especially if the computer does not have current system updates and service packs.

If you are having problems seeing your FTC Blocks Programming Wi-Fi network in your list of available networks, make sure that your Driver Station is paired and connected to your Robot Controller (see section 3.4 of this document). Also, make sure that your Robot Controller is in Programming Mode (see section 6.4 of this document). Also, make sure that your Windows 10 device has its most current updates installed from Microsoft.

If you have verified that the Driver Station is paired and connected to the Robot Controller and that the Robot Controller is in Programming Mode, and if you have verified that your Windows 10 updates are current, then you might have to manually connect your Windows 10 computer to the blocks programming mode Wi-Fi network.

You can manually connect to this network as if the network were a *hidden* network (i.e., a network that does not broadcast its presence to other Wi-Fi devices).

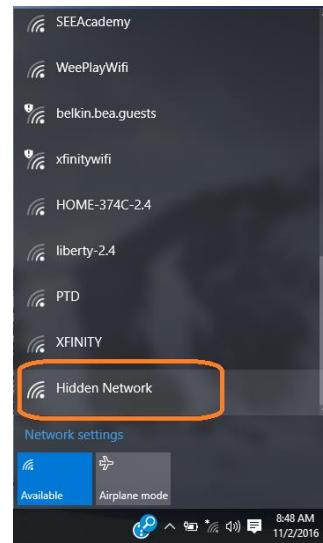
Manually Connecting to the Programming Mode Wi-Fi Network

(Time Needed to Complete Task: 15 minutes)

Step 1:

In the lower right hand corner of the Windows 10 desktop, click on the network icon in the system tray to display a list of available Wi-Fi networks.

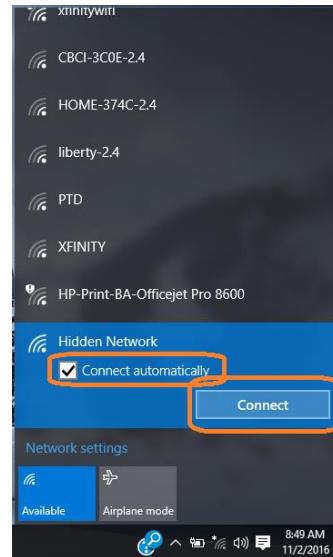
If you still do not see your blocks programming mode network listed, then scroll to the bottom of the list and look for the item “Hidden Network”.



Step 2:

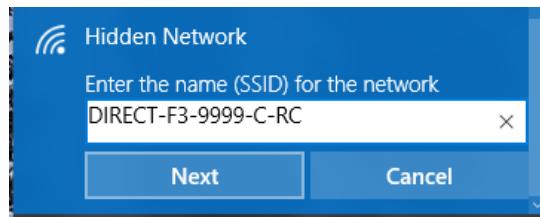
Click on the “Hidden Network” listing to start the connection process. The listing should display a “Connect” button.

Make sure the option “Connect automatically” is checked and then click on the “Connect” button to continue with the process.



Step 3:

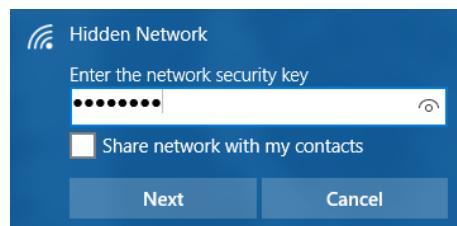
The computer should prompt you for the name or *SSID* of your blocks programming mode Wi-Fi network. You should type in the network name that is displayed in the Programming Mode window of the Android device.



Note, the SSID or network name is *case sensitive*. Make sure the capitalization of the name that you enter matches the capitalization of the name displayed in the Programming Mode Window.

Step 4:

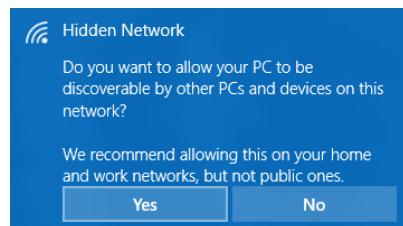
The computer should then prompt you for the passphrase to access this Wi-Fi network. You should type in the network passphrase that is displayed in the Programming Mode window of the Android device.



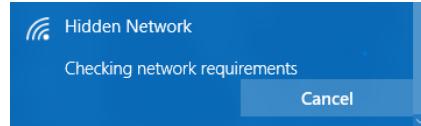
Note that the passphrase is *case sensitive*. Make sure that your spelling and capitalization matches the original spelling and capitalization shown on the Programming Mode screen.

Step 5:

Your computer will prompt you on whether you want to make your PC discoverable by other devices on this network. Click "Yes" to continue.

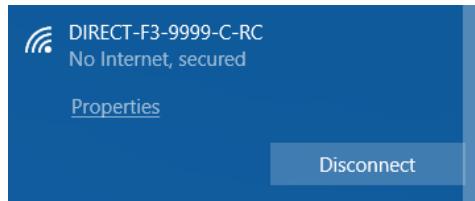
**Step 6:**

The computer will attempt to connect to your network. Note that it could take several minutes before it connects.

**Step 7:**

If you could successfully connect to the network, it will eventually appear in the list of networks on your computer.

Note that when your computer is connected to the blocks programming server on your Robot Controller phone, *it will not have access to the Internet*.



10.2 Troubleshooting Tips

In this section, we provide some basic tips on troubleshooting problems that you might encounter when using the blocks programming mode server to write op modes for your Robot Controller.

10.2.1 Cannot See the Blocks Programming Mode Wireless Network

If you are trying to connect to the blocks programming mode wireless network so that you can create/edit an op mode for your Robot Controller, but you cannot see this wireless network listed as an available network for your laptop to connect to, verify the following items:

1. Make sure the Driver Station is successfully paired to the Robot Controller (see section for details). Often the Robot Controller's Wi-Fi Direct network will time out if it is not connected to the Driver Station.
2. Make sure the Robot Controller has been switched successfully to programming mode (see section 0).
3. Power cycle (turn off and then turn back on) your Robot Controller phone and then relaunch the FTC Robot Controller app. Reconnect the Driver Station to the Robot Controller, and then turn off the wireless adapter on your laptop for a few seconds, and then turn it back on (to force a rescan of the available Wi-Fi networks).

10.2.2 “Save project failed. Error code 0.”

If you attempt to save the op mode that you are currently editing, but you receive an error message indicating that the “Save project failed. Error code 0.” you might not be connected to the blocks programming mode sever:

1. Make sure the Robot Controller is in programming mode.
2. Make sure that your laptop is connected to the blocks programming mode Wi-Fi network.
3. If you have verified the first two items, press the “Save Op Mode” button again to re-attempt the save operation.

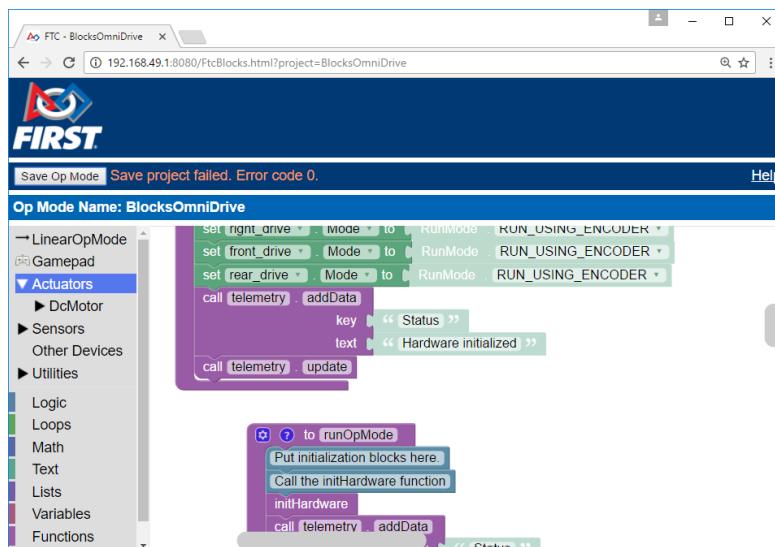


Figure 14 – If the save attempt fails, you might not be connected to the blocks programming mode network and/or server.

10.2.3 Op Mode Blocks Are Missing...

If you have opened an existing op mode to edit it in your Javascript-enabled browser, but the programming blocks are missing, check the following:

1. Did you remember to save the op mode the last time you edited and then exited the op mode? If you did not save the op mode after the last editing session, you might have lost some of your changes.
2. Are the blocks *collapsed* and/or in an area of the design “canvas” (or design pane) that is outside your current browser window? If so, you can use the *expand* and *cleanup* functions of the blocks programming tool to expand all the blocks on your screen and to organize them in an easy-to-view (and easy-to-find) manner.

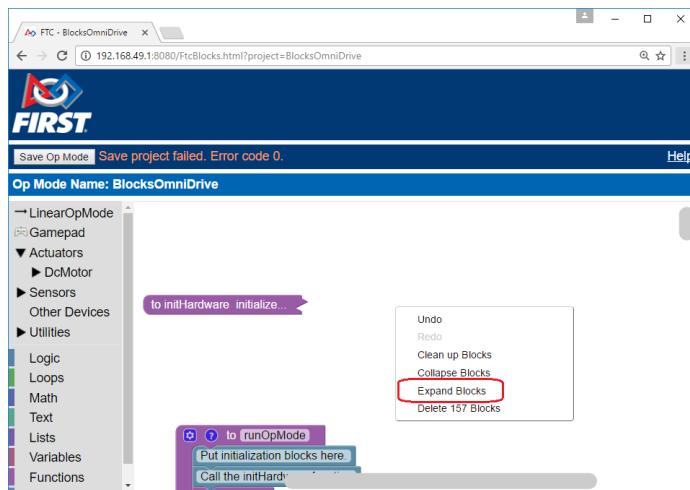


Figure 15 – You can right mouse click on “canvas” and select Expand Blocks to expand all of the blocks in your op mode.

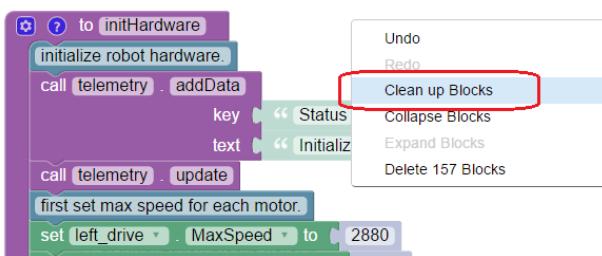


Figure 16 – Right mouse click on the canvas/design pane and select Clean up Blocks to organize all your blocks.

3. Are your programming blocks missing and you only see a solitary gray rectangular block on your screen? If this is the case, then you should check to see if the active configuration file for the Robot Controller is the same configuration file that you originally used to create the op mode. There is a bug in early versions of the blocks programming software that prevents the blocks server from properly rendering the programming blocks if the active configuration of the Robot Controller does not match the original configuration file used to create the op mode. More specifically, if some of the hardware devices (such as the DC motors or servos) from the original

file are missing from the current configuration file, the blocks mode server will not properly display the programming blocks in the design pane.

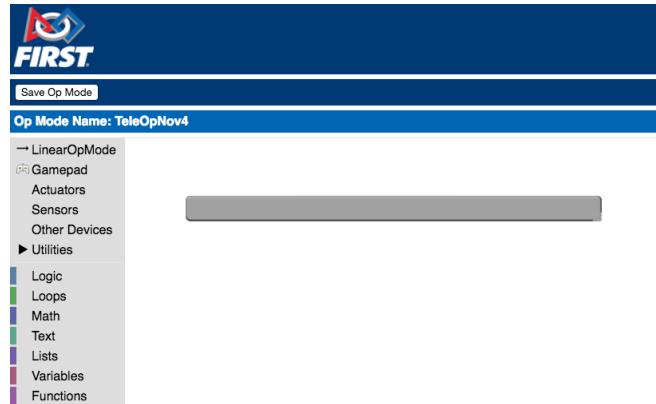


Figure 17 – Are the programming blocks missing and only a solitary gray rectangular block is visible?

10.2.4 Driver Station Appears Unresponsive

If you are ready to run an op mode, but the Driver Station is unresponsive and you cannot initialize or start your selected op mode, check the following items:

1. Verify that the Driver Station is properly paired to the Robot Controller.
2. Make sure that the Robot Controller is not in Programming Mode.
3. Check the *ping* times on the Driver Station main screen. The ping time is the average time it takes for the Driver Station to send a message to the Robot Controller and for the Robot Controller to acknowledged that it received the message. If the ping time is low (< 20 msec) the wireless connection between the Driver Station and Robot Controller is good. If the ping time is consistently high (> 50 msec) there could be some wireless interference in your venue that is causing the problems between the Driver Station and the Robot Controller.



10.2.5 Warning: problem communicating...

If you are trying to run an op mode and you notice error messages like the ones displayed below, it could be that your wired connection between the phone and the electronic modules is bad.

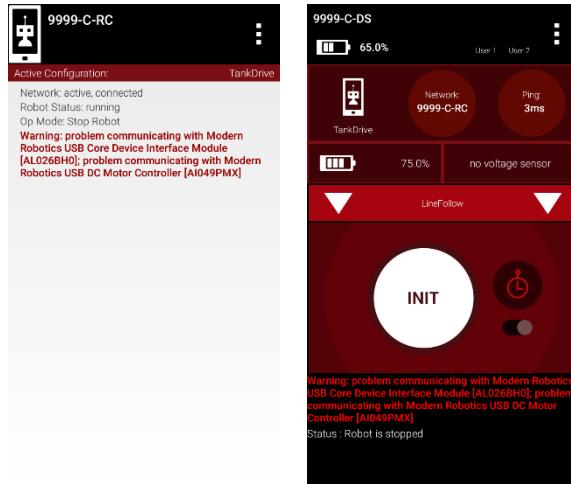


Figure 18 - A "problem communicating with..." message often indicates a bad connection between the phone and modules.

If you notice this error message, here are some things you can try:

1. Verify that the USB cable connecting the phone to the Expansion Hub is secure and well connected.
2. Verify that the 12V power cables connecting the battery to the switch and the Expansion Hub are properly secured and connected. Also, verify that the power switch is in the on position.
3. Try to do a "Restart Robot" from the pop up menu (touch the three vertical dots in the upper right hand screen of the Robot Controller or Driver Station apps).
4. If that does not work, disconnect the USB cable from the phone, then shut down the main power switch on the Expansion Hub. Wait for 5 seconds, then power the device back on and reconnect the USB cable to the phone.