SparkFun Inventor's Kit for Edison Experiment Guide

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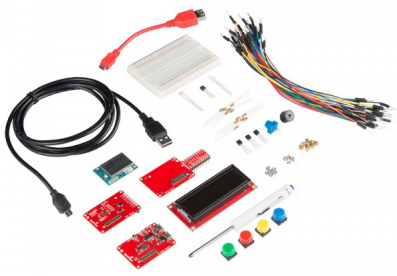
Introduction

The SparkFun Inventor's Kit for Intel® Edison, otherwise known as the *Edison SIK*, introduces the Edison as a powerful Internet of Things (IoT) platform. The experiments contained within these pages will guide you through programming the Edison using JavaScript and controlling various electronics. Whether you are new to electronics and JavaScript or are looking to take your skills to the next level (to the "cloud!"), this kit is a great starting point.

Set Aside Some Time - Please allow yourself ample time to complete each experiment. You may not get through all the experiments in one sitting. Each experiment also contains suggestions on project ideas and taking the examples to the next level. We suggest that you challenge yourself and try some of them!

Included Materials

Here is a complete list of all the parts included in the Edison SIK.



The SparkFun Inventor's Kit for Intel® Edison includes the following:

- 1x Intel® Edison
- 1x SparkFun Block for Intel® Edison - Base
- 1x SparkFun Block for Intel® Edison - GPIO
- 1x SparkFun Block for Intel® Edison - ADC
- 1x Basic 16x2 Character LCD - White on Black 3.3V
- 1x Mini Photocell
- 1x Temperature Sensor - TMP36
- 1x LED - RGB Diffused Common Cathode
- 20x 100Ω Resistors
- 20x 10kΩ Resistors
- 3x 2N3904 NPN Transistors
- 1x Piezo Speaker
- 1x 10k Trimpot
- 1x USB OTG Cable
- 1x USB microB Cable
- 1x Breadboard
- 1x Intel® Edison Hardware Pack
- 30x Jumper Wires
- 4x Push Buttons
- 1x Screwdriver

If, at any time, you are unsure which part a particular experiment is asking for, reference this section.

Suggested Reading

The following links may help guide you in your journey through the Edison SIK.

- Edison Getting Started Guide - A quick way to program the Edison using the Arduino IDE.
- General Guide to SparkFun Blocks for Intel® Edison - Describes how the Blocks work with the Edison and provides a brief overview of all the available Blocks.
- Intel's Getting Started Guide - Tutorial on how to get the Edison running with either the Arduino Breakout Board or the Mini Breakout Board.

Each experiment will also have a Suggested Reading section to aid you in understanding the components and concepts used in that particular experiment.

NOTE: If you would like to see all of the example code in one place, it can be found on GitHub! Just click the button below to be taken to the GitHub repository and click the link to **Download ZIP.**

EDISON SIK EXAMPLE CODE

Using the Kit

Before exploring the experiments, there are a few items to cover first. If you have completed one of our other Inventor's Kits before, you should already be familiar with most of the concepts in this section. If this is your first Inventor's Kit, please read this part carefully to ensure the best possible SIK experience.

Intel® Edison

The Intel® Edison acts as the brain for the kit. The Edison sports a dual-core, 500 MHz Atom Z34XX processor, 1 GB of RAM, and 4 GB of onboard flash storage. It has built-in WiFi and Bluetooth. Those are some impressive statistics, but what does that mean? Well, the Edison is a complete computer in a tiny package. It is even capable of running a Linux operating system! To learn more about the Edison, visit the Edison Getting Started Guide.

Edison Getting Started Guide
DECEMBER 5, 2014
An introduction to the Intel® Edison. Then a quick walk through on interacting with the console, connecting to WiFi, and doing...stuff.

Breadboard

Solderless breadboards are the go-to prototyping tool for those getting started with electronics. If you have never used a breadboard before, we recommend reading through our How to Use a Breadboard tutorial before starting with the experiments.

How to Use a Breadboard
MAY 14, 2013
Welcome to the wonderful world of breadboards. Here we will learn what a breadboard is and how to use one to build your very first circuit.

Jumper Wires

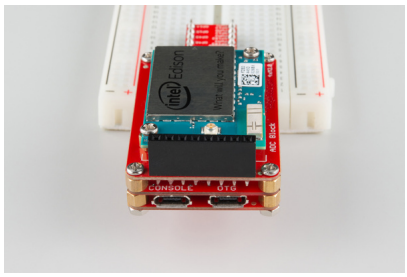
This kit includes thirty 7" long jumper wires terminated as male to male. You can use these to connect terminal strips on a solderless breadboard or connect them to the header on the ADC Block.

Screwdriver

We've included a pocket screwdriver to aid you in any mechanical portions of this guide. Note that the screwdriver bit can be pulled out from the plastic handle. The bit can be turned around and inserted back into the handle if you need to choose between a Phillips or a flathead driver.

USB Ports

The Edison Base Block has 2 USB ports.



- **Console** - This port is attached to an FTDI chip that converts USB signals to serial. This allows you to connect to a serial terminal on the Edison. Only the **USB microB cable** (the 6-foot cable) can fit into this port.
- **OTG** - OTG stands for On-the-Go, and it means that the Edison can act as a USB host or a USB device. You may plug either the **USB microB cable** (for using the Edison as a USB device) or the 4-inch **USB microA cable** (for using the Edison as a USB host) into this port.

Building the Block Stack

Before we can use the Edison in any of our circuits, we must first attach it to the Blocks in the kit. The Blocks stack in a particular order to work best with the kit.

Parts needed

You will need the following parts:

- **1x** Intel® Edison
- **1x** ADC Block
- **1x** Base Block
- **1x** GPIO Block
- **1x** Edison Hardware Pack

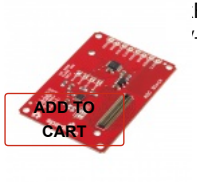
Don't have the kit? No worries! You can still have fun and follow along with these experiments. We suggest using the parts below:

) Edison
'-13024
★★☆ 24

.Fun Block for Intel® Edison - Base
'-13045
★★⯪ 16

) Edison Hardware Pack
M-13187
★☆☆ 9

.Fun Block for Intel® Edison - GPIO
'-13038
★⯪☆ 4



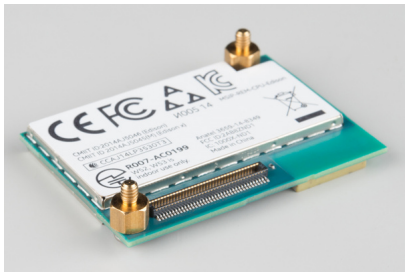
Fun Block for Intel Edison - ADC
'-13770

NOTE: If you do not have the kit, you will need to solder male headers to the GPIO Block and female headers to the ADC Block.

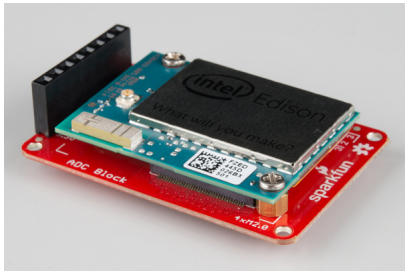
Attach the Edison to the ADC Block

Open the Edison Hardware Pack. Put 2 screws through the mounting holes in the Edison, such that the screws' heads are facing up (we'll call "up" the surface of the Edison with the "Intel® Edison" logo).

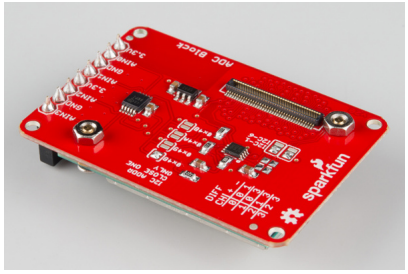
Attach 2 standoffs to the screws sticking out the bottom of the Edison. Use the pocket screwdriver to carefully tighten the screws.



Snap the Edison into the socket on the ADC Block. Make sure that the bottoms of the standoffs are protruding through the mounting holes on the ADC Block.



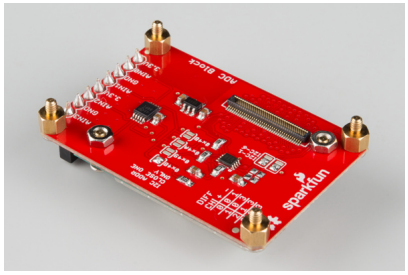
Screw 2 nuts onto the standoffs, securing the Edison to the ADC Block. You can use the pocket screwdriver to hold the screws in place while you tighten the nuts. Go slowly! The nuts can be tightened by hand, but it requires some finesse as they are quite small.



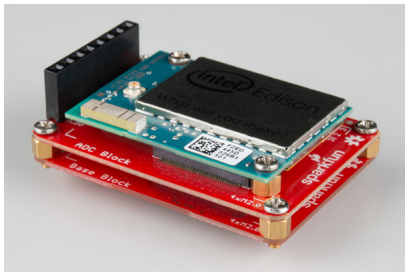
Attach the Base Block

Put 4 screws through the mounting holes on the corners of the ADC Block, such that the screws' heads are facing up (the same direction as the screws securing the Edison).

Attach 4 standoffs to those screws. Use the pocket screwdriver to carefully tighten the screws.

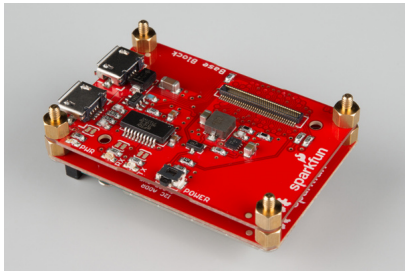


Snap the ADC Block (which has the Edison on top) into the socket on the Base Block. Make sure that the bottoms of the standoffs are protruding through the mounting holes on the Base Block.

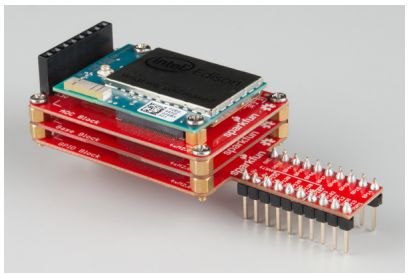


Attach the GPIO Block

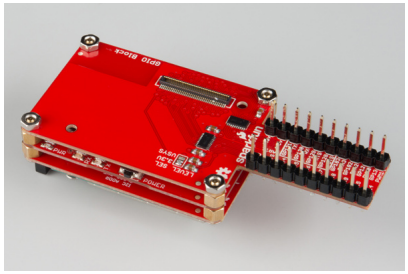
Attach 4 standoffs to the bottoms of the standoffs that are protruding from the mounting holes on the Base Block.



Snap the Base Block (which has the ADC and Edison mounted on top) into the socket on the GPIO Block. Make sure that the bottoms of the standoffs are protruding through the mounting holes on the GPIO Block.

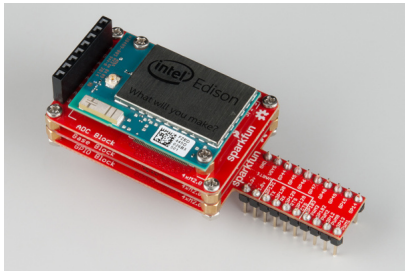


Screw the remaining 4 nuts onto the standoffs, securing the entire stack of Blocks together.



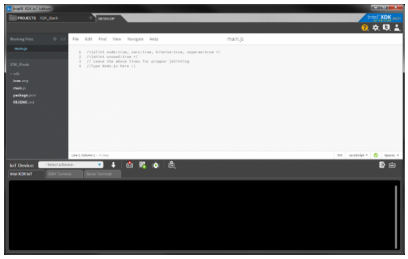
Flip the entire stack around, and make sure it is in the following order:

1. Edison
2. ADC Block
3. Base Block
4. GPIO Block



Installing the Intel® XDK IoT Edition

The Intel® XDK is Intel's integrated development environment (IDE) for creating, testing, and deploying mobile apps. We will be using the XDK IoT Edition, which was specifically designed to help users develop Node.js and HTML5 applications for the Intel® Edison and Intel® Galileo.



NOTE: You will need to sign up for an Intel® Developer Zone Account to use the XDK. If you would prefer not to use the XDK, you can program Node.js applications directly in the Edison (you will just miss out on cool things like code completion, and you might have to skip some of the phone app exercises.). Visit Appendix B: Programming Without the XDK to learn how.

Download the Installer

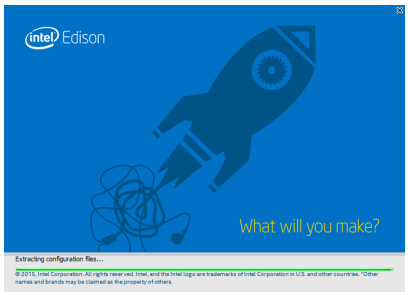
The easiest way to install the XDK is to use the Intel® Edison Integrated Installer. This contains the XDK, drivers, and Flashing Tool (to update the Edison Firmware). Follow the link below and download the Installer for your operating system:

INTEL® EDISON INTEGRATED INSTALLER

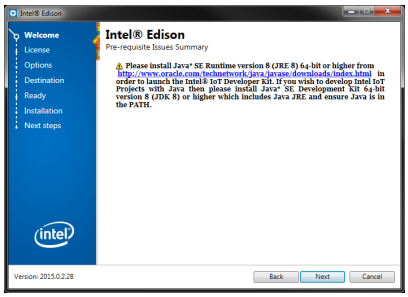
WARNING: Make sure you do **not** have any Edisons plugged in to your computer for the installation!

Windows

Run the Installer that you just downloaded. You will see a splash screen as it unzips and prepares to install.

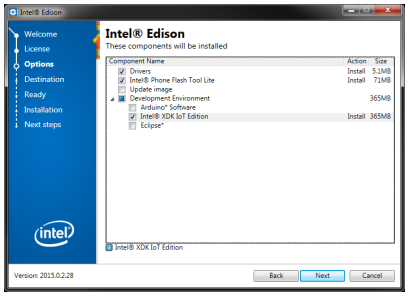


Once you get the "Welcome to Intel® Edison" screen, click **Next**. You might get a screen telling you to install "Java SE Runtime." Just ignore it, as we will not be developing in Java (JavaScript is not the same as Java!).



Click **Next** to continue the installation process. The ubiquitous License Agreement will pop up. Feel free to read it (or not).

Select **I accept the terms of the license** and click **Next**. You will then be presented with options to install. Deselect **Update Image** (we will do that separately in the next section), deselect **Arduino Software**, and select **Intel® XDK IoT Edition**.



Click **Next**. On the next screen, make sure that you have enough space to install the programs. Leave the installation directory as default.

Click **Next**, verify that the installation summary looks correct, and click **Next** again. Wait a few minutes while the installation completes.

> **NOTE:** The installation process might attempt to install other drivers and programs. **Accept all the defaults and choose to install additional programs**. This is especially true on Windows where the Installer will want to install drivers, which are necessary for deploying code to the Edison. This includes things like "FTDI Drivers" and the "Phone Flash Tool Lite." Also, if the installation seems to have frozen, **check for new windows** that may have been opened.

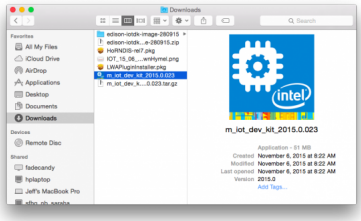
Once the installation process is done, you will see a “Complete” window.

Click **Finish**. If the Intel® Phone Flash Tool Lite opened during the process, you can leave it open if you wish (we will use it in the next section).

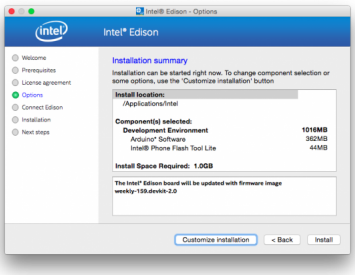
The installer or drivers may ask you to restart your computer.

OS X

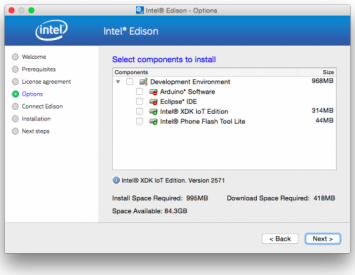
The OS X Installer link will download a .tar.gz file. Double-click on that file to extract it. Double-click on the extracted file to run the installer.



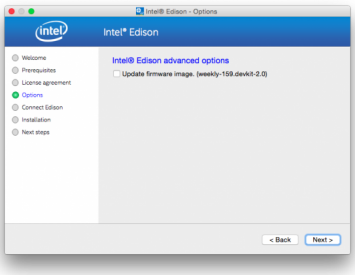
Follow the prompts, clicking **Next** to advance to the next screen. Accept the End User License Agreement when prompted. On the *Installation summary* screen, click **Customize Installation**.



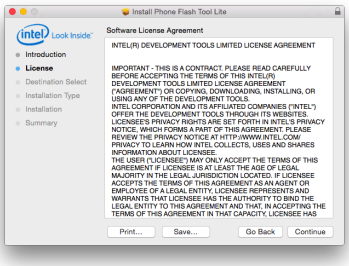
Keep the destination folder (/Applications) at the default and click **Next**. You will be presented with the option to select the components to install. Deselect **Arduino Software**, and select **Intel® XDK IoT Edition**.



Click **Next** and deselect **Update firmware image** (we will do that manually in the next section).



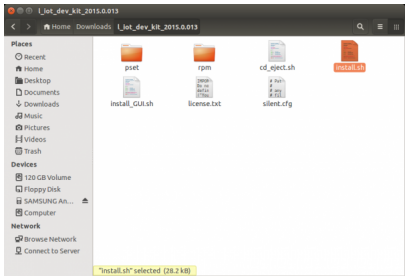
Click **Next** and then **Install**. Wait while the installer downloads. You will then be prompted to install the Phone Flash Tool Lite.



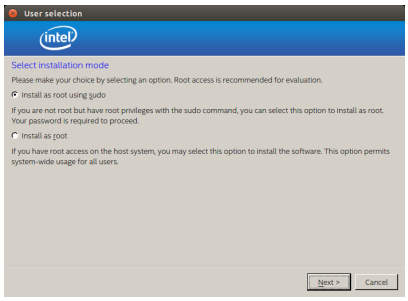
Click **Continue** and follow the prompts. Once the XDK has finished installing, the XDK can be found under *Applications*.

Linux

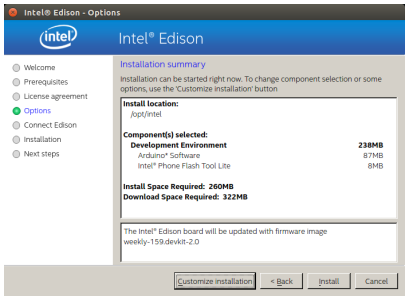
Download the installer, double-click on the file to extract it, and navigate into the directory that it creates.



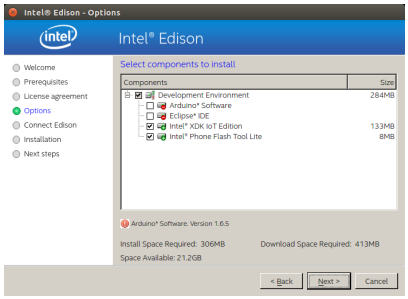
Double-click on the **install.sh** script (select *Run* if prompted) to begin the installer.



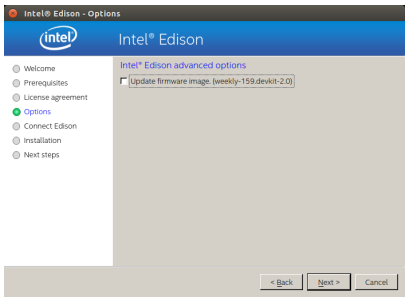
If you want the XDK to be available to all users, select *Install as root*. Otherwise, select *Install as root using sudo*. Accept the terms of the End User License Agreement, and accept all defaults until you are presented with a summary screen.



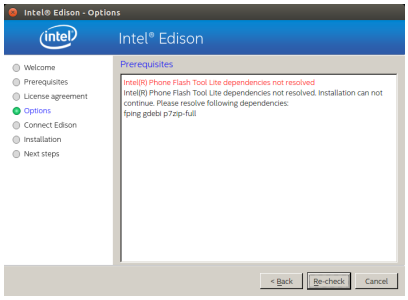
Click **Customize installation**, and accept the default installation directory on the next screen. You will be presented with some installation options.



Deselect **Arduino Software**, and select **Intel® XDK IoT Edition**. Click **Next**.



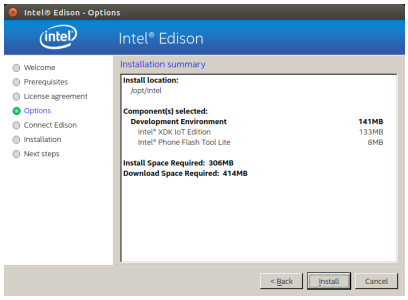
Deselect **Update firmware image**, and click **Next**. There is a chance that your system might be missing some dependencies (e.g. “Dependencies not resolved”).



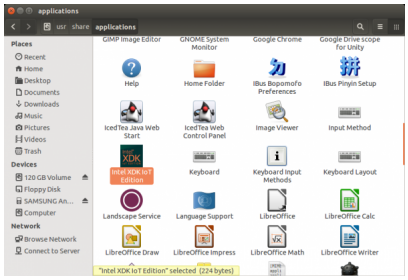
If so, you will need to open a command prompt and install them using `apt-get`. For example, I am missing *fping*, *gdebi*, and *p7zip-full*. So, I entered the following commands:

```
sudo apt-get update
sudo apt-get install fping gdebi p7zip-full
```

Wait for those to finish installing, and click **Re-check** on the missing dependencies screen. You should be good to install.



Click **Install** and wait for the installation to complete (clicking to accept any defaults on prompts). The XDK IoT Edition can be found in `/usr/share/applications` when the installation is complete.



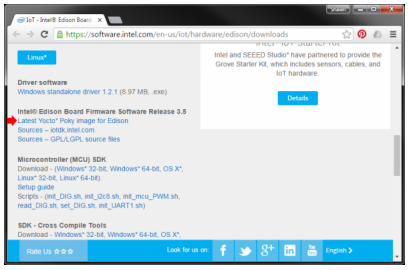
NOTE: If the Phone Flash Tool Lite failed to install, you can install it manually by following these instructions.

Updating the Edison Firmware

Most Edisons will ship with an older firmware (perhaps many months out of date). They will either contain bugs or simply not work with the latest version of the XDK IoT Edition. To remedy this problem, we highly recommend updating the firmware on the Edison.

To begin, download the latest firmware. Navigate to Intel's site using the link below and click to download the **Latest Yocto Poky image for Edison**.

INTEL® DOWNLOADS PAGE

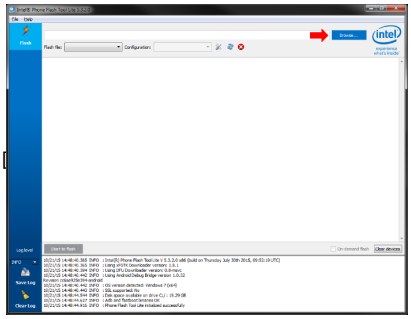


Once the download is complete, locate the file on your computer, and unzip it.

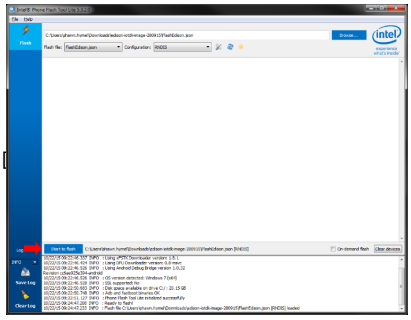
NOTE: If you did not install the XDK or do not wish to use the Phone Flash Tool Lite to update your Edison, you may try the Manual Firmware Update method in Appendix D.

Updating the Firmware with the Phone Flash Tool

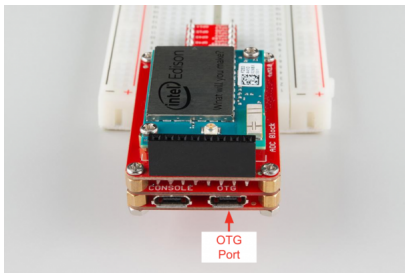
If it is not open already, open the Intel® Phone Flash Tool Lite program that we installed in the last section.



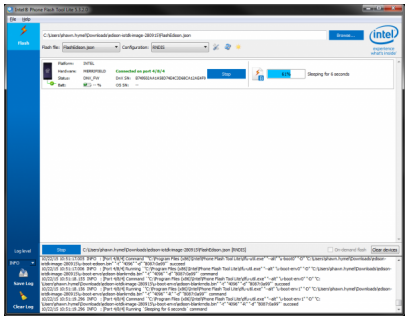
Click **Browse**, and navigate to the unzipped Edison firmware directory. Locate the *FlashEdison.json* file, and click **Open**. This will load the firmware into the Phone Flash Tool.



Click the **Start to flash** button. The Phone Flash Tool will tell you to plug in your Edison. Plug the USB micro cable into the **OTG Port** on the Base Block, and plug the other end into an open USB port of your computer.

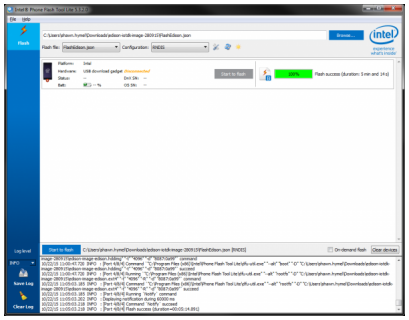


The Phone Flash Tool should begin to flash the Edison with a new firmware image.



The updating process can take anywhere from 5-10 minutes. We recommend making a sandwich and catching up on web comics in that time. The Edison will restart once or twice after the installation is complete. Wait at least **2 more minutes** after the update to allow the Edison to finish rebooting. Do not unplug the Edison in that time!

That's it! You should see a "Flash success" message in the Phone Flash Tool. If this worked, you can close the Phone Flash Tool Lite, and move on to the next section.



NOTE: If the Edison failed to flash, try the process again from the beginning. Close the Flash Tool Lite and unplug the Edison. Start the Flash Tool Lite again. This might take a few tries. If that still does not work, try the Manual Firmware Update method.

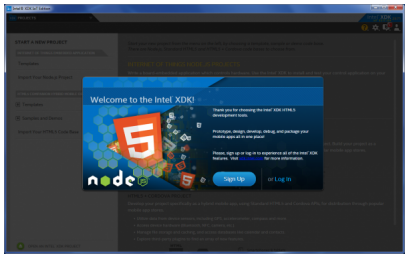
Using the XDK

If you have used other Integrated Development Environments before, the Intel® XDK IoT Edition might look familiar. If not, no worries! We will walk you through how to use the XDK (don't worry, it's not very complicated). If you would like to take a look at Intel's official documentation on the XDK, it can be found here:

INTEL® XDK IOT EDITION GUIDE

Starting the XDK for the First Time

Start the Intel® XDK IoT Edition program, and you should be presented with a login screen.



Click **Sign Up** if you do not already have an Intel Developer Zone Account (don't worry, it's free), and follow the on-screen instructions to create a new account. You will need to accept another Terms and Conditions statement.

The Welcome Screen

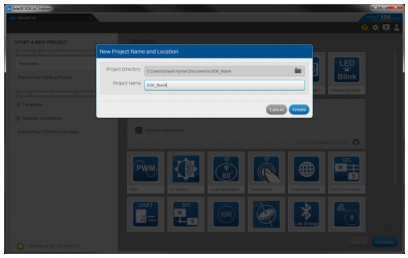
Once you have created an account (or not), you will be presented with the welcome screen. In this screen, you can choose an existing project to work on or create a new one.

Click the image above for a larger view.

Creating a Project

To familiarize ourselves with the XDK IDE, we will create a blank project. Click on **Templates** under the **Internet of Things Embedded Application** tab. You will see a number of different templates appear that will help you get started with your IoT program. Select the **Blank Template**.

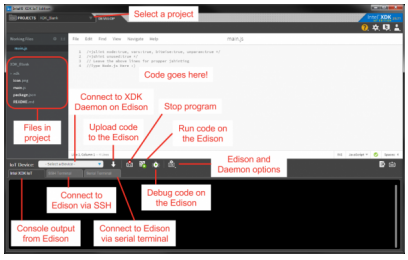
Click **Continue**, and you will be presented with a pop-up window to name your project. You can name it anything you want, as we are just using it to explore the IDE right now. To keep all my XDK projects together, I like to use the prefix "XDK_". I will use "XDK_Blank" for this example.



Click **Create**. The project screen will greet you with a mostly empty JavaScript file.

> **NOTE:** You might be asked to take a quick tour of the XDK when you first create a project. Feel free to do it or skip it.

The Project Screen



We use the XDK to write code. There are several tools available that help us do that: code examples, syntax completion, a debugging interface, and so on. Once we have finished writing code, we click the **Upload** button to send that code to the Edison. The **Run** button then tells the Edison to run the code we just sent to it.

By default, the Yocto image on the Edison contains an "XDK Daemon." A daemon is a computer program that runs in the background (at least according to Wikipedia). The XDK Daemon begins running as soon as the Edison boots and listens for a connection from a host computer (i.e. one running the XDK IoT Edition). It knows how to receive and store new code, and it will accept commands from the host computer to run, stop, and debug that program.

NOTE: You can click the word **PROJECTS** at the top-left of the window to return to the navigation screen.

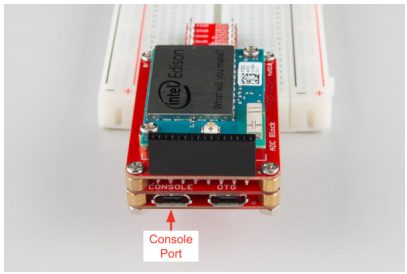
Connecting to WiFi

We will want connect our Edison to a local WiFi network if we want to program it using the XDK or complete some of the experiments that require Internet access.

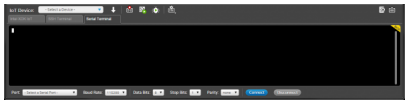
NOTE: Alternatively, you can use a USB Network to program the Edison from the XDK. Refer to Appendix C to see how to use a USB network with your Edison. Note that without a WiFi connection, you will not be able to complete the exercises that require Internet access.

Connecting Over Serial

Unplug the USB cable from the OTG port on the Base Block, and plug it into **Console port**.

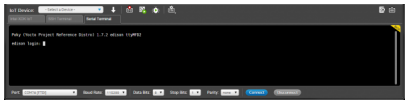


If it is not already open, start the XDK, and create a blank project (like we did in Using the XDK). Click on the **Serial Terminal** tab.



At the very bottom, click the drop-down list for **Port** and select the Edison device. This will change depending on the operating system. For example, it might be */dev/tty.usbserial-A402IXA0* in OS X, */dev/ttyUSB0* in Linux, or *COM78* in Windows. Note that in Windows, you want COMxx[FTDI], not the *Standard Serial Port option*.

Make sure that the Baud Rate is 115200, Data Bits is 8, Stop Bits is 1, and Parity is “none.” Click **Connect**, and you should see the Edison’s terminal login appear.

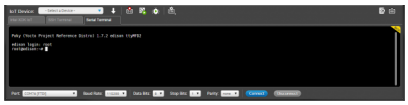


Getting on the Internet

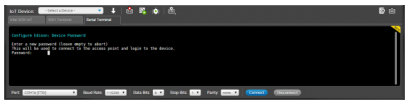
Click in the Serial Terminal window and log in to the Edison:

Username: **root**

Hit ‘enter’ (there is no password). You should be presented with a root command prompt.

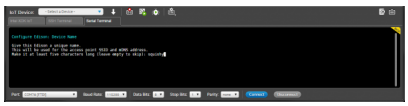


Enter `configure_edison --setup` . You will be walked through a series of steps. The first will ask you to create a password.

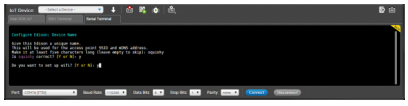


We *definitely* recommend you set a password! It can be anything you want, so long as you can remember it. If you don’t set a password, evil hackers might be able to control your lights from their car. Or read your emails. That would be bad.

Press ‘enter’ and enter your password again. On the next screen, you will be asked to rename the Edison. You can give it a unique name or just press ‘enter’ to keep the default name. I shall call mine squishy.



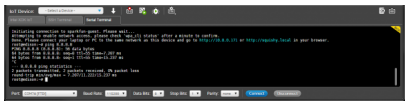
The Edison will ask you to confirm the name. Type ‘y’ and press ‘enter’. You will then be asked to set up WiFi. Enter ‘y’ again.



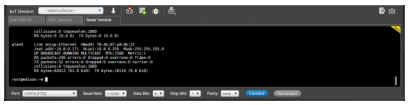
Wait while the Edison scans for networks. You will then be presented with a list of available networks.

Type the number of the network you would like to join and press 'enter'. Enter 'y' to accept the network, and enter the password for that network.

The Edison should automatically connect to the network. Enter `ping 8.8.8.8` to try pinging one of Google's Public DNS servers.



You should see a few responses in the form of "bytes received from 8.8.8.8." Press 'ctrl+c' to stop the pinging. You can get the IP address of the Edison by entering `ifconfig` .



Under the *wlan0* entry, make a note of the *inet addr*. In my case, it is 10.8.0.171. You can use this to connect to your Edison manually from the *IoT Device* drop-down menu if, for example, the Bonjour service is not running (if you ran the Installer and accepted all the defaults, Bonjour should have been installed).

> **NOTE:** If you restart your Edison, it should auto-connect to the last network you set. However, you might not get the same IP address. We recommend connecting over serial and typing `ifconfig` to see that address if you need it. You can also give your Edison a static IP address, if you so desire. See here to lear more about networking in Linux.

Experiment 1: Hello, World!

Introduction

We realize that starting with "Hello, World!" is a cliché in the programming world, but it really is the perfect starting place with the XDK and Edison. We spent quite some time installing the XDK, flashing new firmware, and configuring the Edison. We can test all these things with one line of code!

Parts Needed

You will need the Edison and Block stack that we constructed in Building the Block Stack section.

Suggested Reading

- JavaScript Syntax – Whether you are new to JavaScript or a seasoned developer, you might want to look at how JavaScript statements are structured. For example, JavaScript uses semicolons.
- Oject-Oriented Programming (OOP) – JavaScript relies on *objects* to get work done. Reading about the history of OOP might be enlightening and entertaining.

Concepts

A Very Light Introduction to Objects

In JavaScript *almost* everything is an object. What is an object? In the real world, an object is just another word for a thing. A dog, for example, is a type of object.

A dog has *properties*, such as a breed, a fur color, a name, and so on. Dogs can also *do* things, like bark, sleep, play, etc.

OK, so how does this translate to the programming world? In most object-oriented languages, an *object* is a collection of data (bytes stored somewhere on the computer) that has been grouped together and wrapped up in a way that makes for easy access. If we wanted to make a JavaScript version of our dog, we might write something like:

```
var dog = {
    name: "Roland",
    color: "fawn",
    bark: function() {
        console.log("woof");
    }
};
```

In this example, we created a *variable* (as noted by the keyword `var`) called *dog*. A *variable* is a way to store things. In this case, we are storing our object (a collection of *properties*) in a storage container called *dog*.

All of the properties for this object are defined between the outside set of curly braces {}. We create a *property* called `name` and assign it the value `"Roland"` . If we wanted to get the name of our `dog` object, we could access that property with:

```
dog.name;
```

Calling `dog.name` results in “Roland”.

In addition to our *name* and *color* properties, we also defined a *function* as a property. If we called

```
dog.bark();
```

the dog would *do* something. *Functions* are actions! They cause the object to do something. The parentheses () after `dog.bark` let us know that it is a function. They can also be used to pass parameters to the function, which we will see in a minute. Because `bark()` is a *function* inside an *object*, it is known as a *method* (functions not part of objects are just called *functions*).

If we dig into the `bark()` method, we see that it contains `console.log("woof");`. `console` is a special object that is known by most implementations of JavaScript (i.e. it is an object that always exists when we run the program). `.log()` is a method of the `console` object. By calling `console.log()` we can print something to the screen (assuming we have access to some kind of text output console).

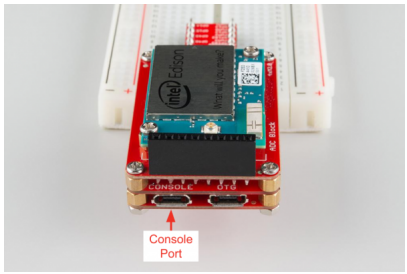
`"woof"` is a *parameter*, which is a value that is passed to a function. In this case, “woof” is a string (as noted by the double quotes), which is a collection of *characters*. The function then, ideally, uses that value in its own code. In this case, `console.log("woof")` prints the word `woof` to the screen.

Ultimately, calling `dog.bark();` prints `woof` to the screen.

This might be a lot to take in, but never fear! We will revisit these concepts over the course of these experiments. For now, know that *objects* are containers for *properties* and *methods*. We will be using the special `console` object to output text to the screen.

Hardware Hookup

We won’t need any new hardware. Just connect the USB cable from your computer to the **Console Port** on the stack you made in Building the Block Stack.

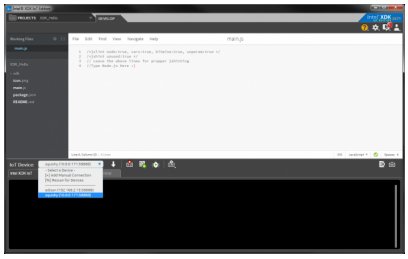


The Code

Open the XDK, and create a new project. Use the **Blank Template**, and give it an appropriate name (we’ll call this one “XDK_Hello”). If you need a refresher on creating projects, see Using the XDK.

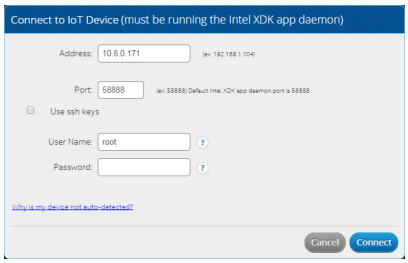
> **NOTE:** The Edison is remotely programmable, but your host computer must be on the same network (subnet) as the Edison if you want to use the XDK (i.e. both your computer and Edison are connected to the same WiFi network). Alternatively, you can use a USB cable to create a USB network between your computer and the Edison.

The first thing we want to do is connect to our Edison. To do that, click the drop-down list by **IoT Device**, and select your Edison device.

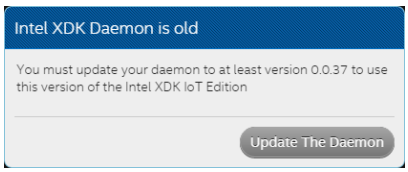


> **NOTE:** If the Edison device does not appear automatically (e.g. you don't have Bonjour installed), then you can select **Add Manual Connection** and fill in the IP address of the Edison you got from Connecting to WiFi.

You should be presented with a connection screen. Type in the password you set for the Edison in the **Password** field.



Click **Connect**. If you get presented with a message claiming that the “Intel XDK Daemon is old” or that you need to sync clocks with the Edison, choose to **Update the Dameon** or **Sync** as appropriate and follow the prompts.

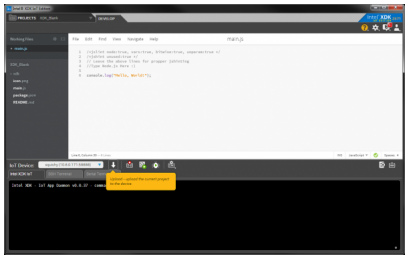


Once you have updated, synced, and connected, you should see a message in the console of the **Intel XDK IoT** tab.

In *main.js*, add the following line:

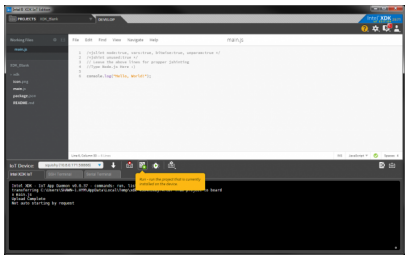
```
console.log("Hello, World!");
```

Find and click the **Upload** button.



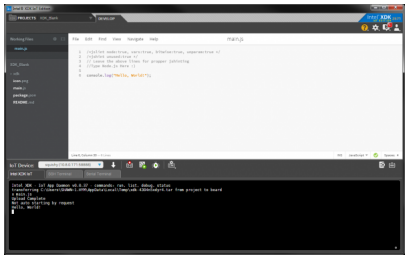
If you are presented with a message exclaiming that you have “Modified Project Files,” click **Save and Proceed**.

In the console, you should see the message “Upload Complete.” Press the **Run** button.



What You Should See

The phrase “Hello, World!” should appear in the console.



If you see this, feel free to celebrate. We’ll wait a moment while you do that.

Why is this simple phrase monumental? Well, it means all our preparing and configuring worked! We wrote a simple program, sent it to the Edison, and had the Edison run it. Cool.

Code to Note

The Console Object

`console` is a special object that has been pre-defined elsewhere in our JavaScript environment. It outputs to standard output, which is a text display device (real or virtual) for most computer systems.

The Edison relies on Node.js to run JavaScript programs. More information about the console object can be found in the official documentation.

Methods

We mentioned methods briefly in our introduction to objects. In this exercise, we used the `.log()` method, which takes input in the form of a string (a parameter) and displays it on a new line in the console. The Node.js documentation contains a section on .log().

Comments

There are different ways to make comments in your code. Comments are a great way to quickly describe what is happening in your code.

```
// This is a comment - anything on a line after "//" is ignored by the computer.
```

```
/* This is also a comment - this one can be multi-line, but it must start and end with these characters */
```

Troubleshooting

- **The Edison won’t connect** – This is possible if the Edison is not powered or configured properly. See the “Edison won’t connect” section in the Appendix A: Troubleshooting.

- **Code will not upload** – Make sure the Edison is on the same network as your computer and you have selected your Edison from the *IoT Device* drop-down menu in the XDK.
- **Nothing prints on the console** – Make sure that the Edison is connected. Additionally, if you see any errors on the console, read them carefully, as they will often tell where to look in your code (for example, you might have forgotten the quotation marks around “Hello, World!”).
- **Nothing works!** – Don’t worry! We have an awesome tech support staff to help you out if there is something wrong. Please contact our tech support team.

Going Further

Now that you see how to connect your Edison to the XDK, upload code, and run a program, we will move on to more advanced topics including connecting other pieces of hardware to the Edison Block stack. After each experiment, we will give you a few challenges to try on your own as well as some suggested reading.

Challenges

1. Remember the description of the dog object in the beginning of this chapter? Copy the definition of the dog object (the snippet of JavaScript code) into the XDK. Write some code that has the dog bark (e.g. you will see *woof* appear in the console). *Hint*: you will need to use `console.log()`.
2. Using the same dog object example, print out the dog’s name and color to the console.

Digging Deeper

- Node.js official documentation
- Intel’s official getting started with XDK IoT Edition guide
- More on objects in JavaScript

Experiment 2: Pushing Some Buttons

Introduction

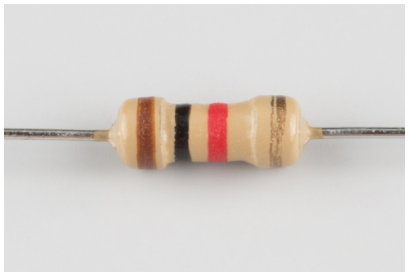
In the previous exercise, we tested the connection to the Edison and showed that we could upload code. Now, we can move on to more interesting circuits and examples. In this section, we introduce the humble push button. We connect it to one of the Edison’s general-purpose input/output (GPIO) pins and write some code that does something whenever the button is pushed.

This experiment has 2 parts. Both parts use the same hardware, but each has its own code. We recommend you try them both to get an understanding of the different ways to use button pushes.

Parts Needed

In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** Push Button
- **1x** 1kΩ Resistor
- **4x** Jumper Wires

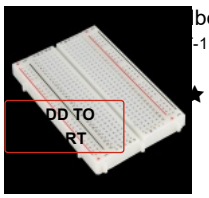


The 1kΩ resistor has the color bands brown, black, red, gold

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

tor Kit - 1/4W (500 total)
M-10969

★★½ 122



board - Self-Adhesive (White)
-12002

★★½ 34

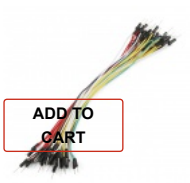
Away Headers - Straight
-00116

★★½ 20

) Edison
'-13024
★★☆ 24

le Headers
-00115
★★☆ 7

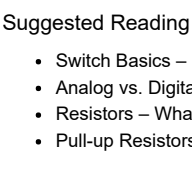
.Fun Block for Intel® Edison - Base
'-13045
★★½ 16



er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026
★★½ 20

e Button Assortment
M-10302
★★☆ 4

.Fun Block for Intel® Edison - GPIO
'-13038
★½☆ 4



Suggested Reading

- Switch Basics – How switches and push buttons work.
- Analog vs. Digital – What does it mean to say something is “digital?”
- Resistors – What they do and how to read those funny color bands.
- Pull-up Resistors – How to use resistors to create a default logic level for circuits.

Concepts

Functions

We mentioned briefly in the last section that *functions* are pieces of code that *do* things. To make this more clear, a *function* is a block of code created to perform a particular task. Functions are useful because they can be written once and called many, many times from other parts of code (we call this code reuse).

In our two code examples below, we will write our own functions and then call them. In JavaScript, functions looks like this:

```
function doSomething( /* parameters */ ) {
    /* Things happen here */
}
```

We know it is a function because we used the `function` keyword. Thanks for making this explicit, JavaScript. We can also have 0 to any number of parameters in our function. *Parameters* are variables that are used to store pieces of information passed to the function. For example:

```
function saySomething(thing) {
    console.log(thing);
}

saySomething("Hi");
```

We first created a function that outputs something to the console. In this case, the function accepts the parameter `thing`, which becomes a variable. We can access the contents of that variable by writing `thing`.

Then, we call our function by writing `saySomething()`. In between the parentheses, we wrote the string `"Hi"`. This string is passed to the `saySomething()` function as a parameter and assigned to the variable `thing`. We then print the contents of `thing` ("Hi" in this example) to the console.

If we wanted to print something else, we could write `saySomething("Something else");`. And that's a simple form of code reuse!

Libraries

OK, not THAT kind of library

Libraries are pieces of code that have been packaged up for easy reuse. Often, they are written by someone else (or a group of people).

Node.js (the runtime environment that runs our code on the Edison) uses *modules*, which are very similar to libraries. Modules are just other pieces of code that we can reuse in our code. In these experiments, we rely heavily on MRAA, which is a library (and subsequent Node.js module) created by Intel and allows us to easily communicate with the hardware pins on the Edison.

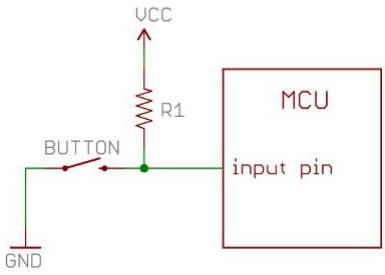
We can import the MRAA module with the line

```
var mraa = require('mraa');
```

With that, all the objects, variables, and functions in the MRAA module are loaded into the variable `mraa`. We can access those objects, variables, and functions by calling `mraa`. For example, `mraa.Gpio()` creates a new GPIO pin that we can access.

The Pull-Up Resistor

We can use a resistor to set a default state of a pin on a microcontroller (or, in this case, the Edison). The pull-up resistor, specifically, sets the state of the pin to a voltage (VCC in the diagram below). For our circuit, we will be using 3.3V as the *high* voltage. *Low* will be ground (GND or 0V).



When the switch (or button) is *open* (as in the diagram), the *input pin* is VCC. Because little or no current flows through R1, the voltage at the pin is the same (or very nearly the same) as VCC. We will say that the pin is in the "high state" or "logic '1'".

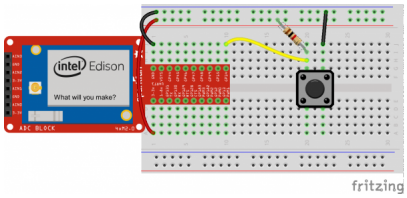
When the switch (or button) is *closed*, the *input pin* is the same voltage as GND (0V). The switch creates a short circuit to GND, which causes some current to flow from VCC, through R1, to GND. However, because of the short circuit, the *input pin* has the same voltage as GND. We will say that the pin is in the "low state" or "logic '0'".

Hardware Hookup

Your kit comes with a bunch of different color push button. All push buttons behave the same, so go ahead and use your favorite color! Follow the Fritzing diagram below.

> **NOTE:** We are using GP14 on the GPIO Block, which connects to GPIO pin 14 on the Edison's 70-pin Hirose connector (see here for the pinout). However, the MRAA library uses a different numbering scheme. GP14 is actually pin 36 according to MRAA. The GPIO pin to MRAA pin mapping can be found in Appendix E: MRAA Pin Table. Find the GPIO number you are using on the left-most column and lookup the MRAA number on the next column. The MRAA number is what you will use in software.

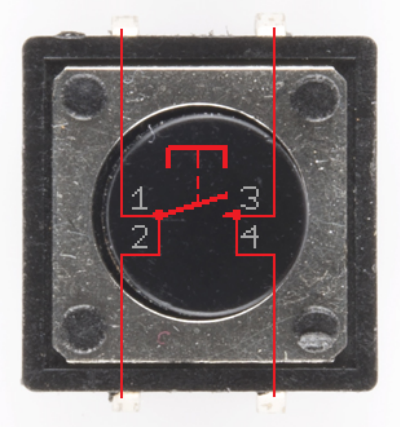
Fritzing Diagram



Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

Tips

The leads across each other on the push buttons are always connected to each other. The leads on the same side are only connected when button is pressed.



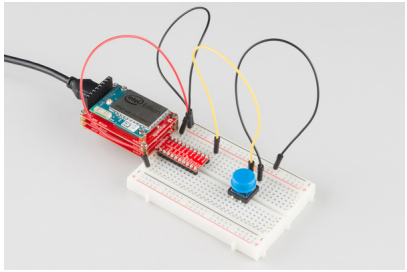
Part 1: Polling

The Code

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 2 - Part 1: Pushing Some Buttons
 * This sketch was written by SparkFun Electronics
 * October 27, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * This is a simple example program that displays the state of a button
 * to the console.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the MRAA module
var mraa = require('mraa');

// Set up a digital input/output on MRAA pin 36 (GP14)
var buttonPin = new mraa.Gpio(36);

// Set that pin as a digital input (read)
buttonPin.dir(mraa.DIR_IN);

// Call the periodicActivity function
periodicActivity();

// This function is called forever (due to the setTimeout() function)
function periodicActivity() {

    // Read the value of the pin and print it to the screen
    var val = buttonPin.read();
    console.log('Button is ' + val);

    // Wait for 250 ms and call this function again
    setTimeout(periodicActivity, 250);
}
```

What You Should See

Try pushing the button.



The console should start outputting “Button is 1”, which means that the pin connected to the button is currently in the *high* state (3.3V, logic ‘1’). When you push the button (hold it down for a second), the console should show “Button is 0”, which means that the pin is in the *low* state (0V, logic ‘0’).

Code to Note

In JavaScript, functions are objects. Say what? I know it is weird to think about, but they are. The good news is that we can pass functions (like objects) as parameters to other functions. For example, we pass `periodicActivity` (a function) to `setTimeout` (another function), which causes `periodicActivity` to be called every 250 ms (in this example).

Additionally, note that we told MRAA that we want to use pin 36. Pin 36 is defined by MRAA and mapped to GP14, which is the pin definition according to the Edison hardware. Knowing which MRAA pin maps with which GP pin can be confusing, so we crated a nice table in Appendix E. The Edison pinout can be found here.

Part 2: Interrupt Service Routine

The Code

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 2 - Part 2: Interrupt Service Routine
 * This sketch was written by SparkFun Electronics
 * October 27, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * This is a simple example program that prints an incrementing number
 * to the console every time a button is pushed.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the MRAA module
var mraa = require('mraa');

// Set up digital input on MRAA pin 36 (GP14)
var buttonPin = new mraa.Gpio(36);
buttonPin.dir(mraa.DIR_IN);

// Global counter
var num = 0;

// Our interrupt service routine
function serviceRoutine() {
    num++;
    console.log("BOOP " + num);
}

// Assign the ISR function to the button push
buttonPin.isr(mraa.EDGE_FALLING, serviceRoutine);

// Do nothing while we wait for the ISR
periodicActivity();
function periodicActivity() {
    setTimeout(periodicActivity, 1000);
}
```

What You Should See

You should not see anything when you first run the program. Press the button, and the word “BOOP” should appear along with a number. Press the button again, and that number should increment by 1.

Code to Note

Interrupt service routines (ISRs) are important in the world of embedded electronics. It is very similar to JavaScript’s notion of event-driven programming. When a user or some other external force performs an action, the program responds. In this case, whenever a button was pushed, the `serviceRoutine()` function gets called.

As in the previous polling example, we use a function as a parameter. We pass the function `serviceRoutine` to the `buttonPin.isr()` function. We use `mraa.EDGE_FALLING` to declare that `serviceRoutine` should be called whenever the pin’s voltage goes from high (3.3V) to low (0V).

Troubleshooting

- **The Edison won’t connect** – This is possible if the Edison is not powered or configured properly. See the “Edison won’t connect” section in the Appendix A: Troubleshooting.
- **Nothing happens when the button is pushed** – Double-check the wiring. Often, a jumper wire is off by 1 hole!

Going Further

Challenges

1. Add a second button so that when the first button is pushed, it prints “BOOP” to the console, and when the second button is pushed, it prints “BEEP” to the console.
2. You might have noticed that pushing the button on the second example causes more than one “BOOP” to appear (if not, try pushing the button many times to see if you can get more than one “BOOP” to appear per button push). This is a phenomenon known as *bouncing*. Modify the Part 2 example to prevent this from happening (known as *debouncing*).

Digging Deeper

- MRAA GitHub repository

- MRAA JavaScript documentation
- Interrupt service routine

Experiment 3: Blinky

Introduction

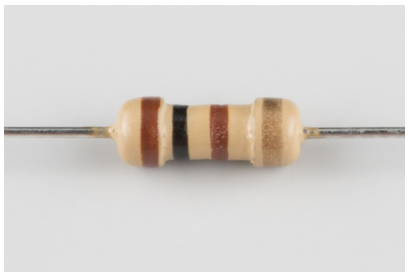
Often, blinking an LED is the first step in testing or learning a new microcontroller: a veritable “Hello, World!” of embedded electronics. However, the GPIO Block requires that we introduce a new component, the transistor, into the mix. As a result, we saved the blinky example for the third experiment.

We will connect an LED to the Edison (using the GPIO Block and a transistor). With some JavaScript, we can control that LED by turning it on and off.

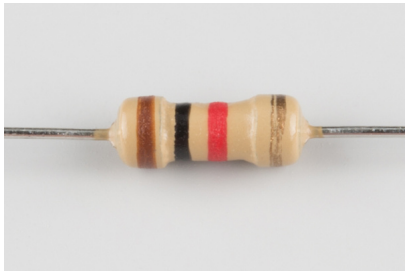
Parts Needed

In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** RGB LED
- **1x** NPN Transistor
- **1x** 1kΩ Resistor
- **1x** 100Ω Resistor
- **5x** Jumper Wires



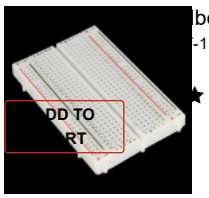
The 100Ω resistor has the color bands brown, black, brown, gold



The 1kΩ resistor has the color bands brown, black, red, gold

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

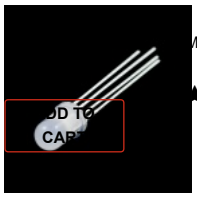
tor Kit - 1/4W (500 total)
M-10969
★★½ 122



board - Self-Adhesive (White)
-12002
★★½ 34

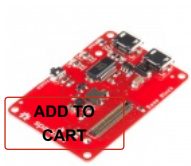
Away Headers - Straight
-00116
★★½ 20

Intel® Edison
DEV-13024
★★★★☆ 24

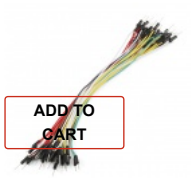


RGB Diffused Common Cathode
M-09264
★★½ 2

le Headers
-00115
★★☆ 7

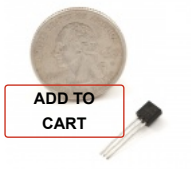


Fun Block for Intel® Edison - Base
-13045
★★½ 16



er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026
★★½ 20

Fun Block for Intel® Edison - GPIO
-13038
★½☆ 4



istor - NPN (2N3904)
M-00521

Suggested Reading

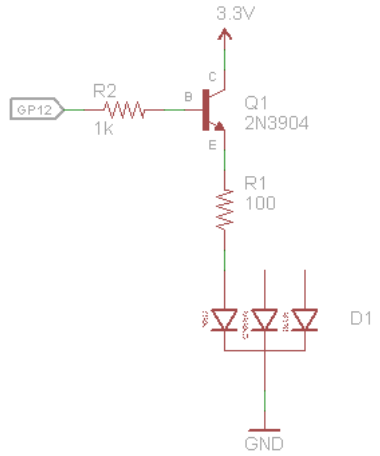
- Transistors – An introduction to transistors

Concepts

The Transistor

The GPIO Block is not capable of sourcing more than a few milliamps, which is not enough to fully light up an LED. To do that, we will use a *transistor*. A transistor is a device that can be used to amplify or switch electrical current. We will be using a bipolar junction transistor (BJT), which allows current to flow through the *collector* and *emitter* pins whenever a (much smaller) current flows into the *base* pin.

In this experiment, we will connect the *base* of the BJT to GP12 on the GPIO Block. When the GP12 pin goes high (3.3V), this causes a little bit of current to flow from GP12 through the *base*, which turns the transistor on. This allows current to flow from the 3.3V supply (also on the GPIO Block), through the *collector*, and out the *emitter*. This current then flows through the 100Ω resistor and LED, turning the LED on.



We can calculate the amount of current flowing through the LED, as we want to make sure it is not over 20mA, as per the RGB LED datasheet. To do that, we need to figure out what the voltage drop across the 100Ω resistor. Starting with 3.3V, we can determine that the voltage across the *collector* and *emitter* (Vce) is 0.2V (Vce(sat) in the datasheet) when the transistor is fully on. Again from the LED's datasheet, we see that that typical drop across the red LED is 2V. As a result, the voltage drop across the resistor can be calculated:

$$3.3V - 0.2V - 2.0V = 1.1V$$

Knowing that the drop across the resistor is 1.1V, we can use Ohm's Law (V = I x R) to calculate the current flowing through the resistor:

$$1.1V = I \cdot 100\Omega$$
$$I = 0.011A = 11mA$$

How to Use Logic Like a Vulcan

One of the things that makes the Edison so useful is that it can make complex decisions based on the input it's getting. For example, you could make a thermostat that turns on a heater if it gets too cold, or a fan if it gets too hot, and it could even water your plants if they get too dry. In order to make such decisions, JavaScript provides a set of logic operations that let you build complex "if" statements. They include:

==	**EQUIVALENCE**	**A == B** is true if A and B are the **SAME**.
!=	**DIFFERENCE**	**A != B** is true if A and B are **NOT THE SAME**.
&&	**AND**	**A && B** is true if **BOTH** A and B are **TRUE**.
||	**OR**	**A || B** is true if **A** or **B** or **BOTH** are **TRUE**.
!	**NOT**	**!A** is **TRUE** if A is **FALSE**. **!A** is **FALSE** if A is **TRUE**.

You can combine these functions to build complex `if()` statements. For example:

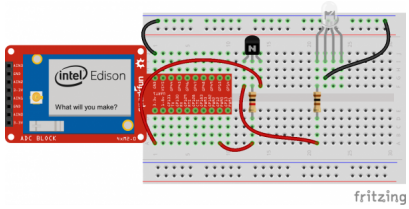
```
if ((mode == heat) && ((temperature < threshold) || (override == true))) {
    turnOnHeater();
}
```

…will turn on a heater if you're in heating mode **AND** the temperature is low, **OR** if you turn on a manual override. Using these logic operators, you can program your Edison to make intelligent decisions and take control of the world around it!

In addition to the comparator '==' and '!=', JavaScript also has the strict comparators '===' and '!==' where the two values being compared need to be the same type (e.g. both a string). See this page to learn more about JavaScript comparators.

Hardware Hookup

Fritzing Diagram



Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

Tips

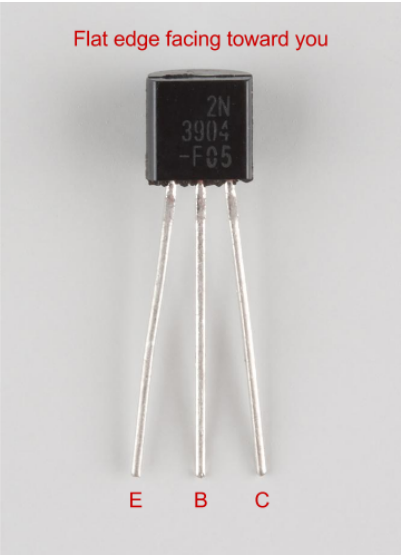
RGB LED

You can use a set of needle nose pliers to bend the LED's leads and a pair of cutters to fit the LED in the breadboard. Note that there is a flat side on the plastic ring around the bottom of the LED. This denotes the side with the pin that controls the red color. See this tutorial to learn more about polarity.

NPN Transistor

WARNING: The 2N3904 transistor and TMP36 temperature sensor look very similar! Examine the flat face of the TO-92 packages very carefully and find one that says **2N 3904**.

Note that the flat face with the 'N' of the transistor in the Fritzing diagram matches up with the flat face (with the writing) of the physical part. With the flat edge facing you, the pins are as follows:

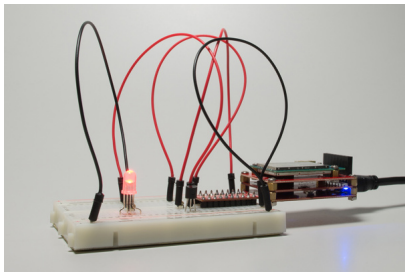


The Code

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 3: Blinky
 * This sketch was written by SparkFun Electronics
 * October 29, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Blink an LED connected to GP12 (need a transistor if using the Base Block).
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the MRAA module
var mraa = require('mraa');

// Set up a digital output on MRAA pin 20 (GP12)
var ledPin = new mraa.Gpio(20);
ledPin.dir(mraa.DIR_OUT);

// Global variable to remember the LED state
var led = 0;

// Call this function over and over again
periodicActivity();
function periodicActivity() //
{
    // Switch state of LED
    if (led === 0) {
        led = 1;
    } else {
        led = 0;
    }

    // Turn the LED on
    ledPin.write(led);

    // Wait for 500 ms and call this function again
    setTimeout(periodicActivity, 500);
}
```

What You Should See

Upload and run the program. The LED should start flashing red.



Code to Note

After we declare the `ledPin` as an output with `mraa.DIR_OUT`, we create the variable `led` that stores the state of the led ('1' for on and '0' for off). Because this variable (and similarly `mraa` and `ledPin`) is declared outside of any object or function, they are considered `global variables`, which means they can be accessed by any function, object, etc. in the **entire program**. In most programming circles, using global variables is considered very bad practice. However, we rely on them in most of our examples because:

1. JavaScript makes creating and accessing global variables very easy. This is not a legitimate excuse, but it does make the examples easier to follow.
2. Most of the examples are simple, 1-file programs where we can keep track of all the global variables. Global variables are still used by embedded programmers, as most embedded programs are relatively small and they allow for different types of CPU, RAM, or storage optimization.

Troubleshooting

- **The Edison won't connect** – This is possible if the Edison is not powered or configured properly. See the "Edison won't connect" section in the Appendix A: Troubleshooting.
- **The LED doesn't flash** – Once again, check the wiring. Make sure you are connecting the base of the transistor to GP12 (through a 1kΩ resistor). Additionally, you can add some `console.log()` statements in the code to see if certain parts are being executed.

Going Further

Challenges

1. Make the LED turn on for 1 second and off for 1 second.
2. Make the LED turn on for 200 ms and off for 1 second.
3. Add a button (like in the previous experiment). Create a program such that the LED turns on only when the button is pushed.

Digging Deeper

- More information about the history, making of, and different types of transistors
- General-purpose input/output (GPIO)
- Accessing GPIO in Linux

Experiment 4: Email Notifier

Introduction

While flashing an LED is not the most interesting activity, we could use the LED as a way to notify us if something is happening. For example, we could turn on an LED if we have a new email. That way, we would know that we needed to check our inbox!

To do this, we will have the Edison log in to an email account, read the number of unread emails, and turn on an LED if it is over 0.

NOTE: This example shows how to connect to **Gmail** and **Yahoo** mail servers. If you are not using one of those, you still might be able to connect (see here for a list of IMAP servers), but only Gmail and Yahoo have been tested. Also, you will need to enter your username and password as plain text into the code. It's a fun project, but you don't have to do it if you are not comfortable with that!

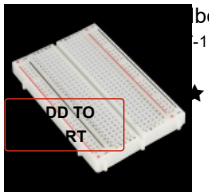
Parts Needed

We'll be using the same circuit as in the previous example, so you don't need to build anything new! In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** RGB LED
- **1x** NPN Transistor
- **1x** 1kΩ Resistor
- **1x** 100Ω Resistor
- **5x** Jumper Wires

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

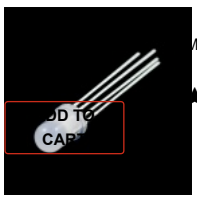
tor Kit - 1/4W (500 total)
M-10969
★★½ 122



board - Self-Adhesive (White)
-12002
★★½ 34

Away Headers - Straight
-00116
★★½ 20

Edison
-13024
★★☆ 24

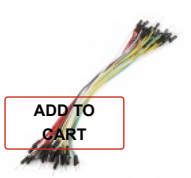


RGB Diffused Common Cathode
M-09264
★★½ 2

Female Headers
PRT-00115
$1.50
★★★★☆ 7

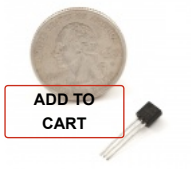
Fun Block for Intel® Edison - Base
-13045
16

er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026
20



Fun Block for Intel® Edison - GPIO
-13038
4

istor - NPN (2N3904)
-00521



Suggested Reading

- How Email Works – What actually happens when you send an email
- Callbacks – What is a callback function?

Concepts

External Modules

In the previous few examples, we have been relying on the MRAA module to control various hardware from the Edison. MRAA comes pre-installed on the Edison, so we did not have to perform any extra steps to install it. However, in this example, we will use node-imap, which contains several useful functions for connecting to Internet Message Access Protocol (IMAP) servers and retrieving email.

If we were to log in to the Edison via SSH or serial terminal, we could install Node.js packages (e.g. modules) using the `npm` command (e.g. `npm install imap`). However, with the XDK, we can tell the IDE to install necessary modules automatically whenever we upload code. This is accomplished by adding the library name to a list of dependencies in the project. The specifics on how to do this can be found in “The Code” section.

Callbacks

I wonder if caller ID was a feature

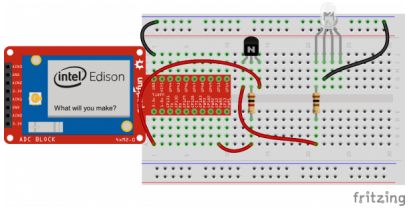
A *callback* is a piece of code (often a function) that is expected to be called by another piece of code at a convenient time. A popular way to use callbacks in web programming is to assign a function to a mouse click event. For example:

```
element.on('click', myFunction);

myFunction() {
    console.log("Hi!");
}
```

Whenever a user clicks on the web page element (called `element` in this example), `myFunction()` gets called. In this instance, `myFunction()` is the callback, and our assignment, `element.on('click', myFunction);` , is known as creating an *event handler*. See here to learn more about the .on() event handler.

Hardware Hookup

The circuit is the same as in the previous experiment.



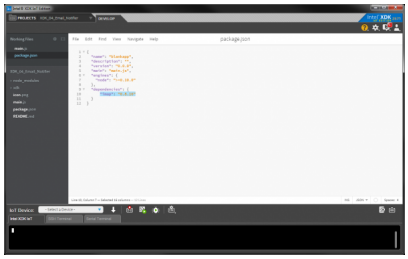
Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

The Code

Create a new project in the XDK. Click on **package.json** in the files browser on the left pane. Add the line

```
"imap": "0.8.16"
```

under `"dependencies"` . This will tell the XDK to download and install the node-imap v0.8.16 module before running the program.



NOTE: If you are using Gmail, you will need to go to the account security settings page and turn **access for less secure apps** to **ON**. We recommend turning it off once you are done with this exercise (unless you want to keep a permanent email notifier!).

Copy the following code into **main.js**. If you are not using Gmail, you can comment out (or delete) the part labeled “Set email credentials (Gmail)”. If you are using Yahoo, you will want to uncomment the part labeled “Set email credentials (Yahoo)”.

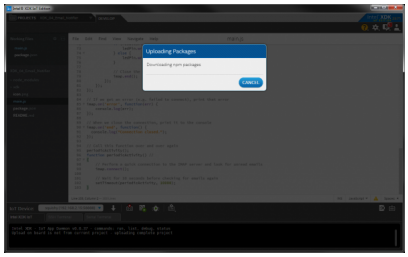
Finally, change the `<username>` and `<password>` parts to your actual email username and password.

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 4: Email Notifier
 * This sketch was written by SparkFun Electronics
 * October 29, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Connect to an email service and turn on an LED if there are any unread
 * emails.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the MRAA and IMAP modules
var mraa = require('mraa');
var Imap = require('imap');

// Set up a digital output on MRAA pin 20 (GP12)
var ledPin = new mraa.Gpio(20);
ledPin.dir(mraa.DIR_OUT);

// It's usually a good idea to set the LED to an initial state
ledPin.write(0);

// Global LED variable to know if the LED should be on or off
var led = 0;

// Set email credentials (Gmail)
// Turn on "Acess for less secure apps" in Google account settings
// https://www.google.com/settings/security/lesssecureapps
var imap = new Imap({
  user: "<username>@gmail.com",
  password: "<password>",
  host: "imap.gmail.com",
  port: 993,
  tls: true
});

// Set email credentials (Yahoo)
/*var imap = new Imap({
  user: "<username>@yahoo.com",
  password: "<password>",
  host: "imap.mail.yahoo.com",
  port: 993,
  tls: true
});*/

// Open the mail box with the name "INBOX"
function openInbox(cb) {
  imap.openBox("INBOX", true, cb);
}

// This is called when a connection is successfully made to the IMAP server.
// In this case, we open the Inbox and look for all unread ("unseen")
// emails. If there are any unread emails, turn on a LED.
imap.on('ready', function() {
    openInbox(function(err, box) {
        if (err) throw err;

        // Search for unread emails in the Inbox
        imap.search(["UNSEEN"], function(err, results) {
            if (err) throw err;

            // Print the number of unread emails
            console.log("Unread emails: " + results.length);

            // If there are unread emails, turn on an LED
            if (results.length > 0) {
                ledPin.write(1);
            } else {
                ledPin.write(0);
            }

            // Close the connection
            imap.end();
        });
    });
});

// If we get an error (e.g. failed to connect), print that error
imap.on('error', function(err) {
    console.log(err);
```

```
});

// When we close the connection, print it to the console
imap.on('end', function() {
  console.log("Connection closed.");
});

// Call this function over and over again
periodicActivity();
function periodicActivity() //
{
    // Perform a quick connection to the IMAP server and look for unread emails
    imap.connect();

    // Wait for 10 seconds before checking for emails again
    setTimeout(periodicActivity, 10000);
}
```

What You Should See

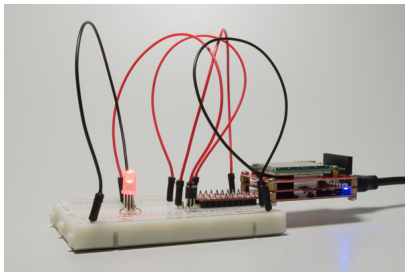
When uploading the code, you might see some notifications that the XDK is downloading and installing npm packages. Just be patient while the packages are installed.



When you run the code, it should connect to your email account and print to the console the number of unread emails every 10 seconds.

I really should get in the habit of checking my emails more often

If you have one or more unread emails, the red LED should come on.



Code to Note

Callbacks

I know that we talked about callbacks in the Concepts section, but now we get to see them in action. The *node-imap* package heavily relies on them, so it is important to get used to them if you plan to use that package in the future.

`imap.on` is used several times. This function gets called when something particular happens in our program. These are known as "Connection Events" according to the Application Program Interface (API) documentation. We can define particular connection events using strings.

For example, `imap.on('ready', function() {...});` allows us to define a function (as noted by the `function()` keyword) that is called whenever a successful connection is made with the IMAP server.

`imap.on('error', function() {...});` is called if there is a problem making a connection.

`imap.on('end', function() {...});` is called whenever the connection with the server is closed.

There is another seemingly odd callback. In our `imap.on('ready',...)` code, we call `openInbox(function(err, box) {...});` . A few lines above, we define the `openInbox()` function, which tells the `imap` object to open our inbox and then call another function (as denoted by `cb` for "callback"). This callback function (cb) is the function we defined inside `openInbox(function(err, box) {...});` . So yes, we call a function that accepts another function as a parameter, which then calls that function as a callback. Don't worry if this was confusing; it is a bit hard to follow. Knowing how to use the `.on()` callback functions is the most important part of this exercise.

Error Handling

Being able to appropriately deal with errors is a very useful ability in a program. The example relies on `if (err) throw err;` to determine if an error has occurred (e.g. could not connect to the IMAP server).

If we dig into the node-imap code, we would likely find a few `catch` statements. `if (err)` only executes the second part (`throw err`) if an err actually exists (not null or undefined). `throw` stops execution within that loop, function, etc., and program control is passed to the first `catch` statement it finds within the calling stack (e.g. look for a function that called the callback withing a try/catch statement).

If an error occurs, the *node-imap* module calls our callback function `imap.on('error', function() {...});` , which lets us handle the error. In this case, all we do is print the error to the console.

Troubleshooting

- **It won't connect to the IMAP server** – This could be caused by several reasons:
  - Make sure your Edison has Internet access
  - Ensure you are using the correct IMAP server settings (Gmail and Yahoo examples are given in the code)
  - Check that your email and password are correct in the code
- **The LED won't come on** – As always, double-check the wiring. Make sure you are seeing `Unread emails:` is appearing in the console, and that number is at least 1. Be patient, as it can take a few seconds for the program to make a connection to the IMAP server.

Going Further

Challenges

1. Have the LED flash rapidly when there are unread emails.
2. Have the LED turn on only when there are unread emails from a particular sender (e.g. a friend or your boss). You will need to carefully read the examples in the node-imap documentation.
3. When you receive a new email, print its contents to the console and flash the LED. *Hint*: Take a look at the `mail(...)` callback in *Connection Events* in the node-imap documentation.

Digging Deeper

- How IMAP works
- Handling errors with try, catch, and throw in JavaScript
- How the throw statement works
- node-imap GitHub repository and documentation

Experiment 5: Web Page

Introduction

We know that we are exhausting this one LED circuit, but it really does prove useful in showing different features of the Edison. Hopefully, it spawns some cool project ideas for you! Just remember, if you can blink an LED, you can connect that output to any number of electrical devices. Relays, for example, are great for controlling more powerful components, like light bulbs, ceiling fans, and toasters. Additionally, going from an output (e.g. an LED) to an input (e.g. a button) is not too difficult.

Now that we have reached out to our email inbox to light an LED, why don't we serve up a web page that allows us to control that LED? This experiment is divided into 2 parts. In the first section, we will create a basic web page that we can navigate to from any computer on the network. In the second section, we add a button to that page to allow control over an LED attached to the Edison.

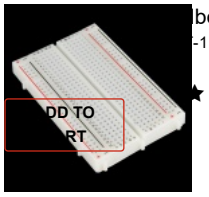
Parts Needed

We'll be using the same circuit as in the previous example, so you don't need to build anything new! In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** RGB LED
- **1x** NPN Transistor
- **1x** 1kΩ Resistor
- **1x** 100Ω Resistor
- **5x** Jumper Wires

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

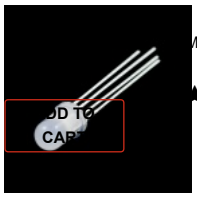
tor Kit - 1/4W (500 total)
M-10969
★★½ 122



board - Self-Adhesive (White)
-12002
★★½ 34

Away Headers - Straight
-00116
★★½ 20

Intel® Edison
DEV-13024
★★★★☆ 24



RGB Diffused Common Cathode
M-09264

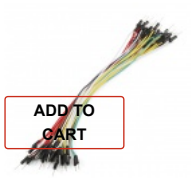
2

le Headers
-00115

7

Fun Block for Intel® Edison - Base
-13045

16

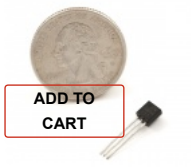


er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026

20

Fun Block for Intel® Edison - GPIO
-13038

4



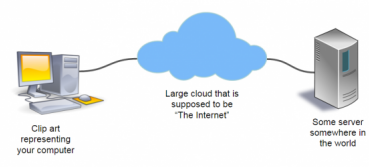
istor - NPN (2N3904)
M-00521

Suggested Reading

- How Web Servers Work – A look at how information is served to your computer when you browse a web site
- Introduction to HTML – HyperText Markup Language (HTML) is a fairly old computer language still in use today to create web pages. We will be using some HTML to make our web page.
- WebSockets – We will use the socket.io module in the second part of this exercise to implement WebSockets. This will allow us to create a connection between the Edison and another computer so we can simple commands (like toggle an LED).

Concepts

Browsing to a Web Page



It's like a series of tubes!

In simplest terms, when you “browse to a web page,” your computer makes a request to a remote server somewhere on the Internet. The actual server (physical computer) you are accessing can be anywhere in the world (assuming it also has Internet access). The server then sends an HTML file back to your computer, which your browser (Chrome, Safari, Firefox, IE, etc.) parses and displays the HTML elements in a human-readable format.

We will be constructing a very simple web page on our Edison using HTML. We will use the Node.js http module to create this page and host it as a web server from within the Edison. As a result, we can browse to the Edison from any computer on the same network, and it will show us a web page!

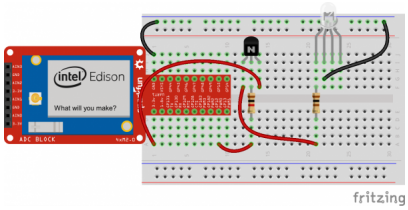
WebSockets

WebSockets is another protocol for sending and receiving messages across the Internet (or other networked computers). As long as Transmission Control Protocol (TCP) can be realized on the network, WebSockets can be used to transmit messages. WebSockets is similar to HyperText Transfer Protocol (HTTP) in that they both rely on TCP and are used for transmitting data across a network. However, WebSockets uses far less overhead and can be used for communication between client and server with lower latency than HTTP. See this article to read more about WebSockets vs. HTTP.

In the second part of this experiment, we rely on the socket.io module to handle WebSockets in JavaScript for us. This allows us to create a connection from our browser (on our host computer) to the web server running on the Edison and send messages back and forth. We will use a simple message that causes an LED connected to the Edison to turn on and off.

Hardware Hookup

The circuit is the same as in the previous experiment.



Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

Part 1: A Simple Web Page

The Code

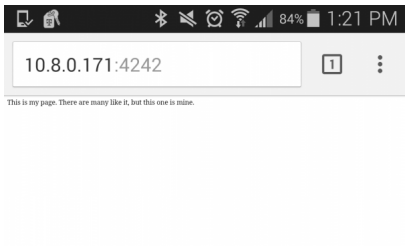
```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 5 - Part 1: Web Page
 * This sketch was written by SparkFun Electronics
 * November 1, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Serves a very simple web page from the Edison.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the HTTP module
var http = require('http');

// Which port we should connect to
var port = 4242;

// Create a web server that serves a simple web page
var server = http.createServer(function(req, res) {
    res.writeHead(200);
    res.write(" <!DOCTYPE html>                                    \
                <html>                                             \
                <head>                                             \
                    <title>My Page</title>                         \
                </head>                                            \
                <body>                                             \
                    <p>This is my page. There are many like it,    \
                    but this one is mine.</p>                      \
                </body>                                            \
                </html>");
    res.end();
});

// Run the server on a particular port
server.listen(port, function() {
    console.log('Server listening on port ' + port);
});
```

What You Should See

Upload and run the code on the Edison. The console should notify you with `Server listening on port 4242`. Open a web browser and navigate to `http://<Edison's IP address>:4242`. You can find the Edison’s IP address from the XDK under the **IoT Device:** drop-down menu. For example, my Edison had the IP address of 10.8.0.171, so I navigated to `http://10.8.0.171:4242` in my browser.

Viewing our web page from the host computer

If you have another computer or a smartphone that is on the same network as the Edison, you can also try navigating to the same page.



Viewing the same web page from a smartphone

Note that we are not using the LED in this part, that's next!

Code to Note

This example is a special case where we write 2 different languages in one file. While most of our code is JavaScript, we write HTML as one long string as an input to the `res.write()` function. `res` is the response of our server, so it sends out the string inside `res.write()` to the client whenever a request is made. Note that we use the character '\' to separate lines in a string in JavaScript. The '\' is ignored, but it prevents the string from ending when we move to a new line.

HTML uses tags, as noted by the **<>** characters, to tell the browser how to structure the page and display text. For example, you could put and around some text to make it bold (try it!). In our example, we use <head> to mark the header of the page, which appears in the tab or title bar, and <body> to mark the main part of the page, which is the text that appears in the browser window. To learn more about tags, see here.

Part 2: Web Page Button

The Code

Add `"socket.io": "1.3.7"` to `"dependencies"` in **package.json**, which should look like:

```
{
  "name": "blankapp",
  "description": "",
  "version": "0.0.0",
  "main": "main.js",
  "engines": {
    "node": ">=0.10.0"
  },
  "dependencies": {
      "socket.io": "1.3.7"
  }
}
```

In **main.js**, copy in the following code:

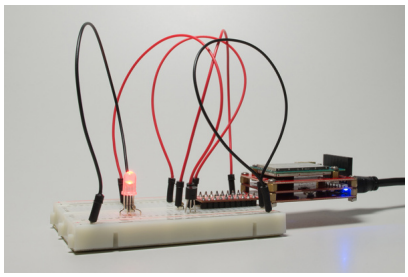
```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 5 - Part 2: Web Page Button
 * This sketch was written by SparkFun Electronics
 * November 1, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Serves a web page that allows users to turn an LED on and off remotely.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the MRAA and HTTP modules
var mraa = require('mraa');
var http = require('http');

// Set up a digital output on MRAA pin 20 (GP12) for the LED
var ledPin = new mraa.Gpio(20);
ledPin.dir(mraa.DIR_OUT);
ledPin.write(0);

// Global LED variable to know if the LED should be on or off
var led = 0;

// Which port we should connect to
var port = 4242;

// Create a web server that serves a simple web page with a button
var server = http.createServer(function(req, res) {
    res.writeHead(200);
    res.write(" <!DOCTYPE html>                                          \
                <html>                                                   \
                <head>                                                   \
                    <title>LED Controller</title>                        \
                    <script src='/socket.io/socket.io.js'></script>      \
                </head>                                                  \
                <body>                                                   \
                    <p><button onclick='toggle()'>TOGGLE</button></p>    \
                    <script>                                             \
                        var socket = io.connect('http://" +
                            req.socket.address().address + ":" +
                            port + "');                                  \
                        function toggle() {                              \
                            socket.emit('toggle');                       \
                        }                                                \
                    </script>                                            \
                </body>                                                  \
                </html>");
    res.end();
});

// Listen for a socket connection
var io = require('socket.io').listen(server);

// Wait for a client to connect
io.on('connection', function(socket) {
    console.log('A client is connected!');

    // Look for the "toggle" message from the client, and toggle the LED
    socket.on('toggle', function() {
        led = led ? 0 : 1;
        ledPin.write(led);
    });
});

// Run the server on a particular port
server.listen(port, function() {
    console.log('Server listening on port ' + port);
});
```

What You Should See

Like in the previous part, run the code and navigate to `http://<Edison's IP address>:4242` with your browser. You should see a button labeled *TOGGLE*. Push it.

We doubt you will be able to resist the allure of a single button

When you click the button, the LED connected to the Edison should come on. Click the button again, and the LED should turn off.



Code to Note

If you thought HTML inside a JavaScript file was bad, take a look at the code for this example. We have JavaScript inside HTML inside a JavaScript file. *Mind = blown*. The JavaScript inside HTML is denoted by the <script> and </script> tags. As before, we are constructing one long string to send to the client's browser. The client's browser should be able to interpret the HTML and display a simple web page. Additionally, most modern browsers are capable of running JavaScript.

The JavaScript embedded in the HTML actually runs on the client's browser (not the Edison). `src='/socket.io/socket.io.js'` requests the socket.io library from the server (assuming the server is running socket.io). `var socket = io.connect('http://" + req.socket.address().address + ":" + port + "');` creates a socket.io connection back to the Edison (we get the Edison's IP address from the client's request in `req` and the port from the global `port` value). We also define `function toggle() { socket.emit('toggle'); }` that sends the very simple message "toggle" back to the Edison over the socket.io connection. This function is called whenever the button is pushed, as per `<button onclick='toggle()'>TOGGLE</button>`.

On the server (Edison), serving the web page is accomplished in the same manner as in the first part of this experiment. The difference is we add a socket.io server that listens for incoming socket.io (WebSocket) connections in addition to listening for requests for a web page. We define `var io = require('socket.io').listen(server);` to listen to connections using the same web page server we created in the beginning of the code. We can then handle incoming socket.io connections with `io.on('connection', function(socket) { ... });`.

Within the `io.on('connection', ... );` code, we define the callback `socket.on('toggle', function() { ... });`, which listens for the message "toggle" on the socket that we created (the variable `socket` was passed as a parameter from `function(socket) { ... }`). In this case, we simply toggle the LED (the ternary operator `?` is a shortcut for a simple `if` statement; read more about it here).

Troubleshooting

- **My browser can't find the web page** – Double-check the HTML in your code to make sure it matches the example. Then, make sure your client computer is on the same network (e.g. if the Edison has the IP address 10.8.0.x, then your computer should also have an IP address on the same 10.8.0.x subnet).
- **I don't see a TOGGLE button** – If you just completed the first part and are moving to the second part, make sure you refresh the page in your browser to get the new HTML from the Edison.
- **Nothing happens when I push the TOGGLE button** – Make sure that you are actually connecting to the Edison server (you should see `A client is connected!` appear in the XDK console). If not, double check the HTML and IP addresses of the Edison and your computer.

Going Further

Challenges

1. Change the web page in part 1 so that it contains the name of your favorite famous scientist and a link to their Wikipedia page (hint).
2. Have the web page button in part 2 change to say "ON" and "OFF" as appropriate to reflect the state of the LED. When you click on the button, it should update to show the LED's state.
3. We've shown you how to make a web page interact with the physical world. Now, it's your turn to make the physical world interact with a web page. Add a button circuit (see Experiment 2) and have it so that when you push the physical button, a piece of text changes on the website (for example, you could have a counter showing how many times the button was pushed).

Digging Deeper

- Node.js http module documentation
- Socket.io documentation
- HTML tags reference

Experiment 6: RGB LED Phone App

Introduction

In the previous experiment, we used WebSockets to create a connection from a client (browser) to the server (Edison). With them, we can send data back and forth to control a simple LED.

In this experiment, we introduce the concept of Web Apps, which are applications designed to run in a browser. Specifically, we will create an HTML application intended for a smartphone. Because the application is written in HTML, it should be capable of running on most phone operating systems, including iOS, Android, and Windows Phone/Mobile.

NOTE: The examples in this part require a smartphone or tablet capable of running HTML5. Feel free to skip this exercise if you do not have access to a phone or do not wish to run applications on one.

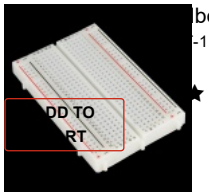
Parts Needed

In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** RGB LED
- **3x** NPN Transistor
- **3x** 1kΩ Resistor
- **3x** 100Ω Resistor
- **12x** Jumper Wires

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

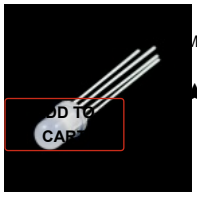
tor Kit - 1/4W (500 total)
M-10969
★★½ 122



board - Self-Adhesive (White)
-12002
★★½ 34

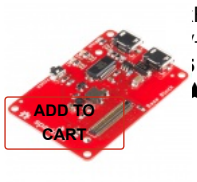
Away Headers - Straight
-00116
★★½ 20

Edison
-13024
★★☆ 24



RGB Diffused Common Cathode
M-09264
★★½ 2

le Headers
-00115
★★☆ 7



Fun Block for Intel® Edison - Base
-13045
★★½ 16

Jumper Wires Standard 7" M/M - 30 AWG (30 Pack)

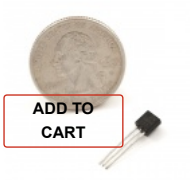
-11026

20

Fun Block for Intel® Edison - GPIO

-13038

4



istor - NPN (2N3904)

-00521

Suggested Reading

- Web App Using Intel® XDK – Creating a simple Web App using the XDK
- Pulse-width Modulation – How PWM works, and how to use to control the brightness of an LED
- JavaScript basics – Introduction to JavaScript in the context of web applications

Concepts

Web App

A web application (or web app for short) is a program that runs on a client's browser (although, some of the computing may be shared by the server). With the rise of HTML5 and JavaScript, most browsers are capable of running simple (or even complex) programs with these now ubiquitous languages.

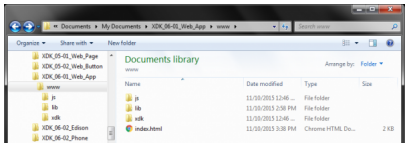
Many smartphones have built-in or third-party browsers capable of running HTML5 and JavaScript. As a result, we can write software in the XDK that runs inside a phone's browser. This allow us to make programs that run across a variety of operating systems and can make network connections (e.g. to the Internet or the Edison). The down side is that some of the phone's native capabilities (e.g. accelerometer, GPS, camera) are not available to web apps. If we want native functionality, we either need to create a native app, designed specifically for a particular phone or operating system, or we need to make a hybrid app, which combined native functionality and web app portability.

We will cover hybrid apps (with Cordova) in a future exercise.

Web App Libraries

In previous examples, we included libraries by adding the appropriate name and version (usually found from npmjs.com) into the *package.json* file. This told the XDK to download the Node library, build it (if needed), and transfer it to the Edison along with the other necessary program files.

When building a web app, it is often necessary to include other pieces of code as a library, much like we did with Node modules. However, the XDK does not have a good way of automatically knowing which libraries to find when it comes to web apps. As a result, we will need to manually download the library (often packaged as a .js file) and include it with the project files.



The suggested file structure of a web app looks slightly different from the file structure of the Node.js IoT application. In fact, it looks very much like the suggested file structure for web pages. We will keep HTML (user interface) in *index.html*, JavaScript in *js/app.js*, and libraries (usually, third-party .js files) in the *js* directory.

LED Current

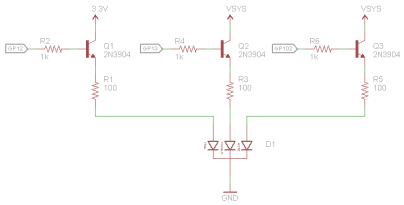
The brightness of an LED is controlled by the amount of current flowing through it. LEDs, generally, have a fixed voltage drop across their anode and cathode. In order to fix the amount of current, we usually need to choose the right resistor for the LED.

In our previous circuit, we used just the red channel of the RGB LED, which we will assume is 1 LED. We found that the red LED has a voltage drop of about 2.0V, and by using a 100Ω resistor and a 3.3V rail, we could get 11mA to pass through the resistor (well below its maximum current rating of 20mA.

Now, we want to add 2 more LEDs into the mix. The green and blue LEDs (all packaged within the same RGB LED housing) have a voltage drop of about 3.2V (according to the RGB LED datasheet). If we connect a 100Ω resistor to each of the green and blue LEDs and connect that to the 3.3V rail through a transistor (like we did for red), we would end up with almost no current flowing through them. They probably wouldn't turn on!

$$3.3V - 0.2V - 3.2V = -0.1V$$

That can't happen! So, we need to increase the rail voltage that we are using for the green and blue LEDs (and not for the red channel). We will connect the *collector* of the transistors for green and blue to the V_{SYS} rail, which is nominally 4.2V.



Now, we should have some current flowing through our green and blue LEDs. We can calculate that voltage drop across the 100Ω resistor:

$$4.2V - 0.2V - 3.2V = 0.8V$$

With that, we can calculate the current flowing through the resistor (and, as a result, the LED):

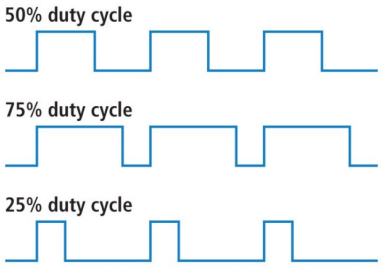
$$0.8V = I \cdot 100\Omega$$
$$I = 0.008A = 8mA$$

8mA is not exaclty the same as the current flowing through the red LED (11mA), so the brightnesses will be different. For our purposes, it will be good enough to demonstrate how to mix red, green, and blue into different colors.

Pulse Width Modulation

In addition to controlling the current, we can also rapidly turn the LED off and on to give the appearance of a dimmer LED. This is known as "Pulse-Width Modulation" (PWM). Note that we are flipping the LED off and on so fast that generally our eyes cannot see the flickering.

We adjust the "duty cycle" of this flipping process in order to control the brightness. Duty cycle just refers to how long our LED stays on in relation to how long it stays off.



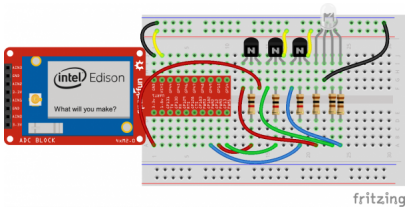
The higher the duty cycle (e.g. 75% in the image above), the brighter the LED will appear to be. At lower duty cycles (e.g. 25%) the LED will hardly appear to be on. For a full tutorial on PWM, see Pulse-width Modulation.

In our program, we will rely on the Edison's built-in PWM functionality (using MRAA's PWM class) to control the duty cycle of the individual red, green, and blue channels of the LED.

Hardware Hookup

Fritzing Diagram

We build upon the previous, single LED example and add another set of transistors and resistors.

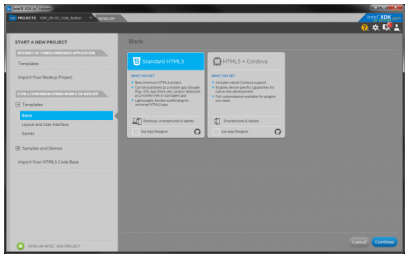


Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

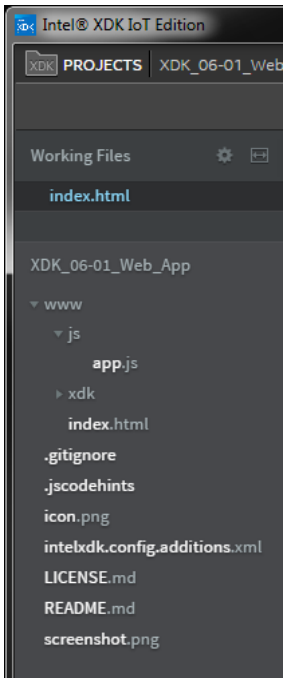
Part 1: Simple Web App

Create a Web App

In the XDK, create a new project, and under **HTML5 Companion Hybrid or Web App** select **Templates** and **Blank**. Select **Standard HTML5**, and click **Continue**.



Give your new app a name (e.g. “XDK_MyApp”), and click **Create**. You will notice that the files and folders in the web app template are different from the ones in IoT project templates.



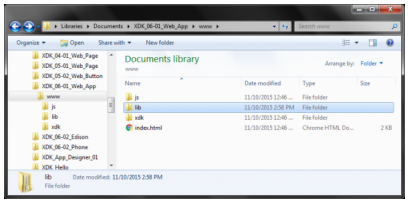
Our code will live in www/index.html and www/js/app.js

Libraries

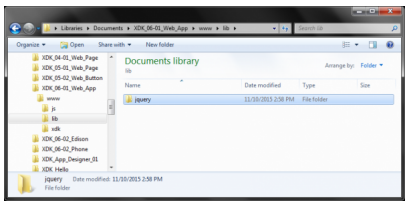
Similar to loading Node.js modules for code that runs on the Edison, we will rely on JavaScript libraries in our web app. In the first part, we will include jQuery, which makes it easier to select HTML elements (from the index.html page) in our JavaScript (app.js) code and handle events like text entry or button clicks.

Navigate to http://jquery.com/download/ and download the latest, uncompressed version (e.g. “Download the uncompressed, development jQuery 2.1.4”). That will download a .js JavaScript file, which we need to copy into our project.

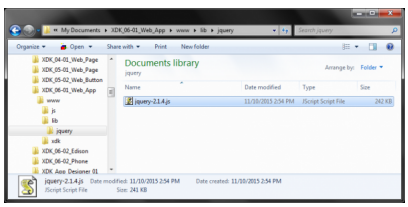
Navigate to your Downloads directory, and copy the newly downloaded .js file. Then, navigate to your project directory. In the *www* directory (e.g. *<Your XDK Web App Directory>/www*), create a directory named **lib**.



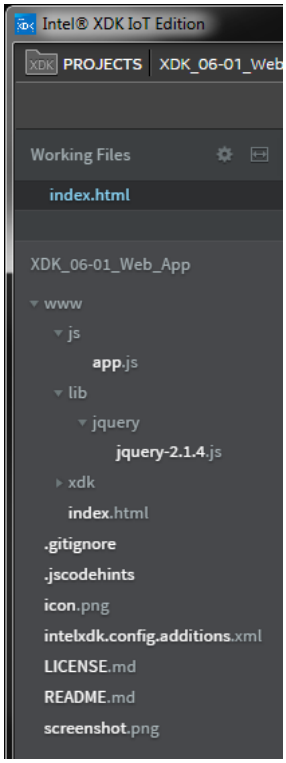
In that directory, create another directory named **jquery**.



Finally, paste the jQuery JavaScript (.js) file in the jquery directory.



The XDK should now show the jQuery file in the file browser pane (if not, switch to another project and then back to the web app project to reload the file browser).



HTML

Open the *index.html* file (found in the *www* directory in the project), and copy in the code below. Don't forget to save the file (File → Save) when you are done!

```
<!DOCTYPE html>

<!--
SparkFun Inventor's Kit for Edison
Experiment 6 - Part 1: Simple Web App
This sketch was written by SparkFun Electronics
November 10, 2015
https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments

Create a some dynamic text that appears when a button is pushed.

Released under the MIT License(http://opensource.org/licenses/MIT)
-->

<html>

<head>
  <title>Simple Web App</title>
    <meta http-equiv="Content-type" content="text/html; charset=utf-8">
    <meta name="viewport" content="width=device-width, minimum-scale=1, initial-scale=1, user-scalable=no">
    <style>
        @-ms-viewport { width: 100vw ; min-zoom: 100% ; zoom: 100% ; }  @viewport { width: 100vw ; min-zoom: 100% zoom: 100% ; }
        @-ms-viewport { user-zoom: fixed ; min-zoom: 100% ; }           @viewport { user-zoom: fixed ; min-zoom: 100% ; }
    </style>
</head>

<body>

    <!-- Static text -->
    <div>
        <h2>The Button</h2>
        <p><button id="toggle_button">Push Me!</button></p>
    </div>

    <!-- Text that appears on button push -->
    <div id="toggle_text" style="display: none;">
        <p>Boo!</p>
    </div>

    <!-- Load the various JavaScript files -->
    <script type="text/javascript" src="lib/jquery/jquery-2.1.4.js"></script>
    <script type="text/javascript" src="js/app.js"></script>
</body>

</html>
```

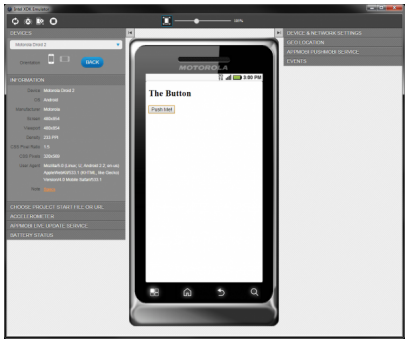
JavaScript

Open the *app.js* file (found in the *www/js* directory), and copy in the following code. Don't forget to save the file (File → Save) when you are done!

```
/*jslint unparam: true */
/*jshint strict: true, -W097, unused:false,  undef:true, devel:true */
/*global window, document, d3, $, io, navigator, setTimeout */

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 6 - Part 1: Simple Web App
 * This sketch was written by SparkFun Electronics
 * November 10, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Create a some dynamic text that appears when a button is pushed.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Make the toggle text div appear and disappear
function toggleText() {

    // Put in strict mode to restrict some JavaScript "features"
    "use strict";

    // Declare our variables at the beginning of the scope
    var toggleTextEl = $('#toggle_text');

    // Toggle the visibility of the text
    toggleTextEl.fadeToggle();

    // Print the visibility to the console
    console.log("Visibility: " + toggleTextEl.css('visibility'));
}

// Short for jQuery(document).ready() method, which is called after the page
// has loaded. We can use this to assign callbacks to elements on the page.
$(function() {
    "use strict";

    // Assign a callback to the "Push Me" button
    $('#toggle_button').on('click', function(){
        toggleText();
    });
});
```

What You Should See

To test the program in the XDK's phone emulator, click on *Run My App* in the right-side pane. Click on the "Play" symbol (triangle) next to *Run in Emulator*. The XDK Emulator should boot up and give you a phone-like interface running our web app. Click the "Push Me!" button for a (very insignificant) surprise.

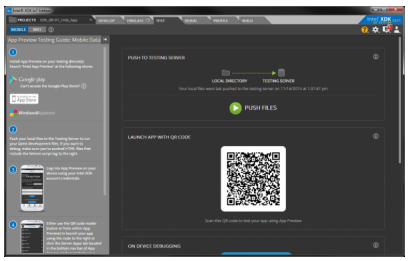


In the top-left pane, you can also select the model of phone you wish to test. It may not be as good as the real thing, but it's a start!

To test the program on a real phone, we will first need to download and install the Intel App Preview from the appropriate app store. App Preview can be found here for iOS, here for Android, or here for Windows.

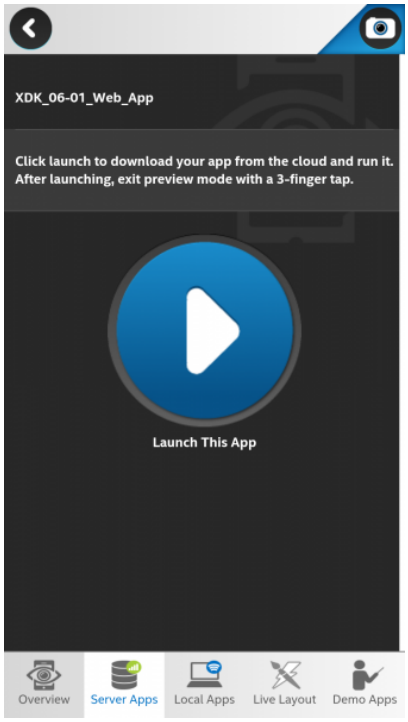
> For the next steps, you **must** be logged into the Intel® Developer Zone in the XDK.

In the XDK, go to the **TEST** tab, and click on the **Push Files** button. This will upload the project to Intel's servers, where you will be able to download it on your phone.

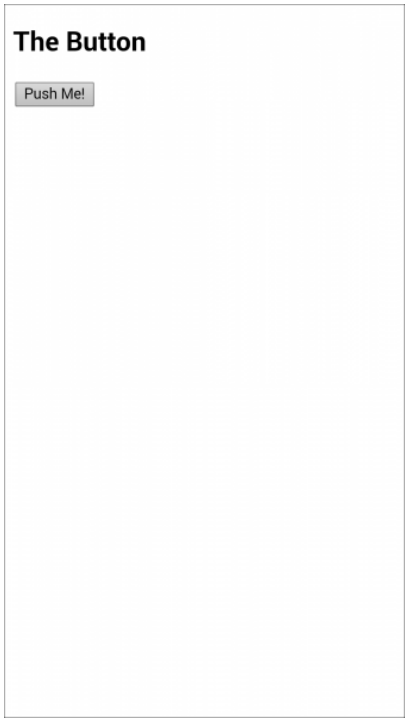


On your phone, open the Intel® App Preview app (don't think about the redundancy too hard). Press the **Login** button, and enter your Intel® Developer Zone username and password. Press the **Server Apps** tab on the bottom of the screen to view your uploaded projects (at this point, you should only see one).

Press on your project's name, and you will be presented with a launch screen.



Press the rather large *Play* button to start your app.



And that's it! Your web app is now running on your phone. To exit, tap the screen with three fingers simultaneously.

To build and deploy your app (i.e. run without the App Preview app), navigate to the **BUILD** tab in the XDK. There, you will see several options on building your app. To build your program as a Web App, click the **WebApp** button. To learn more about building XDK apps, read this article.

Code to Note

The *<html>*, *<head>*, and *<body>* tags should look very similar to how we created a simple web page in the previous experiment. The difference here is that the HTML is located in a separate file (*index.html*) than the JavaScript (*app.js*).

We load the JavaScript file with

```
<script type="text/javascript" src="js/app.js"></script>
```

at the end of the *body*. This allows us to make functions calls to JavaScript as well as have HTML elements be referenced by the JavaScript. For example, we create a button with `<button id="toggle_button">` that has the id "toggle_button". In *app.js*, we assign an event handler (the function `.on()`) to the `toggle_button` element.

To make the HTML-JavaScript communication easier, we rely on the jQuery library. jQuery adds event handling, page manipulation, and animations to JavaScript in an easy-to-use fashion. The syntax might take some time to get used to, but for starters, know that `$` is short for the class `jQuery`. That means `$('#toggle_button')` is really `jQuery('#toggle_button')` (i.e. it's just a shortcut).

The piece of code

```
$('#toggle_button').on('click', function(){
    toggleText();
});
```

assigned the function `toggleText()` to the *on click* action for the `toggle_button` HTML element, which we created in *index.html*.

Finally, `"use strict";` is an odd piece of code that sits in the beginning of functions. This line puts JavaScript into "strict mode" running in browsers, which restricts certain functions and is generally considered more "safe."

Part 2: RGB Color Picker

The Web App

In the previous part, we created a simple web app to demonstrate how web apps work. You might have noticed that we did not use the Edison at all. In this part, we will need to create 2 programs: one that runs on the Edison as a server and one that runs as a client on a smartphone.

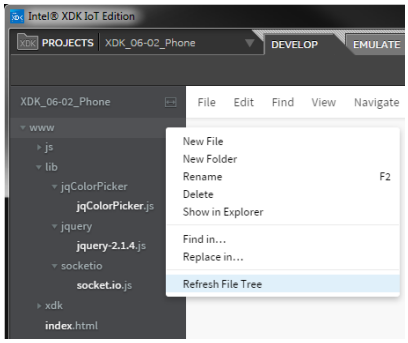
Create a new **Standard HTML5** app using the **Blank Template** (just like we did in part 1). Then, we need to add some libraries.

First, download the uncompressed, latest version of jQuery from http://jquery.com/download/. Copy that file (e.g. **jquery-2.x.x.js**) to *<Your XDK Web App Directory>/www/lib/jquery* (just like we did in part 1). Create any directories that do not exist.

Second, download the socket.io client library from https://github.com/socketio/socket.io-client (click **Download ZIP**). Unzip the .zip file, and copy **socket.io.js** to *<Your XDK Web App Directory>/www/lib/socketio*.

Third, download the JavaScript tinyColorPicker from https://github.com/PitPik/tinyColorPicker. Unzip the .zip file, and copy **jqColorPicker.min.js** to *<Your XDK Web App Directory>/www/lib/jqColorPicker*. Note that we are using the minified) version of the tinyColorPicker library.

You might have to refresh the project in the XDK (i.e. right-click in the file explorer pane and select **Refresh File Tree**).



In *www/index.html*, paste in the following code:

```
<!DOCTYPE html>

<!--
SparkFun Inventor's Kit for Edison
Experiment 6 - Part 2: Phone RGB LED
This sketch was written by SparkFun Electronics
November 9, 2015
https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments

Runs as a web app on a smartphone. Creates a socket.io connection to the
Edison and sends RGB values.

Released under the MIT License(http://opensource.org/licenses/MIT)
-->

<html>

<head>
  <title>Set RGB of Edison</title>
    <meta http-equiv="Content-type" content="text/html; charset=utf-8">
    <meta name="viewport" content="width=device-width, minimum-scale=1, initial-scale=1, user-scalable=no">
    <style>
        @-ms-viewport { width: 100vw ; min-zoom: 100% ; zoom: 100% ; }  @viewport { width: 100vw ; min-zoom: 100% zoom: 100% ; }
        @-ms-viewport { user-zoom: fixed ; min-zoom: 100% ; }           @viewport { user-zoom: fixed ; min-zoom: 100% ; }
    </style>
</head>

<body>

    <!-- IP address and port inputs -->
    <div id="connection">
        <h2>Edison Address</h2>
        <p>Please provide the IP address &amp;amp; port to the Edison</p>
        <p>
            <input id="ip_address" type="text" placeholder="IP Address">
            <input id="port" type="text" placeholder="Port">
        </p>
        <p><button id="send_ip_port">Connect</button></p>
    </div>

    <!-- RGB Color Picker -->
    <div id="rgb" style="display: none;">
        <h2>Color Selector</h2>
        <input id="colorSelector" class="color">
    </div>

    <!-- Load the various JavaScript files -->
    <script type="text/javascript" src="lib/jquery/jquery-2.1.4.js"></script>
    <script type="text/javascript" src="lib/jqColorPicker/jqColorPicker.min.js"></script>
    <script type="text/javascript" src="lib/socketio/socket.io.js"></script>
    <script type="text/javascript" src="js/app.js"></script>
</body>

</html>
```

Save the file, and in *www/js/app.js*, paste in the following code:

```
/*jslint unparam: true */
/*jshint strict: true, -W097, unused:false,  undef:true, devel:true */
/*global window, document, d3, $, io, navigator, setTimeout */

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 6 - Part 2: Phone RGB LED
 * This sketch was written by SparkFun Electronics
 * November 9, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Runs as a web app on a smartphone. Creates a socket.io connection to the
 * Edison and sends RGB values.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Connect to Edison server with socket.io
function connectIP() {

    // Put in strict mode to restrict some JavaScript "features"
    "use strict" ;

    // Declare our variables at the beginning of the scope
    var scoket;
    var ipEl = $('#ip_address');
    var portEl = $('#port');
    var connectionEl = $('#connection');
    var rgbEl = $('#rgb');
    var colorSelectorEl = $('#colorSelector');

    // Attach a socket.io object tot he main window object. We do this to avoid
    // a global socket variable, as we will need it in the colorPicker callback.
    window.socket = null;

    // Connect to Edison
    console.log("Connecting to: " + ipEl.val() + ":" + portEl.val());
    window.socket = io.connect("http://" + ipEl.val() + ":" + portEl.val());

    // If we don't have a connection, disconnect and hide the RGB selector
    window.socket.on('connect_error', function() {
        window.socket.disconnect();
        alert("Could not connect");
        rgbEl.fadeOut();
    });

    // If we do have a connection, make the RGB selector appear
    window.socket.on('connect', function() {
        rgbEl.fadeIn();
        colorSelectorEl.trigger('click');
    });
}

// Short for jQuery(document).ready() method, which is called after the page
// has loaded. We can use this to assign callbacks to elements on the page.
$(function() {
    "use strict" ;

    // Assign a callback to the "Connect" port
    $('#send_ip_port').on('click', function(){
        connectIP();
    });

    // Assign initial properties to the color picker element
    $('.color').colorPicker({
        opacity: false,
        preventFocus: true,
        color: 'rgb(0, 0, 0)',

        // This is called every time a new color is selected
        convertCallback: function(colors, type) {
            if (window.socket && window.socket.connected) {
                window.socket.emit('color', colors.RND.rgb);
            }
        }
    });
});
```

Don't forget to save!

Edison Code

Create a new project (**Blank** template under **Internet of Things Embedded Application**). This code will run on the Edison. Copy in the following code into *main.js*:

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 6 - Part 2: Edison RGB LED
 * This sketch was written by SparkFun Electronics
 * November 9, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Waits for socket.io connections and received messages to change RGB LED.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the MRAA and HTTP modules
var mraa = require('mraa');
var server = require('http').createServer();
var io = require('socket.io').listen(server);

// Port
var port = 4242;

// Set up PWM pins
var rPin = new mraa.Pwm(20);
var gPin = new mraa.Pwm(14);
var bPin = new mraa.Pwm(0);

// Enable PWM
rPin.enable(true);
gPin.enable(true);
bPin.enable(true);

// Set 1000 Hz period
rPin.period(0.001);
gPin.period(0.001);
bPin.period(0.001);

// Turn off LEDs initially
pwm(rPin, 0.0);
pwm(gPin, 0.0);
pwm(bPin, 0.0);

// Wait for a client to connect
io.on('connection', function(socket) {
    console.log("A client is connected!");

    // Look for the "color" message from the client and set the LED
    socket.on('color', function(rgb) {
        console.log("RGB(" + rgb.r + ", " + rgb.g + ", " + rgb.b + ")");
        pwm(rPin, rgb.r / 255);
        pwm(gPin, rgb.g / 255);
        pwm(bPin, rgb.b / 255);
    });
});

// PWM needs a "fix" that turns off the LED on a value of 0.0
function pwm(pin, val) {
    if (val === 0.0) {
        pin.write(0.0);
        pin.enable(false);
    } else {
        pin.enable(true);
        pin.write(val);
    }
}

// Run the server on a particular port
server.listen(port, function() {
    console.log("Server listening on port " + port);
});
```

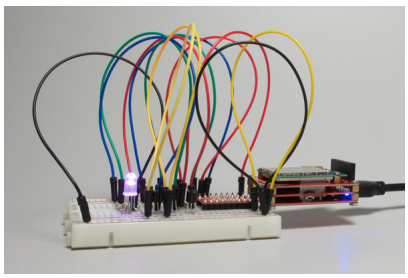
What You Should See

Upload the Edison code to the Edison and run it. You should see a note in the console, “Server listening on port 4242”. Take note of the Edison’s IP address.

Open the web app project back up and run it in an emulator or your smartphone. You will be presented with a couple of fields for IP address and port number. Enter the IP address of the Edison and 4242 for the port.

Click **Connect** and the web app should make a connection with the Edison (assuming your phone/emulator and Edison are on the same network). If it was successful, you should see an RGB color selector appear.

Try selecting different colors, and see how the LED connected to the Edison responds!



Code to Note

In the web app, we are using jQuery again to control elements, like in part 1. We rely on `fadeIn()` and `fadeOut()` to make the RGB selector appear and disappear. Additionally, we use the `alert()` function to make a pop-up appear letting the user that the connection failed.

You might have noticed that we used `window.socket` in `connectIP()`. The window object is pre-defined as the open window in a browser. It contains all the displayed HTML. As it turns out, we need to access a `socket` object in the function `connectIP()` as well as the callback for the RGB color picker. However, `socket` was never declared as a global variable, and as a result, the color picker callback (`convertCallback`) does not know about the existence of `socket` , as it was declared in `connectIP()` . This is a problem of “scope.”

To solve this issue (and without creating unnecessary global variables), we create a `socket` object inside the `window` object (we say that `window` owns a `socket` object) with `window.socket`. Because `window` is global, we can then access `window.socket` anywhere in our code! To make sure that the window.socket object exists and has a connection before we use it to send data, we rely on the conditional

```
if (window.socket && window.socket.connected) {
    ...
}
```

in `convertCallback`. That way, we don't throw any `undefined` errors when we try to use the `socket`.

In the Edison code, we use the MRAA `Pwm` object to control the brightness of the RGB LED, which is created with an MRAA pin number. To find the MRAA pin number, first find the pin number as it is listed on the GPIO Block, and find the associated MRAA pin number in Appendix E: MRAA Pin Table. For example, GP12 is MRAA pin 20.

Troubleshooting

- **The web app does not start** – Try it in the XDK emulator first. In the emulator, click on the "debug" button (bug icon with an 'X' in the upper-left corner), and click on the **Console** tab to view error messages.
- **The web app won't run on my phone** – Your phone might not be supported. If it is an older phone, read about legacy phone support for the XDK.
- **The web app won't connect to the Edison** – Make sure the Edison and phone are on the same network (e.g. the phone must be connected to WiFi and on the same subnet as the Edison).

Going Further

Challenges

1. Make a modified email notifier that changes the color of the LED depending on different parameters of your inbox. For example, you could have the LED be green for 1-10 new emails and red for 11+ emails.
2. Add an image to the web app that turns the LED off and back on when you press it (hint).

Digging Deeper

- What is JavaScript "strict mode"
- More about scope
- tinyColorPicker example page

Experiment 7: Speaker

Introduction

Many microcontrollers have the ability to create analog voltages using a digital-to-analog converter (DAC). DACs are incredibly useful for connecting to a speaker (usually through an amplifier) to make sounds.

Many other microcontrollers and computer modules (like our Edison) do not have an onboard DAC. While separate DAC chips can be added, we are often left with using PWM to approximate sounds with a speaker.

In this experiment, we will read musical note information from a file and use that to create PWM signals. We then amplify the PWM signals and feed it to a small speaker that converts those signals to sound.

WARNING: This exercise is not for the faint of heart nor people with perfect pitch. We will create some sounds that approximate basic musical notes, but they will be far from pleasing. It is, however, a useful exercise in learning how to read files and discovering why Linux makes for a poor real-time operating system (RTOS).

Parts Needed

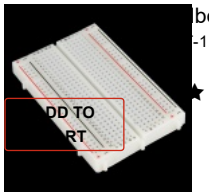
In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** Piezo Speaker
- **1x** NPN Transistor
- **1x** 1kΩ Resistor
- **1x** 100Ω Resistor
- **6x** Jumper Wires

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

tor Kit - 1/4W (500 total)
M-10969

★★½ 122



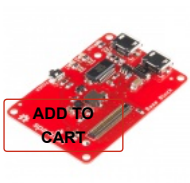
board - Self-Adhesive (White)
-12002

★★½ 34

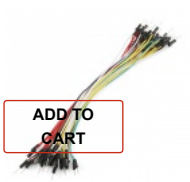
. Away Headers - Straight
-00116
20

Edison
-13024
24

le Headers
-00115
7



Fun Block for Intel® Edison - Base
-13045
16



er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026
20

peaker - PC Mount 12mm 2.048kHz
-07950
5

Fun Block for Intel® Edison - GPIO
-13038
4

istor - NPN (2N3904)
-00521

Suggested Reading

- How a Speaker Works – Simple electromagnets can be used to create sound waves!

Concepts

Reading a File

The ability to read and write to and from a file in a program can be incredibly useful. Often, we want to store settings and other parameters in a piece of plain text so that users can adjust the configuration of the program without digging through code.

To accomplish that, we will rely on the node module fs. Specifically, we want to use `fs.readFileSync()`.

`fs.readFile()` will also read the contents of a text file, but it does so *asynchronously*, which means other parts of the program might execute before the file is completely read. This could result in the variable that's supposed to hold the file contents being `undefined`.

`fs.readFileSync()` blocks execution of the program until the file has been completely read.

Sleeping

JavaScript, in its attempt to be as *asynchronous* (e.g. non-blocking) as possible, does not have a built-in `wait()` or `sleep()` function. As JavaScript is primarily intended for use in browsers, telling a client's computer to sleep on a thread is generally considered a bad idea.

As a result (and since we don't care about browser behavior in this Node example), we will write our own `sleep` function.

We will use the process time, which is found in the Node process object. The "high resolution" time can be found by calling process.hrtime(), which returns the process's run time in seconds and nanoseconds. By doing nothing in a do-while loop, we can effectively sleep for a given number of nanoseconds.

PWM Sounds

While a DAC is normally used to make sounds with a speaker, we can approximate sounds with PWM. Because PWM is a digital signal (a square wave), it contains a lot of harmonic frequencies on top of the original frequency, and thus producing an unclean sound (i.e. not a true representation of the actual frequency). Played through a speaker, a square wave sounds very different from a sine wave.

Without a true DAC on the Edison, we can use a 50% PWM signal (a basic square wave) to create sounds. Played at the correct frequency, we can even make notes!

Based on some testing with an oscilloscope, the fastest the Edison is able to switch a pin on and off is about 475 µs, which translates to about 2.1 kHz. As a result, we need to keep notes to C_7 (2093.00 Hz) or lower. A note-to-frequency table can be found here.

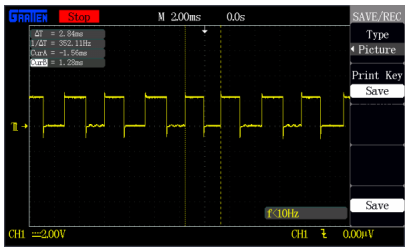
Real-Time Operating System

A real-time operating system (RTOS) is an operating system (OS), but unlike popular operating systems like Linux, OS X, or Windows, an RTOS is intended to meet strict timing deadlines.

For example, an HDTV receiver often relies on an RTOS within a microcontroller (or microprocessor) to receive a digital signal and decode it within a very small amount of time (every frame!). If deadlines are missed, the TV's picture may be garbled or worse, not displayed at all.

Linux (like the one running in your Edison), generally, is NOT an RTOS! Linux was originally designed as a general-purpose OS with the focus on user experience. If we give Linux several tasks, there is no guarantee as to when those tasks will execute, when they will finish, and in what order. There are several versions of real-time Linux available and in the works, but the default Yocto image on the Edison is not one.

If we create a fast switching signal (a square wave) in our Edison and output it to a pin, we can measure it with an oscilloscope. In this example, we create a square wave with a frequency of 440 Hz.



See anything wrong?

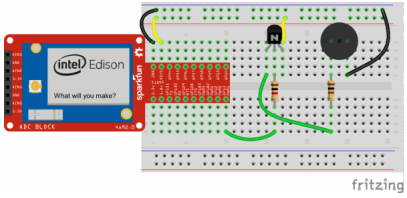
Well, first of all, the measured frequency is WAY off from 440 Hz! The period of a 440 Hz signal is about 2.27 ms, and we measured 2.84 ms. That means Linux is taking its sweet time (around 0.57 ms in this case) to do whatever it needs (switch to some other task, run it for a while, switch back, and then notice that we should toggle that pin). 0.57 ms may not seem like a lot (especially when we are talking about doing things like browsing sites and reading text files), but when it comes to music, that means the difference between reading an A and playing an F note. Talk about tone deaf.

Secondly, not all of the highs and lows in that oscilloscope image are the same width. That means that Linux is not even guaranteeing the frequency will be constant! Unless it is an intentional fluctuation, it often makes a note very unpleasing.

If you still decide to go through with this experiment, please forgive me for assaulting your ears.

Hardware Hookup

Fritzing Diagram



Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

Tips

Speaker

Note the + marking on the top side of the speaker (there are also + and - markings on the underside).

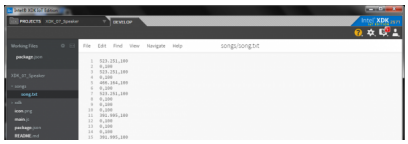
The pin associated with the positive (+) polarity should be connected to the 100Ω resistor. Negative (-) should be connected to the ground rail on the breadboard.

The Code

In the XDK, create a new directory named *songs* in the file browser, and in that, a file named *song.txt*. In *song.txt*, copy in the following text:

```
523.251,100
0,100
523.251,100
0,100
466.164,100
0,100
523.251,100
0,100
0,100
0,100
391.995,100
0,100
0,100
0,100
391.995,100
0,100
523.251,100
0,100
698.456,100
0,100
659.255,100
0,100
523.251,100
0,100
```

Save that file.



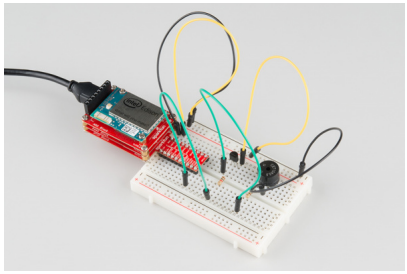
Then, copy the following code into *main.js*:

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 7: Speaker
 * This sketch was written by SparkFun Electronics
 * November 17, 2015
 * Updated: August 1, 2016
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Plays a tune using a PWM speaker.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

var mraa = require('mraa');
var fs = require('fs');

// Global constants
var MAX_FREQ = 2100;

// Set up a digital output on MRAA pin GP13 for the speaker
var speakerPin = new mraa.Gpio(13, true, true);
speakerPin.dir(mraa.DIR_OUT);
speakerPin.write(0);

// Read and parse song file
var song = fs.readFileSync(__dirname + "/songs/song.txt", 'utf-8');
song = song.replace(/\r/g, '');
song = song.split('\n');

// Play song
console.log("Playing...");
for (var t = 0; t < song.length; t++) {

    // Read the frequency and time length of the note
    var note = song[t].split(',');

    // Play the note
    playNote(speakerPin, parseFloat(note[0]), parseInt(note[1], 10));
}
console.log("Done!");

// Play a note with a given frequency for msec milliseconds
function playNote(pin, freq, msec) {

    // Check to make sure we actually have valid numbers
    if (freq === "NaN" || msec === "NaN") {
        return;
    }

    // Make sure we don't go over the maximum frequency
    if (freq >= MAX_FREQ) {
        freq = MAX_FREQ;
    }

    // If the frequency is 0, don't play anything
    if (freq === 0) {
        console.log("Silence for " + msec + "ms");
        delaynsec(msec * 1e6);
        return;
    }

    // Define the note's period and how long we play it for
    var period = 1 / freq;
    var length = msec / (period * 1000);

    console.log("Playing " + freq + "Hz for " + msec + "ms");

    // For one period, send pin high and low for 1/2 period each
    for (var i = 0; i < length; i++) {
        pin.write(1);
        delaynsec(Math.round((period / 2) * 1e9));
        pin.write(0);
        delaynsec(Math.round((period / 2) * 1e9));
    }
}

// Delay for a number of given nanoseconds
function delaynsec(nsec) {

    var time = process.hrtime();
    var diff;
    var diffNSec;
```

```
    // Wait until the specified number of nanoseconds has passed
    do {
        diff = process.hrtime(time);
        diffNSec = (diff[0] * 1e9) + diff[1];
    } while (diffNSec < nsec);
}
```

What You Should See

Well, you shouldn't actually *see* anything. However, you should *hear* an awful rendition of a popular '70s song. Bonus points if you can name that tune (and with it being horribly off key, those bonus points really count).



Code to Note

Regular Expressions (Regex)

We get the contents of our song file with `fs.readFileSync()`, but then we must *parse* that file to know which notes we need to play and for how long. To do that, we get rid of all the *carriage return* characters ('\r') by using the regular expression `/\r/g`, which says "find all \r characters in the string."

We can use the `.replace(regex, string)`, which finds all the occurrences of the regex and replaces it with the given string. In this case, we replace all '\r' with '' (nothing).

String Manipulation

JavaScript plays very nicely with strings. You have just seen the `.replace()` method, and there are many others.

We also rely on `.split()` to split up the string containing the file contents into an array of smaller strings. We first split on the newline character \n. We iterate (using a for loop) over that array, and in each case, we split the substring even further.

In each substring, we look for the comma ',' character. As the *song.txt* file is set up, we list the frequency we want to play first (the note) and for how long (milliseconds) next. They make up the first and second (0 and 1) elements of the array, respectively.

GPIO Raw Pin Numbers

A few pin objects in MRAA (for example, GPIO) allow us to use "raw" pin numbers (e.g. GP13). To do that, we need to pass `true` to the third parameter. For example:

```
var speakerPin = new mraa.Gpio(13, true, true);
```

The second parameter says that we "own" the pin (the descriptor to the pin will automatically close when we exit). The third parameter says that we want to use "raw" values (by default, this value is `false`, and says that we should treat the first parameter as the MRAA pin number). The number 13 actually corresponds to GP13 on the board!

This does not work for all pin-related objects. For example, PWM does not support raw pin numbers. More about raw pin numbers can be found here.

Troubleshooting

- **There is no sound** – Double-check the wiring of the speaker and the transistor. Make sure the + symbol on the speaker is on the same row as the 100Ω resistor in the breadboard.

Going Further

Challenges

1. Create a new song! Take a look at how the *song.txt* file is organized (frequency,time) and generate a new song text file with one of your favorite tunes. Don't forget to change the file location in `fs.readFileSync()`!

Digging Deeper

- Node fs API
- How a square wave is created with sine waves
- Piano notes and frequencies
- Regex reference

Experiment 8: Temperature and Light Logger

Introduction

On its own, the Edison is not capable of taking analog voltage readings, unlike many other microcontrollers (such as the Arduino). The kit, however, contains an analog-to-digital converter (ADC) Block for the Edison. On this Block is a special chip that is capable of measuring analog voltages and reporting them over the I^2C bus.

Because the Edison has built-in networking capabilities, we can use WiFi (and the power of the Internet!) to log these analog readings to a remote site. In this case, we are going to use SparkFun's own data.sparkfun.com. By constructing a simple HTTP request, we can post values to our own feed on data.sparkfun. That way, we can monitor various sensor readings from anywhere in the world!

Parts Needed

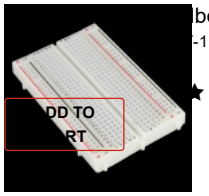
In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard

- **1x** TMP36 Temperature Sensor
- **1x** Photocell
- **1x** 1kΩ Resistor
- **7x** Jumper Wires

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

tor Kit - 1/4W (500 total)
M-10969
122



board - Self-Adhesive (White)
-12002
34

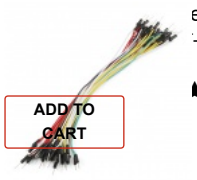
Away Headers - Straight
-00116
20

Edison
-13024
24

hotocell
-09088
7

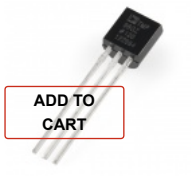
le Headers
-00115
7

Fun Block for Intel® Edison - Base
-13045
16



er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026
20

Temperature Sensor - TMP36
SEN-10988



16

Fun Block for Intel® Edison - GPIO
'-13038

4

Fun Block for Intel Edison - ADC
'-13770

Suggested Reading

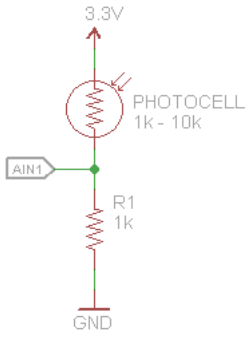
- Analog vs. Digital – What's the difference between analog and digital electrical signals?
- Analog to Digital Conversion – How to measure an analog signal with a digital device
- Voltage Dividers – How to reduce the voltage of a signal using a couple of resistors
- Pushing Data to data.sparkfun.com – Using various systems to remotely log data on data.sparkfun
- I2C – An introduction to the Inter-integrated Circuit (I^2C)

Concepts

Voltage Divider

Our two sensors, the TMP36 and the photocell, change their voltage or resistance based on the property they are measuring. The TMP36, luckily, changes the *voltage* on its V_{OUT} pin directly as the temperature changes.

The photocell, on the other hand, varies its *resistance* as the measured light changes. Since we don't have a good way to measure resistance on the Edison, we can set up a *voltage divider* to measure the voltage.



As the photocell detects more light, its resistance *decreases* (down to about 1kΩ). Conversely, as it detects less light, its resistance *increases* (up to about 10kΩ). The voltage divider allows us to measure that change is resistance through a change in voltage at AIN1. The equation for this circuit is:

$$V_{OUT} = \frac{R_1}{R_1 + R_{PHOTOCELL}} \cdot V_{IN}$$

We know that V_{IN} is 3.3V and R_1 is 1kΩ. In a light environment, we can calculate that the voltage measured at V_{OUT} (AIN1) should be around:

$$V_{OUT} = \frac{1k\Omega}{1k\Omega + 1k\Omega} \cdot 3.3V = 1.65V$$

and in a dark environment:

$$V_{OUT} = \frac{1k\Omega}{1k\Omega + 10k\Omega} \cdot 3.3V = 0.3V$$

Luckily, that voltage can be measured with an analog-to-digital converter!

Analog-to-Digital Conversion

Being able to measure an analog voltage is extremely useful in the world of digital electronics. Many sensors, like our TMP36 temperature sensor and photocell, vary output voltage or resistance based on its measured value. For example, the resistance in the photocell *increases* as the amount of light falling on the sensor *decreases*.

The ADC on the ADC Block (a TI ADS1015) is capable of measuring the voltage on some of pins within a given range (for example, +/- 4.096 V). Many ADC chips, like our ADS1015, determine analog voltage by measuring the amount of time it takes that voltage to charge a capacitor. That time is converted to a *quantized* level that corresponds to the measured voltage.

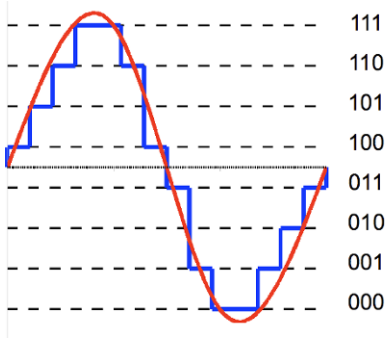


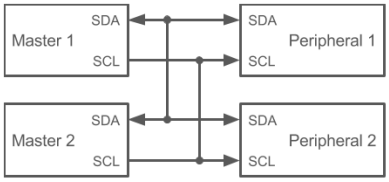
Image courtesy of Hyacinth of Wikimedia Commons.

In the example above, the analog signal was converted to a 3-bit digital value. Because analog values are *continuous* and digital values are *discrete*, we are essentially rounding analog values to fit within the digital value's *resolution* (e.g. 3 bits).

Luckily for us, the ADS1015 offers 12 bits of resolution for its conversion values. That allows us to measure voltages down to the 2 mV resolution (assuming the +/-4.096 V range), which should be good enough for most basic sensor readings.

I2C

I^2C is communication protocol capable of supporting multiple masters and peripheral devices on the same 2-wire bus.



For now, we will use 1 master (the Edison) and 1 peripheral device (ADS1015). The master is in control of the SCL (clock) line, which it toggles at a pre-determined rate (generally, 100 kHz). To make sure that the master talks to the correct peripheral, we can send a specific address across the SDA line first (e.g. 0x48 for our ADS1015).

Most I^2C peripherals rely on a series of *registers* to store data that should be written to or read from over I^2C. If you look at the datasheet for the TI ADS1015 (p. 15), you will notice that there are 4 registers: conversion, config, low threshold, and hi threshold. We won't need to worry about the last two, as we are not using the threshold capabilities on the ADS1015 for this experiment.

To request an analog sample be taken, we need to write 16 bits to the config register (register address 0x01). First, we write the *peripheral* address (0x48), then we write the register we want (0x01), and finally, we can send the data we want. The specific bits for the config register can be found on pp. 15-16 in the datasheet.

Once the sampling has been taken and stored in the ADS1015, we can then read it back by using a similar method: the master sends the peripheral device and the conversion register address. The ADS1015 will then send the data in the conversion register back across the I^2C bus.

Once again, we can rely on the MRAA library to handle much of the I^2C communication for us.

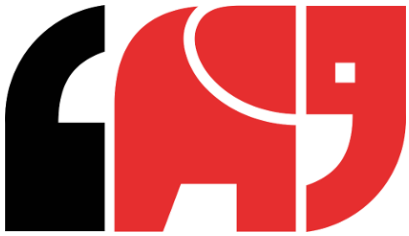
NTP

The Network Time Protocol (NTP) is a relatively old (1985) networking protocol intended to synchronize clocks on interconnected computer systems. There are several NTP servers in the world, and we can use one of them (pool.ntp.org), which connects to the NTP Pool Project. By requesting the time, the NTP server responds with a value corresponding to the current date and time given in Greenwich Mean Time (GMT).

For our purposes, we can use the ntp-client module to assist with making NTP requests to servers.

Phant

Phant is SparkFun's software for logging data to a web server.



data.sparkfun is a site that runs Phant. Using data.sparkfun, we can create our very own data stream and log values to it. This can be anything from local computer time to wind speed. Anything we can measure (and store as a number or string), we can log to data.sparkfun.

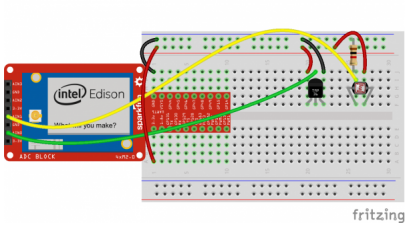
To post something to a stream, we need the Public Key and Private Key for that stream, which we will create later. Knowing those, we can log values to the individual streams with the HTTP GET request:

```
http://data.sparkfun.com/input/<YOUR PUBLIC KEY>/?private_key=<YOUR PRIVATE KEY>&field1=<VALUE 1>&field2=<VALUE 2>
```

For our purposes, we will be logging a relative light value (as a voltage), the ambient temperature (in Celsius), and the current time (Greenwich Mean Time, taken at the time of the readings). We will be able to access a page on data.sparkfun to view these logs.

Hardware Hookup

Fritzing Diagram



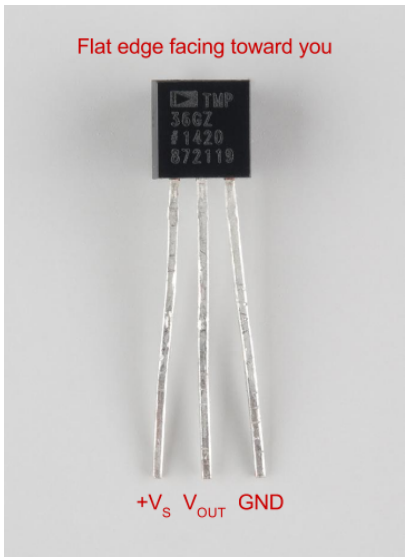
Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

Tips

TMP36 Temperature Sensor

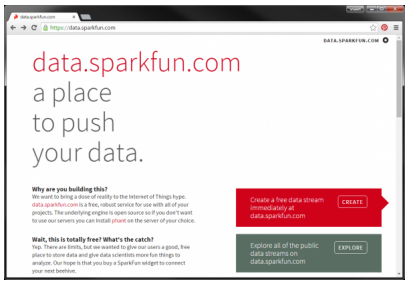
WARNING: The 2N3904 transistor and TMP36 temperature sensor look very similar! Examine the flat face of the TO-92 packages very carefully and find one that says **TMP**.

Like some of the other components that we've used, we need to care about polarity when it comes to the TMP36 temperature sensor. With the flat edge of the component body facing toward you, note the pins.



data.sparkfun Stream

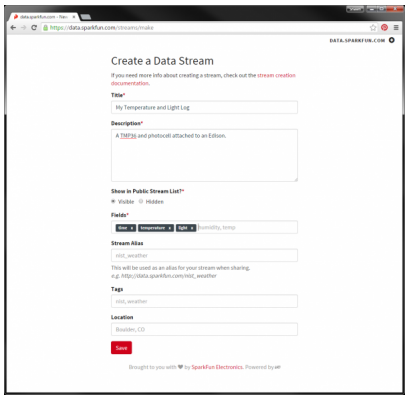
In order to log data to data.sparkfun, we first need to create a stream. The good news is that we don't even need an account! Navigate to data.sparkfun.com.



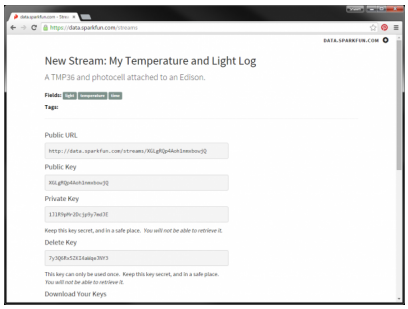
Click the **CREATE** button. You will be presented with a form to fill out for your stream. Go ahead and create a name and description for it. You need to add the following fields:

- time
- temperature
- light

Make sure they are spelled just like that! They need to match the field names in the code below. You can optionally fill out the rest of the form, if you wish.



Click **Save** at the bottom of the page, and you will be presented with the keys (public, private, and delete) for your stream.

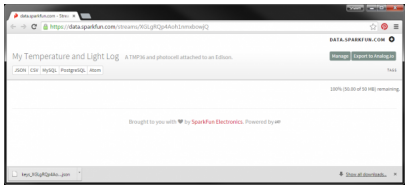


Make sure you write them down, save them as a file, or email them to yourself! Once you exit out of this screen, you can't go back.

The three keys are quite important:

- **Public Key** – Used for accessing and viewing your stream. Notice that the URL to your stream is http://data.sparkfun.com/streams/<YOUR PUBLIC KEY>
- **Private Key** – Used to post data to your stream (it's like password). Don't share this with people if you don't want them to post, modify, or delete your stream!
- **Delete Key** – Use this to permanently delete your stream. If used, your stream will be gone forever!

Click on the **Public URL** link to go to your stream's page.



As you might have noticed, there is nothing in the stream, right now.

The Code

Create a new Blank Template in *IoT Application* in the XDK. In *package.json*, we need to add a couple of libraries:

```
{
  "name": "blankapp",
  "description": "",
  "version": "0.0.0",
  "main": "main.js",
  "engines": {
    "node": ">=0.10.0"
  },
  "dependencies": {
    "request": "2.67.0",
    "ntp-client": "0.5.3"
  }
}
```

In *main.js*, copy in the following:

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 8: Temperature and Light Logger
 * This sketch was written by SparkFun Electronics
 * December 2, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Reads temperature and light values from ADC Block and posts them to
 * data.sparkfun.com.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// MRAA, as per usual
var mraa = require('mraa');

// The Request module helps us make HTTP calls (e.g. to data.sparkfun)
var request = require('request');

// The ntp-client module allows us to get the current time (GMT)
var ntp = require('ntp-client');

// Save our keys for data.sparkfun
var phant = {
    server: "data.sparkfun.com",        // Base URL of the feed
    publicKey: "xxxxxxxxxxxxxxxxxxxx",  // Public key, everyone can see this
    privateKey: "xxxxxxxxxxxxxxxxxxxx", // Private key, only you should know
    fields: {                           // Your feed's data fields
        "time": null,
        "temperature": null,
        "light": null
    }
};

// Define a timeout period for the HTTP request (2 seconds)
var reqTimeout = 2000;                  // milliseconds

// TI ADS1015 on ADC Block (http://www.ti.com.cn/cn/lit/ds/symlink/ads1015.pdf)
var adc = new mraa.I2c(1);
adc.address(0x48);

// Read from ADC and return voltage
adc.readADC = function(channel) {

    // The ADC Block can't have more than 4 channels
    if (channel <= 0) {
        channel = 0;
    }
    if (channel >= 3) {
        channel = 3;
    }

    // We will use constant settings for the config register
    var config = 0;                 // Bits     Description
    config |= 1 << 15;              // [15]     Begin a single conversion
    config |= 1 << 14;              // [14]     Non-differential ADC
    config |= channel << 12;        // [13:12]  Choose a channel
    config |= 1 << 9;               // [11:9]   +/-4.096V range
    config |= 1 << 8;               // [8]      Power-down, single-shot mode
    config |= 4 << 5;               // [7:5]    1600 samples per second
    config &= ~(1 << 4);            // [4]      Traditional comparator
    config &= ~(1 << 3);            // [3]      Active low comparator polarity
    config &= ~(1 << 2);            // [2]      Non-latching comparator
    config |= 3;                    // [1:0]    Disable comparator

    // Write config settings to ADC to start reading
    this.writeWordFlip(0x01, config);

    // Wait for conversion to complete
    while (!(this.readWordFlip(0x01) & 0x8000)) {
    }

    // Read value from conversion register and shift by 4 bits
    var voltage = (adc.readWordFlip(0x00) >> 4);

    // Find voltage, which is 2mV per incement
    voltage = 0.002 * voltage;

    return voltage
};

// The ADS1015 accepts LSB first, so we flip the bytes
```

```
adc.writeWordFlip = function(reg, data) {
    var buf = ((data & 0xff) << 8) | ((data & 0xff00) >> 8);
    return this.writeWordReg(reg, buf);
};

// The ADS1015 gives us LSB first, so we flip the bytes
adc.readWordFlip = function(reg) {
    var buf = adc.readWordReg(reg);
    return ((buf & 0xff) << 8) | ((buf & 0xff00) >> 8);
};

// Send an HTTP request to data.sparkfun to post our data
function postData(values) {

    var prop;

    // Construct the HTTP request string
    var req = "https://data.sparkfun.com/input/" + phant.publicKey +
              "?private_key=" + phant.privateKey;
    for (prop in values) {
        req += "&" + prop + "=" + encodeURI(values[prop].toString());
    }

    // Make a request and notify the console of its success
    request(req, {timeout: reqTimeout}, function(error, response, body) {

        // Exit if we failed to post
        if (error) {
            console.log("Post failed. " + error);

        // If HTTP responded with 200, we know we successfully posted the data
        } else if (response.statusCode === 200) {
            var posted = "Posted successfully with: ";
            for (prop in values) {
                posted += prop + "=" + values[prop] + " ";
            }
            console.log(posted);
        } else {
            console.log("Problem posting. Response: " + response.statusCode);
        }
    });
}

// Take temperature and light readings at regular intervals
takeReadings();
function takeReadings() {

    // Read temperature sensor (on ADC0) and calculate temperature in Celsius
    var v0 = adc.readADC(0);
    var degC = (v0 - 0.5) * 100;

    // Read light sensor (on ADC1)
    var v1 = adc.readADC(1);

    // Get the current time and post to data.sparkfun
    ntp.getNetworkTime("pool.ntp.org", 123, function(error, datetime) {

        // If it's an error, don't post anything
        if (error) {
            console.log("Error getting time: " + error);

        // Otherwise, post all the data!
        } else {

            // Construct a values object to send to our function
            phant.fields.time = datetime;
            phant.fields.temperature = degC.toFixed(1);
            phant.fields.light = v1.toFixed(3);

            // Post to data.sparkfun
            postData(phant.fields);
        }

        // Wait 10 seconds before taking another reading
        setTimeout(takeReadings, 10000);
    });
}
```

Find the phant object in the beginning of the code:

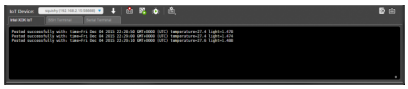
```
var phant = {
    server: "data.sparkfun.com",        // Base URL of the feed
    publicKey: "xxxxxxxxxxxxxxxxxxxx",  // Public key, everyone can see this
    privateKey: "xxxxxxxxxxxxxxxxxxxx", // Private key, only you should know
    fields: {                           // Your feed's data fields
        "time": null,
        "temperature": null,
        "light": null
    }
};
```

Replace the first `"xxxxxxxxxxxxxxxxxxxx"` with your data.sparkfun public key and the second `"xxxxxxxxxxxxxxxxxxxx"` with your private key. For example, my code would look like:

```
publicKey: "XGLgRQp4Aoh1nmxbowjQ",  // Public key, everyone can see this
privateKey: "1JlR9pMr2Dcjp9y7mdJE", // Private key, only you should know
```

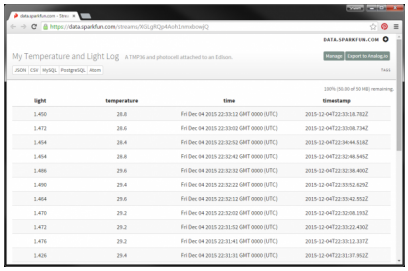
What You Should See

Save, upload, and run the code on the Edison. If all goes well (and your Edison has a connection to the Internet), you should get a “Posted successfully” note in the console.

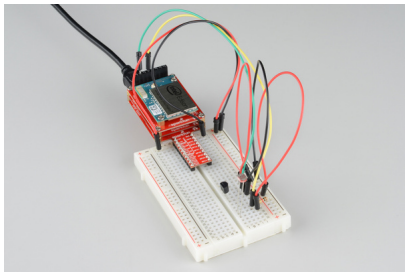


The Edison will sample the temperature from the sensors and attempt to post to data.sparkfun every 10 seconds.

Refresh your stream’s page, and you should see new values in each of the fields.



Try breathing on the temperature sensor and covering the photocell with your finger. How does that affect the readings?



See the buttons at the top of the stream in the page? You can download a snapshot of your data as a JSON, CSV, etc. file if you wish to graph it. You can also try exporting it to analog.io for some browser-based graphing abilities.

Code to Note

Endianness

“Endianness” refers to how a system stores bytes. The Edison, for example, is “big endian,” which means that in a 2-byte “word,” the first byte is the most significant byte (MSB). If you stored the value 0x12AB (decimal: 4779) into memory, the first byte would be 0x12 and the second byte would be 0xAB.

The ADS1015, however, communicates the least significant byte (LSB) first (“little endian”) when it transmits and receives values over I^2C. For example, if we wanted to send the number 4779 to the ADS1015, we would have to send 0xAB followed by 0x12. As you might have noticed, that is flipped from how the Edison stores values.

In our code, we need to create a couple of helper functions, `writeWordFlip()` and `readWordFlip()`, as part of the `adc` object. Before we send data (often in the form of 16 bits or 2 bytes), we need to flip the two bytes. We do that with `((data & 0xff) << 8) | ((data & 0xff00) >> 8);`. The first part masks the lower 8 bits of our 2-byte value and shifts it left by 8 bits. The second part masks the upper 8 bits of the 2-byte value and shifts it right 8 bits. In effect, this swaps the high and low bytes in our 16-bit word.

HTTP Requests

We’ve used HTTP requests in the past when we were creating web servers. To that end, we waited for an HTTP request to come in, and we responded with HTML text that was then rendered on the client’s broswer.

This time, however, we are creating our own HTTP request. To send something to data.sparkfun, we used the HTTP GET request (not the POST request, as you might think). With a specially crafted Uniform Resource Locator (URL), we can tell data.sparkfun which stream to post to, to which fields, and with what data.

We accomplish that in code by creating a string for our URL. We do that with

```
// Construct the HTTP request string
var req = "http://data.sparkfun.com/input/" + phant.publicKey +
          "?private_key=" + phant.privateKey;
for (prop in values) {
    req += "&" + prop + "=" + values[prop].toString().replace(/ /g, "%20");
}
```

This snippet of code constructs the URL consisting of the host site (data.sparkfun), the page we want (/input), the stream (phant.publicKey), and our password (phant.privateKey).

The next part is interesting and requires its own section.

for…in Loop

JavaScript offers us a unique way to deal with properties in an object: the *for…in* loop. Much like the basic *for* loop, we can iterate over several properties. Instead of an array, however, we use an object with several properties.

Given our object `values` (which is actually `phant.fields` as passed into our `postData()` function), we can iterate over arbitrary property names and values in that object. For example, let's say we have the following within our `values` object:

```
values: {
    "time": "Fri Dec 04 2015 17:43:03 GMT 0000 (UTC)",
    "temperature": 24.2,
    "light": 0.980
}
```

The for…in loop would, on each iteration, give us one of the property names in the parameter `prop`. So,

```
for (prop in values) {
    console.log(prop);
}
```

would output:

```
time
temperature
light
```

If we want to access the value within each property, we can do so with brackets ([]), much like an array. So,

```
for (prop in values) {
    console.log(values[prop]);
}
```

would output:

```
Fri Dec 04 2015 17:43:03 GMT 0000 (UTC)
24.2,
0.980
```

In our experiment code, we simply append the property name and value (as strings) to the HTTP request (making sure to replace all spaces with %20, first!).

> **NOTE:** for...in does not guarantee any particular order for the properties that it iterates over. It will likely be the order in which they are defined, but there is no guarantee.

Light Value

You might have noticed that we are posting the raw voltage level of the photocell to data.sparkfun. Why? Well, as it turns out, most photocells are not very accurate. Additionally, the color of the light affects the measured value. For instance, our photocell is more sensitive to green light than red light. As a result, coming up with an equation to convert voltage to a light measurement (e.g. lux) is extremely difficult, especially without the ability to accurately calibrate each photocell.

So, for our purposes, we will just post the raw voltage measured from the photocell. That acts as a good relative measure for how bright the surroundings are.

Troubleshooting

- **NTP keeps failing** – Check for an Internet connection with the Edison, and make sure that the NTP server is set to `"pool.ntp.org"`.
- **Posting to data.sparkfun keeps failing** – Ensure that your public and private keys are set properly. You can also add a `console.log(req)` just before the `request(req, ...)` line to verify the HTTP request string.
- **My values seem off** – More than likely, this is a problem with wiring, so double-check that.

Going Further

Challenges

1. Just something to think about: why do we need to replace all the spaces in a URL with "%20"?
2. Change the `setTimeout()` function to log data once per minute (instead of once per 10 seconds). Find somewhere you can leave your Edison with the temperature and light sensors (making sure it still has an Internet connection) for a day. We recommend somewhere indoors, since the Edison is not exactly waterproof. Log data for a day, and create a graph using something like Excel, Google Sheets, or Google Charts. What interesting patterns do you notice?
3. Create another field (of your choosing) in your stream and post a value to it along with time, temperature, and light. This can, for example, be something like the state of a button connected to the Edison.

Digging Deeper

- TI ADS1015 Datasheet
- Photocell Datasheet

- MRAA I²C API
- Endianness
- ntp-client GitHub repository
- request GitHub repository
- for…in loop

Experiment 9: Weather on an LCD

Introduction

While the Edison itself has no standard port for monitors, we can make use of the GPIO pins to drive a different type of display: the character LCD! These somewhat simplistic liquid crystal displays (LCDs) are capable of drawing characters (and some basic shapes) in 1 or more rows.

In this exercise, we will show how to first display simple strings on the character LCD and then pull weather forecast data from the Internet and display it on the LCD.

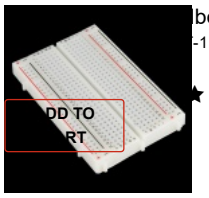
Parts Needed

In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** Character LCD
- **1x** 10k Potentiometer
- **16x** Jumper Wires

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

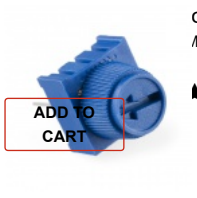
tor Kit - 1/4W (500 total)
M-10969
★★½ 122



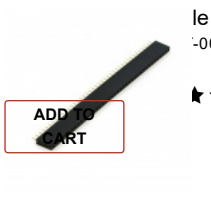
board - Self-Adhesive (White)
-12002
★★½ 34

Away Headers - Straight
-00116
★★½ 20

Edison
-13024
★★☆ 24



ot 10K with Knob
M-09806
★★★ 6

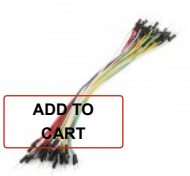


le Headers
-00115
★★☆ 7

SparkFun Block for Intel® Edison - Base
DEV-13045
$19.95

16

er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026



20

16x2 Character LCD - White on Black 3.3V
-09052

2

Fun Block for Intel® Edison - GPIO
-13038

4

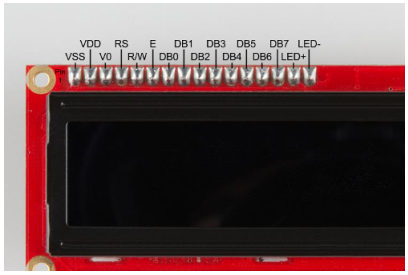
Suggested Reading

- How LCDs Work – Learn how a liquid crystal display does its thing
- OpenWeatherMap – Why is it cool?

Concepts

Parallel Interface

The character LCD that we will be using relies on a *parallel interface*. Instead of a predefined protocol like I^{2}C or UART, the parallel interface sets up the bits on the wires and clocks them in on another wire.



In our case, we will be using the LCD in 4-bit mode. We write a half-byte (nybble) by setting D4-D7 to the nybble. For example, b1011 would be HIGH, LOW, HIGH, HIGH on D4-D7. Then, we would set the R/W pin to LOW (for “write”). Finally, we toggle the E pin from LOW to HIGH, hold it for at least 150 ns, and then toggle it back LOW. This “latches” the data into the LCD. We can send all sorts of commands and data over to LCD with this!

Luckily, we won’t have to write that interface in code ourselves. We have Johnny Five to the rescue!

Johnny Five

Johnny-Five is a JavaScript framework for programming robotics. Much like MRAA, it simplifies the calls we need to make to control various pieces of hardware. At the time of this writing, MRAA did not support parallel interface character LCDs, but Johnny-Five does!

Johnny-Five has support for several boards, and the Edison is one of them. As a result, we can include Johnny-Five in our program (like any Node module), and have it handle LCD communications for us.

Yahoo Weather

There are plenty of weather APIs out there, and all of them would likely work for getting current weather data about a particular city. However, Yahoo Weather allows us to make calls without signing up for an account and returns data in JSON format, which is easily parsed by JavaScript.

We can perform a database lookup on Yahoo's weather servers by constructing a SQL-like string called "YQL". In this example, we will ultimately create a program that constructs a YQL that requests weather data for a particular city and sends it to Yahoo. Yahoo then returns a JSON object that we can parse for temperature and weather conditions.

We realize that we are glossing over SQL and YQL, as they are languages in their own right. To learn more about YQL, visit the Yahoo YQL page.

JSON

JavaScript Object Notatation, or JSON, is a text format for exchanging data between computers. It has the benefit of also being easily read by humans. It consists of a collection of name and value pairs (given as "name" : "value") within an object (as denoted by curly braces {}).

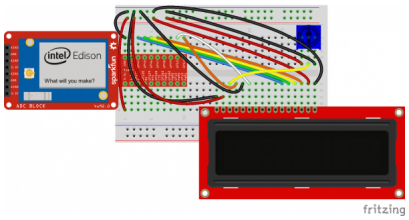
Objects and strings within JSON can aslo be stored in an ordered array (as denoted by brackets []).

Here is an example of a JSON object (from http://json.org/example.html):

```
{
    "glossary": {
        "title": "example glossary",
        "GlossDiv": {
            "title": "S",
            "GlossList": {
                "GlossEntry": {
                    "ID": "SGML",
                    "SortAs": "SGML",
                    "GlossTerm": "Standard Generalized Markup Language",
                    "Acronym": "SGML",
                    "Abbrev": "ISO 8879:1986",
                    "GlossDef": {
                        "para": "A meta-markup language, used to create markup languages such as DocBook.",
                        "GlossSeeAlso": ["GML", "XML"]
                    },
                    "GlossSee": "markup"
                }
            }
        }
    }
}
```

Because this looks very much like a JavaScript object, we can easily parse it with the `JSON.parse()` method. After that, we can access values just by giving the name. For example, if we assigned the above example to myJSON and parsed it, `myJSON.glossary.GlossDiv.title` would return the string `S`.

Hardware Hookup



Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

Part 1: A Simple LCD Message

The Code

Create a new Blank Template *IoT Application*. In *package.json*, paste in the following:

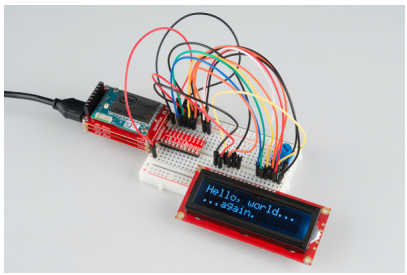
```
{
  "name": "blankapp",
  "description": "",
  "version": "0.0.0",
  "main": "main.js",
  "engines": {
    "node": ">=0.10.0"
  },
  "dependencies": {
      "johnny-five": "0.9.11",
      "edison-io": "0.8.18"
  }
}
```

In *main.js*, paste in the following:

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 9 - Part 1: Character LCD
 * This sketch was written by SparkFun Electronics
 * November 28, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Display a simple string on the character LCD.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// We'll need johnny-five and its Edison wrapper
var five = require('johnny-five');
var Edison = require('edison-io');

// Create a new Johnny-Five board object that we will use to talk to the LCD
var board = new five.Board({
    io: new Edison()
});

// Global variables
var lcd;

// Initialization callback that is called when Johnny-Five is done initializing
board.on('ready', function() {

    // Create our LCD object and define the pins
    // LCD pin name:    RS  EN DB4 DB5 DB6 DB7
    // Edison GPIO:     14  15  44  45  46  47
    lcd = new five.LCD({
        pins: ["GP14", "GP15", "GP44", "GP45", "GP46", "GP47"],
        rows: 2,
        cols: 16
    });

    // Make sure the LCD is on, has been cleared, and the cursor is set to home
    lcd.on();
    lcd.clear();
    lcd.home();

    // Print our string
    lcd.print("Hello, world...");

    // Move to the second line, and continue our thought
    lcd.cursor(1, 0);
    lcd.print("...again.");
});
```

What You Should See

Run the program, and you should see some familiar text on the LCD. Turn the potentiometer's knob to adjust the contrast of the LCD until you see the text appear.



Code to Note

Like any good asynchronous JavaScript library, Johnny-Five requires us to create an instance of the boarr, which we do with `new five.Board()`, and then wait for the board to finish initializing. We provide a callback function within `board.on('ready', ...)` that is run when Johnny-Five is done initializing.

Within that callback, we create an instance of our LCD (affectionately named `lcd`), which is part of hte Johnny-Five library. When we create the LCD object, we assign raw pin numbers to the LCD. After that, we are free to use any of the LCD methods as defined by the API. For our purposes, we make sure the LCD is on, clear it, move the cursor back to the starting position, and write some text to it.

Part 2: Weather Information

The Code

> **NOTE:** This part of the experiment requires the Edison to have an Internet connection.

Now, we get to make our LCD do something a little more interesting. Create a new blank *IoT Application* template, and copy the following into *package.json*:

```
{
  "name": "blankapp",
  "description": "",
  "version": "0.0.0",
  "main": "main.js",
  "engines": {
    "node": ">=0.10.0"
  },
  "dependencies": {
      "johnny-five": "0.9.11",
      "edison-io": "0.8.18"
  }
}
```

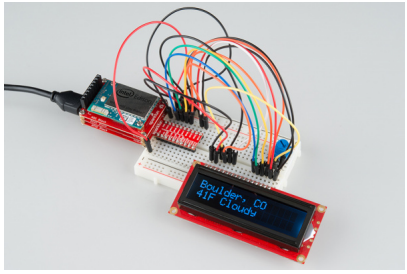
In **main.js**, copy in the following code:

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 9 - Part 2: Weather
 * This sketch was written by SparkFun Electronics
 * November 29, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Download a city's weather information from Yahoo Weather
 * (https://developer.yahoo.com/weather/) and display that city's
 * temperature and current condition.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// We'll need johnny-five, the Edison wrapper, and OpenWeatherMap
var five = require('johnny-five');
var Edison = require('edison-io');
var http = require('http');

// Replace this with the city you want to get the weather from
var cityStr = "Boulder, CO";

// Create a new Johnny-Five board object that we will use to talk to the LCD
var board = new five.Board({
    io: new Edison()
});

// Initialization callback that is called when Johnny-Five is done initializing
board.on('ready', function() {

    // Create our LCD object and define the pins
    // LCD pin name:    RS  EN DB4 DB5 DB6 DB7
    // Edison GPIO:     14  15  44  45  46  47
    lcd = new five.LCD({
        pins: ["GP14", "GP15", "GP44", "GP45", "GP46", "GP47"],
        rows: 2,
        cols: 16
    });

    // Make sure the LCD is on, has been cleared, and the cursor is set to home
    lcd.on();
    lcd.clear();
    lcd.home();

    // Print a splash string
    lcd.print("My Weather App");

    // Start getting weather data
    setInterval( function() {
        getTemperature(cityStr, lcd);
    }, 5000);
});

// A function to make a request to the Yahoo Weather API
function getTemperature(cityReq, lcd) {

    // Construct YQL (https://developer.yahoo.com/weather/)
    var yql = "select * from weather.forecast where woeid in " +
              "(select woeid from geo.places(1) where text='" + cityReq + "')";

    // Construct GET request
    var getReq = "http://query.yahooapis.com/v1/public/yql?q=" +
                    yql.replace(/ /g,"%20") +
                    "&format=json&env=store%3A%2F%2Fdatatables.org%2" +
                    "Falltableswithkeys";

    // Make the request
    var request = http.get(getReq, function(response) {

        // Where we store the response text
        var body = '';

        //Read the data
        response.on('data', function(chunk) {
            body += chunk;
        });

        // Print out the data once we have received all of it
        response.on('end', function() {
            if (response.statusCode === 200) {
                try {
```

```
                    // Parse the JSON to get the pieces we need
                    var weatherResp = JSON.parse(body);
                    var channelResp = weatherResp.query.results.channel;
                    var conditionResp = channelResp.item.condition;

                    // Extract the city and region
                    var city = channelResp.location.city;
                    var region = channelResp.location.region;

                    // Get the local weather
                    var temperature = conditionResp.temp;
                    var tempUnit = channelResp.units.temperature;
                    var description = conditionResp.text;

                    // Construct city and weather strings to be printed
                    var cityString = city + ", " + region;
                    var weatherString = temperature + tempUnit + " " +
                                        description;

                    //Print the city, region, time, and temperature
                    console.log(cityString);
                    console.log(weatherString + "\n");

                    // Truncate the city and weather strings to fit on the LCD
                    cityString = cityString.substring(0, 16);
                    weatherString = weatherString.substring(0, 16);

                    // Print them on the LCD
                    lcd.clear();
                    lcd.home();
                    lcd.print(cityString);
                    lcd.cursor(1, 0);
                    lcd.print(weatherString);

                } catch(error) {

                    // Report problem with parsing the JSON
                    console.log("Parsing error: " + error);
                }
            } else {

                // Report problem with the response
                console.log("Response error: " +
                            http.STATUS_CODES[response.statusCode]);
            }
        })
    });

    // Report a problem with the connection
    request.on('error', function (err) {
        console.log("Connection error: " + err);
    });
}
```

What You Should See

Run the code on the Edison, and you should see a splash screen of “My Weather App”, which will then change into the weather for Boulder, CO.



Code to Note

We have used the `http` module before to create a server, but now, we are using it to issue HTTP GET requests to a remote server. In this case, we construct a query consisting of the city we want to search for usign YQL. We send that request to Yahoo with `http.get()`.

Once again, we create a callback, but this time in `http.get()`. If all goes well, Yahoo’s server responds with the code “200” (which means “OK” in HTTP code-speak) along with a JSON containing the requested data.

We parse that data with `JSON.parse()` and extract the pieces we want (city, region, temperature, temperature unit, and weather condition. We then display that information both in the console and on the LCD.

Troubleshooting

- **The LCD does not work or displays garbage** – More than likely, this is a wiring problem. Double-check the wires and move them around to make sure they are making good contact in the breadboard.
- **The LCD is on but not displaying anything** – Turn the knob on the potentiometer to adjust the contrast on the LCD.
- **I get errors trying to request weather data** – This could be a few things:
    - Make sure the Edison has an Internet connection (try logging in and issuing a `ping` command from the Edison)

- Make sure that `citystr` is a viable location request to YQL. Try a known location first, such as “Boulder, CO”.

Going Further

Challenges

1. Go back to part 1 and make the LCD say something of your choosing, for example, your name.
2. Notice that we are truncating the strings before we send them to the LCD in part 2. Have the LCD scroll the text so that we don't have to truncate it. *Hint:* See the Johnny-Five LCD API.
3. Display a different piece of weather information on the LCD. For example, show the wind speed of a city of your choosing.

Digging Deeper

- Character LCD datasheet
- Johnny-Five GitHub repository
- Yahoo Weather API documentation

Experiment 10: Keyboard

Introduction

The Edison, luckily for us, has a USB On-the-Go (OTG) port, which means that we can optionally treat the Edison as a USB host or a USB device. In this experiment, we will use the OTG port as a USB host port and connect a keyboard to our Edison. We will then be able to type and have the characters appear on the LCD.

In the second part of the experiment, we take the concept one step further and have the Edison host a web page that acts as a simplistic chat room. Anyone on the same network can view the page, post messages, and see messages from the Edison (as they were typed into the keyboard).

You will need to provide your own USB keyboard for this example. Not all keyboards will work. Do not feel obligated to complete this experiment if you cannot find a USB keyboard that will work.

NOTE: Because we are using the OTG port in this experiment, you will not be able to use it to create a USB network with the Edison. You will need to connect the XDK to your Edison over WiFi instead.

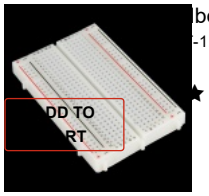
Parts Needed

We'll be using the same circuit as in the previous example. The only thing we will be adding is the USB OTG cable, which will be plugged into the Base Block. In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** Character LCD
- **1x** 10k Potentiometer
- **16x** Jumper Wires
- **1x** USB OTG Cable

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

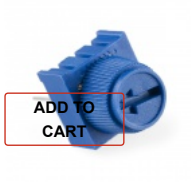
tor Kit - 1/4W (500 total)
M-10969
★★½ 122



board - Self-Adhesive (White)
-12002
★★½ 34

Away Headers - Straight
-00116
★★½ 20

Edison
-13024
★★☆ 24



ot 10K with Knob
M-09806

★★★ 6

le Headers
-00115

★★☆ 7

Fun Block for Intel® Edison - Base
-13045

★★½ 16

er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026

★★½ 20

16x2 Character LCD - White on Black 3.3V
-09052

★★☆ 2

Fun Block for Intel® Edison - GPIO
-13038

★½☆ 4

OTG Cable - Female A to Micro A - 4"
-11604

★½☆ 3

Suggested Reading

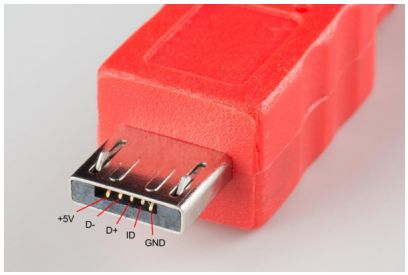
- How USB Works – How USB sends data over a couple of wires
- Socket.IO chat room example – We base our chat room on this example. This Socket.IO example does a great job of explaining how it works.

Concepts

USB OTG

USB OTG is an interesting concept in the world of computer peripherals. Most USB connections require a host and a device (or several devices that have been plugged into a hub that goes to a host). However, OTG allows for a device to automatically detect whether it should play the role of a host or a peripheral.

Normally, USB plugs have 4 pins. OTG introduces a fifth pin (known as the “ID pin”) that allows the device to determine if it should be a host or a peripheral.



In our case, we will be using a special OTG cable that enumerates that ID pin and terminates with a normal type-A receptacle. This allows us to plug in USB peripherals (such as keyboards and mice) and the Edison will become the USB host.

If you were using the OTG port for previous exercises to create a USB network, you were putting the Edison into device mode. The powers of OTG are very useful.

Linux Hacking

OK, we're not going to actually hack Linux. However, we are going dig into the file system in order to detect key presses on the keyboard.

Whenever we plug in a keyboard, Linux creates a file in */dev/input/* with the name *eventX*, where *X* is a number assigned to that device. In our Edison, the keyboard is *event2*, assuming no other devices are plugged in (you can also figure out which device is your keyboard by logging into the Edison and executing the command `cat /proc/bus/input/devices`).

If we read the contents of this file, it updates every time a keyboard event occurs (e.g. key down, key up). We can create a stream listener with `fs.readStreamListener()` on this file that calls a function every time new data appears in the file.

The data that is provided to the callback is in the form of a fairly large buffer of raw bytes. Knowing that, we can look at specific bytes to figure out what kind of event is occurring:

- Byte 24 is a key event
- Byte 28 is the type of event (0x01 means "key down")
- Bytes 26 and 27 refer to the key that has been pressed (for example, 19 is the 'r' key)

The input event codes can be found in the input-event-codes.h file.

Chat Room

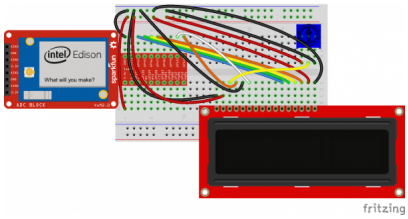
Chat rooms are nearly as old as the Internet itself. Dating back to the early 1970s, users could send text messages to everyone viewing a page or connected with a special program.

We are going to construct a very simple chat room using Socket.IO. In this exercise, we create a web page with three fields. At the bottom, users can enter a text message and send it with a button. Taking up most of the page is the "room" itself.

When a user sends a message, the text is sent to the server running the chat room (the Edison, in this case), and the server then sends out that text to all users currently looking at the page in a browser.

Hardware Hookup

The circuit is the same as in the previous experiment.



Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

Plug the USB OTG cable into the port labeled "OTG" on the Base Block. Plug your USB keyboard into the other end of the OTG cable.

Part 1: Keyboard to LCD

The Code

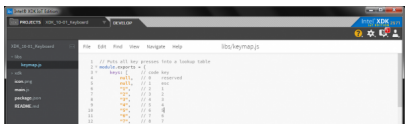
Create a new Blank *IoT Application* Template. Copy the following into *package.json*:

```
{
  "name": "blankapp",
  "description": "",
  "version": "0.0.0",
  "main": "main.js",
  "engines": {
    "node": ">=0.10.0"
  },
  "dependencies": {
      "johnny-five": "0.9.11",
      "edison-io": "0.8.18"
  }
}
```

In the file explorer, create a new directory named *libs*. In *libs*, create a file named *keymap.js*. In that file, copy in the following:

```
// Puts all key presses into a lookup table
module.exports = {
    keys: [     // code key
        null,   // 0    reserved
        null,   // 1    esc
        "1",    // 2    1
        "2",    // 3    2
        "3",    // 4    3
        "4",    // 5    4
        "5",    // 6    5
        "6",    // 7    6
        "7",    // 8    7
        "8",    // 9    8
        "9",    // 10   9
        "0",    // 11   0
        "-",    // 12   minus
        "=",    // 13   equal
        "bksp", // 14   backspace
        null,   // 15   tab
        "q",    // 16   q
        "w",    // 17   w
        "e",    // 18   e
        "r",    // 19   r
        "t",    // 20   t
        "y",    // 21   y
        "u",    // 22   u
        "i",    // 23   i
        "o",    // 24   o
        "p",    // 25   p
        "[",    // 26   left brace
        "]",    // 27   right brace
        "enter",// 28   enter
        null,   // 29   left ctrl
        "a",    // 30   a
        "s",    // 31   s
        "d",    // 32   d
        "f",    // 33   f
        "g",    // 34   g
        "h",    // 35   h
        "j",    // 36   j
        "k",    // 37   k
        "l",    // 38   l
        ";",    // 39   semicolon
        "'",    // 40   apostrophe
        "`",    // 41   grave
        null,   // 42   left shift
        "\\",   // 43   backslash
        "z",    // 44   z
        "x",    // 45   x
        "c",    // 46   c
        "v",    // 47   v
        "b",    // 48   b
        "n",    // 49   n
        "m",    // 50   m
        ",",    // 51   comma
        ".",    // 52   dot
        "/",    // 53   slash
        null,   // 54   right shift
        null,   // 55   kpasterisk
        null,   // 56   left alt
        " "     // 57   space
    ]
};
```

Your project should have the following files:



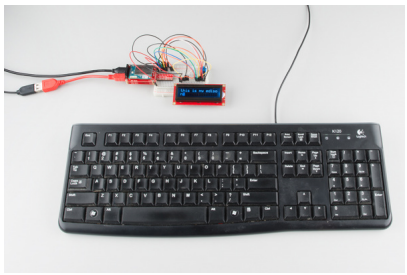
In *main.js*, copy in:

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 10 - Part 1: Keyboard
 * This sketch was written by SparkFun Electronics
 * November 18, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Capture keystrokes from a USB-connected keyboard and display them on a
 * character LCD.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the filesystem module and our keymap table
var fs = require('fs');
var keymap = require('./libs/keymap.js');

// We'll also need johnny-five and its Edison wrapper
var five = require('johnny-five');
var Edison = require('edison-io');
var board = new five.Board({
    io: new Edison()
});

// Global variables
var lcd;
var cursorPos;

// Johnny Five initialization
board.on('ready', function() {

    // Create our LCD object and define the pins
    // LCD pin name:    RS  EN DB4 DB5 DB6 DB7
    // Edison GPIO:     14  15  44  45  46  47
    lcd = new five.LCD({
        pins: ["GP14", "GP15", "GP44", "GP45", "GP46", "GP47"],
        backlight: 6,
        rows: 2,
        cols: 16
    });

    // Turn on LCD, clear it, and set cursor to home
    lcd.on();
    lcd.clear();
    lcd.home();
    lcd.blink();
    cursorPos = 0;
    console.log("Start typing!");
});

// Create a stream that emits events on every key stroke
var readableStream = fs.createReadStream('/dev/input/event2');

// Callback for a key event
readableStream.on('data', function(buf) {

    // Check for key down event and determine key pressed
    if ((buf[24] == 1) && (buf[28] == 1)) {
        var keyCode = ((buf[27] & 0xff) << 8) | (buf[26] & 0xff);
        var keyChar = keymap.keys[keyCode];

        // Make the character appear on the LCD
        if (lcd !== undefined) {

            // If it is a backspace, delete the previous character
            if (keyChar === 'bksp') {
                cursorPos--;
                if (cursorPos <= 0) {
                    cursorPos = 0;
                }
                lcd.print(" ");
                lcd.cursor(
                    Math.floor(cursorPos / lcd.cols),
                    (cursorPos % lcd.cols)
                );
                lcd.print(" ");
                lcd.cursor(
                    Math.floor(cursorPos / lcd.cols),
                    (cursorPos % lcd.cols)
                );

            // If it is a return character, clear the LCD
```

```
            } else if (keyChar == 'enter') {
                lcd.clear();
                cursorPos = 0;

            // Otherwise, print the character to the LCD
            } else if ((keyChar !== null) && (keyChar !== undefined)) {
                lcd.print(keyChar);
                cursorPos++;
            }

            // Stop the cursor at the end of the LCD
            if (cursorPos >= (lcd.rows * lcd.cols)) {
                cursorPos = (lcd.rows * lcd.cols) - 1;
            }

            // Update the cursor position (wrap to second line if needed)
            lcd.cursor(
                Math.floor(cursorPos / lcd.cols),
                (cursorPos % lcd.cols)
            );
        }
    }
});
```

What You Should See

Make sure that your keyboard is plugged into the OTG port and run the program. You should be able to type on the keyboard and have the text appear on the LCD!



Code to Note

`readableStream.on('data', function(buf) {...})` is the callback for when the */dev/input/event2* file receives new data (e.g. a key was pressed). Within the function of the callback, we figure out which key was pressed by looking at specific bytes in `buf`.

Using bytes 26 and 27 of `buf`, we create an index for our lookup table (called `keymap`). This keymap was created in the *keymap.js* file. The keymap is just an array. When we index into the array with the number created from bytes 26 and 27, we are returned a string corresponding to the key that was pushed.

You might have noticed that we defined our keymap table in a separate file (*keymap.js*). We can store functions, variables, objects, etc. in another file and access them if we do 2 things:

1. Define an exports object in the *external* file with `module.exports`. This allows properties of that object to be accessed by code in the *importing* file. In this case, we want access to the `keys` array.
2. In the *importing* file (*main.js* in this instance), include the *external* file with a `require()` statement and assign it to a variable. In this case, we included the *keymap.js* file with `var keymap = require('./libs/keymap.js');`. Then, we were able to access the `keys` variable with `keymap.keys` later in the code.

Part 2: Chat Room

The Code

NOTE: This part of the experiment requires the Edison to have an Internet connection.

Create another project with the Blank *IoT Application* Template. In *package.js*, copy in:

```
{
  "name": "blankapp",
  "description": "",
  "version": "0.0.0",
  "main": "main.js",
  "engines": {
    "node": ">=0.10.0"
  },
  "dependencies": {
      "socket.io": "1.3.7",
      "express": "4.10.2",
      "johnny-five": "0.9.11",
      "edison-io": "0.8.18"
  }
}
```

Like in part 1, create a new directory and file within the project: *libs/keymap.js*. In that file, copy in:

```
// Puts all key presses into a lookup table
module.exports = {
    keys: [     // code key
        null,   // 0    reserved
        null,   // 1    esc
        "1",    // 2    1
        "2",    // 3    2
        "3",    // 4    3
        "4",    // 5    4
        "5",    // 6    5
        "6",    // 7    6
        "7",    // 8    7
        "8",    // 9    8
        "9",    // 10   9
        "0",    // 11   0
        "-",    // 12   minus
        "=",    // 13   equal
        "bksp", // 14   backspace
        null,   // 15   tab
        "q",    // 16   q
        "w",    // 17   w
        "e",    // 18   e
        "r",    // 19   r
        "t",    // 20   t
        "y",    // 21   y
        "u",    // 22   u
        "i",    // 23   i
        "o",    // 24   o
        "p",    // 25   p
        "[",    // 26   left brace
        "]",    // 27   right brace
        "enter",// 28   enter
        null,   // 29   left ctrl
        "a",    // 30   a
        "s",    // 31   s
        "d",    // 32   d
        "f",    // 33   f
        "g",    // 34   g
        "h",    // 35   h
        "j",    // 36   j
        "k",    // 37   k
        "l",    // 38   l
        ";",    // 39   semicolon
        "'",    // 40   apostrophe
        "`",    // 41   grave
        null,   // 42   left shift
        "\\",   // 43   backslash
        "z",    // 44   z
        "x",    // 45   x
        "c",    // 46   c
        "v",    // 47   v
        "b",    // 48   b
        "n",    // 49   n
        "m",    // 50   m
        ",",    // 51   comma
        ".",    // 52   dot
        "/",    // 53   slash
        null,   // 54   right shift
        null,   // 55   kpasterisk
        null,   // 56   left alt
        " "     // 57   space
    ]
};
```

Create a new file in the project called *index.html*, and copy in the following:

```
<!doctype html>
<html>
    <head>
        <title>Socket.IO chat</title>
        <style>
            * { margin: 0; padding: 0; box-sizing: border-box; }
            body { font: 13px Helvetica, Arial; }
            form { background: #000; padding: 3px; position: fixed; bottom: 0; width: 100%; }
            form input { border: 0; padding: 10px; width: 90%; margin-right: .5%; }
            form button { width: 9%; background: rgb(130, 224, 255); border: none; padding: 10px; }
            #messages { list-style-type: none; margin: 0; padding: 0; }
            #messages li { padding: 5px 10px; }
            #messages li:nth-child(odd) { background: #eee; }
        </style>
    </head>
    <body>
        <ul id="messages"></ul>
        <form action="">
            <input id="m" autocomplete="off" /><button>Send</button>
        </form>
        <script src="/socket.io/socket.io.js"></script>
        <script src="http://code.jquery.com/jquery-1.11.1.js"></script>
        <script src="http://code.jquery.com/jquery-2.1.4.js"></script>
        <script>

            // Create our socket.io object
            var socket = io();

            // Get content from the input box and sent it to the server
            $('form').submit(function() {
                socket.emit('chat message', $('#m').val());
                $('#m').val('');
                return false;
            });

            // If we receive a chat message, add it to the chat box
            socket.on('chat message', function(msg) {
                $('#messages').append($('<li>').text(msg));
            });
        </script>
    </body>
</html>
```

Save that file. You should have the following files:

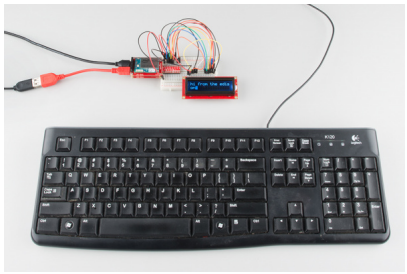
In *main.js*, copy in:

```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 10 - Part 2: Chat Room
 * This sketch was written by SparkFun Electronics
 * November 20, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Serves a chat room where users can post messages. Captures keyboard input
 * and posts messages to the chat room.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Import the filesystem module and our keymap table
var fs = require('fs');
var keymap = require('./libs/keymap.js');

// We'll also need johny-five and its Edison wrapper
var five = require('johnny-five');
var Edison = require('edison-io');
var board = new five.Board({
    io: new Edison()
});

// Import HTTP and Express modules
var app = require('express')();
var http = require('http').Server(app);
var io = require('socket.io')(http);

// Global variables
var port = 4242;
var lcd;

// Johnny Five initialization
board.on('ready', function() {

    // Create our LCD object and define the pins
    // LCD pin name:    RS  EN DB4 DB5 DB6 DB7
    // Edison GPIO:     14  15  44  45  46  47
    lcd = new five.LCD({
        pins: ["GP14", "GP15", "GP44", "GP45", "GP46", "GP47"],
        backlight: 6,
        rows: 2,
        cols: 16
    });

    // Turn on LCD, clear it, and set cursor to home
    lcd.on();
    lcd.clear();
    lcd.home();
    lcd.blink();
    lcd.cursorPos = 0;
    lcd.msg = "";
    console.log("Start typing!");
});

// Create a stream that emits events on every key stroke
var readableStream = fs.createReadStream('/dev/input/event2');

// Callback for a key event
readableStream.on('data', function(buf) {

    // Check for key down event and determine key pressed
    if ((buf[24] == 1) && (buf[28] == 1)) {
        var keyCode = ((buf[27] & 0xff) << 8) | (buf[26] & 0xff);
        var keyChar = keymap.keys[keyCode];

        // Make the character appear on the LCD
        if (lcd !== undefined) {

            // If it is a backspace, delete the previous character
            if (keyChar === 'bksp') {
                if (lcd.msg !== "") {
                    lcd.msg = lcd.msg.slice(0, -1);
                }
                lcd.cursorPos--;
                if (lcd.cursorPos <= 0) {
                    lcd.cursorPos = 0;
                }
                lcd.print(" ");
                lcd.cursor(
                    Math.floor(lcd.cursorPos / lcd.cols),
```

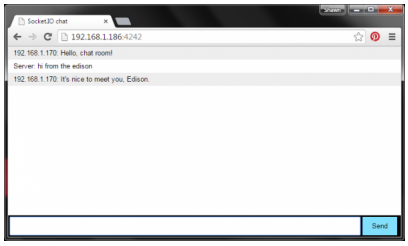
```
                    (lcd.cursorPos % lcd.cols)
                );
                lcd.print(" ");
                lcd.cursor(
                    Math.floor(lcd.cursorPos / lcd.cols),
                    (lcd.cursorPos % lcd.cols)
                );

            // If it is a return character, post message and clear the LCD
            } else if (keyChar == 'enter') {
                console.log("Server: " + lcd.msg);
                io.emit('chat message', "Server: " + lcd.msg);
                lcd.clear();
                lcd.cursorPos = 0;
                lcd.msg = "";

            // Otherwise, print the character to the LCD
            } else if ((keyChar !== null) && (keyChar !== undefined)) {

                // Have the character appear on the LCD and append to message
                lcd.print(keyChar);
                lcd.cursorPos++;

                // Stop the cursor at the end of the LCD
                if (lcd.cursorPos >= (lcd.rows * lcd.cols)) {
                    lcd.cursorPos = (lcd.rows * lcd.cols) - 1;
                }

                // Remove the last char if we reached the end of the buffer
                if (lcd.msg.length >= (lcd.rows * lcd.cols)) {
                    lcd.msg = lcd.msg.slice(0, -1);
                }

                // Append character to message
                lcd.msg = lcd.msg.concat(keyChar);
            }

            // Update the cursor position (wrap to second line if needed)
            lcd.cursor(
                Math.floor(lcd.cursorPos / lcd.cols),
                (lcd.cursorPos % lcd.cols)
            );
        }
    }
});

// Send the web page on client request
app.get('/', function(req, res) {
    res.sendFile(__dirname + "/index.html");
});

// Create a handler for when a client connects
io.on('connection', function(socket) {
    var clientIP = socket.client.conn.remoteAddress;

    // If we get a chat message, send it out to all clients
    socket.on('chat message', function(msg) {
        console.log(clientIP + ": " + msg);
        io.emit('chat message', clientIP + ": " + msg);
    });
});

// Start the server
http.listen(4242, function() {
    console.log('Server listening on port ' + port);
});
```

What You Should See

You should be able type on the keyboard and have the text appear on the LCD, like in part 1.



However, if you open a browser on a computer that is on the same network as the Edison, you should be able to browse to `http://<Edison's IP address>:4242` and see a simple chat room. Enter in some text at the bottom. Then, type in some text on the keyboard attached to the Edison. Press ‘enter’ to send that message to the chat room!



Code to Note

```
app.get('/', function(req, res) {
    res.sendFile(__dirname + "/index.html");
});
```

Serves the web page (*index.html*) to the client's browser on a request.

```
// If we get a chat message, send it out to all clients
socket.on('chat message', function(msg) {
    console.log(clientIP + ": " + msg);
    io.emit('chat message', clientIP + ": " + msg);
});
```

This is the crux of the chat room. Any new message we receive from the socket.io connection, we broadcast it to all other clients connected.

In *index.html*, we handle text entry with:

```
$('form').submit(function() {
    socket.emit('chat message', $('#m').val());
    $('#m').val('');
    return false;
});
```

When we click the "Send" button, we capture the text in the input box and send it to the server (Edison). the Edison then relays that text, and we look for messages from the Edison with:

```
socket.on('chat message', function(msg) {
    $('#messages').append($('<li>').text(msg));
});
```

On a message from the Edison, we add it as a list item in the main *messages* pane.

Troubleshooting

- **The LCD isn't working!** – Double-check the wiring and adjust the potentiometer.
- **Nothing happens when I type on the keyboard** – Make sure that the keyboard is plugged into the OTG port on the Base Block. Additionally, some keyboards are not supported, so we recommend trying a different USB keyboard, if you can.

Going Further

Challenges

1. You might have noticed that capital letters are not supported from the keyboard. We can detect that the shift key has been pushed, but in our examples, we ignore it. Make the shift key work and have capital letters actually appear on the LCD and in the chat room!
2. Create a chat room log. By default, once messages are broadcast, they only appear in the browsers for clients who are connected. Sometimes, it is helpful for the server to maintain a log of all the messages that appeared in the chat room. Devise a way to store all messages into a file on the Edison so that it can later be read (also known as "auditing").

Digging Deeper

- Linux key events header file
- Linux event types header file
- Socket.IO documentation

Experiment 11: Phone Accelerometer

One interesting feature of the XDK is its ability to let us create cross-platform programs for various phone operating systems without having to rewrite code in different langauges. This ability is possible thanks to a framework called Cordova. Cordova allows us to write programs in HTML and JavaScript (much like the web apps we wrote in previous exercises) but includes plugins that allow us to control hardware components in the phone (e.g. GPS, accelerometer, etc.).

In addition to Cordova, we are also going to introduce Bluetooth Low Energy (BLE) communication. BLE is very useful for communicating between devices within a very short distance of each other.

In the end, we want to turn our phone into a type of controller that reads accelerometer data, sends it to the Edison over BLE, and moves a character on an LCD attached to the Edison.

IMPORTANT: Cordova needs to run native code on your smartphone in order to operate. As a result, you will need to be able to install native apps.

- If you have an iPhone, you will need to enroll in the Apple Developer Program (there is a yearly membership fee) and create Ad Hoc Provisioning Profiles (discussed later)
- If you have an Android, you can allow the installation of apps from "Unknown Sources" and install the app from a downloaded .apk file

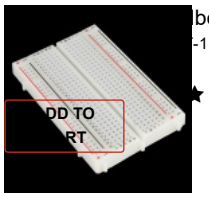
Parts Needed

We'll be using the same circuit as in the previous example, only without the keyboard and USB OTG cable. In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **1x** Character LCD
- **1x** 10k Potentiometer
- **16x** Jumper Wires

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

tor Kit - 1/4W (500 total)
M-10969
★★½ 122



board - Self-Adhesive (White)
-12002
★★½ 34

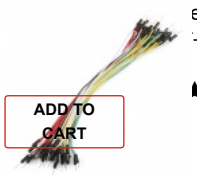
Away Headers - Straight
-00116
★★½ 20

Edison
-13024
★★☆ 24

ot 10K with Knob
M-09806
★★★ 6

le Headers
-00115
★★☆ 7

Fun Block for Intel® Edison - Base
-13045
★★½ 16



er Wires Standard 7" M/M - 30 AWG (30 Pack)
-11026
★★½ 20

16x2 Character LCD - White on Black 3.3V
-09052
2

Fun Block for Intel® Edison - GPIO
-13038
4

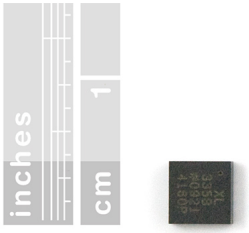
Suggested Reading

- The State of Native vs. Web vs. Hybrid – What's the difference between a native app, a web app, and a hybrid app?
- Apache Cordova – Learn a little bit about Cordova
- Bluetooth Basics – A brief overview of how Bluetooth works

Concepts

Accelerometer

Most modern accelerometers measure acceleration (or g-force) by using a tiny electromechanical system: small beams that moves when the system undergoes some type of acceleration. The chip can measure the capacitance between sets of beams and determine the acceleration of the device.



Most modern cell phones contain built-in accelerometers. Most often, they are used to determine the orientation of the phone (as gravity offers a 9.8 m/s acceleration toward the center of the Earth). This information allows the phone to adjust the contents of the screen to always be "up" for the user!

In this experiment, we are going to use our smartphone's internal accelerometer to control something on the Edison.

Cordova

Cordova is an open-source framework for creating smartphone apps in standard web languages (e.g. JavaScript, HTML, CSS). It allows developers to access low-level features of the phone, such as GPS and the accelerometer as well as create apps that compile for multiple mobile operating systems, such as iOS and Android, with one set of code.

Cordova relies on a set of *plugins* that enables developers to call native phone features without having to write native code. In essence, the plugins offer a JavaScript API for calling native features. We will use some of these plugins to access the accelerometer and Bluetooth radio in the phone.

Bluetooth Low Energy

Bluetooth is a protocol for sending and receiving data over a 2.4 GHz wireless link. It was designed to be low-power, low-cost, and short-range. Many devices, including most smartphones, have embedded Bluetooth radios, which allow them to talk to other devices and peripherals, like keyboards and pedometers.

Bluetooth Low Energy is an extension of Bluetooth that was introduced in the Bluetooth 4.0 standard. It offers a huge reduction in power consumption by sacrificing range and data throughput.

Along with great power savings came a new set of terminology and programming model. BLE uses the concept of “servers” and “clients.”

- **Client** – A device that initiates a commands and connections. For example, your smartphone.
- **Server** – A device that accepts commands and returns responses. For example, a temperature sensor.

We also need to be aware of how BLE groups data:

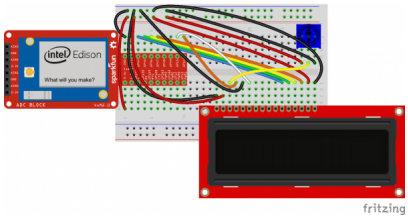
- **Service** – A group of related characteristics
- **Characteristic** – A data value to be transferred between a server and a client
- **Descriptor** – Additional information about the characteristic. For example, an indication of units (e.g. Celsius).

Note that what we have described is the Generic Attribution Profile (GATT). BLE also defines a Generic Access Pofile (GAP) that allows a peripheral to broadcast to multiple *central* devices, but we will not be using it in this experiment.

In our example, we will treat the Edison as the server (using the bleno module) and the smartphone as the client (using cordova-plugin-ble-central).

Hardware Hookup

The circuit is the same as in the previous experiment.



Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

The Code

Edison Code

Unfortunately, at this time, the Edison does not enable its Bluetooth radio by default and runs *bluetoothd* on default, which conflicts with our bleno module. To fix it, we need to issue a few commands in order to use it. Log in to the Edison over SSH or serial and enter your credentials (username *root* and the password you’ve created).

Enter the following commands:

```
rfkill unblock bluetooth
killall bluetoothd
hciconfig hci0 up
```

IMPORTANT! The Edison will re-block bluetooth and begin running bluetoothd on every reboot. As a result, you will need to issue these commands every time you boot up the Edison *before* running a Bluetooth Low Energy application.

We will need to copy the Bluetooth MAC address of the Edison so that we can connect to it from our phone. To do that, enter the following command into your SSH or serial console:

```
hciconfig dev
```

You should have 1 (possibly more) entries. One of them should be labeled “hci0,” which is our Bluetooth device. Copy or write down the 6 hexadecimal numbers under **BD Address**.

Create a new Blank *IoT Application* and copy the following into *package.json*:

```
{
  "name": "blankapp",
  "description": "",
  "version": "0.0.0",
  "main": "main.js",
  "engines": {
    "node": ">=0.10.0"
  },
  "dependencies": {
      "bleno": "0.3.3",
      "johnny-five": "0.9.14",
      "edison-io": "0.8.18"
  }


}
```

Copy the following into *main.js*:

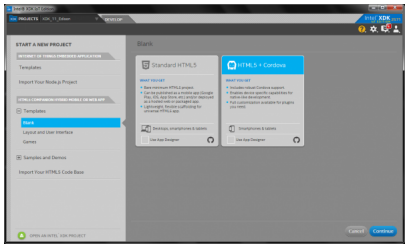
```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 11: Edison BLE Display
 * This sketch was written by SparkFun Electronics
 * November 30, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Accepts a connection from a smartphone and processes accelerometer data
 * from the cell phone (sent over BLE). Displays a character on the LCD that is
 * moved with the phone's accelerometer data.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// bleno makes the Edison act as a BLE peripheral
var bleno = require('bleno');

// We'll also need johnny-five and its Edison wrapper
var five = require('johnny-five');
var Edison = require('edison-io');

// Global game object
var game = {
    lcd: null,
    charX: 7,
    prevX: 0
};

// Create a new Johnny-Five board object that we will use to talk to the LCD
var board = new five.Board({
    io: new Edison()
});

// BLE service and characteristic information
var edison = {
    name: "Edison",
    deviceId: null,
    service: "12ab",
    characteristic: "34cd"
};

// Define our display characteristic, which can be subscribed to
displayCharacteristic = new bleno.Characteristic({
    uuid: edison.characteristic,
    properties: ['write'],
    onWriteRequest : function(data, offset, withoutResponse, callback) {

        // Parse the incoming data into X, Y, and Z acceleration values
        var accel = {
            x: data.readInt16LE(0) / 100,
            y: data.readInt16LE(2) / 100,
            z: data.readInt16LE(4) / 100
        };

        // Write the X, Y, and Z values to the console
        console.log("Write request: X=" + accel.x +
                    " Y=" + accel.y +
                    " Z=" + accel.z);

        // Update character's position and bound it to the limits of the LCD
        game.charX += accel.y / 10;
        if (game.charX < 0) {
            game.charX = 0;
        }
        if (game.charX > 15) {
            game.charX = 15;
        }

        callback(this.RESULT_SUCCESS);
    }
});

// Once bleno starts, begin advertising our BLE address
bleno.on('stateChange', function(state) {
    console.log('State change: ' + state);
    if (state === 'poweredOn') {
        bleno.startAdvertising(edison.name,[edison.service]);
    } else {
        bleno.stopAdvertising();
    }
});
```

```
// Notify the console that we've accepted a connection
bleno.on('accept', function(clientAddress) {
    console.log("Accepted connection from address: " + clientAddress);
});

// Notify the console that we have disconnected from a client
bleno.on('disconnect', function(clientAddress) {
    console.log("Disconnected from address: " + clientAddress);
});

// When we begin advertising, create a new service and characteristic
bleno.on('advertisingStart', function(error) {
    if (error) {
        console.log("Advertising start error:" + error);
    } else {
        console.log("Advertising start success");
        bleno.setServices([

            // Define a new service
            new bleno.PrimaryService({
                uuid: edison.service,
                characteristics: [
                    displayCharacteristic
                ]
            })
        ]);
    }
});

// Initialization callback that is called when Johnny-Five is done initializing
board.on('ready', function() {

    // Create our LCD object and define the pins
    // LCD pin name:    RS  EN DB4 DB5 DB6 DB7
    // Edison GPIO:     14  15  44  45  46  47
    game.lcd = new five.LCD({
        pins: ["GP14", "GP15", "GP44", "GP45", "GP46", "GP47"],
        rows: 2,
        cols: 16
    });

    // Make sure the LCD is on, has been cleared, and the cursor is set to home
    game.lcd.on();
    game.lcd.clear();
    game.lcd.home();

    // Start running the game thread
    setInterval(draw, 50);
});

// Main game thread
function draw() {

    // Erase previous character
    game.lcd.cursor(0, game.prevX);
    game.lcd.print(" ");

    // Set cursor to character's current position
    var x = Math.round(game.charX);
    game.lcd.cursor(0, x);

    // Draw character
    game.lcd.print("o");

    // Set previous character location
    game.prevX = x;
}
```

Upload and run the code. We want the Edison to be looking for connection requests from the smartphone when we start running the phone app.

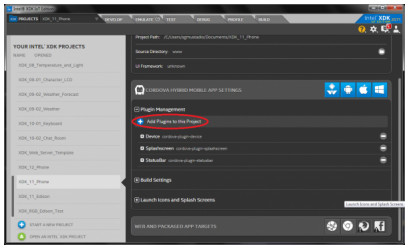
Phone App

We need to create a Cordova app. To do that, create a new project in the XDK and select **HTML5 + Cordova** under *Blank Templates* in *HTML5 Companion Hybrid Mobile or Web App*.

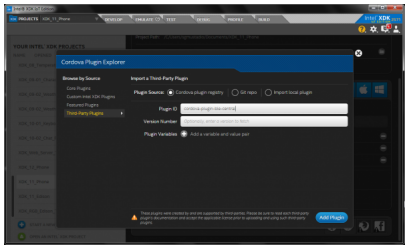


Give your app some appropriate name and click **Create**. You should be presented with a development environment much like the one for the web app. In the upper-left corner of the XDK, click the word **Projects**.

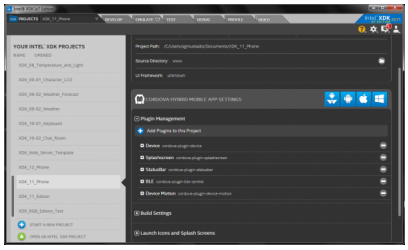
You will be brought to the project settings. Under *Cordova Hybrid Mobile App Settings*, expand **Plugin Management**, and click **Add plugins to this project**.



Click on **Third-Party Plugins** and enter `cordova-plugin-ble-central` into the *Plugin ID* field.



Click **Add Plugin**, and repeat this same process to add `cordova-plugin-device-motion` , which allows us to access the phone's accelerometer. Once you have added the two plugins, you should see them listed under *Plugin Management* in the project settings.



Before we can add code, we need to include *jQuery*. Download the latest, uncompressed version of jQuery from http://jquery.com/download/. Create two new directories in your project so that you have */www/lib/jquery*. Copy the .js file into the *jquery* directory.

Go back to the *Develop* tab. In *www/index.html*, copy in the following:

```
<!DOCTYPE html>

<!--
SparkFun Inventor's Kit for Edison
Experiment 11: Accelerometer Demo
This sketch was written by SparkFun Electronics
November 29, 2015
https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments

Runs as BLE central on smartphone. Connects to the Edison and sends
accelerometer data.

Released under the MIT License(http://opensource.org/licenses/MIT)
-->

<html>

<head>
  <title>Accelerometer</title>
    <meta http-equiv="Content-type" content="text/html; charset=utf-8">
    <meta name="viewport" content="width=device-width, minimum-scale=1, initial-scale=1, user-scalable=no">
    <style>
        @-ms-viewport { width: 100vw ; min-zoom: 100% ; zoom: 100% ; }  @viewport { width: 100vw ; min-zoom: 100% zoom: 100% ; }
        @-ms-viewport { user-zoom: fixed ; min-zoom: 100% ; }           @viewport { user-zoom: fixed ; min-zoom: 100% ; }
        .accel {
            clear:both;
            font-family:Arial;
            font-size:14pt;
            margin: auto;
            text-align:right;
            width: 280px;
        }
        .accel:after {
            visibility: hidden;
            display: block;
            font-size: 0;
            content: " ";
            clear: both;
            height: 0;
        }
        .accel * {
            -webkit-box-sizing: border-box;
            -moz-box-sizing: border-box;
            box-sizing: border-box;
        }
        .accel div {
            background-color:#B6B6B6;
            float: left;
            padding: 3px;
            width: 20%;
        }
        .accel div.label {
            background: transparent;
            font-weight: bold;
            width: 10%;
        }
    </style>
</head>

<body>

    <!-- Our header -->
    <h3 style="text-align:center;">Accelerometer Demo</h3>

    <style>

    </style>

    <!-- X, Y, Z accelerometer fields -->
    <div class="accel">
        <div class="label">X:</div>
        <div id="x">0.00</div>
        <div class="label">Y:</div>
        <div id="y">0.00</div>
        <div class="label">Z:</div>
        <div id="z">0.00</div>
    </div>

    <!-- Debugging -->
    <div style="margin:auto;
                width:280px;
                height:20px;
                padding:1px;">
        Debugging console
    </div>
    <div id="debug_box" style="margin:auto;
```

```
                            width:280px;
                            height:240px;
                            padding:1px;
                            overflow:auto;
                            background:#0d0d0d;">
        <ul id="debug" style="color:#00BB00;"></ul>
    </div>

    <!-- Load the various JavaScript files -->
    <script type="text/javascript" src="cordova.js"></script>
    <script type="text/javascript" src="lib/jquery/jquery-2.1.4.js"></script>
    <script type="text/javascript" src="js/app.js"></script>
</body>

</html>
```

In *www/js/app.js*, copy in the following:

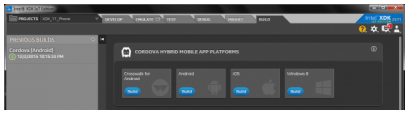
```
/*jslint unparam: true */
/*jshint strict: true, -W097, unused:false,  undef:true, devel:true */
/*global window, document, d3, $, io, navigator, setTimeout */
/*global ble*/

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 11: Accelerometer Demo
 * This sketch was written by SparkFun Electronics
 * November 29, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Runs as BLE central on smartphone. Connects to the Edison and sends
 * accelerometer data.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Put in strict mode to restrict some JavaScript "features"
"use strict" ;

// BLE service and characteristic information
window.edison = {
    deviceId: "98:4F:EE:04:3E:F9",
    service: "12ab",
    characteristic: "34cd"
};

/*****************************************************************************
 * Bluetooth connection
 *****************************************************************************/

// Global app object we can use to create BLE callbacks
window.app = {

    // A way for us to reference the thread
    watchID: null,

    // Call this first!
    initialize: function() {
        window.app.connect();
    },

    // Scan for and connect to our statically-encoded Edison MAC address
    connect: function() {
        ble.scan([],
                 5,
                 window.app.onDiscoverDevice,
                 window.app.onError);
    },

    // Find BLE devices in range and connect to the Edison
    onDiscoverDevice: function(device) {
        debug("Found " + device.name + " at " + device.id);
        if (device.id === window.edison.deviceId) {
            debug("Connecting to: " + window.edison.deviceId);
            ble.connect(window.edison.deviceId,
                        window.app.onConnect,
                        window.app.onError);
        }
    },

    //  On BLE connection, notify the user
    onConnect: function() {
        debug("Connected to " + window.edison.deviceId);

        // Set the accelerometer to sample and send data every 100 ms
        window.watchID = navigator.accelerometer.watchAcceleration(
            function(acceleration) {
                window.app.onAccelerometer(acceleration, window);
            },
            window.app.onError,
            { frequency: 100 }
        );
    },

    // This gets executed on new accelerometer data
    onAccelerometer: function(accel, win) {

        // Create an array of accelerometer values
        var a = [accel.x, accel.y, accel.z];

        // Set new values for X, Y, and Z acceleration on phone
        $('#x')[0].innerHTML = a[0].toFixed(2);
        $('#y')[0].innerHTML = a[1].toFixed(2);
        $('#z')[0].innerHTML = a[2].toFixed(2);
```

```
        // Assign X, Y and Z values to a 16-bit, signed integer array
        var buf = new Int16Array(3);
        buf[0] = a[0] * 100;
        buf[1] = a[1] * 100;
        buf[2] = a[2] * 100;

        // Write data to the characteristic
        ble.write(win.edison.deviceId,
                  win.edison.service,
                  win.edison.characteristic,
                  buf.buffer);
                  //function() {debug("Acc data written!");},
                  //function() {debug("Acc data NOT written");});
    },

    // Alert the user if there is an error
    onError: function(err) {
        navigator.accelerometer.clearWatch(window.watchID);
        debug("Error: " + err);
        alert("Error: " + err);
    }
};

/*********************************************************************
 * Execution starts here after the phone has finished initializing
 *********************************************************************/

// Wait for the device (phone) to be ready before connecting to the Edison
// and polling the accelerometer
document.addEventListener("deviceready", onDeviceReady, false);
function onDeviceReady() {

    // Prepare the BLE connection
    window.app.initialize();
}

// Create a pseudo-debugging console
// NOTE: Real apps can also use alert(), but list messages can be useful when
// you are debugging the program
function debug(msg) {
    $('#debug').append($('<li>').text(msg));
}
```

Remember the Bluetooth MAC address that we copied from the Edison? You will need to find the MAC address in the code and replace it with your MAC address. Look for `"98:4F:EE:04:3E:F9"` (my MAC address) under `window.edison` and replace it with the Bluetooth MAC address for your Edison.

Building the Phone App

Unlike the web apps we made in previous experiments, we need to actually build our project because we are including native code as part of the Cordova framework. In the XDK, go to the **Build** tab.

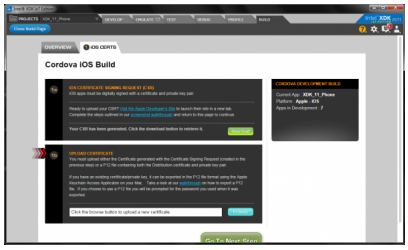


Click **Build** on the phone OS of your choice and follow the instructions.

iPhone

Intel's

Go to the **iOS Certs** tab and follow the directions on the screen.

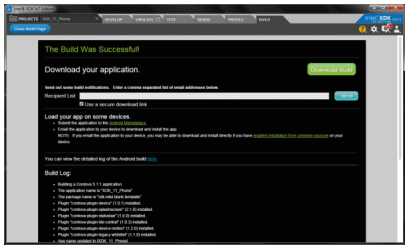


You will first need to create an iOS Certificate Signing Request (CSR). Upload that file to the Apple Developers iOS certificate page in order to generate an ad-hoc certificate signed by Apple. Note that this requires you to be enrolled in the Apple Developer Program.

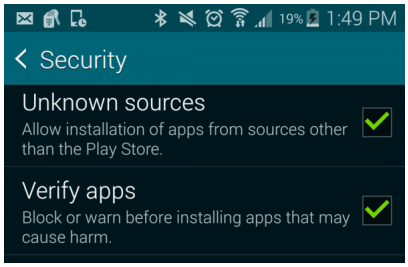
A walkthrough with screenshots for creating an ad-hoc certificate can be found here.

Android

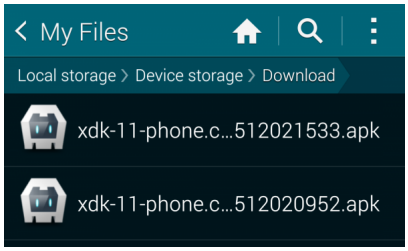
Upload and build your program. Once it is complete, you should see an option to *Download Build*.



This will download a .apk file, which you can install directly from your Android phone. However, you will need to allow installation of apps from **Unknown Sources** from the **Security** features in **Settings**.



From there, you can simply find the .apk package in a file browser and tap on it to install the program.

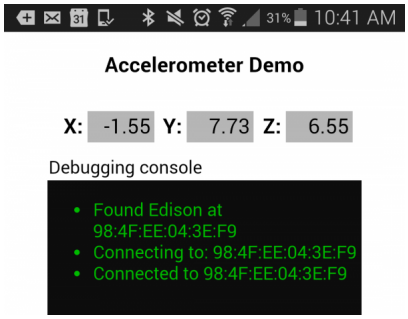


Other

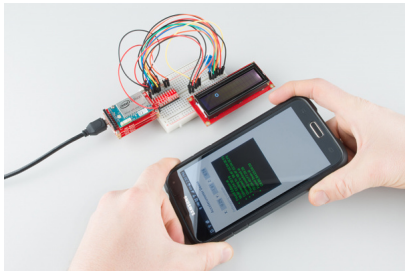
More information about the build process for iOS, Android, and other phone operating systems can be found on Intel's site.

What You Should See

With the Edison running, start the phone app. The app should automatically connect to the Edison over BLE. You will see a notification in the "debug" area.



Hold your phone parallel to the ground (in a landscape fashion), and tilt it from side to side. The character on the LCD should move based on the direction of the tilt!



Code to Note

bleno

Bleno, much like many other JavaScript packages, works asynchronously. That means we need to wait for events to happen rather than calling specific functions, and this is accomplished through several `bleno.on()` definitions.

We wait for bleno to initialize the Bluetooth driver with `bleno.on('stateChange', function() {...})`, which calls the callback parameter once its done. In our code, we tell bleno to start advertising our service and characteristic.

We define our own characteristic (bleno.Characteristic) near the beginning of the code, which we call `displayCharacteristic`. The characteristic contains a number of properties and callbacks. In displayCharactersitic, we only allow for writes to that characteristic, as given by `properties` in the displayCharacteristic definition. `onWriteRequest` is called whenever that characteristic is written to (from the phone in this example).

We don't broadcast the name "displayCharacteristic." Instead, we broadcast a *universally unique identifier* (UUID) for our service and characteristic (as given by the properties `edison.service` and `edison.characteristic`). Our phone also has those numbers (*12ab* and *34cd*) hardcoded into its app, so it knows which service and characteristic to write to.

cordova-plugin-ble-central

cordova-plugin-ble-central is similar to bleno, but it is meant to be used as a Cordova plugin for phones (instead of bleno, which was created as a module for Node.js).

In our phone app, we wait for the device (our phone) to tell us that it has finished initializing with the `"deviceReady"` event. With that, we can start the Bluetooth driver and the plugin. To make the app easier to use, we don't wait for the user to input anything; we try to connect immediately to the Edison using the hardcoded MAC address.

This connection process is accomplished by first scanning for available devices (`ble.scan`). When we find a device that matches our hardcoded MAC address (`if (device.id === window.edison.deviceId)`), we attempt to connect to it (`ble.connect()`).

Once a connection has been made, we immediately begin sampling the accelerometer once every 100 ms using the `accelerometer.watchAccerlation()` function built into device-motion Cordova plugin.

Scaling

Trying to disassemble and reassemble the bytes in a floating point number can prove troublesome. In order to make life easier, we round the X, Y, and Z acceleration data (measured in meters per second) to 2 decimal places and multiply each one by 100. This turns each one into an integer, which we then store in a 16-bit value before sending over the BLE link.

Once the Edison has received the 3 numbers, it divides each one by 100 to get the correct acceleration. This trick is known as "scaling," and is often used to save space or reduce the required throughput on a communication channel.

Debugging

Many cell phones do not have a built-in consoles for debugging apps, like we did when simulating the web apps. We can, however, create a very simple debugging console in the app itself by using the same principles from the chatroom example in the last experiment.

In JavaScript, we create a function `debug(msg)` that we can call with a string. This function simply appends that string as a list element to a division (named "debug_box"), which we defined in *index.html*.

In the rest of the JavaScript portion of our program, we can call `debug("Some message");` to have a message appear in our makeshift debugging console. This can be very useful to see if Bluetooth messages are being received or not!

CSS

We have been sneaking in yet another language in our HTML that you may or may not have noticed for the past few experiments.

We would like to introduce Cascading Style Sheets (CSS). Almost all modern websites use CSS to format text and media. Most of them keep CSS in a separate file along with the likes of *index.html* and *app.js*. For brevity, we are going to use CSS inline with the rest of our HTML.

CSS can be used to format pieces of HTML by using the HTML property `style` within a tag. For example:

```
<div style="margin:auto; width:280px; padding:10px; font-size:14pt">
    ...
</div>
```

The properties set by `style` are used to:

- Center the division within the page
- Set the width of the division box to 280 pixels
- Create a buffer of 10 pixels between the border of the division box and the text within
- Set the default font size of text in the division to 14-point

To learn more about CSS, see this guide.

Troubleshooting

- **Bluetooth doesn't work** – On the Edison, make sure you typed in the commands into an SSH or serial console to unblock the Bluetooth radio and kill bluetoothd. On your phone, make sure that Bluetooth is enabled (through the OS's settings) and that the MAC address in the code matches the MAC address of the Edison.
- **Nothing happens when I tilt the phone** – Make sure you are tilting along the long edge of the phone. Add a `debug()` statement in the phone code to make sure your phone is successfully reading the accelerometer. Finally, put a `console.log()` statement in the Edison code to make sure the Edison is correctly receiving the accelerometer data over BLE.
- **Bluetooth is showing up as "Dual Mode"** – This happens sometimes on Android, even though the Edison does not support Dual Mode Bluetooth (at this time). Try powering down your Android phone and turning it on again to reset the Bluetooth driver.

Going Further

Challenges

1. Have the character move whenever you tilt the phone along its short axis (instead of its long axis).
2. Create a phone app that grabs GPS data (hint) and sends it over BLE to the Edison. Have the Edison animate a character that moves whenever you walk along a line (say, longitudinally).

Digging Deeper

- Cordova Documentation
- Bluetooth Overview
- Cordova plugin database
- bleno GitHub repository
- cordova-plugin-ble-central GitHub repository
- cordova-plugin-device-motion GitHub repository
- CSS Reference

Experiment 12: Bluetooth Game Controller

We will continue with the concept of BLE. This time, we will keep the phone as the central (master) device, but we will use the Edison as a controller to send data as *notifications* to the phone.

In this experiment, we are going to construct a type of very powerful (probably overkill) Bluetooth game controller out of the Edison with 4 buttons. The Edison will periodically poll the state of these buttons and notify the smartphone over BLE of any button pushes.

On the phone, we will create a very simple “game” that consists of a red ball in the middle of a box. Pushing one of the four buttons on the Edison will cause the ball to move in a cardinal direction (up, down, left, or right). While the game itself does not have a real purpose, it could easily be the starting point for a real video game that requires some kind of Bluetooth controller.

IMPORTANT: Cordova needs to run native code on your smartphone in order to operate. As a result, you will need to be able to install native apps.

- If you have an iPhone, you will need to enroll in the Apple Developer Program (there is a yearly membership fee) and create Ad Hoc Provisioning Profiles (discussed later)
- If you have an Android, you can allow the installation of apps from "Unknown Sources" and install the app from a downloaded .apk file

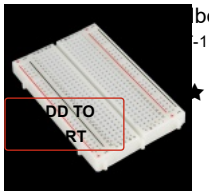
Parts Needed

In addition to the Edison and Block Stack, you will need the following parts:

- **1x** Breadboard
- **4x** Push Buttons
- **4x** 1kΩ Resistors
- **10x** Jumper Wires

Using the Edison by itself or don't have the kit? No worries! You can still have fun and follow along with this experiment. We suggest using the parts below:

tor Kit - 1/4W (500 total)
M-10969
★★½ 122



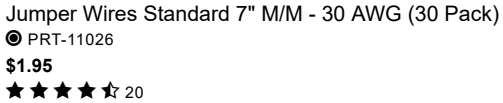
board - Self-Adhesive (White)
-12002
★★½ 34

Away Headers - Straight
-00116
★★½ 20

Edison
-13024
★★☆ 24

le Headers
-00115
★★☆ 7

Fun Block for Intel® Edison - Base
-13045
★★½ 16



Jumper Wires Standard 7" M/M - 30 AWG (30 Pack)
PRT-11026
$1.95
★★★★½ 20

ɜ Button Assortment
ʌ-10302

4

.Fun Block for Intel® Edison - GPIO
'-13038

4

Suggested Reading

- Introduction to Object-Oriented JavaScript – What constitutes an *object* and an overview of *prototypes*
- The Game Loop – What is a game loop, and why almost every video game has one

Concepts

The Class

In previous experiments, we have either used existing objects or created a one-off object in JavaScript with something like:

```
var oneOff = {
    prop1: "red",
    prop2: 42
};
```

In this experiment, we finally get to create our own object. If you are familiar with other object-oriented programming language, you might be familiar with the concept of a *class*. JavaScript is considered *classless*, since you can create objects without a blueprint (class). However, there are times when we want to create several instances of an object and don't want to rewrite code. As a result, JavaScript still offers us a way to create classes.

The *class* is like a blueprint or a recipe. We create properties and functions that all objects of that type must have (it saves us rewriting lots of code when we want many ojects of the same type). To define this blueprint in JavaScript, we first create a *constructor* and assign any *members* (variables unique to that object).

```
function MyBlueprint() {
    this._member = 0;
}
```

Wait, this is a function! Correct. In order to create an *instance* of the class `MyBlueprint`, we need to use the special `new` keyword. The following creates one instance (named `myInstance`) from the class `MyBlueprint` (notice that we capitalize the first character in the class but not for instances):

```
var myInstance = new MyBlueprint();
```

We've just created an object from our class! It is very similar to following a blueprint, schematic, or recipe to make a bridge, circuit, or meal. `myInstance`, thanks to the constructor, contains a *member* variable called `_member`. The value of `_member` is unique to that one instance. We can access that value with `myInstance._member` in order to get or set its value.

In addition to members, we can create functions that are shared among all instances of our class. We need to use the special keyword `prototype`:

```
MyBlueprint.prototype.updateMember = function(num) {
    this._member = num;
};
```

This function (called a *method*), when called from an instance, allows you to set the value of that instance's member variable (`_member` in this case). We use the `this` keyword to refer to the instance. For example, if we named our instance `myInstance`, `this` would refer to the `myInstance` object. By specifying `this._member`, we refer to the member variable within that particular instance.

Some jargon you should be aware of:

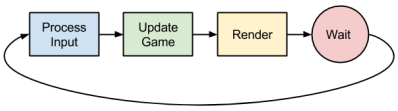
- **Object** – A piece of code that contains properties (variables and/or functions)
- **Class** – A blueprint to create several objects of the same type
- **Instance** – An object created using a class (as a blueprint)
- **Member** – A variable unique to an instance as defined within a class
- **Method** – A function defined by a class

Here is a basic example of a class and some instances created from that class. Feel free to run the code on your Edison. What do you expect to see in the console when you run it? Can you identify the class, the instances, the member, and the methods?

```
// This is the constructor. Calling this with "new" creates a new object
// (instance) of type "MyBlueprint"
function MyBlueprint() {
    this._member = 0;
}

// Objects of type "MyBlueprint" will all have this function, which allows you
// to update the member variable within that instance.
MyBlueprint.prototype.updateMember = function(num) {
    this._member = num;
};

// Again, all instances of "MyBlueprint" will have this function. Calling this
// will print the member variable's value to the screen.
MyBlueprint.prototype.printMember = function() {
    console.log(this._member);
};

// Let's test this by creating 2 instances of our MyBlueprint class.
var instance_1 = new MyBlueprint();
var instance_2 = new MyBlueprint();

// To test the methods, we can update the member variable for one instance
instance_1.updateMember(42);

// Print the member's value to the console. What do you expect to see?
instance_1.printMember();
instance_2.printMember();
```

The Game Loop

Almost all video games rely on the *Game Loop*. This loop is a simple programming construct with 4 parts and executes endlessly (at least until the game ends).



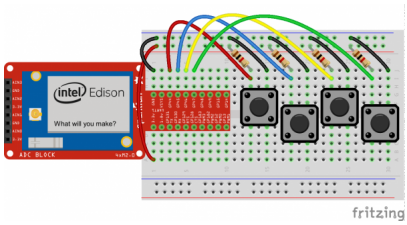
The Game Loop consists of the 4 main parts:

1. **Process Input** – Look for input from the controller or input device. For example, the player is pushing a button.
2. **Update Game** – Take input from the controller and update the game variables as a result. For example, the button input told the character to move up. Update the character's Y position by -1 (toward the top of the screen).
3. **Render** – Render is another fancy name for "draw." Most simple games will clear the screen and re-draw the whole scene. In our example, this includes having the character appear 1 pixel above where they used to be.
4. **Wait** – Do not do anything so that we can reach our target *framerate* (measured in frames per second or FPS). This is often variable. For example, if the first three steps took 32 ms, we need to wait 18 ms in order to meet our framerate goal of 20 FPS (1 frame every 50 ms).

In our experiment, our game loop is only going to consist of steps 3 and 4. Thanks to JavaScript's asynchronous nature, we will update the game variables (the position of a ball) whenever a button push event arrives over BLE from the Edison. This means that the Edison is handling step 1 (polling for button pushes), and the phone is handling step 2 asynchronously (whenever a button push event arrives).

However, steps 3 and 4 will still execute in an endless loop. Every 50 ms, the game's *canvas* (play area on the phone) is cleared and a new ball is drawn in the position determined by the ball's x and y properties. We then wait for the rest of the 50 ms until the `draw` function is called again.

Hardware Hookup



Having a hard time seeing the circuit? Click on the Fritzing diagram to see a bigger image.

The Code

Edison Code

Before we run any code on the Edison, we need to enable Bluetooth. Connect via SSH or Serial, and enter the following commands:

```
rfkill unblock bluetooth
killall bluetoothd
hciconfig hci0 up
```

In the XDK, create a new Blank *IoT Application*. In *package.json*, copy in the following:

```
{
  "name": "blankapp",
  "description": "",
  "version": "0.0.0",
  "main": "main.js",
  "engines": {
    "node": ">=0.10.0"
  },
  "dependencies": {
      "async": "1.5.0",
      "bleno": "0.3.3"
  }
}
```

In *main.js*, copy in the following:

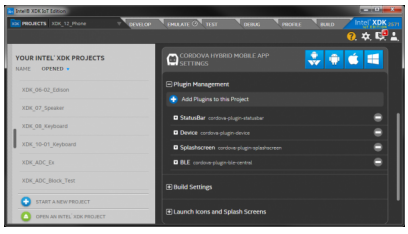
```
/*jslint node:true, vars:true, bitwise:true, unparam:true */
/*jshint unused:true */
// Leave the above lines for propper jshinting

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 12: Edison BLE Controller
 * This sketch was written by SparkFun Electronics
 * November 24, 2015
 * https://github.com/sparkfun
 *
 * Broadcasts as a BLE device. When a central device (e.g. smarthphone)
 * connects, it sends out button pushes as a notification on a characteristic.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// As per usual, we need MRAA. Also, bleno.
var mraa = require('mraa');
bleno = require('bleno');

// Define our global variables first
var bleno;
var controllerCharacteristic;

// BLE service and characteristic information
var edison = {
    name: "Edison",
    deviceId: null,
    service: "12ab",
    characteristic: "34cd"
};

// Create buttons on pins 44, 45, 46, and 47
var upPin = new mraa.Gpio(44, true, true);
var downPin = new mraa.Gpio(45, true, true);
var leftPin = new mraa.Gpio(46, true, true);
var rightPin = new mraa.Gpio(47, true, true);

// Set that pin as a digital input (read)
upPin.dir(mraa.DIR_IN);
downPin.dir(mraa.DIR_IN);
leftPin.dir(mraa.DIR_IN);
rightPin.dir(mraa.DIR_IN);

// Define our controller characteristic, which can be subscribed to
controllerCharacteristic = new bleno.Characteristic({
    value: null,
    uuid: edison.characteristic,
    properties: ['notify'],
    onSubscribe: function(maxValueSize, updateValueCallback) {
        console.log("Device subscribed");
        this._updateValueCallback = updateValueCallback;
    },
    onUnsubscribe: function() {
        console.log("Device unsubscribed");
        this._updateValueCallback = null;
    },
});

// This field holds the value that is sent out via notification
controllerCharacteristic._updateValueCallback = null;

// We define a special function that should be called whenever a value
// needs to be sent out as a notification over BLE.
controllerCharacteristic.sendNotification = function(buf) {
    if (this._updateValueCallback !== null) {
        this._updateValueCallback(buf);
    }
};

// Once bleno starts, begin advertising our BLE address
bleno.on('stateChange', function(state) {
    console.log('State change: ' + state);
    if (state === 'poweredOn') {
        bleno.startAdvertising(edison.name,[edison.service]);
    } else {
        bleno.stopAdvertising();
    }
});

// Notify the console that we've accepted a connection
bleno.on('accept', function(clientAddress) {
    console.log("Accepted connection from address: " + clientAddress);
});
```

```
// Notify the console that we have disconnected from a client
bleno.on('disconnect', function(clientAddress) {
    console.log("Disconnected from address: " + clientAddress);
});

// When we begin advertising, create a new service and characteristic
bleno.on('advertisingStart', function(error) {
    if (error) {
        console.log("Advertising start error:" + error);
    } else {
        console.log("Advertising start success");
        bleno.setServices([

            // Define a new service
            new bleno.PrimaryService({
                uuid: edison.service,
                characteristics: [
                    controllerCharacteristic
                ]
            })
        ]);
    }
});

// Call the periodicActivity function
periodicActivity();

// This function is called forever (due to the setTimeout() function)
function periodicActivity() {

    // If a button is pushed, notify over BLE
    if (upPin.read() == 0) {
        controllerCharacteristic.sendNotification(new Buffer([0]));
    }
    if (downPin.read() == 0) {
        controllerCharacteristic.sendNotification(new Buffer([1]));
    }
    if (leftPin.read() == 0) {
        controllerCharacteristic.sendNotification(new Buffer([2]));
    }
    if (rightPin.read() == 0) {
        controllerCharacteristic.sendNotification(new Buffer([3]));
    }

    // Wait for 20 ms and call this function again
    setTimeout(periodicActivity, 20);
}
```

Phone App

As in the previous experiment, create a blank *HTML5 + Cordova* app under *HTML5 Companion Hybrid Mobile or Web App*.

In the project settings, add the plugin **cordova-plugin-ble-central**.



Once again, we need to include jQuery. Download the latest, uncompressed version of jQuery from http://jquery.com/download/. Create two new directories in your project so that you have */www/lib/jquery*. Copy the .js file into the *jquery* directory.

Go back to the Develop tab. In *www/index.html*, copy in the following:

```
<!DOCTYPE html>

<!--
SparkFun Inventor's Kit for Edison
Experiment 12: Phone BLE Ball
This sketch was written by SparkFun Electronics
November 23, 2015
https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments

Runs as BLE central on smartphone. Accepts BLE connection from Edison and
moves ball around screen based on BLE notifications from the Edison.

Released under the MIT License(http://opensource.org/licenses/MIT)
-->

<html>

<head>
  <title>BLE Ball</title>
    <meta http-equiv="Content-type" content="text/html; charset=utf-8">
    <meta name="viewport" content="width=device-width, minimum-scale=1, initial-scale=1, user-scalable=no">
    <style>
        @-ms-viewport { width: 100vw ; min-zoom: 100% ; zoom: 100% ; }  @viewport { width: 100vw ; min-zoom: 100% zoom: 100% ; }
        @-ms-viewport { user-zoom: fixed ; min-zoom: 100% ; }           @viewport { user-zoom: fixed ; min-zoom: 100% ; }
    </style>
</head>

<body>

    <!-- IP address and port inputs -->
    <h3 style="text-align:center;">BLE Controller Demo</h3>
    <div id="connection" style="margin:auto; width:240px; padding:5px;">
        <input id="ble_name" type="text" placeholder="Name of device"
               style="width:60%;">
        <button id="connect_ble" style="width:35%;">Connect</button>
    </div>

    <!-- Canvas for drawing our game -->
    <div style="margin:auto; width:260px; height:260px;">
        <canvas id="ball_canvas" width="240" height="240"
                style="background:#E5E5E5;
                       margin-left:auto;
                       margin-right:auto;
                       display:block;">
        </canvas>
    </div>

    <!-- Debugging -->
    <div id="debug_box" style="margin:auto;
                               width:280px;
                               height:140px;
                               padding:1px;
                               overflow:auto;
                               background:#0d0d0d;">
        <ul id="debug" style="color:#00BB00;"></ul>
    </div>

    <!-- Load the various JavaScript files -->
    <script type="text/javascript" src="cordova.js"></script>
    <script type="text/javascript" src="lib/jquery/jquery-2.1.4.js"></script>
    <script type="text/javascript" src="js/app.js"></script>
</body>

</html>
```

In *www/js/app.js*, copy in the following:

```
/*jslint unparam: true */
/*jshint strict: true, -W097, unused:false,  undef:true, devel:true */
/*global window, document, d3, $, io, navigator, setTimeout */
/*global ble*/

/**
 * SparkFun Inventor's Kit for Edison
 * Experiment 12: Phone BLE Ball
 * This sketch was written by SparkFun Electronics
 * November 23, 2015
 * https://github.com/sparkfun/Inventors_Kit_For_Edison_Experiments
 *
 * Runs as BLE central on smartphone. Accepts BLE connection from Edison and
 * moves ball around screen based on BLE notifications from the Edison.
 *
 * Released under the MIT License(http://opensource.org/licenses/MIT)
 */

// Put in strict mode to restrict some JavaScript "features"
"use strict" ;

// BLE service and characteristic information
window.edison = {
    name: null,
    deviceId: null,
    service: "12ab",
    characteristic: "34cd"
};

/*****************************************************************************
 * Game Class
 *****************************************************************************/

// Game constructor
function Game(canvas) {

    // Assign the canvas to our properties
    this._canvas = canvas;
    this._ctx = this._canvas.getContext("2d");

    // Initialize the rest of the properties
    this._gameThread = null;
    this._ball = {
        x: this._canvas.width / 2,
        y: this._canvas.height / 2,
        radius: 10,
        visible: false
    };
}

// Call this to update the ball's position
Game.prototype.updateBallPos = function(dx, dy) {

    // Increment the ball's position
    this._ball.x += dx;
    this._ball.y += dy;

    // Make the ball stick to the edges
    if (this._ball.x > this._canvas.width - this._ball.radius) {
        this._ball.x = this._canvas.width - this._ball.radius;
    }
    if (this._ball.x < this._ball.radius) {
        this._ball.x = this._ball.radius;
    }
    if (this._ball.y > this._canvas.height - this._ball.radius) {
        this._ball.y = this._canvas.height - this._ball.radius;
    }
    if (this._ball.y < this._ball.radius) {
        this._ball.y = this._ball.radius;
    }
};

// Draws the ball on the canvas
Game.prototype.drawBall = function() {
    this._ctx.beginPath();
    this._ctx.arc(this._ball.x,
                  this._ball.y,
                  this._ball.radius,
                  0,
                  Math.PI * 2);
    this._ctx.fillStyle = "#BB0000";
    this._ctx.fill();
    this._ctx.closePath();
};

// This gets called by the main thread to repeatedly clear and draw the canvas
```

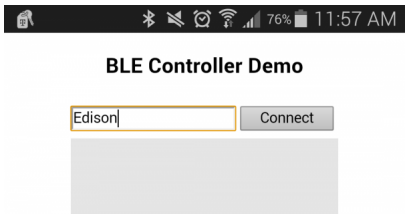
```
Game.prototype.draw = function() {
    if (typeof this._ctx != 'undefined') {
        this._ctx.clearRect(0, 0, this._canvas.width, this._canvas.height);
        if (this._ball.visible) {
            this.drawBall();
        }
    }
};

// Call this to start the main game thread
Game.prototype.start = function() {
    var that = this;
    this._ball.visible = true;
    this._gameThread = window.setInterval(function() {
        that.draw();
    }, 50);
};

// Call this to stop the main game thread
Game.prototype.stop = function() {
    this.ball.visible = false;
    this.draw();
    window.clearInterval(this.gameThread);
};

/*****************************************************************************
 * Main App
 *****************************************************************************/

// Global app object we can use to create BLE callbacks
window.app = {

    // Game object
    game: null,

    // Call this first!
    initialize: function() {

        // Create a new instance of the game and assign it to the app
        this.game = new Game($('#ball_canvas')[0]);

        // Connect events to page elements
        this.bindEvents();
    },

    // Connect events to elements on the page
    bindEvents: function() {
        var that = this;
        $('#connect_ble').on('click', this.connect);
    },

    // Scan for a BLE device with the name provided and connect to it
    connect: function() {
        var that = this;
        window.edison.name = $('#ble_name').val();
        debug("Looking for " + window.edison.name);
        ble.scan([],
                 5,
                 window.app.onDiscoverDevice,
                 window.app.onError);
    },

    // When we find a BLE device, if it has the name we want, connect to it
    onDiscoverDevice: function(device) {
        var that;
        debug("Found " + device.name + " at " + device.id);
        if (device.name == window.edison.name) {
            window.edison.deviceId = device.id;
            debug("Attempting to connect to " + device.id);
            ble.connect(window.edison.deviceId,
                        window.app.onConnect,
                        window.app.onError);
        }
    },

    //  On BLE connection, subscribe to the characteristic, and start the game
    onConnect: function() {
        window.app.game.start();
        debug("Connected to " + window.edison.name + " at " +
              window.edison.deviceId);
        ble.startNotification(window.edison.deviceId,
                              window.edison.service,
                              window.edison.characteristic,
                              window.app.onNotify,
                              window.app.onError);
    },
```

```
    // Move the ball based on the direction of the notification
    onNotify: function(data) {
        var dir = new Uint8Array(data);
        debug("Dir: " + dir[0]);
        switch(dir[0]) {
            case 0:
                window.app.game.updateBallPos(0, -1);
                break;
            case 1:
                window.app.game.updateBallPos(0, 1);
                break;
            case 2:
                window.app.game.updateBallPos(-1, 0);
                break;
            case 3:
                window.app.game.updateBallPos(1, 0);
                break;
            default:
                debug("Message error");
        }
    },

    // Alert the user if there is an error and stop the game
    onError: function(err) {
        window.app.game.stop();
        debug("Error: " + err);
        alert("Error: " + err);
    }
};

/*******************************************************************************
 * Execution starts here after page has loaded
 ******************************************************************************/

// Short for jQuery(document).ready() method, which is called after the page
// has loaded. We can use this to assign callbacks to elements on the page.
$(function() {

    // Initialize the app and assign callbacks
    window.app.initialize();
});

// Create a pseudo-debugging console
// NOTE: Real apps can also use alert(), but list messages can be useful when
// you are debugging the program
function debug(msg) {
    $('#debug').append($('<li>').text(msg));
}
```

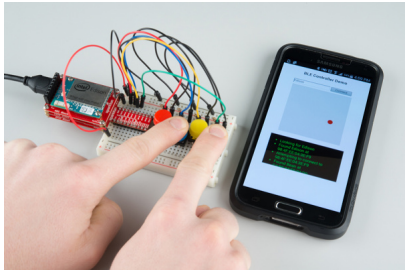
Refer to the previous example on how to build the phone app for your smartphone.

What You Should See

Make sure that you have enabled Bluetooth on the Edison and that it is running the controller program. Run the phone app, and you should be presented with an input, a blank game canvas, and a debugging console (much like in the last experiment). Enter **Edison** into the input field and tap **Connect**.



Once your phone connects to the Edison, a small, red ball should appear in the middle of the canvas (you should also see a “Connected to” message in the debugging console). Push the buttons connected to the Edison to move the ball around!



Code to Note

The Game Object

As introduced in the Concepts section, we create a class named `Game` along with some members and methods. The `window.app.game` object (an instance of the `Game` class) is responsible for remembering the ball’s X and Y coordinates (stored as variables within the `this._ball` member) as well as drawing the ball on the canvas, which is accomplished using an HTML Canvas element.

Once a BLE connection has been made, the program starts the game loop by calling `window.app.game.start()`. This function sets up an interval timer that calls the `.draw()` function every 50 ms. In `.draw()`, the canvas is cleared, and the ball is drawn every interval.

In `window.app.onNotify`, which is called on a received BLE notification, the BLE's data (the first and only byte) is parsed to determine which way the ball should move. A received '0' means "move the ball up", '1' means "down", '2' means "left", and '3' means "right". Updating the ball's position is accomplished by calling `window.app.game.updateBallPos(dx, dy)`.

BLE by Name

In the previous experiment, we needed to hardcode the Edison's Bluetooth MAC address into the program. This time, we take a different approach. When the user presses the *Connect* button, the program retrieves the value of the input (ideally, "Edison") and stores it in the global `window.edison` object (as `window.edison.name`).

The program then scans for all available BLE peripherals, noting their names (`device.name` in the `onDiscoverDevice` callback). If one is found to be equal to `window.edison.name` (ideally, "Edison" once again), the program attempts to connect to that device. No need to set the MAC address anywhere!

In the Edison code, we assign the BLE name "Edison" in the global `edison` object. If we change that name, we will need to enter the same name into the input field of the phone app.

BLE Notifications

In the Edison code, we define a BLE characteristic called `controllerCharacteristic`. Unlike the previous example where we only allowed *writing* to the characteristic, we allow *notifications* to this characteristic.

A BLE *notification* sends out an update to all devices that have *subscribed* whenever that characteristic has changed. To accomplish this in the Edison, we create a member variable of the `controllerCharacteristic` named `_updateValueCallback`. This variable is assigned the function `updateValueCallback` whenever a device subscribes to the characteristic. We create the external function `controllerCharacteristic.sendNotification(buf)` so that other parts of the code may send data as a notification over BLE.

'sendNotification(buf) `calls the function` updateValueCallback() `with the data it received from the caller (` buf`). The causes the bleno module to send a notification for that particular characteristic over BLE.

On the phone side, cordova-plugin-ble-central is configured to subscribe to the characteristic with `ble.startNotification(...)`. Notifications to that characteristic call the function `onNotify()`, which then parses the received data to determine how to move the ball.

This and That (Dummy Functions)

As mentioned previously, the keyword `this` refers to the calling object. Sometimes, we have to create a wrapper around a callback function so that we can pass the object to the function.

For example, in the phone code *app.js*, the method `Game.prototype.start` uses the built-in function `setInterval()` to call the draw method repeatedly. As it is, `setInterval()` is a method of the global `window` object. If we were to write

```
Game.prototype.start = function() {
    this._ball.visible = true;
    this._gameThread = window.setInterval(this.draw, 50);
};
```

the keyword `this` (only within `setInterval`) would refer to `window`, not the `Game` object! And, as you might guess, `window` has no `draw()` function. This piece of code would throw an error (unless you made a `window.draw()` function).

To get around this, we first assign `this` to a placeholder variable, which we will (humorously) call `that`. Then, we can create a dummy function as the callback for `setInterval`, which calls `that.draw()`, referring to the `draw()` method in the Game object.

```
Game.prototype.start = function() {
    var that = this;
    this._ball.visible = true;
    this._gameThread = window.setInterval(function() {
        that.draw();
    }, 50);
};
```

Troubleshooting

- **Bluetooth is not connecting** – If you restarted the Edison since the last experiment, make sure you enter the three commands `rfkill unblock bluetooth`, `killall bluetoothd`, and `hciconfig hci0 up` into an Edison terminal (SSH or serial) before running the Edison code.
- **The ball does not move** – If you see the ball on the screen, then Bluetooth is connected. A visible ball that does not move could be caused by several issues:
  - The Edison might not be detecting button pushes. Insert `console.log()` statements into the Edison code to determine the state of each of the buttons.
  - The Edison might not be sending notifications over BLE. Use another BLE phone app (e.g. BLE Scanner) to see if the characteristic is being updated.
  - The phone app might not be receiving notifications. Place `debug()` statements in `onNotify` to see if it is being called.
  - The phone app might not be updating the ball postion. Place `debug()` statements in `Game.prototype.updateBallPos` to see if it is being called.

Going Further

Challenges

1. Make the ball's radius grow by 1 every time it touches a wall.
2. Make the ball move faster (this can be accomplished in several ways).
3. Make a real game! For example, you could make a Breakout clone that uses the Edison controller to move the paddle. See this tutorial to help you get started.

Digging Deeper

- Object.prototype reference
- Canvas element

Finale: Next Steps

Where do you go from here? The purpose of the kit was to provide an overview of the many different things you can do with the Edison (and all this with only JavaScript!). By this point, you've hopefully gained some confidence in programming the Edison with the XDK, creating simple web pages, and making wireless connections over WiFi and Bluetooth Low Energy. Along the way, perhaps you were inspired to create a project of your own imagination.

Beyond JavaScript

As you probably noticed, the experiments in this guide focused primarily on JavaScript and the so-called “web languages” (at least some of the popular ones). If you followed along with the experiments to create web pages and web apps, you can apply the knowledge to create your own web pages or simple smartphone apps.

There is nothing wrong, of course, with using strictly JavaScript. Some people might want to try different languages. Because the Edison is a full computer, it is capable of compiling and running many more languages. Out of the box, the Edison has Node (for running JavaScript), Python, and a C/C++ compiler (gcc).

- See here for getting started with Python on the command line
- Check out this tutorial for using Eclipse to program C/C++ for the Edison

In reality, you can likely compile or run almost any programming language on the Edison. For those of you who enjoy esoteric interests, you can even find a Malbolge interpreter.

Online Resources

- If you wish to delve deeper into JavaScript, the entirety of the book Eloquent JavaScript can be found online as a free resource. It is also available as a paperback book.
- The Intel® Edison forums are a great place to share knowledge and get help for Edison-related topics
- Getting Started with the Yocto Project is a good place to start if you want to dig into the inner workings of Linux on the Edison

Books

- A Smarter Way to Learn JavaScript
- HTML and CSS: Design and Build Websites
- Embedded Linux Development with Yocto Project

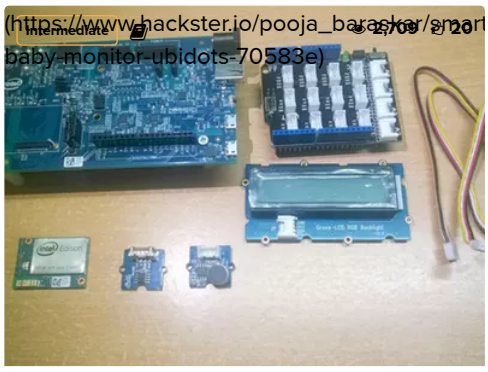
Discussion

Have ideas, comments, or suggestions? Feel free to post them and ask questions about the Edison SIK in the Comments section.

Project Ideas

If you are still looking for inspiration for projects, perhaps some of these can help:

(https://www.hackster.io/pooja_baraskar/smart (https://www.hackster.io/shrey/havocshome-baby-monitor-ubidots-70583e)



automation-with-voice-control-f96689)

(https://www.hackster.io/crisscrosskaos/myodro the-selfie-drone-cb40e5)

Appendix A: Troubleshooting

Help! I bricked my Edison!

This is very much a possibility when loading new firmware. If you find that you have put the Edison in an unrecoverable state, it should be possible to recover (unbrick) it.

Connect a USB cable from your computer to Console port on the Base Block. Open a serial terminal to the Edison. If you see the Edison begin to POST to your serial terminal, look for the line (it will count down to 0):

```
Hit any key to stop autoboot: 0
```

Press ‘enter’ and enter the command:

```
run do_flash
```

This will put the Edison into DFU mode. You can now run the flashall.bat or flashall.sh script from your host computer to re-image the Edison.

Many thanks to user ddewaele for finding this solution. You can see an example of his error (bricked Edison) and his solution as a gist on GitHub.

The Phone Flash Tool Lite Shows the Edison as “Disconnected”

If the Phone Flash Tool refuses to show the Edison as *Connected*, make sure that you have enabled USB networking (Appendix C). Flashing the Edison also requires a very specific order with the Phone Flash Tool:

1. Ensure the Edison is disconnected from the computer
2. Start the Phone Flash Tool Lite
3. Browse to the FlashEdison.json file (in the unzipped Yocto firmare image directory)
4. Click **Start to flash**
5. Connect a USB cable from the computer to the OTG port on the Base Block

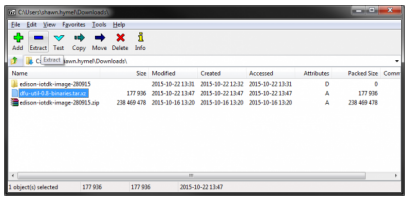
dfu-util or libusb not found (Windows)

If you see an error message such as “The program can’t start because libusb-1.0.dll is missing from your computer” or a message about dfu-util not being found, you will need to add a .dll library and .exe program to the Yocto image directory.

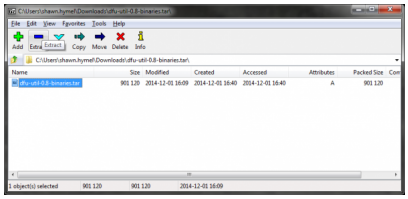
Download and install 7-zip from the 7-zip.org page. You will probably want the .msi version.

Download dfu-util for Windows (this executable came from the particle.io community).

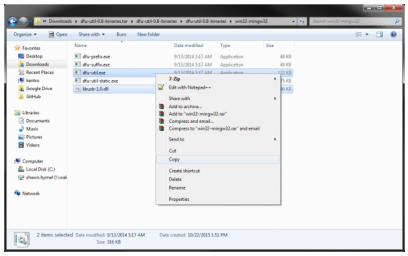
Go to Start → All Programs → 7-Zip → 7-Zip File Manager. Within the file manager, navigate to your downloads folder. Select “dfu-util-0.8-binaries.tar.zx” and select “Extract.”



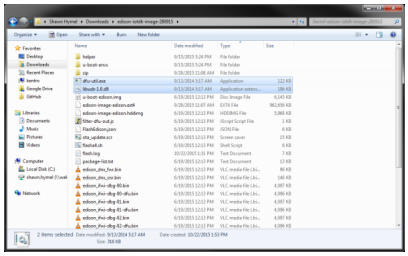
Click “OK” when prompted on where to extract the files to accept the defaults. “dfu-util-0.8.binaries.tar” will appear in the 7-Zip File Manager. Double-click on it to enter the folder. Select “dfu-util-0.8-binaries.tar” and click “Extract” to extract dfu-util one more time.



Open up a File Explorer window and navigate to <YOUR DOWNLOADS FOLDER>\dfu-util-0.8-binaries.tar\dfu-util-0.8-binaries\dfu-util-0.8-binaries\win32-mingw32. Copy both **dfu-util.exe** and **libusb-1.0.dll**.



Paste them into <YOUR DOWNLOADS FOLDER>\edison-iotdk-image-… (the place where you unzipped the Yocto image).



dfu-util not found (Linux)

If you get an error like “dfu-util: command not found” when trying to update to the latest Yocto image then you need to install dfu-util. Run the command:

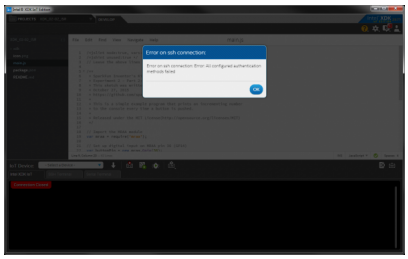
```
sudo apt-get install dfu-util
```

The Edison won’t connect

If you are trying to connect to the Edison and you don’t see it listed as an *IoT Device* in the XDK, then a few things might be wrong.

- The Edison is not powered. Make sure you the blue LED on the Base Block is lit up.
- The Bonjour service is not installed or not working. You can still connect manually if you do not want to use Bonjour. You will need the IP address of the Edison (see Connecting to WiFi).
- Make sure your computer is on the same WiFi network as the Edison. Alternatively, you could use a USB network instead.

If you get an error when trying to connect, such as “Error on ssh connection: Error: All configuration authentication methods failed,” then you need to try reconnecting and entering the root password you set during the Connecting to WiFi step.



Bluetooth Low Energy

BLE is not on by default in the Edison. Additionally, you must unblock the bluetooth radio and stop the `bluetoothd` daemon before running any JavaScript that relies on the bleno module. To do that, every time you boot the edison, you must log in (SSH or serial) and enter the following commands:

```
rfkill unblock bluetooth
killall bluetoothd
hciconfig hci0 up
```

Android is also known to have some issues with BLE, especially bleno. If your phone does not connect to the Edison, and the Edison shows up as “Dual Mode” in 3rd party applications (e.g. BLE Scanner), then try turning Bluetooth off and on again in Android. Additionally, resetting the phone (turn power off and on again) also seems to help.

It’s Still Not Working!

If it is a problem with the hardware (things are not getting power, the temperature sensor doesn’t work, etc.), we have an awesome tech support staff to help you out. Please see our tech support page to find out how to contact them.

If you have a question, concern, or suggestion for the documentation, feel free to post that in the Comments section of this guide.

Appendix B: Programming Without the XDK

The Intel® XDK offers some really useful features when programming, such code completion, automatic installation of libraries, and formatting new projects (e.g. templates). However, we totally understand if you don’t want to use the XDK. The good news is that the Edison is a full computer, which means it is more than capable of installing libraries and running code on its own!

Writing Code

There are several ways to write code. Finding a good editor can be a challenge. If you fancy yourself an old-school Unix guru, you might be comfortable with vi. All you need to do is log in to the Edison through SSH or serial and enter the command

```
vi
```

You will be greeted with the perhaps familiar vi interface.

If you dislike vi but still want to edit code on the Edison directly, you could install another editor. For example, nano has been added to the Edison’s package repositories. See here to install nano.

XDK offers the benefit of editing code on your computer (desktop or laptop) and the ability to send that code directly to the Edison. You can use any number of editors on your personal computer for editing code. For example, Notepad++ for Windows, TextWrangler for Mac, or Emacs for Linux.

Once you are done writing the code, you can send it to the Edison through a number of ways:

- Copy and paste the code into vi on the Edison and save it
- Use scp (Linux/Mac) or WinSCP (Windows) to transfer the file(s) from your computer to the Edison
- Upload the code as part of a GitHub repository and download it on the Edison

Running Node.js

By default, the Edison comes pre-loaded with Node.js, which is the runtime environment used to run JavaScript. To run a Node program written in JavaScript, we just need to enter the command

```
node <name_of_program>.js
```

into the SSH or serial terminal of the Edison.

For example, let’s make a simple JavaScript program:

```
langauge:javascript
for (var i = 0; i < 3; i++) {
  console.log("Hi " + i);
}
```

Save it as *test.js* in the home directory on the Edison (/home/root). Log into the Edison and make sure we are in the home directory.

```
cd /home/root
```

Then, run the program.

```
node test.js
```

You should see a few messages printed to the console.

Installing Node Modules

You can include JavaScript libraries (Node.js modules) in your program by installing them directly on the Edison. From the console, you just need to call

```
npm install <module name>@<version number>
```

For example, to install the version of Socket.IO as required by Experiment 5, Part 2, enter the following command into the Edison console:

```
npm install socket.io@1.3.7
```

Note that this requires the Edison to be connected to the Internet, as it will attempt to find and install Socket.IO v1.3.7 from the npm package repository.

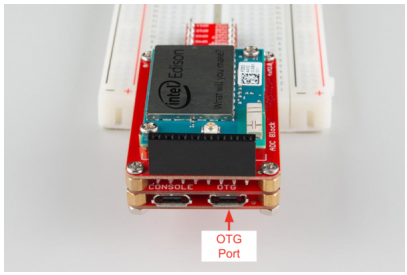
You do not need to create a *package.json* file (like we did with the XDK) to accompany your code. The `npm install` command installs the package directly on the Edison. As long as your code as the necessary `require('socket.io')` line, you will be able to use Socket.IO.

A list of available modules can be found on npmjs.com.

Appendix C: Using a USB Network

If you are trying to update the Edison's firmware via the Phone Flash Tool Lite program or want to upload code from the XDK without using WiFi, you can enable USB Ethernet networking. For Windows, this relies on the RNDIS driver. OS X needs to use HoRNDIS, and Linux users will need to use USB CDC.

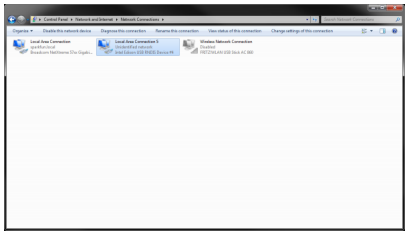
For all operating systems, start by connecting a USB cable from the OTG port of the Edison Base Block to an available USB port on your computer.



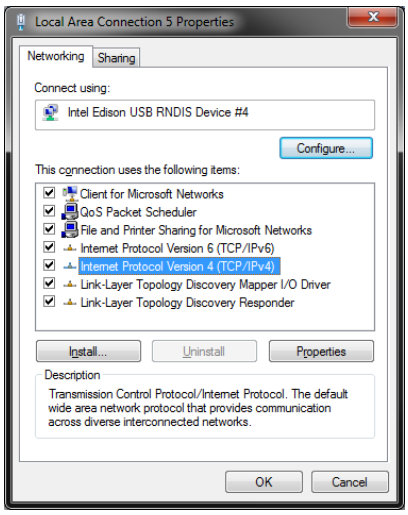
NOTE: By default, the IP address of the Edison on the USB network is **192.168.2.15**. Additionally, you can program the Edison from the XDK by connecting over the USB network!

Windows

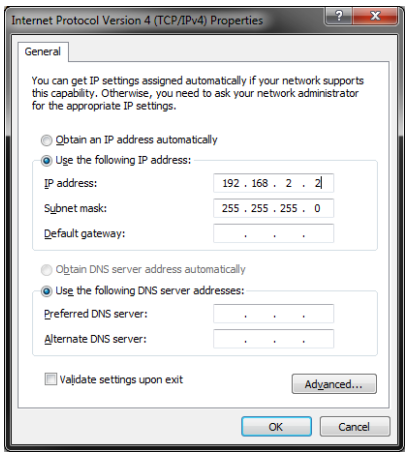
Go to Start → Control Panel → Network and Internet → Network and Sharing Center → Change Adapter Settings



Right-click on the **Local Area Connection** that says **Intel Edison USB RNDIS Device** and select **Properties**. This will bring up a new window.

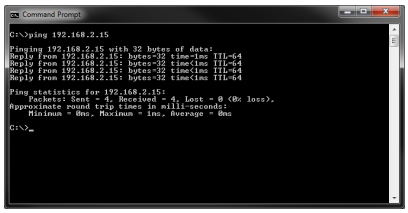


Select **Internet Protocol Version 4 (TCP/IPv4)** and click **Properties**. This will, once again, bring up a new window.



Select **Use the following IP address:** and enter **192.168.2.2** for the **IP Address**. Click anywhere in the **Subnet mask** fields and it should auto-populate. Click **OK** on this window and **OK** on the *Local Area Connection* window.

Your computer and Edison should now be networked together over USB. To check this, go to Start → Accessories → Command Prompt. Enter `ping 192.168.2.15` and you should see several replies from the Edison (192.168.2.15).



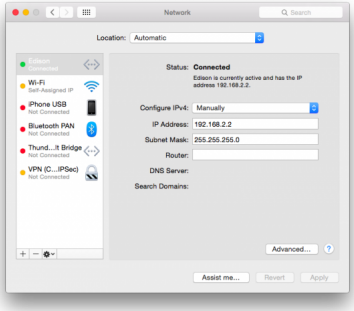
OS X

> **WARNING:** At this time, the HoRNDIS driver does not work on OS X 10.11 (El Capitan). If you are using 10.11, keep watching the HoRNDIS site for updates.

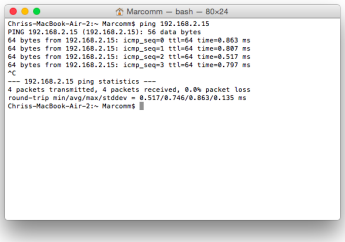
Modern versions of OS X do not come with USB networking drivers. As a result, we will need to install a custom driver. Download the latest release (in .pkg form) for HoRNDIS:

DOWNLOAD HORNDIS DRIVER

Open the .pkg file and follow the instructions to install the driver. Restart your Mac just to be sure. Once it has booted back up, open up **System Preferences** and go to **Network**, and you should see the Edison listed. Change *Configure IPv4* to **Manually**, set *IP Address* to **192.168.2.2**, and *Subnet Mask* to **255.255.255.0**.



Click **Apply** and you should be able to connect to the Edison over the USB network. Open a console and enter the command `ping 192.168.2.15`. You should see some ping replies. Press 'Ctrl+C' to stop pinging.



OS X also come packaged with an SSH client. In a console, enter:

```
ssh root@192.168.2.15
```

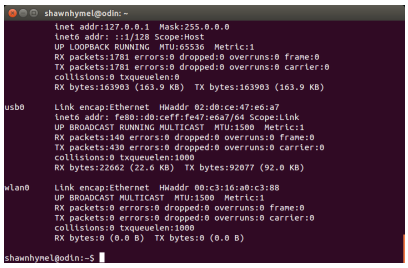
Type `yes` if prompted to accept the RSA key, and enter your Edison's root password.

Linux

Many modern distributions contain USB network drivers by default. With a USB cable connected between your computer and the OTG port on the Base Block, open up a console and enter the command:

```
ifconfig
```

You should see an entry labeled *usb0*, which refers to a USB network. That should be the Edison, assuming you have no other USB Ethernet devices plugged in.

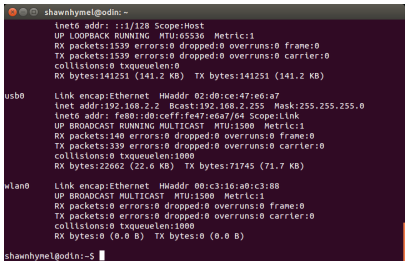


Enter the commands:

```
sudo ip address add 192.168.2.15/24 dev usb0
sudo ip link set dev usb0 up
```

If your system does not support the `sudo` command, use `su` to become root before entering the commands (without `sudo`).

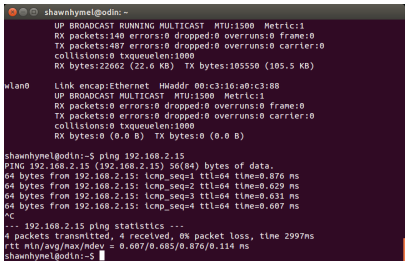
You can check to make sure that the IP address was set with `ifconfig`. You should see an IP address assigned to *usb0*.



To test that you have a connection to the Edison, you can ping it:

```
ping 192.168.2.15
```

That should give you a few replies, showing that the Edison is indeed at 192.168.2.15. Press 'Ctrl+C' to stop pinging.



Many versions of Linux also come packaged with an SSH client. If so, you won't need any special programs to connect to the Edison over the USB network. Just enter:

```
ssh root@192.168.2.15
```

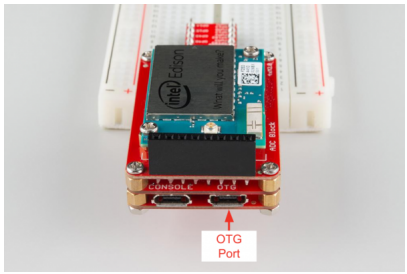
Type `yes` if prompted to accept the RSA key, and enter your Edison's root password.

Appendix D: Manually Updating the Firmware

If the Phone Flash Tool was not working properly or you did not want to use the Phone Flash Tool, you can try to flash the Edison manually.

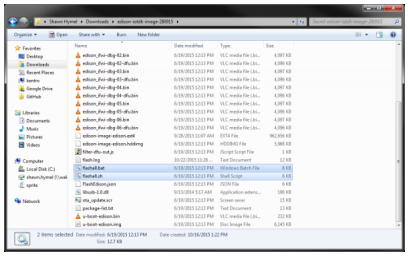
> **NOTE:** These steps are more involved and requires some familiarity with the command line. If you run into issues, check in Appendix A: Troubleshooting first before posting a question in the Comments section.

Find your operating system below and follow the directions. Note that you will need to use the USB OTG port of the Edison.

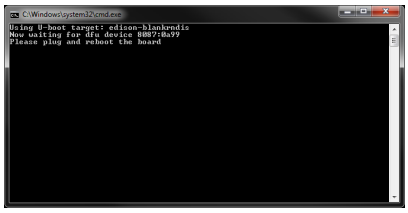


Windows

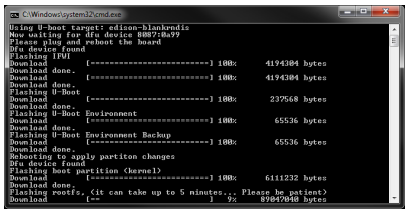
Navigate to the unzipped directory of the downloaded Yocto image. Look for the file *flashall.bat*.



Double-click **flashall.bat**. That should bring up a window asking you to plug in your Edison.



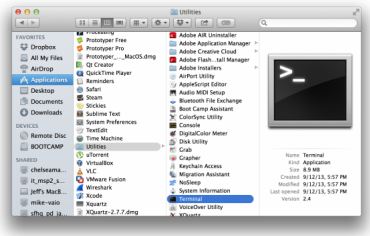
Plug the USB micro cable into the **OTG Port** of the Edison, and plug the other end into an open USB port of your computer. Wait a few moments, and the script will begin flashing the Edison.



> You will either get a notice that the flashing process is complete or the window will close. Wait at least **2 more minutes** after the update to allow the Edison to finish configuring. Do not unplug the Edison during that time!

OS X

Open a terminal (Finder → Applications → Utilities → Terminal).



We need to install a few utilities in order to flash the Edison from OS X.

Install Homebrew:

```
ruby -e "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"
```

Press RETURN and enter your password when asked to continue the installation process.

Homebrew might need to clean or check things before we use it. Run:

```
brew doctor
```

Once Homebrew has been installed and cleaned, use it to install a few other utilities:

```
brew install coreutils gnu-getopt dfu-util
```

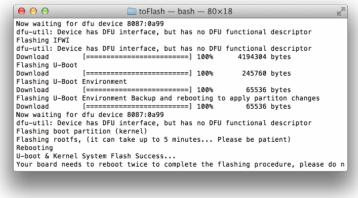
Change to the Edison Yocto image directory in your Downloads. The directory name will be different depending on the version of the image you downloaded earlier.

```
cd ~/Downloads/edison-iotdk-image-...
```

Run the install script.

```
sudo ./flashall.sh
```

You will see a message like “Now waiting for dfu device.” At that, plug the USB micro cable into the **OTG Port** of the Edison, and plug the other end into an open USB port of your computer. You should see the script start to flash the Edison in the terminal. Wait while that finishes (it could take a few minutes).



You will should get a notice that the flashing process is complete. Wait at least **2 more minutes** after the update to allow the Edison to finish configuring. Do not unplug the Edison during that time!

Linux

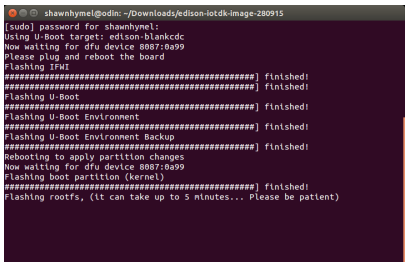
Navigate to the Yocto image that you unzipped. Open a terminal and enter:

```
cd Downloads/edison-iotdk-image-...
```

Where the directory is the unzipped Yocto image (e.g. edison-iotdk-image-280915). Run the install script:

```
sudo ./flashall.sh
```

You will see a message like “Now waiting for dfu device.” At that, plug the USB micro cable into the **OTG Port** of the Edison, and plug the other end into an open USB port of your computer. You should see the script start to flash the Edison in the terminal. Wait while that finishes (it could take a few minutes).



You will should get a notice that the flashing process is complete. Wait at least **2 more minutes** after the update to allow the Edison to finish configuring. Do not unplug the Edison during that time!

Appendix E: MRAA Pin Table

MRAA pin map table based on Intel’s IOT Dev Kit Repository

Rows highlighted in yellow are available on the GPIO Block.

Edison Pin (Linux)	MRAA Number	Arduino Breakout	Mini Breakout	Pinmode0	Pinmode1	Pinmode2
GP12	20	3	J18-7	GPIO-12	PWM0	
GP13	14	5	J18-1	GPIO-13	PWM1	
GP14	36	A4	J19-9	GPIO-14		
GP15	48		J20-7	GPIO-15		
GP19	19		J18-6	GPIO-19	I2C-1-SCL	
GP20	7		J17-8	GPIO-20	I2C-1-SDA	

Edison Pin (Linux)	MRAA Number	Arduino Breakout	Mini Breakout	Pinmode0	Pinmode1	Pinmode2
GP27	6		J17-7	GPIO-27	I2C-6-SCL	
GP28	8		J17-9	GPIO-28	I2C-6-SDA	
GP40	37	13	J19-10	GPIO-40	SSP2_CLK	
GP41	51	10	J20-10	GPIO-41	SSP2_FS	
GP42	50	12	J20-9	GPIO-42	SSP2_RXD	
GP43	38	11	J19-11	GPIO-43	SSP2_TXD	
GP44	31	A0	J19-4	GPIO-44		
GP45	45	A1	J20-4	GPIO-45		
GP46	32	A2	J19-5	GPIO-46		
GP47	46	A3	J20-5	GPIO-47		
GP48	33	7	J19-6	GPIO-48		
GP49	47	8	J20-6	GPIO-49		
GP77	39		J19-12	GPIO-77	SD	
GP78	52		J20-11	GPIO-78	SD	
GP79	53		J20-12	GPIO-79	SD	
GP80	54		J20-13	GPIO-80	SD	
GP81	55		J20-14	GPIO-81	SD	
GP82	40		J19-13	GPIO-82	SD	
GP83	41		J19-14	GPIO-83	SD	
GP84	49		J20-8	GPIO-84	SD	
GP109	10		J17-11	GPIO-109	SPI-5-SCK	
GP110	23		J18-10	GPIO-110	SPI-5-CS0	
GP111	9		J17-10	GPIO-111	SPI-5-CS1	
GP114	24		J18-11	GPIO-114	SPI-5-MISO	
GP115	11		J17-12	GPIO-115	SPI-5-MOSI	
GP128	13	2	J17-14	GPIO-128	UART-1-CTS	
GP129	25	4	J18-12	GPIO-129	UART-1-RTS	
GP130	26	0	J18-13	GPIO-130	UART-1-RX	
GP131	35	1	J19-8	GPIO-131	UART-1-TX	
GP134	44		J20-3			
GP135	4		J17-5	GPIO-135	UART	
GP165	15	A5	J18-2	GPIO-165		
GP182	0	6	J17-1	GPIO-182	PWM2	
GP183	21	9	J18-8	GPIO-183	PWM3	