# Microcontroller

One of the most important parts of our project is choosing a microcontroller that fits our system needs. The microcontroller is an important part of our system design, because it will collect data from the sensors and send out the data to a mobile device. This will allow us to manipulate the data received from the sensors so that we can output the desired information for the user.

As a group, we decided that there were a lot of specific requirements that we needed in our microcontroller. These specific requirements allowed us to narrow down our possible microcontrollers to use for our project:

* **Number of ADC’s –** Since the microcontrollers is collecting data from the sensors, it will need to convert the analog input from the sensors to a digital output for the mobile device. We plan on having multiple sensors, so the number of ADC channels on the microcontroller is important.
* **Power requirement –** Ideally, we would like the microcontroller to be powered by the voltage received from the sensors. Therefore, it is beneficial for us to have a microcontroller that requires as little power as possible.
* **Size –** The microcontroller chip will need to be embedded on the shoe so that it can connect to the sensors. Therefore, we need a microcontroller that is small enough to fit in a shoe, but also big enough for us to properly work with.
* **Cost –** We would like to have multiple working copies of microcontrollers for us to work on while creating a prototype. Therefore, we need a microcontroller that isn’t too expensive.
* **Leadtime –** Since we only have until the end of spring 2019 to finish our project, we need a microcontroller that can arrive quickly.
* **Programmability –** We would like our microcontroller to be as easy to program as possible.
* **Documentation –** Having as much documentation as possible for our chosen microcontroller will make it easier for us to work with.

Originally, our group discussed the idea of having a Bluetooth module that would connect to the microcontroller. After more discussion, we decided it would be more beneficial for us to select a microcontroller that already has Bluetooth capability embedded in it, therefore saving us the step of connecting to another module. Because of this, our microcontroller options all included embedded Bluetooth.

# Microcontroller Options

By researching, I found a handful of microcontroller options that we could use for our project. Each microcontroller is embedded with Bluetooth, and meets each of the specific requirements mentioned above. The first microcontroller option is the CC2540 chip from Texas Instruments. The second microcontroller option is the nRF52832 chip from Nordic Semiconductor. The third option is the ESP32 chip from Espressif Systems. Each microcontroller option has its own advantages and disadvantages, and they will be explored by reviewing the specific requirements mentioned above for each option.

## ADC count

The ADC count of the microcontrollers is important because we need enough channels to read each sensor input. Both the CC2540 and the nRF52832 have 8 channels for a 12-bit ADC. The ESP32 excels in ADC count, having 18 channels for a 12-bit ADC. Although it seems that the ESP32 is the best choice in terms of ADC count, our group would like to have a simpler design in terms of sensors. Therefore, our microcontroller won’t require more than a few ADC channels, so the large number of channels with the ESP32 is not very important.

## Power

The power requirement for the microcontroller is one of the more important requirements, since we are hoping to be able to power the microcontroller with the voltage created by the sensors. Primarily, we are hoping to supply a voltage to the microcontroller that exceeds the supply voltage range. The CC2540 has a supply voltage range of 2 – 3.6 volts. The ESP32 has a recommended supply voltage between 1.8 – 3.3 volts. The nRF52832 has a supply voltage range of 1.7 – 3.6 volts.

Overall, the nRF52832 chip has the best power options. Not only does it have the smallest voltage requirement, it also provides a low power mode that will be helpful for our project. The low power mode will choose the most efficient supply option so that it can save the most power possible.

## Size

The size of the chip is important so that it can properly fit in a shoe and connect with the sensors. The size of the microchip itself isn’t very helpful, since it has to be mounted on a board for all of its features to be accessed. Various development kits for each microcontroller chip have been found and compared.

SparkFun Electronics is a website that provides development platforms for microcontrollers and provides a very useful platform for both the nRF52832 and the ESP32 microcontrollers. Both development boards are the same size: slightly longer and less wide than a quarter. The CC2540 development kit is a lot larger than the SparkFun development platforms.

Overall in terms of size, the nRF52832 and ESP32 development boards are both very size efficient. They would be small enough to use in our system design, while also being large enough to properly work with and connect the sensor inputs.

## Cost

During development, our group determined that it would be best to have multiple microcontrollers for us to work on at the same time, if necessary. Also, it would be best to have an extra microcontroller in case there are any problems or malfunctions with the ones we are working with. Therefore, cost is an important factor for our group. The development boards mentioned in the size section both sell for $19.95, while the CC2540 development kit sells for around $50.

Overall in terms of cost, the development boards provided from SparkFun Electronics are the cheaper options.

## Leadtime

Leadtime is an important aspect of our development process, since our project is expected to be finished by the end of spring 2019. Therefore, we need to choose a microcontroller that is both readily available, and ships out quickly. Both of the SparkFun Electronics development boards are in supply and can be shipped within 3 – 11 business days (or faster with a cost increase). The development kit for the CC2540 microcontroller is also readily available and will ship in 4-7 business days.

Overall, the availability and lead time for each microcontroller chip is about the same, so it isn’t a very important deciding factor.

## Programmability

Programmability is one of the most important aspects of a microcontroller for our group, since we would like to have a microcontroller that is as simple to work with as possible. The programmability for each microcontroller can be determined by looking at documentation provided for the development boards that we would be working with.

The CC2540 programming kit provides a datasheet for the microcontroller kit. It provides information about the microcontroller itself like a regular datasheet while also providing information about software available to use. It doesn’t provide much in terms of program examples or troubleshooting. The nRF52832 and ESP32 development boards both provide a hookup guide to get started with their board. They both provide example circuits and programs that can be used to ensure that the microcontroller and board is working overall. The difference between the two is the documentation for the microcontroller itself. The ESP32 provides a well-documented IDF along with a few example applications. The Nordic website provides numerous example applications as well as an open forum for continuous support when working with the nRF52832 microcontroller.

Overall in terms of programmability, the provided example applications and code for the ESP32 and the nRF52832 are extremely helpful for programmers looking to use the product. Beyond sample applications, the nRF52832 microcontroller has an extensive amount of support and application examples for it, making it most likely the easiest product to work with.

## Documentation

The documentation for a microcontroller is an important aspect for anyone wanting to use it. The datasheet for a microcontroller provides a lot of incredibly useful information for programming it, like power specifications, operating conditions, peripheral information, schematic diagrams, and pin configurations.

The smallest datasheet is the CC2540 datasheet with 33 pages. It is mostly made up of schematic diagrams and characteristic information. The next smallest datasheet is the ESP32 datasheet with 43 pages. It is mostly made up of pin definitions and peripheral information. The largest datasheet is the nRF52832 datasheet with 555 pages. This is far and away the most detailed and most helpful datasheet out of the microcontroller choices. It contains a very detailed table of contents that makes it easy to navigate to a certain topic of interest.

Overall in terms of documentation, the nRF52832 microcontroller has by far the best documentation provided for users. The datasheet covers nearly every possible topic of interest, making it very easy to find answers for any questions our group has. Not only is the datasheet much better than the other choices, but the Nordic Semiconductor website provides an extensive amount of helpful documentation including starting guides, product specifications, and software user manuals.

## Conclusion

After looking at the specific requirements for each microcontroller option, it could be seen that each would be a viable option for our project. The ADC count, power requirement, size, cost, and lead time for each microcontroller is acceptable for what our project would need. Therefore, choosing a microcontroller mostly came down to the programmability and documentation for each option.

Our group decided that the Nordic Semiconductor’s nRF52832 microcontroller is the best option. Not only does SparkFun Electronics provide an incredibly useful development kit with very detailed instructions, but the Nordic website provides much more documentation and support than the other microcontroller options. The nRF52832 should be the most accessible microcontroller for our group and should be the least challenging to work with.

## Sources

<http://www.ti.com/lit/ds/symlink/cc2540.pdf>

<https://www.mouser.com/datasheet/2/297/nRF52832_PS_v1.3-1117956.pdf>

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