Blue2

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**Concept of Operations**

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Concept of Operations

for

Blue2

Team <13>

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# Executive Summary

Principles of Electrical Engineering, ECEN 215, covers the fundamentals of electric circuit analysis and an introduction to electronics for engineering majors other than electrical and computer engineering. ECEN 215 provides the option for the course to be conducted in a distance learning format. To perform the labs for this course if the distance learning format was in place, the Analog Discovery 2 (AD2) device is required. However, the students taking this course are more likely to stray away from purchasing an expensive device that will only be used for one semester. The Blue2 device will provide all of the functions necessary to succeed in this course, it will be designed with Bluetooth capabilities, it will be operated through a phone application, and it will be low-cost. With all of these implementations, students will be able to purchase all of the equipment they need to perform the labs in the ECEN 215 course.

# Introduction

This document introduces Blue2, an instrumentation device that will serve as a replacement for the Digilent Analog Discovery 2 (AD2) device. Blue2 will be a low-cost purpose-built Bluetooth-enabled instrumentation system that can be integrated with a breadboard for enabling ECEN 215 students to perform their labs.

## Background

The cost of the AD2 device is a hefty $400. The rather expensive device offers more capabilities than are required to complete all of the ECEN 215 labs. Blue2 will be built and programmed specifically to enable ECEN 215 students to execute their assigned labs. One of the main differences between the AD2 and Blue2 is that Blue2 will be connected to a phone via Bluetooth where the analysis data will be displayed. While most instrumentation systems on the retail market are built for general-purpose, Blue2 will be a single-purpose instrumentation system to be used by ECEN 215 students for their labs. This single-purpose solution will reduce cost and exclude features of the AD2 that ECEN 215 labs will not require. The approximate cost of the Blue2 device is $150, resulting in a savings of about $250 per student.

## Overview

Blue2 will serve as a purpose-built replacement for the AD2 device. Blue2 will connect via Bluetooth to the user’s phone for control and measurement display. The Blue2 device will come equipped with an oscilloscope, an ohmmeter, a variable amplitude and frequency wave generator, DC power supplies, a voltmeter, and an ammeter. Since Bluetooth will be used to connect the instrumentation device to a phone, the USB wire from the device to a computer will be eliminated. There will still be wires for the probes for connecting the instrumentation device to a breadboard for lab analysis. The input parameters of these measurement subsystems will be controlled via the phone app. Likewise, the output values of the measurements will be displayed via the phone app.

## Referenced Documents and Standards

* <https://vtsociety.org/wp-content/uploads/2019/07/Core_v5.1.pdf>
* <https://developer.android.com/docs>
* <https://en.cppreference.com/w/>
* [What is ESP32 and Why Is It Best for IoT Projects? - IoT Tech Trends](https://www.iottechtrends.com/what-is-esp32/#:~:text=ESP32%20is%20a%20low-powered%2C%20low-cost%20microcontroller%20%28MCU%29%20board%2C,and%20is%20based%20on%20a%20dual-core%20processor%20mechanism.)
* <https://docs.espressif.com/projects/esp-idf/en/latest/esp32/>

# Operating Concept

## Scope

This project is intended to provide the same functionality as the current AD2 but has the ability to operate through a phone application via Bluetooth. The student will connect their device to their phone when they are ready to perform the lab. On the phone, the user can view a display of all of the functions, the changes that can be made, and the output of their device. The device will include everything necessary to complete the lab. This allows students to perform the lab anywhere, as long as they have the Blue2 device, their phone, and the lab instructions.

## Operational Description and Constraints

The Blue2 device is intended to be used by ECEN 215 students, and it will house all of the required functionality for the students to complete their labs. The Blue2 device will take input parameters from the phone app and output desired measured values onto the phone screen. Both inputs from the user and outputs from the device will be transmitted over a Bluetooth connection.

## System Description

* Android App
  + An application that is on an Android device that connects to the Blue2 device using Bluetooth. The Android device will be used as a display and control interface in place of the AD2’s Waveforms application.
* Hardware/Firmware
  + The hardware consists of the measurement device circuits used to complete the ECEN 215 labs.
  + Oscilloscope - A two-channel oscilloscope to measure output waveforms from the user’s circuit.
  + Voltmeter - The voltmeter measures instantaneous voltage from the user’s circuit by subtracting channel 1 from channel 2.
  + Ohmmeter - The ohmmeter measures instantaneous resistance from the user’s circuit.
  + Ammeter - The ammeter measures instantaneous current from the user’s circuit.
  + DC Power Supplies - The +/- 5V power supplies will be able to supply DC voltage to the user’s circuit, mostly for op-amp-related circuits.
  + Wavegenerator - The wave generator produces sine, square, triangular, and varying DC waveforms and applies them to the user’s circuit.
  + Bluetooth Receiver/Transmitter - Both the input and the output data of the Blue2 hardware device will need to be sent to and from the device between the app via Bluetooth.



## Figure 1: Blue2 System Block Diagram



## Figure 2: Microcontroller Connection with Phone Application

## Modes of Operations

The Blue2 device will have two modes of operation. In mode one (reading data), the user has initiated continuous data reading via the phone app for each analysis device separately. In this case, data is sent to and from the phone with at least one device up to all six devices. In mode two (sleep), the user has not initiated continuous data reading from at least one device up to all six devices. The Blue2 device can only exist in one of these two modes: either reading data or sleep. The Blue2 device will be wall-powered, and therefore will only be powered-up while plugged in.

## Users

Non-Electrical and Computer engineering students taking ECEN 215 will be using our device. This device will take the place of the measurement equipment inside the labs. With the Blue2 device, the students can operate all of the required functions for the lab using the phone application. To get the phone application, the students would need to download the app. The students will be able to follow the lab manual to design and configure the Blue2 device and their breadboard. With minimal experience working with similar devices, the students can figure out how to use the device following Blue2 instructions and the lab instructions. With distance learning in place, these students will have the advantage of performing these labs outside of the designated lab rooms. This gives them flexibility for when and where they can do the lab.

## Support

Included with each Blue2 will be a PDF version of the ECEN 215 lab manual accessible through the app.

# Scenarios

## ECEN 215 Lab 1

The Blue2 device will be equipped to complete all ECEN 215 labs replacing the need for an AD2. In lab 1, students will understand Ohm’s law, Kirchhoff's Voltage Law, Kirchhoff’s Current Law, and a voltage divider by creating the circuits shown in the figures given in the lab manual. In this lab, the students will be required to measure and record resistances using the ohmmeter function on the Blue2 device and voltages using the voltmeter on the Blue2 device. The output values will show on the phone app that is connected to the device. For the circuits to work, the students are required to use the DC power supplies that are from the Blue2 device to provide power to their circuits.

## ECEN 215 Lab 4

The purpose of lab 4 is for the student to understand the time-dependent behavior of a resistor-capacitor circuit and a resistor-inductor circuit when an AC input is applied. In lab 4, the student is instructed to use a waveform generator to generate a square wave input at a specific frequency and amplitude. The Blue2 device and phone app software will be able to configure parameters of onboard analysis devices and function generators to read the data correctly. The student is also instructed to use an oscilloscope to retrieve the input and output waveforms of the circuit. The oscilloscope on the Blue2 device will output the waveforms onto the phone screen via the phone app. The phone app will be capable of any post-reading user analysis including frequency, amplitude, and delta t readings.

# Analysis

## Summary of Proposed Improvements

* The Blue2 device will have the capability to connect via Bluetooth to the user's phone.
* The user will operate the functions required for the lab from their phone.
* The Blue2 device will be significantly cheaper compared to the existing Analog Discovery 2.
* The Blue2 device allows users to perform the lab without having to connect the device to a computer.

## Disadvantages and Limitations

* Using the device via Bluetooth may cause the phone not to connect, it may randomly disconnect, or one can run into interference from other devices.
* Using the device via Bluetooth will give the student a limited amount of distance they can be apart from the device.
* The Blue2 device is built to provide the necessary functions for the lab but the device does not come with wires, resistors, and a breadboard which are necessary components to perform the lab.
* When analyzing output values or simulations created by using the Blue2 device, it might be difficult to read the specifications on a smaller device like a phone compared to a laptop.

## Alternatives

* The industry alternative is the AD2. While the AD2 offers more capabilities than the Blue2, it also boasts a significantly higher price. It also does not have bluetooth capabilities that the Blue2 has.
* Another alternative would be to use the bench equipment in the lab rooms of the Zachry engineering building. The monetary cost would be negligible to the user; however, the time spent on each portion of their lab would be significantly higher as each device is a standalone device. Those devices operate with a high degree of precision that the user, during his or her ECEN 215 lab, would not require.

## Impact

* Less material waste and E-waste when the product is discarded when compared to AD2
* Decrease the monetary value that is required to properly complete the ECEN 215 labs
* Ethical concern about making this product or a significantly more costly product the only source of completing the ECEN 215 labs