# Project Description
# UNL School of Computing – Husker Scope 3.0

## Project Overview

*The Husker Scope project is an all-in-one cross platform (IOS, Android, and Web App) application that currently implements a Dual Channel Function Generator, Oscilloscope, and Spectrum Analyzer functionality for use within UNL engineering courses and around the world. The second-year students were able to enable multi-channel inputs for the Oscilloscope and Spectrum Analyzer into the app. Students were able to setup USB connections and Bluetooth to Android, but iOS is not yet functional. Additionally, the current hardware interface has limited storage and transmission speeds to the app.*

- *More Advanced Dual Channel Oscilloscope/Spectrum Analyzer Functionality:*
  - *Re-Develop the hardware input interface that uses time division multiplexing to digitally merge and transmit the two channels into the O-Scope and Spectrum Analyzer apps via a single Bluetooth to Android, iOS and Web App.*
  - *Increase the serial transmission speed.*
  - *Determine new hardware (likely an FPGA) and build a new hardware interface that will enable increased sampling rates and the number of samples collected:*
    - *At least 2-channels ADC inputs at least 1-10MSPS.*
    - *Enough High-speed RAM to store at least two buffers of 1-10 Million Bytes.*
- *Logic Analyzer Functionality (Multi-Channel)*
  - *Modify the hardware input interface to digitally merge a bus of up to 8 digital input channels into the app via a serial Bluetooth interface.*
  - *Have enough RAM to store 1-10 Million Bytes of samples.*
  - *Logic analyzer will be able to implement protocol decoding for signals like (PWM, SPI, UART, Timing, etc). Students may be able to leverage sigrok (https://github.com/sigrokproject) decoding libraries to accomplish more.*

## Sponsor Background

*I am an Assistant Professor of Practice in the School of Computing at the University of Nebraska-Lincoln, a Computer Engineer, and recently retired U.S Air Force Major. My research interests include robotics, embedded systems, 3D modeling, and simulation design. My areas of specialization include VLSI Systems, Computer Architecture, Embedded Systems, Advanced Digital Design. I have been teaching in the CSCE department for four years and have taught the Advanced Embedded Systems Course for four years. Additionally, I taught a similar course at the Air Force Academy for two years prior to that. This course teaches engineering students how to develop the hardware and software interfaces of an Oscilloscope and Function Generator using a Nexys Video FPGA. Having an all-in-one cross platform (IOS, Android, and Web App) application for students to test out their hardware has been very helpful in the course. The new hardware interface will expand the capabilities of the current app.*

## Project Stakeholders

*This application will be used by engineering students and faculty throughout UNL and other Colleges/Universities.*

- *Jeffrey Falkinburg, Assistant Professor of Practice, Principle Investigator and Primary Contact*
- *Charles Daniel, Computing Coordinator, SoC Computing Expert*
- *CSCE 436 – Advanced Embedded Systems Students*
- *Other UNL Engineering Students*

## Current System Overview

*The Husker Scope app is an all-in-one cross platform (iOS, Android, and Web App) application that currently implements a Dual Channel Function Generator, Oscilloscope, and Spectrum Analyzer functionality for use within UNL engineering courses and around the world. The second-year students were able to enable multi-channel inputs for the Oscilloscope and Spectrum Analyzer into the app. The Dual Channel Function Generator is currently able to output waveforms (sine, square, triangle, and sawtooth, etc.) via the left and right headphone channels within the audio range (20Hz to 20,000Hz). The user is able to adjust output Amplitude, Frequency, and Phase of the two channels. The AM/FM Modulator provides another unique output waveform on the audio channels. The Oscilloscope and Spectrum Analyzer functionalities are able to function like a standard single channel oscilloscope and spectrum analyzer to analyze audio range (20Hz to 20,000Hz) signals and dual channel using the Husker Scope 2.0 hardware interface. The oscilloscope and spectrum analyzer interfaces includes many of the standard control features. Figure 1 gives you a broad overview of how the application currently interfaces in the audio range as a piece of engineering test equipment in single channel mode.*

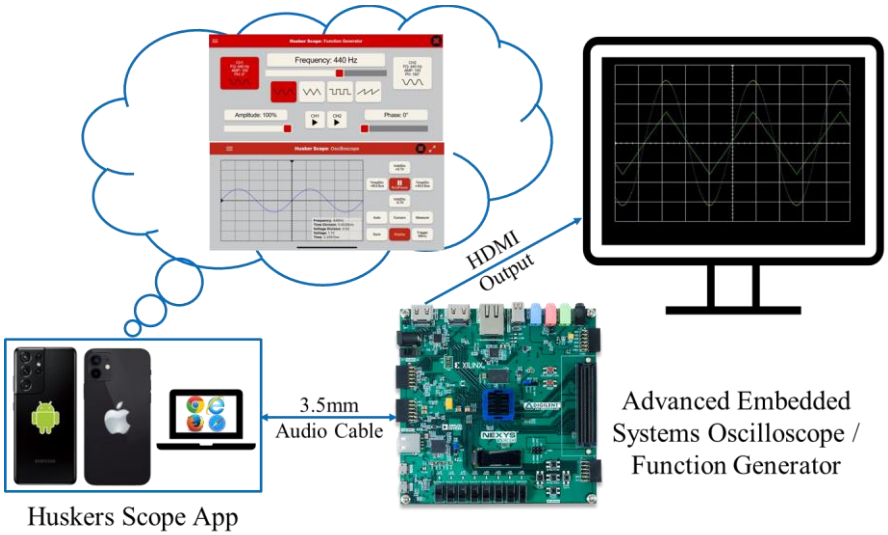


Figure 1: Husker Scope 1.0 App Interface Overview

*The app currently outputs through the left and right channels and inputs through the microphone on a standard 3.5mm headphone jack. The app still works for phones that don't have a physical headphone jack by connecting an adapter to the USB-C or Lightning charging port. A typical stereo jack pinout is show in Figure 2.*


Figure 2: Typical Stereo Jack pinout

*In order to get the mobile and web apps to allow an external microphone input we had to build small hardware interface. The breakout board takes the left and right channel outputs from the function generator and allows you to select which is sent to the microphone input of the oscilloscope. The design is shown in Figure 3 below.*

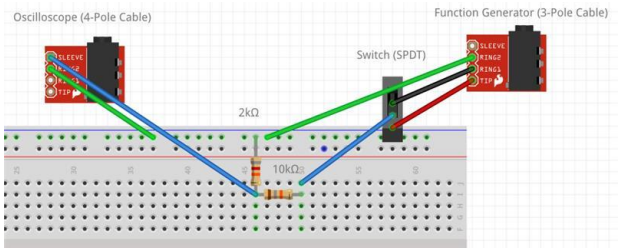


Figure 3: Husker Scope breakout board interface design

*We then prototyped a breakout board for the students to use in class shown in Figure 4 below.*

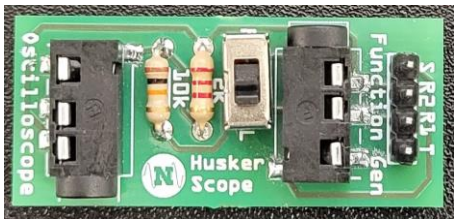


Figure 4: Husker Scope breakout board

*Find more information on the Husker Scope app at [https://www.huskerscope.com/](https://www.huskerscope.com/).*

## Proposed System/Scope

In the following four subsections, we will provide the project vision.

### 1. Business Justification

*This all-in-one cross platform (iOS, Android, and Web App) application will provide a cheap and easy way for engineering students to have ready access to test equipment*

*like a two-channel Function Generator, Oscilloscope, Spectrum Analyzer, and Logic Analyzer. This year we will redesign the hardware interface to enable two-channel inputs for the Oscilloscope and Spectrum Analyzer, enable functionality outside the normal audio range, as well as adding in a Logic Analyzer functionality into the app.*

## 2. Proposed System Overview and Strategy

*Expand the all-in-one cross platform (iOS, Android, and Web App) Husker Scope application so it can accept multiple inputs and can analyze analog and digital signals outside of the standard audio range (20Hz to 20,000Hz). Additionally, we will be adding in a Spectrum Analyzer functionality for frequency analysis and a Logic Analyzer functionality for digital signal analysis. An overview of the prospective Husker Scope input interface to the Husker Scope app is shown in Figure 5 below.*

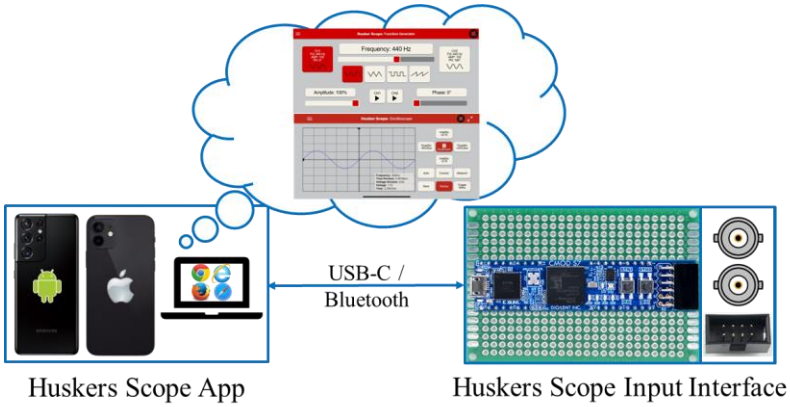


Figure 5: Husker Scope 2.0 Overview

## 3. Scope of Work

*This team is tasked to redesign the Husker Scope hardware interface to enable two-channel inputs for the Oscilloscope and Spectrum Analyzer, to enable functionality outside the normal audio range, as well as adding in a Logic Analyzer functionality into the app.*

- *More Advanced Dual Channel Oscilloscope/Spectrum Analyzer Functionality:*
  - *Re-Develop the hardware input interface that uses time division multiplexing to digitally merge and transmit the two channels into the O-Scope and Spectrum Analyzer apps via a single Bluetooth to Android, iOS and Web App.*
  - *Increase the serial transmission speed.*
  - *Determine new hardware (likely an FPGA) and build a new hardware interface that will enable increased sampling rates and the number of samples collected:*
    - *At least 2-channel ADC that inputs at least 1-10MSPS.*
    - *Enough High-speed RAM to store at least two buffers of 1-10 Million Bytes.*
- *Logic Analyzer Functionality (Multi-Channel)*
  - *Modify the hardware input interface to digitally merge a bus of up to 8 digital input channels into the app via a serial Bluetooth interface.*

- *Have enough RAM to store 1-10 Million Bytes of samples.*
- *App will be able to display the 8 channels of data to the user.*
- *Logic analyzer will be able to implement protocol decoding for signals like (PWM, SPI, UART, Timing, etc). Students may be able to leverage sigrok (https://github.com/sigrokproject) decoding libraries to accomplish more.*

## 4. High Level Architecture Requirements (Technical Specifications)

*The current application was built using Ionic React App Framework so that we could deploy to iOS, Android, and Web App with the same code. The system will be expanded with the following Technical Specifications:*

- *Hardware input interface circuit design to expand the Husker Scope input capabilities:*
  - *Interface will be prototyped using breadboards, and a PCB will be created with the final design.*
  - *Initial PCB designs should be assembled to be tested by early spring.*
  - *Interface will have a serial Bluetooth interface to connect to a phone/computer.*
  - *Interface will use time division multiplexing to merge and transmit two channels for the Oscilloscope/Spectrum Analyzer and Multiple Channels for the Logic Analyzer.*
  - *At least 2-channel ADC that inputs at least 1-10MSPS.*
  - *Enough High-speed RAM to store at least two buffers of 1-10 Million Bytes of samples.*
  - *Interface will sample analog signals for the Oscilloscope/Spectrum Analyzer and digital signals for the Logic Analyzer.*
  - *Research alternatives, but it is likely that only an FPGA will be able to sample both two analog and multiple digital signals at a high enough sampling rate while providing enough on chip storage. Otherwise, you will need a processor with a high clocking rate (100MHz or more) with an external 2 channel ADC capable of 1-10 MSPS*
    - *This may be a good FPGA option: https://digilent.com/shop/cmod-s7-breadboardable-spartan-7-fpga-module/*
- *Logic Analyzer Functionality (Multi-Channel)*
  - *Modify the hardware input interface to digitally merge a bus of up to 8 digital input channels into the app via a serial Bluetooth interface.*
  - *Have enough RAM to store 1-10 Million Bytes of samples.*
  - *App will be able to display the 8 channels of data to the user.*
  - *Logic analyzer will be able to implement protocol decoding for signals like (PWM, SPI, UART, Timing, etc). Students may be able to leverage sigrok (https://github.com/sigrokproject) decoding libraries to accomplish more.*

## 5. Development Environment

*The current application was built using Ionic React App Framework so that we could deploy to iOS, Android, and Web App with the same code. The*

## Expected Deliverables from Project Team (Senior Design Provides)

*The expectation is a fully functional mobile application that is deployed to both the Google Play Store, the Apple Store, and via Web App that is capable of interfacing with the new hardware input interface and using the standard audio codec by the end of this effort. The students will also create a custom PCB for the new hardware input interface using KiCad by the end of this effort.*

## Supporting Materials (Sponsor Responsibilities and Provisions)

*You will be expanding the capabilities of the Husker Scope app and will have test equipment available in the labs as a guide for your development of our multi-function apps. The Husker Scope app will be tested with the test equipment used in the labs and will continue to be used and tested by students in the Advanced Embedded Systems course in the spring semester. See the spring 2023 CSCE 436 course website for more information on how an Oscilloscope (Lab 1-3) and Function Generator (Lab 4) function.*
*https://cse.unl.edu/~jfalkinburg/cse_courses/2023/436/index.html.*

*The PCB hardware/circuitry*

## Communication Plan

*The communication will be mainly via Teams (text, audio, or Zoom/Teams calls). Meetings will be held via Zoom for weekly meetings and in-person for major milestone meetings would be preferred. The primary contact is available weekly to answer any questions during his office hours or at scheduled office/Zoom visits. Email for an appointment. Otherwise, send a message via Teams and we will get back to you asap.*

## Sponsor Contact Information

| Name | Primary Contact (Y/N) Select one person | Contract Signer (Y/N) Select one person | Email Address | Title | Address | Phone Number |
|---|---|---|---|---|---|---|
| Jeffrey Falkinburg | Y | Y | jfalkinburg2@unl.edu | Assistant Professor of Practice | 368 Avery Hall | 402-312-8078 |
| Charles Daniel | N | N | cdaniel@cse.unl.edu | Computing Coordinator | 27D Avery Hall | 402-472-7577 |

## Organizational Logo


## Any Other Information

Provide any other information that the student team should be aware of.