Project Description
UNL SoC Falkinburg Daniel – Husker Scope 2.0

Project Overview
For this project will expand on the current Husker Scope app. The Husker Scope app is an all-in-one cross platform (iOS, Android, and Web App) application that implements a Dual Channel Function Generator, AM/FM Modulator, and Single Channel Oscilloscope functionality for use within UNL engineering courses and around the world.

The first year was able to successfully create the basic app functionality and we would like to develop it further by creating a hardware interface to enable two-channel inputs for the Oscilloscope, enable functionality outside the normal audio range, as well as adding in a Spectrum Analyzer and Logic Analyzer functionality into the app.

Sponsor Background
I am a Lecturer 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 three 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, Lecturer, 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 implements a Dual Channel Function Generator, AM/FM Modulator, and Single Channel Oscilloscope functionality for use within UNL engineering courses and around the world. 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 functionality is able to function like a standard one-channel oscilloscope to analyze audio range (20Hz to 20,000Hz) signals or learning oscilloscope measurement basics. The oscilloscope interface includes many of the standard oscilloscope control features like triggering, time and volts per division, cursors for signal measurement, pause for screen capture, and save options. Figure 1 gives you a broad overview of how the application currently interfaces with other systems as a piece of engineering test equipment.

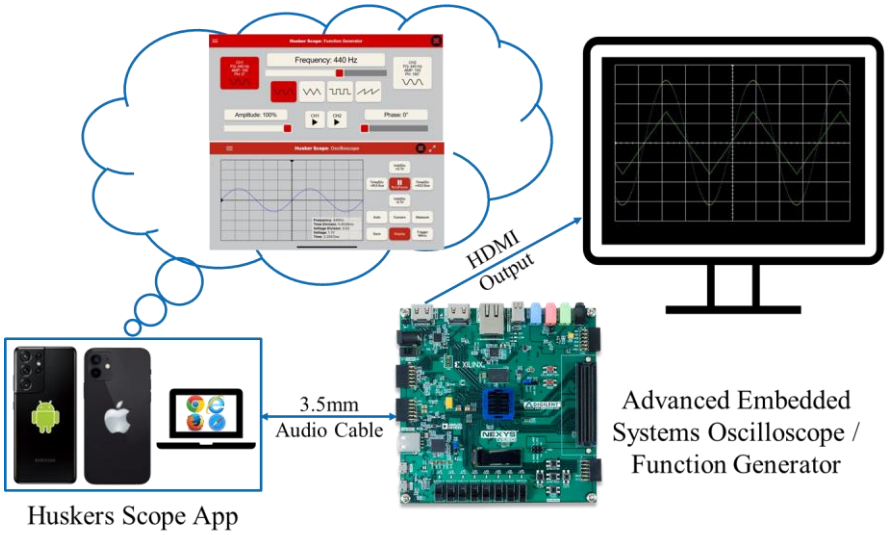

Figure 1: Husker Scope 1.0 App Interface Overview

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.

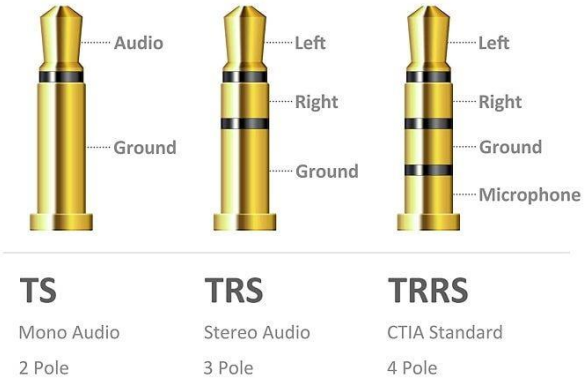

Figure 2: Typical Stereo Jack pinout

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.

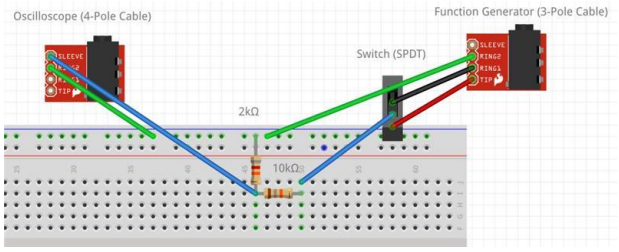

Figure 3: Husker Scope breakout board interface design

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/.

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 create a hardware interface to enable two-channel inputs for the Oscilloscope, enable functionality outside the normal audio range, as well as adding in a Spectrum Analyzer and 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.

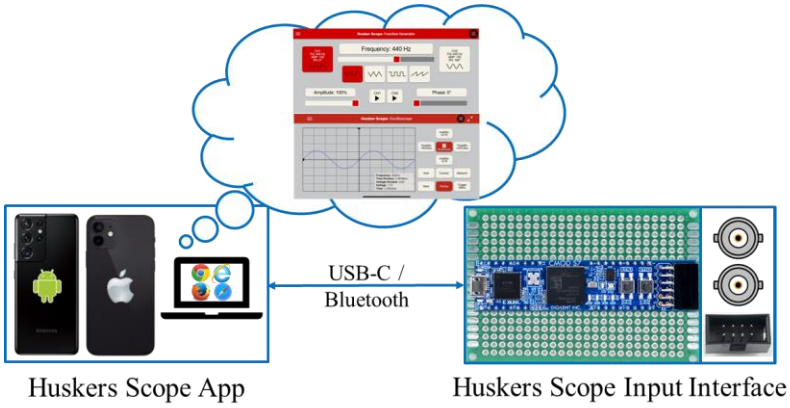

Figure 5: Husker Scope 2.0 Overview

3. Scope of Work

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

- *Dual Channel Oscilloscope Functionality:*
  - *Develop a hardware input interface that uses time division multiplexing to digitally merge and transmit the two channels into the O-Scope app via a single input. Most likely using some sort of serial (USB and/or Bluetooth) interface vs the microphone input to achieve two-channels.*
    - *Interface will be capable of a sampling rate of at least 1MSPS to increase the input signal range while staying cost effective.*

    - *Add in single trigger capability to capture data buffer on the oscilloscope input.*
    - *Add in the Fast Fourier Transform capability into the O-Scope to view the frequency domain spectrum of signals.*
- *Spectrum Analyzer Functionality (single and dual-channel capability):*
    - *App will be able to show the frequency components of ambient sound, music, or your voice within the audio range (20Hz to 20,000Hz) without the new input interface and beyond that with the new input interface.*
- *Logic Analyzer Functionality (Multi-Channel)*
    - *Modify the hardware input interface to digitally merge up to an 8 input channels into the app via a serial interface.*
    - *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.*
    - *Interface will have a serial (USB and/or Bluetooth) interface with phone/computer.*
    - *Interface will use time division multiplexing to merge and transmit two channels for the O-Scope and Multiple Channels for the Logic Analyzer. Onboard storage may be required.*
    - *Interface will be capable of a sampling rate of at least 1MSPS to increase the input signal range while staying cost effective.*
    - *Interface will sample analog signals for the O-Scope 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. Otherwise, you will need a processor with a high clocking rate (100MHz or more) with an external 2 channel ADC capable of 1+MSPS*
        - *This may be a good FPGA option: https://digilent.com/shop/cmod-s7-breadboardable-spartan-7-fpga-module/*
- *Two-Channel Oscilloscope Functionality:*
    - *Two BNC inputs capable of connecting O-Scope probes.*
    - *Analog sampling rate of at least 1MSPS.*
    - *Single trigger capability to capture data buffer on the oscilloscope input.*
    - *Fast Fourier Transform capability to view the frequency domain spectrum of signals.*
- *8-Channel Logic Analyzer Functionality:*
    - *Eight digital inputs capable of being sampled at 1MSPS for each.*
- *Spectrum Analyzer Functionality (single and dual-channel capability):*
    - *App will be able to show the frequency components of ambient sound, music, or your voice within the audio range (20Hz to 20,000Hz) without the new input interface and beyond that with the new input interface.*

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 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 app. The Husker Scope app will be tested with the test equipment used in the labs and will eventually be used and tested by students in the Advanced Embedded Systems course in the spring. 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.

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 if possible. 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 I will get back to you asap.

Sponsor Contact Information

Below is a list of the stakeholders on this project.

Name	Primary Contact (Y/N)	Email Address	Title	Address	Phone Number
Jeffrey Falkinburg	Y	jfalkinburg2@unl.edu	Lecturer – Computer Engineering	368 Avery Hall	402-312-8078
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