wDAQ: Design (Part 2)

TEAM 19: LISA, ADAM, HENRY, VAUGHN

CLIENT: AVISHEK DAS

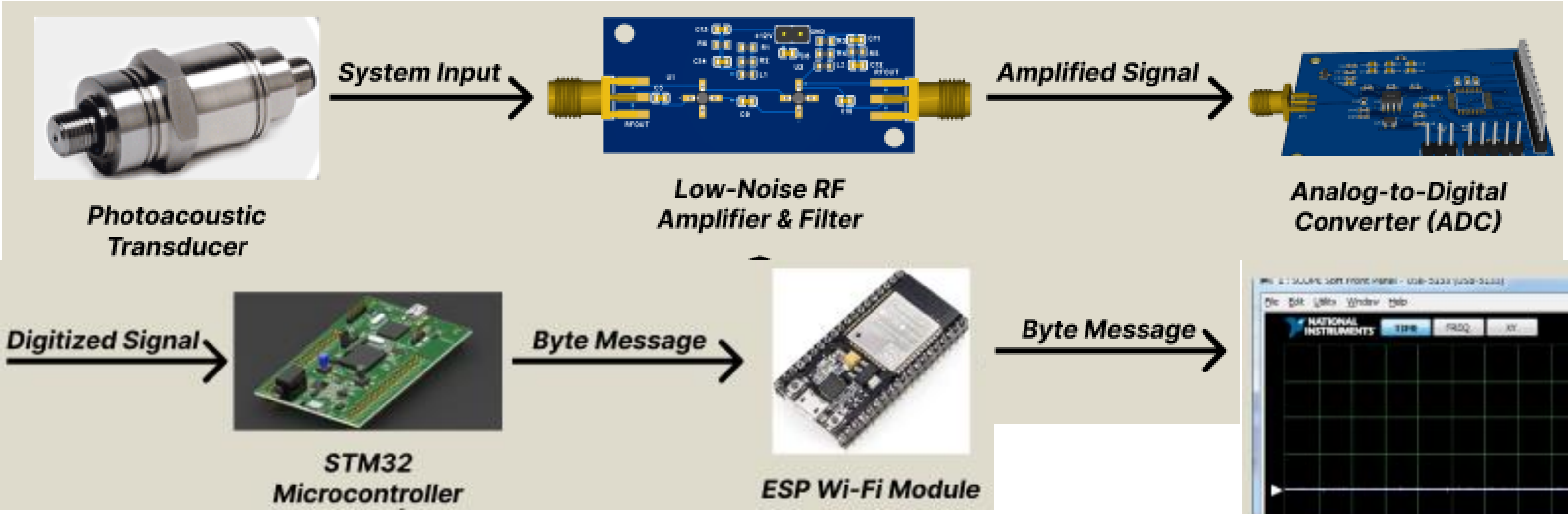
FACULTY ADVISOR: PROF. MANOJIT PRAMANIK

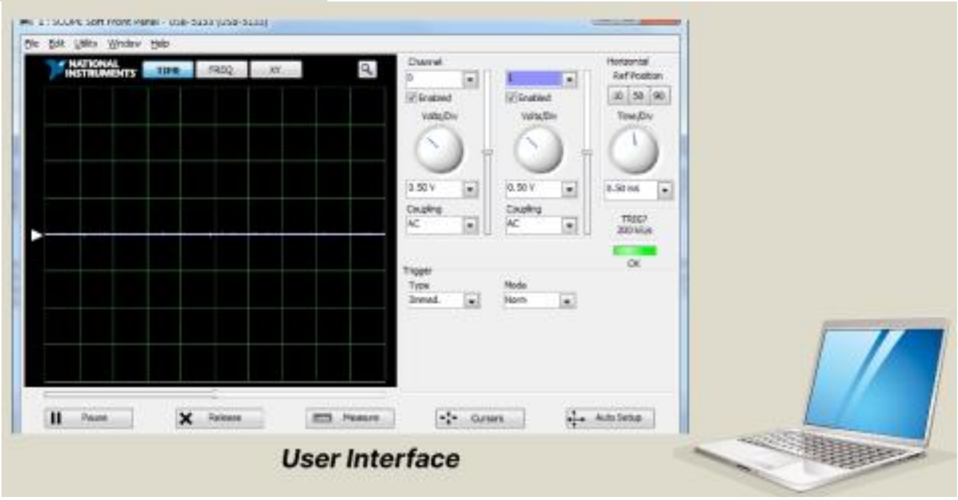
Project Overview

Project: Wireless Data Acquisition (wDAQ) system to capture/transmit high-frequency analog signals to a device in real time using Wi-Fi technology

- The DAQ will amplify a 1 mV analog input signal to approximately 1-2 V before digitizing it
  - ADC will have a 12-bit resolution
- Wi-Fi will be used to wirelessly transmit signals to a computer
  - Bluetooth can be used for signal transmission, but has a significantly lower data transfer rate than Wi-Fi
- The DAQ will be fabricated on a small PCB with surface-mount components
- A graphical user interface (GUI), written in LabVIEW, will be used to analyze data

Detailed Design and Visuals





Figma Flowchart shows images of components, PCBs, and User Interface and their connections

The next slide describes each of these components in detail

Detailed Design and Visuals (Continued)

Photoacoustic Transducer: Converts a real-world physical signal to an electrical signal

RF Amplifier & Filter: Amplifies high-frequency signal by a factor of ~1000. The Design cascades two MAR-6SM+ amplifiers (from Mini-Circuits) powered by a 12 V DC supply. The system maintains a bandwidth of 100kHz-2GHz using an RC network and an inductor to limit current.

Analog-to-Digital Converter: Converts amplified analog signal to a digital signal (taking discrete rather than continuous amplitude values). The system establishes a differential input using instrumentation amplifiers.

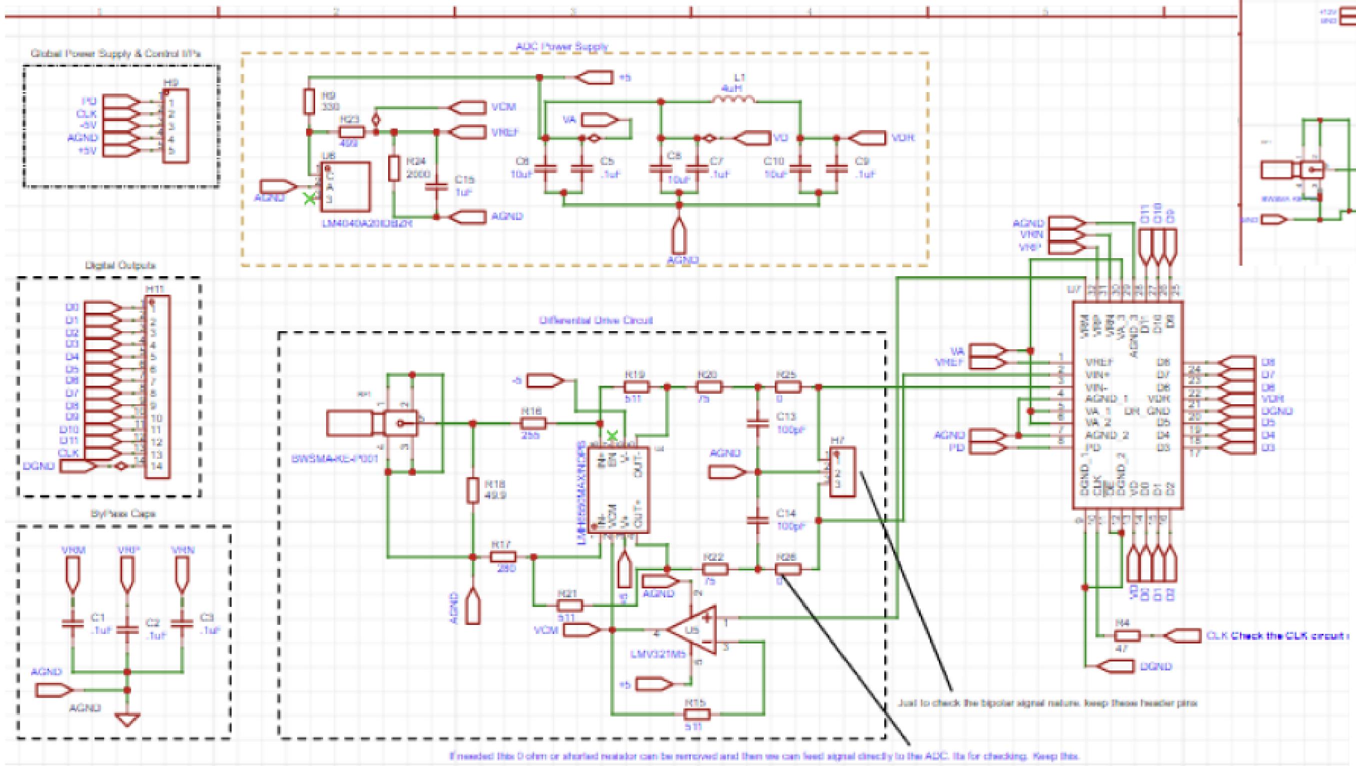
STM32F Microcontroller: Clocks the ADC with a timer to ensure synchronized transmission of data bits in parallel. Reads bits into memory and simultaneously packs down sampled 12-bit values into messages on a serial line.

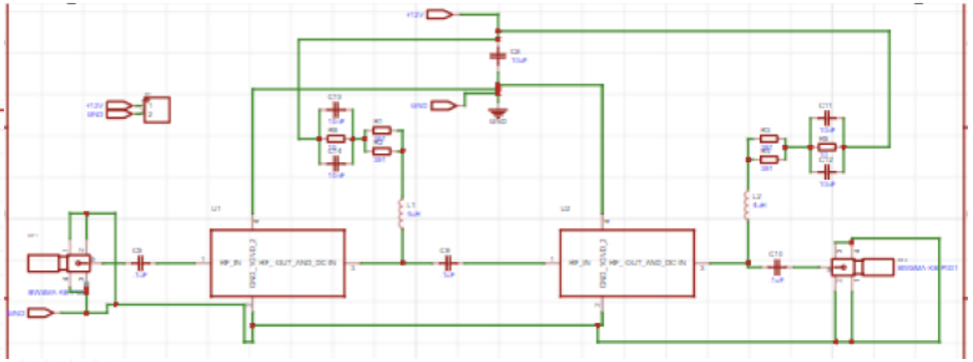
ESP Wi-Fi Module: Transmits data from microcontroller through server to the LabVIEW GUI

User Interface: Reads in 6-byte message from Wi-Fi server. Interprets message to an integer and displays in a graph visible on user's laptop

Detailed Design and Visuals (Continued)

Circuit Schematic for ADC Circuit (Designed in EasyEDA)





Circuit Schematic for Low-Noise Amplifier (Designed in EasyEDA)

Functionality

<u>**User Context:**</u> Photoacoustic Tomography (PAT) System at ISU Biomedical Imaging Lab (BILab)

- 10 to 20 copies of the device will be connected to an array of transducers (devices that convert physical signals to electrical signals) in a circular configuration within the PAT System
- Primary users will be lab technicians, but the device should be catered to less-skilled users
- Users will connect to the devices over Wi-Fi and control them on a user interface in LabVIEW
- The devices will collect physical signals from small animals (like an ultrasound machine), amplify and digitize them, and send them to the user program for analysis
- Users will be able to select which signal (from the array of DAQ systems) they wish to view, as well as adjust the viewing window and axis scales for the signal(s) they are viewing

Technology Considerations

- **<u>EasyEDA:</u>** Schematic & PCB Design Software
  - <u>Advantages:</u> Easy to use and collaborate on designs
  - <u>Disadvantages:</u> Some components must be imported
- **<u>LabVIEW:</u>** Virtual engineering design workbench that connects to instruments
  - <u>Advantages:</u> User-friendly (programming conducted using blocks); can connect to almost any instrument for accelerated testing
  - <u>Disadvantages:</u> Difficult to collaborate on files
- **<u>MAR-6SM+:</u>** Integrated circuit chip for RF amplification
  - <u>Advantages:</u> Only requires one supply voltage; small size profile
  - <u>Disadvantages:</u> Requires multiple chips to achieve our required gain (amplification factor)

Technology Considerations (Continued)

- **STM32F411 Microcontroller:**
  - Advantages: Can easily process digitized data; cost-friendly; has widely available documentation
  - Disadvantages: Requires a development board for testing
- **ESP32 Wi-Fi Module:**
  - Advantages: Has a data transfer rate of 120 M samples/sec; easy to integrate with LabVIEW
  - Disadvantages: Needs to be tested alongside other components

- **ADC 12020:** Analog-to-Digital converter to digitize our signal
  - Advantages: 12 bits of resolution with a sampling rate of 20MSamples/S
  - Disadvantages: Requires a driving circuit for the differential input, which uses a biasing voltage that is different from the 12 V DC used across the rest of the device

Areas of Concern and Development

Current design satisfies most user needs and requirements

- Most individual aspects of the device have been selected or designed to a functional level: Low-Noise Amplifier & Filter, Analog-to-Digital Converter (ADC) Circuit, SMTM32F411 Microcontroller, ESP Wi-Fi Module, and LabVIEW User Interface
  - Schematics and PCBs for the LNA and ADC circuit have been designed and boards have been ordered
- Individual portions of the design will be combined in late April to form a functional prototype
- Future/final iterations of the design should emphasize compact size, clean PCB traces, strong wireless connection between device & software, and compatibility with all user needs & requirements
  - Some PCB traces are somewhat messy, and designs may be unnecessarily overcrowded with wires
  - Initial tests have indicated some unexpected latency with the Wi-Fi data transfer rate
- Our primary concern is successfully designing, ordering, and testing a completed prototype for the full device before the spring semester is over

Conclusions

Given the complexity of the project and its required functionality, our team must make considerations on the advantages of technologies as well as be aware of their potential shortcomings. This will allow the team to adapt to challenges encountered while staying aware of areas of concern within the development process.

When we encounter problems or weaknesses with the technologies we are using, having an idea of potential solutions or alternatives will enable us to cope with the issues effectively and implement changes to ensure we are consistently meeting design requirements.

As we complete future iterations of our design and come closer to the final product, we will need to be more conscious of the constraints we are working with to ensure our design does not exceed sizing limits