Wireless Data Acquisition (wDAQ) System for High Frequency Ultrasound signals

sddec25-06

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Problem Statement

- Photoacoustic Effect
  - When a laser shines light pulses onto an object, this stimulates that object to generate ultrasound waves.
  - fundamental mechanism behind ultrasound technology.
- Ultrasound transducer
  - an electronic device that converts ultrasound signals into voltage signals.
  - The intensity of the light shined will alter the ultrasound signals magnitude which will in turn affect the voltage signals magnitude.
  - requires an oscilloscope to measure these signals, however, the ultrasound transducer is a rotating device, so a wired oscilloscope would get tangled.

Because of this the client requires a device with the signal displaying capability of an oscilloscope, but is wireless and mobile.

Description of Users (Personas)

-Lab Faculty: Want to be able to conduct experiments using oscilloscopes without the constraints of a wired device. Want to make efficient use of lab space.

-Primary user will be the Lab Technicians in the ultrasound lab.

-Students: Want to use convenient & simple measurement tools to complete their labs.

-Lab Management staff: Want to avoid clutter and make best use of space available.

Requirements and Standards

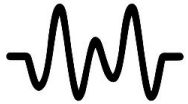
- Requirements and Constraints
  - Wireless
  - Real-Time transmission
  - Input amplified and filtered
  - Two channels
  - Resolution of display in 12 bits
  - Interface program is LabView
  - Transmission Chip is ESP32

- Standards
  - IEEE 802.11ac - Wireless Communication Standard
  - IEEE 1657-2009 - Battery Management Standard
  - IEEE 11073 - Medical Device Communication Standard
  - ISO 9001 - Quality Management Standard
  - ISO/IEC 27001 - Information Security Management Standard

User Needs

Wireless & Portable

Replaces BNC cables; supports remote use

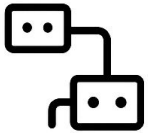


Real-Time MHz Acquisition

Fast sampling; supports real-time or buffered mo

Clean & Stable Signal

Low-noise amplification; strong EMI shielding

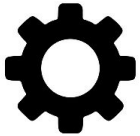


Modular & Scalable

2 channels/module; supports multi-module setup

User-Friendly GUI

LabVIEW-based interface for control and display



Reliable & Affordable

Stable performance with controlled cost

User Needs- Wireless & Portable

Wireless-

- Due to the spinning nature of the transducer, any sort of cables are a no-go
- Wi-fi or bluetooth connectivities are ideal alternatives, allowing the use of an oscilloscope without the problem of attaching it to a display

Portable-

- Most oscilloscopes are large and bulky (such as the ones used in Coover for the E E 2010 and 2300 labs) which are inconvenient to use on variety of machines
- Making the final product small will massively improve the range of applications the oscilloscope will be usable with, enabling mobility to take to different labs as a personal device

User Needs- Real-Time MHz Acquisition

- The ultrasound transducer emits its signal at very high frequencies
- To accurately sample its signals, it is necessary to use a much faster sampling rate to yield usable data
- 20-25 MHz will be a fast enough sampling rate

User Needs- Clean & stable signal

- The system needs to effectively shield most electromagnetic interference (EMI)
- Complies with appropriate electromagnetic compatibility standards
  - the device will not be subject to excessive interference during wireless transmission
  - doesn’t affect surrounding equipment

User Needs- Modular and Scalable

- Two channels/modules
  - Trigger, to keep the waveform stable on the display
  - Acquisition, to collect the data
- This breakdown enhances the device’s ability to handle large amounts of data without causing internal interference

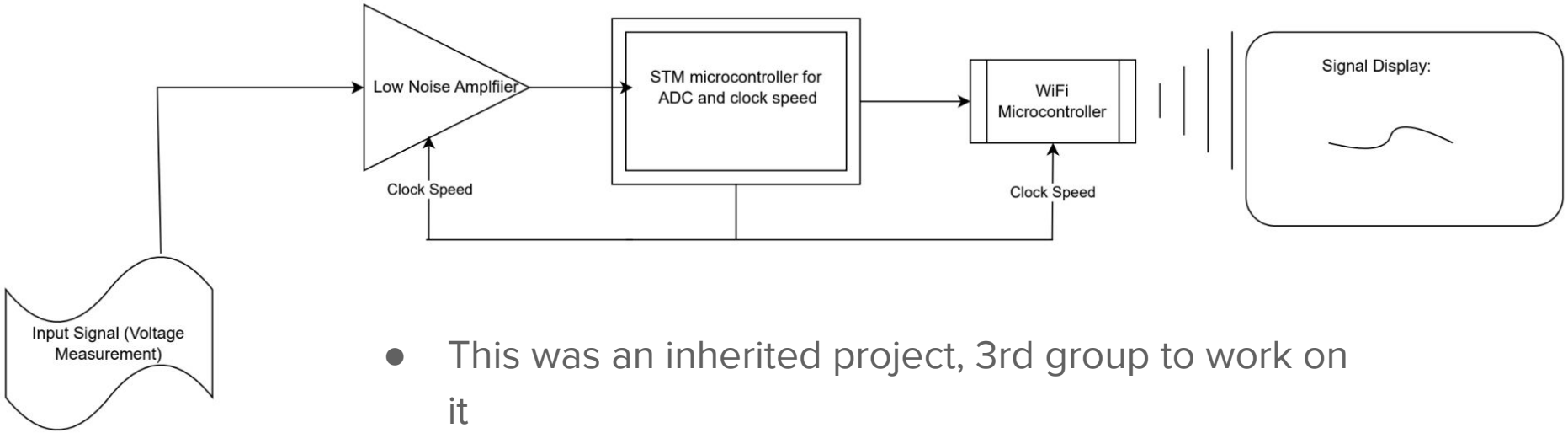
User Needs- User-friendly GUI

- User should be able to easily
  - Access the main PCB board
  - Set data with the process coding run what was asked for
  - Read information and data being display
- The main system needs to be easy to
  - Disassemble
  - Install
  - Move
  - Have stability when rotating at varying speeds
- Users should be able to easily connect to the computer program and view the data.

User Needs- Reliable and Affordable

- Reliability is vital- an unreliable wDAQ is difficult and annoying to use, which would be almost worse than not having one at all
- Other wDAQ devices already exist, none are affordable
  - Most $1000+
  - Other cheaper options don’t have specific or any of the requirements
- The wDAQ made in this project will be very affordable

Detailed Design- Overview



- This was an inherited project, 3rd group to work on it
- Our project focuses primarily on the later half
  - ADC to display

Detailed Design- ADC

- Since the measurements are analog, they will need to be converted to a digital signal for display.
- STM Black Pill microcontroller
  - Up to 200 MHz clock speed
    - driving the amplifier and the wi-fi/bluetooth transmission
  - Necessary for the sampling of the already high frequency analog signal with internal clock
- The digital signal will be able to be transmitted wirelessly
- Able to be read by humans, not in 1s and 0s
- For development and prototyping purposes
  - STM Blue Pill microcontroller
    - 20MHz clock speed,
    - Good for creating experimental code
    - Cheaper than black pill
    - Need to be upgraded later

Detailed Design- Wi-fi Transmission & Display

Wireless transmission-

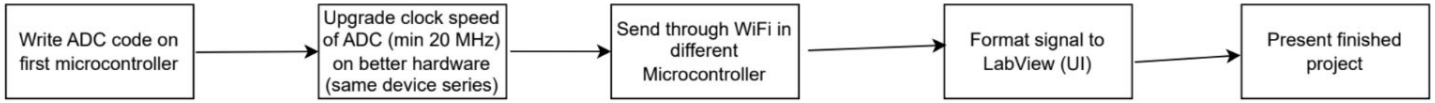
- STM BlackPill does not have native wireless capabilities
- ESP32 microcontroller
  - Only be used for wi-fi
  - Given the converted data from the ADC
  - Wirelessly transmit it to the display

Display-

- LabView
  - Ease of use with programing and testing
  - Voltage waveform graph
  - Amplitude measurements
  - Frequency measurements
- Prototype display is currently being done through Arduino and MATLAB

Project Timeline

Task Name	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
ADC Code												
Upgrade clock speed												
WiFi												
Format Output												
Present Finished Project												



Due to unforeseen circumstances, the final testing of the upgrades clock will be finished in the fall semester

Project Planning - Task Decomposition

- ADC
  - Code for the STM Blue pill
  - Altering the code for the STM Black pill
- Wifi/Bluetooth Connection
  - Coding for the ESP32 data transfer chip
- Display
  - LabView display focused on user-friendliness
- Testing
  - Testing the STM Black Pill and ESP32 together
  - Testing all STM Black Pill, ESP32 and full display together

Risk Management

- High quality chips
- Chip compatibility
  - Due to selection being from client, assumed compatibility
- Code malfunctions and damage to hardware
  - Chips can get really hot, especially if programmed wrong
- Amplifier output and input into second system
  - Chips have specific required inputs
- In-depth testing
- Complying to standards

Metrics of Evaluation

- ADC
  - With direct connected display and controlled input
    - Show input data with 95% accuracy
    - Have full graph shown with axis names, title and record length of 50-100 µsec
    - Sampling rate is within 5% accuracy of 20-25 MS/sec
- Wifi/Bluetooth connection
  - With controlled input, not connected to ADC
    - Connects with Display 95% of the time
  - Controlled input, ADC connected
    - Connects with display 95% of the time with above ADC requirements
- Display
  - On it’s own
    - 12-bit Resolution
    - Allows for real time transmission
    - Have a record length of more than 100 µsec
    - Ability to show full wave up to ± 2V
  - In connection with ADC and ESP32
    - All of the above requirements

Questions?