Lightning Talk: Project and Progress

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Introduction

Problem

- Traditional Data Acquisition (DAQ) systems are wired oscilloscopes with BNC cables and power cords
  - Contain built-in graphical displays and bulky buttons/knobs to adjust settings
  - Large, heavy devices that are poorly suited for mobile data gathering or larger device applications
- Objective: Create a rechargeable battery-powered, Wi-Fi connected, compact DAQ device that is compatible with mobile usage and larger-scale integrated applications while meeting performance specs

Users and Stakeholders

- Key Users: Researchers, Lab Assistants, and Educational Institutions
- Current Customer: BILab (Biomedical Imaging Lab) @ ISU Applied Science Complex

Significance

- Economic Advantages to Users: Cost savings with a reliable device that doesn't require accessories
- Innovation and Financial Opportunities: Increased long-term allocation of funds toward progressive research instead of equipment troubleshooting
- Integrated Data Acquisition Application: Coordinated usage of multiple wDAQ systems in a rotating Photoacoustic Tomography (PAT) system for animal cancer cell imaging & research

Requirements

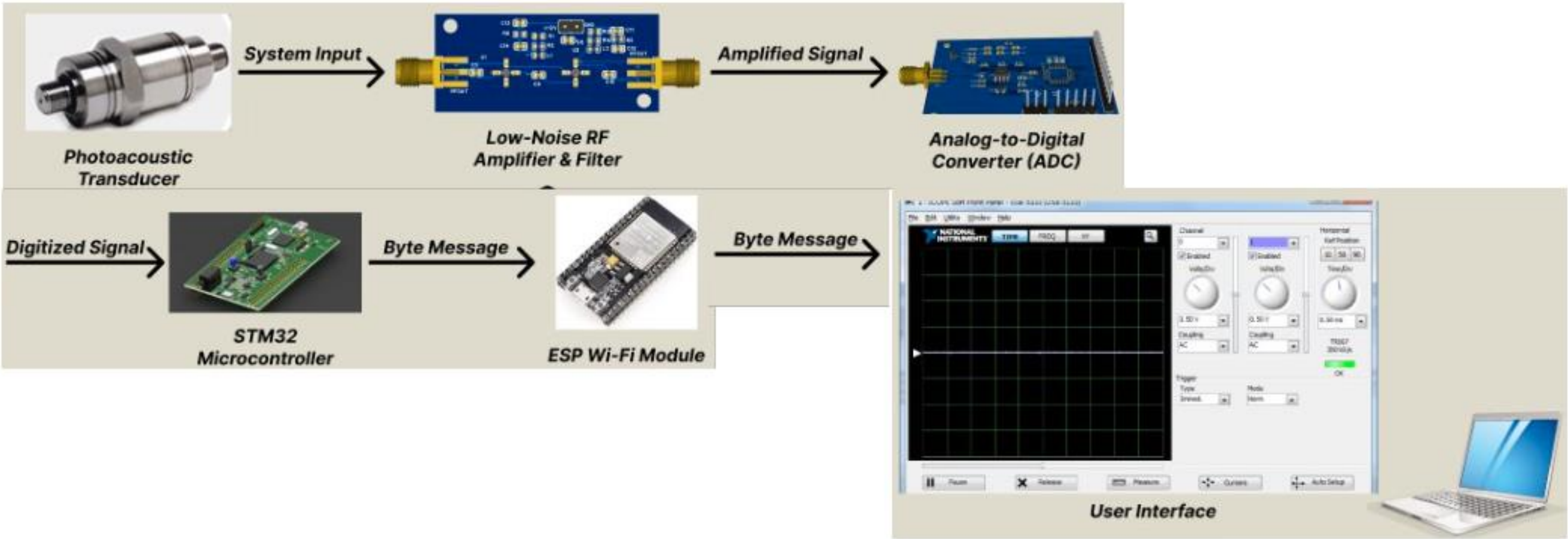
Intended Functionality

- We want to create a wireless data acquisition device that can acquire, amplify, and digitize analog signals, and send data to a LabVIEW user interface over Wi-Fi at high speeds.
- We want our device to be compact and portable enough to be implemented in a rotating transducer array for application in a Photoacoustic Tomography (PAT) System

Key Requirements and Constraints

- <u>Functional Requirements:</u> Amplifies a small radio-frequency (RF) analog (1-10 mV, 0.1-20 MHz) signal to a 1-3 V output and digitizes it at a rate of 100 MSPS, before transmitting it to a user interface at a rate of 100 Mbps (megabits per second)
- <u>Physical and Logistical Requirements:</u> Wireless (battery-powered and Wi-Fi connected) and compact enough to fit in an approximately 1" by 1" by 5" volume
- <u>User Experiential Requirements:</u> Easy and straightforward to use for users of varied skill levels; seamlessly connected to the device via Wi-Fi with the capability to acquire and analyze data from multiple wDAQ devices at once (since ~20 devices will be connected to the PAT System)

Design Overview: High Level

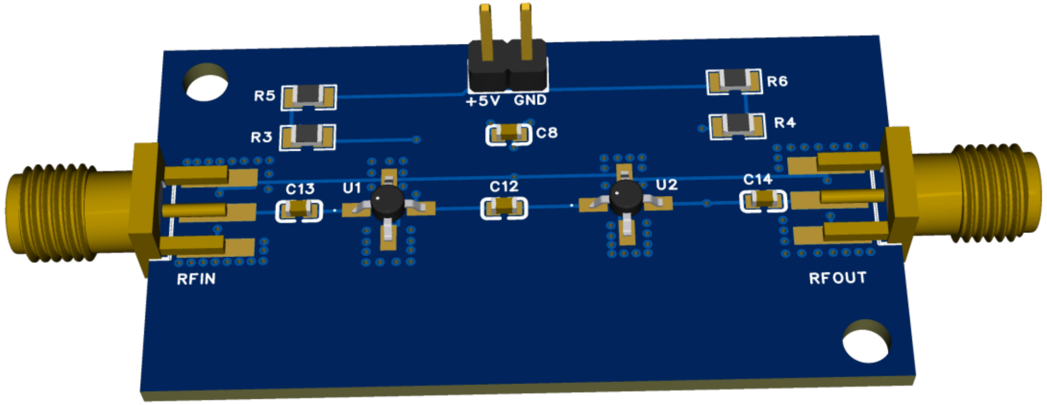


Design Overview: Subsystem Level

Low-Noise Amplifier (LNA)

- Cascade of two MAR-6SM+ amplifiers
  - Device has a low SNR of approximately 2 dB at 300 MHz
  - Biased using 12 V DC supply

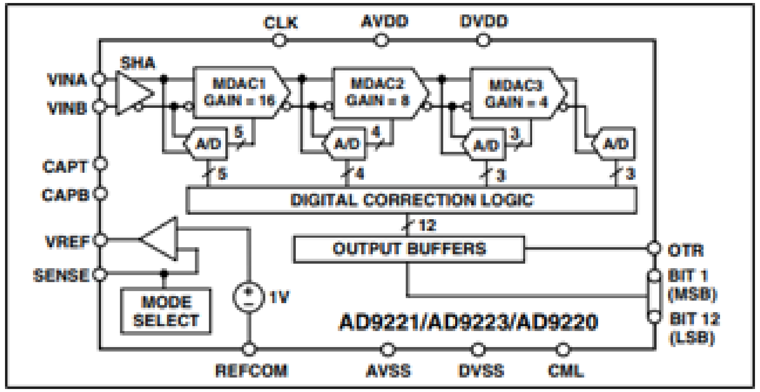
- Amplifies a 1-3 mV signal to 1-3 V (60 dB gain)
- 50-Ω input and output terminations to negate signal reflections
- Low Power Consumption: ~864 mW
- Establishes system bandwidth of 100 kHz ~ 20 MHz



Design Overview: Subsystem Level

Analog to Digital Converter (ADC)

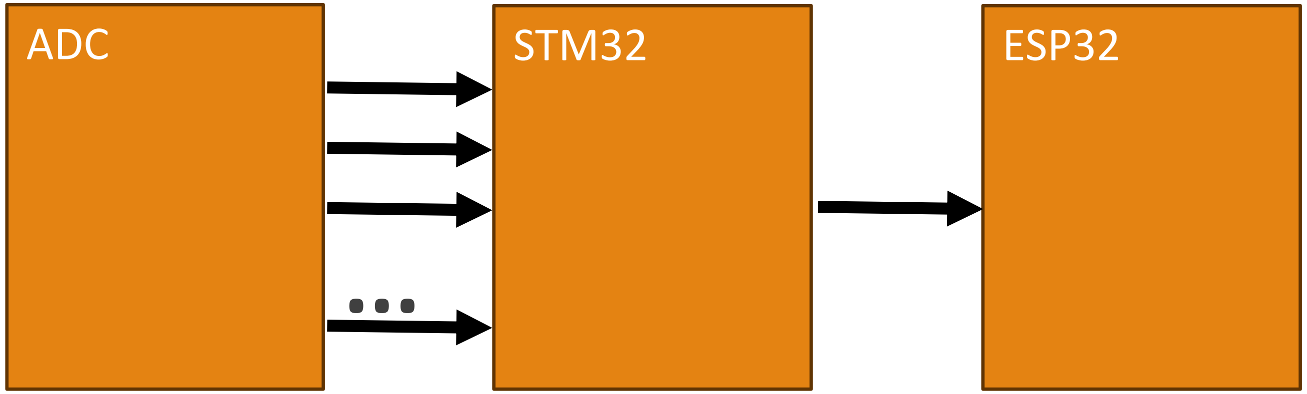
- Analog Devices AD9220
  - 10 MSPS conversion rate
  - 12-bit digital output
  - AD9220 operates with supply voltage of DVDD = 5 V and AVDD = 2.7 to 5.25 V
  - AD9220 has a typical SNR of 70.2 dB and minimum of 69.0 dB
  - The four-stage pipeline architecture of the AD9220 provides faster data throughput at the cost of some latency



Design Overview: Subsystem Level

Microcontroller: STM32F4

- Parallel 12-bit input from ADC output
- Packages 12-bit sample into SPI messages, sending one message per sample
- SPI, GPIO, and DMA peripherals utilized



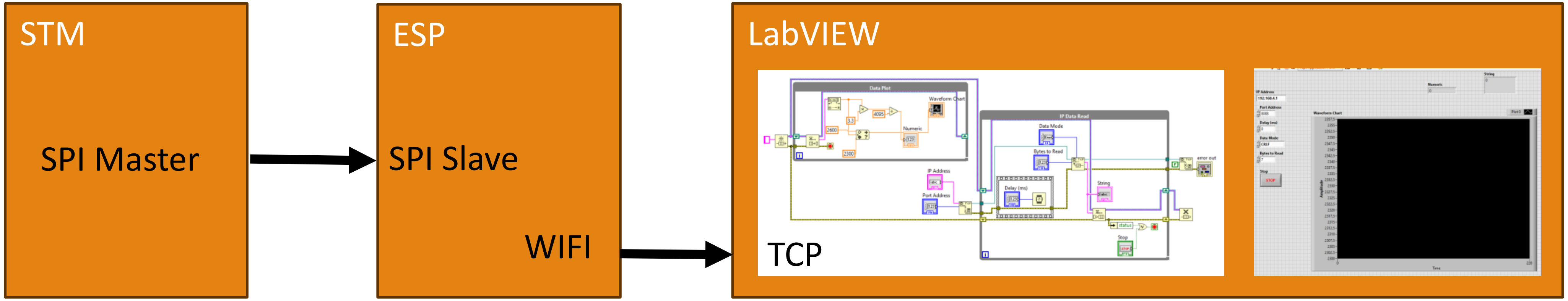
Design Overview: Subsystem Level

ESP32 Wi-Fi Module

- SPI Communication with STM
- Programmed to read in SPI and send out on WIFI

LabVIEW User Interface

- Interface reads in ESP WIFI messages
- Displays on graph



Progress and Outcomes

Implementation Progress

- Working low-noise amplifier (LNA) with gain and bandwidth specifications satisfied
- Analog-to-digital converter (ADC) circuit (AD9220) with proper sampling rate and resolution
- STM32F4 32-bit Microcontroller and ESP32 Wi-Fi Module selected and tested
- LabVIEW User Interface and Serial Peripheral Interface (SPI)
- Battery and Battery Management System (BMS)

Requirements and User Needs Currently Satisfied

- Functional Requirements (gain, bandwidth, sampling rate, resolution, data rate, impedance, etc.)
- Physical Requirements (cordless operation, Wi-Fi connectivity, compact size [in progress])
- User Experiential Requirements (ease of use, integrated application)

Evidence of Functionality, Requirements, and User Needs

- PCBs and/or development boards for LNA, ADC, STM32F4, ESP32, and BMS
- Supporting test results demonstrating specifications and functional/physical requirements met
- Testimonies from client and faculty advisor on functionality of our design

Pending Issues and Concerns

Items Remaining to be Accomplished

- Interfacing Microcontroller with ADC (using ESP32 Wi-Fi Module)
- Testing & implementation of battery and BMS and connection with rest of device
- Fabrication of completed device on one board

Concerns

- Complete system functionality after integration of all subsystems.
- User feedback on overall system's ease of use
- <u>System longevity:</u> given we haven't fabricated a complete device yet, data cannot be obtained on the system's long-term performance.

Advice and Feedback Requested

- Is it acceptable to present the individual subsystems of our design working together, rather than the final integrated product? (For example, we may not be able to show the system functioning on battery power yet, as we have not tested the battery and BMS with the rest of the design.)