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Autonomous Underwater Waveform Generator and Capture System

Project Background

Vemco, a division of Innovasea, designs various acoustic tags and receivers for rivers and oceans. These are used to monitor fish and other marine life behavior for researchers to study migration, predation, and invasive species. A wide range of communication protocols are required for the tags and receivers depending on the environmental conditions.

Problem Definition

Task:

- Vemco wishes to test acoustic waveforms for data transmission in a variety of aquatic environments for R&D purposes.

Current System and Shortfalls:

- Signal capture performed by a repurposed DSP FPGA.
- To generate signals, special transducers must be designed on a case-by-case basis.

Electrical Issues

- Limited frequency range.
- Unreliable storage.
- Two systems needed (capture and generation).

User Operation Issues

- Unreliable electronics.
- Bulky receiver.
- Custom-made transmitter.
- Time consuming setup.

Client Specifications

Engineering Characteristics:

- Analog Bandwidth: 30 to 500 [kHz]
- Selectable Sample Rate: **up to 2 [MSa/s]**
- Minimum 12-bit ADC and DAC Resolution
- Able to play .wav files/generate arbitrary signals continuously.
- Record captured waveforms to 8GB removable data storage.
- Battery operated (rechargeable) for 24 hours of operation.

User Operation:

- Fit in the HR2 waterproof case (pictured below).
- Wireless control for data transfer.
- Remote system activation over for recording/ transmission control.

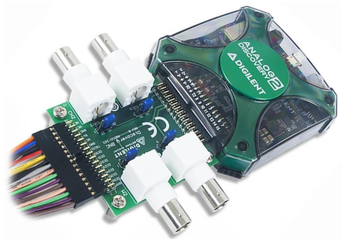
Data Acquisition and Generation System Selection

TI ADS7883 & TI DAC7801: Not Selected

- Low power, cheaper material cost.
- Significantly longer to develop, higher risk of failure.
- Complex evaluation board, reliability risk.
- Cost: $20 (Chips), $60 (Evaluation Board).

Analog Discovery 2: Selected

- Out-of-the-box solution, higher power.
- Reliable system that is easily replaceable.
- Interfaces with Raspberry Pi and associated software for signal generation and capture.
- Cost: $400



Product Design

- There are **six** primary systems that work together to accomplish the needs of the clients. A short overview of each system and the proposed design implementations are displayed below.
- Other design elements are The data acquisition system was deemed to be the foundational system that the others would have to adapt to, as the 2MSa/s client requirement was the most challenging to overcome.
- The proposed design specifications are based on the client specifications, input from industry experts, electrical parameters and group member experience.

Switching Relay

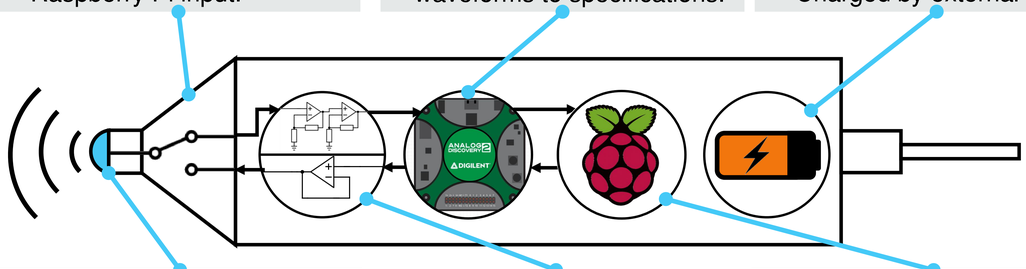
- SPDT Relay to switch between signal capture and generation modes.
- Switch controlled via the Raspberry Pi input.

Signal Acquisition/ Generation

- Implemented on Analog Discovery 2 Board.
- Samples and generates waveforms to specifications.

Power System

- Rechargeable Lithium Ion battery pack.
- Also contains charge control and protection circuitry.
- Charged by external cabling.



Hydrophone

- Can receive and transmit underwater acoustic signals.
- Functions as a piezoelectric transducer.
- Supplied by industry sponsor.

Signal Input and Output Amplification

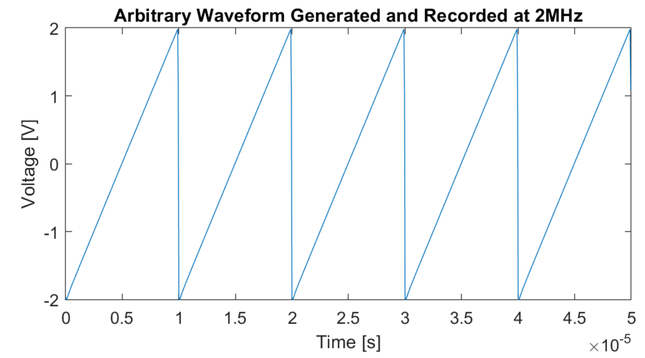
- Input signal is conditioned by a cascaded set of selective amplifiers.
- Output signal is amplified by voltage buffer.

Controller

- System controlled by Raspberry Pi 4.
- Handles data and program processing, storage and external wireless communications.

System Testing Progress

- Validated Analog Discovery 2 (AD2) data logging of up to 2 MSa/s and signal generation of 500kHz (pictured below).
- Validated ability of the AD2 to generate a signal based on a wave file output via outputting to an oscilloscope.
- Confirmed the Raspberry Pi 4 and AD2 were able to interface properly and verified power consumption was within an acceptable limit.



Potential Barriers to Completion

- At high sample rates, the Analog Discovery 2 has been found to skip data acquisition bits as it is uploading the wave file.
- COVID-19 has affected lab testing this semester, causing delays in hardware development and testing.
- The size of the HR2 case may limit the full set of electronics that are intended to be inside, specifically in relation to the battery bank required.

Future Work

- Address barriers to completion such that they are mitigated and/or eliminated completely.
- Develop Power System and Signal Amplification PCB.
- Develop wireless user interface and validate with client.
- Create a user manual for the finished product.

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