A Miniature Data Logger with Underwater Wireless Communication Capabilities

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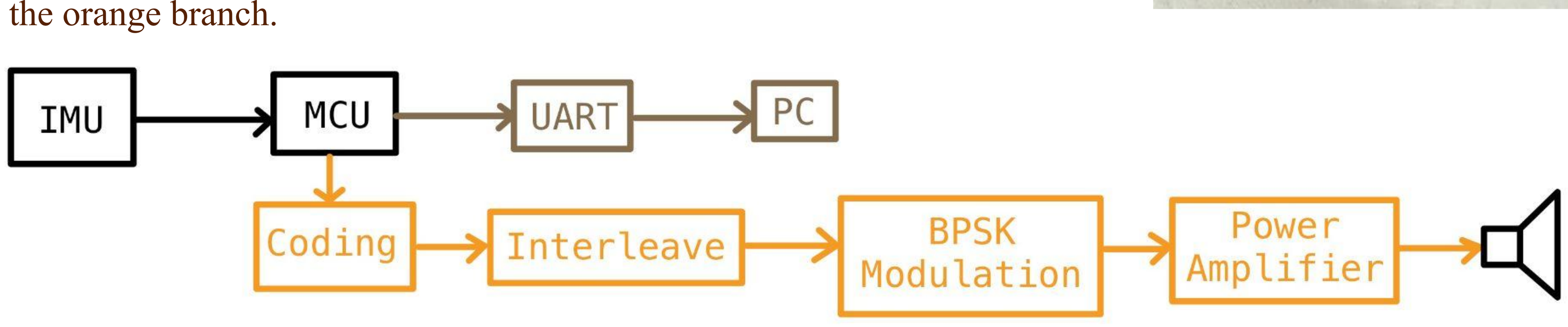
Motivation

- Mini data loggers are beneficial for various civil engineering applications and studies, such as soil erosion, bridge scouring, stormwater and sediment management.
- Current data loggers save data to memory for downloading or need connection to BlueTooth or WiFi for data transfers after they are retrieved out of water. Both techniques lack the value of real-time data transferring.
- The goal is to use a high frequency acoustic transducer to combine data sensing and logging through acoustic communication in small-form-factor microcontroller.

Introduction

- Real-time data transfer while working underwater needs to be done via acoustic communication. The challenge comes from trying to create a compact device when acoustic communication systems are often made from larger components.
- The designed underwater data logger consists of IMU sensors and the sensing data is coded, interleaved, and then modulated to a 200 kHz carrier
- The power amplifier also uses a small form factor multiplexer design so that the data logger can shrink the size down to be as small as a ball with a diameter of 25 - 30 cm. The targeted underwater communication range is 200 – 500 meters with a data rate of 25 kbps.

Figure 1: Block diagram of how data is collected, transmitted, and received. The current data logger follows the brown branch whereas this project focuses on transmitting data through the techniques in the orange branch.



Data Logger System Design

- The current data logger design uses a TI microcontroller and MPU 9250 to achieve functionality. It takes in data through the I2C bus and using UART to transfer the output.

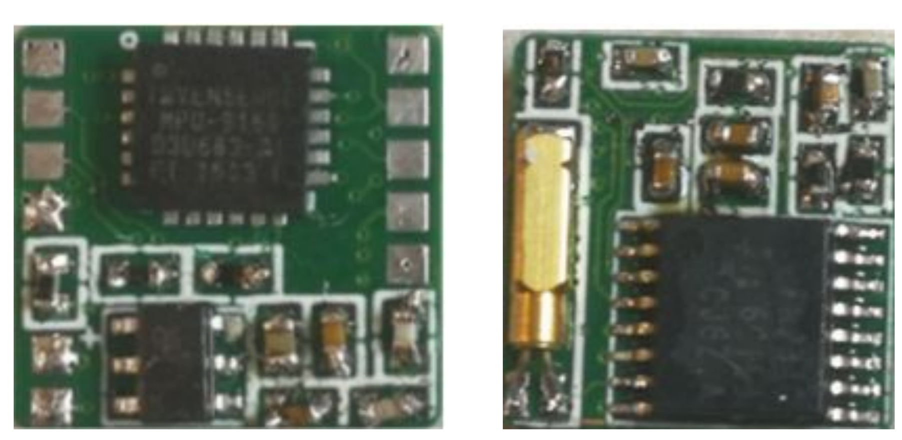


Figure 2: PCB circuit board of data logger (12mm x 12mm)

Figure 3: Data logger encapsulated in 3D printed cartridge to keep a water tight seal.

- The new design will integrate a TI MSP430 FR5969 microcontroller with the data logger sensor, trying to use one transducer to both transmit and receive.

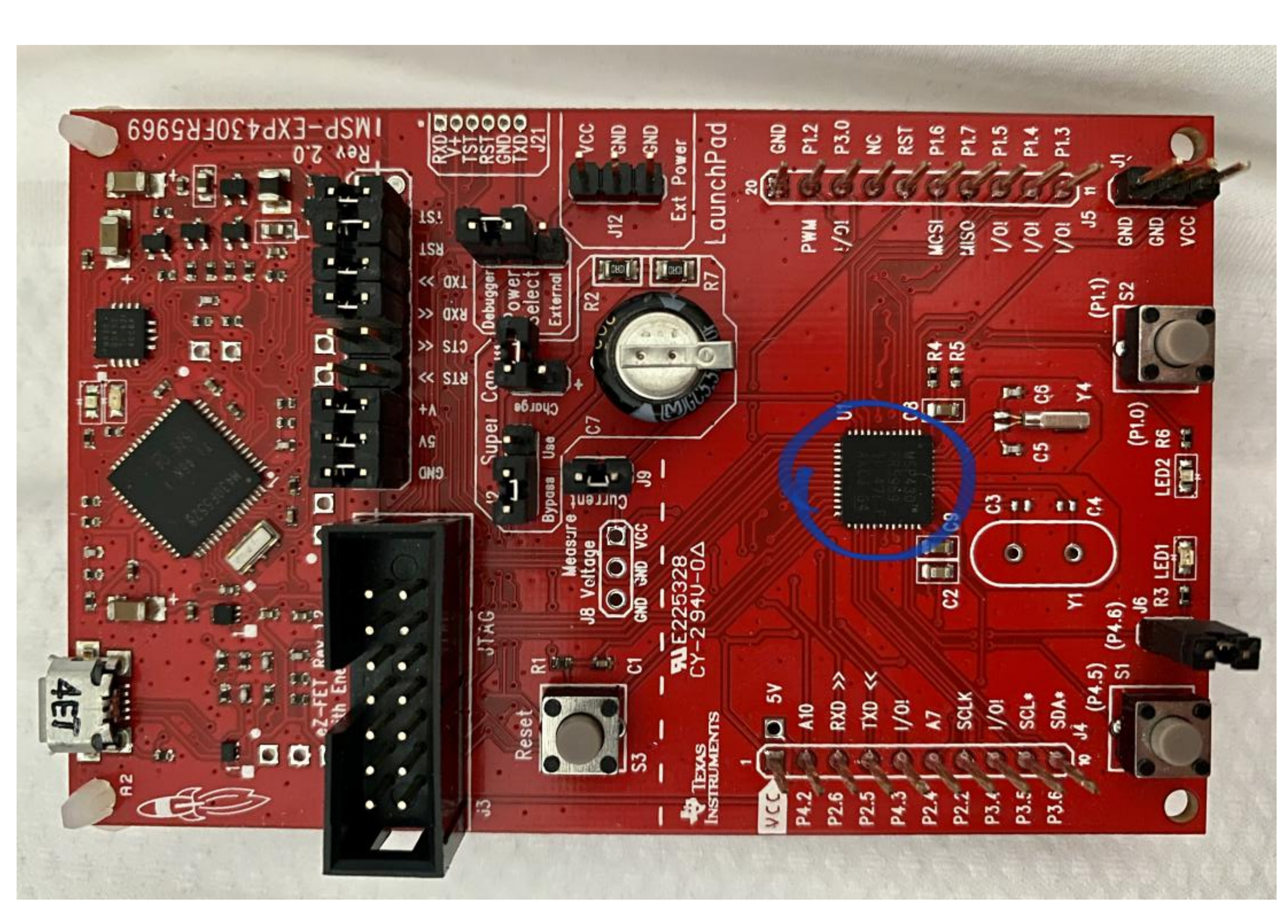


Figure 4: MSP430 FR5969 board used for programming the microcontroller which is circled in blue.

BPSK Modulation of the Signal

- Define carrier frequency of 200k Hz and a bandwidth of 20kHz.
- CPS, cycles per symbol, is how many times a symbol must be repeated in one cycle. CPS is calculated by frequency/bandwidth, 200 kHz/20kHz, gives way to a 10 cycle CPS.
- BPSK: binary phase shift keying
  - Two phase modulation process: 0's and 1's in binary message represented with two different phase states

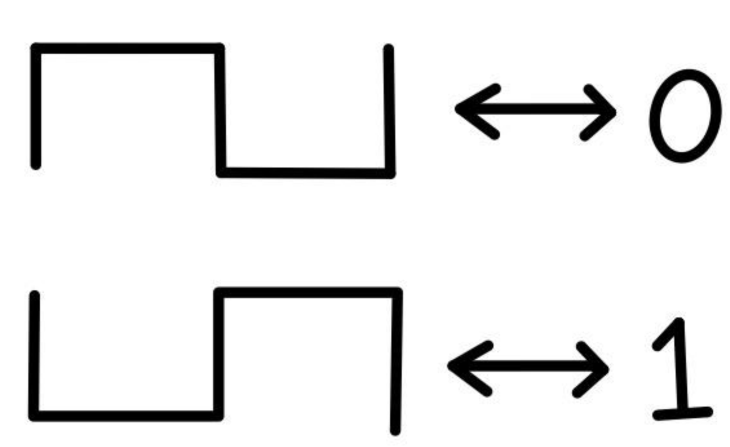


Figure 5: The two phase states that represent 0 and 1.

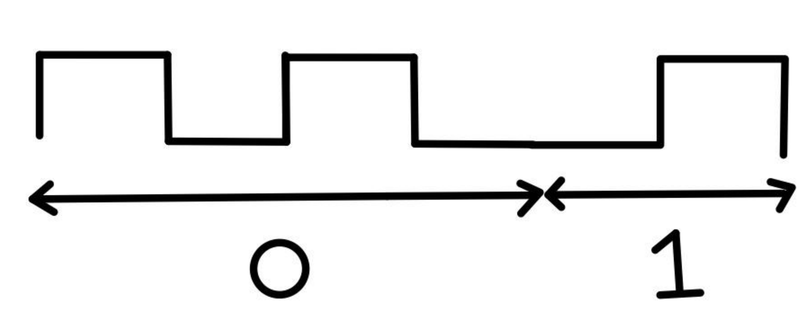


Figure 6: How the two phase states look in a snapshot of what a modulated signal may look like.

Results of Modulation

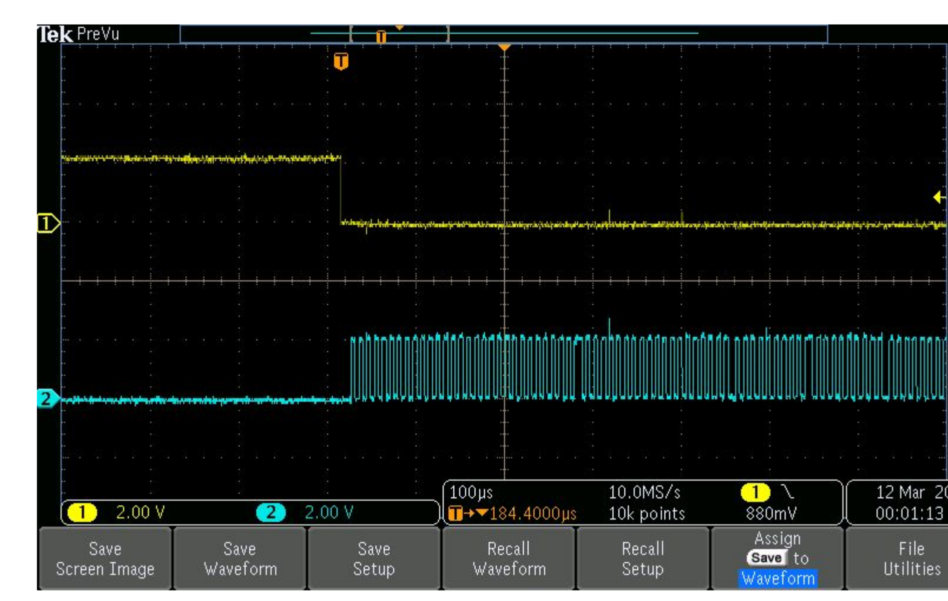


Figure 7: Snapshot of output of modulated signal. The yellow line shows when the modulation cycle is free or not, so when low, it is in use and not free. Here the modulation can be seen in the output wave depicted by the blue square wave.

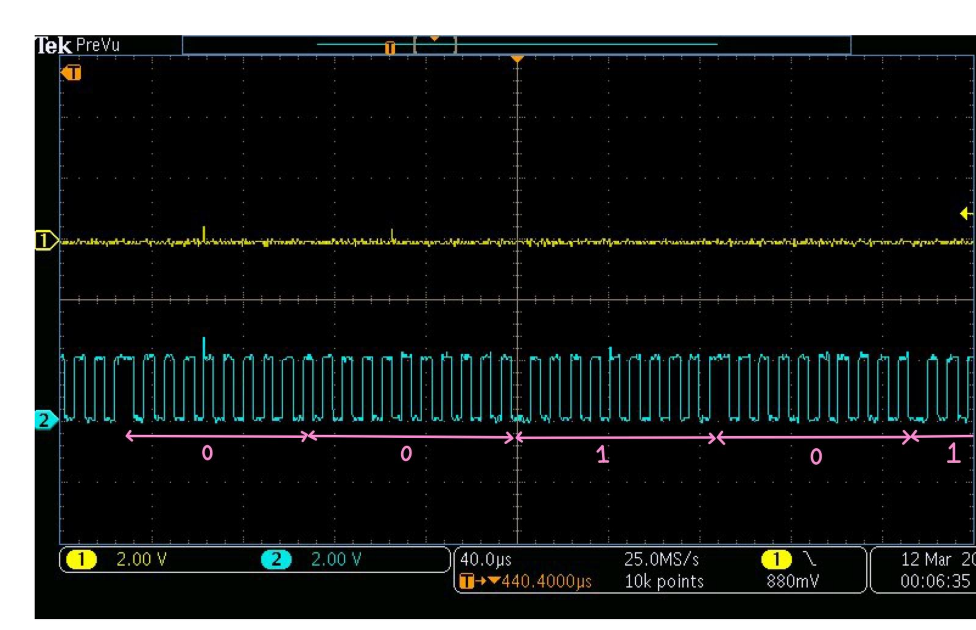


Figure 8: Break down of the bit by bit modulation for each symbol in 10 cycles. Shows how one bit is read by 10 cycles of a repeating phase state.

Conclusion & Future Works

- With the microcontroller programmed to modulate the signal the second half of the goal is to receive the signal through a receive instead of mapping to a scope.
- The next step is to design a PCB to integrate the transmitter and receiver to one chip and one transducer.
- Once that successfully works, then the program will be expanded to more than one channel as well as focusing on routing a smaller PCB design.