SUMMER 2022 FAU ISENSE REU

FAU I-SENSE
Division of Research
Florida Atlantic University

FAU
CENTER FOR CONNECTED AUTONOMY AND ARTIFICIAL INTELLIGENCE
College of Engineering and Computer Science
Florida Atlantic University

PARKER WILMOTH

TARIQ WARDAK

YNES INEZA

REU MENTOR

DR. SKLIVANITIS

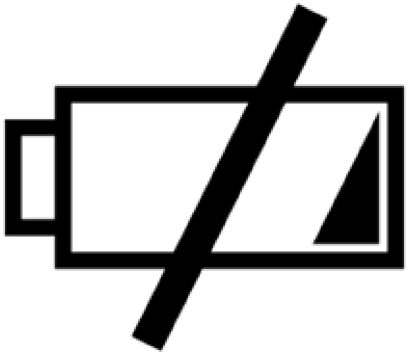
BATTERY-FREE UNDERWATER WIRELESS COMMUNICATION SENSORS USING SCATTER COMMUNICATION PRINCIPLES

WHY WE NEED UNDERWATER IOT

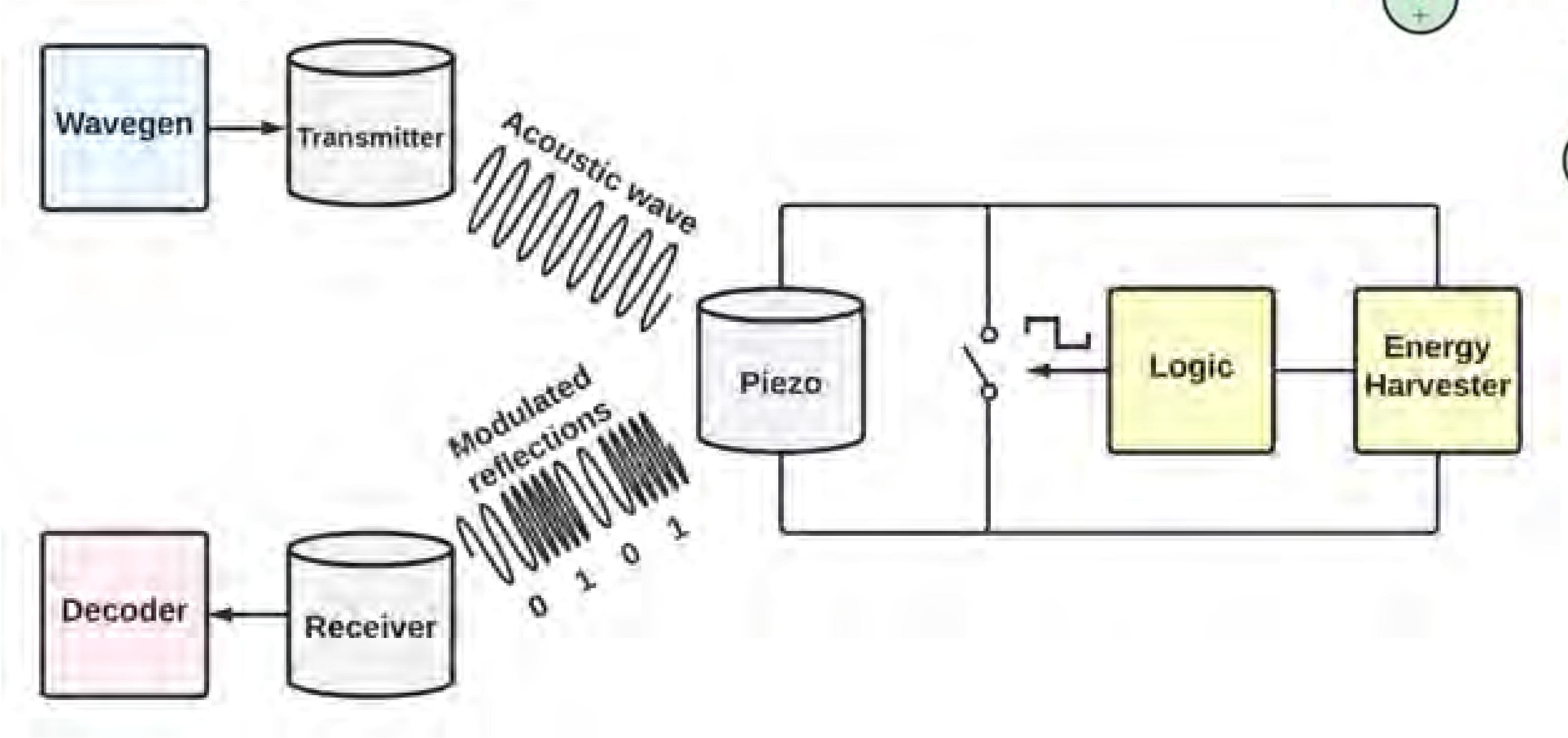
FAU I-SENSE
Division of Research
Florida Atlantic University

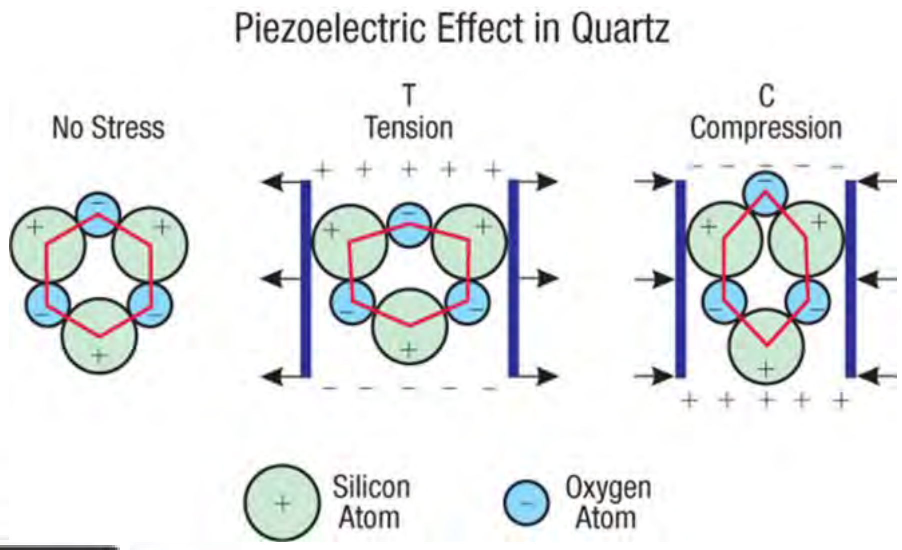
FAU CENTER FOR CONNECTED AUTONOMY AND ARTIFICIAL INTELLIGENCE
College of Engineering and Computer Science
Florida Atlantic University

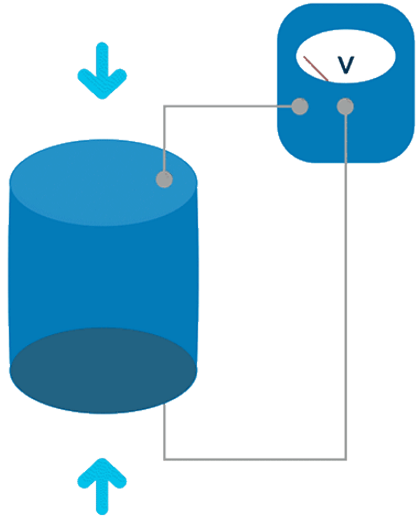
THE PROBLEM WITH UNDERWATER WIRELESS TODAY



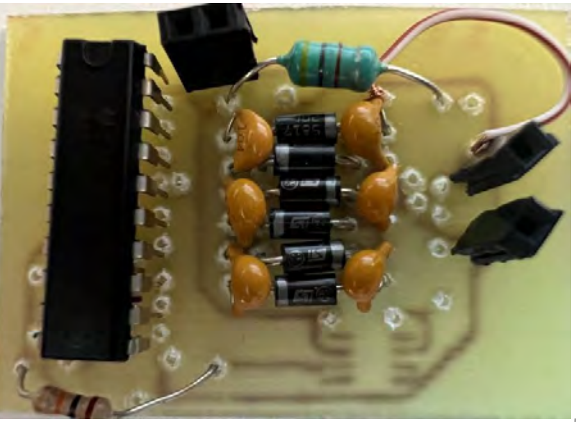
OUR SOLUTION

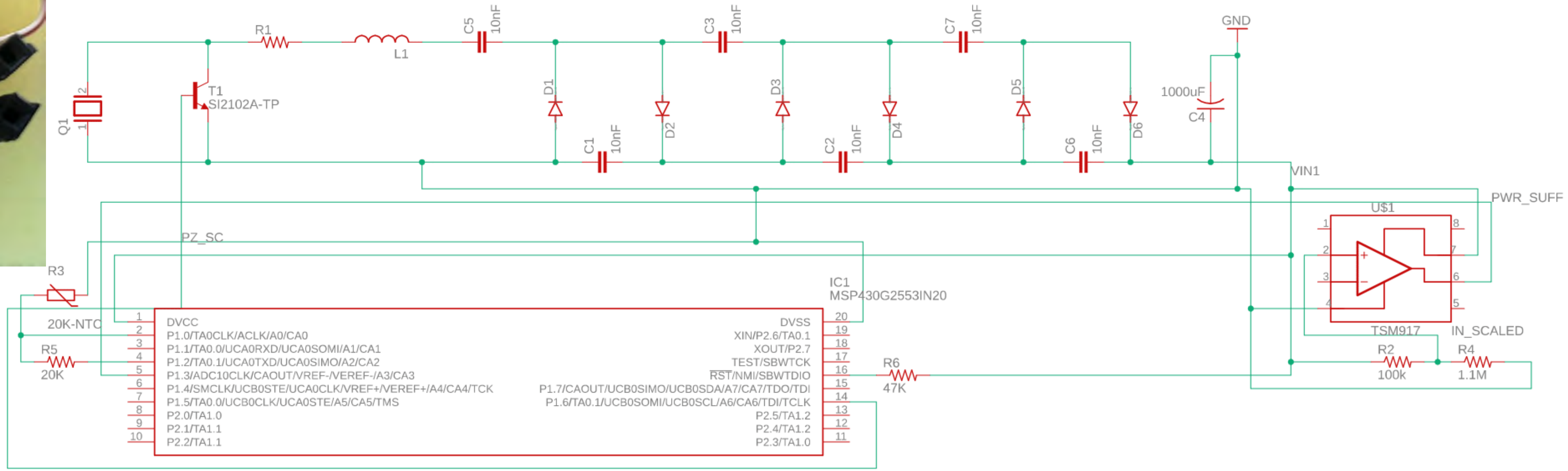




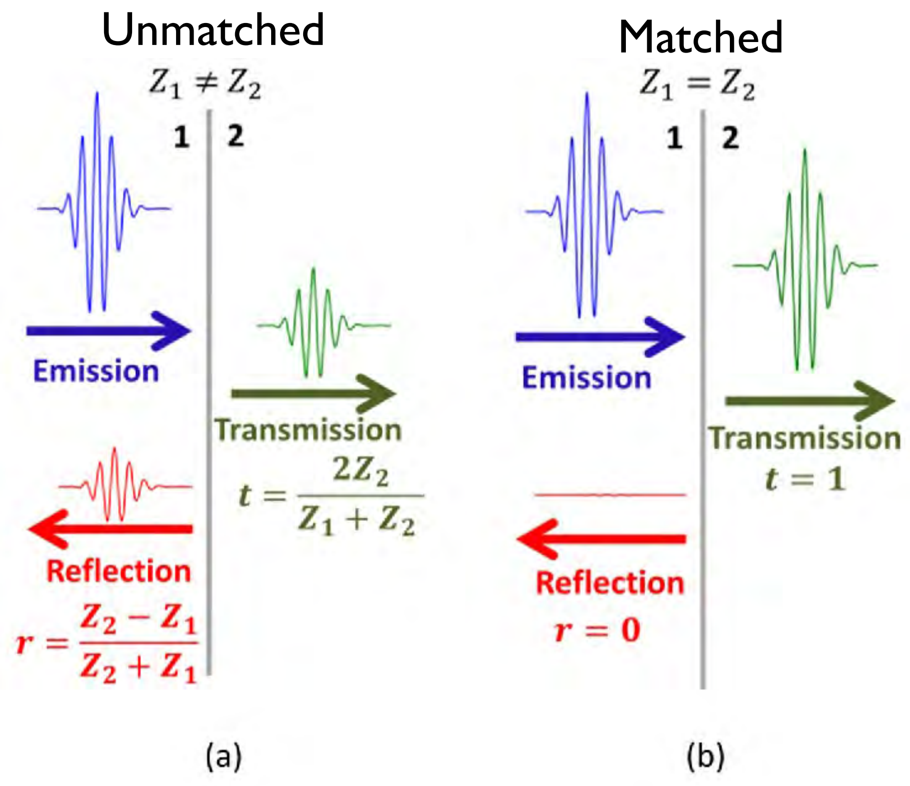


DESIGNING AND FABRICATING THE SCATTER ACOUSTIC SENSORS





FAU I-SENSE
Division of Research
Florida Atlantic University
FAU CENTER FOR CONNECTED AUTONOMY AND ARTIFICIAL INTELLIGENCE
College of Engineering and Computer Science
Florida Atlantic University



Z = p/v

No.	Materials	Density (kg/m^3)	Sound speed (m/s)	Impedance (Rayl)
1	air	1.23	340	418
2	Water	1053	1490	1.56×10^6
3	Cork	0.24	530	1.27×10^5
4	Aluminum	2690	6420	1.73×10^7
5	Steel	7860	5950	4.64×10^7
6	PDMS	969	1119	1.08×10^6
7	PU	1528	1040	1.59×10^6
8	Epoxy	1180	2490	2.95×10^6
9	Hydrogel	1000	1600	1.60×10^6
10	Ecoflex	1070	989	1.06×10^6

ACOUSTIC IMPEDANCE MATCHING

TESTING WITH DIFFERENT MATERIALS


UV Resin


Epoxy

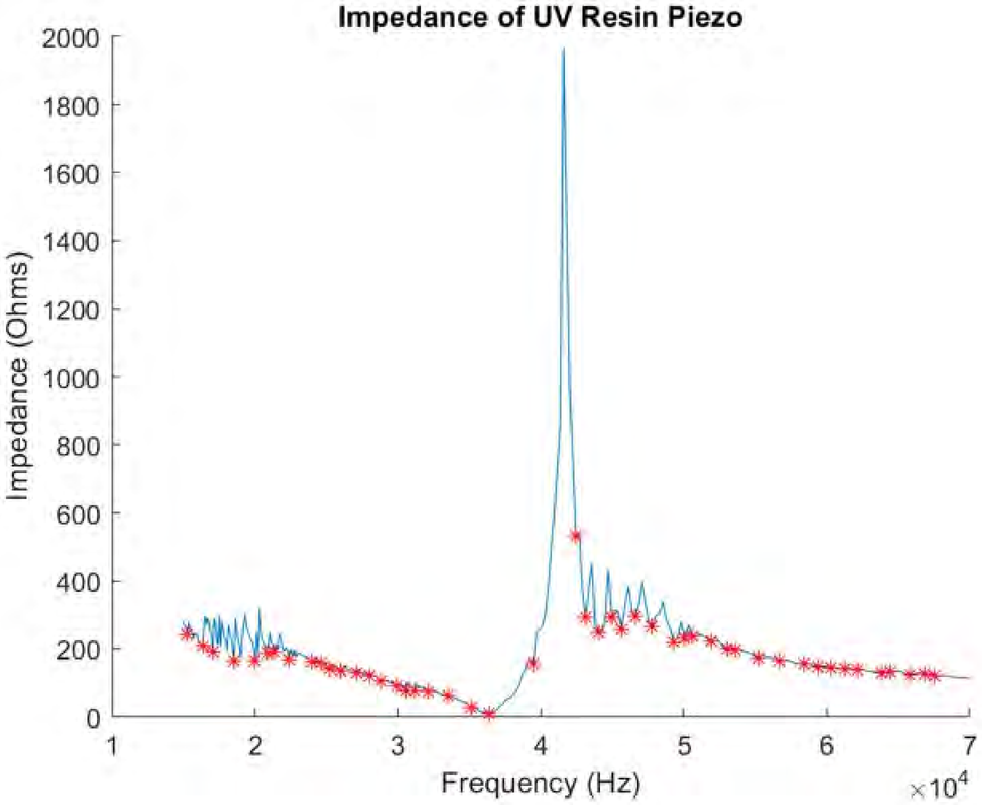

Rubber Sealant

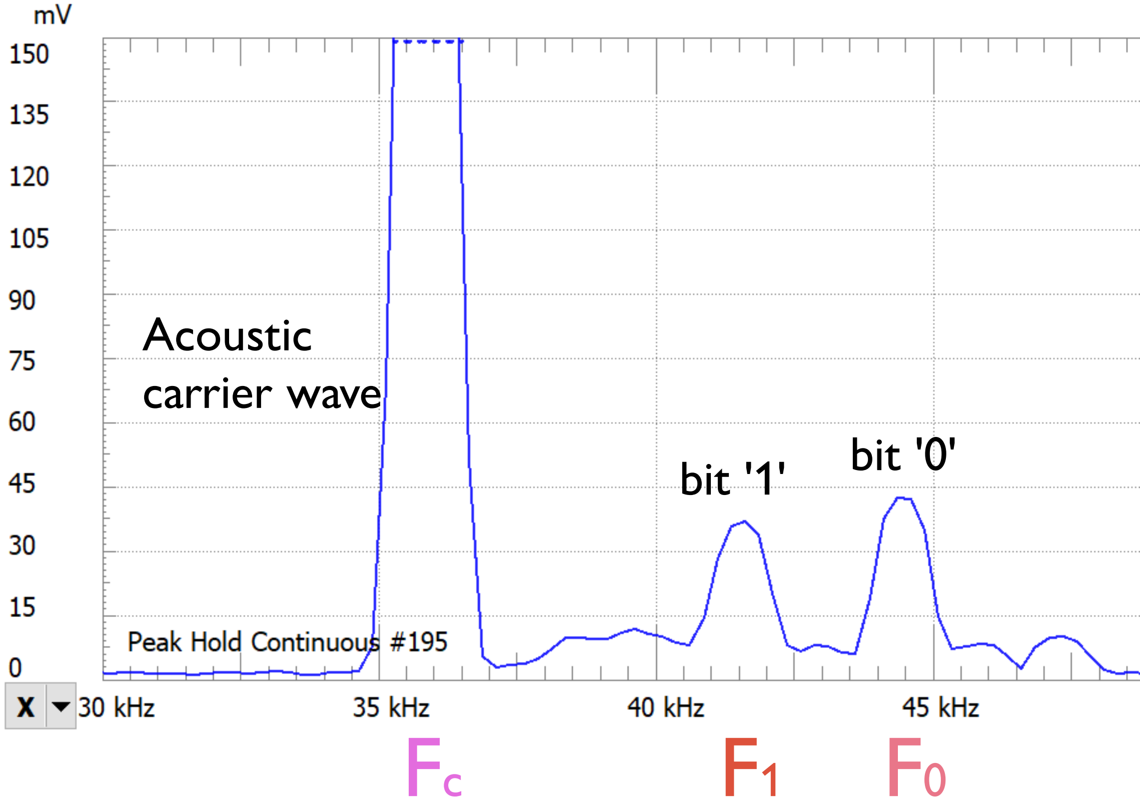

Bare Piezo

Polyurethane

CHOOSING THE RIGHT FREQUENCIES

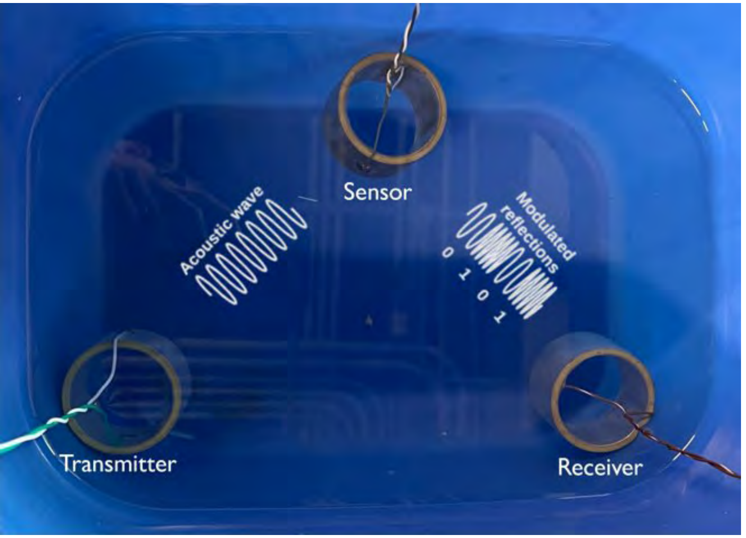
UV Resin



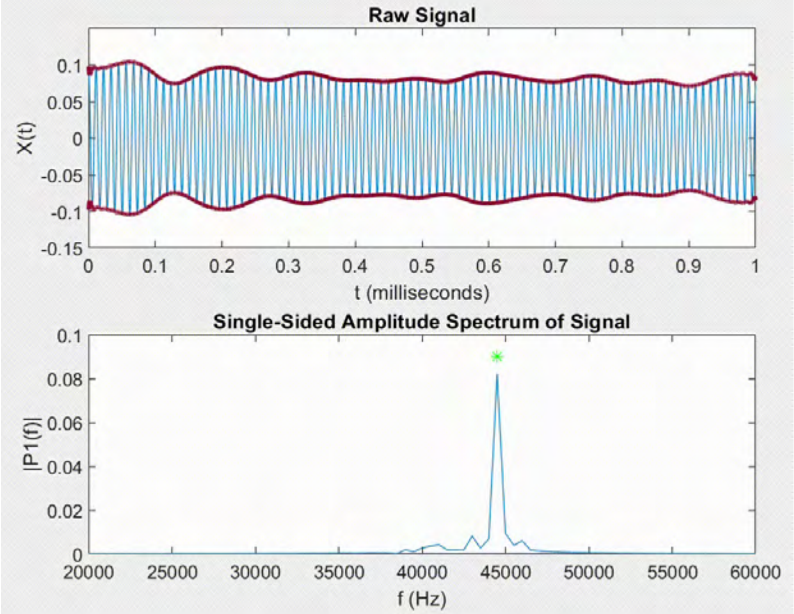


DATA DECODING FROM REFLECTIONS

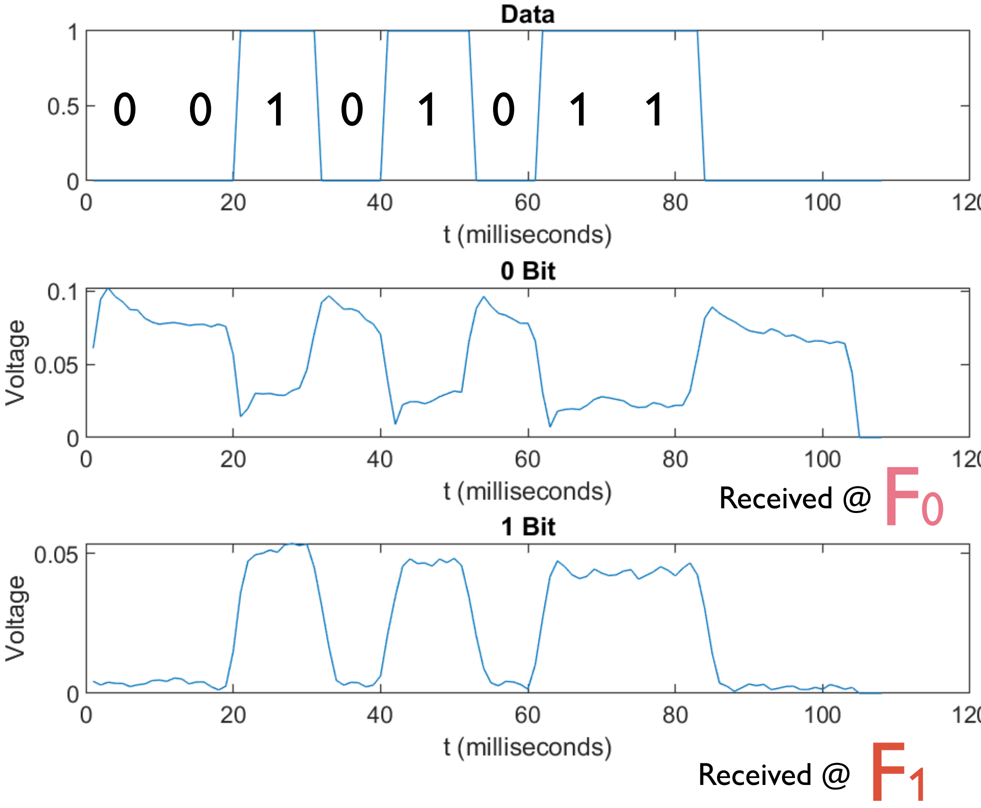
Experimental setup in the lab



Received

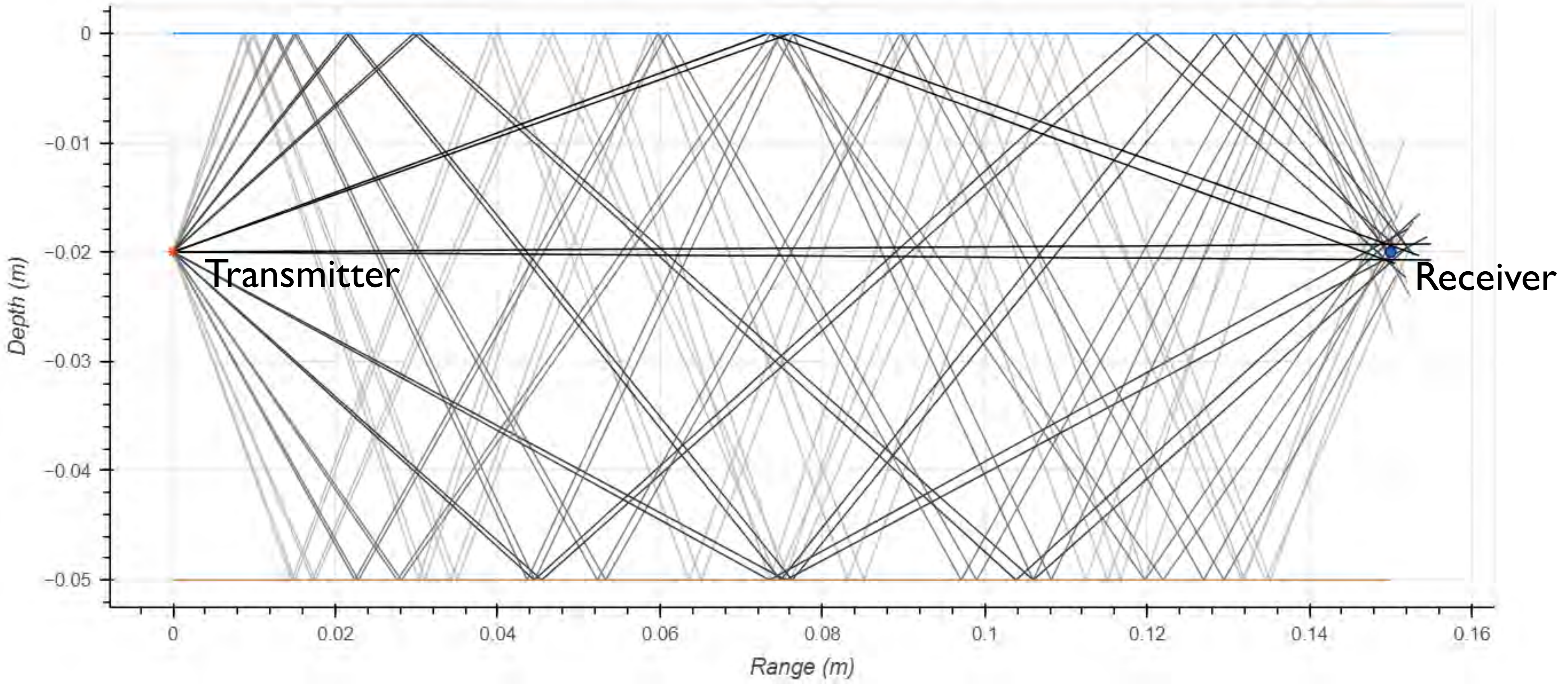


Scatter Acoustic Sensor



SNR >= 48dB

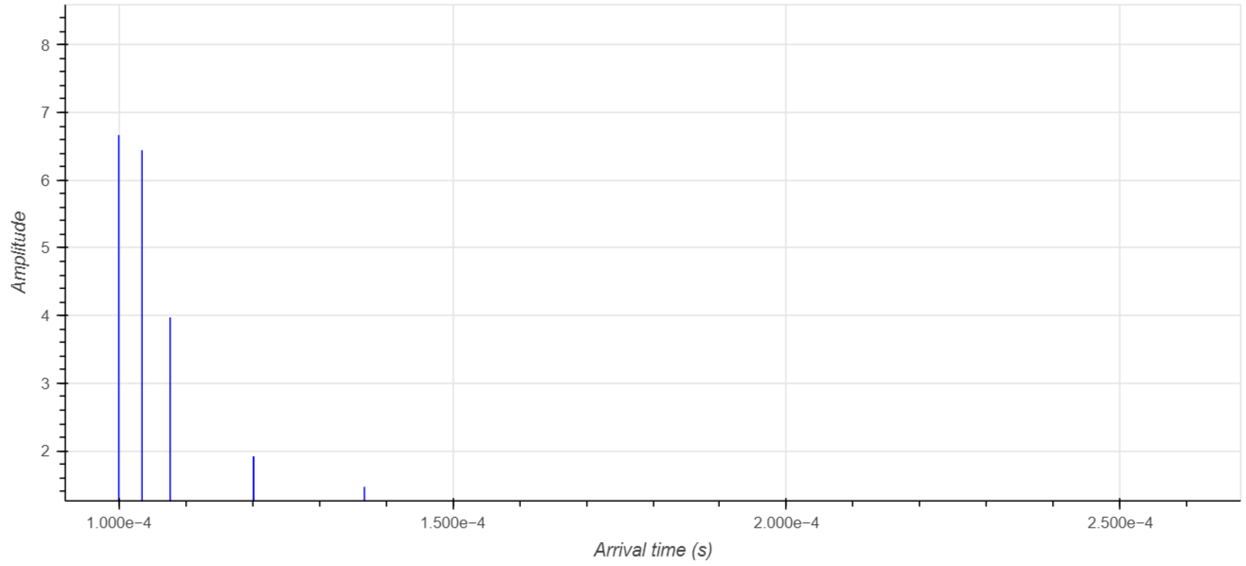
SIMULATING THE UNDERWATER CHANNEL



- Simulate underwater acoustic propagation using the popular Bellhop ray-tracing framework
- **Objectives**
  - Test our decoder with simulation data before we apply it to field data
  - "Train" our decoder with data from multiple environments

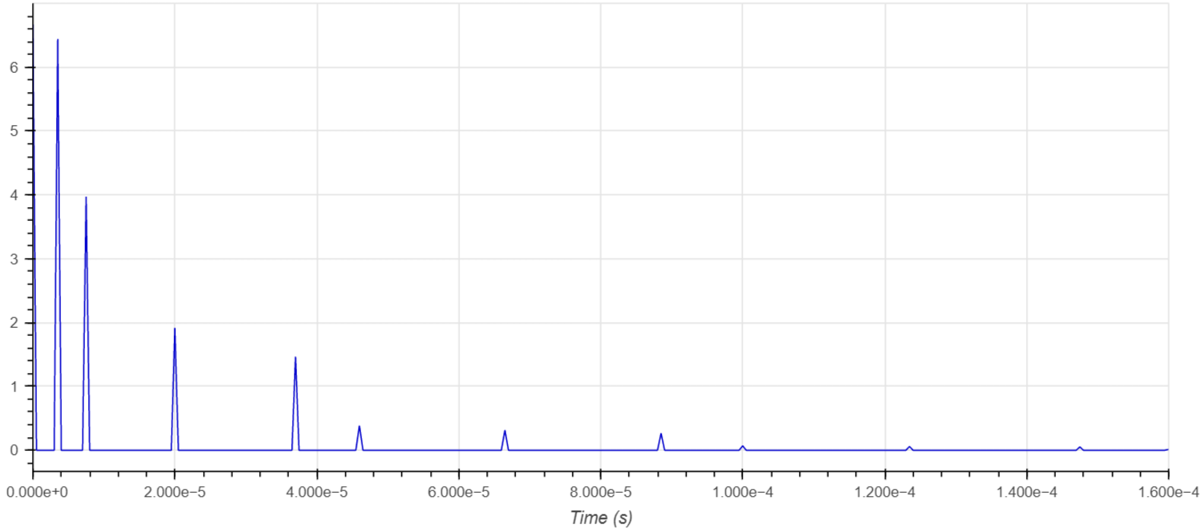
FAU I-SENSE
Division of Research
Florida Atlantic University

FAU CENTER FOR CONNECTED AUTONOMY AND ARTIFICIAL INTELLIGENCE
College of Engineering and Computer Science
Florida Atlantic University



- Convert arrivals to impulse response time series
- Use impulse response to simulate our received signal

- Arrival structure at the receiver
- We can look up the time-of-arrival, angle-of-arrival and number of surface/bottom bounces



EXAMPLE OF UNDERWATER ACOUSTIC CHANNEL IMPULSE RESPONSE

CONCLUSIONS AND FUTURE WORK

FAU I-SENSE
Division of Research
Florida Atlantic University
FAU CENTER FOR CONNECTED AUTONOMY AND ARTIFICIAL INTELLIGENCE
College of Engineering and Computer Science
Florida Atlantic University

Conclusions

- The sensor is capable of wirelessly harvesting 2.8V from an acoustic carrier wave of 10 V
- Data can be decoded at the receiver with no errors
- Demonstrated low-bit rates of 100 bps at small ranges 15cm

Future Objectives

- Increase the communication range and bit rate
- Test with multiple sensors
- Attempt potting with materials that offer better acoustic impedance with the water (e.g. PU)