SAWbots: A Platform for Affordable Minimally Invasive Surgeries

Remotely controlled miniature robot that traverses liquid surfaces with no motors or moving parts

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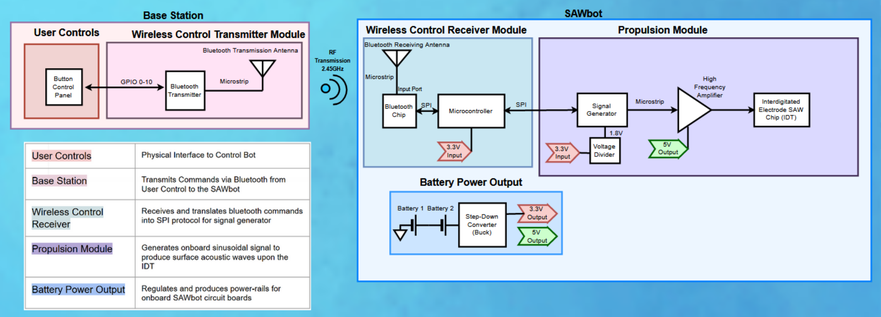
Baskin Engineering | UC SANTA CRUZ

There is currently a lack of minimally invasive procedure (MIP) technology in the medical industry. This type of technology significantly decreases the size and number of incisions needed to operate, which has been shown to improve patient outcomes when compared to traditional surgery. SAWbots provide the optimal solution by providing MIP technology at a decreased cost, thereby making safer surgery more accessible to the medical field. This project improves upon a novel form of propulsion in fluid in compliance with our stakeholder's requirements. The team used Yannyk Bourquin and Jonathan M. Cooper's *Swimming Using Surface Acoustic Waves* as a starting point for our research and benchmark for our results.

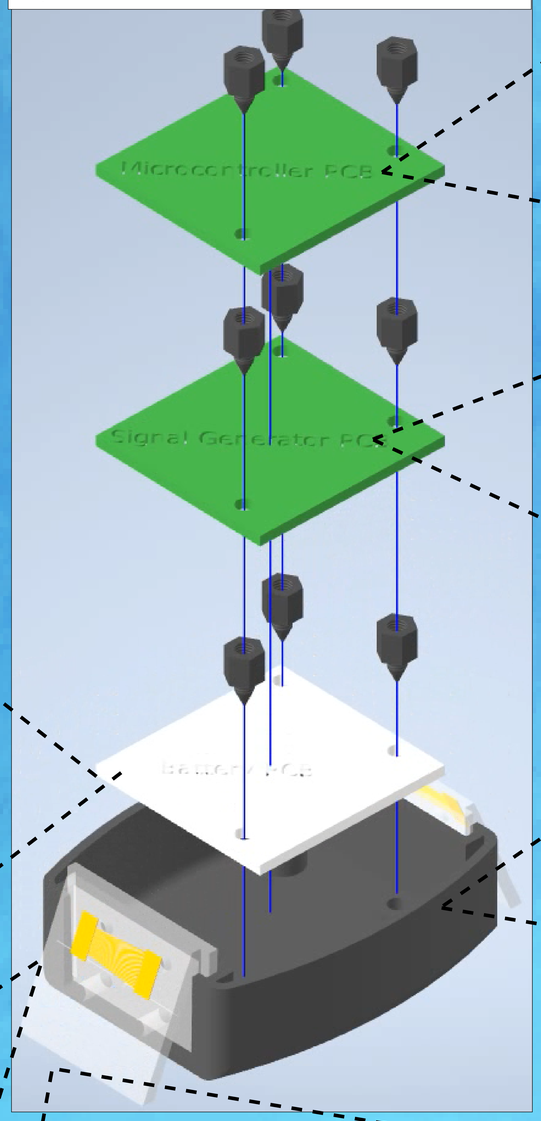
System Overview Block Diagram



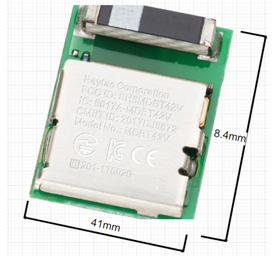
User Controls	Physical Interface to Control Bot
Base Station	Transmits Commands via Bluetooth from User Control to the SAWbot
Wireless Control Receiver	Receives and translates bluetooth commands into SPI protocol for signal generator
Propulsion Module	Generates onboard sinusoidal signal to produce surface acoustic waves upon the IDT
Battery Power Output	Regulates and produces power-rails for onboard SAWbot circuit boards

Assembly

Expanded 3D model of surface acoustic wave SAWbot

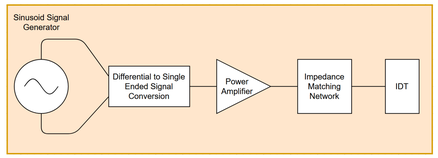


Onboard Microcontroller



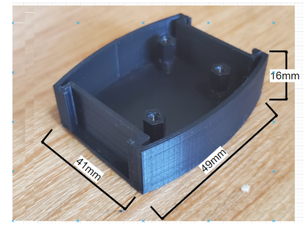
- Recieves inputs from offboard control panel
- Controls signal generator via SPI to move bot
- Bluetooth 5.1 Low Energy based communication - 10x more power efficient than WiFi

On Board Signal Generation



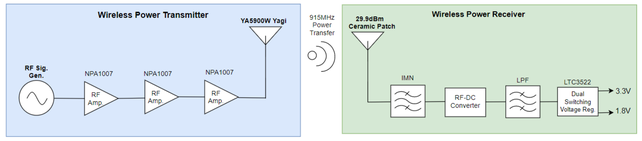
Propulsion Module Block Diagram
The AD9913 Digital Synthesizer generates a variable high-frequency sinusoid: this waveform is amplified to provide electrical power to excite the IDT

Chassis



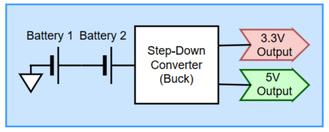
- 3D printed in biodegradable PLA
- Waterproofed using spray-on coating
- Designed for rapid, modular prototyping

RF Power



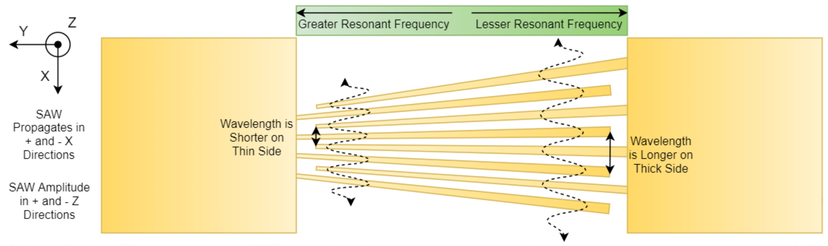
Block Diagram of Simulated Wireless RF Power System
RF Signal Amplified, Transferred to Receiver, and then Converted to DC Power

Battery Power



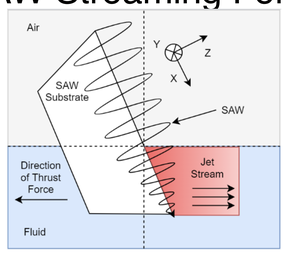
Block Diagram of Battery System
Battery Output Sent through Dual Converter to Provide DC Power Rails

IDT SAW Generation



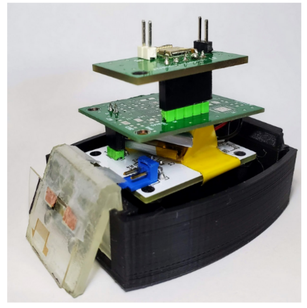
Interdigital Transducer: IDTs excite SAWs in piezoelectric substrate in response to AC voltage. IDTs with Slanted Fingers provide control of the y-axis location of the SAW beam through varying the frequency of the AC input. Thus, by varying our electrical input frequency, we can generate thrust at different locations and steer the robot

SAW Streaming Force



SAW Streaming: When a SAW enters a fluid interface, it attenuates and leaks energy into the fluid, generating a streaming force

Final Design Prototype:



The final prototype houses three circuit boards. These boards enable communication with the base station, provide on-board signal generation, and deliver battery power to the bot. The IDTs are mounted to provide maximum thrust. The bot is expected to generate 1mN of thrust which is 10x more efficient than ultrasonic thrusters.

Physical Bot

Isometric view of the physical bot

Length: 48.5 mm Width: 40.6 mm
Height: 16.5 mm