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DAXSONICS ultrasound [3]
nova scotia health authority

Department of Electrical and Computer Engineering

# Minimally Invasive Ultrasound Probe for Guiding Spinal Surgery

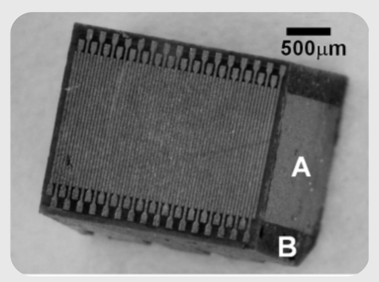
## Project Objective

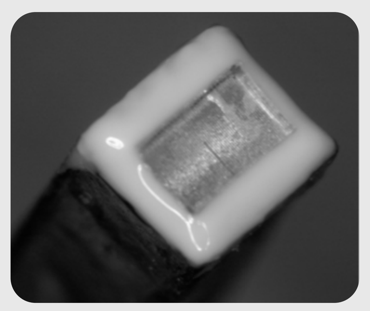
The overall objective of this project is to design, fabricate, and pre-clinically evaluate an ultrasound endoscope that can be used to image nerve rootlets during surgical procedures on the spine. The probe must allow the user to determine the physical state of the nerves to aid in determining the level of recovery.

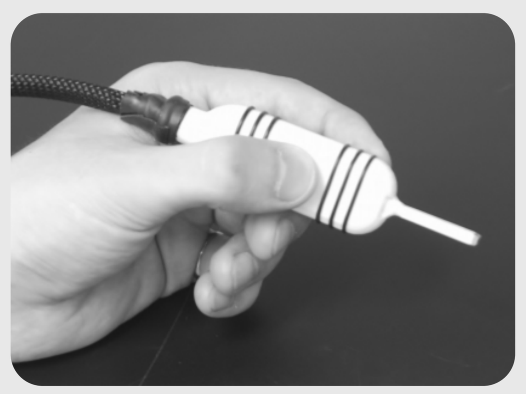
[1]

## Original Design

The development of this probe will be an extension to an existing prototype developed by the Dalhousie Ultrasound Group. Features of the existing endoscope probe include a forward facing 64-element high-frequency phased array with an operating frequency of 45 MHz. It is fabricated using novel micro-fabrication techniques in which the array elements are wire bonded to the thickness a flexible circuit board [2].



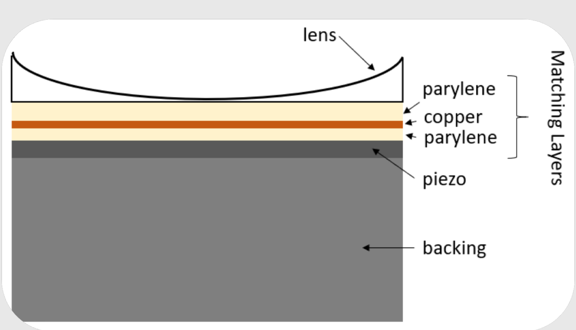





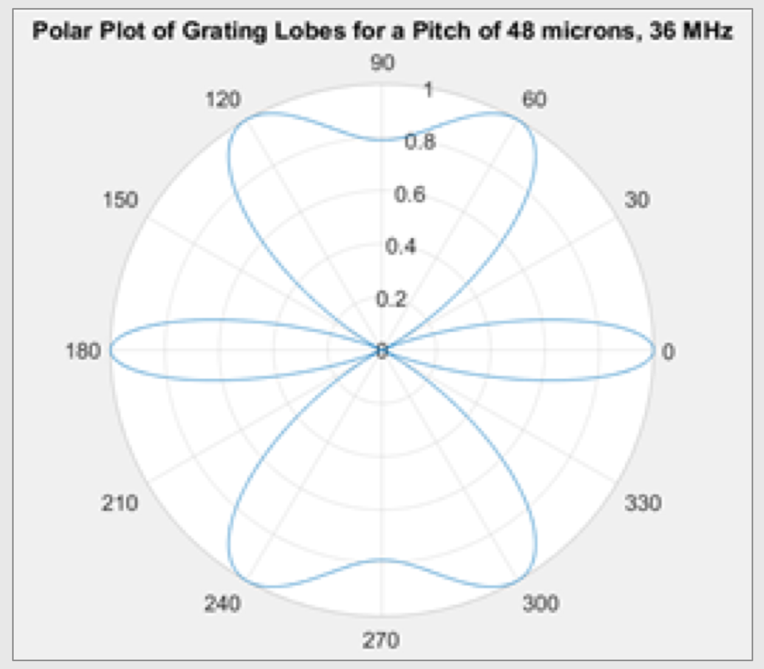
## Design Criteria

The corresponding requirements for the proposed application include the following:

- Resolution high enough to enable nerve imaging
- Optimized matching layer for nerve tissue penetration
- Minimum length of 90mm
- Perpendicular imaging capabilities
- Meets medical-grade standards
- Reduces PCB manufacturing costs




## Design and Preliminary Results




**Grating Lobes:** Grating lobes can compromise the image quality when they produce large areas of constructive interference at a certain angle. The grating lobes with the new pitch and calculated frequency (top left) were identical to the previous conditions, meaning that no additional compensations had to be made.

**Matching Layer Optimizations:** The matching layer quantities were optimized to ensure that the maximum ultrasonic wave transmission can be achieved. Matching layer values were iterated (bottom left) to find the optimal values, and their performance was then modelled (bottom right) [4]

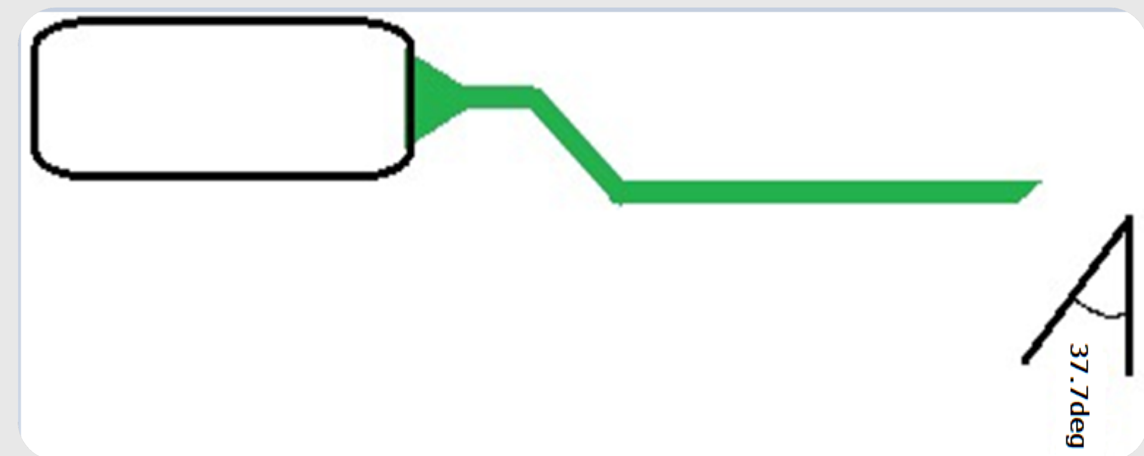
**Details of Design:**

*Cut Angle:* 37.7º

$cos\theta = \frac{38\mu m}{48\mu m} \rightarrow \theta = 37.7^{o}$

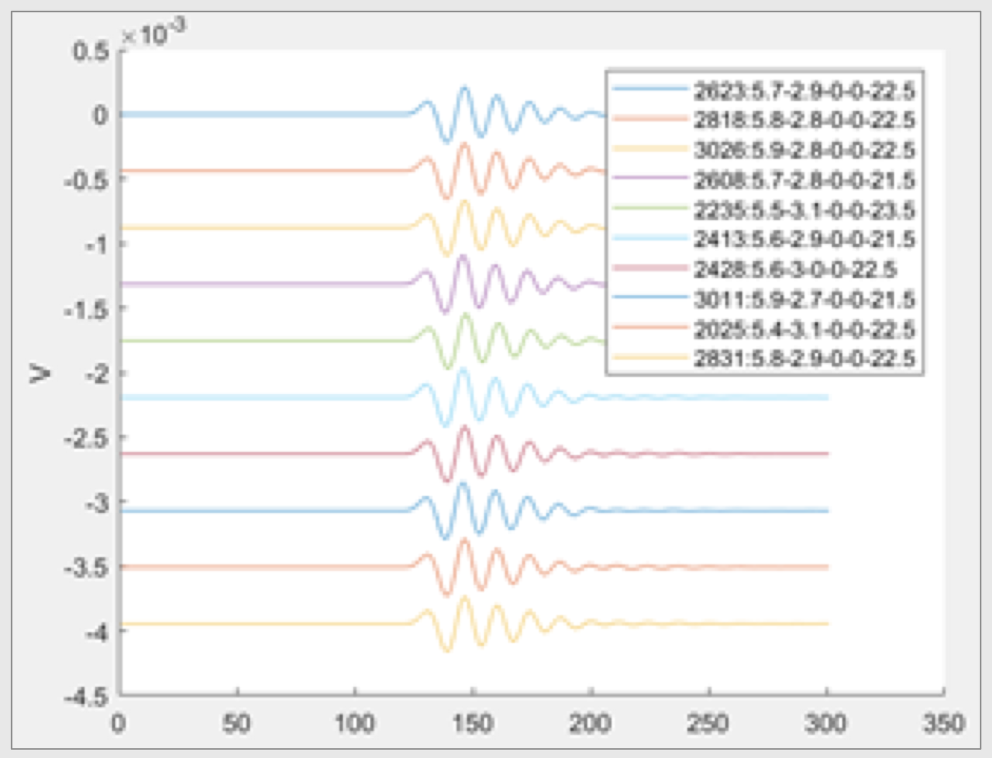
*Length of PCB arm:* 98.4 mm

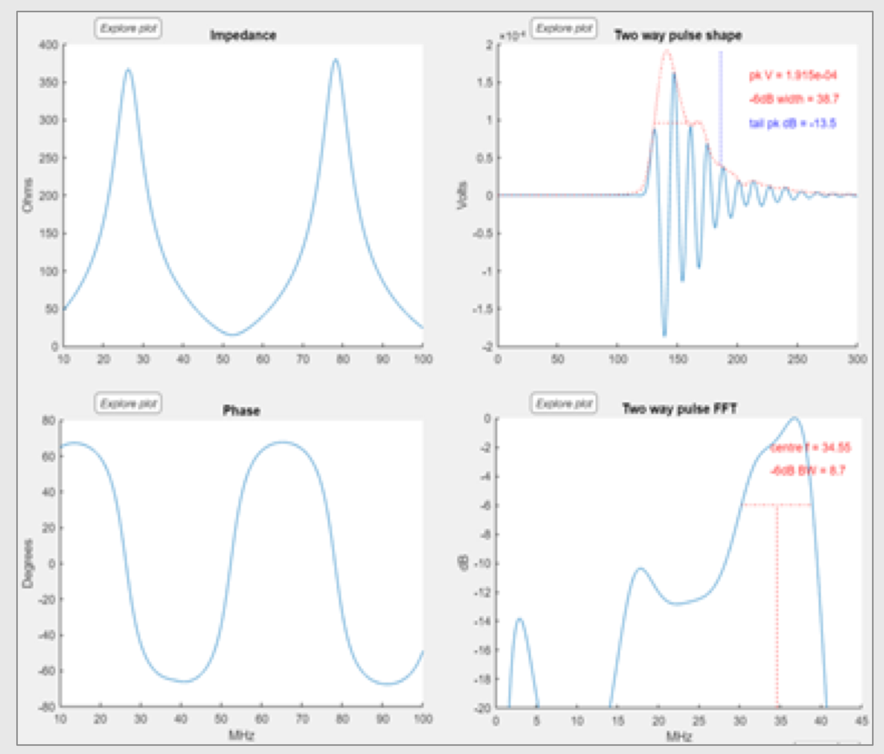
*Array Pitch:* 48 μm




*Frequency of operation:* 36 MHz

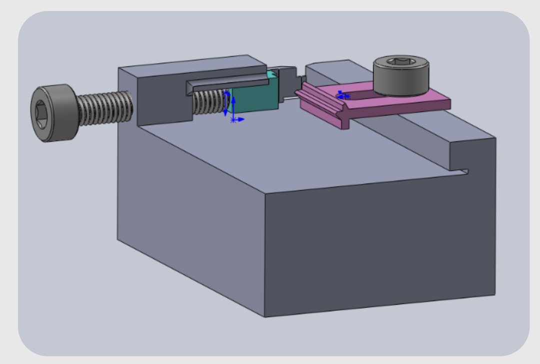
$f = 45MHz \cdot \cos(37.7) = 35.625\ MHz$



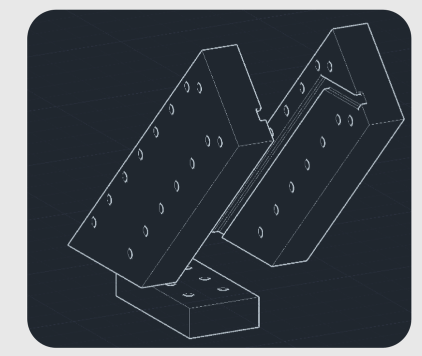




**Supporting Fixtures:**

Alignment Tool



Silicone Mold



## Verification

| Task | Brief Description |
|---|---|
| **Flex PCB** | PCB cut at an angle to provide visibility on spinal nerve rootlets. |
| **Reducing PCB costs** | Reduce production cost of flex PCB used in this project. |
| **Transducer Results** | New design must perform to the standard defined by the client. |
| **Overall Design** | Ensuring that the overall design meets the client requirements. |

## Conclusions and Future Work

- Current models and simulations are on track to meet client requirements.
- Engineering drawings for mechanical components need to be finalized.
- Flex PCB will need to be ordered and design must support the goal of cost reduction.
- Wire Bonding and Phased Array will need to be produced and tested.
- Testing will need to be done, and results will be compared with simulations.
- Final assemblies of the transducer will be done in Fall 2020.

## References

[1] J.A. Brown, “Slides for SYP,” *SENSElab.* [PowerPoint]

[2] A. Bezanson, A. Adamson, J.A. Brown, “Fabrication and Performance of a Miniaturized 64 Element High Frequency Phased Array,” Proc. IEEE Ultrasonics Symposium, pp. 765-768, 2013.

[3] “Daxsonics Ultrasound,” *Daxsonics Ultrasound.* [Online]. Available: https://www.daxsonics.com/. [Accessed: 31-Mar-2020].

[4] T. Landry, “Matching layer design: A semi-empirical approach,” *Dalhousie University.* [PowerPoint].