Encoded Ultrasound Array for Intravascular Imaging

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Background

Atrial fibrillation is the “most common arrythmia, affecting approximately 200,000 Canadians”. [1] Untreated atrial fibrillation can increase stroke and heart risk failure.

A treatment for atrial fibrillation is cardiac ablation where an ablation catheter is used to scar or destroy tissue in the heart that triggers or sustains an arrythmia.

- **Need**: improved imaging resolution to determine if the scarring is sufficient to cut off the electrical pathways

This would increase the success rate of atrial fibrillation catheter ablations and reduce the need for repeat procedures

Intravascular ultrasound imaging (IVUS) catheters are medical devices that are used to visualize blood vessels.

In an IVUS catheter:

1. A transducer is used to emit high-frequency sound waves that echo off the vessel walls.
2. Depending on the tissue, the received signals will vary in intensity
3. Can be processed to display a cross-sectional image [2]

Limitations of Current Systems

Most systems use single element mechanically scanned transducers, which have:

- lower resolution
- lower penetration depth
- lower SNR

compared to an array transducer

Using an array transducer would improve these deficits but comes with the challenge of making the added components fit into the same sized catheter.

Project Objective

To design, fabricate, and package an ultrasound array suitable for intravascular ultrasound (IVUS) into a small catheter.

System Architecture

- 64 linear piezoelectric element ultrasound array
- Connected to traces on two printed circuit boards of 32 elements each (2 double layer PCBs, 16 pads per side)
  - — Dr. Brown's wire bonding technique
  - — Mechanically secured using epoxy
- 64 coaxial cables (46 AWG) slid through a size 10 catheter sheath used to connect PCB traces to a
- Special computer connector
- Ground wires of the cables are soldered together to create a common ground

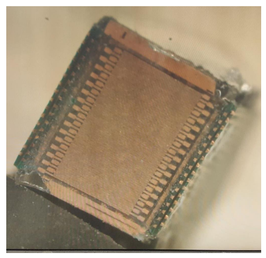

Figure 1: Array

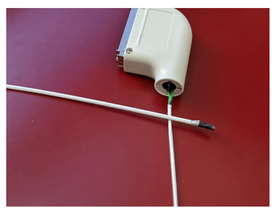

Figure 2: Packaged Catheter

Results

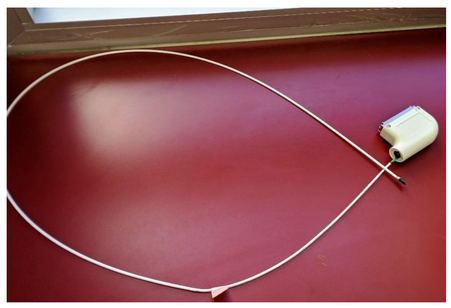

Figure 3: Full Packaged Catheter

Figure 4: Special Connectors

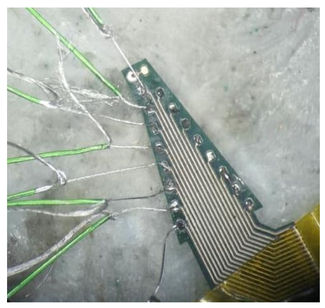

Figure 5: Cables Soldered to PCB

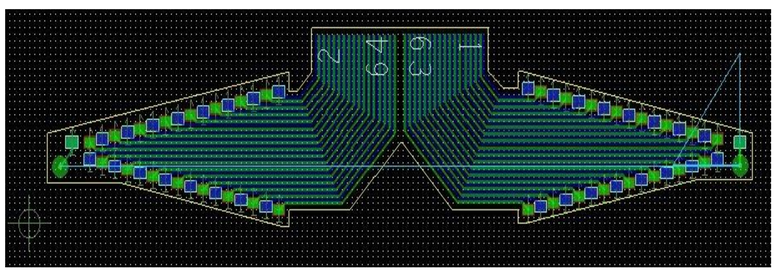

Figure 6: Printed Circuit Board (PCB)

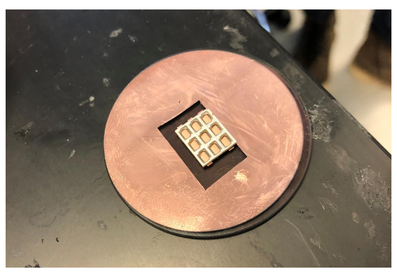

Figure 7: Array Material

Analysis

- Cables fit into required catheter size (size 10 French catheter)
- Suitable medium for connecting computer connectors to circuit board
- Tip is too bulky due to ground wire configuration and PCB rigidity
- Performance could not be evaluated due to lab lockdown

Recommendations

Moving forward, the following steps are recommended to optimize the design:

- Remove protrusion on PCB to make PCB more of a pyramid shape (rather than ‘L’)
  - — Minimize horizontal size of PCB and allow tip to fit into smaller catheter
- Elongate PCB; add individual ground pads
  - — Minimize bulkiness of tip and allow it to fit into smaller catheter

Conclusion

- Two iterations of IVUS catheter prototype
  - — Able to implement some improvements and make recommendations for more
- Use of array in IVUS catheter distinguishes this product from those currently available and used in medical procedures
- Improved image resolution can help doctors and benefit patients

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References

[1] “Atrial fibrillation.” *Heart & Stroke Foundation*, Heart & Stroke Foundation. https://www.heartandstroke.ca/heart/conditions/atrial-fibrillation
[2] “IVUS imaging.” *Phillips*, Phillips. https://www.philips.ca/healthcare/education-resources/technologies/igt/intravascular-ultrasound-ivus