HACETTEPE UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
ELE 401-402 GRADUATION PROJECT

UNDERSTANDING OPERATING PRINCIPLES OF FLEXIBLE RECEIVE-ONLY COIL ARRAYS FROM COAXIAL CABLE FOR 3T MAGNETIC RESONANCE IMAGING

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Project Description

The project focuses on enhancing Magnetic Resonance Imaging (MRI) by investigating whether flexible receive coils, particularly high impedance coaxial coils, can match or exceed the performance of conventional copper coils. Traditional rigid coils often fail to conform to the diverse contours of the human body, compromising image quality. Flexible coils, however, are designed to better fit specific body areas, potentially improving the signal-to-noise ratio (SNR) and facilitating high-resolution imaging. This study aims to evaluate the proposed flexible coil designs based on articles to determine if they can provide equivalent or superior imaging performance compared to conventional copper coils.

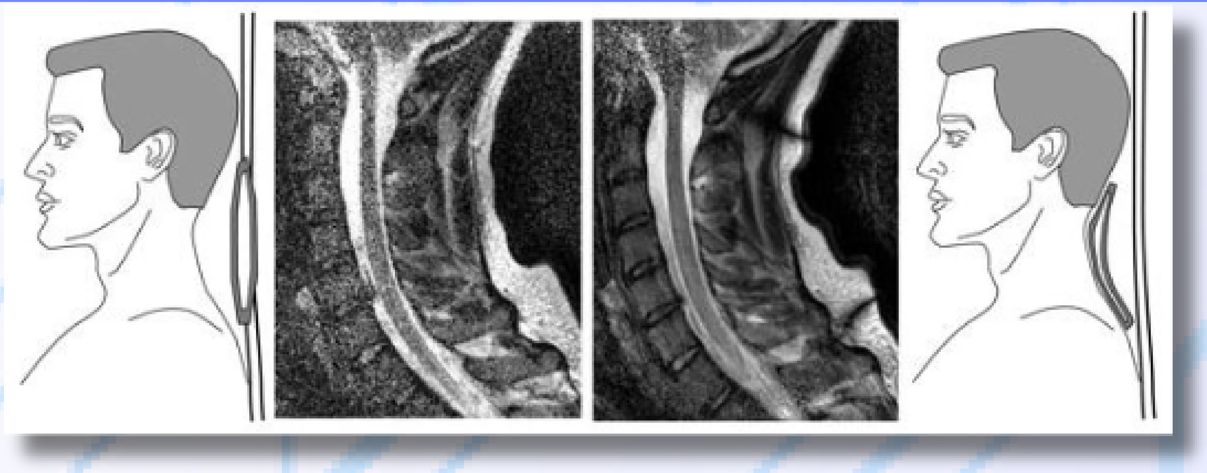

Figure 1: The difference between the scanning results of rigid coil and flexible coil

Methodology

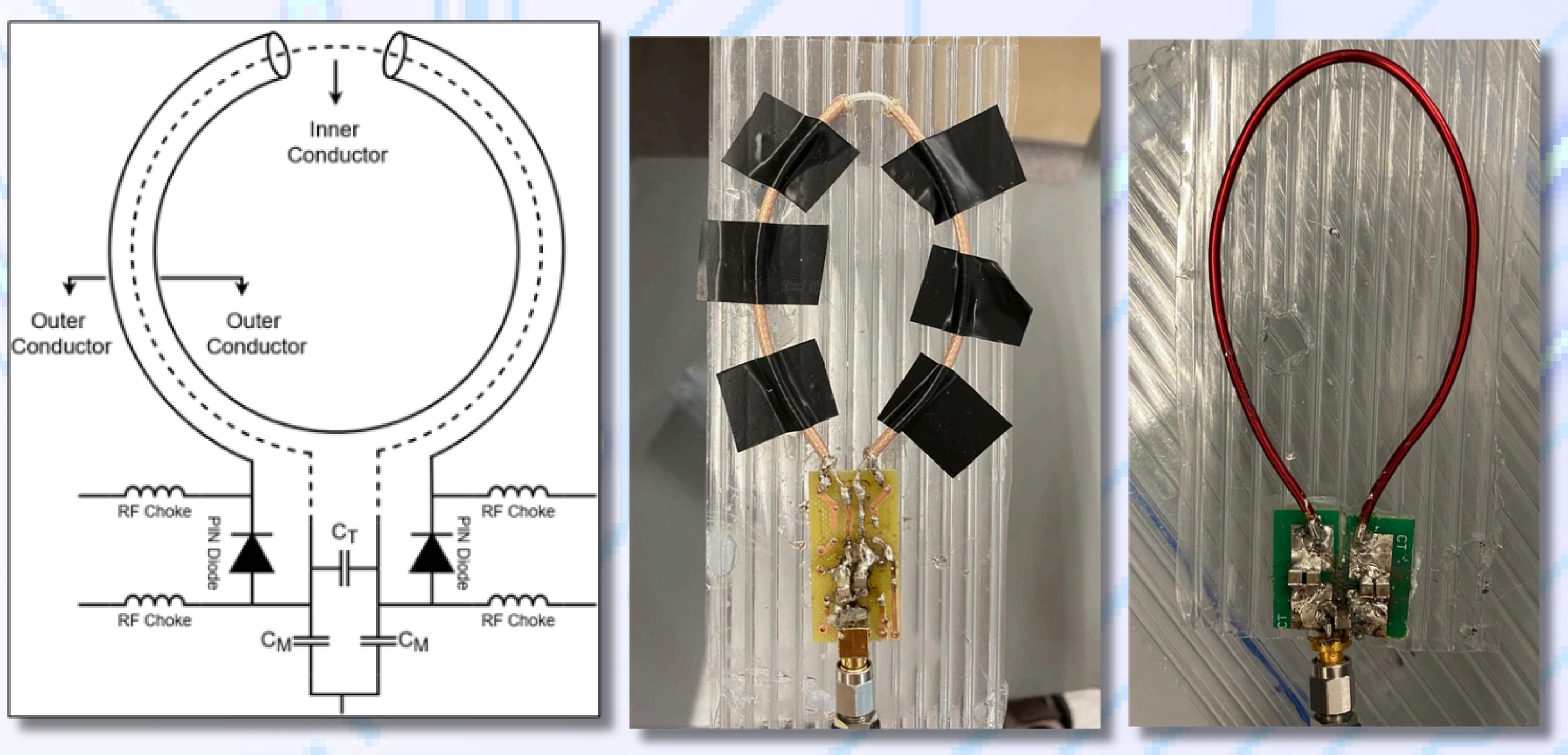

Figure 2: Examined Circuit Design

There are different examples of circuit designs for flexible coils. We specifically examine this circuitry based on findings from related articles. The innovative design incorporates active detuning circuits within each receive coil element. These circuits utilize PIN diodes placed between the coaxial conductors to obstruct current during Radio Frequency (RF) transmissions. During signal reception, the diodes' stray capacitance merges into the tuning network, accompanied by RF chokes connecting both ends to the power supply. Consequently, a secondary circuit emerges, boasting a resonance frequency of 123.24 MHz. Upon diode activation, this secondary circuit fine-tunes the primary circuit's frequency, thereby enabling the operation of the smaller loop while disabling the larger one.

Results and Conclusions

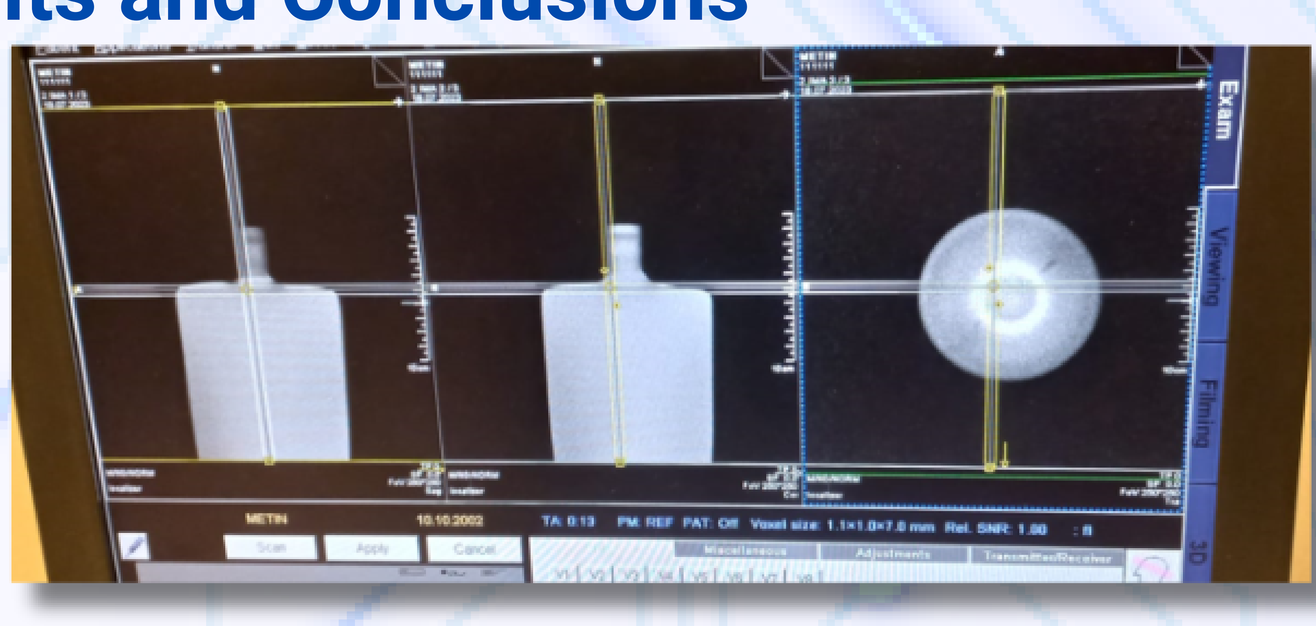

Figure 3: Scanning result of body coil

The body coil is the primary coil in an MR machine, known for its high image quality. The main idea is to achieve similar image quality with our custom coils.

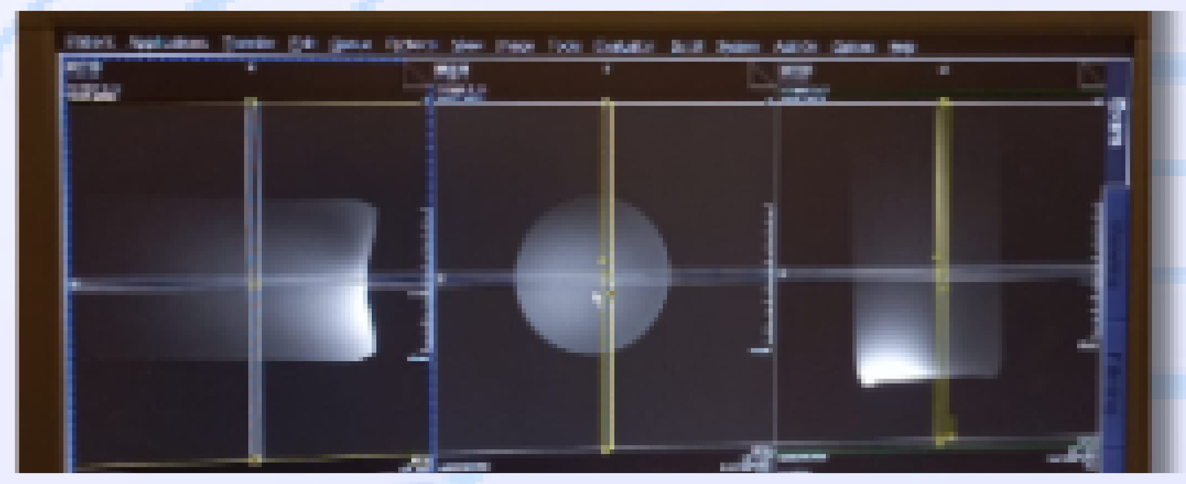

Figure 4: Scanning result of coaxial coil

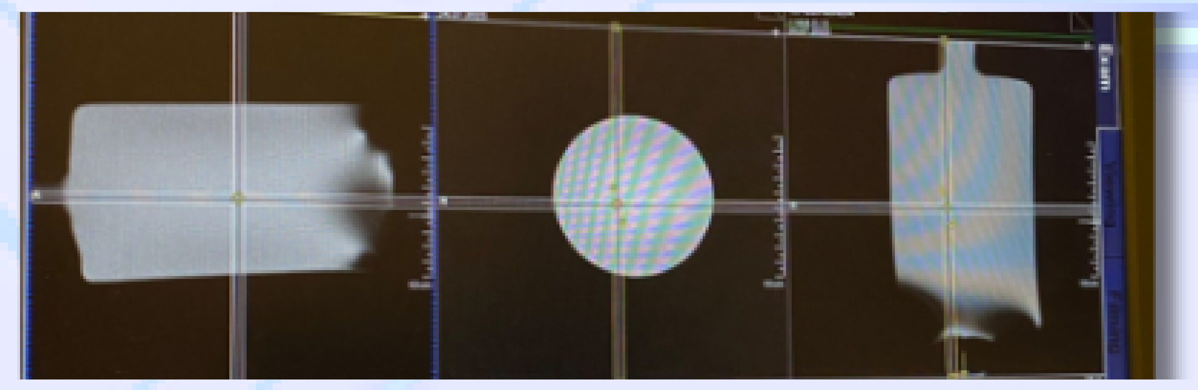

Figure 5: Scanning result of copper coil

From the figures, we can see that the image quality of the copper coil is better than that of the coaxial high impedance coils (HICs).

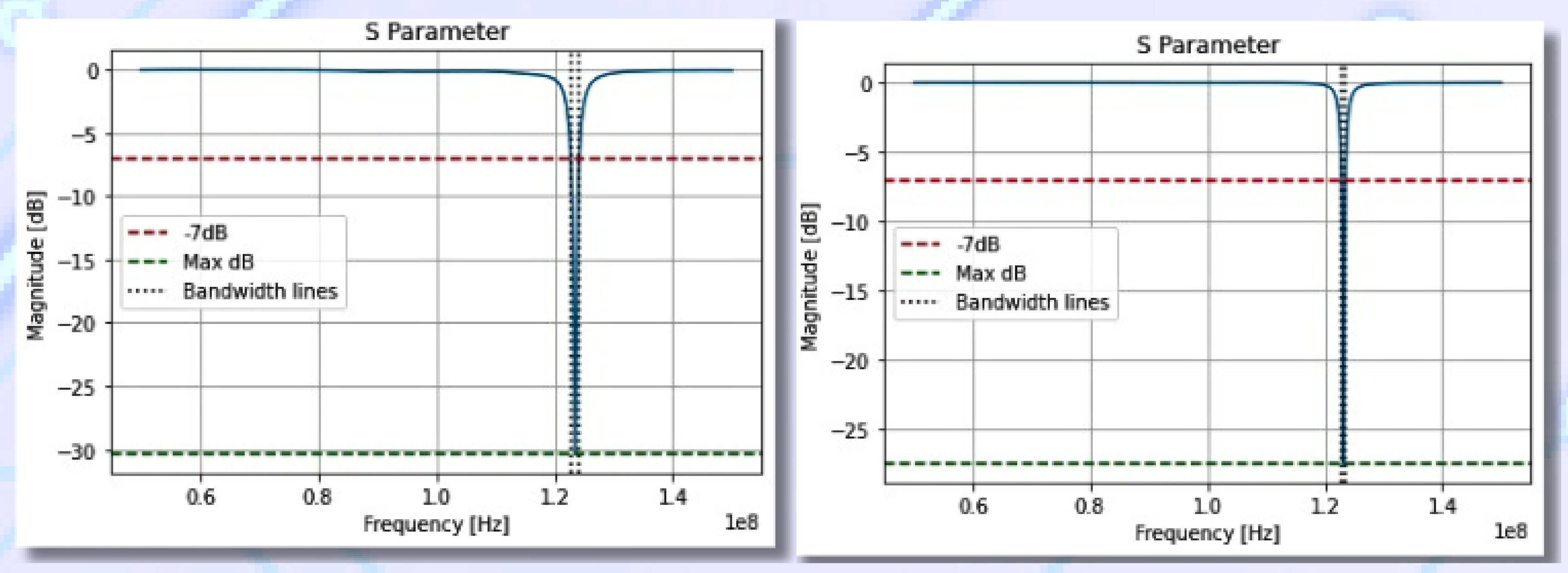

Figure 6: Coaxial Coil's and Copper Coil's S11 Parameters

$$Q = \frac{\text{Resonant Frequency}}{\text{Bandwidth at } -7\text{dB Point}} = \frac{f_{\text{resonance}}}{\text{BW}} = \frac{123 \text{ MHz}}{1.37 \text{ MHz}} \cong 90$$

$$Q = \frac{\text{Resonant Frequency}}{\text{Bandwidth at } -7\text{dB Point}} = \frac{f_{\text{resonance}}}{\text{BW}} = \frac{123 \text{ MHz}}{696 \text{ KHz}} \cong 177$$

Figure 7: Quality Factor Calculations

These results suggest that while flexible HICs offer improved adaptability to body contours, they may not yet achieve the same level of image clarity as traditional copper coils. Further optimization and refinement of the flexible coil designs are necessary to enhance their performance and make them viable alternatives for high-resolution MRI imaging.

References

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