Poynting Vector Calculation in Loop Antenna

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***Abstract*—The effect of matching layer on the performance of the loop antenna, which was designed in the previous report, is investigated by using HFSS. In order to determine the impact, an average power delivered to the center of the muscle is considered as a comparison criterion.**

***Index Terms*—Planar Circular Loop Antenna, HFSS, Impedance Matching, Muscle, Matching Layer**

I. Introduction

As concluded in the previous report, the planar circular loop antenna, working at the frequency of 2.4 GHz, in the presence of muscle and matching layers is matched to the impedance of 50Ω with a matching network circuit. The matching network connections and the values of the component are modified according to the input impedance of the antenna.

In order to analyze the effect of adding a matching layer between the muscle and the antenna, the average power delivered to the center of the muscle layer. It is calculated as first, determining the total power observed by a defined rectangular surface on the center of the muscle and then, dividing the computed total power to the area of the rectangular:

$$P_{ave} = \frac{\oiint_S \mathcal{W} \cdot d\mathbf{S}}{\oiint_S dS}$$

, where $\mathcal{W}$ is the poynting vector of the antenna, and S is the defined rectangular surface on the center of the muscle.

II. Average Power

A. Simulation with only muscle layer:

Firstly, the planar circular loop antenna, whose resonance frequency is $2.4GHz$, is optimized without using a matching network. Since in the previous report, the antenna was not further shrunk, the resonance frequency of $2.4GHz$ could not be reached without using a matching network. However, in this report, the antenna is made further smaller (its radius becomes $0.5cm$ which is approximately 25% of actual dimension).

Therefore, the simulation of the loop antenna of loop radius of $0.5cm$ and $0.8cm$, wire width of $0.1cm$ and port gap of $0.1cm$ in the presence of only muscle layer is run and the corresponding return loss graphs are shown in the Fig. 1.

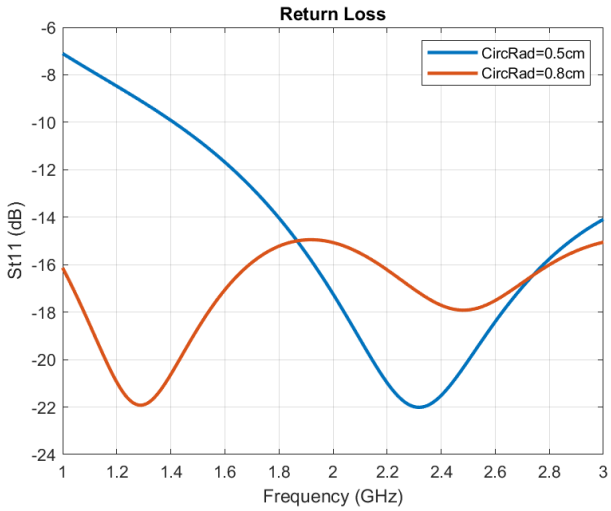

Fig. 1. The return loss with muscle layer and wire width of $0.1cm$

The calculated average power of the above antenna with the dimensions of loop radius of $0.5cm$, wire width of $0.1cm$ and port gap of $0.1cm$ is $\mathbf{0.0064W/m^2}$.

The dimensions of the circular loop antenna with a matching network, which was designed in the previous report, were the circular loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$, and the matching network consisted of $8pF$ of series capacitance and $4nH$ of parallel inductance. Its return loss is shown in the Fig. 2

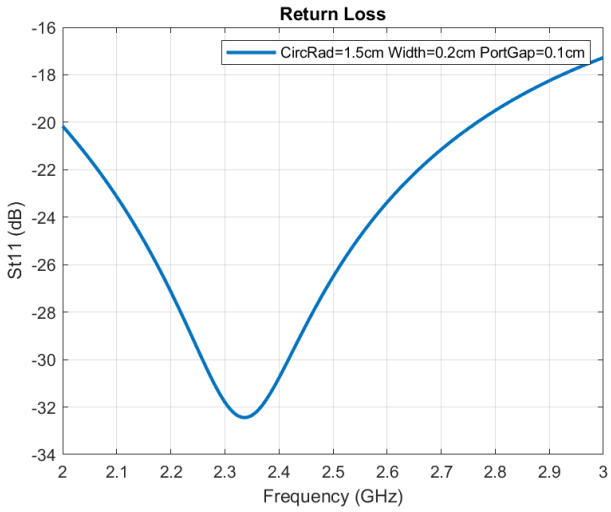

Fig. 2. The return loss with muscle layer and circular loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$

The calculated average power of the above antenna with the dimensions of loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$ is $\mathbf{0.0020W/m^2}$.

B. Simulation with both muscle and matching layer:

Firstly, the planar circular loop antenna in the presence of both muscle and matching layer is optimized without using a matching network. As in the previous report, various parameters of antenna dimensions are considered in the simulation and the resonance frequency of $2.4GHz$ is obtained in the antenna dimensions of loop radius of $0.7cm$, wire width of $0.1cm$ and port gap of $0.1cm$.

Therefore, the simulation of the loop antenna of loop radius of $1.2cm$, $0.8cm$ and $0.7cm$, wire width of $0.1cm$ and port gap of $0.1cm$ in the presence of both muscle and matching layer is run and the corresponding return loss graphs are shown in the Fig. 3.

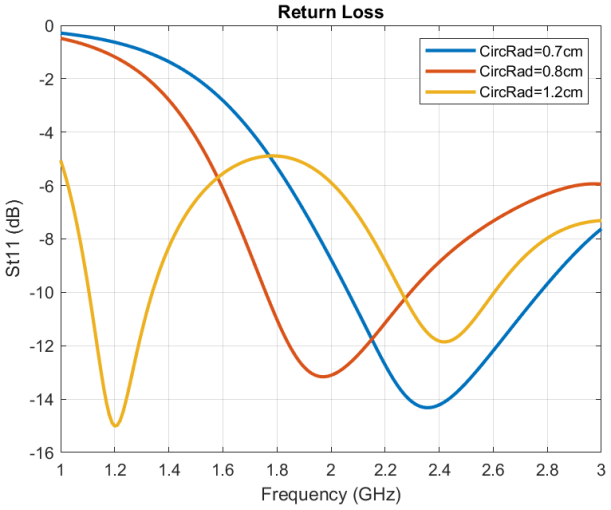

Fig. 3. The return loss with muscle and matching layers, and wire width of $0.1cm$

The calculated average power of the above antenna with the dimensions of loop radius of $0.7cm$, wire width of $0.1cm$ and port gap of $0.1cm$ is $\mathbf{0.0103W/m^2}$.

The dimensions of the circular loop antenna with a matching network, which was designed in the previous report, were the circular loop radius of $1.2cm$, wire width of $0.2cm$ and port gap of $0.1cm$, and the matching network consisted of $0.1pF$ of parallel capacitance and $2nH$ of series inductance. Its return loss is shown in the Fig. 4.

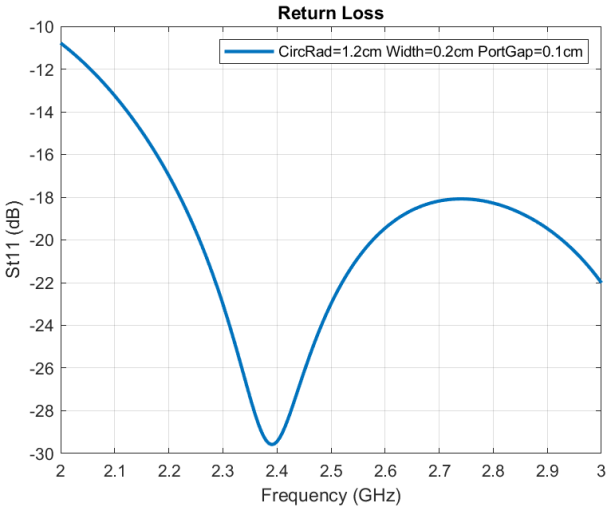

Fig. 4. The return loss with muscle and matching layers, circular loop radius of $1.2cm$, wire width of $0.2cm$ and port gap of $0.1cm$

The calculated average power of the above antenna with the dimensions of loop radius of $1.2cm$, wire width of $0.2cm$ and port gap of $0.1cm$ is $\mathbf{0.0059W/m^2}$.

III. Results

The table I shows all the average power values which are calculated in the previous part.

TABLE I
AVERAGE POWER OF THE PLANAR CIRCULAR LOOP ANTENNA

		Circle Rad (cm)	Wire Width (cm)	Port Gap (cm)	Value (W/m^2)
ML[1]	MN	1.2	0.2	0.1	0.0059
	No MN	1.2	0.2	0.1	0.0054
		0.7	0.1	0.1	0.0103
No ML	MN	1.5	0.2	0.1	0.0020
	No MN	1.5	0.2	0.1	0.0019
		0.5	0.1	0.1	0.0064

IV. Conclusion

There exist three observations to point out from the table:

- The matching layer increases the delivered average power almost two times.
- The matching network does not affect the average power as the matching layer does and it increases the average power almost 10 percent.
- Making the antenna much smaller also increases the delivered average power almost two times.

[1]ML: Matching Layer, MN: Matching Network