Loop Antenna with Muscle

Sefa Kayraklık

***Abstract*—The impedance matching to 50Ω of a planar circular loop antenna, which works at a resonance frequency of 2.4GHz in the presence of muscle material and matching layer, is analyzed by the means of the simulation tool of Ansys High Frequency Structure Simulator (HFSS). Since the antenna cannot be self-resonant at 2.4GHz, a matching network consisting of a capacitor and/or an inductance can be deployed to ensure that the antenna operates at the specified frequency.**

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

I. INTRODUCTION

As concluded in the previous report, a planar circular loop antenna can be matched to 50Ω by using a matching network consisting of a capacitor and/or an inductor. In this implementation, the designed antenna is simulated and matched in two different setups: presence of only muscle layer, and muscle and matching layers.

In order to match the antenna, the antenna without the matching network is first simulated to determine the input impedance; then, with the calculated values of capacitance and inductance at the frequency of 2.4GHz, the input impedance will be shifted to the center of the Smith Chart (50Ω).

II. THE ANTENNA WITH THE MUSCLE LAYER

The constructed simulation setup is shown in the Fig. 1. The light green cube is the muscle layer, and the dark red structure is the designed antenna.

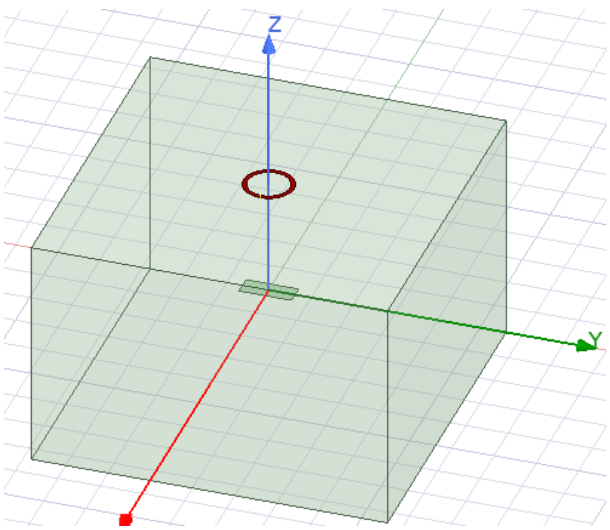


Fig. 1. The simulation setup with muscle

A. The antenna without matching network

The HFSS model is simulated with the parameter of circular loop radius of from $1.2cm$ to $2.4cm$ by the increments of $0.3cm$, wire width of $0.3cm$ and port gap of $0.1cm$ is simulated between the frequencies of $1GHz$ and $3.GHz$. The obtained return loss is shown in the Fig. 2.

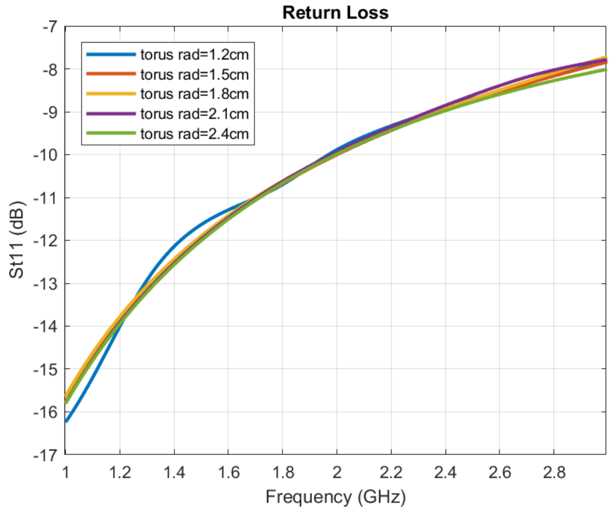


Fig. 2. The return loss with muscle layer and wire width of $0.3cm$

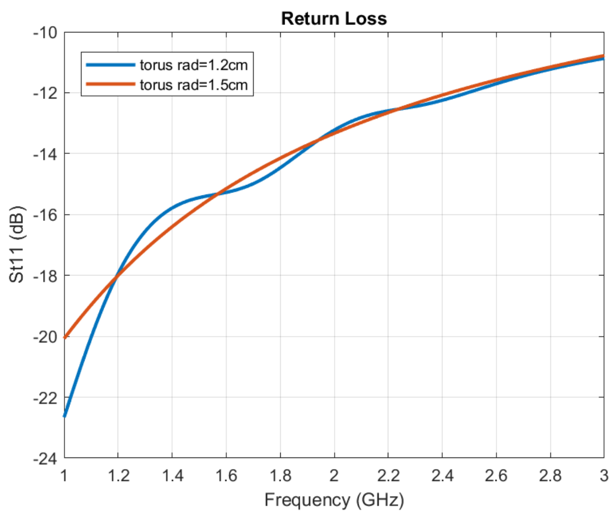
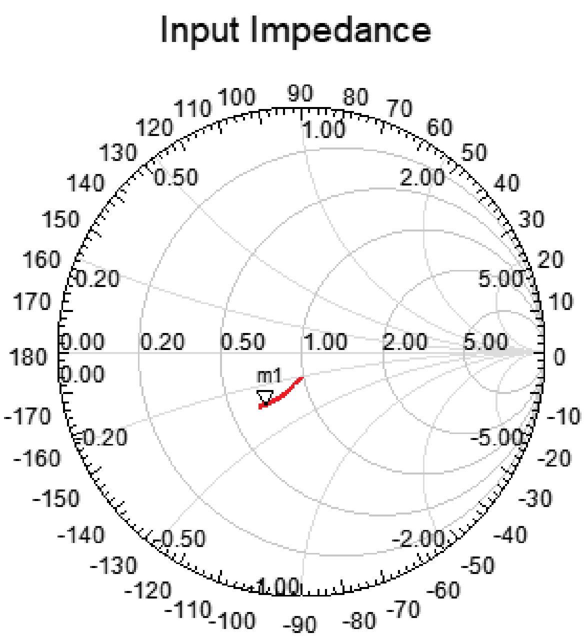


Fig. 3. The return loss with muscle layer and wire width of $0.2cm$

Since the resonance region could not be found, the model is again simulated with the parameter of circular loop radius of $1.2cm$ and $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$ is simulated between the frequencies of $1GHz$ and $3.GHz$. The obtained return loss is shown in the Fig. 3. Actually, due to the not enough memory error, the size of the antenna could not be furthermore shrunk; therefore, the resonance region could not be determined. So, the simulation is proceeded to the matching 50Ω via matching network with the best obtained parameters of circular loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$.

In order to construct the matching network, the input impedance of the antenna with the above mentioned parameters is shown in the Fig. 4.



Name	Freq	Ang	Mag	RX
m1	2.4000	-122.6732	0.2490	0.7049 - 0.3149i

Fig. 4. The input impedance with muscle layer and circular loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$

So, to match the impedance to 50Ω, a series capacitor to shift to the $20mS$ circle and a parallel inductor to shift to the center are needed.

B. The antenna with matching network

The value of the external components are calculated at the frequency of 2.4GHz via an online Smith Chart tool [1] as $8pF$ of series capacitance and $4nH$ of parallel inductance. Since the matching network is changed from the previous project, the antenna port is shown in the Fig. 5.

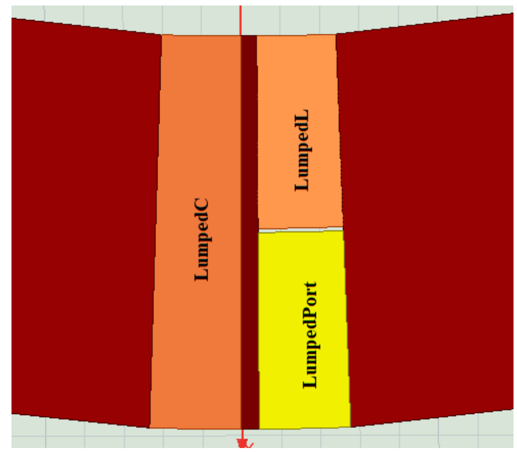
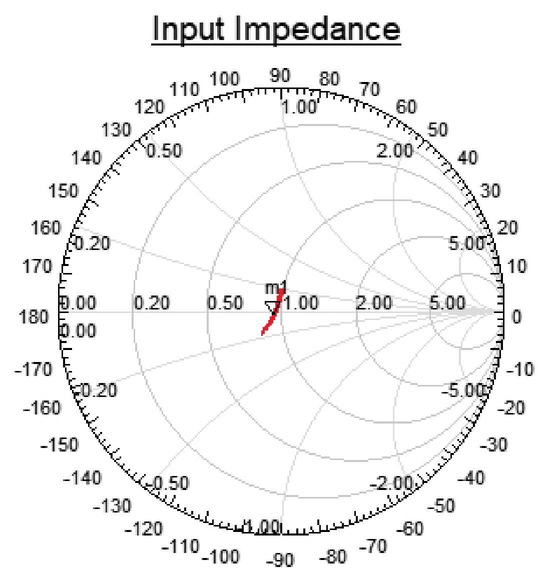


Fig. 5. The antenna port with the matching network

The HFSS model with the determined parameter in the previous section and the above determined values is simulated between the frequencies of $2GHz$ and $3.GHz$. The obtained input impedance and return loss are shown in the Fig. 6 and Fig. 7, respectively.



Name	Freq	Ang	Mag	RX
m1	2.4000	-166.7857	0.0289	0.9451 - 0.0125i

Fig. 6. The input impedance with muscle layer, circular loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$ and matching network

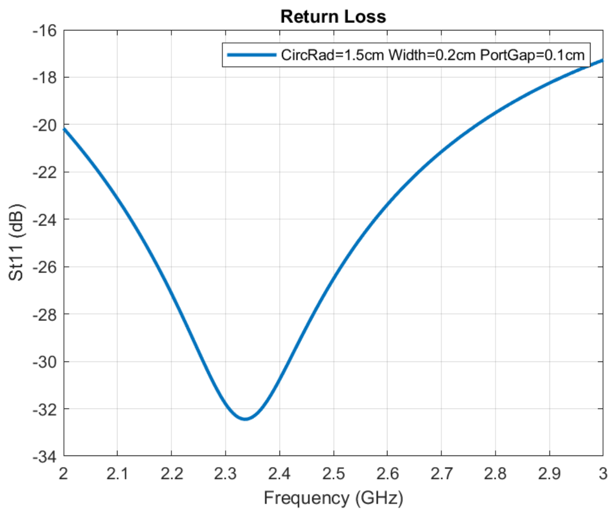


Fig. 7. The return loss with muscle layer and circular loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$

Since the simulation with the further smaller dimensions could not be done due to the lack of memory, the best achieved results are shown above.

III. The Antenna with the Muscle and Matching Layer

The same procedure is repeated in the presence of matching layer.

The constructed simulation setup is shown in the Fig. 8. The light green cube is the muscle layer, the yellow one is the matching layer and the dark red structure is the designed antenna.

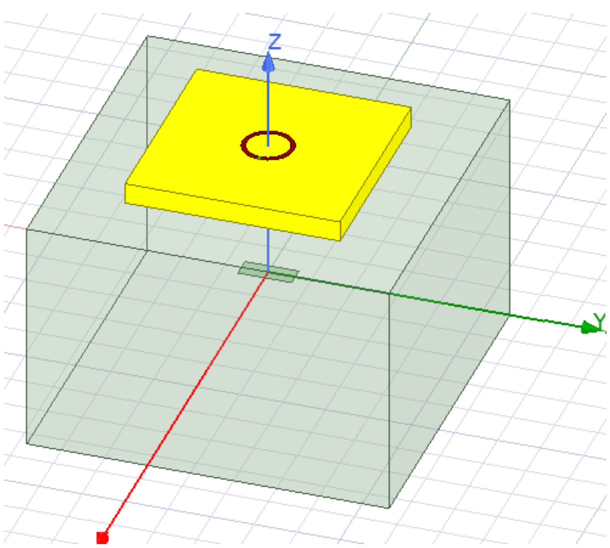


Fig. 8. The simulation setup with muscle and matching layers

A. The antenna without matching network

The HFSS model is simulated with the parameter of circular loop radius of from $1.2cm$ to $2.1cm$ by the increments of $0.3cm$, wire width of $0.3cm$ and port gap of $0.1cm$ is simulated between the frequencies of $2GHz$ and $3.GHz$. The obtained return loss is shown in the Fig. 9.

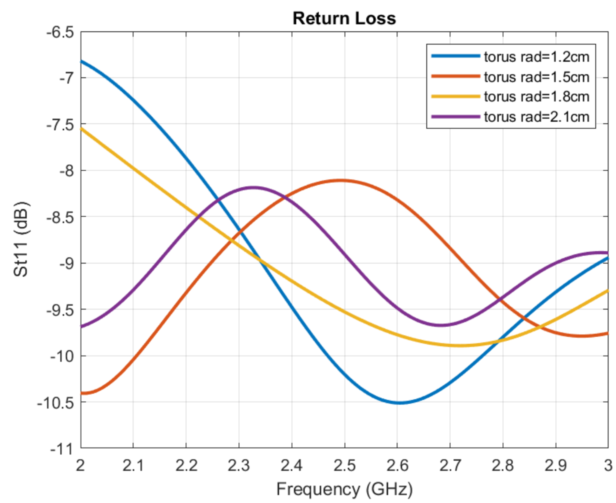


Fig. 9. The return loss with muscle and matching layers and wire width of $0.3cm$

It can be seen from the above figure that the resonance region for 2.4GHz can be acquired with the parameters of circular loop radius of $1.2cm$, wire width of $0.3cm$ and port gap of $0.1cm$. Also, the simulation is run for the wire width of $0.2cm$, the obtained return loss is shown in the Fig. 10.

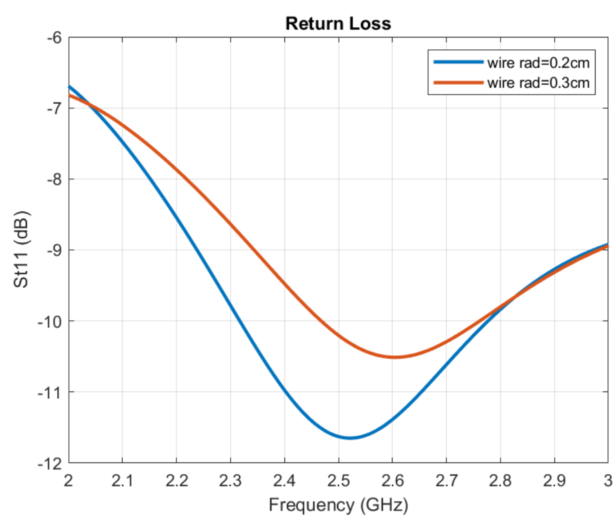
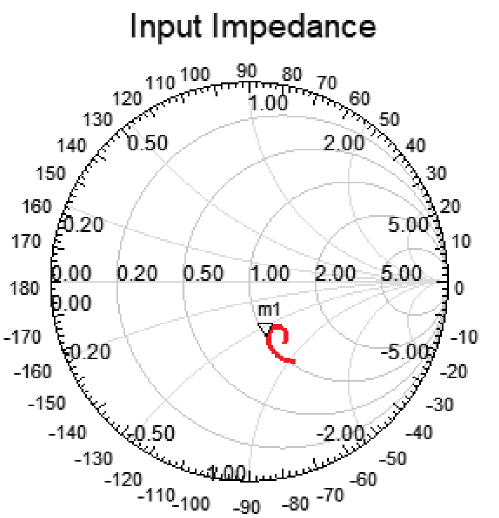


Fig. 10. The return loss with muscle and matching layers and circular loop radius of $1.2cm$

So, the simulation is proceeded to the matching 50Ω via matching network with the best obtained parameters of circular loop radius of $1.2cm$, wire width of $0.2cm$ and port gap of $0.1cm$.

In order to construct the matching network, the input impedance of the antenna with the above mentioned parameters is shown in the Fig. 11.



Name	Freq	Ang	Mag	RX
m1	2.4000	-69.6992	0.2827	1.0411 - 0.6001i

Fig. 11. The input impedance with muscle and matching layers, circular loop radius of $1.2cm$, wire width of $0.2cm$ and port gap of $0.1cm$

So, to match the impedance to 50Ω, a parallel capacitance to shift to the 50Ω circle and a series inductor to shift to the center is needed.

B. The antenna with matching network

The value of the external components are calculated at the frequency of 2.4GHz via an online Smith Chart tool [1] as $0.1pF$ of parallel capacitance and $2nH$ of series inductance. And the antenna port is shown in the Fig. 12.

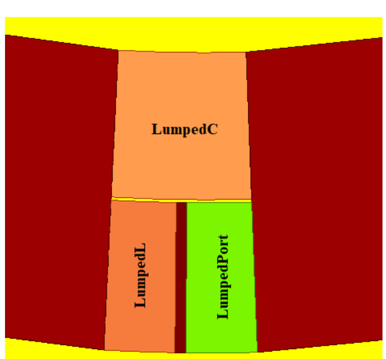
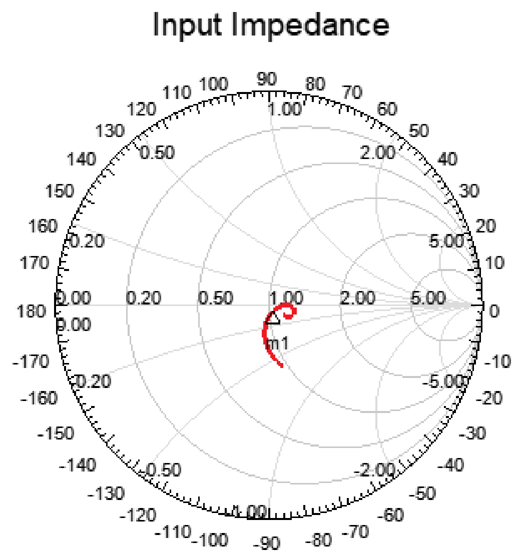


Fig. 12. The antenna port with the matching network

The HFSS model with the determined parameter in the previous section and the above determined values is simulated between the frequencies of $2GHz$ and $3.GHz$. The obtained input impedance and return loss are shown in the Fig. 13 and Fig. 14, respectively.



Name	Freq	Ang	Mag	RX
m1	2.4000	-38.3828	0.0337	1.0533 - 0.0441i

Fig. 13. The input impedance with muscle and matching layers, circular loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$ and matching network

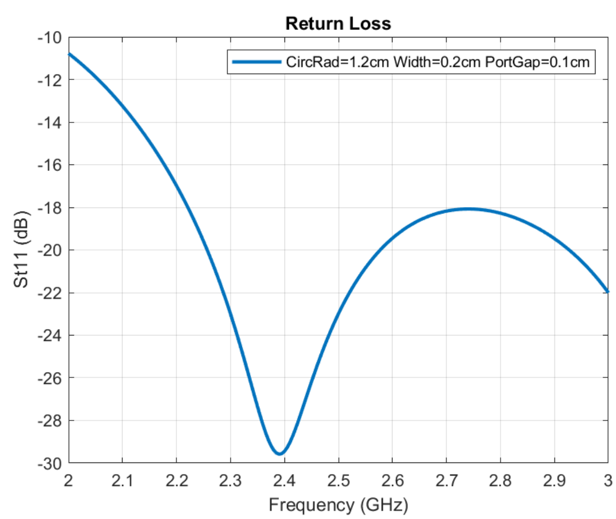


Fig. 14. The return loss with muscle and matching layers, circular loop radius of $1.5cm$, wire width of $0.2cm$ and port gap of $0.1cm$

IV. Conclusion

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.

References

[1] Retrieved 20 December 2020, from https://www.will-kelsey.com/smith_chart/