Design and Simulation of Band-notched Ultra Wideband Ring Monopole Antenna

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Abstract— **With the increasing improvement of computer and computational method, many electromagnetic simulators solving antenna problems are widely used. In this paper, the electromagnetic simulator CST is applied to the analysis and design of a planar circular ring antenna with stub for ultra wideband applications with band notch performance. The antenna parameters are adjusted to achieve return loss of 10 dB over the desired frequency range (3.1 – 10.6 GHz) except the notch frequency band. The simulated result for return loss is in good agreement with the measured result.**

Index Terms—**Band notched antenna, Circular ring monopole antenna, electromagnetic simulator.**

I. Introduction

Recent advancements in computing power have led to the implementation of computational modeling and simulation techniques in various scientific and engineering areas. These computational techniques have enabled scientists and engineers to simulate quantities those are difficult to measure physically. The electromagnetic simulators are widely used nowadays for solving antenna and propagation problems [1], [2]. The desired antenna parameters e.g. radiation pattern, impedance data, resonance frequency etc. can be computed accurately using these simulators. The simulation results for field and current distribution on a radiating structure provides the essential insight into the radiating mechanisms, whereas it is quite difficult to experimentally measure electromagnetic field quantities near an antenna without altering its operation. However, users need to have adequate experience of using the simulator and to be acquainted with its application.

In recent years, the ultra wideband (UWB) wireless technology has grown rapidly. As the front-end to the UWB communication, the design of ultra wideband antenna has become an important research area [3]-[5]. The planar monopole antennas are used to cover the entire UWB bandwidth (3.1–10.6 GHz) defined by FCC. The antennas with band rejection characteristics are used to reduce the interference between the UWB transmitters on different communication systems with overlapping frequency band (e.g. Wireless LAN) [6]-[9]. The circular ring monopole antenna with stub placed vertically on a circular ground plane is found as a suitable UWB antenna with band stop characteristics [10]. This paper presents the frequency domain characteristics of this UWB band notched antenna using electromagnetic simulator e.g. CST [11]. The band notched feature is achieved by introducing a tuning stub inside the ring monopole. The UWB performance of an antenna in frequency domain is characterized by the impedance matching characteristics, stable radiation pattern and high efficiency over bandwidth. Here, electromagnetic simulation software Computer Simulation Technology (CST) Microwave Studio is used for the modeling and simulation of the UWB band-notched antenna [11]. The prototype band–notch antenna is fabricated and the result for the return loss of the prototype antenna is compared with the simulation data.

II. Antenna Geometry

The structure of the antenna is shown in Fig. 1. The circular ring monopole is mounted on a circular ground plane of radius = 75 mm with a feed gap of 2 mm. The band notch characteristics are achieved by the introduction of a rectangular tuning stub of length L and width W. The length of tuning stub is taken approximately as quarter wavelength at the desired notch frequency. All these parameters are optimized to achieve the best performance.

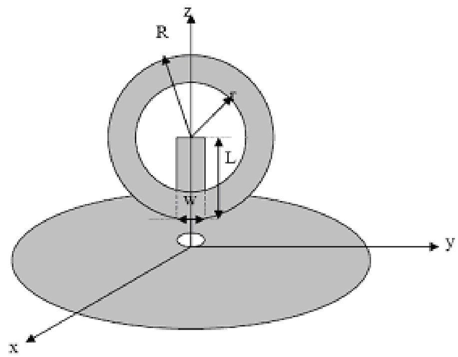

Fig. 1. Geometry of the band-notched antenna [10].

III. Results and Discussions

The antenna is modeled using electromagnetic simulation software CST microwave studio that utilizes the finite integral technique (FIT) to evaluate the currents on the structures [11]. For the simulation, the antenna is considered to be excited by a waveguide port. Fig. 2(a) shows the plot of simulated S11 versus frequency of ring monopole with different inner radii (without notch). The graph shows that by adjusting the inner radius of the ring, an impedance bandwidth defined by 10 dB return loss is achieved over UWB frequency range 3.1 – 10.6 GHz. Next, keeping the inner radius r = 8 mm (the value is chosen to acquire the

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desired bandwidth) the stub is introduced to achieve the band notch characteristics. The plot of S_{11} versus frequency for various stub lengths is shown in Fig. 3. A hike in the return loss over a certain frequency band is achieved by including the stub of suitable dimension. The surface current distributions on the ring monopole (with and without stub) at the notch frequency and also at another frequency in the ultra wideband are presented in Fig. 4 – 5. At the resonant frequency of the stub, the surface-current distribution of the ring monopole is disturbed. The 3D gain pattern of the ring antenna (without and with the stub) at the same frequency is shown in Fig. 6 – 7. The gain pattern is almost identical for the two cases. The radiation pattern at different frequencies of the band-notched antenna within the UWB range (Fig. 8) shows good omni directional radiation pattern, which are about the same as those of the corresponding simple circular-disk monopole antenna (Fig. 9). Next, a prototype antenna is fabricated for experimental verification. The design parameters of the prototype antenna are same as Fig. 4. A circular finite ground plane of radius of 75 mm is used for the measurement. The circular ring with the stub is supported on the ground plane by a SMA connector. The circular ring is soldered with the pin of the connector protruding through the hole made in the ground plane. The length of the pin is 2 mm which determines the height of the ring above the ground plane. A comparison between the simulated and measured S_{11} using HP 8757 C network analyzer is presented in Fig. 10. Fig. 10 shows good agreement between the measured and simulated results, though a small shift of the notch frequency band is noticed for the measured data. The slight deviation of the fabricated antenna structure from the simulated one causes this difference. However, the measured return loss data shows the same impedance bandwidth as that of the simulation data.

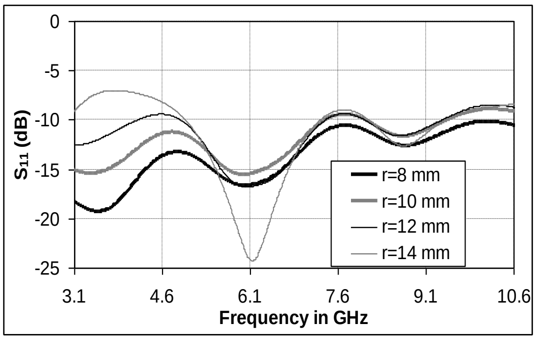


Fig. 2. Simulated S_{11} data for various inner radius of the circular ring monopole (without notch) with fixed outer radius R=18 mm.

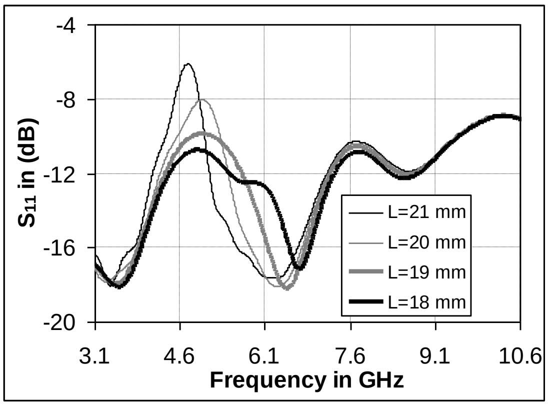
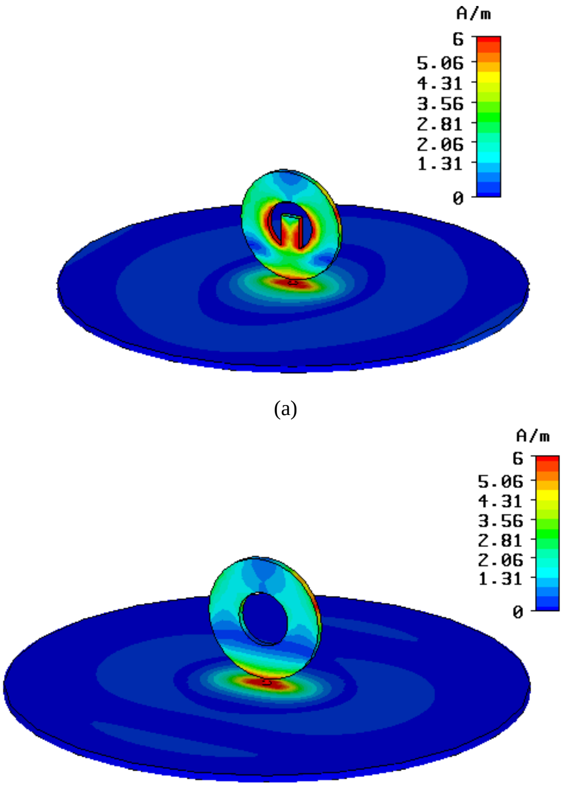


Fig. 3. S_{11} versus frequency plot for various stub length inside the circular ring monopole (with notch) with R = 18 mm, r = 8 mm, W = 6.7 mm.



(b)

Fig. 4. Surface current distribution at 4.75 GHz on the (a) band notched circular ring antenna with R = 18 mm, r = 8 mm, W = 6.7 mm, L=21 mm and (b) circular ring antenna with R=18 mm, r=8 mm.

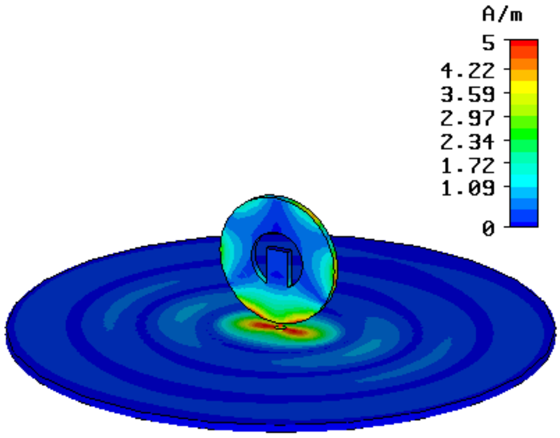


Fig. 5. Surface current distribution for frequency 8 GHz of the band notched circular ring monopole.

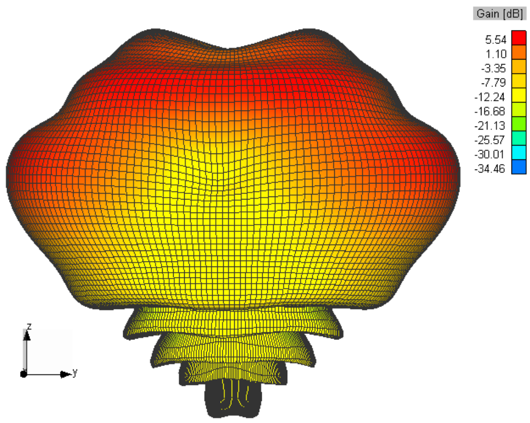


Fig. 6. Gain pattern at 10 GHz of the circular ring monopole.

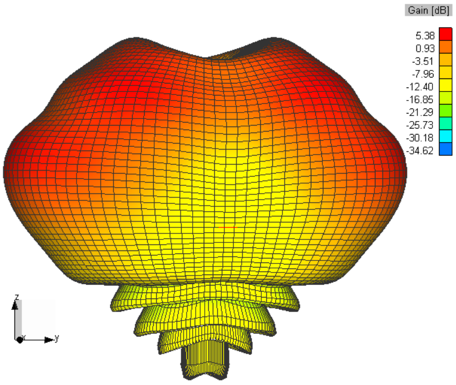


Fig. 7. Gain pattern at 10 GHz of the band notched circular ring monopole.

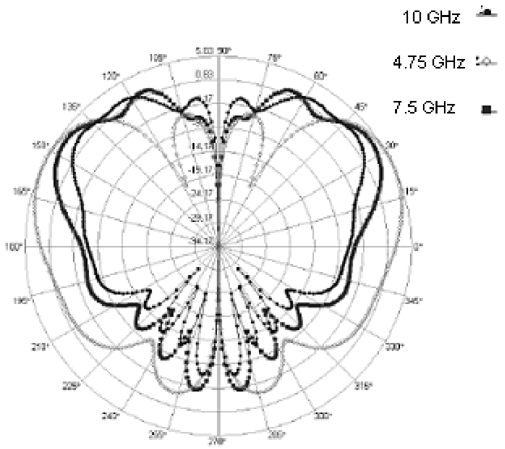


Fig. 8. Radiation pattern in the vertical plane at different frequencies of the band notched circular ring monopole. The angle is measured from the vertical *z* axis.

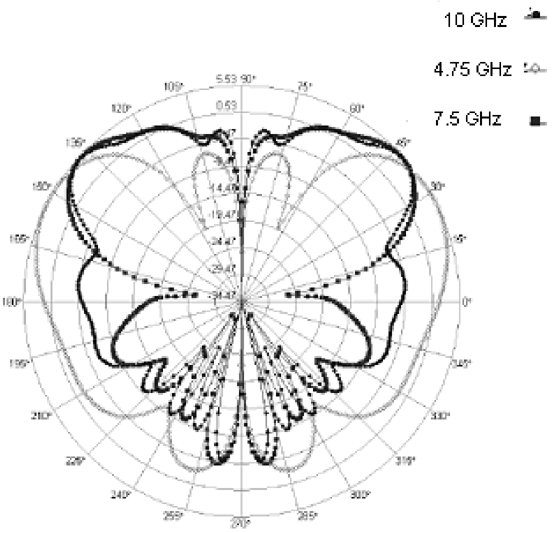


Fig. 9. Radiation pattern in the vertical plane at different frequencies of the circular ring monopole with R = 18 mm, r = 8 mm.

IV. Conclusion

This paper presents the performance of a modified planar ring monopole antenna as an UWB band-notched antenna based on the simulation results using electromagnetic simulator. The simulated results for the return loss show that the desired bandwidth with desired frequency notch can be achieved and easily controlled by adjusting stub length and the other parameters of the antenna. The omni directional radiation pattern of a conventional monopole antenna is maintained over the frequency range.

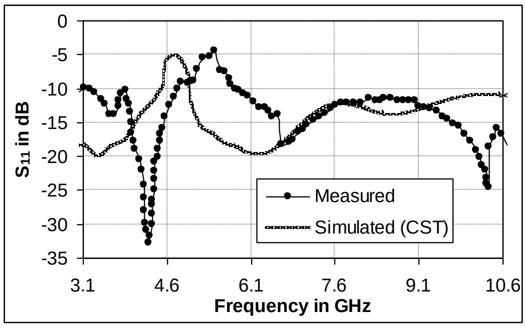


Fig. 10. Plot of S_{11} versus frequency of the band-notched modified circular ring monopole antenna.

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