An Ultra-Wide Band Monopole Eclipse Antenna

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Abstract
In this paper a monopole eclipse antenna is presented. The proposed antenna was simulated using Computer Simulation Technology (CST) and HFSS Package. The performance parameters like return loss of the single antenna as well as transmission function, group delay are calculated. Good ultra wide band performance is achieved.

Keywords: *CST Microwave Studio**,** Novel planar UWB antenna, monopole antenna.*

1. Introduction

Ultra-wideband has its roots in the original "spark-gap" transmitters that pioneered radio technology. Ultra-wide band technology has attracted much attention these years. In this technology, directly transmitting and receiving of short pulses with wide frequency bandwidth is the main purpose. Basic analog part of UWB systems is transmitting and receiving antennas. Hence, design and implementation of antennas that meet all specifications of UWB requirements is one of the major challenges for antenna designers and researchers. The most important requirements for UWB antennas are ultra wide operation bandwidth, constant gain, omnidirectional pattern, constant group delay, high radiation efficiency, and low profile. In literature, we find many different antennas that are suggested for this application. Two major groups of those are three dimensional monopole antennas and planar antennas. The first group is often made by a radiating element on a ground plane. The radiating element has different shapes such as square [1, 2],diamond. Although these antennas are suitable for UWB applications they are not planar structures. Therefore, for applications that need to integrate antennas and digital boards, planar antennas are suitable.

In this paper, an investigation on a useful radiating element for UWB application, named monopole eclipse antenna, is performed. UWB performance characteristics of this antenna in terms of input impedance matching condition, radiation patterns, magnitude transfer function, group delay and time domain fidelity factor is presented.

Simulation results are obtained using commercial simulator package such as CST Microwave Studio [3]which utilizes the finite integration technique and HFSS [4] which utilizes the finite element technique for electromagnetic simulations.

2.Geometric Aspects of Proposed Antenna

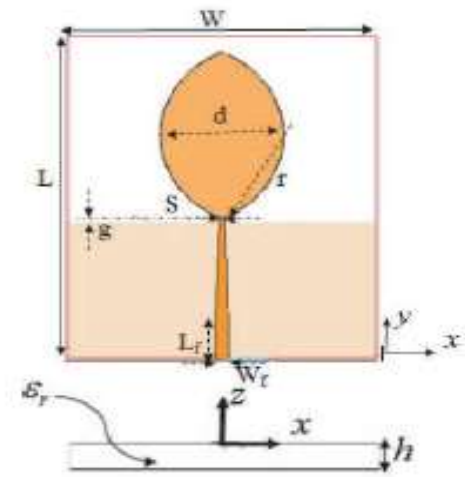

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Figure (1) Proposed monopole eclipse antenna design

In this communication, a new UWB antenna is presented. Fig. (1) Shows the proposed monopole eclipse antenna. Using a coaxial probe through a SMA connector the antenna has been fed. For dipole configuration, the antenna is fed in center by a lumped port or a balance structure, and in monopole configuration, we used a tapered micro strip feed line. The rectangular shape ground plane, printed on the back side of the substrate, is also shown in the figure by the light gray area.

In monopole configuration the ground plane is placed at distance *g* from the lower edge of radiating element. The tapered micro strip line is employed for broadband matching of the antenna to the 50Ω micro strip line. The width and length of the 50Ω micro strip line are denoted by W_f and L_f respectively, and the width of the taper at its connecting point to the antenna is given by *S*. The substrate is assumed to be RO4003 (ε_r = 3.55, tanδ = 0.0027) with the thickness of 20mil. The antenna design procedure is given below.

Based on numerical experiments for impedance stability over the whole operating band and small size of the antenna, *W* = 30mm and *L* = 35mm are selected. Also simulations show that if we place the first resonance of the antenna at 3.3 GHz, the return loss at the lower edge of the frequency band, i.e., 3.1 GHz will remain lower than 15dB.For this aim, the value *r* is optimized to 10 mm, and *d* is optimized to6 mm. While *Wf* is calculated to be 1.2mm to match a 50- micro strip line, and *Lf* = 5mm for fabrication and SMA connector installation reason, *S* and *g* are found by optimizing the antenna return loss to remain below 10 dB throughout the frequency band 3.1-10.6 GHz. The optimized values for *S* and *g* are found to be 0.4mm and 0.3 mm, respectively.

3. Results

The simulated return loss of the monopole eclipse antenna is shown in Fig. 2.

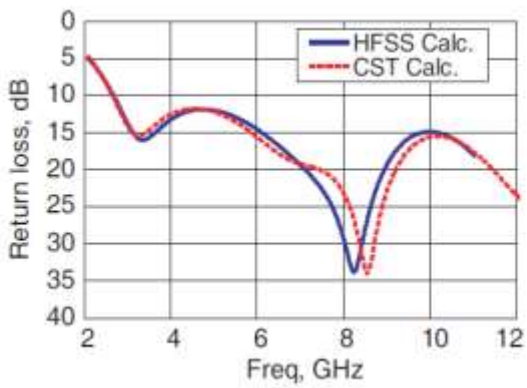

Figure 2. Return loss of the planar monopole eclipse antenna With *r* = 10 mm, *d* = 6 mm, *S* =0:4 mm, *g* = 0:3 mm.

It is clear that both the simulated results by HFSS and CST return losses for the monopole eclipse antenna have values better than 10 dB throughout the UWB frequency band. The simulated *H*-plane (*xz*-plane, = 0±, 180±) antenna gain patterns at 4, 6, 8, 10 GHz for monopole eclipse antenna are shown in Fig. 3. It can be observed that the *H*-plane patterns are all omnidirectional. Figure 4 shows the simulated magnitude of the antenna transfer function in a two-antenna configuration. In this case the two antennas are separated by 60 cm in face to face (T-T), face to side (T-S), and side to side (S-S) configurations. In UWB applications, magnitude of the transfer function should be as flat as possible, and its phase must be linear throughout the frequency band[8]. As shown in Fig. 4, the variations of the transfer function for monopole eclipse antenna link are within 10 dB in the whole frequency band. Figure 5 shows the simulated group delay of the monopole eclipse antenna. To observe the level of distortions imposed on the trans-mitted pulses by the monopole eclipse antenna, the transmitting antenna is fed by the fourth order Rayleigh pulse as the excitation signal.

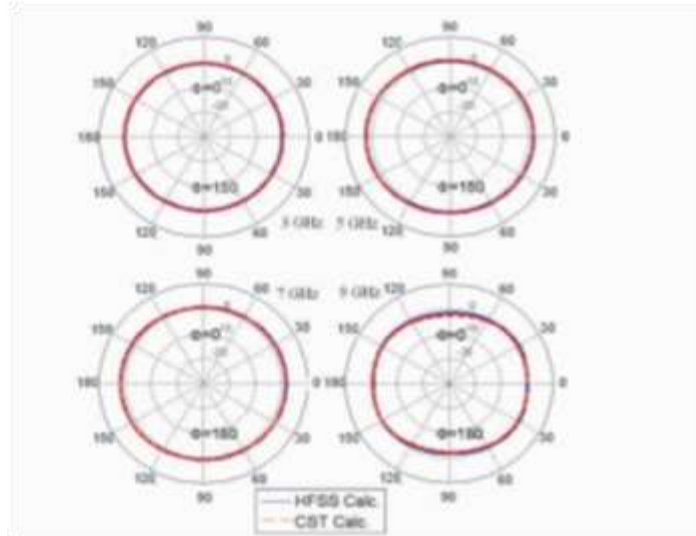

Figure 3. *H* plane radiation patterns of the monopole eclipse antenna.

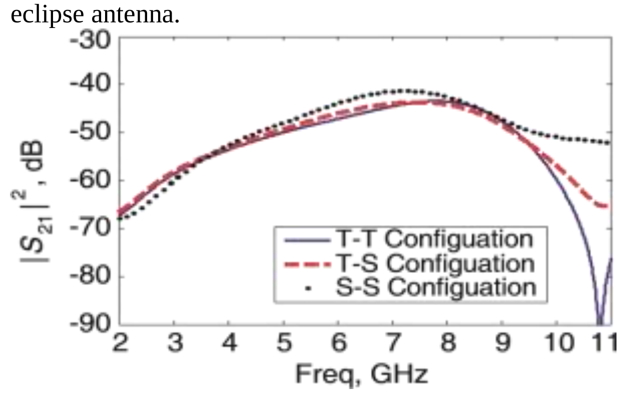

Figure 4. Magnitude of transfer functions of the three different configuration of the monopole eclipse antenna

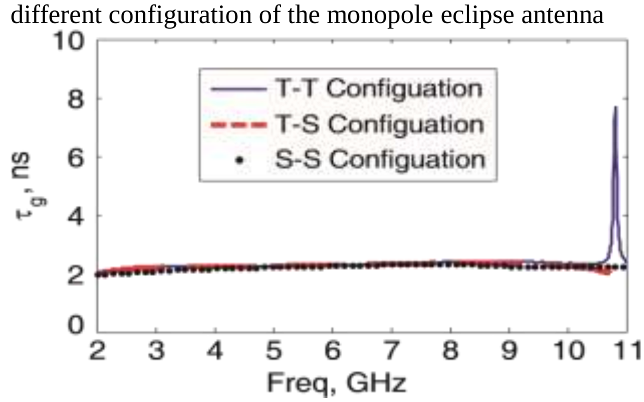

Figure 5. Group delays of the three different configuration of the monopole eclipse antenna

. The excitation signal is given by:

$$s(t) = A\left(\frac{(t-\mu)^4 - 6(t-\mu)^2 + 3\sigma^4}{\sigma^8}\right) e^{-\left(\frac{(t-\mu)^2}{2\sigma^2}\right)} \quad (1)$$

where *A* is a normalization factor; μ, and σ are the center of time axes and the pulse width factor, respectively.

It is seen that the received pulses are distorted and broadened about 1ns. To measure the similarity of the received and transmitted signals, one may use the fidelity factor *F* defined in [5-7]. That is

$$F = \max_{\tau} \int_{-\infty}^{+\infty} L(f(t)) S_R(t-\tau) dt \quad (2)$$

where $f(t)$, $S_R(t)$ are the transmitted and received signals, respectively, and operator *L* is

$$L(f(t)) = \frac{d^{n-1}(f(t))}{dt^{n-1}} \quad (3)$$

It is clear that *F* gives the correlation between the two signals and varies between 0 and 1 with $F = 1$ meaning that the two signals are exactly the same. Using the above-mentioned definition, the fidelity factor between the transmitted and received signals for the monopole eclipse antenna in the two-antenna configuration is calculated for different values of the pulse width factor.

The fidelity factor between transmitted and received signal (i.e. n= 1) is about 0.8747 for pulse width factor σ= 50ps, and the fidelity factor between the received signal and first derivative of the transmitted signal i.e., the fifth order Rayleigh pulse ($n = 2$) is about 0.9248 for pulse width factor σ= 60 ps. These values for the fidelity factor show that the antenna imposes negligible eject on the transmitted pulses.

Conclusion

A monopole eclipse antenna for UWB applications was proposed. Using a monopole configuration, the antenna dimensions were optimized to gain the best return loss response throughout the UWB frequency band. The optimized antenna was simulated, and its performance parameters were calculated in terms of the frequency domain parameters such as return loss, magnitude of *S*21 and the group delay. Calculated results show that the designed antenna satisfies the UWB design goals very well.

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