Inclusion of Metamaterial to Design Ultra-wideband Antenna

Sanjay kumar sahu[1],, Parulpreet Singh[2], Shelej Khera[3]
[1,2,34]SEEE, Lovely Professional University Punjab
sanjay.23393@lpu.co.in

Abstract:

This paper include an arc-shaped patch using complementary split ring resonator (CSRR) embedded in it that showing band notch characteristics. The design suggest a sharp rejection at desired frequencies can be achieved to overcome interference for some bands pertaining to wireless application. The notch bands are observed 5.04 GHz-5.35 GHz and 7.3 GHz-7.46 GHz which finds an application in the downlink of X-band satellite communication systems at 7.4 GHz. One more notch band from 10.1 GHz-10.21 GHz is achieved as well. The frequency band of the antenna is 3.1 GHz-11.8 GHz which confirm the requisite UWB.

Introduction:

UWB technology [1] is a revolutionary radio technology in the wireless communication field that transmits huge data in a physical channel. The rapid growth for ultra-wideband communication demands the development of ultra-wideband antennas that can occupy large frequency spectrum to accommodate many existing wireless devices. Due to limited spectral band the design of UWB antenna are quite essential to avoid some kind of interference with existing band. To solve the problem of interference within the existing wireless networks such as WLAN (5.15 GHz-5.35 GHz) band, satellite communication band and many more, it is the required to design UWB antennas with a band notch characteristic [2].

This design include a U-shaped arc [3] etched on the monopole antenna using metamaterial split ring resonator structure [6], to get notch at the desired frequency Metamaterials [5], [6], [7], [8], [9] are artificially engineered materials which are not available in the physical world but it can be developed artificially where permeability and permittivity can be made negative to alter the properties of an existing design. Of course we can achieve any one parameter out of permeability and permittivity to justify metamaterial. The structures that are responsible for simultaneously negative could be SRR (split ring resonator) and CSRR (complementary split ring resonator. The structure is composed of pair of rings with gaps in opposite direction. When the current flows through this structure an inductance and capacitance effect is developed. The reason behind this is that the ring or circular wire create inductance effect and the gap provide the capacitance effects to work like a resonant circuit. Normally when the resonance takes place in a circuit, either maximum or minimum impedance is achieved. But at resonance condition energy get absorbed to show notch characteristics. CSRR and SRR [6] provides a negative effective permittivity and permeability respectively.

Antenna Design and Result analysis

The shape and structure of the antenna which shows an ultra-wideband (UWB) is given in Fig.1. The antenna is fabricated on Roger RO3003 substrate with the relative dielectric constant of $\varepsilon_r=3$ ($\tan\delta=0.0013$) and the thickness of 0.762 mm. The desired antenna is simulated by using high frequency structure simulator (HFSS). The S-parameter result corresponds to the base antenna is depicted in figure 2 which almost show UWB. From the plot X-axis represents frequency in GHz whereas Y-axis denotes return loss in dB. The result shows that the antenna is resonating mostly about 3.6 and 9.8 GHZ. In the second attempt we tried to inculcate a CSRR structure to the base design. After including the metamaterial structure which is available in figure3, further simulated. The result corresponds to the structure where CSRR is embedded in it is depicted in figure 4. Figure5 represents the structure of CSRR with outer radius 'a' and inner radius 'b'. The result now we are achieving is guarantee about band notch characteristics ta 7.3 GHz-7.46 GHz for the downlink of X-band satellite communication systems and from 10.1 GHz-10.21 GHz.

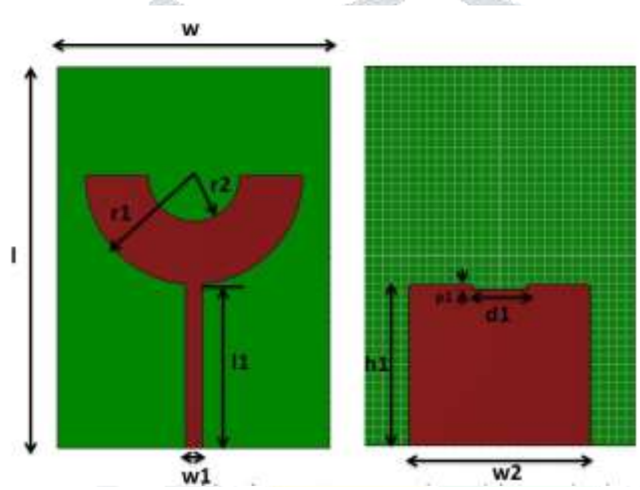

Figure SEQ Figure * ARABIC 1 Arc shape monopole Antenna with top and bottom view

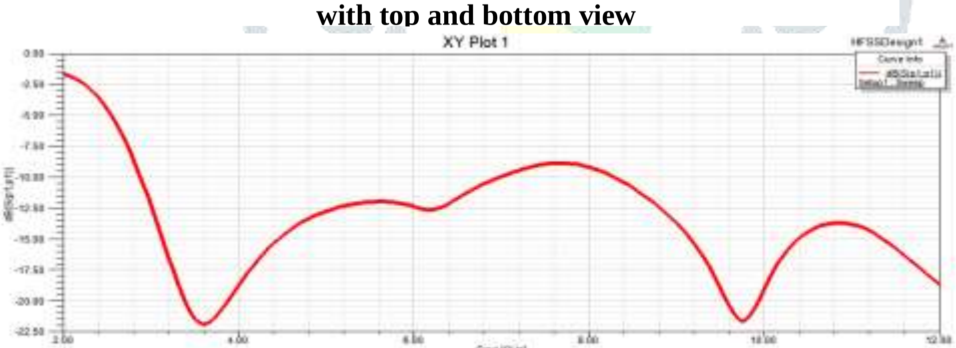

Figure SEQ Figure * ARABIC 2 Frequency response plot corresponds to Fig.1

Figure 3 U -shape monopole Antenna with CSRR

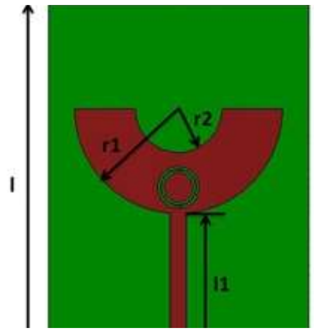

Figure 4 CSRR structure with gap mechanism

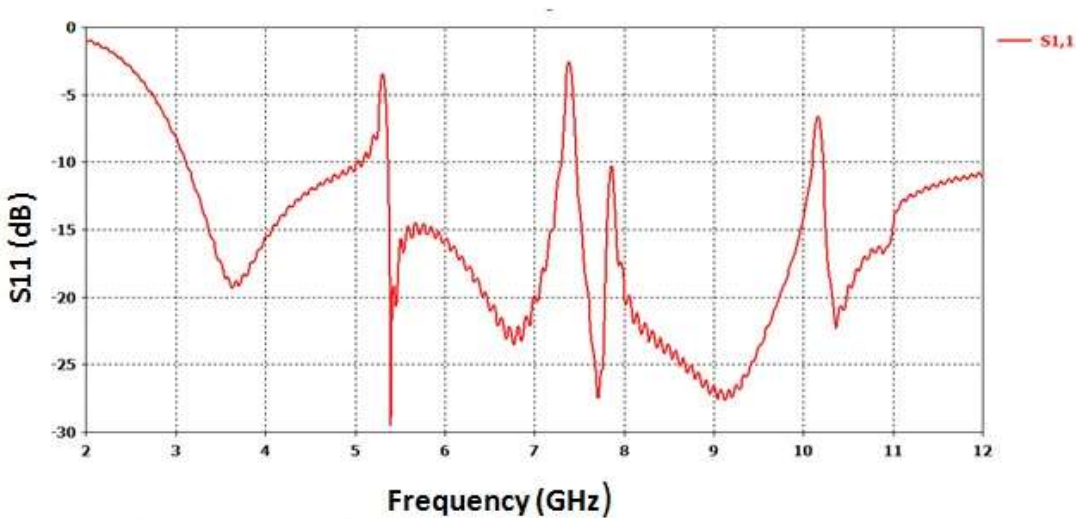

Figure 5 S-Parameter result corresponds fig.3

Conclusion

In this article we have designed a U-shape monopole antenna. Next to this we intended to encounter an metamaterial structure to it. The base structure provide mostly an UWB with little amount of variation seen in terms of S-parameter result where the figure found to be little less than -10dB. But in the later design where negative kind of characteristics are observed bring the notch band to the original result. The main purpose to bring notches in the result is that we can avoid any kind of interference to the existing band which is very necessary as per as the wireless communication is concerned.

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