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Triple Frequency Notch in UWB Antenna with Single Ring SRR loading

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Abstract

A compact coplanar waveguide (CPW) fed ultrawideband (UWB) printed circular monopole antenna (PMA) with triple frequency notched function is presented and validated here on a low cost FR4 Epoxy substrate. Here the antenna loaded with three single circular ring SRRs to create triple frequency notching in 3.5 GHz for WiMAX, 5.5 GHz for WLAN, and 7.9 GHz for X-band satellite communication systems, respectively. The SRR design equations are analyzed in detail here. Return loss and voltage standing wave ratio (VSWR) are used to show the effect of these rings. Measured result shows a close correlation to the theoretical results.

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Keywords: ultrawideband (UWB); split ring resonator (SRR); monopole antenna; WLAN; WiMAX; X band.

1. Introduction

Ultra-wideband also known as UWB is a radio technology that can use a very low energy level for short-range, high-bandwidth communications over a large portion of the radio spectrum. Ultra-wideband is a technology for transmitting information spread over a large bandwidth ranging from 3.1GHz to 10.6GHz (>500 MHz) this should share spectrum with other system users. Ultra-wideband characteristics are well-suited to short-distance applications, such as peripherals of PC. Due to short duration of UWB pulses, it is easier to provide high data rates.

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Ultra-wideband characteristics are well-suited to short-distance applications, due to its low emission levels permitted by regulatory agencies[1]. There also some existing narrow band systems such as WLAN, WiMAX, HIPERLAN which overlap with the other frequencies in the designated UWB spectrum. Due to the coexistence of the UWB system with frequency bands reserved for narrowband wireless technologies, there is a need in notching methods to provide filtering in order to avoid interference from, or causing interference to, narrowband devices. Hence, differentiating against signals from such narrowband sources is an important requirement for UWB systems. Using a stop-band filtering in the design, which will increase complexity of the UWB system, hence the method employed to extract the desired UWB bands that is to use an antenna with inherent band-notch properties. Till this time there are such antennas are implemented by making several variations in radiator or ground plane. There are many designs are available in open literature. Notch properties are accomplished by changing the shape of radiator with various types of slot or by parasitic strip loading[2-6]. Filtering achieved by using modified ground plane[7-9]. Other design configurations are dual-frequency notch and wideband notching by loading SRRs on the CPW-fed monopole antenna[10-12].

This paper describes a novel and effective method to design a frequency notched UWB antenna by loading single circular ring multiple SRRs on the back side of a CPW fed printed circular monopole antenna on a low cost FR4 Epoxy material. Unlike other previous methods here it uses single circular ring SRR for each notched frequencies instead of using pair of rings with splits in the opposite side. The single ring SRRs are placed symmetrically on the opposite surface of the printed planar monopole antenna along the signal line which results in a notch frequency. Resulting notch frequency changes in accordance with the dimensions of single ring SRRs. Propagation of electromagnetic (EM) signals, with their magnetic fields along the axes of the SRR's, interacts with the SRRs, and causes the SRRs to behave as magnetic dipoles. The propagating EM signal induces an electro-motive force on the SRR, which in turn induces oscillating current within the single ring SRR[13]. At a particular frequency which corresponds to the dimensions of SRR yields a resonance and prohibits signal propagation at this resonance frequency. When the excitation is given the propagating signal is rejected and reflected back, which yields a weak radiation at the desired notch frequencies. Multiple notches can be achieved by loading multiple SRR with different geometrical dimensions.

In this letter simulated results are describe as four sections such as antenna with 3.5GHz WiMAX notch, antenna with 5.5GHz WLAN notch, antenna with 7.9GHz X band for satellite communication notch and by combining these three in a single printed circular monopole antenna yields triple frequency notch. Here we proposed frequency notching technique using single ring SRR, which yields a quasi-static resonance that is the notching at a single frequency[13]. In most of the previous methods described earlier, where most of the changes and inclusions are on the ground plane or radiator. The novelty of our design is that the antenna designed on a low cost FR4 Epoxy material and also here it uses single circular ring SRR for each frequency notching, which avoids the complexity of the system.

2. Antenna design

Schematic of the proposed antenna with triple frequency notch is shown in Fig.1. The proposed antenna is fabricated on FR4 Epoxy material having relative permittivity, $\varepsilon_r=4.4$, thickness $h=1.6mm$ and $tan\delta=0.02$. The circular uwb monopole having radius R is fed by a CPW consisting of ground planes having widths W_1 and W_2, length L_s and a signal line having length L_s+t and width S. The slots between the signal line and ground planes have width Sg. Antenna loaded with three circular shaped single ring split ring resonators, shown in Fig. 1(c), where r is the radius of the SRR, conductor width w and the split gap g. Circular shaped single ring SRRs of three different dimensions are printed on the opposite surface of a CPW separated by the substrate height h, as shown in Fig. 1(b). A single ring SRR is shown in Fig. 1(c) having dimensions r_i, which is radius of SRR, conductor thickness d_i, and split gaps w_i, where i=1,2,3 corresponding to the SRR 1,2,and 3 respectively. Table I shows the design parameters used for the prototypes. Single circular ring SRR's radius r_1, r_2 and r_3 corresponds to the notch frequencies 3.5GHz, 5.5GHz and 7.9GHz respectively.