American Journal of Electronics & Communication

Sovan Bhattacharya et. al., American Journal of Electronics & Communication, Vol. V (1), 58-61

A Javelin Shaped UWB Antenna with Notch Band for Remote Sensing Applications

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***Abstract*— In present manuscript we propose a triangular printed antenna functioning in the ultra-wide band (UWB) spectrum for remote sensing applications. The proposed javelin type patch antenna design resonates between 2.83 GHz to beyond 10.6 GHz covering the ultra-wideband spectrum as per the standard. Throughout the resonating wide band; the minimum reflection coefficient level obtained is -36.2 dB at 5.17 GHz which is ISM band. The highest gain is obtained at 5.17GHz. Our proposed design antenna has also good radiation characteristics both at azimuthal plane and elevation plane. The designs are investigated using CST 2019 simulator. Circular split rings are loaded on the patch to realize notch band at 2.4 GHz. The UWB antenna with notch is suitable to implement in Surface Penetrating Radar for sensing hazardous and explosive objects beneath the ground.**

Keywords*— *UWB, notch, javelin shaped, remote sensing, ground penetrating radar

I. Introduction

In the era of recently used technologies, with the progression in the wireless communication industry, the call for condensed, wideband, broadside and cost effective antennas with adequate gain has augmented largely as antennas are one of the fundamental parts in RF communication system [1]. Microstrip printed antenna with co-planar waveguide (CPW) feeding are often utilized in order to meet these needs instead of utilizing separate antennas for distinct bands of operation [1-3]. It is therefore always a vital and critical work for the engineers to develop antenna operating at various resonating frequencies and wideband response. The corner cuts and slots in the ground together are responsible for multiband operation having better bandwidth. Several printed antennas operating over UWB band (covering the 3.1-10.6 GHz band as defined by FCC) have been developed by researchers till date [4-9]. S. Ahmad et al. presented a jug-shaped planar antenna exhibiting monopole like radiation with CPW feeding working in the UWB band 3-11 GHz [7]. The FR4 based antenna with the dimension of 25 mm × 22 mm acquires 2-4 dBi average gain and efficiency of 85% throughout the entire band. It was also shown that the antenna offers broadside radiation pattern. A LC equivalent circuit model was developed and the circuit simulation was compared to the EM simulation result. Researchers in many UWB antenna designs introduced notch frequencies in the UWB spectrum at frequencies that are used in Wi-Fi, Bluetooth, ISM applications etc. in order to avoid the interference [10-14]. O. P. Kumar et al. introduced a UWB antenna over 2.5-11 GHz with elliptical shaped patch and introduced two notch frequencies in the 5.2-5.7 GHz for WLAN application and in 7.2-8.5 GHz for ITU application [12]. A stable gain of 4.9 dB was maintained over the band. The UWB antennas with monopole like radiation designed on substrate with or without notches in the band are being popularly implemented in the remote sensing applications to detect explosive objects underneath the ground by the researchers [15-18]

The primary intend of the present manuscript is to propose an ultra wide band (UWB) printed antenna using CPW feed designed on FR4 material and later on to set off notch frequency in the UWB band to pass up intrusion with the other wireless applications here in the ISM band. The presented UWB radiator is developed by javelin shaped patch. Notch creation is accomplished on the wide frequency band at 2.4 GHz for avoiding interference with the ISM band is also incorporated.

II. Antenna Design and Analysis

A javelin shaped patch is used initially to build the presented UWB antenna. The radiator is premeditated in the EM simulator Microwave CST Studio 2019. The antenna has been designed above the FR4 substrate of the dimension 50 mm×50 mm ($\epsilon r = 4.4$, $\tan\delta = 0.02$). The antenna patch with javelin shape consists of two simple triangular patches merged together with the two corners rounded up using circular shape and both the circles are of same radius of 2 mm. CPW feeding is used in this antenna. The microstrip line width is evaluated using conventional method to acquire proper impedance matching. We are using the feeding line with Width is 3mm and height is 16mm. The ground affects the radiation from of an antenna and also the impedance matching leading to control of -10 dB band. The choice of "L_g" and "W_g" with adequate patch radius of 10.2 mm is accomplised. The S parameter for three different presented antenna with same Length (L_g) i .e. 23.75 mm and width (W_g) i.e. 12.6 mm in both side of the strip line used to feed the patch. The distance of the ground to the strip line used to feed (W_f) is 0.30mm. The alteration in a frequency of resonance is due to the width are not noteworthy with respect to the length of ground. In antenna 2, ground plane resizing by 9mm circular patch (RgC1 & RgC2) from antenna 1 (Fig 1). After that in antenna 2 (Fig 2), 13.2mm triangular patches cut is added and within this 13.2mm triangular cut, 6mm circular patch is also added. Therefore in the 6mm circular patch we are adding two different circular cut patches i.e. 2mm and 3mm to produce antenna 3 (shown in Fig 3). Our proposed three different antennas with the schematic, dimensions are provided in the Fig. 1, Fig. 2 and Fig. 3. The detailed dimensions in mm are included in the Table 1, Table 2 and Table 3 for the three antennas respectively.

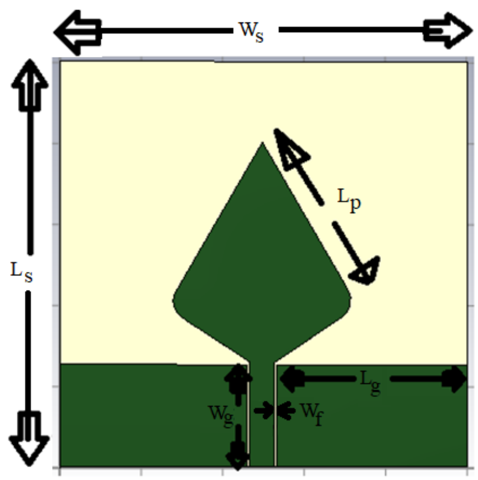

Fig. 1 Schematic of the Antenna 1 with dimensions

Parameter	L_S	W_S	R_{1P}	R_{2P}	L_F
Values	50	50	2	2	16
Parameter	W_F	L_g	W_g	W_f	L_P
Values	3	23.75	12.6	0.3	13.5

Table 1 Parameters of the proposed Antenna 1

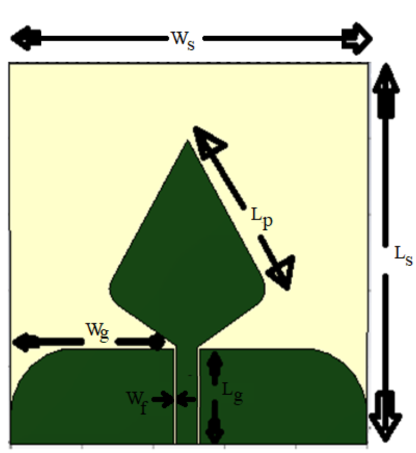

Fig. 2 Schematic of the Antenna 2 with dimensions

Parameter	L_S	W_S	R_{1PC}	R_{2PC}	L_F
Values	50	50	2	2	16
Parameter	W_F	L_g	W_g	$R_{gC1}=R_{gC2}$	L_P
Values	3	23.75	12.6	9	13.5

Table 2 Dimensions of the proposed Antenna 2

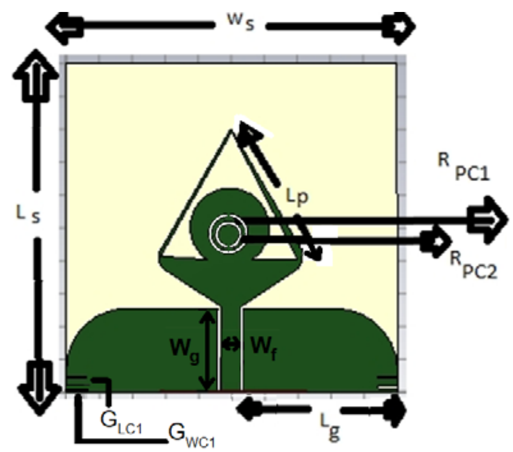

Fig. 3 Schematic of the Antenna 3 with dimensions

Parameter	L_S	W_S	R_{PC1}	R_{PC2}	G_{WC1}
Values	50	50	3	2	3
Parameter	W_f	L_g	W_g	G_{LC1}	L_P
Values	3	23.75	12.6	0.3	13.5

Table 3 Dimensions of the proposed Antenna 3

III. Results and Discussion

The three designs of the proposed antenna are investigated and the antenna parameters i.e. reflection coefficient, radiation pattern and gain are investigated by CST EM simulator. The patch size is verified in order to shift the operating band towards lower frequencies.

The frequency range that an antenna can effectively transmit and receive power is known as its bandwidth. As observed from Fig. 4, the javelin patch antenna contains multiband (3.99GHz to 8.18GHz) with notch and the resonance frequencies are 2.78GHz, 6.04 GHz and 11.69 GHz. The reflection coefficient of the antenna 1 is depicted in Fig. 4. The antenna 1 exhibits -10dB bandwidth at 4.82 GHz with the lower resonating frequency is 6.04 GHz. Antenna 1 exhibits a percentage of bandwidth is 79%. The E plane radiation pattern is depicted in the Fig. 5.

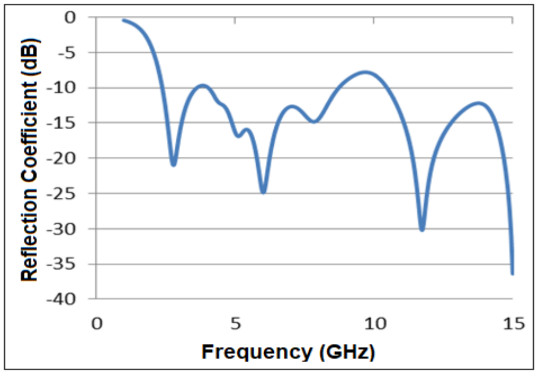

Fig. 4 Simulated reflection coefficient for antenna 1

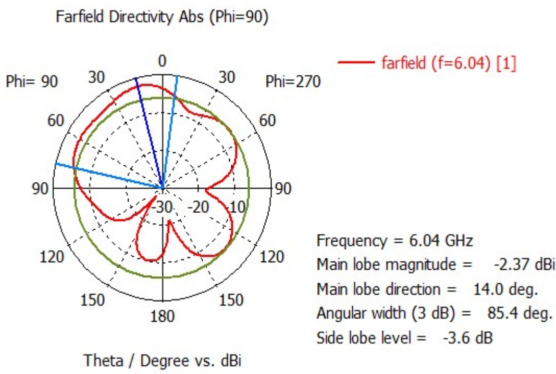

Fig. 5 E-field radiation pattern of antenna 1.

All resonance frequencies exhibit a uniform radiation plots in y-z plane and the both sided radiation pattern at the x-y plane. The S11 of the Antenna 2 is depicted in Fig. 6. Another triangular patch added below the primary javelin type patch. Antenna 2 exhibits -10dB bandwidth from 4.02 GHz to 5.85 GHz as shown in the Fig. 6. In antenna 2 we are observed that multiple resonances present through the entire band and the lower resonating frequency shown at 7.07 GHz. Antenna 2 percentage of bandwidth is 25%.

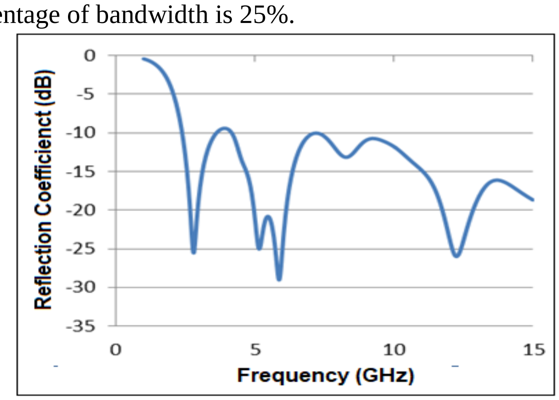

Fig. 6 Simulated reflection coefficient for antenna 2

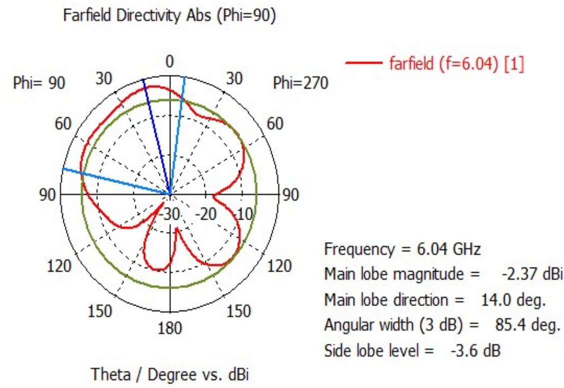

Fig. 7 E-field radiation pattern of antenna 2

The S11 of the antenna 3 is depicted in Fig. 8. It exhibits -10dB bandwidth from 2.83 GHz to 8.78 GHz and also clearly shown that bandwidth is better than the antenna 1 and 2. The E plane radiation pattern is shown in the Fig. 9. Maximum radiation is shown an angle slightly different from broadside direction. However the radiation patterns are uniform at various frequencies.

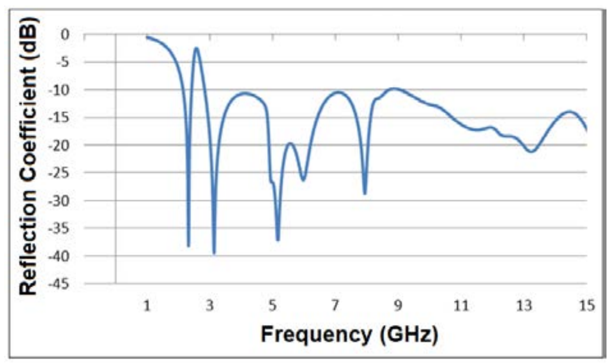

Fig. 8 Simulated reflection coefficient for antenna 3

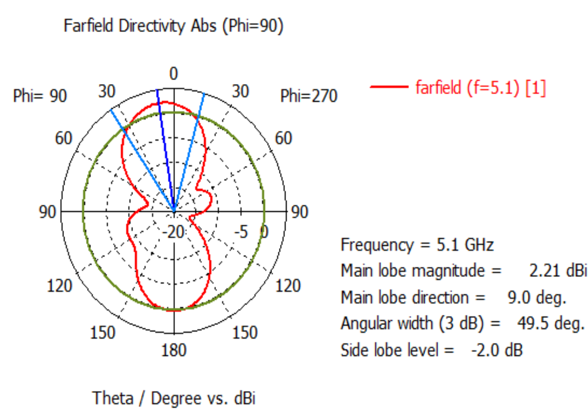

Fig. 9 E-field radiation pattern of antenna 3

IV. Remote Sensing Application

The proposed UWB antenna can be implimented in Surface Penetrating Radar with purpose of detecting objects underneath the ground. For this purpose two similar UWB antennas are placed at a definite distance on the GPR above the test bed that is representing the ground. The antennas are kept at the far field at resonance. The object is buried in the ground to be detected. The two antennas work as transmitter and receiver (Tx and Rx) respectively. The signal transmitted by the Tx gets reflected by the object if any and the is received by Rx. The transmission coefficient (S21) of this antenna system can be analyzed with and without the object. By comparing the S21 for both the cases the presence of an object can be detected. The use of UWB antenna in this case increases the resolution of the detection because of the wideband response of the antenna. Moreover adequate gain over the entire band ensures large penetration depth of the signal.

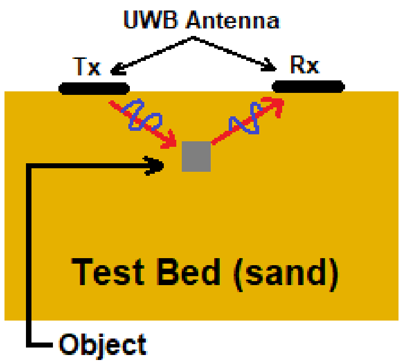

Fig. 10 Proposed antennas for sensing object buried

V. Conclusion

Three Ultra wide band antennas with the modified CPW triangular patch are proposed. The outcomes demonstrate that the presented antenna gives a constant gain, a bandwidth with impedance matched to input ($|S11| \leq -10$ dB) over the entire band in the 3.1-10.6 GHz spectrum of UWB. Proposed three antennas also exhibit Omni-directional radiation pattern through the whole range with the exception of at the notch frequency near 2.4 GHz. The notch minimizes the interference with nearby systems. The notched UWB antenna can be implemented in surface penetrating radar system for sensing objects buried beneath the ground.

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