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A Design Approach of GSM, Bluetooth and Dual band Notched UWB Antenna

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Abstract

In this paper, printed GSM Bluetooth dual band notch UWB antenna is presented. In this prototype corner cut patch for Bluetooth application and dual band notch characteristics of UWB antenna perform by inverting U-Slot in the radiation patch of antenna. With the enclosing of λ/4 stub in the patch of antenna for GSM (1.710-1.885 GHz) band operation. Simulation results show that the antenna yields an impedance bandwidth of 2.4-2.48 and 3-11 GHz with -10 dB reflection coefficients, except for the dual notched bands of 3.3-3.7 for Wi-MAX and 5.15-5.825 GHz for WLAN. The electrical characteristics in frequency domain show suitability of this antenna for use in UWB systems.

Index Terms: GSM, Bluetooth, UWB, Dual band Notch.

1. Introduction

Due to allocating unlicensed band from 3.1 to 10.6 GHz by the Federal Communications Commission (FCC) for industrial and academic communities, ultra wideband (UWB) communication systems have get massive attention because of possessing significant advantages, such as high-speed data rate, high-precision ranging, , low complexity, low power consumption, simple hardware configuration and low cost [1]. Though, to design UWB antennas, there are some challenges including high radiation efficiency, the ultra-wideband performance in cost of the antenna size, constant gain etc. Antenna designs for UWB applications are facing many challenges including their impedance matching, electromagnetic interference (EMI) problems, radiation stability and especially the compact size design.

In the designated UWB operating band, several narrowband wireless standards have been allocated to share some parts of this spectrum. These include Worldwide Interoperability for Microwave Access (WiMAX) Service (3.3–3.7 GHz) and Wireless Local Area Network (WLAN) services IEEE802.11a (5.15–5.35 GHz and 5.725–5.825 GHz) [2], which might potentially interfere with the UWB systems. Hence, it is desirable for

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UWB antennas to perform the band-notched function to diminish the unwanted interferences from these coexisting wireless systems and remove the requirement of an additional band-stop filter. Among previously

Design of antenna there would be inserting several type of slot in the radiation patch or in the ground. A possible way to solve this problem is to design UWB antennas with band-notched characteristics Various techniques have already been proposed, such as using the embedded resonant cells [3], parasitic elements [4] and embedding U-shaped, L-shaped, V-shaped slots, or simple slits in planar antennas to introduce a frequency notch [5-7]. In [8] the dielectric resonator antenna (DRA) is proposed for UWB with U- strip and T-shaped slot in back plane embedded for the Dual band notch characteristics. Nowadays, GSM system has found wide application in mobile and portable wireless communications due to its great network capability and good stability [9].Various design of a novel approach to design an antenna for a transponder in radio frequency identification (RFID) is proposed. [13]

In this work, a novel compact micros trip-fed monopole antenna Design with GSM, Bluetooth and UWB applications is presented. By truncating radiation patch corner with circle, the Bluetooth and UWB are obtained. The rejection of WIMAX (3.3-3.7GHz) and WLAN (5.15-5.825GHz) is performed by the adding inverting U-shaped slot in the centre of the patch. The length of each slot has been taken about half of the guided wavelength at their respective notched band frequency. The position of each notched band can be controlled individually according to requirements of the system by changing the dimension or position of their respective slot.

2. Antenna Design and Discussion

2.1. Structure of the Antenna

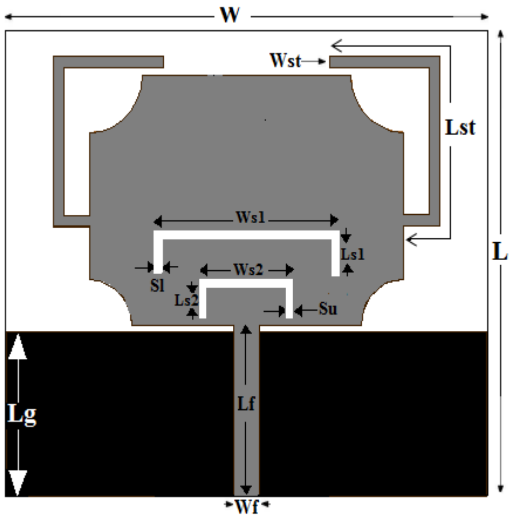


Fig.1. Geometry of Proposed Antenna

Fig. 1 shows the geometry of the proposed antenna. This antenna is built on a FR-4 substrate with a relative permittivity of $\varepsilon_r = 4{:}4$ and a loss tangent of 0.02. The transverse dimension of this antenna is $48 \times 46mm^2$. In designing, the patch antenna is used to cover the UWB range, which is the highest frequency band of the multi-band antenna. Initially Bluetooth (2.4-2.48 GHz) and UWB (3.1-10.6 GHz) antenna is obtained by partial grounding technique (DGS) and a Dual notched band characteristic is performed on the UWB antenna without disturbing the Bluetooth and UWB antenna. After that for GSM band (1.710-1.885 GHz), the Quarter wavelength stub of centre frequency 1.797 GHz is added to both side of the radiation patch of the antenna.

Several aspects were considered to optimize the Final design like the overall impedance bandwidth of the antenna, the bandwidth of the notched bands, and the level of band rejection at notched frequency [10].

Table 1. Parameters of the Proposed Antenna.

Parameter	W	L	Wp	Lp	Ws1	Ws2	Ls1	Ls2	Sl	Su	Lst	Wst	Lg
Values/mm	46	48	22	30.1	17.8	8.4	3.75	3.75	0.4	0.4	28.95	1	13.5

2.2. Antenna Performance

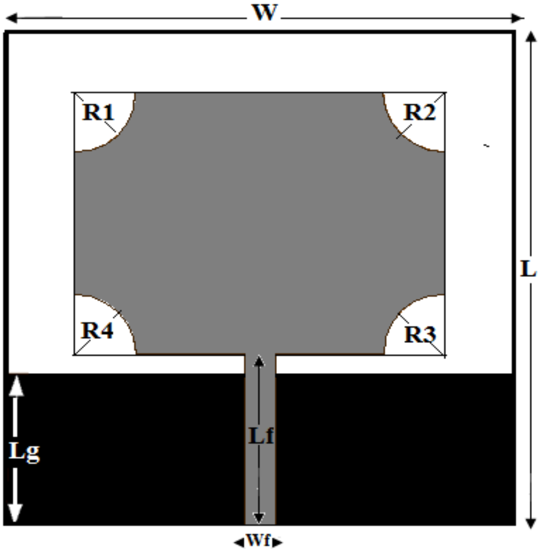


Fig.2. Shows Geometry of Bluetooth UWB antenna

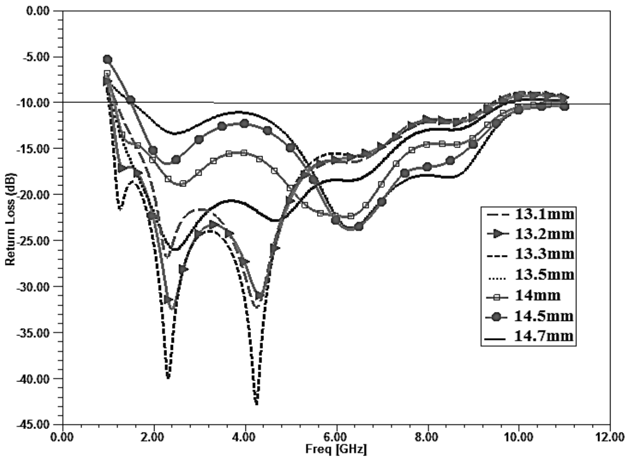


Fig.3. Show Parametric study of Ground (Lpg)

An important feature of the proposed antenna is the capability of impedance matching of 1.5-10.6 GHz, except two frequency stop-bands by using the two slots which are presented. Fig. 2 shows the Bluetooth UWB antenna with the corner cut of R1=R2=5mm & R3=R4=4mm. For impedance matching, effect of ground plane is more important.

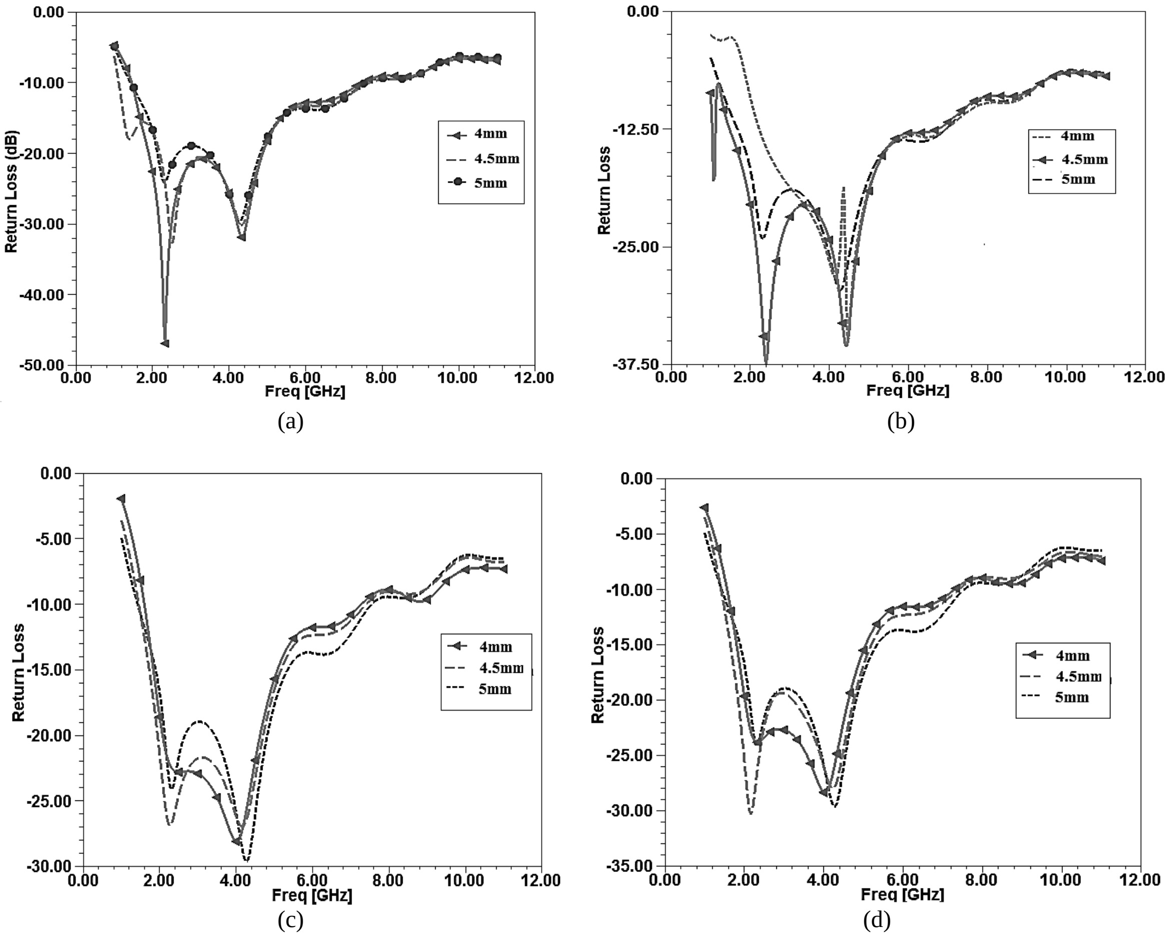


Fig.4. (a) Shows parametric Study of R1 (b) Shows parametric Study of R2 (c) Shows parametric Study of R3 (d) shows parametric Study of R4

As length of ground is increasing there is increasing the isolation but it will cause the Frequency resonance of antenna, while it should be constant at certain value shown in fig 3. For the Bluetooth operation of proposed antenna cut the corner of radius R1, R2, R3 & R4. Parametric comparison of radii shown in fig 4. All the corner cut radiuses of antenna sustain their noble value for better impedance performance.

2.3. Dual band Notched

For dual band notch operation, inverted U-shaped slot has been cut on the patch of the antenna. Geometric parameters of the radiating patch and the ground plane affect characteristics of the impedance match. Due to the increasing demand for wireless connectivity, a single antenna to cover several allocates wireless frequency bands.

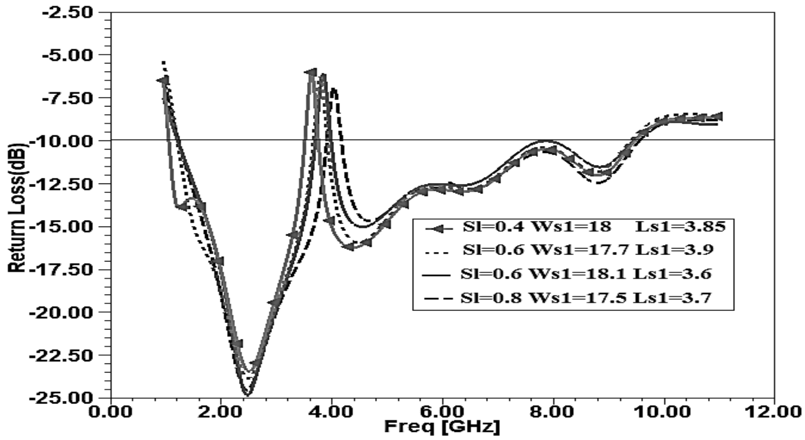


Fig.5. Shows Return Loss of Proposed Antenna with Slot of Centre Frequency 3.5GHz.

Due to interference of the dual band WIMAX (3.3-3.7 GHz) and WLAN (5.15-5.825GHz) is notched in the UWB. The length of slot is half of wavelength at centre frequency of the 3.3 -3.7 GHz. The gap between the radiating patch and the ground plane affects impedance bandwidth because it acts as a matching network.

The length of the U-shaped slot can be calculated by,

$$li = \frac{c}{2f_i\sqrt{\frac{\varepsilon_r+1}{2}}} \tag{1}$$

The length of lower and upper slot is L_{lower}= 26.1mm L_{upper} =19.6mm for WIMAX and WLAN respectively. The U- shaped slot shown in fig 1 which is performing band notch function for WIMAX and WLAN. The effect of the width of Lower slot and upper slot shown in fig.6 & fig.7 correspondingly. In addition, at the desired frequency, only are the corresponding slots active while the others are inactive, approving the independence of the frequency bands. The natural elucidation is that the slots are not the major contributor of antenna performance [5]. The current distribution of the particular rejected band in proposed dual band notched antenna shown in fig.8.

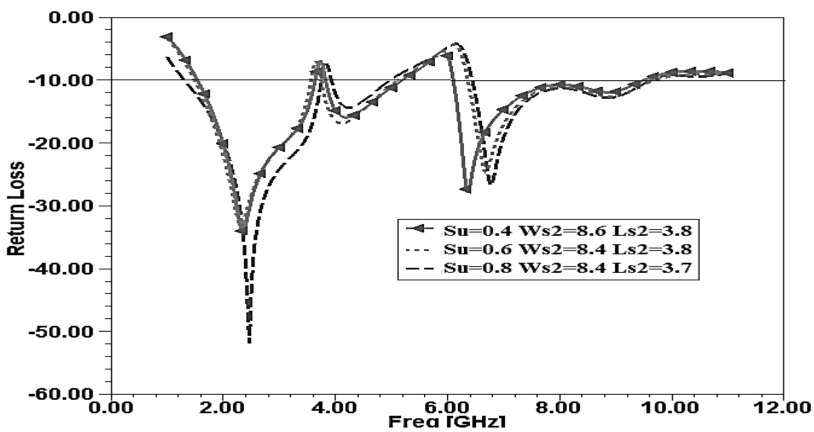


Fig.6. Shows Return Loss of Proposed Antenna with Slot of Centre Frequency 3.5 & 5.5 GHz.

Finally, half of wavelength stub of centre frequency 1.797 GHz for GSM band to boost the particular frequency band. The stub dimensions are given in table no.1. In proposed band notch antenna the performance of the GSM operation of by optimising the length of stub shown in fig.1. The Simulated return loss of the proposed antenna shown in fig.7.

Fig. 8(a) and (b) shows the surface current concentrates along the 3.5 GHz and 5.5 GHz slot which acts as a capacitance of slot. If width of slot varies then the contrast in shunt capacitance of slot line occurs. The surface current along the slot differ with respect to slot width changes and bandwidth performance of proposed antenna is quiet change. The simulated surface current distribution on radiation patch has been stirred along the stub of the 1.797 GHz which is shown in fig. 8(c).

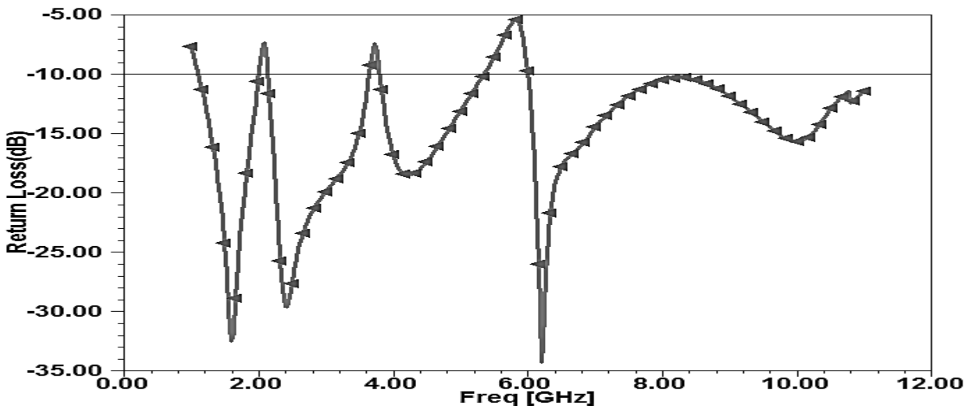
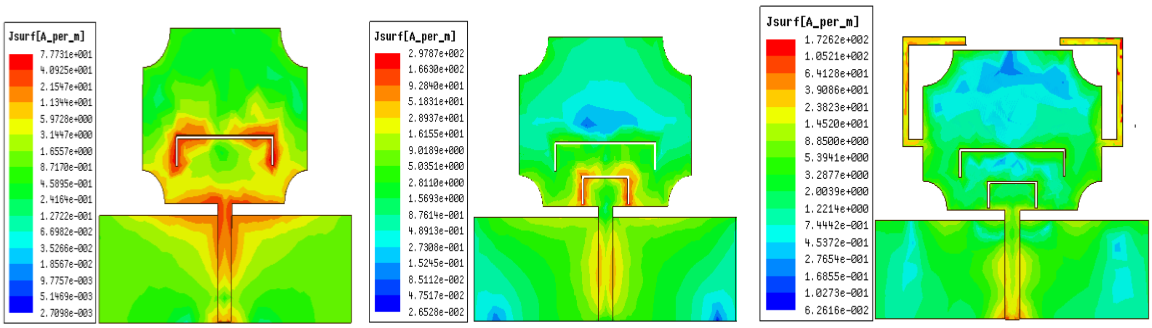


Fig.7. Shows the Simulated Return Loss of Proposed Antenna



(a) (b) (c)

Fig.8. Surface Current Distribution on Antenna (a) with lower slot of 3.5 GHz (b) With Upper slot of 5.5 GHz (c) With the Stub of 1.7 GHz

3. Results and Discussion

In Fig. 9, it is can be seen that the proposed antenna has an impedance bandwidth of 1.5 GHz to 10.6 GHz for $S11 \leq 10$ dB, except two frequency stop-bands of 3.3-3.7 GHz for Wi-MAX and 5.2-5.825 GHz for WLAN. The proposed GSM integrated, Bluetooth, dual band notched UWB antenna is simulated and shown in fig. Omnidirectional characteristics and radiation bandwidth can be improved if the ground plane length is approximately the same size as that of the radiating structure width [11] and by using a thin substrate or a substrate with low dielectric constant [12]. The proposed antenna has nearly omnidirectional radiation characteristic in the *H* plane and a fig. of eight radiation pattern in the *E* plane over the desired band. The proposed antenna provides more than 85% radiation efficiency except at the notched frequency bands as shown in Fig. 13. The gain varies between 2 dB and 5 dB over the 1.5-10.6 GHz frequency range except in the 3.3-3.7 GHz and 5.2.-5.825 GHz notched frequency bands.

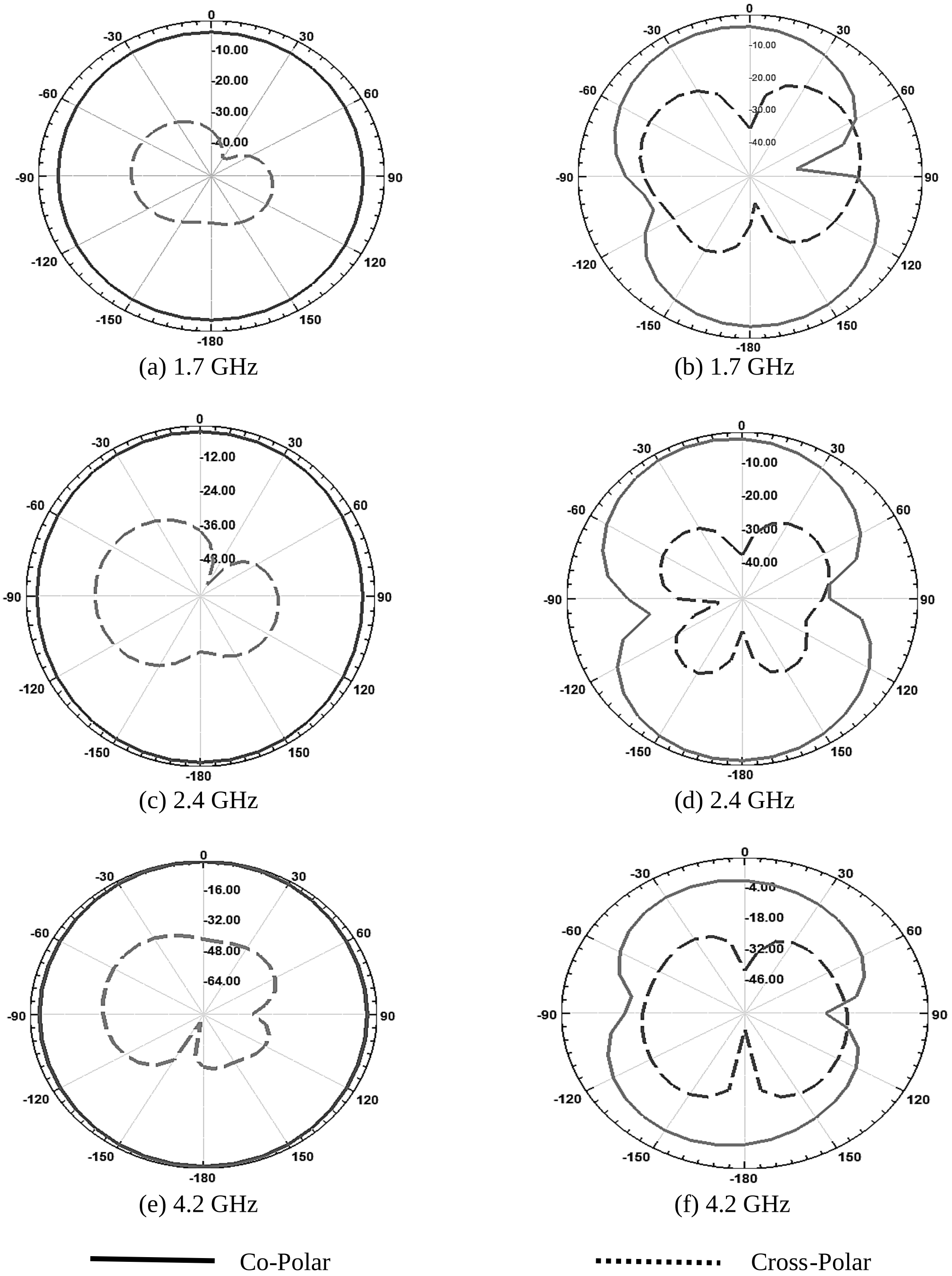


Fig.9. Simulated Radiation Pattern For proposed Antenna (a) (c) (e) H-plane and (b), (d), (f) E-plane

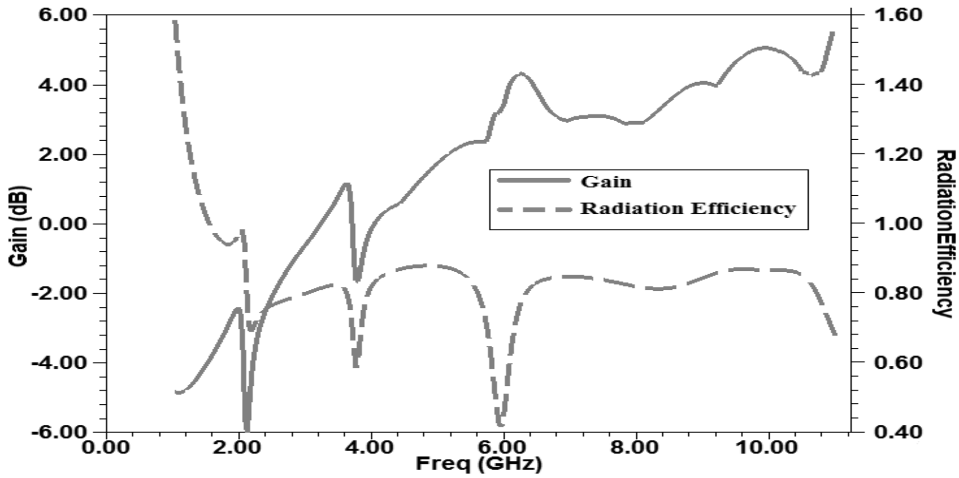


Fig.10. Simulated Gain and Radiation Efficiency of Proposed Antenna.

4. Conclusion

The characteristics novel approach of GSM, Bluetooth, UWB antenna with the rejection of the Wi-LAN and Wi-MAX is presented and verified with simulation result. By parametric study, to find the optimal dimension of the Stub and resonating structure of antenna. With amendment of inverted U-Shaped slot rejection in Wi-LAN and Wi-MAX is obtained.

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