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A Symmetrical Dual Slot and Single Slit Partial Ground Wi-MAX Notched Band Monopole Microstrip Antenna for Wireless Communication Applications

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Abstract: In this paper design of a symmetrical dual slot and single slit partial ground WiMAX notched band monoploe microstrip antenna for wireless communication applications is proposed. The overall dimensions of proposed antenna are 23.3×24×21.3 mm^3 fabricated on 50×40 mm^2 modify epoxy substrate material. The return loss S_{11}<-10 over 1.67 - 8.39 GHz except for the Wi-MAX notched band 3.0 - 4.5 GHz. The dual symmetrical slots at a gap of 10mm from the centre of the single slit is introduced the desired notched band characteristics. The simulation is carried out using Ansoft HFSS Software. The measured and simulation results of the proposed antenna are good in agreement. The antenna exhibits the nearly omnidirectional radiation pattern and desirable gain.

Key words: Symmetrical, Dual slots, Single Slit, Partial ground, Monople, WiMAX, Notched Band.

I. Introduction

The advanced features of wireless communication technology gains attentions since form long time because of large bandwidth spectrum allocation declared by the federal communication commission (FCC) for unlicensed radio frequency band 3.1-10.6 GHz for commercial use [1]. UWB technology gain more attention in indoor and outdoor applications because of low cost, high data rates and average radiated power is most suitable for wireless social networks, internet of things, car communications, home and office networking, wireless grids and personal communications and significantly depends on short wave range technology. UWB systems have disadvantage that they are very sensitive to electromagnetic interferences with existing narrowband wireless communication systems. The solution to avoid the interference with coexisting bands is to design a broadband antenna with band notch characteristics. There are many techniques proposed in the literature to achieve band notch characteristics for broadband antennas such as type of slots on the radiating patch or on the ground plane, split-ring resonators, tuning stubs, meandering, folded strips, EBG structure etching on patch/ground plane, etching of U slot, V- shaped slot, C-shaped slot, S- shaped slot in feed line, a quasi complementary split ring resonator (CSRR) in fed line, a quarter- wavelength tuning stub in a large slot on the patch, or compact folded stepped impedance resonators (SIRs) or capacitively loaded loop (CCL) resonators in fed, a parasitic slit along with tuning stub used, C shaped slot on patch and L shaped stub on ground, semi-circular slot on patch[2-23]. In this paper a symmetrical dual slot and single slit partial ground Wi-MAX notched band monopole microstrip antenna for wireless communication applications is presented. The impedance bandwidth of proposed antenna is from the frequency range of 1.1 to 8.39 GHz with the magnitude of return loss less than -10 dB except at the notched band from 3.0-4.5 GHz which covers the coexisting narrow Wi-MAX band. The proposed antenna can also be used for filtering C band (3.8-4.2 GHz). The antenna is simple in design and fabricated on low cost modify epoxy substrate of ϵ_r of 4.2, tangential loss (tanδ of 0.02) and thickness (h) of 1.6 mm with dimension 50X40 mm^2.

II. Antenna Design and Geometry

The proposed symmetrical dual slot and single slit partial ground Wi-MAX notched band monoploe microstrip antenna (SDSSSPGWiMAXNBMMSA) designed geometry with dimensional parameters are shown in Fig.1. The overall size of the antenna including bottom ground plane is 24×23.3×21.3 mm^3, which is printed on commercially available modify epoxy dielectric substrate with a relative permittivity ϵ_r of 4.2, tangential loss (tanδ of 0.02) and thickness (h) of 1.6 mm with dimension 50X40 mm^2 the length Ls and width Ws of the substrate fed by a simple 50Ω microstripline feed line of length L_f=23.3mm and width W_f=3.2mm. The top layer consists of rectangular patch of length L and width W of dimensions LXW=24X31 mm^2 with symmetrical dual notch n1 and n2 of dimensions 4×5.5 mm^2. The ground plane bottom layer is modified by placing two identical slots at a gap 'd' of 10 mm from the center of the feed line and deep slit notch cut at the center below the microstripline feed line of dimension N_W and N_l the length and the width of 5mm and 10mm to achieve the desired notched band characteristics. The gap between the radiating DNMRMSA patch and the ground plane is g=2 mm which is selected for better impedance matching and bandwidth enhancement. The prototype of the antenna is fabricated and experimentally analyzed with a Rohde & Schwarz (ZVK model 1127.8651) vector network analyzer. The photograph of the fabricated SDSSSPGWiMAXNBMMSA with SMA connector at the tip of the microstripline feed is as shown in Fig.2.

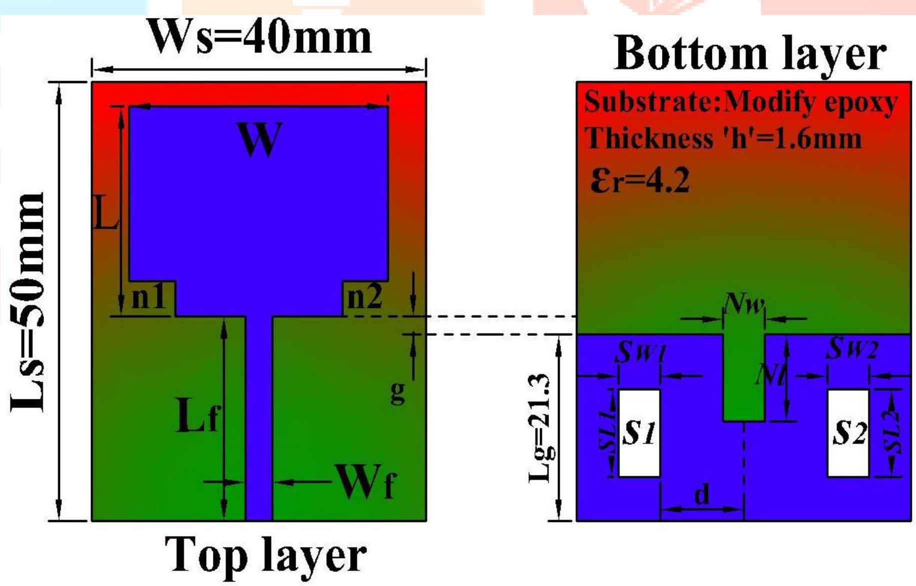


Fig.1 Top and bottom configuration of SDSSSPGWiMAXNBMMSA

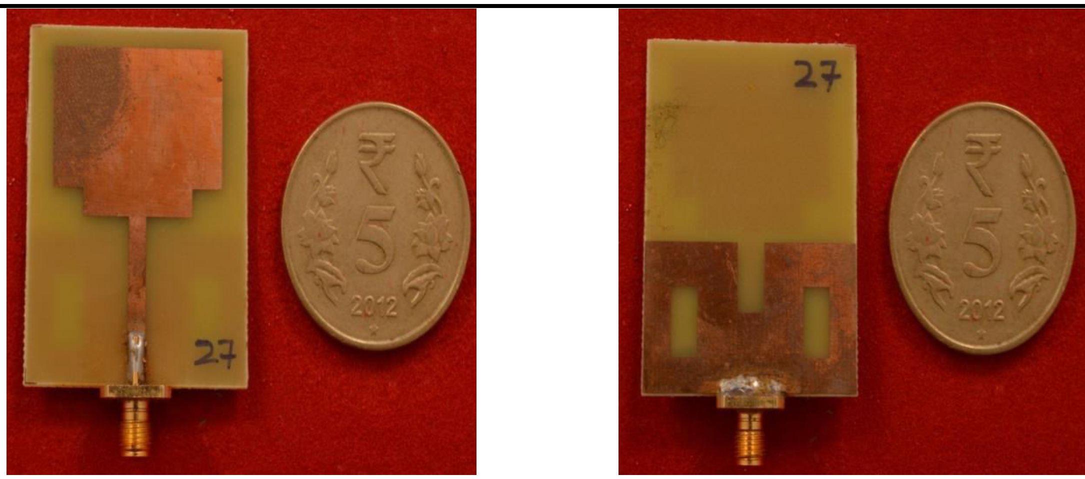


Fig. 2 Photographs of the top and bottom view of fabricated SDSSSPGWiMAXNBMMSA

III. Results and Discussions

For validating the simulation results of SDSSSPGWiMAXNBMMSA carried out using Ansoft 3-D full-wave electromagnetic high frequency structural simulator (HFSS) is fabricated which is shown in Fig. 2 and experimentally analyzed using Rohde & Schwarz ZVK model 1127.8651 German make Vector Network Analyser (VNA). Figure 3 illustrates the variation of measured and simulated return loss versus frequency plot of the fabricated SDSSSPGWiMAXNBMMSA. From this figure, it can concluded that, the impedance bandwidth covers the frequency range from 1.1 to 8.39 GHz with the magnitude of return loss less than -10 dB except at the notch band from 3.0-4.5 GHz which covers the coexisting narrow Wi-MAX band. The simulation and experimental results are compared and they are in very good agreement with each other.

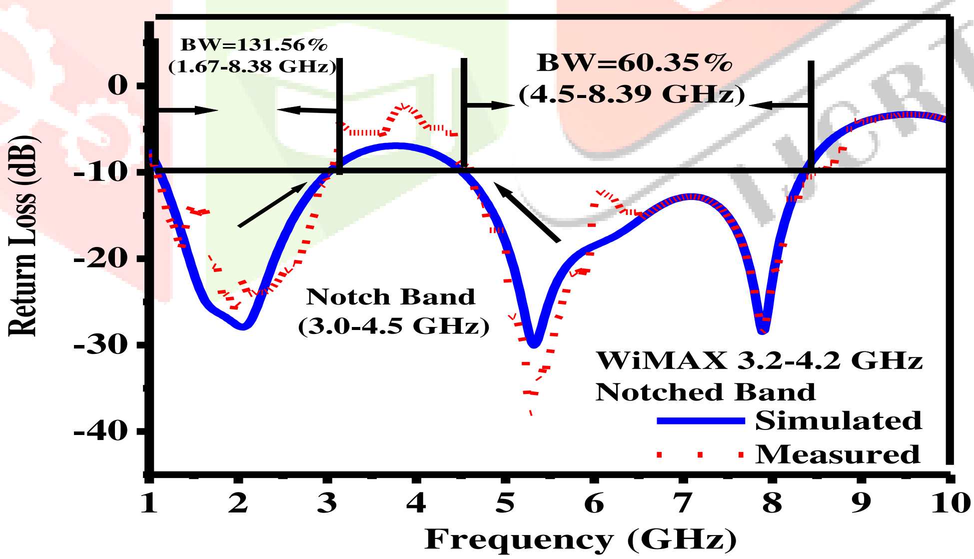
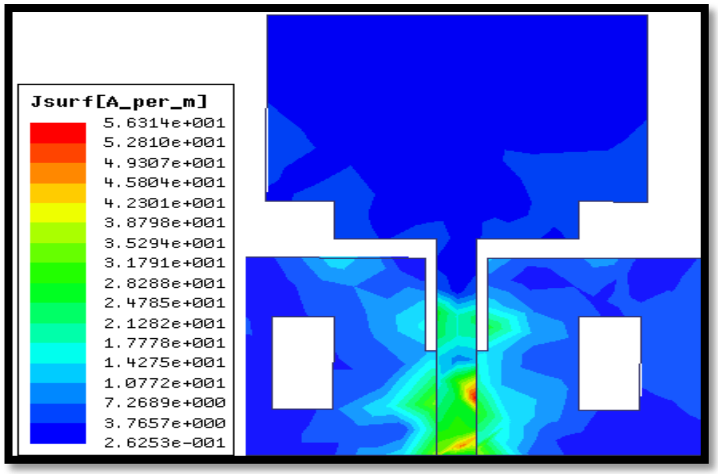
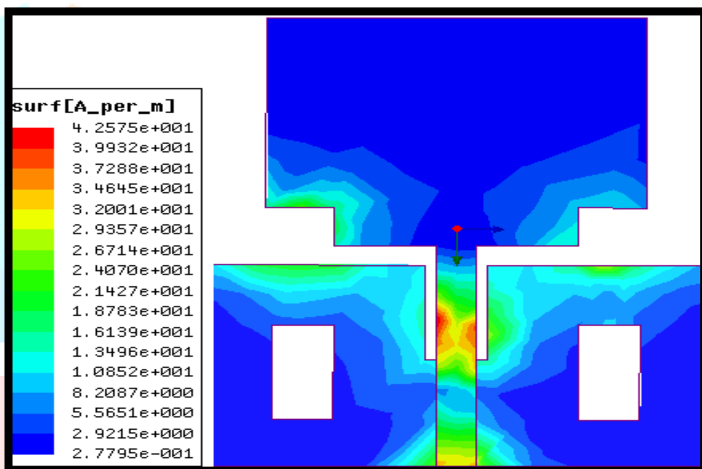


Fig. 3 Variation of measured and simulated return loss versus frequency plot of SDSSSPGWiMAXNBMMSA

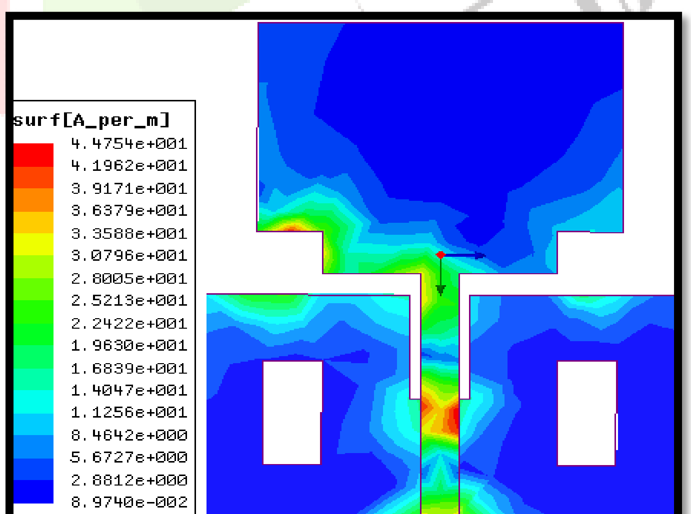
For better understanding the characteristics of the antenna the surface current distribution is studied and discussed. Figure 4 shows a simulated surface current distribution on the radiating element and the ground plane SDSSSPGWiMAXNBMMSA. It is evident that, the current density is mainly distributed on the edge of the monopole microstripline feed line which is evident of first resonant frequency in Fig 4(a). Figure 4(b) and (c) strongly support notch band characteristics because strong current is seen on the area of feed line parallel to deep slit notch cut. The SDSSSPGWiMAXNBMMSA is simulated with the aid of HFSS software and the results are analyzed.



(a)



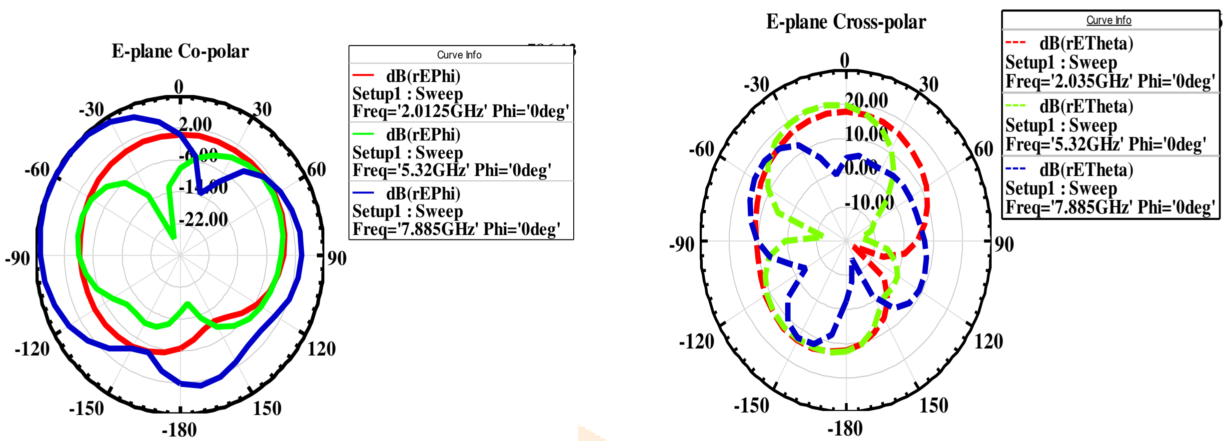
(b)



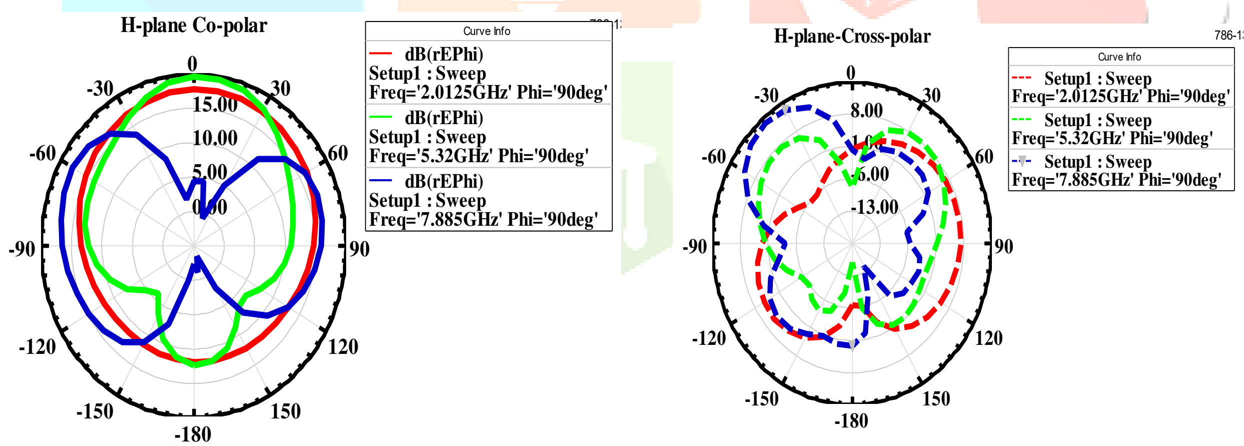
(c)

Fig. 4 Simulated surface current distribution of SDSSSPGWiMAXNBMMSA observed at (a) 2.03 GHz (b) 5.32 GHz and (c) 7.88 GHz

The typical far-field E- and H-plane co- and cross- polarization radiation pattern of SDSSSPGWiMAXNBMMSA are depicted in Fig. 5 (a) and (b) measured at the frequencies of 2.03, 5.32, and 7.88 GHz respectively. From the radiation pattern plots, it is clear that, the antenna gives nearly omni-directional pattern in X-Y (E-plane) plane and a slightly bidirectional pattern in Y-Z (H-plane) plane with cross-polarization at respective frequencies. The simulated peak gain is plotted from 1 to 10 GHz which is as shown in Fig.6. From this figure, it is observed that, the gain is suddenly drops in the vicinity of 3.75 GHz which validates the notch band characteristics of antenna and a stable gain of 2.3 - 4.2 dB is observed for the other resonating band of frequencies.



(a)



(b)

Fig. 5 Typical (a) far field E-plane co- and cross-polar radiation patterns (b) far field H-plane co and cross-polar radiation patterns of SDSSSPGWiMAXNBMMSA measured at 2.03 GHz, 5.35 GHz and 7.88 GHz

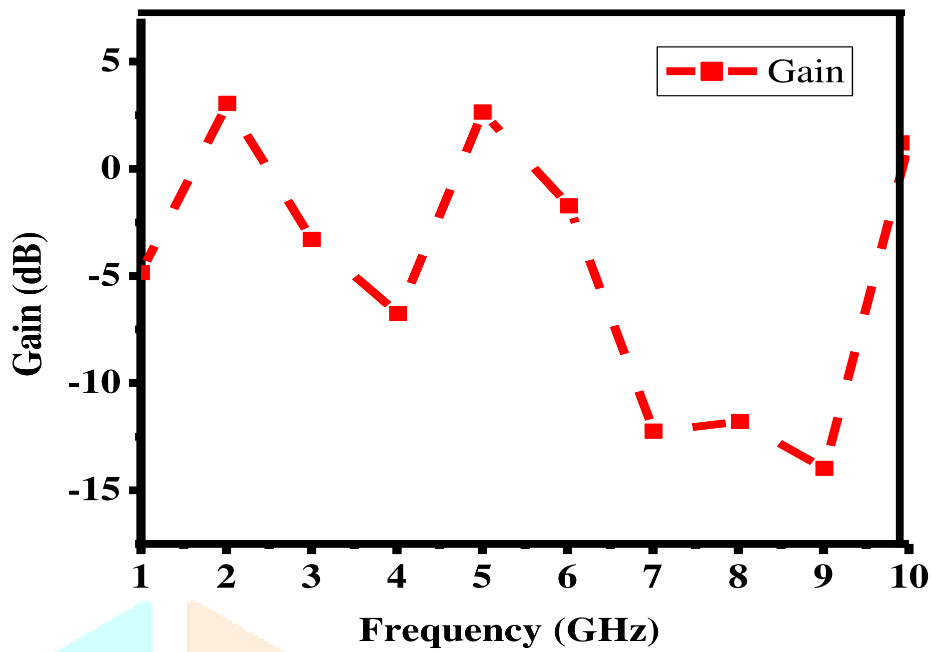


Fig. 6 Variation of gain versus frequency of SDSSSPGWiMAXNBMMSA

Figure 7 shows variation of simulated VSWR versus frequency curve of this antenna. From figure, it is clear that, the VSWR is <2 for over all resonating bands except at the WiMAX (3.2-4.2 GHz) notched band.

Figure 8 shows simulated real and imaginary impedances curves of this antenna. From this figure, it is clear that, the real value of impedance is high where the imaginary (reactance) value is less. In this study the proposed antenna is fed by 50 ohm monopole microstripline feed line. It is clearly observed in impedance plot curve in Fig.8 that, at the resonance frequencies VSWR<2 and impedance of around 50 ohm, is seen which is very well matching with 50 ohm microstripline feed line.

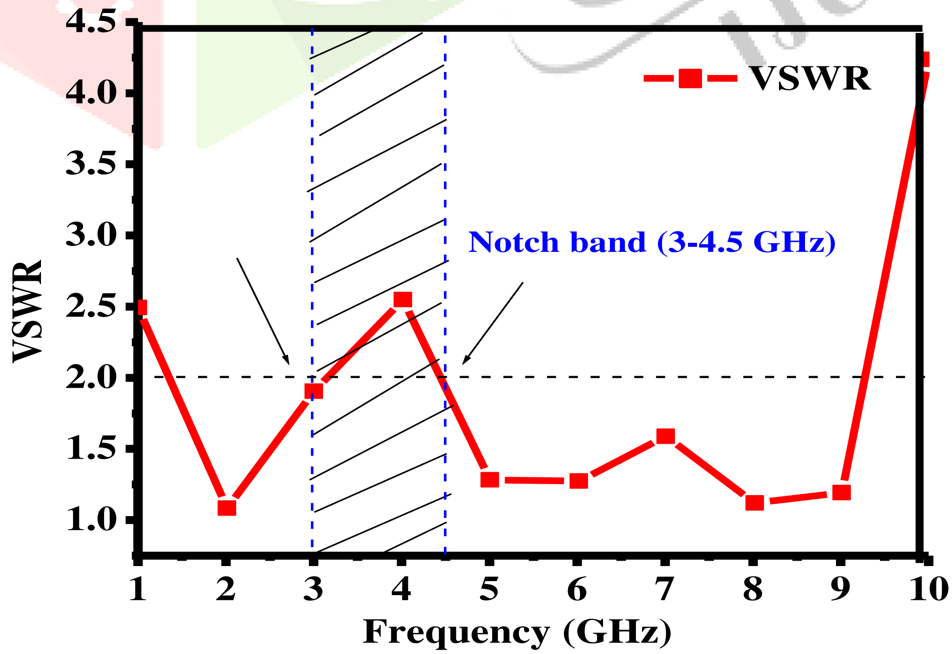


Fig. 7 Variation of VSWR versus frequency of SDSSSPGWiMAXNBMMSA

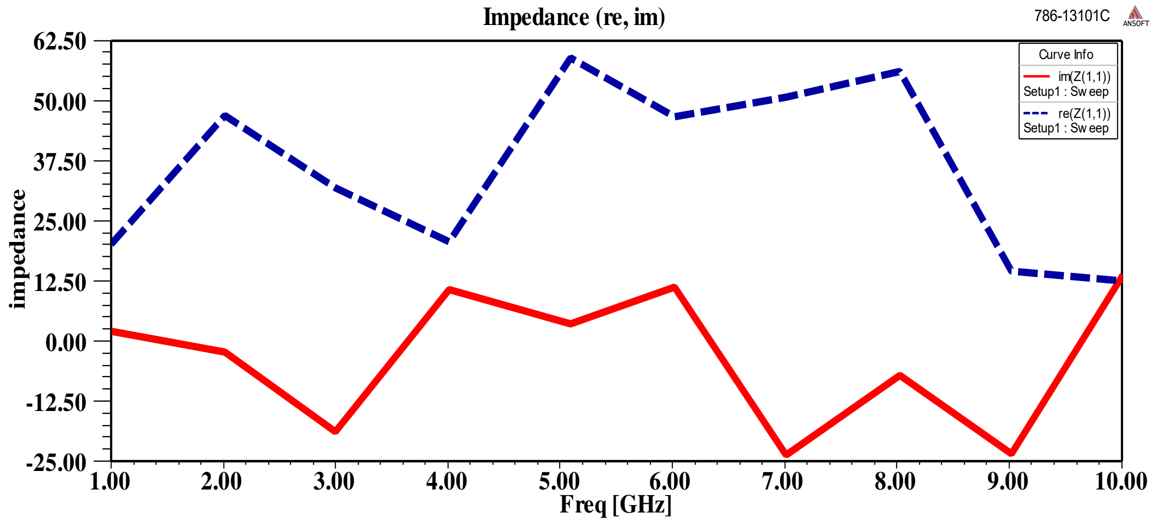


Fig. 8 Variation of impedance (re-im) versus frequency of SDSSSPGWiMAXNBMMSA

IV. Conclusion

A symmetrical dual slot and single slit partial ground Wi-MAX notched band monoploe microstrip antenna is presented in this paper The ground plane bottom layer is modified by placing two identical slots at a gap'd' of 10 mm from the center of the feed line and deep slit notch cut at the center below the microstripline feed line of dimension N_W and N_l the length and the width of 5mm and 10mm. Finally the notched band characteristics from 3.0-4.5 GHz which covers the coexisting narrow WiMAX band is achieved in the desired operating band of the impedance bandwidth covers the frequency range from 1.1 to 8.39 GHz with the magnitude of return loss less than -10 dB except at the notch band. The prototype of the antenna is fabricated and experimentally analyzed with a Rohde & Schwarz (ZVK model 1127.8651) vector network analyzer. The proposed antenna shows nearly omni directional radiation patterns with suitable gain throughout the operating band except the notched band frequency range. Measured and simulated results show good agreement. The proposed antenna is simple in design and inexpensive and good candidate for Wi-MAX notched band wireless communication applications.

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