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Triple-band Printed Monopole Antenna for Bluetooth (2.4GHz), WLAN(5.65GHz) and Satellite (8.3GHz) Applications

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Abstract—The printed monopole antenna having triple band is presented which operates at frequency 2.4 GHz (Bluetooth), 5.65GHz(WLAN) and 8.3GHz (Satellite and space). The antenna comprises of two rectangular patches of different sizes for the required triple-band operations. The proposed antenna is fed by corporate feed network which improves impedance bandwidth. The proposed antenna is printed on the double layer FR4 substrate because of planar structure which adds compactness to the antenna to be embedded in portable devices such as the tablets, Cell phones, laptop and various other portable devices. Good return loss and VSWR (less than 2) of the designed antenna is obtained by simulating on IE3D software.

Keywords—*Bluetooth, WLAN, multiband, impedance bandwidth.*

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I. Introduction

In this modern wireless communication world, the multiband antenna has been playing a vital role for all requirements of wireless services. The rapid improvements in wireless communication technology has bloomed the need for developments in antenna designs and there has been a growing interest in printed multiband monopole antenna. The design equations are presented in [1] for different shapes of printed monopole antennas for lower band-edge frequency with various feed positions. The development and design of multiband antenna with operational bands: UMTS , 2.4-GHz WLAN, WiMAX, 5-GHz WLAN, and ITS are described in [2] whereas an effect of variations in the feed gap, length and width of the patch, width of feed-line and the substrate along with dielectric constant of the substrate on PRMA is demonstrated in [3]. A study of simple circular-arc-shaped strips which produces three different frequency bands respectively has been shown in [4]. The 9-shaped folded antenna having dual band operation which exhibits broadened impedance matching, invariable omnidirectional radiation patterns with greater than 2.5dBi gain characteristics in the WLAN and RFID frequency bands is described in [5]. A simple strip monopole antenna especially used for the wireless universal serial bus (USB) dongle application has been demonstrated in [6] whereas by reducing ground plane size,the compact antenna offers a wide bandwidth which is used in WiMAX and WLAN Dongle applications is shown in [7]. A different technique of broad banding PRMA has been described briefly in [8].

The hardware design specifically of the antennas had a large evolution. The first mobile phone antennas were the simple monopole or spiral antennas, which can only operate at a single frequency band, located outside the shell of mobile devices. Nowadays the need for multiband antennas is increasing. In order to enable one mobile device to support these mobile wireless protocols, it is essential to have one multiband antenna. In particular, compact size and broad bandwidth is contradictory. Thus, how to reduce the size of an antenna without decreasing its bandwidth is of great interest when designing compact antennas. The multiband printed antenna can control multiple radiating portionsseparately each having different bands and are formed together on one substrate to emit the electromagnetic wave signals.

In this paper, the compactprinted antenna controlling triple bands operating at 2.4GHz, 5.65GHz& 8.3GHz which are commonly used for Bluetooth, WLAN and satellite applications is presented. The simulation is performed by using IE3D software and it shows the results consisting return loss, VSWR, efficiency, gain and radiation patterns. The proposed antenna provides a new approach of feed network in which power splitting along with improvement in impedance bandwidth is achieved and this greatly reduces the manufacturing cost which satisfies increasing demands of wireless technology.

II. ANTENNA DESIGN

Fig 1 shows the dual band proposed antenna configuration which is fabricated on the FR4 substrate with the relative dielectric constant ε_r = 4.34, the thickness of the substrate is 1.59 mm, and the loss tangent is 0.01.

In this proposed structure, the antenna is working at 1.96 GHz to 2.814 GHz , 4.645 GHz to 6.741 and 7.763GHz to 8.978GHz which is used for Bluetooth , WLAN and satellite/space bands respectively. The dimensions of the antenna are 66 x66 mm^2. There are two radiating patches of 10x20mm^2 and 10x40mm^2 which are separated by a distance of 20mm. The value of L1 and L2 are kept fixed at 20mm and 40mm respectively which provides two resonating frequencies. The value of L2 gives resonating frequency at 2.4GHz and that of L1 gives another resonating frequency at 5.65GHz. Therefore, by taking the appropriate values of the length of dual patches, the antenna resonance is fixed at 2.4GHz and 5.65GHz respectively. According to the formula discussed in [8] lower edge frequency $f_L$can be acquired by following relation,

$$f_L=7.2/ \{ L+ p + 0.159W\} k \text{ GHz} \qquad (1)$$

where all the dimensions are taken in centimeters. In above equation,*L* = length of patch (L1 and L2), *W* = width of patch (W1 and W2), *p* = feed gap, *k* iscorrection factor taken as 1.15 for glass epoxy FR-4 substrate. The optimized impedance bandwidth is achieved in the 2.4GHz and 5.65GHz band by adjustments of the parameters such as width of the patch. The third resonating frequency is achieved by varying size of ground plane. Through simulation, the optimized dimensions of the antenna obtained are *L*1=20 mm, *L*2 = 40 mm, *W1* = 5 mm, *W2* = 5 mm, *Ws* = 3 mm and *Gnd* = 22 mm.

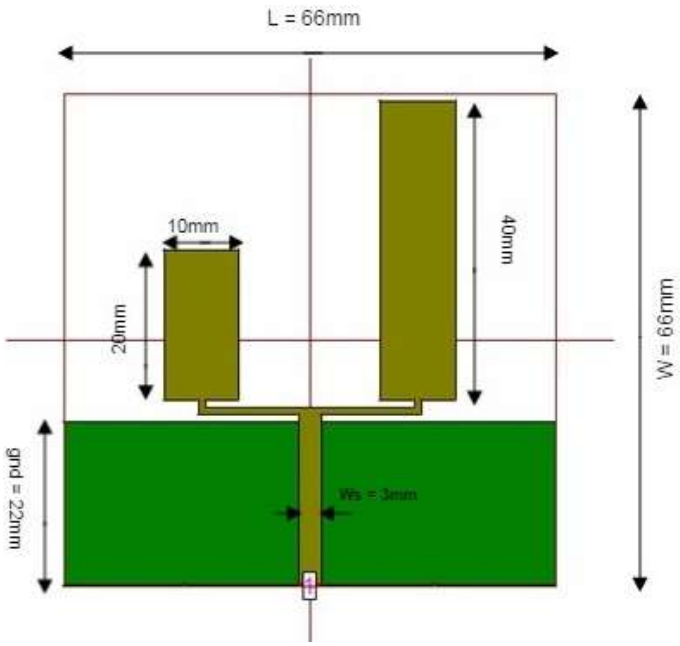

Fig. 1:Dual band antenna configuration

III. RESULTS AND PARAMETRIC STUDIES

A) Parametric study:

The parametric study is done to increase the bandwidth by keeping F_L same.By increasing the width of the rectangular patch and keeping height constant, bandwidth is increased. The effect of varying widths W1 and W2 on return lossof three bands can be observed.

W1= W2 (mm)	*f*1 [GHz]	*f*2 [GHz]	*f*3 [GHz]	Return loss (dB at *f*1, dB at *f*2, dB at *f*3)
12	2.24	6.17	8.29	-12.26, -10.61, -16.93
10	2.39	5.65	8.37	-13.89, -14.73, -14.66
8	2.36	5.24	8.22	-10.84, -15.60, -13.87

Table 1: Comparison of return loss and % BW

From the table 1, it is cleared that optimized result is obtained at W1=W2=10mm. Hence, from the above results it can be seen that the proposed antenna is useful for the triple band applications such as Bluetooth (2.4 GHz), WLAN (5.65 GHz) and Satellite (8.3GHz) . Hence,the optimized values obtained for dual patches are L1=20mm, W1=10mm, L2=40mm and W2=10mm. Further optimization is done by using corporate feed technique where impedance matching is achieved.

B) Result:

1) Simulated VSWR:

Fig. 2 compares the simulated and measured VSWR of the required antenna.It can be seen that simulated and measured VSWR is below 2 i.e. (VSWR<2) as required.

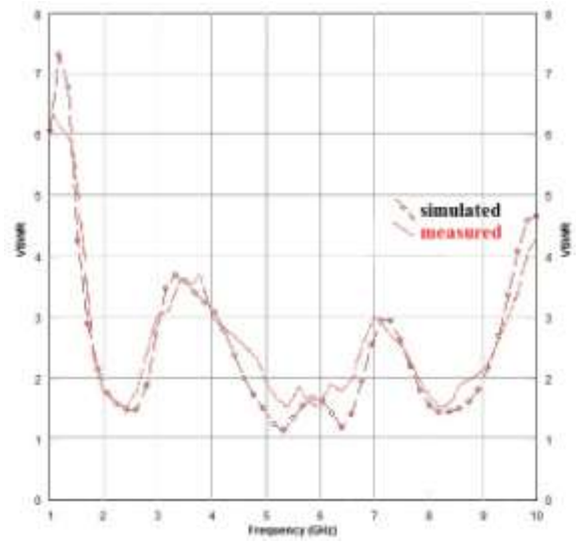

Fig. 2:Comparison of measured and simulated VSWR.

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It is clear from Fig. 2 measured and simulated VSWR is very close. The measured results are tested by vector network analyser.

2)Simulated Efficiency

Fig. 3 shows the radiation efficiency of the simulated dual bands. The efficiency at 2.4GHz is 92.27%, 5.65GHz is 82.88% and that of 8.3GHz is 75.5%. So the overall efficiency is in between 62.34% to 92.7%.

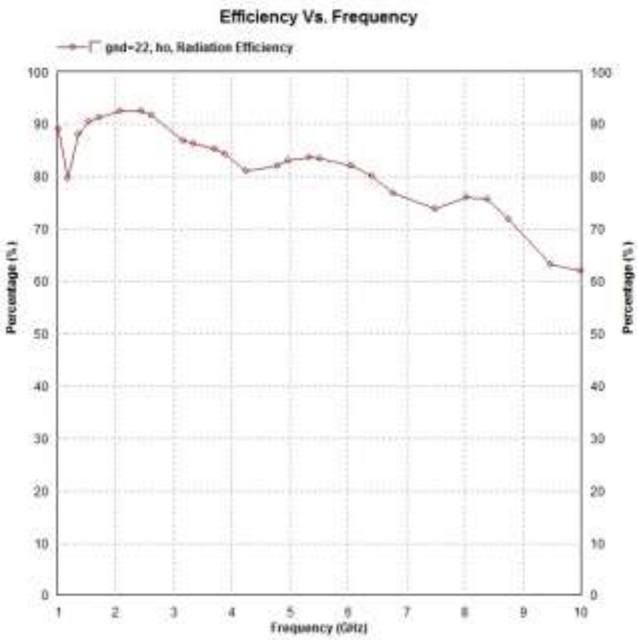


Fig. 3: Simulated efficiency of proposed antenna.

3)SimulatedGain

Fig. 4 shows the simulated gain of the proposed antenna. The antenna gain is in the range of -2.2 to 2.15 dBi. It is observed that the gain at 2.4GHz, 5.65GHz and 8.3GHz increases.

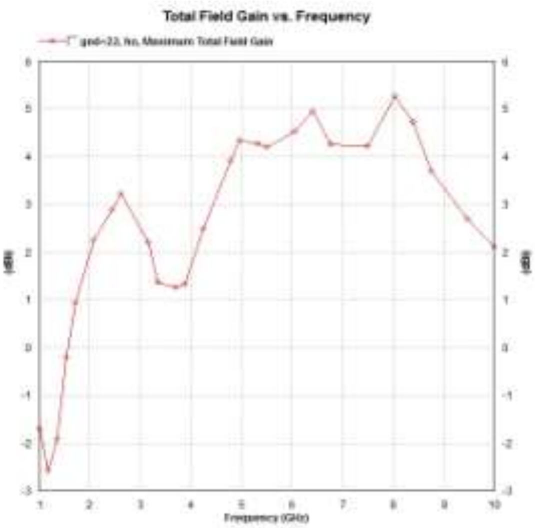


Fig. 4: Simulated Gain of proposed antenna

4) Radiation pattern

Fig 5 (a), (b) and (c) shows the E field radiated power of the antenna at 2.4GHz, 5.65GHZ and 8.3GHz respectively. It is clear from the patterns that figure of eight is achieved successfully and all the bands are nearly omni-directional.

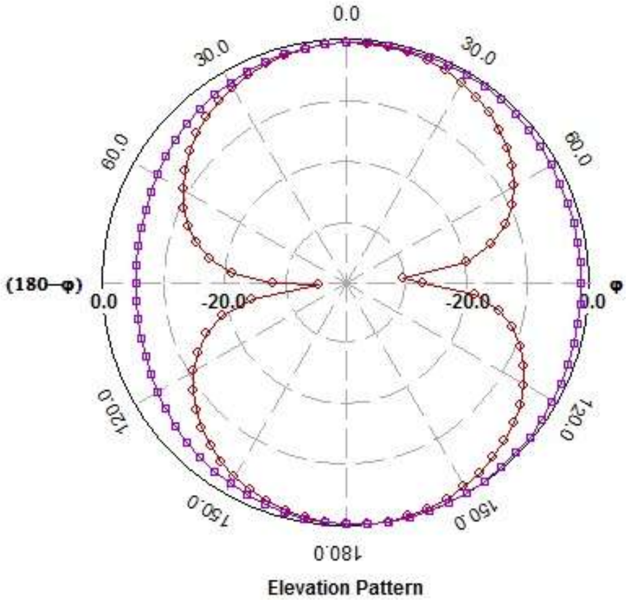
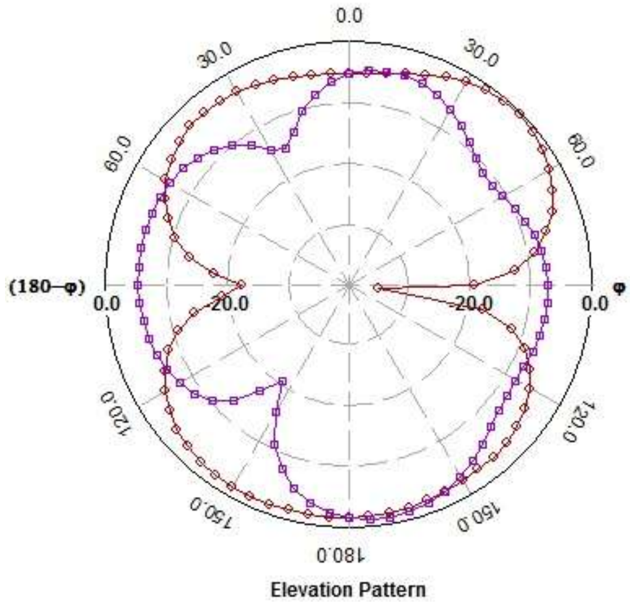
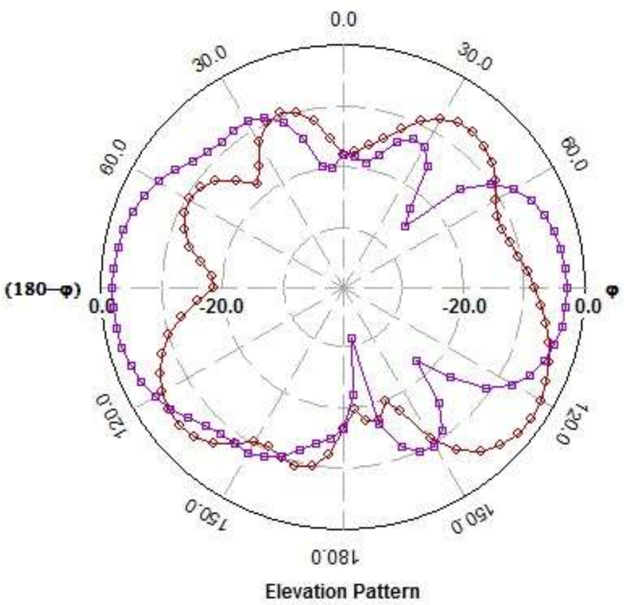


Fig. 5: (a) E Plane Radiation Pattern of the proposed Antenna at 2.4 GHz



(b) E Plane Radiation Pattern of the proposed Antenna at 5.65GHz



(c) E Plane Radiation Pattern of the proposed Antenna at 8.3GHz

IV. CONCLUSION

From the results & discussion, it can be concluded that printed monopole antenna is suitable for obtaining the required bandwidth which covers multiple bands namely Bluetooth, WLAN and satellite band frequencies. The parametric study clearly shows that its bandwidth can be increased by varying width of the two rectangular patches. The proposed multi-band antennas showstable omnidirectional radiation patterns over all the frequency bands. With the obtainedresults, the antenna can be used for practical and portable devices like tablet computer, cellphones, and various handheld GPS and other devices.

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