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A Design of Simple Gap Coupled Rectangular Microstrip Antenna for Wideband Operation

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ABSTRACT: This paper presents a novel design of simple partial ground plane gap coupled rectangular microstrip antenna (GCRMA) for wideband operation. The radiating patch of antenna is splited into smaller parts along its width. By suitably gap coupling the splited elements, the triple band, dual band and single band operation can be achieved. The antenna operates from 1.45 GHz. to 5.65 GHz and gives a maximum impedance bandwidth of 118% with a peak gain of 3.90dB, when the radiating patch is splited in to two parts and by placing the splited parasitic element gap coupled to the driven element with a gap of 0.1cm .The antenna gives the stable omnidirectional radiation pattern in its operating band. The operating range of antenna may find applications for WLAN, WiMAX and Bluetooth. The proposed antennas are very compact and simple in their structure and are realized using low cost glass epoxy substrate material.

KEYWORDS: Gap coupled rectangular microstrip antenna, Partial ground, Dual band, WLAN, WiMAX.

I.INTRODUCTION

The use of microstrip antennas (MSAs) have become increasingly popular because of their various inherent advantages such as light weight, simplicity of fabrication, ease of mass production, compactness etc. [1]. However, MSAs also have some limitations as compared to conventional antennas. The major limitations of MSAs are narrow impedance bandwidth, low gain, low efficiency, low power handling capability, poor isolation etc. Various techniques have been proposed by the researchers to improve different parameters of these antennas. The methods are found to be use of thick substrate, stacking of patches, use of materials with low relative permittivity, monopole techniques, proximity and aperture coupling techniques, use of matching networks, multi resonators, multilayer substrates, slot loading techniques and so on [2]. The use of a single wideband antenna with adequate gain and omnidirectional radiation pattern to cover a wide range of frequencies is very much desirable for many applications including wireless and high data rate communications. The MSAs with wide impedance bandwidth have been developed using many techniques. But, the use of gap coupled with monopole technique to achieve wide impedance bandwidth is found to be rare in literature. This technique is simple and also provides more freedom to the designer to achieve desired radiation requirements by properly varying the parameters related to the parasitic element and ground plane.

II. ANTENNA GEOMETRY AND DESIGNING

Figure-1 shows the top view geometry of partial ground plane rectangular microstrip antenna (RMA). The RMA is designed for the frequency of 3.5 GHz using the formulae available in the literature, using low cost glass epoxy substrate material of area Ls × Ws cm with thickness h = 0.16 cm and a relative permittivity(Er) of 4.2.The RMA consists of a radiating patch of width 'W' and length 'L' cm. The antenna is excited by using a single 50Ω microstripline feed of length (Lg +d) = 2.77 cm and width W_f= 0.32 cm. A partial copper ground plane of height

Lg = 2.5 cm is placed below the microstripline feed on the bottom layer of the substrate. The gap between the radiating patch and the partial ground plane is'd'which is equal to 0.27 cm.In this design, the only one simple 50Ω microstripline feed is used for impedance matching. The simulation performances are done by using commercial Ansoft HFSS software.

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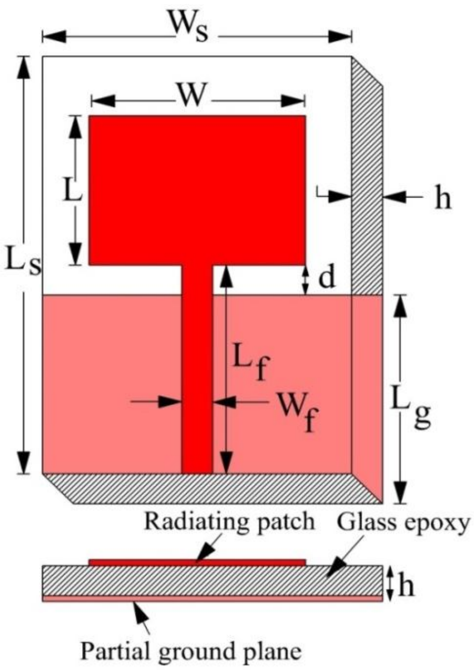

Fig-1: Top view geometry of RMA

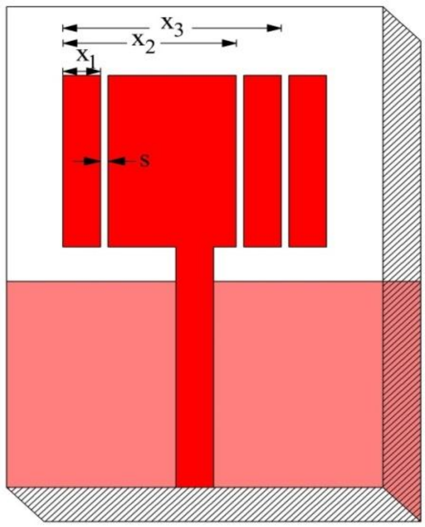

Fig-2: Top view geometry of RMAW3G

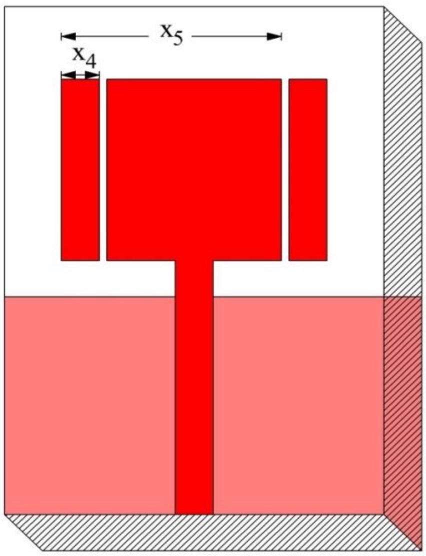

Fig-3: Top view geometry of RMAW2G

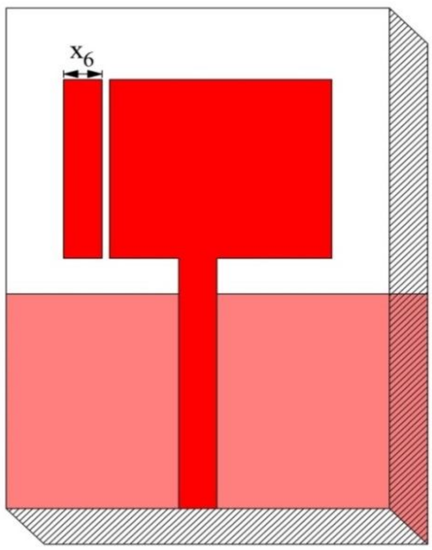

Fig-4: Top view geometry of RMAW1G

Fig-2, Fig-3 and Fig-4 shows the top view geometry of proposed antennas realized from Fig-1 when the radiating patch is divided in to smaller elements having three gaps, two gaps and one gap with a gap size of S= 0.1cm.These antennas are named as gap coupled rectangular microstrip antenna with three gaps (RMAW3G), gap coupled rectangular microstrip antenna with two gaps(RMAW2G) and gap coupled rectangular microstrip antenna with one gap (RMAW1G) respectively. The ground plane in each case is same as that of Fig-1.The other parameters of Fig-2,Fig-3and Fig-4 are also taken as that of Fig-1.

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In Fig-2 it is seen that by dividing the radiating patch in to four parts, the splitted elements are looks like parasitic elements gap coupled to the driven element. The first ,second and third gap lies at a distance of x_1,x_2 and x_3 respectively from the left edge corner of the parasitic patch. In Fig-3 the gap lies at a distance of x_4 and x_5 from the left edge of the parasitic patch. Similarly in Fig-4 the gap lies at a distance of x_6 from the left edge of the parasitic patch. The design parameters of the proposed antennas are given in Table-1.

Table -1: Design parameters of the proposed antennas

Antenna parameters	W	L	W_f	L_f	d	L_g	W_s	L_s	S	X_1	X_2	X_3	X_4	X_5	X_6	h
Dimensions in cm	2 66	2.04	0.32	2.77	0.27	2.5	6	5	0.1	0.4	1.66	2.16	0.4	2.16	0.4	0.16

III. RESULTS AND DISCUSSION

The variation of return loss versus frequency of RMAW3G is as shown in Fig-5. From this figure, it is clear that, the antenna operates for three bands of frequencies and gives an-10dB impedance bandwidth of BW1=72.8% (1.64GHz-3.52GHz), BW2 = 29% (4.91GHz-6.58GHz) and BW2 = 3.7% (8.35GHz-8.67GHz) respectively with a peak gain of 3.35dB.The m1,m2and m3 are the resonant mode for the operating bands of BW1,BW2 and BW3 respectively. Hence the use of parasitic elements shown in Fig-2 makes the antenna to resonate repetitively.

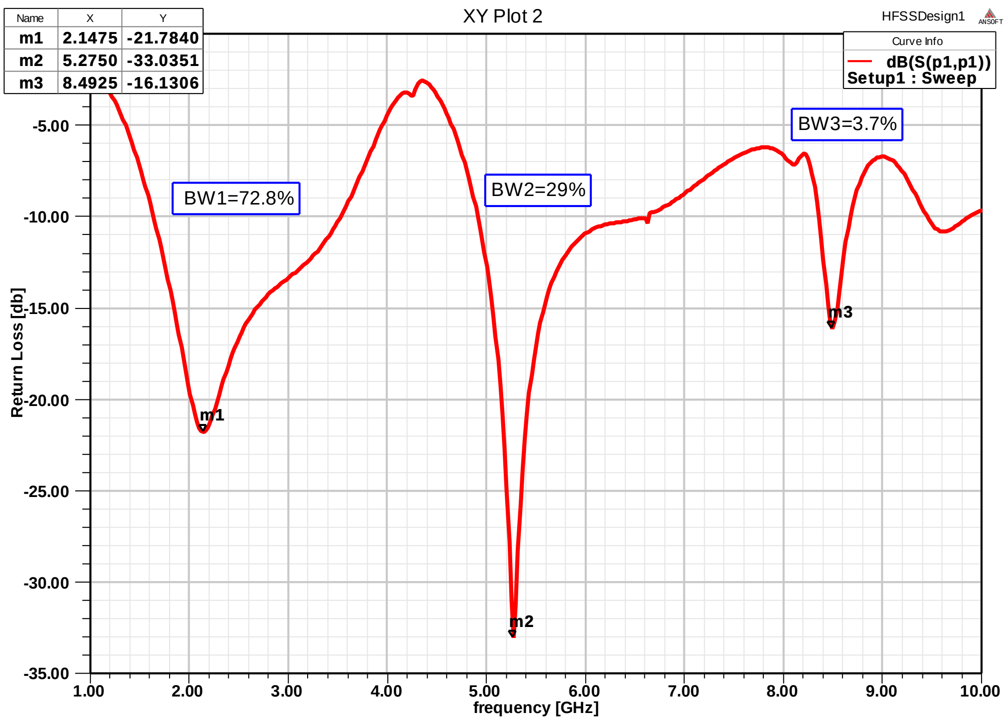

Fig -5: Variation of return loss versus frequency of RMAW3G

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The variation of return loss versus frequency of RMAW2G is as shown in Fig-6. From this figure it is clear that antenna operates for two bands of frequencies with an impedance bandwidth of BW1 =80.44% (1.62GHz-3.8GHz) and BW2= 15.32% (4.82GHz-5.62GHz).Thus by changing the number of gaps on the radiating patch, the antenna, can be made to operate for two bands of frequencies.

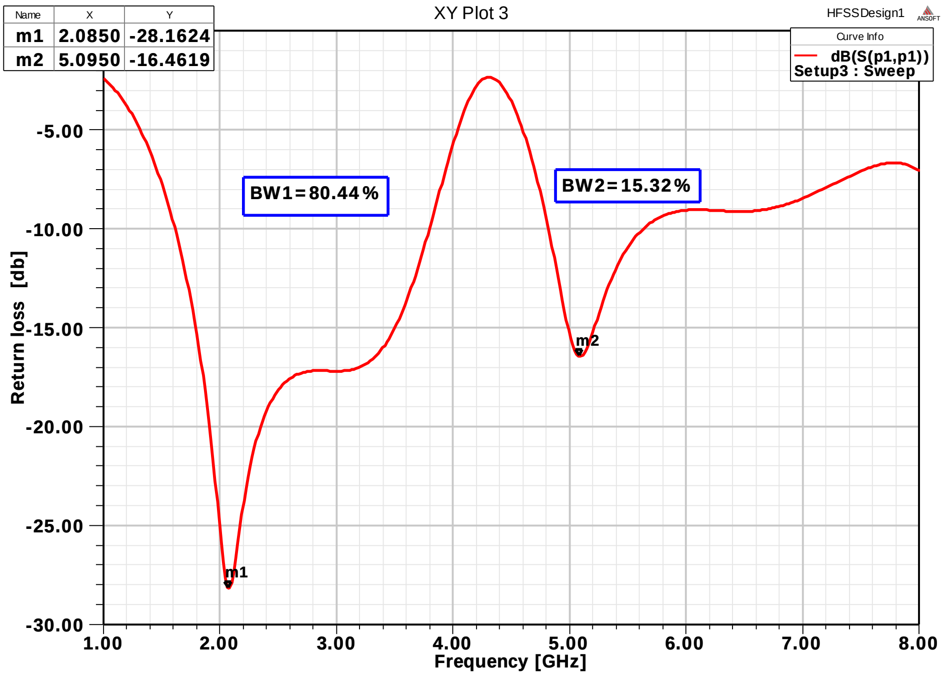

Fig-6: Variation of return loss versus frequency of RMAW2G

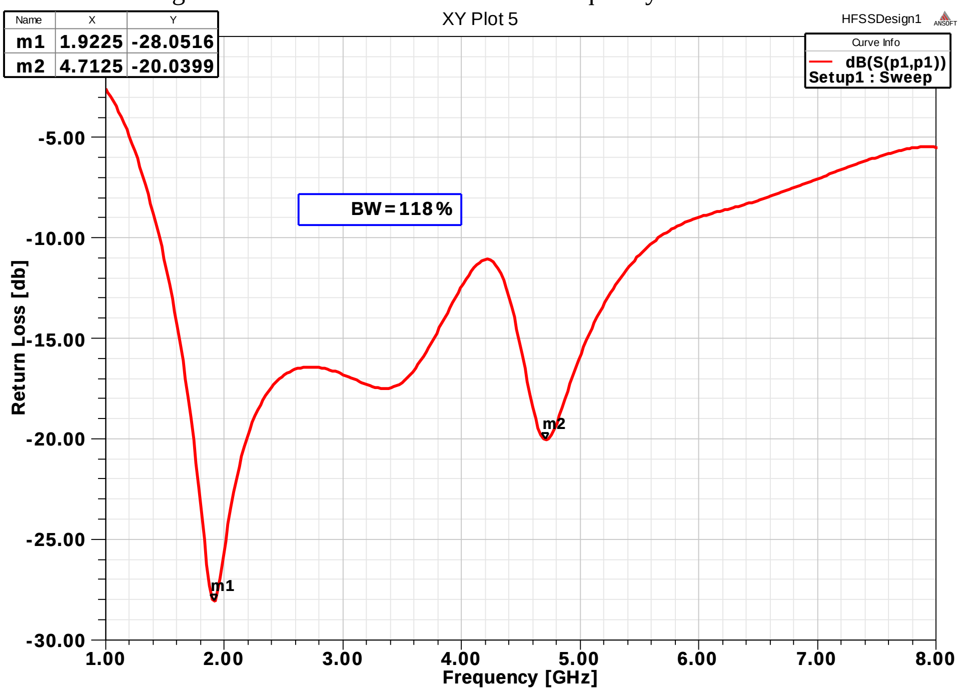

Fig-7: Variation of return loss versus frequency of RMAW1G

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Figure-7 shows the variation of return loss verses frequency of RMAW1G. In this case dual band shown Fig-6 is merged in to single band by placing a gap at a distance of x_6 as shown in Fig-4 and antenna operates for a wide band of frequency and gives a highest impedance bandwidth of BW1=118% (1.45GHz-5.65GHz). Hence gap coupled technique is effective to get a wide band operation of an antenna. Since Fig-4 gives highest impedance bandwidth. Its radiation pattern is measured.

A typical E-plane and H-plane radiation patterns of RMAW1G is measured at the resonant frequencies m1 and m2 shown in Fig-8 and Fig-9 respectively. The obtained radiation patterns are nearly omnidirectional in nature. The peak gain of the RMAW1G in its operating band is found to be 3.90 dB. Figure-10 shows the variation of gain of RMAW1G with respect to frequency.

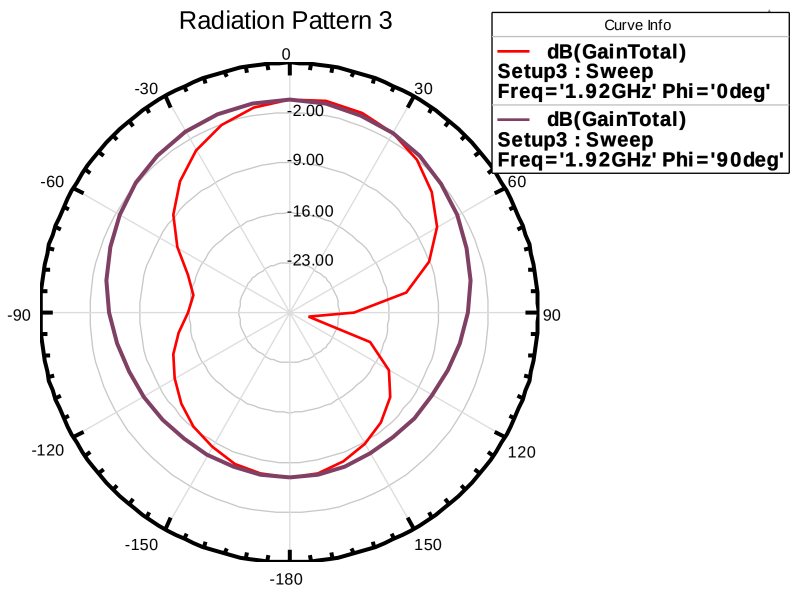

Fig-8: Radiation pattern of RMAW1G measured at 1.92 GHz

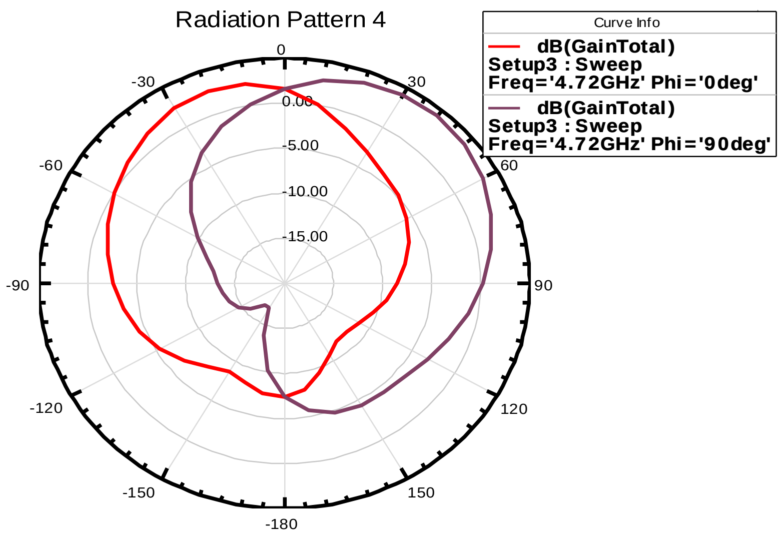

Fig-9: Radiation pattern of RMAW1G measured at 4.72 GHz

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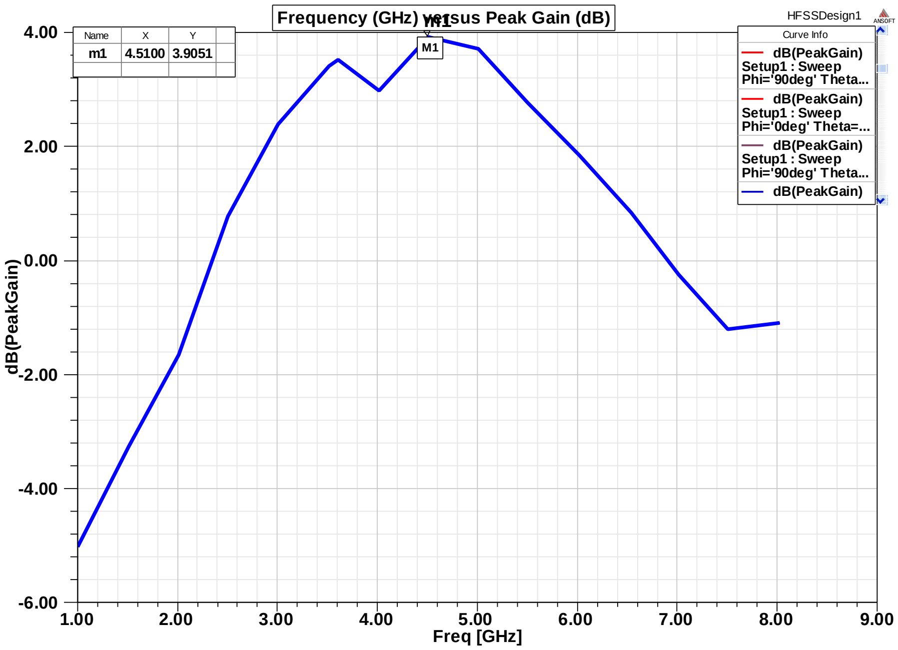

Fig-10: Variation of peak gain versus frequency of the RMAW1G

Figure-11 shows surface current distributions of RMAW1G.From this figures it is seen that, the current distribution is observed towards the edge point of the microstripline feed, at the gaps on patch and uniform current distribution is also observed at the ground plane surface of the antenna causing wideband operation.

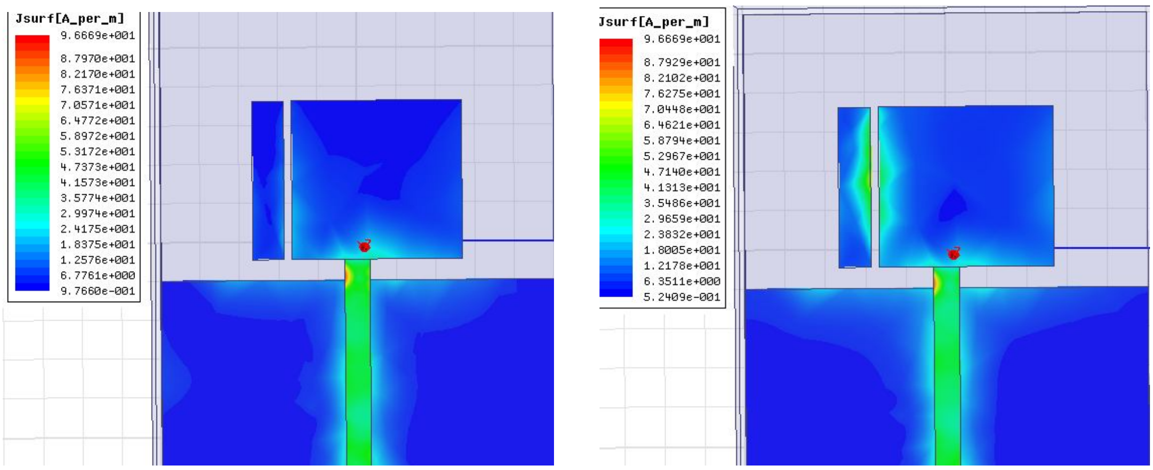

Fig-11. Current distribution of Gap coupled RMAW1G measured on patch and ground plane surfaces at m1 and m2

IV.CONCLUSION

A simple gap coupled rectangular microstrip antenna with partial ground is designed for wide band operation. From the detailed study it is found that, when the radiating patch of RMA is splitted in to smaller parasitic elements using three gaps along the width of radiating patch, then antenna operates for three bands of frequencies. This triple

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band operation can be converted to dual bands by splitting the radiating patch using two gaps. Further the duals bands are merged to single band by splitting the radiating patch using single gap, which gives the highest impedance bandwidth of 118% with a peak gain of 3.90 dB and shows the stable omnidirectional radiation pattern in its operating band. As the parasitic elements are obtained from the radiating patch itself, the designed antennas are simple and compact in nature and can be fabricated using low cost modified glass epoxy substrate material and may find the applications in WLAN, WiMAX and Bluetooth etc.

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BIOGRAPHY

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