Indian J.Sci.Res. 13 (1): 83-87, 2017

ISSN: 0976-2876 (Print)
ISSN: 2250-0138 (Online)

GAP COUPLED TRUNCATED RECTANGULAR MICROSTRIP ANTENNA FOR TRIPLE BAND OPERATION

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ABSTRACT

This paper presents the design and development of microstripline fed partial ground plane gap coupled truncated rectangular microstrip antenna (GCTRMSA) for triple band operation. The antenna is designed by splitting the rectangular radiating patch into smaller elements along the width and truncating the top and bottom portion of the splitted parasitic element. By proper gap coupling these splitted parasitic elements to the driven patch ,the antenna operates for three bands of frequencies and gives -10dB impedance bandwidth of BW_1=52.56% (2.30GHz-3.94GHz), BW_2 = 12.45% (5.27GHz-5.97GHz) and BW_3 = 39.32% (6.62GHz-9.86GHz) respectively with a peak gain of 8.22dB.The antenna gives the stable omnidirectional radiation pattern in its operating band. Commercially available Ansoft High Frequency Structured Simulator (HFSS) software is used for simulation of designed antenna and experimentally return losses measured using Vector Network Analyzer (VNA).The simulated and experimentally measured results are in good agreement with each other. The designed antenna is very compact and simple in the structure and is realized using low cost FR4 dielectric substrate material. The antenna may find applications for Bluetooth, WLAN, WiMax and C-band satellite communication.

KEYWORDS: Gap Coupled Rectangular Microstrip Antenna, Monopole, Triple Band, WLAN, WiMax.

There has been ever growing demand for microstrip patch antennas(MSAs) in communication system applications that poses the highly desirable attributes such as compact, size, low profile, low cost, easy installation and lightweight [Constantine, 1997]. However, the MSAs also suffer with their narrow impedance bandwidth, low gain and multiband operation. Numerous techniques have been proposed to increase the impedance bandwidth and simultaneously operate for more than one band [Bahl and Bharatia, 1981]. The bandwidth of the microstrip antenna can be increased using various techniques such as by using slot loading a patch, by using a thicker substrate, by reducing the dielectric constant and by using gap-coupled multi-resonator etc. The problem with a thicker substrate is generation of spurious radiation and there are some practical problems in decreasing the dielectric constant [Kumar and Gupta ,1984 & 1985].Full sizes as well as shorted MSAs are coupled with each other to achieve broadband and dual/triple frequency operations. These configurations occupy relatively large area [Ray and Kumar, 1997]. To overcome this problem, a compact gap coupled rectangular microstrip antenna (RMSA) is realized by splitting it into smaller elements. Planar monopole antenna is a good candidate for wireless communication services because of its wide impedance bandwidth, omnidirectional radiation pattern, compact simple structure and ease of fabrication [Kumar and Ray, 2003, Ray, 1999, Ray et.al., 2007 & 2006].

In this paper a triple band operation is obtained by splitting an RMSA into smaller elements along the width of radiating patch and then each splitted element is truncated at top and bottom portion, the lengths of the individual splitted elements and gap between them are optimized so as to sufficiently increase the separation between the resonances to obtain satisfactory triple band operation. This technique also reduces the overall size of the RMSA by 24% when compared to conventional RMSA designed for same resonant frequency.

ANTENNA GEOMETRY AND DESIGNING

The art work of the proposed antenna is sketched by using computer software Auto-CAD version 2006 to achieve better accuracy and is fabricated on low cost FR4-epoxy dielectric substrate material of having permittivity εr = 4.2 , loss tangent(δ) = 0.05 and thickness of h =1.6 mm. Figure-1 shows the top view geometry GCTRMSA. In this figure the area of the substrate is Ws x Ls mm. which consists of rectangular radiating patch of size Lp x Wp mm. On the bottom side of the substrate a truncated ground plane of height Lg is placed. The gap between the radiating patch and the partial ground plane is equal to 1.7mm.The GCTRMSA is designed for 3.5 GHz of frequency using the equations available for the design of conventional RMSA in the literature [Bahl and Bharatia, 1981]. The antenna is excited by using a single 50Ω microstripline feed of length(Lg + g) = 27.7 mm and width W_f = 3.2 mm. A semi miniature (SMA) connector is used at the tip of the

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microstripline feed for feeding the microwave power. The simulation performances are done by using commercial Ansoft HFSS software [Ansoft, 2008]. The triple frequency operation obtained by splitting RMSA into smaller elements along the width and then truncating the top and bottom portion of these smaller element .One of the elements is fed microstripline feed while others are gap coupled to its nonradiating edges. Then, the truncation and gap between the individual elements is optimized so as to sufficiently increase the separation between the resonances to obtain satisfactory triple frequency operation.

Optimized design parameters of the proposed antennas are given below:

Ws=50mm, Ls=60mm, W_f =3.2mm, L_f =27.7mm, Lg=26mm,W_p=26.6mm,Lp=20.4mm, gap=1.2mm

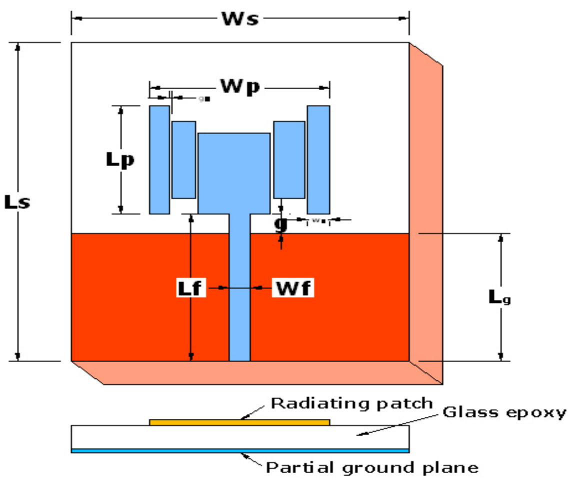
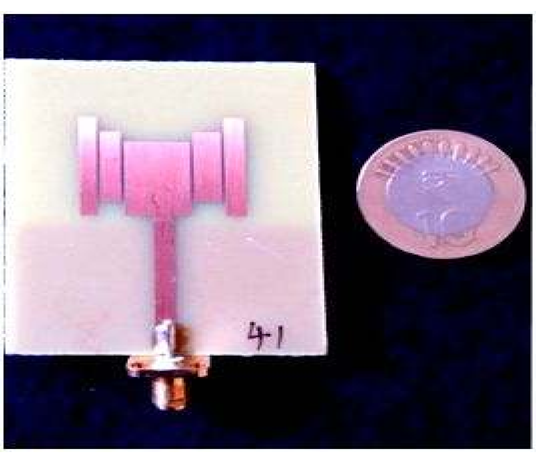


Figure 1: Top view geometry of partial ground plane GCTRMSA.



(a)

(b)

Figure 2: Photograph (a) Top view (b) Bottom view of GCTRMSA

RESULTS AND DISCUSSION

The proposed antenna is designed and simulated using commercial available Ansoft HFSS software and return loss, radiation pattern, VSWR, surface current distribution are measured and studied. The variation of return loss versus frequency of GCTRMSA is as shown in Fig-3. From this figure, it is clear that, the antenna operates for triple band of frequencies and gives a maximum impedance bandwidth of BW_1=52.56% (2.30GHz-3.94GHz), BW_2 = 12.45% (5.27GHz-5.97GHz) and BW_3 = 39.32% (6.62GHz-9.86GHz) respectively with a peak gain of 8.22dB. The operating range of this antenna covers WiMax, WLAN, GPS, X-band satellite communication etc.

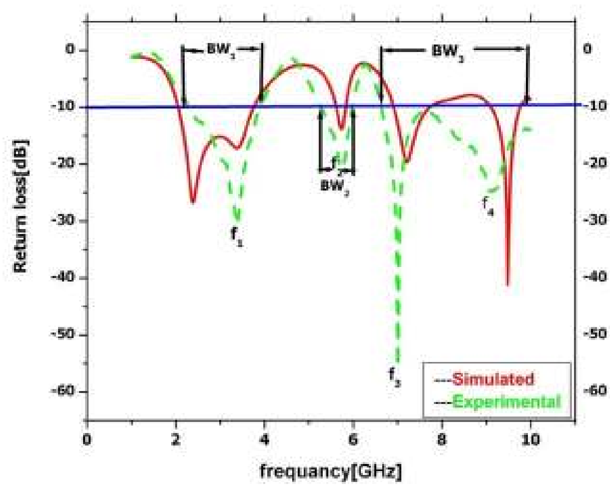
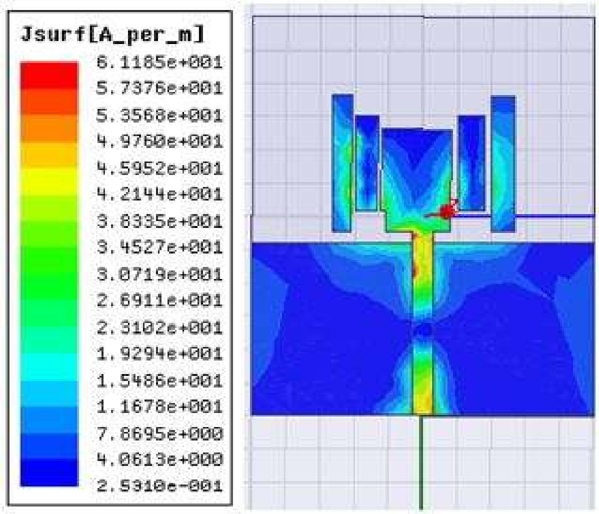
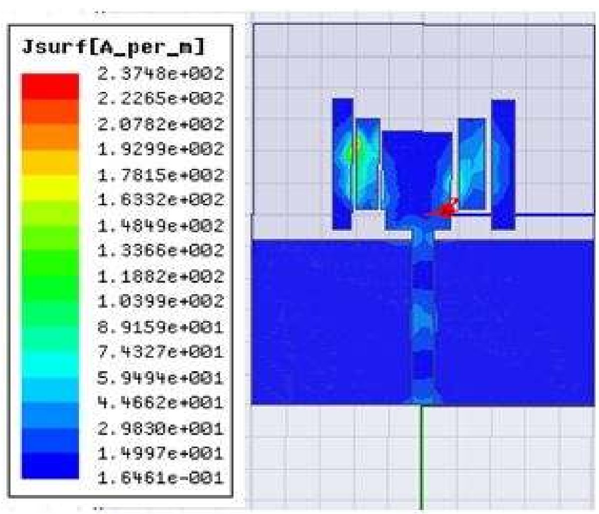


Figure 3: Return loss verses frequency plot of GCTRMSA.



(a)



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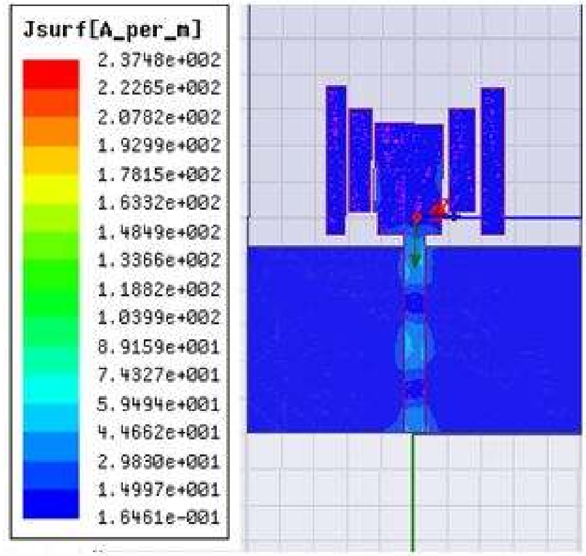
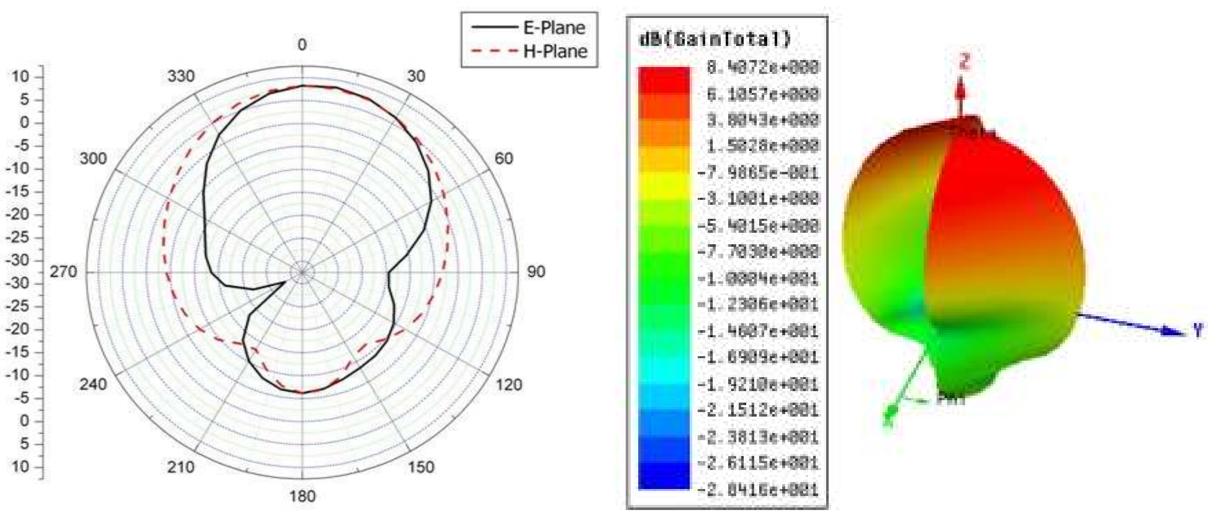


(c)

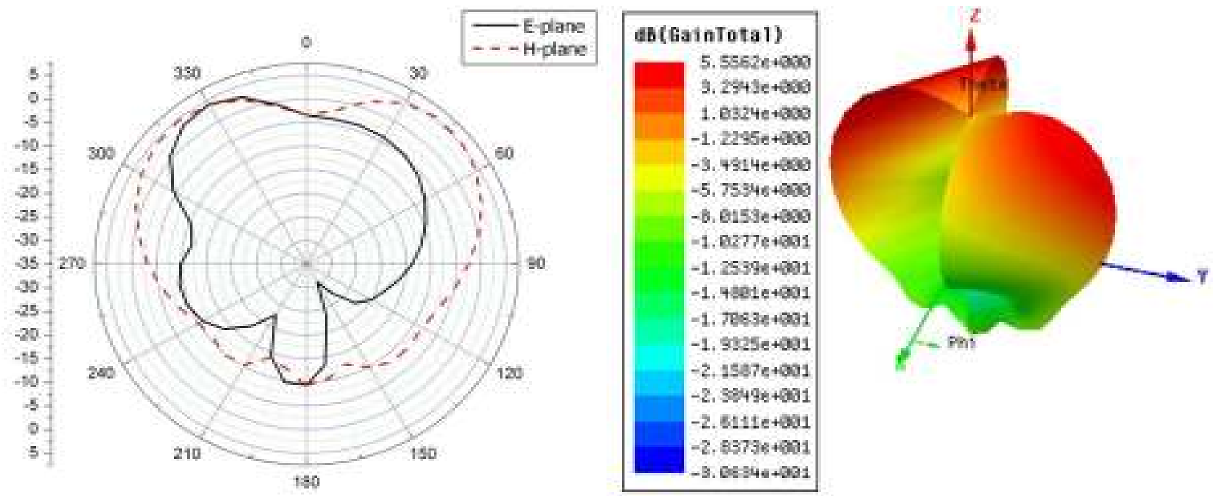
Figure 4: Current distribution of GCTRMSA measured at (a) 3.38(b) 5.70 and(c) 9.05 GHz.

Figure-4 shows the surface current distributions of GCTRMSA measured at (a) 3.38 (b) 5.70 and (c) 9.05 GHz. From this figures it is clear that, the current distribution is mainly observed along the microstripline feed, across the gaps and on patch. The current distribution is also observed at the ground plane surface at lower frequency.

A typical 2D and 3D E-plane and H-plane radiation patterns GCTRMSA is measured at the resonant frequencies and are shown in Fig-5.From these figures it is clear that the antenna radiates nearly omnidirectional radiation pattern in E and H plane.



(a)



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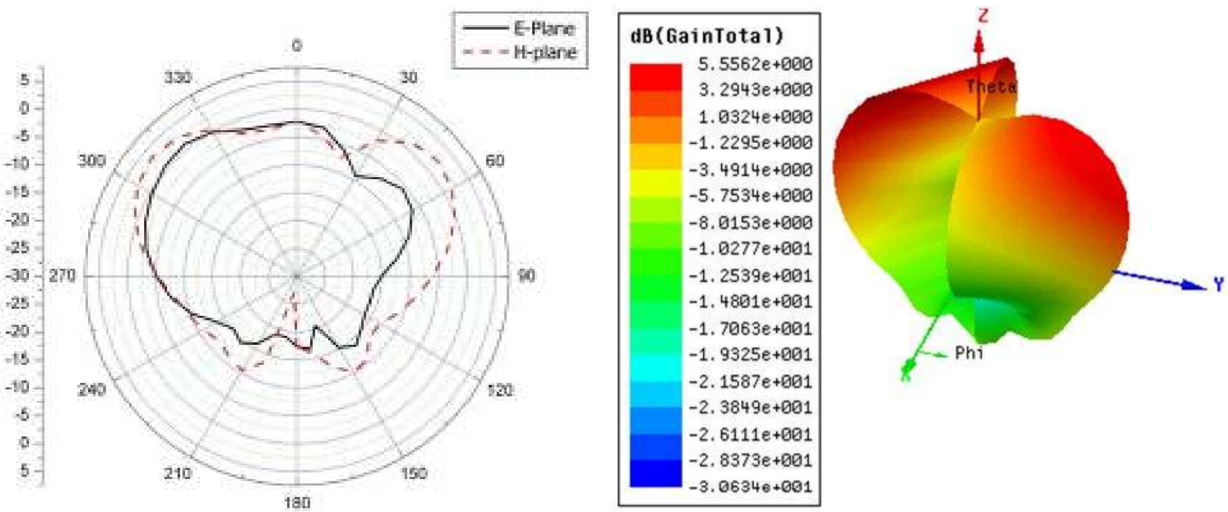

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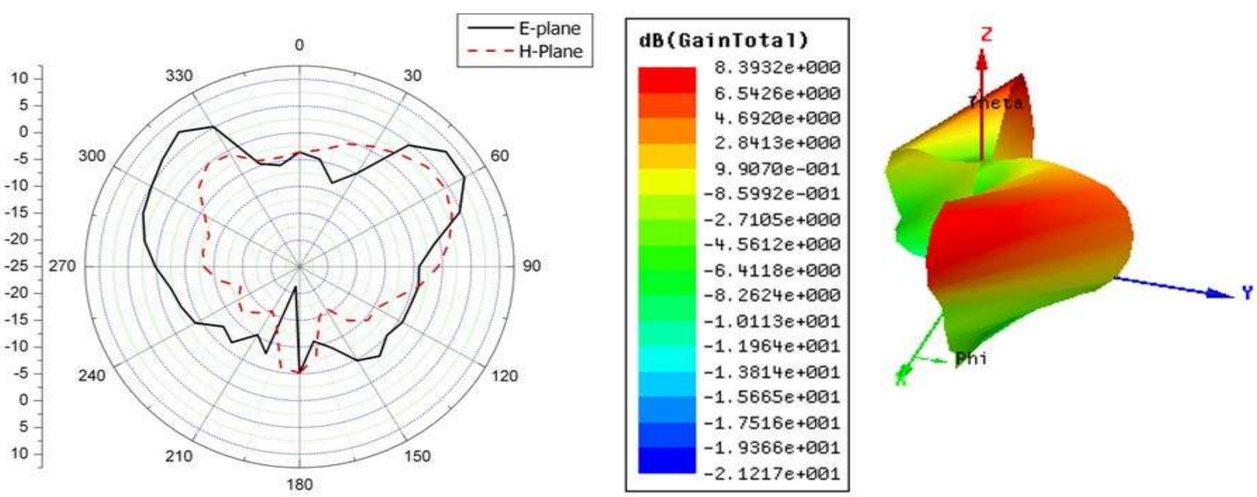

(d)

Figure 5: 2D-3D E - plane and H-plane radiation Pattern of GCTRMSA measured at (a) 3. 38GHz, (b) 5.70GHz and (c) 7. 02 GHz (d) 9. 05GHz

CONCLUSION

A compact partial ground plane gap-coupled rectangular microstrip antenna is presented for triple band operation. From the detailed simulation and experimental study it is clear that, when the partial ground plane RMSA is splitted vertically along the width of radiating patch and then truncating the top and bottom portion of the splitted parasitic element the antenna operates for triple band of frequency with impedance bandwidth of BW_1=52.56% (2.30GHz-3.94GHz), BW_2 = 12.45% (5.27GHz-5.97GHz) and BW_3 = 39.32% (6.62GHz-9.86GHz) respectively with peak gain of 8.22dB.The designed antenna is simple in geometry and compact in size by 24% compared with size of conventional antenna designed for same frequency, This antenna is fabricated using low cost modified glass epoxy dielectric substrate material**.** The dimensions of the applied gaps and truncation of splitted elements are optimized for multiband bandwidth requirement without spoiling other radiation characteristics. The antenna exhibits nearly omnidirectional radiation in H-plane and E-plane and may find application in Bluetooth, WiMax, WLAN and X-band satellite communication. The experimental and simulated results of the proposed antenna are in good agreement with each other.

ACKNOWLEDGEMENT

The author would like to thank the Dept. of Science and Technology (DST), Govt. of India, New Delhi, for sanctioning Vector Network Analyzer to this Department under FIST Project.

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