U - Slot Loaded Broadband Rectangular Microstrip Antenna

Rajesh Kumar Verma, P. K. Singhal

Abstract - To enhance the bandwidth, a new design of rectangular microstrip antenna is presented. The proposed geometry consists of an E – shaped ground plane structure, a truncated radiating patch layer and a U- slot loaded patch layer. The radiating patch layer and U slot loaded patch layer are separated using a thick air substrate (10 mm) to enhance the bandwidth. The two major impedance BWs determined are 40 % at centre frequency 3815 MHz and 29 % at centre frequency 5995 MHz. The microstrip antenna is fed by a coaxial probe. The proposed geometry provides a band of 1530 MHz (3.05 GHz to 4.58 GHz) and of 1750 MHz (5.12 GHz to 6.87 GHz) that is suitable for certain frequencies of S band as well as of C band applications. Also, the proposed geometry provides a peak directivity 6.59 dBi, gain 4.78 dBi, axial ratio 42.46 dB, aperture efficiency 85.7 %, radiation efficiency 89 % for a band (3.05 GHz to 4.58 GHz) whereas for a band of (5.12 GHz to 6.87 GHz) the proposed geometry provides a peak directivity 6.22 dBi, gain 4.32 dBi, axial ratio 70.9 dB, aperture efficiency 68.8 %, radiation efficiency 70 %. All the simulations are carried out using Zeland IE3D simulation software for a dielectric substrate with dielectric constant 4.4 and loss tangent 0.02.

Keywords: Broadband, RMSA, Truncated.

I. INTRODUCTION

An MSA in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side as shown in figure 1.1. There are different shapes of the microstrip antenna, such as the square, circular, triangular, semicircular, sectoral, annular ring, but the most common is rectangular. Due to its advantages such as low weight, low profile , low fabrication cost and capability to integrate with microwave integrated circuits technology, the microstrip antennas are well suited for applications such as wireless communication systems, cellular phones, pagers , radar and satellite communication systems[1-3]-[5-8]. A major drawback of the MSAs is that they have a narrow bandwidth, typically 1 – 5% which is the major limiting factor for the widespread application of these antennas.

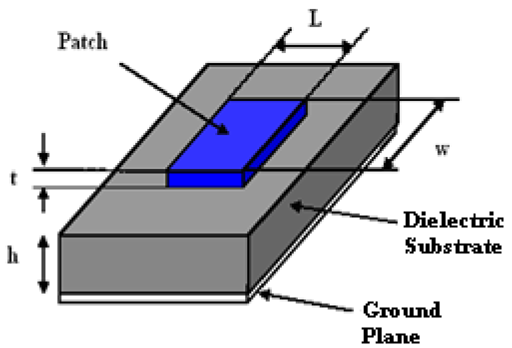

Fig. 1.1 Rectangular microstrip antenna

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The BW of the MSAs can be increased by using the modified shape patches, planar multiresonator configurations, multilayer configurations, stacked multiresonator configurations [8, 17].

In this paper, a new prototype is presented which consist of an E-shaped ground plane, a truncated radiating patch and a U slot loaded RMSA. The radiating patch layer and U slot loaded patch layer are separated using a thick air substrate (10 mm) to enhance the bandwidth. A previous study of U slot loaded RMSA with an air substrate of 12 mm provides the impedance BW of 27.5 % at centre frequency 1815 MHz [4], another U slot loaded triangular microstrip antenna with an air substrate of 14.3 mm provides the impedance BW of 18.3% at centre frequency 1677 MHz [15], whereas in this paper dual bands are achieved with impedance BW 40 % at centre frequency 3815 MHz and 29 % at centre frequency 5995 MHz.

II. ANTENNA DESIGN

A typical design of rectangular microstrip antenna has been presented here and results are discussed at centre frequency of 2.0 GHz. The width and length of the patch are given by [1, 8]:--

$$w = \frac{c}{2f\sqrt{(\varepsilon r+1)/2}} \qquad (1)$$

$$L = L_{eff} - 2\Delta L \qquad (2)$$

$$\Delta L = \frac{0.412h\,[\varepsilon_{eff}+0.300]\left[\left(\frac{W}{h}\right)+0.264\right]}{[\varepsilon_{eff}-0.285]\left[\left(\frac{W}{h}\right)+0.8\right]} \qquad (3)$$

$$\varepsilon_{eff} = (\varepsilon_r+1)/2+[(\varepsilon_r-1)/2](1+12h/W)^{-1/2} \qquad (4)$$

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon eff}} \qquad (5)$$

Where,

C = velocity of light,
ε_r = dielectric constant of substrate,
f = operating frequency
ε_{eff} = effective dielectric constant,
L_{eff} = effective length,
ΔL = edge extension

For designing the proposed antenna, the following parameters are used:--

Design frequency	=	2.0 GHz
Dielectric constant	=	4.4
Loss tangent	=	0.02
Thickness of substrate	=	1.6 mm
Length of the radiating patch L	=	36 mm
Width of the radiating patch W	=	46 mm
Length of the ground plane Lg	=	46 mm
Width of the ground plane Wg	=	56 mm
Length of the slot Ls	=	42 mm
Width of the slot Ws	=	4 mm
Truncated corner	=	6 × 6 mm

Length of the upper patch Lu	=	30 mm
Width of the upper patch Wu	=	40 mm
Dimensions of U slot	=	20 × 20 mm
Width of U slot	=	2 mm

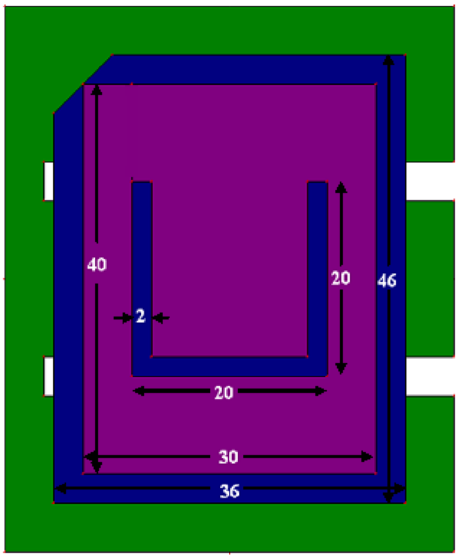

Fig 1.2 U slot loaded Rectangular microstrip antenna .

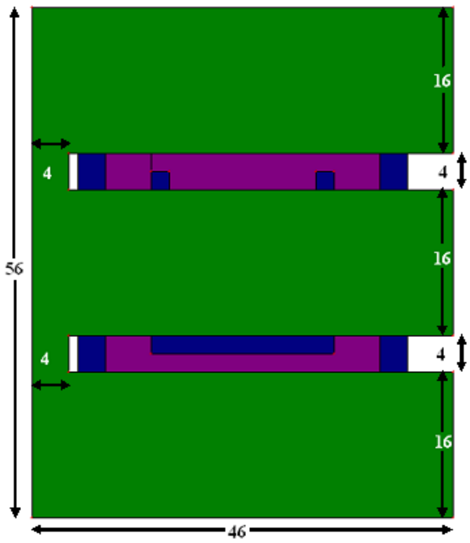

Fig 1.3 E- shaped ground plane Geometry of RMSA.

III. RESULTS & DISCUSSIONS

The truncated rectangular microstrip antenna with E – shaped ground plane resonates at different frequencies such as 1.57 GHz, 1.71 GHz, 1.93 GHz, 2.34 GHz, 3.26 GHz, 3.79 GHz, 4.09 GHz, 4.4 GHz, 5.49 GHz, 6.25 GHz, with maximum impedance BW = 36.9 % (3.16 GHz to 4.59 GHz) at center frequency 3875 MHz and 20.8 % at centre frequency 5825 MHz Now, another layer of U - slot loaded microstrip antenna is added to this geometry. Previous geometry (truncated RMSA with E shaped ground plane) and the U – slot loaded layer are separated using a thick air substrate (10 mm) to enhance the bandwidth. The new RMSA is simulated which resonates at different frequencies such as 0.65GHz, 1.5 GHz, 1.79 GHz, 2.16 GHz, 2.32 GHz, 3.15 GHz, 3.74 GHz, 4.39 GHz, 5.44 GHz, 6.28 GHz, with maximum impedance BW = 40 % (3.05 GHz to 4.58 GHz) at center frequency 3815 MHz and 29 % at centre frequency 5995 MHz The new impedance BW is approximately 10 times the BW of the RMSA with dimensions L × W. Also, the proposed geometry provides a peak directivity 6.59 dBi, gain 4.78 dBi, axial ratio 42.46 dB, aperture efficiency 85.7 %, radiation efficiency 89 % for a band (3.05 GHz to 4.58 GHz) whereas for a band of (5.12 GHz to 6.87 GHz) the proposed geometry provides a peak directivity 6.22 dBi, gain 4.32 dBi, axial ratio 70.9 dB, aperture efficiency 68.8 %, radiation efficiency 70 %.

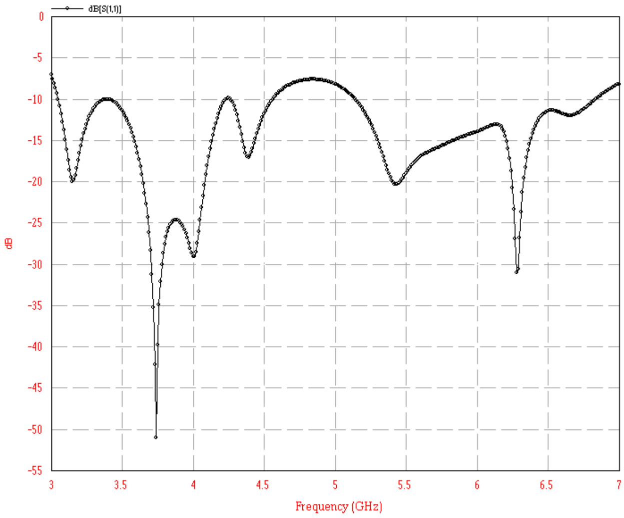

Fig 1.4 Return loss Vs Frequency

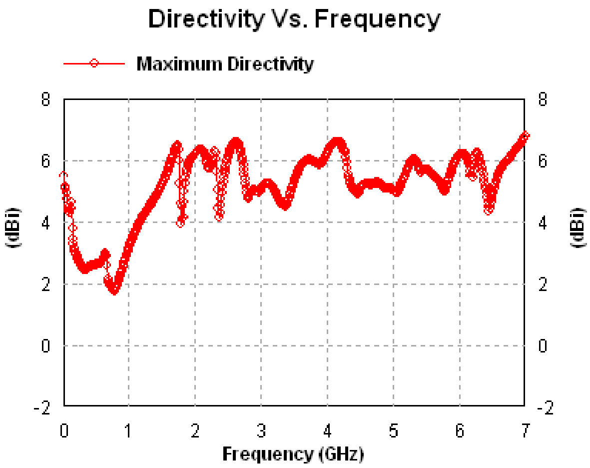

Fig 1.5 Directivity Vs Frequency

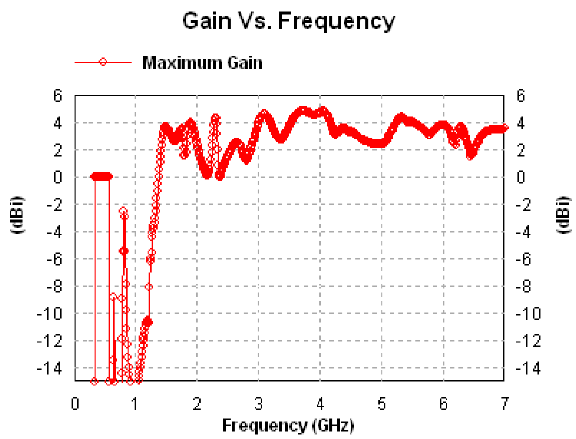

Fig 1.6 Gain Vs Frequency

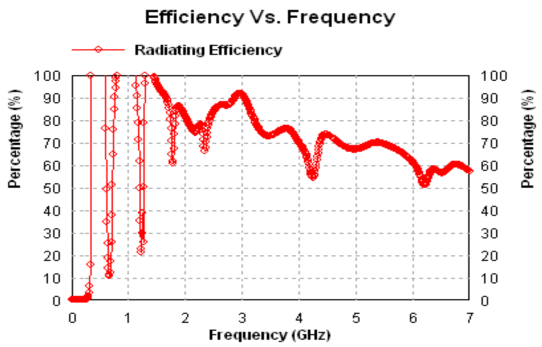

Fig 1.7 Radiating efficiency Vs Frequency

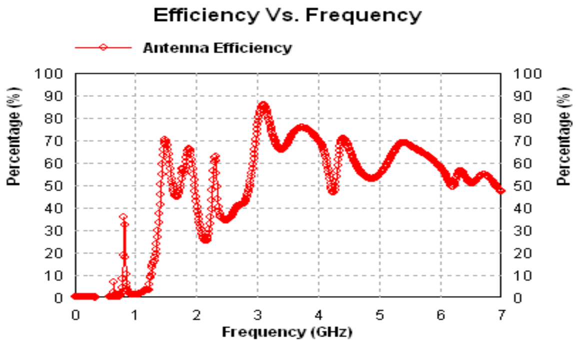

Fig 1.8 Aperture efficiency Vs Frequency

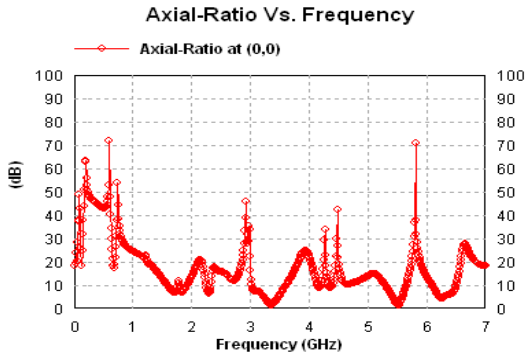

Fig 1.9 Axial Ratio Vs Frequency

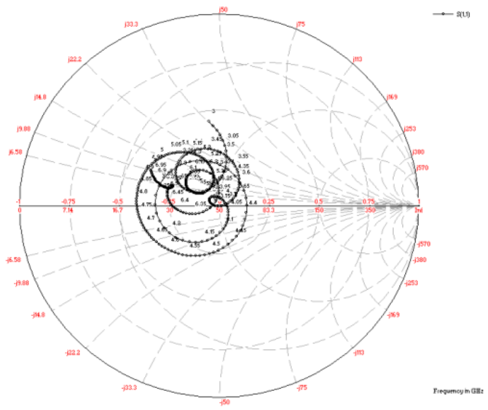

Fig 1.10 Smith chart

IV. CONCLUSION

A coaxially fed U – slot loaded broadband rectangular microstrip antenna is studied, designed and simulated and compared with a conventional rectangular microstrip antenna without any geometry on ground plane. This configuration provides the dual impedance bandwidth of 40 % with peak directivity 6.59 dBi, gain 4.78 dBi, axial ratio 42.46 dB, aperture efficiency 85.7 %, radiation efficiency 89 % for a band (3.05 GHz to 4.58GHz) and 29 % at centre frequency 5995 MHz with peak directivity 6.22 dBi, gain 4.32 dBi, axial ratio 70.9 dB, aperture efficiency 68.8 %, radiation efficiency 70 % for a band (5.12 GHz to 6.87 GHz) which is suitable for S band and lower frequencies of C band applications.

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