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Broadband Response of Planar Four-Edge Gap-Coupled Rectangular Patches of Unequal Length Variation

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***Abstract* – The paper discusses the multiresonator technique in a planar configuration, elaborating on the mechanism of gap coupling for broad BWs in rectangular microstrip patches. The centre frequency of the microstrip antenna operates at 2.96 GHz leading to compactness and it has an impedance bandwidth of 339 MHz (11.48%) with VSWR<2. A very high BW is obtained at a low centre frequency without increasing the height of the substrate.**

***Keywords* – Edge Gap Coupling, Broadband Microstrip Antenna, 339MHz (11.48%), Multiresonator Coupling.**

I. Introduction

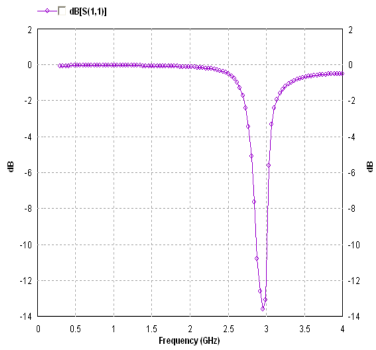
This Microstrip antennas (MSAs) have several advantages, including that they are lightweight and small-volume and that they can be made conformal to the host surface[1]. In addition, MSAs are manufactured using printed-circuit technology, so that mass production can be achieved at a low cost. MSAs, which are used for defense and commercial applications, are replacing many conventional antennas[2]. However, the types of applications of MSAs are restricted by the antennas' inherently narrow bandwidth (BW)[2],[3].Accordingly, increasing the BW of the MSA has been a primary goal of research in the field.

II. Technology

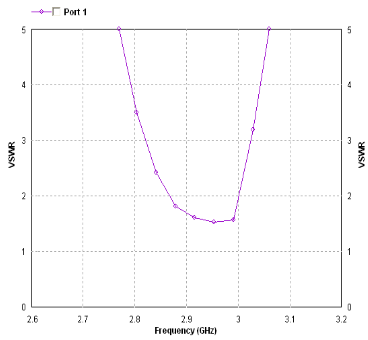
Microstrip patch antennas have a very high antenna quality factor, Q [3]. Q represents the losses associated with the antenna and a large Q leads to narrow bandwidth and low efficiency. Q can be reduced by increasing the thickness of the dielectric substrate. But as the thickness increases, an increasing fraction of the total power delivered by the source goes into a surface wave. This surface wave contribution can be counted as an unwanted power loss since it is ultimately scattered at the dielectric bends and causes degradation of the antenna characteristics [4]. This paper describes the planar multiple-resonator technique using four edge gap coupled rectangular microstrip patches for broadband operation. Though the size increases but the BW is increased without increasing the thickness of the MSA.As a result, their planar characteristics are retained, which makes them conformal to different host surfaces[5],[6]. The coupling between the multiple resonators has been realized by using a small gap between the patches [7][8],[9]. Initially, the effect of parasitic patches on the radiating edges is discussed[10]. Later on, effect of parasitic patches on the four edges of the coaxial fed patch is analyzed.

A. Effect of parasitic patches on the radiating edges

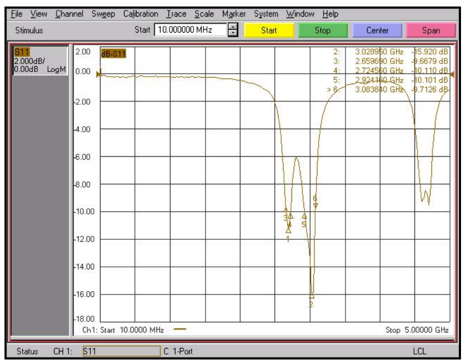
When a parasitic patch is placed next to the fed patch with a gap of s=0.1cm,it gets excited due to coupling with fringing fields along the width of the fed rectangular patch[11].The antenna has been analyzed .The return loss characteristics and the VSWR response is depicted in Fig.1(a) and Fig.1(b) respectively.



(a)



(b)



(c)

Fig.1. (a) Plot of S11 (dB) Vs Frequency (GHz);
(b) VSWR plot of two gap-coupled RMSA
(c) Measured value as observed from VNA

The return loss is S_{11}=-13.568dB at a resonant frequency f_r =2.94 GHz. From the VSWR plot Fig.1(b),it is seen that for the frequency range between 2.85 GHz and 3.01 GHz, the VSWR value is ≤2.. The impedance bandwidth obtained is 156 MHz. The percent bandwidth calculated is around 5.31%.The measurement is done by an Agilent Vector Network Analyzer.

From the measured results in Fig.1(c), it is seen that the antenna is resonance at a centre frequency around 2.87 GHz. The S_{11}value is -11.85dB.From the above results, it can be seen that the bandwidth of the coupled MSA increases when the resonance frequencies of the fed patch and parasitically coupled patches are close to each other. As such performance of four parasitic patches is now analysed considering the presence of multiple resonance frequency of the radiating and non-radiating edges.

III. Analysis of Four Edge Gap Coupled Patches

When the parasitic patches are placed along all the four edges of the RMSA as shown in Fig.2, both gain and bandwidth will increase. The patches along the radiating and non-radiating edges are separately taken unequal. Their resonance frequency is different but close to each other to yield BW.The gap along the non-radiating edges is taken smaller than that of the radiating edges, because field varies sinusoidally along the non-radiating edges.

B. Antenna Configuration

Fig.2 shows the geometry of Four-edge Gap- Coupled RMSA having dimensions: L=2.4cm, L_1=2.4cm,L_2=2.3cm, L_3=2.25cm,L_4=2.225cm,W=3.0 cm.The gap between the radiating edges ,s_1 & the non radiating edges, s_2 is 0.10 cm and 0.05cm respectively. The antenna is simulated using the substrate Epoxy glass (FR4) having parameters: ϵ_r=4.4, h=0.159 cm and tan δ=0.01.

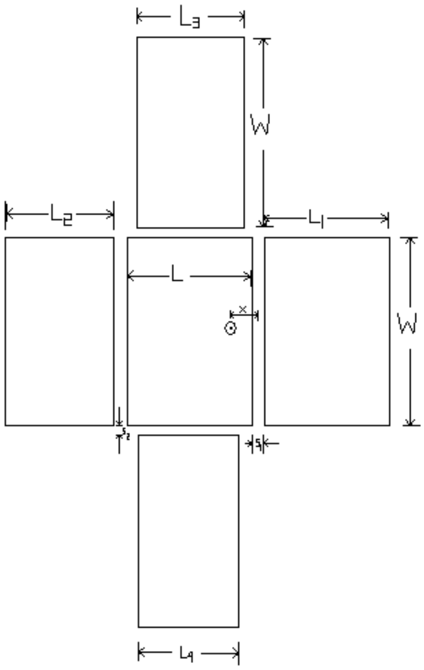


Fig.2 Four- Edge Gap-Coupled RMSA

C. Simulated Results

Here we have used the MoM technique to simulate the various MSA configurations. From the return loss curve as shown in Fig.3 below, we observe that four resonant frequencies are excited which eventually leads to a wider impedance bandwidth. The corresponding input impedance plot & VSWR plot is shown in Fig.4 and Fig.5 respectively.

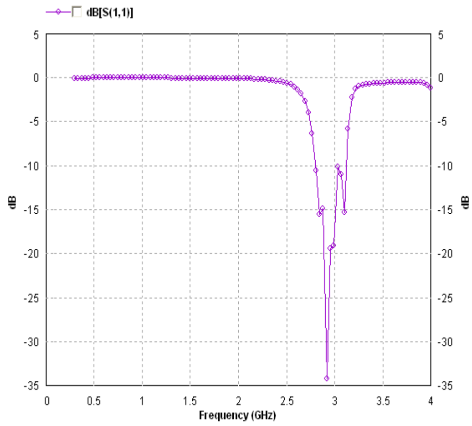


Fig.3. Plot of S11 (dB) Vs Frequency (GHz)

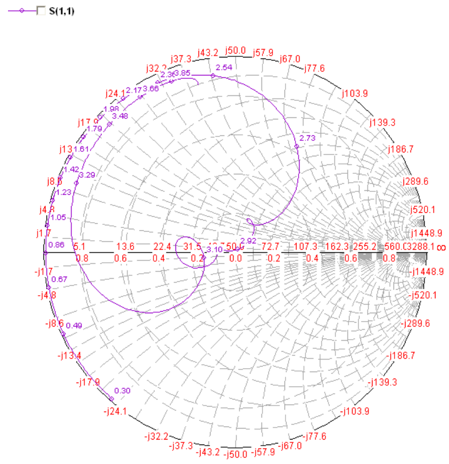


Fig.4. Input Impedance variation

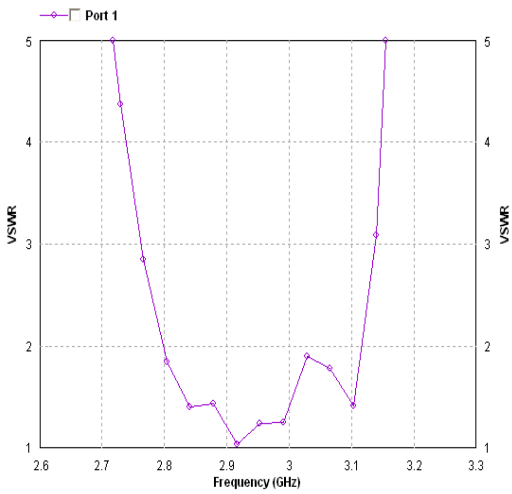


Fig.5. VSWR plot of four edge gap-coupled RMSAs of unequal length

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The corresponding S_{11} values at resonant frequencies f_r=2.837GHz,2.915 GHz,2.993GHz & 3.097GHz are -15.593 dB,-34.138,-19.04dB & -15.269 dB respectively. In Fig.4,we observe that more loops occupy the impedance loci, which comes out of the VSWR=2 circle. The VSWR plot Fig.5 shows that from frequency ranging from 2.785GHz to 3.124 GHz, the value is <2,i.e. the impedance bandwidth is 339 MHz with respect to centre frequency of 2.96 GHz. The percent bandwidth calculated is 11.48%.

The radiation characteristics of the antenna at centre frequency 2.96 GHz is shown below. The coplanar components in the E-plane and H-plane are shown in Fig.6 & Fig. 7 respectively.

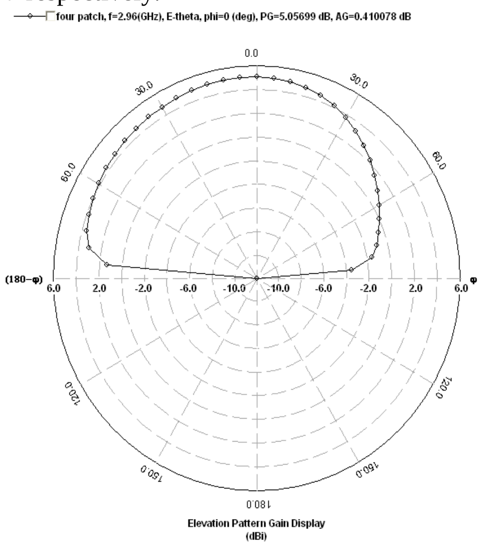

Fig.6 E-plane: coplanar components (Eθ in the φ =0˚plane)

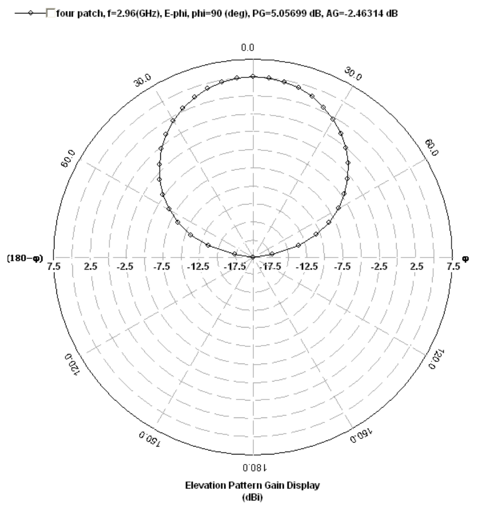

Fig.7. H-plane: coplanar components (Eφ in the φ=90˚plane)

The 3 dB beamwidth is (59.4235, 128.942) deg. The radiation efficiency η is 56.38%.The directivity D of the antenna is 7.58843 dBi. The gain G is 5.059dBi.

Thus, the four-edge -gap-coupled RMSA antenna provides a much improved response in terms of bandwidth & also gain.

IV. Conclusion

This paper describes the gap coupling technique in planar configuration to yield broadband response. The BW of the coupled MSA increases when the resonance frequencies of the fed patch and parasitically coupled patches are close to each other. Four rectangular patches are gap coupled along the radiating as well as non radiating edge taking the best possible feed point location, gap between the patch, and the parasitic length variation. The major advantage of this structure is that the BW is increased without increasing the thickness of the microstrip antenna. The concept led to low Q as well as higher gain and a stable radiation pattern in the entire BW.

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Author's Profile

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