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RESEARCH ARTICLE

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A BROADBAND MICROSTRIP PATCH ANTENNA USING PARASITIC ELEMENTS

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ABSTRACT

A microstrip patch antenna using coaxial feed with parasitic elements has been presented. The proposed antenna has also been suitable for WLAN and WiMAX applications because the antenna is resonating within 5.13-6.44 GHz frequency band. The Rogers RT/duroid 5880 material of dielectric constant 2.2 is used for substrate and 1.6 mm thickness is used for the substrate of the antenna. The substrate and ground size has been considered as 70 mm x 70 mm.

Keywords: Microstrip Patch Antenna, Coaxial Probe, Parasitic Elements, HFSS.

I. INTRODUCTION

This method is chosen to investigate how the Parasitic Patch configuration [1-4] can improve the bandwidth of a typical microstrip antenna. In such type of antenna design, patches are placed near the edges of the original patch. These new placed patches may be coupled to the main patch electro-magnetically or through the direct coupling technique. Each patch can be designed in a similar manner to the original patch. The lengths of the parasitic patches will determine their resonant frequency and their width will determine the bandwidth they display at resonance.

In this project we also use four parasitic patches to enhance the bandwidth of antenna. Two patches are along radiating side and other two are along non-radiating side. Dimension of both sides of parasitic patches is same. Active patch has greater length and width than other four patches. Patch along non-radiating side has smaller dimension than others. Basic design of antenna with parasitic elements is shown in Fig. 1.

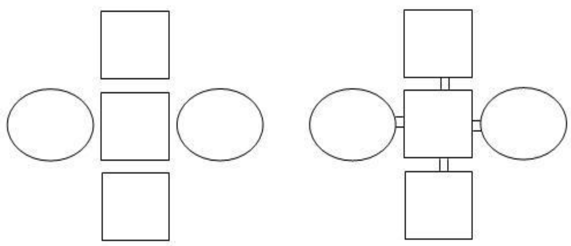

Fig. 1 Basic design of microstrip patch antenna with four parasitic patches

Broadband Gap-Coupled Slot Cut Rectangular Microstrip Antennas: A Review

The broadband microstrip antenna (MSA) is more commonly realized by using multi-resonator gap-coupled technique or by cutting the slot inside patch of the antenna. The gap-coupled configuration increases the antenna size whereas inserting a slot in patch maintains the low profile nature of the antenna and also increases the bandwidth.

Such type of antenna is realized by fabricating the patch on lower dielectric constant thicker substrate. However for substrate thickness (h) more than $0.04\lambda 0$, the bandwidth (BW) is limited by the feed probe inductance. For h > 0.06λ0, the BW is increased by using proximity feeding technique. The BW is also increased by using multi-resonator gap-coupled configurations. However this method increases the antenna size. More commonly the antenna BW is increased by cutting the slots of shapes like, V-slot, U-slot, and rectangular slot at an appropriate position inside the patch. The slot is said to introduce a mode near the fundamental mode of the patch and yields larger BW. In most of the reported designs the slot length is either taken equal to half wave or quarter wave in length at the desired slot frequency. The gain of the antenna is increased by using the gap-coupled configurations or by using the arrays of the individual patch elements. The broadband E-shaped MSA is realized by cutting the pair of rectangular slots on one of the radiating edges of the patch.

In the reported design the slot length is assumed to be nearly quarter wave in length. In this paper, broadband proximity fed E-shaped MSA [2] is discussed. The E-shaped MSA gives a bandwidth of nearly 350 MHz with broadside radiation pattern with gain of more than 7 dBi over the VSWR BW. Further a gap-coupled configuration of parasitic rectangular MSAs (RMSA) with an E-shaped MSA is proposed. This configuration gives a BW of more than 450MHz at centre frequency of around 1000 MHz. The proposed antenna gives broadside radiation pattern with peak gain of nearly 9 dBi. Further increase in the BW of above gap-coupled configuration is realized by cutting the pair of rectangular slots along the non-radiating edges of the gap-coupled RMSAs. This configuration gives a BW of more than 550 MHz at centre frequency of 1000 MHz. The radiation pattern is in the broadside direction with peak gain of more than 9 dBi. All these configurations have been first analyzed using IE3D software followed by experimental verifications. The dimensions of the individual patches were optimized such that they cover 800 – 1200 MHz frequency band. The air substrate is used to maximize the radiation efficiency and gain. In the measurements the antennas were fabricated using copper plate and were suspended in air using the foam spacer support placed towards the antenna corners. The antenna is fed using N-type connector of 0.32 cm inner wire diameter. The measurement was carried out using R & S vector network analyzer. Since an infinite ground plane is used in the measurements, a larger square ground plane of side length 80 cm (2.67λ0) is used in the measurements. The radiation pattern was measured in minimum reflection surrounding with the required minimum far field distance between the reference antenna and the antenna under test. The antenna gain was measured using three antenna method.

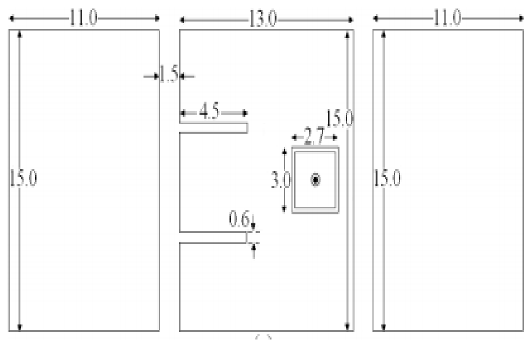

Fig. 2 Proximity fed E-shaped MSA gap-coupled to pair of slot cut RMSA

II. ANTENNA DESIGN

In first step, a simple rectangular patch antenna has been designed to resonate at 5.24 GHz by using the standard equations [6]. In next step, two elliptical shaped patches along radiating sides of patch are designed as a result bandwidth is increased. In last step, another two rectangular shaped patches are designed along non-radiating sides of the patch. Impedance bandwidth is increased up to 1.30 GHz. Coaxial probe feed technique is used. Top view of antenna has been shown in Fig. 3.

Table 1 shows the optimized parameters of the patch and the antenna.

TABLE 1: DIMENSIONS OF THE PATCH ANTENNA

Parameters	Dimension (mm)
L_{SUB}	70
W_{SUB}	70
L	15.55
W	19.66
L_1, L_2	14.5
W_1, W_2	17
R_1, R_2	8
r_1, r_2	6.15

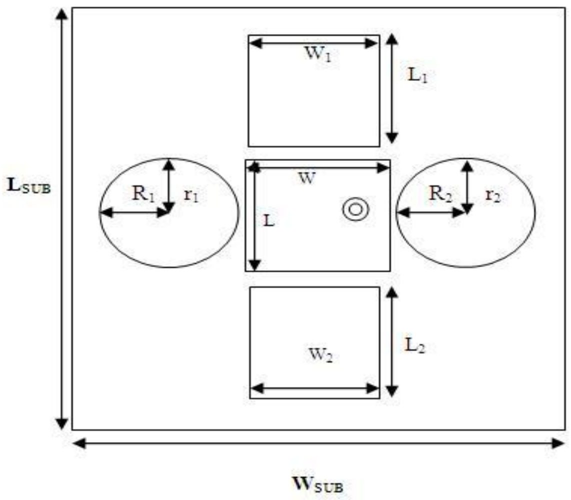

Fig. 3 Top view of patch antenna with parasitic elements

III. SIMULATED RESULTS OF THE OPTIMIZED ANTENNA

In this section, simulated results of the optimized antenna have been presented

Return Loss Plot

Fig 4 shows the S_{11} parameters or Return loss of the microstrip patch antenna with parasitic elements. The return loss is considered below -10 dB. As shown in Fig. 4 the proposed antenna has been resonant on 5.24 GHz having the return loss of -28.21 dB. The bandwidth of the antenna is a range of frequencies over which the return loss is greater than -10 dB. Thus from the Fig. 4 the return loss below -10 dB is started from 5.13 to 6.44 GHz, the bandwidth of the optimized antenna is 1.3096 GHz.

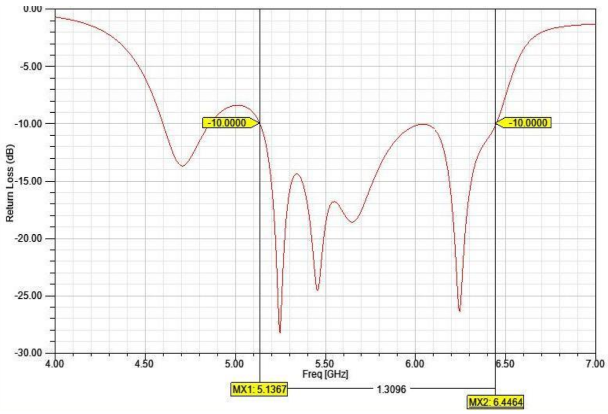

Fig. 4 Return loss plots for optimized antenna

Radiation Patterns

Radiation Pattern represents the power distribution of antenna radiation. It can be in omnidirectional which means it spreads the power in all directions. The radiation pattern can be shown in Fig. 5 at 5.80 GHz frequency. It is omnidirectional in shape. The maximum gain of 10.01 dB has been obtained.

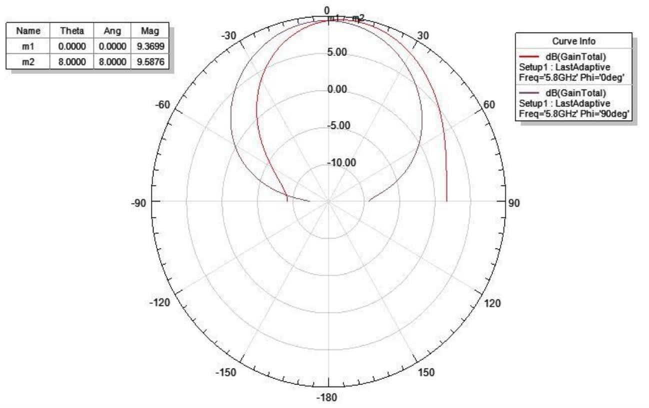

Fig. 5 E-plane and H-plane radiation pattern at 5.8 GHz

VSWR

Voltage Standing Wave Ratio (VSWR), which can be derived from the level of reflected and incident waves, is also an indication of how closely or efficiently, an antenna's terminal input impedance is matched to the characteristic impedance of the transmission line. The VSWR is always a positive and real number. Increasing in VSWR indicates an increase in the mismatch between the antenna and the transmission line. Practically, the VSWR must lie between 1 and 2 which shows in fig. 6 for the proposed antenna.

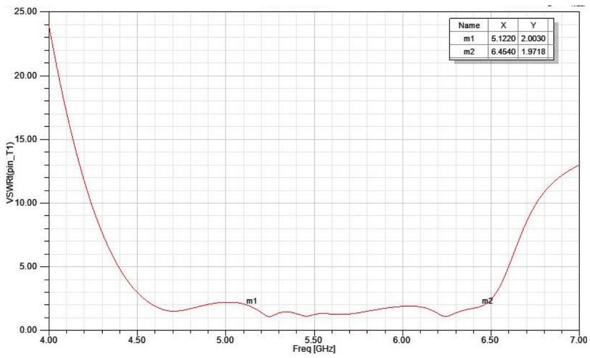

Fig. 6 VSWR v/s Frequency curve

IV.CONCLUSION

A simple patch antenna with parasitic elements fed by coaxial probe feed has been presented. The RT/duroid 5880 material has been used as the substrate of the antenna. Four parasitic elements (two rectangular and two elliptical) are used to enhance the bandwidth. The proposed antenna is resonating from 5.13 GHz to 6.44 GHz resulting in bandwidth of nearly 1.30 GHz. The maximum gain of the proposed antenna is around 10.01 dB. The proposed antenna is useful for higher speed wireless devices. HFSS software is used to simulate the antenna.

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