A Design of Square Micro Strip Antenna for Microwave Communication System

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Abstract— A novel design of square micro strip antenna comprising right angle equal arm inverted slot on the patch and in the ground plane is presented for dual band operation. The magnitude of lower and upper operating band is found to be 15.60% and 44.94% respectively. The upper operating band is enhanced to 63.15% by loading parasitic strip around the patch without changing the nature of radiation characteristics. The design concepts of antennas are presented and experimental results are discussed. The proposed antennas may find applications in microwave communication systems.

Key words: Right Angle Slot, Parasitic Strip, Dual-Band

I. INTRODUCTION

The microstrip antenna (MSA) consists a very thin metallic strip or patch over a substrate. The thickness of the substrate is very small as compared to the free space wavelength λ_0. The substrate is placed only a small fraction of free space wavelength above the ground plane. On the substrate a conducting patch of required geometry is designed. The substrate in between conducting patch and the ground plane is a dielectric sheet. In general, the number of different dielectric substrates can be used in the microstrip antenna. The value of the dielectric constant typically varies in the range of $2.2 \leq \varepsilon_r \leq 12$ for the microstrip antenna. The dielectric constant for the thick substrate is at the lower end of the range. It provides better antenna parameters hence the thick substrate are most desirable. On the other hand, the dielectric constants are higher for the thin substrates and they are less efficient and relatively less raggedness. The thin substrates are useful to get smaller size of the antenna. There are various shapes of MSAs such as rectangular, circular, square, triangular etc. are available for the use at microwave communication system [1]. Compared to conventional microwave antennas, MSAs have several advantages, such as lightweight, low volume, planar configuration, low fabrication cost, low scattering cross-section, etc. However, the main disadvantage is their narrow bandwidth [1]. So many methods are presented in the literature to increase bandwidth such as use of slot loading [2], aperture coupled [3], parasitic elements [4] etc. Further, the dual band antennas are more useful as their each operating band can be used independently for transmit/receive applications. The dual band antennas are designed by many methods. But in this presentation a simple concept has been used to achieve the dual band operation by loading slot on the square patch and parasitic strip around it to enhance the operating band of antenna without changing the nature of radiation characteristics. This kind of study is found rare in the literature.

II. DESCRIPTION OF ANTENNA GEOMETRY

The artwork of proposed antennas is designed by using the equations available for the design of square microstrip antenna [5, 1] and is sketched using computer software Auto CAD–2006 to achieve better accuracy. The antennas are fabricated using photolithography process on low cost glass epoxy substrate material of thickness h = 3.2 mm and dielectric constant ε_r = 4.2.

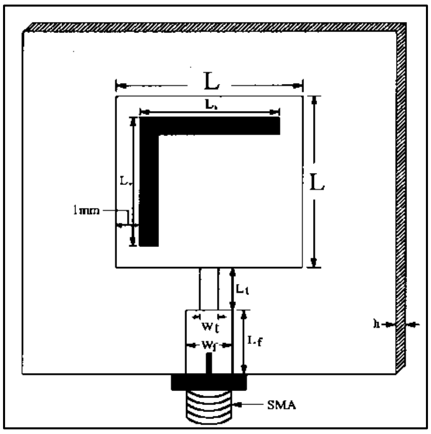

Fig. 1: Geometry of RSSMA

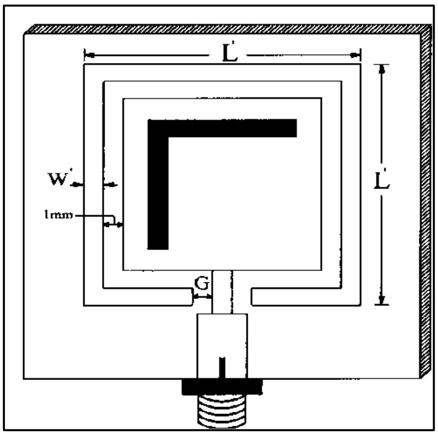

Fig. 2: Geometry Of RSPSMA

Fig. 1 shows the geometry of right angle equal arm inverted slot loaded square microstrip antenna (RSSMA). The length and width of RSSMA is L. The right angle equal arm inverted slot is placed on the square patch and replica in the ground plane at a distance of 1mm from the edge of the square patch. The dimensions of slots are taken in terms of λ_o, where λ_o is the free space wavelength in cm. The length L_h and L_v are taken as λ_o/6. The width of inverted L-slot is 1mm. The antenna is fed by using microstripline feeding. This feeding has been selected because it is simple in design and can be simultaneously fabricated along with the antenna element. A quarter wave transformer of dimensions L_t, W_t is used for better impedance matching between microstripline feed of dimension L_f and W_f of the square microstrip patch. At the tip of microstripline feed a 50 Ω coaxial SMA connector is used for feeding the microwave power.

Fig. 2 shows the geometry of right angle equal arm inverted slot loaded parasitic square microstrip antenna (RSPSMA) is constructed from Fig. 1 by placing parasitic strip around the square patch and by removing the slot used on the ground plane. The length L′ and width W′ of parasitic element is λo/3 and λo/32 respectively. The gap G between the edges of the square parasitic strip from the quater wave transformer is 1mm.The feed arrangement of this antenna remains same as that of Fig. 1. Design parameters of proposed antennas are as shown in Table 1.

III. EXPERIMENTAL RESULT

The bandwidth over return loss less than −10 dB for the proposed antennas is measured on Vector Network Analyzer (Rohde & Schwarz, Germany make ZVK model 1127.8651). The variation of return loss versus frequency of RSSMA is as shown in Fig. 3. From this figure it is seen that, the antenna resonates for two bands of frequencies BW_1 and BW_2. The magnitude of each operating band is found to be 15.60% and 44.94% respectively which is determined by using the equation (1),

$$BW_1(\%) = \left[\frac{f_2 - f_1}{f_c}\right] \times 100 \qquad (1)$$

Where, f_1 and f_2 are the lower and upper cut-off frequencies of the band respectively, when its return loss becomes −10 dB and f_c is the centre frequency between f_1 and f_2. The obtained dual bands are due to the fundamental resonance of the patch and right angle inverted slot on the patch and in the ground plane [6].

The variation of return loss versus frequency of RSPSMA is as shown in Fig. 4. From this figure it is seen that, again the antenna resonates for two bands of frequencies BW_3 and BW_4 with a corresponding bandwidth of 10.65% and 63.15% respectively. It is clear from this figure that, by using parasitic strip around the patch, the BW_4 increases from 44.94% to 63.14% and BW_3 decreases from 15.60% to 10.65% when compared with BW_2 and BW_1 of Fig. 1 respectively. Fig. 5 and 6 shows the co-polar and cross-polar radiation pattern of RSSMA measured at 11.05 GHz and RSPSMA measured at 10.44 GHz respectively. From these figures it is clear that, the pattern are broadsided and linearly polarized.

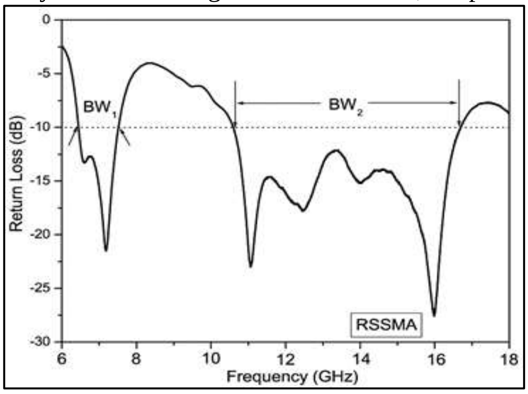

Fig. 3: Variation of return loss verses frequency of RSSMA

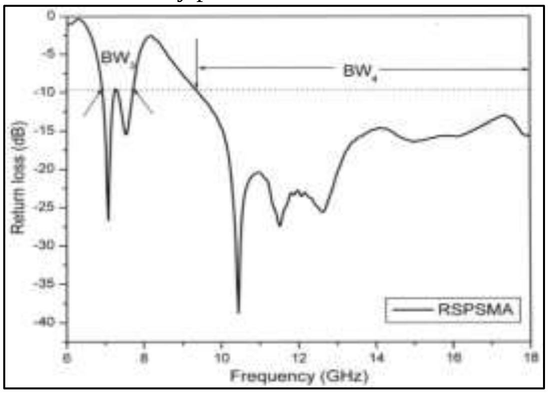

Fig. 4: Variation of return loss verses frequency of RSPSMA

The gain of the proposed antennas is measured by absolute gain method. The power transmitted 'P_t' by pyramidal horn antenna and power received 'P_r' by AUT (antenna under test) are measured independently. With the help of these experimental data, the gain (G) dB of AUT is calculated by using equation,

$$(G)\ dB = 10\log\left(\frac{P_r}{P_t}\right) - (G_t)\ dB - 20\log\left(\frac{\lambda_0}{4\pi R}\right) dB \qquad (2)$$

Where, G_t is the gain of the pyramidal horn antenna and R is the distance between the transmitting antenna and the AUT. Using (2), the maximum gains of RSSMA and RSPSMA are found to be 9.69 and 9.78 dB respectively, measured in their upper bands.

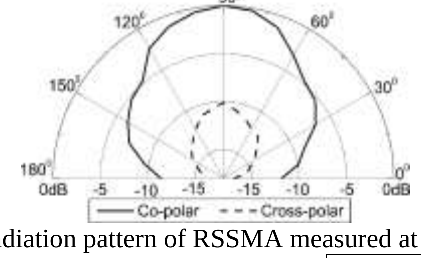

Fig. 5: Radiation pattern of RSSMA measured at 11.05 GHz

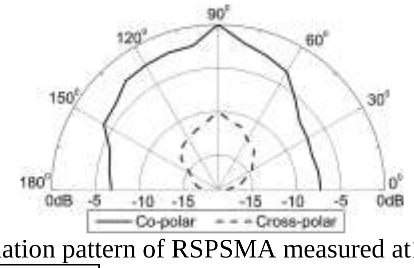

Fig. 6: Radiation pattern of RSPSMA measured at10.44 GHz

Antenna Parameters	Dimension in mm
h	3.2
L	7.6

L_h	5.3
L_V	5.3
W_f	6.3
L_f	4.0
W_t	1.0
L_t	4.1
W′	1.0
L′	11.6
G	1.0

Table 1: Design Parameters Of Proposed Antennas

IV. CONCLUSIONS

From the detail experimental study it is concluded that, the novel design of right angle inverted slot loaded square microstrip antenna, i.e. (RSSMA) is quite capable in producing dual band operation. Further, the upper operating band can be enhanced to 63.12% by incorporating parasitic strip around the square patch without changing the nature of radiation characteristics. This technique also increases the gain from 9.69 to 9.78 dB when compared to the gain of RSSMA. The proposed antennas are simple in their design and fabrication and they use low cost substrate material. These antennas may find applications in microwave communication systems.

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