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A Novel Design and Development of Multiband Corner Truncated Square Microstrip Antenna

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ABSTRACT: This paper presents a novel design of slot loaded corner truncated square microstrip antenna for multiband operation realized from conventional square microstrip antenna (SQMA). The enhancement of bandwidth of conventional SQMA is achieved by truncating its corners. Further, this single band can be converted into multibands by changing the substrate thickness from 0.16 cm to 0.32 cm and by placing unequal vertical slots on the patch and on the ground plane. Realization of multibands does not affect nature of broadside radiation characteristics. Truncating the corners of square patch makes the antenna compact in the size. Details of the antenna design are presented and experimental results are discussed. The multiband antenna works for the frequency ranges of 8 GHz to 24 GHz and find applications in short-range tracking, missile guidance, mapping, marine radar, airborne intercept, high resolution mapping, and satellite altimetry.

Key wards: Single band, multiband, corner truncated, square microstrip antenna

I. INTRODUCTION

The design and development of microstrip antennas (MSAs) are the most important task in microwave communication systems to achieve the desired radiation requirements. Among the various types of microwave antennas, the MSAs have gained a special attraction over other microwave antennas because of their significant applications in microwave communication systems. For the design of MSAs many techniques are available in the literature. The antennas capable of operating for single, dual and multi frequency bands are constructed mainly by using rectangular, triangular, circular patch geometries. But multiband antennas constructed using truncated slotted square patch is found to be rare in the literature. Truncating the corner of the square patch also reduces the overall size of antenna to a greater extent.

II. DESIGNING

The artwork of the proposed antennas is sketched by using computer software Auto-CAD to achieve better accuracy and are fabricated using low cost glass epoxy substrate material of thickness h = 0.16 cm and permittivity $\varepsilon_r = 4.2$.

Fig.1 shows the geometry of conventional SQMA. This is designed for the resonating frequency of 9.4 GHz. The side length of square patch is L = 0.7630 cm. 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 length $L_t = 0.41$ cm and width $W_t = 0.31$ cm is used for better impedance matching between microstripline feed of length $L_f = 0.42$ cm, width $W_f = 0.05$ cm and center point (Cp) along the length of the square microstrip patch. At the tip of microstripline feed a 50 Ω coaxial SMA connector is used for feeding the microwave power. The corner truncated square microstrip antenna (CSQMA) shown in Fig.2 is constructed from Fig. 1 by truncating all the four corners of SQMA with Ls = Ws = 0.2 cm which is equal to $\lambda o/15$, where λo is the free space wavelength in cm corresponding to the design frequency of 9.4 GHz.

Further, the study is carried out by changing thickness of the substrate from 0.16 cm to 0.32 cm and by placing three pairs of unequal vertical length slots on the patch and on the ground plane of CSQMA shown in Fig. 2.

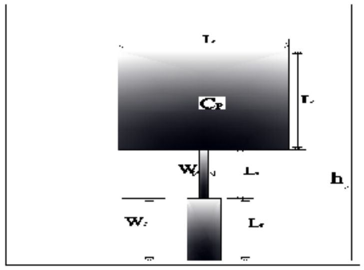

Fig.1. Geometry of conventional SQMA.

This antenna is name as slot loaded corner truncated square microstrip antenna (SCSQMA). When the thickness changes the dimension of square patch remains same [Johan,2006]. However, the dimensions of feed arrangement shown in Fig. 1 changes [kai-Fong,1997], the new values are L'_t = 0.41 cm, W'_t = 0.10 cm and L'_f = 0.40 cm, W'_f = 0.63 cm. The length of the first, second and third slot are 0.31 cm, 0.26 cm and 0.21 cm, which are equal to λ_o /10, λ_o /12 and λ_o /15 respectively.

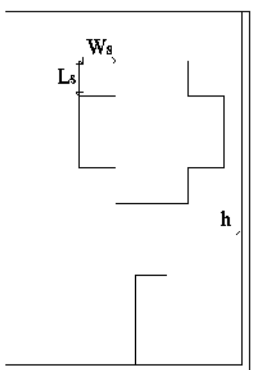

Fig. 2. Geometry of CSQMA.

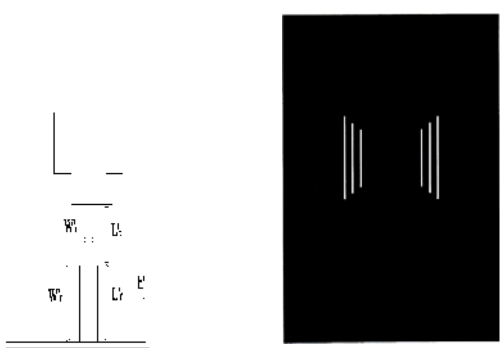

Fig. 3 (a) Fig. 3 (b)

Fig. 3(a) Top view geometry of SCSQMA (b) Bottom view geometry of SCS.

The gap between the pair of slots and from the side edge of square patch is 0.025 cm. The slot used on the top surface of SCSQMA is also used on the bottom surface i.e in the ground plane. The top and bottom view geometry of SCSQMA is as shown in Fig. 3 (a) and (b) respectively.

III. EXPERIMENTAL RESULTS

The bandwidth over return loss less than -10dB 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 conventional SQMA is as shown in Fig. 4. From this figure it is seen that, the antenna resonates for single band of frequency BW_1. The magnitude of BW_1 is found to be 5.11%, which is determined by using the equation,

$$\text{Bandwidth } (\%) = \left[\frac{f_2 - f_1}{f_r}\right] \times 100$$

where, f_1 and f_2 are the lower and upper cut-off frequencies of the band respectively, when its return loss become -10dB and f_r is the centre frequency between f_1 and f_2. Fig. 5 shows the variation of return loss versus frequency of CSQMA. It is clear from this figure that, by truncating all four corners of CSQMA the bandwidth increases from 5.11% to 7.80%, which is 1.52% times more than the bandwidth of conventional SQMA [Gye-teck,2006] and the copper area of the radiating patch is reduced by 27.48% when compared to the area of conventional SQMA.

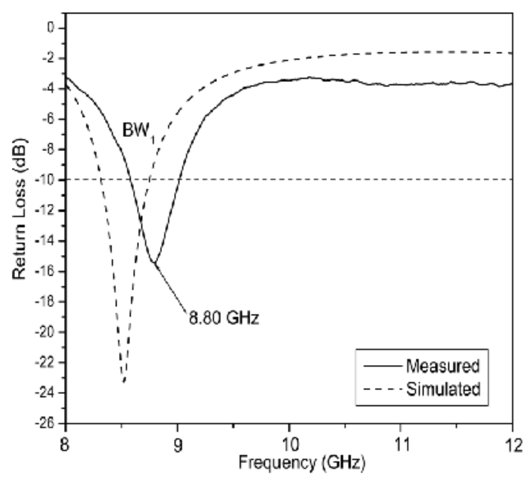

Fig. 4. Variation of return loss versus frequency of SMSA.

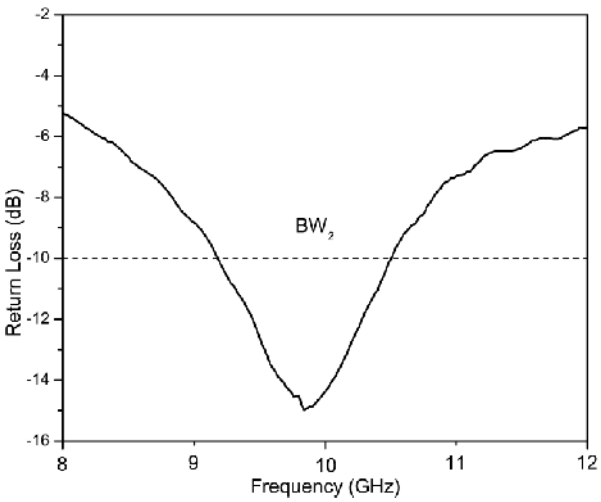

Fig. 5. Variation of return loss versus frequency of CSQMA.

The variation of return loss versus frequency of SCSQMA is as shown in Fig. 6. From this figure it is seen that, the antenna resonates for multi band of frequencies BW_3, BW_4, BW_5, BW_6 and BW_7 with a corresponding bandwidth of 5.93%, 28.46%, 2.9%, 2.44% and 3.69% respectively. The multi bands effect is due to changing the thickness of the substrate and by placing the slots on the patch and in the ground plane of CSQMA [Jui Han Lu,1999].

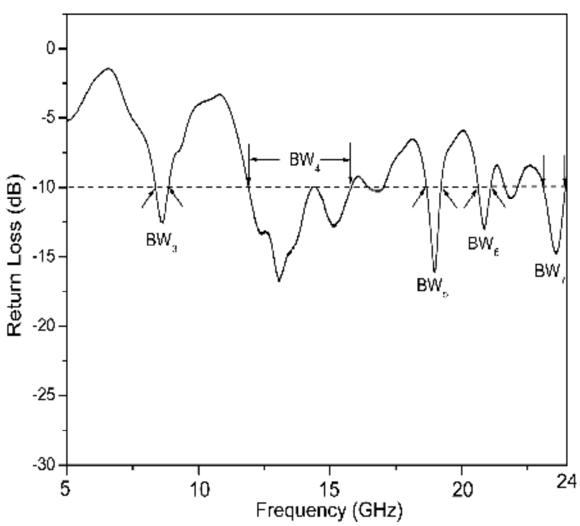

Fig. 6. Variation of return loss versus frequency of CSQMA.

Fig. 7, 8 and 9 shows the co-polar and cross-polar radiation pattern of conventional SQMA CSQMA and SCSQMA measured in their operating frequency BW_1, BW_2 and BW_4 at 8.80GHz, 9.91GHz and 12.5 GHz respectively. It is clear from these figures that, the patterns are broad sided and linearly polarized.

Hence realization of multiband operation from conventional SQMA does not change the nature of broadside radiation characteristics. The gain of the proposed antennas is measured by absolute gain method and the maximum gain of conventional SQMA, CSQMA and SCSQMA are found to be 4.83 dB, 5.67 dB and 9.78 dB.

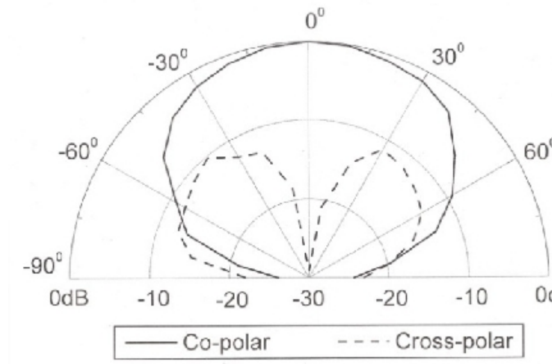

Fig. 7. Radiation pattern of conventional SQMA measured at 8.80 GHz.

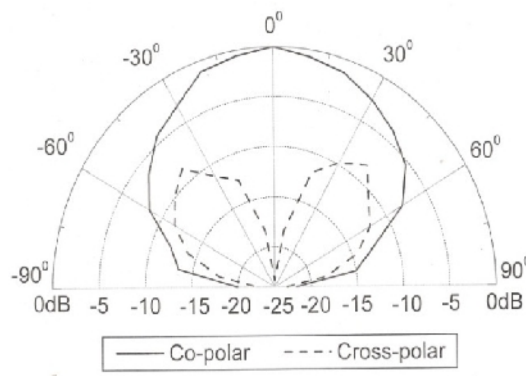

Fig. 8. Radiation pattern of CSQMA measured at 9.91 GHz.

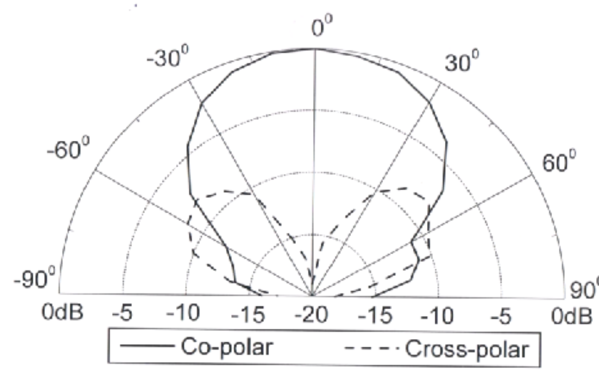

Fig. 8. Radiation pattern of SCSQMA measured at 9.91 GH.

IV. CONCLUSION

From the detailed experimental study it is concluded that, by truncating the corners of conventional SQMA i.e. CSQMA the antenna enhances the bandwidth of conventional SQMA from 5.11% to 7.80%. The antenna uses less copper area of 27.48% when compared to the copper area of conventional SQMA. Further by placing three pairs of unequal vertical length slots on the patch and in the ground of SCSQMA, the antenna converts single band to multi bands without changing the nature of broadside radiation characteristics. The proposed antenna operates between the frequencies range of 8 GHz to 24 GHz. The proposed antenna is simple with geometry and constructed using low cost substrate material. These antennas may find applications in short-range tracking, missile guidance, mapping, marine radar, airborne intercept, high resolution mapping and satellite altimetry.

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