NOVEL WIDE SLOT MICROSTRIP ANTENNA WITH FINITE GROUND PLANE FOR 6 GHZ TO 16GHZ

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Abstract—*In this paper, the design of a novel wide slot micro strip antenna for wideband application is discussed and presented. The bandwidth enhancement of the antenna is achieved by cutting one small circular slot and four wide slots on the patch plane and is named as one small circular slot and four wide slots micro strip antenna (1SCS4WSMA). The bandwidth of the antenna is from 6.5 to 16.55 GHz representing over five different frequencies. In addition, the design has been a planar profile and it can easily be integrated in small mobile units; besides, it also can be in the laptops or various remote-sensing devices etc. The design procedure and practical results are presented and discussed.*

Keywords—Circular;Frequency; Wideband; Bandwidth; Network; Photolithography

1. INTRODUCTION

Microstrip antennas can be divided into two basic types by structure, namely microstrip patch antenna and microstrip slot antenna. Recently, most of the research on microstrip antennas focused on methods to increase their bandwidth. Slot antennas exhibit wider bandwidth, lower dispersion and lower radiation loss than microstrip antennas, and when feeding by a coplanar waveguide they also provide an easy means of the parallel and series connection of active and passive elements that are required for improving the impedance matching and gain [1]. The U-slot antenna, which achieves a relatively broad bandwidth without a parasitic patch, has been reported [2]. A lot of slot antennas for enhancing impedance bandwidth have been investigated [3–5]. A broader bandwidth, obtained using an improved feeding method, has also been reported [6]. It is very important to choose a suitable feeding circuit since it controls the antenna performance in terms of bandwidth.

In this paper, a novel design of microstrip slot antenna with a finite ground plane for the desired band of wireless band (6 GHz - 16 GHz) is studied. This design of the proposed antenna is different from that of the other slot antennas to enhance impedance bandwidth [8-12], and is successfully implemented. From experimental results, the proposed antenna shows that geometries can affect significant increase in the impedance bandwidth obviously and, with respect to 10-dB impedance, the widest band obtained are different or different resonant frequencies.

2. DESIGN & REALIZATION

The configuration of the conventional rectangular microstrip antenna (RMA) and one small circular slot and four wide slots microstrip antenna (1SCS4WSMA) is as shown in Fig. 1 and Fig .2. The antenna has compact dimension in length and width (L x W) of the patch (18.99 x 26.92 mm). The length and width of quarter wave transformer (Lt x Wt) is (10.18 x 0.66 mm). The length and width of feed line (Lf x Wf) is (10.19 x 3.35 mm) keeping other dimensions unchanged, a 50ohm microstrip feed line, a small and a finite ground plane Lg x Wg = 35mm X 35mm. Where the etched portion which is radiating element and the 50ohm microstrip feed line is planar with place in the back ground plane and is printed on the substrate glass epoxy material of thickness 1.6mm and relative permittivity 4.4. This microstrip line feed is designed to be 50 ohms in order to match the characteristic impedance of transmission line.

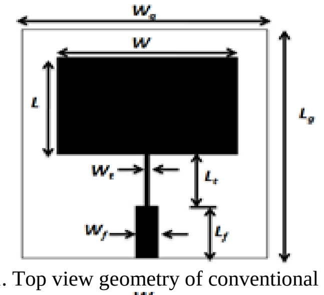

Fig.1. Top view geometry of conventional RMA

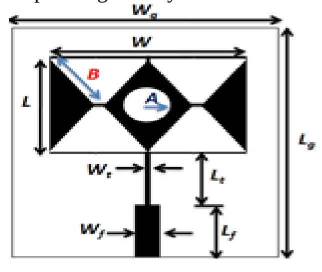

Fig.2. Geometry of 1SCS4WSMA

The dimension of the slots are taken in terms of λ0, where λ0 is the free space wavelength corresponding to the designed frequency of conventional RPA i.e. 3.5 GHz. The radius (R) of the circular slot is 6.89 mm and side length B = 13.46mm for 1SCS4WSMA.

3. MEASUREMENTS AND DISCUSSION

The designs are analyzed on Agilent Technologies E8363B Network Analyzer (10MHz – 40GHz). According to the above-mentioned and obtained design values, the return loss curves, smith chart and VSWR plot are studied. The variation of return loss verses frequency of RMA is as shown in Fig. 3. From the figure it is clear that, the antenna resonates at fr1 = 3.7 GHz of frequency which is close to the designed frequency of 3.5 GHz and hence validates the design. From this graph, the experimental impedance bandwidth is calculated using the formula,

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

Where, f2 and f1 are upper and lower cut-off frequencies of the band respectively when its return loss reaches −10 dB and fc is the centre frequency between f1 and f2. The bandwidth of conventional RPA is found to be BW1 = 2.06 %. Fig. 4 shows the variation of return loss verses frequency of 1SCS4WSMA. The antenna resonates for five different bands with resonant frequencies of fr1 = 7.23 GHz, fr2 = 11.52 GHz, fr3 = 12.57 GHz, fr4 = 14.14 GHz and fr5 = 15.75 GHz with corresponding impedance bandwidths of BW1 = 3.2 % for RL = -11 dB, BW2 = 9.1 % for RL = -22.38 dB, BW3 = 15 % for RL = -14.01dB, BW4 = 19 % for RL = -18.78 dB and BW5 = 27 % for RL = -39.60 dB respectively.

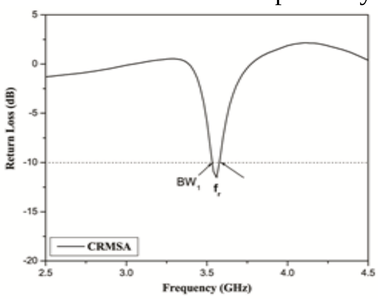

Fig. 3. Variation of return loss Vs frequency of conventional RPA

Fig.5 shows the smith chart plot of 1SCS4WSMA and is quite clear that the resonant frequency points are near to the centre impedance point 1 which validates better matching characteristics between input and load.

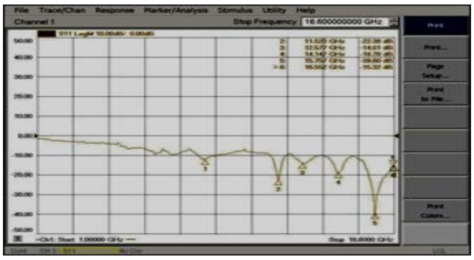

Fig. 4. Variation of return loss verses frequency of 1SCS4WSMA

Fig.6 shows the measured VSWR of 1.17, 1.49, 1.26, 1.02 and 1.42 at respective resonant frequencies of 1SCS4WSMA which are less than 1.5 signifying less reflected power back towards the feed.

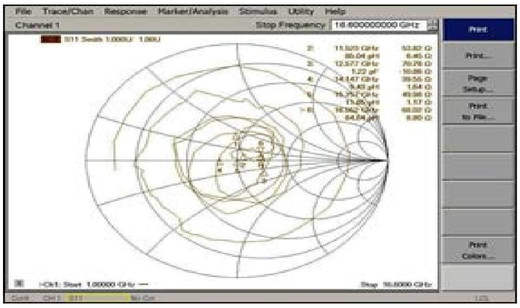

Fig. 5. Smith chart plot of 1SCS4WSMA

Fig.6. VSWR plot of 1SCS4WSMA

4. CONCLUSION

This study provided an insight in determining the performance of microstrip antenna fabricated on glass epoxy substrate. From the results presented it is observed that glass epoxy substrate can be used for X, Ku-band antenna designs. A microstrip-line-fed multi-frequency microstrip antenna with a one circular slot and four wide slots on a finite ground plane are design constraints for use in wireless applications such as wireless local area network (WLAN). A novel low-profile RMA antenna has also been presented with experimental results. The maximum improvement in bandwidth is 27% for RL= -36.90 dB.

5. ACKNOWLEDGMENT

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REFERENCES

[1] Wong, K.-L., Compact and Broadband Microstrip Antennas, John Wiley and Sons Inc., New York, NY, 2002.

[2] Lee, K. F., et al., Experimental and simulation studies of the coaxially fed U-slot rectangular patch antenna," IEE Proceedings | Microwave Antennas and Propagation, Vol. 144, No. 5, 354-358, 1997.

[3] Kahrizi, M., T. K. Sarkar, and Z. A. Maricevic, Analysis of a wide radiating slot in ground plane of a microstrip line," IEEE Trans. Microwave Theory Tech., Vol. 41, 29-37, Jan. 1993.

[4] Tong, K.-F., K.-M. Luk, K.-F. Lee, and R. Q. Lee, A broad-band U-slot rectangular patch antenna on a microwave substrate," IEEE Trans. Antennas Propagat., Vol. 48, 954-960, Jun. 2000.

[5] Chen, H.-D., Compact circularly polarized microstrip antenna with slotted ground plane,"Electron. Lett., Vol. 38, Jun. 20, 2002.

[6] Mak, C. L., K. M. Luk, and K. F. Lee, Microstrip line-fed L-strip patch antenna," IEE Proceedings, Microwave Antennas and Propagation, Vol. 146, No. 4, 282-284, 1999.

[7] Wong, K.-L., C. H. Wu, and S. W. (Stephen) Su, Ultra wide-band square metal-platemonopole antenna with a trident-shaped feeding strip," IEEE Trans. Antennas Propagat., Vol. 53, No. 4, 1262-1269, Apr. 2005.

[8] Lin, X.-C. and L.-T. Wang, A broadband CPW-fed loop slot antenna with harmonic control,"Antennas and Wireless Propagation Letters, Vol. 2, 323-325, 2003.

[9] Chen, H.-D., Broadband CPW-fed square slot antennas with a widened tuning stub," IEEE Trans. Antennas Propagat., Vol. 51, 1982-1986, Aug. 2003.

[10] Leung, K. W. and C. K. Leung, Wideband dielectric resonator antenna excited by cavity- backed circular aperture with microstrip-line tuning fork," Electron. Lett., Vol. 39, 1033{1035, Jul. 10, 2003.

[11] Sze, J.-Y. and K.-L. Wong, Bandwidth enhancement of a microstrip-line-fed printed wide-wide-slot antenna," IEEE Trans. Antennas Propagat., Vol. 49, 1020-1024, Jul. 2001.

[12] Chiou, J.-Y., J.-Y. Sze, and K.-L. Wong, A broad-band CPW-fed strip-loaded square slot antenna," IEEE Trans. Antennas Propagat., Vol. 51, 719-721, Apr. 2003.