P. A. Ambresh, P. M. Hadalgi, P. V. Hunagund / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 3, May-Jun 2012, pp.1166-1168

Single-feed Compact Ring Slot Patch Antenna for S-band Applications

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ABSTRACT
The single-feed design of compact microstrip patch antenna with a rectangular ring slot has been demonstrated and results are presented. Simply by inserting a narrow slot of proper length and width on the patch surface, a bandwidth of 330 MHz (9.04 %) with a gain of 2.93 dB is achieved. Results also indicate that, at fixed operating frequency, the proposed design has good omni-directional radiation characteristics by the use of single probe feed technique with a reduced antenna size of about 10 % compared to simple microstrip patch antenna.

Keywords: **single feed; compact; bandwidth; omni-directional**

I. INTRODUCTION
Patch antennas have become very important in modern communication systems that are used in different applications. Microstrip antennas, such as microstrip patch and slot antennas are found attractive for use in many applications because they are lightweight, low profile, conformable and easy to integrate with monolithic microwave integrated circuits (MMICs). Along with the above mentioned advantages, the reduced antenna size that is compactness [4-9] of microstrip patch antenna (MPA) is also increasingly essential demand in many practical applications. Ring-slot antennas, which have a better bandwidth than microstrip patch antennas, have also been developed [1–3].

The design of compact multimode patch antennas for application in medium size MIMO terminals combining spatial and radiation pattern diversity is given [10] and the design obtained 2.5 % bandwidth. A novel technique for obtaining a single-layer single-feed dual frequency rectangular microstrip antenna with protruding semi ellipse for S-band communication is proposed and demonstrated [11] and it attained a bandwidth of 6.32 %. A novel zeroth-order resonant (ZOR) antenna on vialess coplanar waveguide is presented and attained a bandwidth of 6.8 % [12]. A planar triple-frequency antenna developed to quad-frequency shorted MPA at frequencies 0.9, 1.8, 2.4, and 5.4 GHz has been studied [13] and this design has achieved a bandwidth of 12 MHz. This paper presents the use of slot on the patch surface which provided improved bandwidth characteristics of 330 MHz that is about 9.04 % with a moderate gain suitable for S-band applications. The details of the antenna structure and results are also provided.

II. ANTENNA STRUCTURE AND RESULTS
The structure of the proposed antenna supported on a ground plane by the use of plastic spacers is shown in Figure 1. The rectangular patch is fabricated on FR4 dielectric material having thickness h = 0.16 cm and has dimensions in length L = 17.76 mm and width W = 23.28 mm. Patch also consists of the ring slot with dimensions L_1 = 6 mm, W_1 = 6 mm as shown in Figure 2. The use of ring slot is to achieve the improved bandwidth, gain and compact characteristics compared to simple microstrip patch antenna. The ground plane used in this design is a copper plate with thickness h_1 = 1.6 mm having dimensions L_g = W_g = 40 mm and is placed at a distance Δ = 8.5 mm below the superstarte as shown in Figure 1.

For good impedance matching, probe feeding technique is used. The characteristics of the antenna are sensitive to the antenna design parameters L, W, Δ. And, in this case, the proposed antenna leads to impedance matching in a wide-frequency band with moderate gain characteristics. The patch is energized through single feed (probe feeding technique) and the feed point is placed along the centre line of Y-axis at a distance f_p = 4.2 mm. All the fabricated patch antenna and slot dimensions are the functions of λ_0, where λ_0 is the operating wavelength.

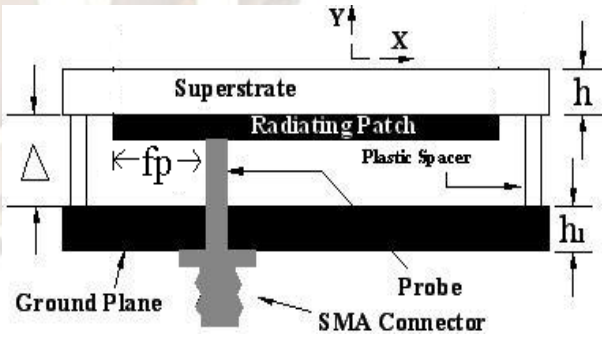

Fig. 1 View of proposed antenna

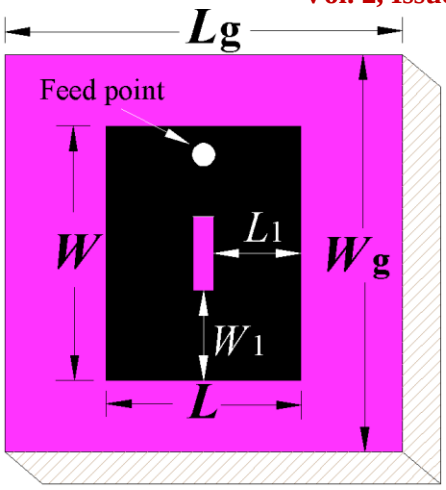

Fig. 2 Ring slot patch antenna

The return loss (RL) and VSWR characteristics of the proposed antenna are measured on Vector Network Analyzer (Rohde and Schwarz, Germany make ZVK model 1127.8651) and the far-field patterns are measured inside the available laboratory range. A FR- 4 dielectric material, which can be purchased at a much lower price, is used instead of expensive substrates. Although the use of a high relative permittivity (ϵ_r = 4.4) substrate usually restricts the operation bandwidth, the experimental bandwidth (with 3.65 GHz center frequency) is approximately 330 MHz (9.04 %) covering frequency range 3.48 – 3.81 GHz for return loss (RL) less than -10 dB with single resonance characteristics. The return loss versus frequency diagram is as shown in Figure 3. The patch antenna incorporated with the ring slot introduces a capacitance that suppresses some of the inductance introduced by the feed due to the thick substrate, and a single resonance of slot is created. Hence, the design parameters of the antenna lead to good impedance matching in an S-band frequency.

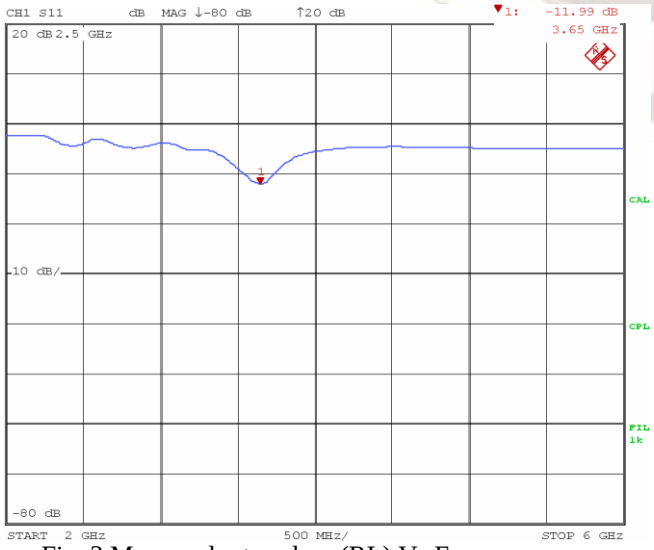

Fig. 3 Measured return loss (RL) Vs Frequency curve

After completing the calibration by using a horn antenna, we measured the radiation pattern at the far field. Figure 4 presents the radiation pattern at center frequency 3.65 GHz for the designed antenna. It is found that throughout the band, pattern is omnidirectional in nature. The cross-polarization level is less than approximately -10 dB in the same frequency. The measured gain for the proposed antenna is 2.93 dB over the entire band with compactness of 10 % compared to simple microstrip patch antenna. Figure 5 shows the VSWR characteristics and it is found to be 1.634 which is less than 2 at resonant frequency 3.65 GHz signifying less reflected power over the entire band.

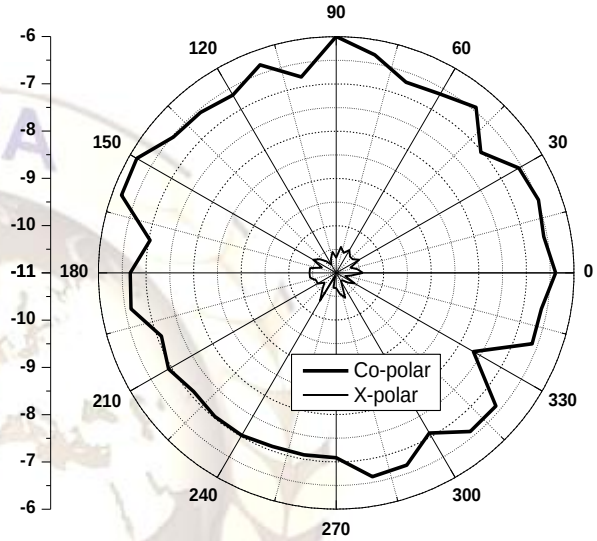

Fig. 4 Measured radiation pattern

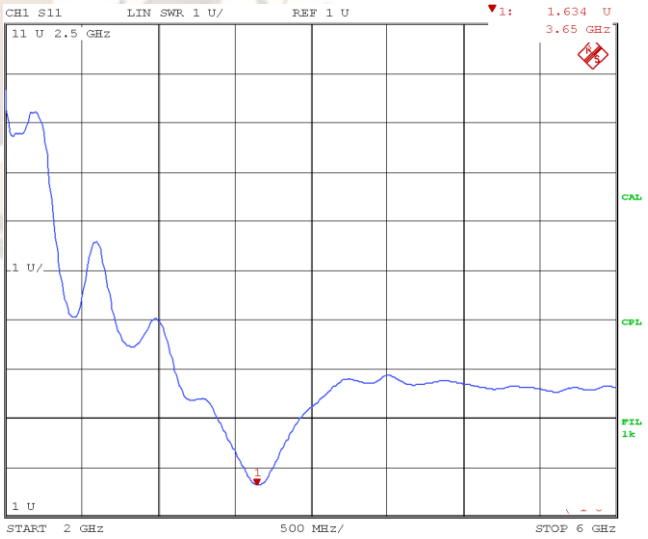

Fig. 5 Measured VSWR characteristics

III. CONCLUSION

The ring slot patch antenna with wideband characteristics has been studied. By using the design parameters of the proposed patch structure, the antenna exhibited wideband along with

moderate gain characteristics. The measured bandwidth is 330 MHz (for return loss less than -10 dB) with 10 % compactness. However, the proposed antenna obtained not only wide bandwidth, but also has gain of 2.93 dB with omnidirectional radiation characteristics. As this antenna is wide band, low profile and light weight, it finds applications in WiMax, maritime mobile services and wideband communication systems.

ACKNOWLEDGMENT

Authors gratefully thank the Department of Science and Technology (DST), Government of India, New Delhi, for sanctioning Vector Network Analyzer to this Department under FIST Project and also providing financial assistance under Rajiv Gandhi National fellowship [No.F.14-2(SC)/2009(SA-III) dated 18 November 2010] scheme by University Grants Commission, New Delhi.

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