Studies on a Modified CPW Feed Planar Monopole Antenna

S. Mondal, S. Sarkar, S. De, P. Samaddar, S. Bhunia, P.P. Sarkar

Abstract*— This paper presents a shorted planar quasi semicircular monopole antenna (SPQSMA) for wideband wireless communication application. The shorting strip reduces the size of the antenna. A modified CPW feed is designed to match with 50Ω input impedance. Simulations have been performed to investigate the different characteristics of the antenna. This antenna has desirable characteristics such as very wide dual band (865 MHz to 1.42 GHz and 2.17 GHz to 20 GHz), low cost, ease of manufacture, compact size, bidirectional radiation pattern. The magnetic field distribution of the antenna is shown and a slot of semicircular shaped is introduced at the centre of radiator to reduce the weight, volume and cost of the antenna. The proposed antenna is suitable specially for GSM band and ultrawideband (UWB) applications.

***Index Terms*—shorting strip, dual band, CPW, ultrawideband**

I. INTRODUCTION

The wideband antennas such as PICA, vivaldi, volcano, log-periodic, spirals and so on have been developed for wireless communication related applications [1-3]. The planar monopole antenna can be formed with different shapes such as circle, square, elliptical, bow tie, trapezoidal, hexagonal and pentagonal [3-8]. Also many non planar metal antennas are reported for wideband application [9-10].

The study of planar circular monopole antenna has been reported [11-14]. In this paper a newly designed shorted planar quasi semicircular monopole antenna (SPQSMA) yields dual band characteristic and compact size. The proposed antenna can cover -10 dB return loss from 865 MHz to 1.42 GHz and 2.17 GHz to 20 GHz. The ground and feed section are in the same plane that makes the antenna completely planar wideband metal antenna.

This antenna provides bidirectional radiation pattern rather than reported omni-directional radiation pattern in azimuth plane [1-6]. The absolute value of gain varies from 1.149 dB to 9.1 dB in the operating frequency band. The signal distortion analysis [13] has been performed by transfer function and group delay.

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The antenna factor which characterizes the reception properties of the antenna in Electromagnetic compatibility (EMC) applications is analyzed. The surface current distribution brings the idea to cut slot at the centre of radiator. As a result the weight, volume and cost of the antenna are greatly reduced. Bidirectional radiation pattern makes the antenna suitable for repeater application and this antenna can be used as wearable antenna.

II. ANTENNA DESIGN

The geometry of the shorted planar quasi semicircular monopole antenna (SPQSMA) is shown in Fig. 1. This antenna is made by a 0.8 mm thick copper plate and the surrounded ground plane consists of the same copper plate. Here a modified CPW feed is designed to match with 50Ω input impedance line. First a planar quasi semicircular monopole antenna (PQSMA) is designed and then a shorting strip with optimized position and width is added to reduce the size of the antenna. All dimensions of the optimized antenna are shown in Fig. 1. The design of proposed planar metal antenna modifies many reported non planar wideband metal antennas [9-10]. The design formula of the proposed antenna has not been developed yet, but the concept of design is taken from the study of reported planar monopole antennas [1-14].

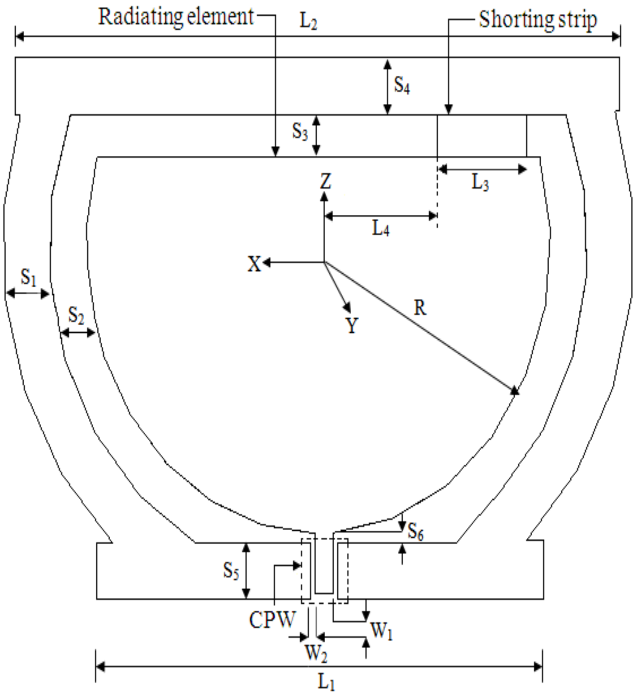
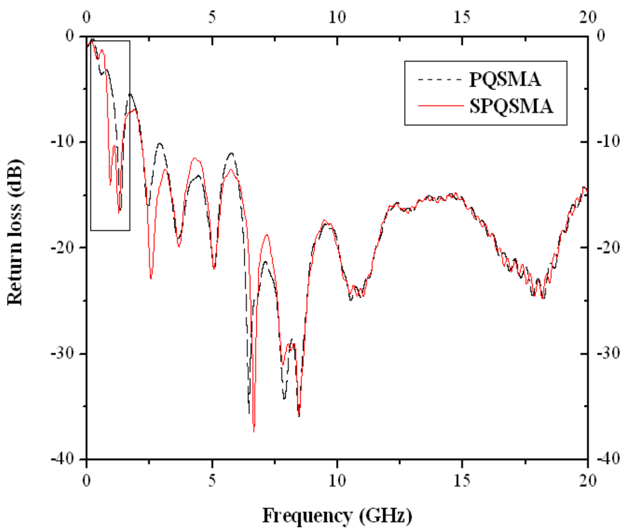


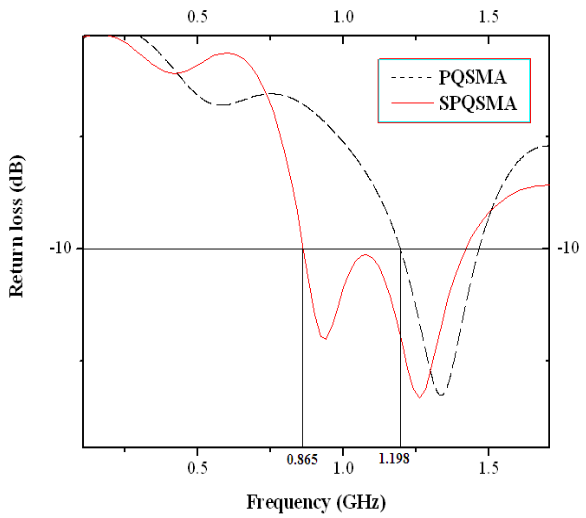
Fig. 1 Geometry of SPQSMA: L_1= 96 mm, L_2 = 130 mm, L_3 = 25 mm, L_4 = 20 mm, W_1 = 4 mm, W_2 = 1 mm, S_1 = 10 mm, S_2 = 8 mm, S_3 = 8 mm, S_4 = 10 mm, S_5= 10 mm, S_6 = 1.5 mm, R = 50 mm

III. SIMULATED RESULTS

The return loss characteristic for PQSMA and SPQSMA is shown in Fig. 2(a). The shorting strip shifts the lower operating frequency to lower side which indicates the size reduction of the antenna. The zoom part for marked portion of Fig. 2(a) is shown in Fig. 2(b) for better visualization. The lower operating frequency of PQSMA and SPQSMA are at 1.198 GHz and 865 MHz respectively which implies almost 28% size reduction of the proposed antenna. The operating frequency band of the SPQSMA ranges from 865 MHz to 1.42 GHz and 2.17 GHz to 20 GHz. Actually due to the shorting strip, we get an additional GSM band which is the most important characteristic of the proposed antenna.



(a)



(b)

Fig. 2 (a) Simulated return loss vs. frequency of PQSMA and SPQSMA and (b) enlarged marked part of Fig. 2 (a)

Actually such shorting strip at the top of antenna provides inductive loading which increases the effective length of the antenna and it shifts the lower operating frequency to the lower side.

The modified CPW line is designed to feed the antenna as shown in Fig. 3. The air gap (W_2) between centre conductor and ground of the CPW line takes a vital role to achieve wideband. The return loss characteristic of the antenna for different values of W_2 is shown in Fig. 4 and from this curve the optimized value of W_2 is 1 mm.

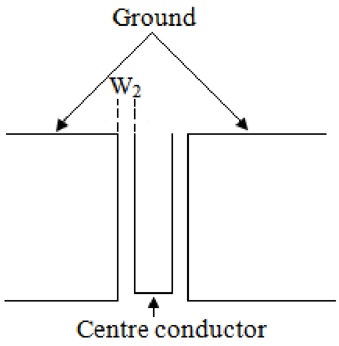


Fig. 3 Design of the proposed CPW line

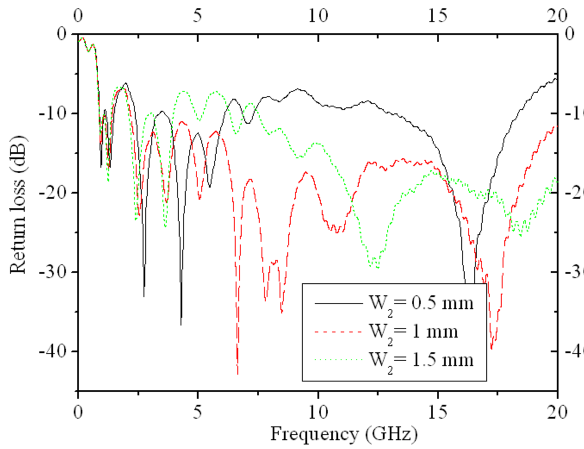


Fig. 4 Return loss characteristic of the antenna for different values of W_2

The proposed antenna provides bidirectional radiation pattern in E and H plane over the operating frequency band. The far field radiation pattern at $\Phi = 0^0$ and $\Phi = 90^0$ for different frequencies at 1 GHz, 7.5 GHz and 15.5 GHz of SPQSMA is shown in Fig. 5. The far field radiation pattern at $\theta = 90^0$ is shown in Fig. 6 which demonstrates this pattern is bidirectional.

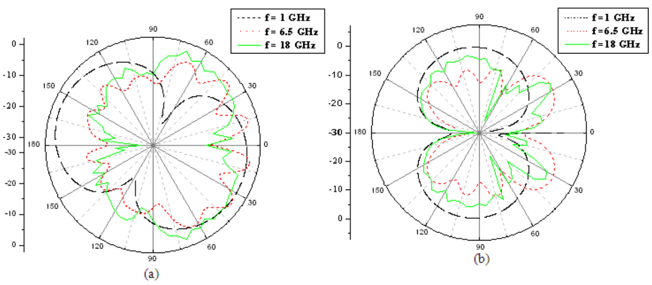


Fig. 5 Farfield radiation pattern at frequencies 1GHz, 6.5 GHz and 18 GHz for (a) $\Phi = 0^0$ Pand (b) $\Phi = 90^0$

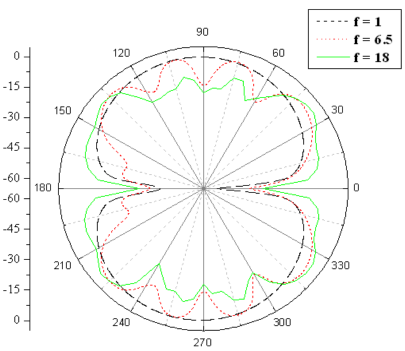


Fig. 6 Far field radiation pattern at frequencies 1 GHz, 6.5 GHz and 18 GHz for $\theta = 90^0$

The variation of absolute gain at $\Phi = 90^0$ plane is shown in Fig. 7. This gain of SPQSMA ranges from 1.149 dB to 9.1 dB in the operating frequency band.

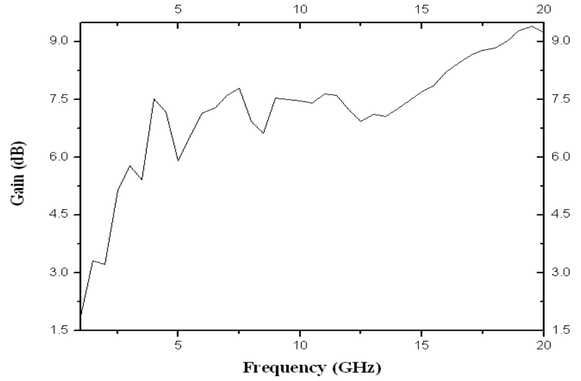


Fig. 7 Variation of maximum gain vs. frequency of SPQSMA

This computed gain can be used to calculate antenna factor (A.F) of the antenna.

$$A.F = 20\log\left(\frac{9.73}{\lambda\sqrt{G}}\right)\ \text{dB/m}$$

Where, G = gain of antenna, λ = wavelength

The antenna factor(AF) almost monotonically increases with frequency in the operating frequency band as shown in Fig. 8 and it indicates this antenna can be used as an EMI Sensor.

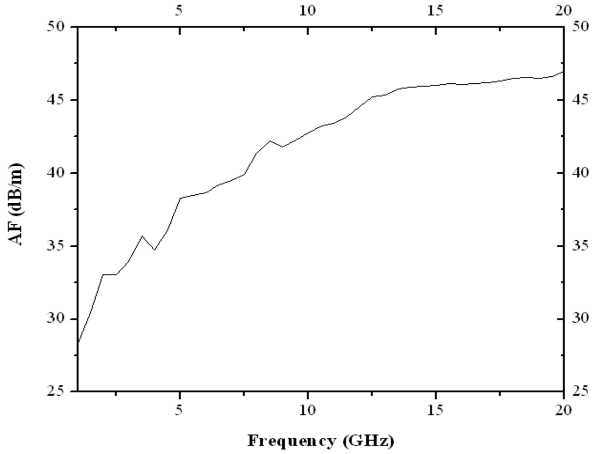


Fig. 8 Variation of AF vs. frequency of SPQSMA

Group delay (GD) describes the phase response of the transmitted signal. Constant and variation of GD means linear and non linear variation of phase of the transmitted signal respectively. So variation of GD for SPQSMA gives the signal distortion characteristic as shown in Fig. 9.

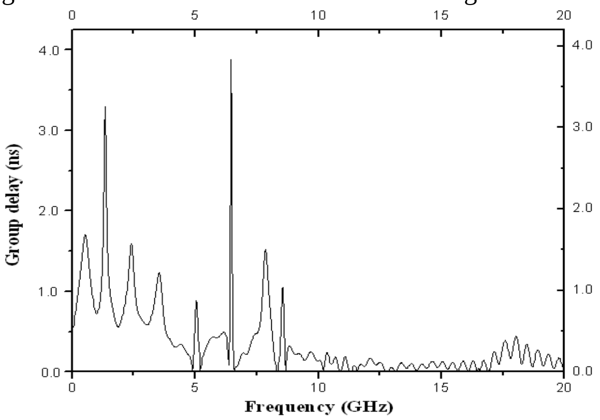


Fig. 9 Variation of group delay vs. frequency of SPQSMA

The variation of phase response of the transfer function is shown in Fig. 10. At the lower side frequency the phase response varies nonlinearly which is good agreement with the plot of GD.

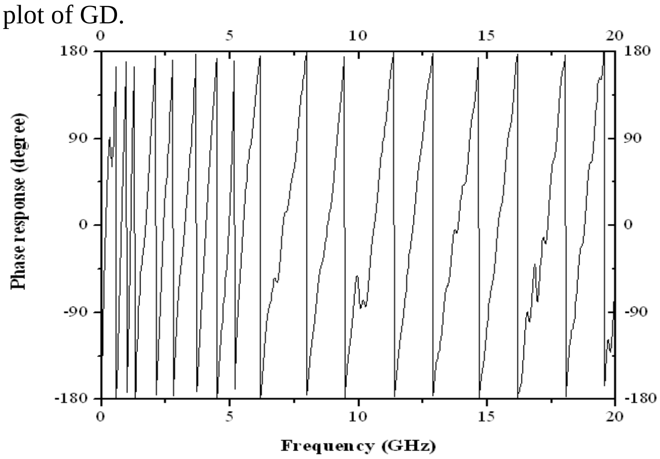


Fig. 10 Variation of phase response vs. frequency of SPQSMA

The H field distribution of the antenna is shown in Fig. 11. From this curve it is clear surface current dominates at the feed section and outer conductor. So the design of feed section is very important to achieve wideband. The concentration of surface currents are less at the centre of radiator and this idea further reduce the weight, volume and cost of the antenna by cutting a slot at the centre of radiator without degrading its characteristics. The geometry of the antenna with semicircular shaped hole at centre is shown in Fig. 12. The return loss characteristic of the antenna for R = 35mm is shown in Fig. 13. This plot shows the introduction of hole at the centre of radiator does not degrade significantly.

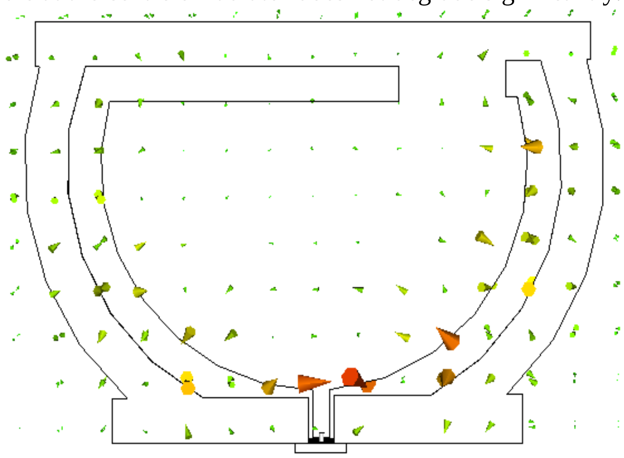


Fig. 11 H field distribution of the antenna

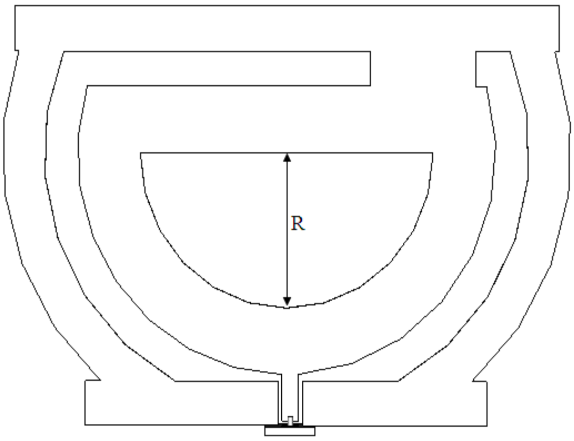


Fig. 12 Geometry of the proposed antenna with slot

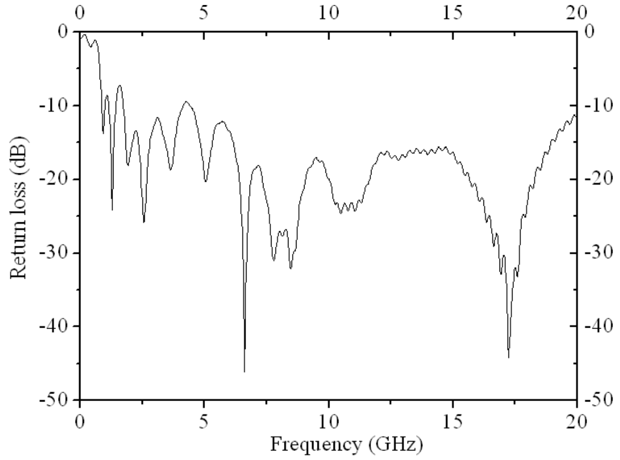


Fig. 13 Return loss characteristic of the proposed antenna with slot

IV. MEASURED RESULT

The photograph of the fabricated antenna is shown in Fig. 14. The simulated and measured return loss characteristic of the antenna upto frequency 8.5 GHz is shown in Fig. 15 due to the frequency limitation of the Agilent E5071B Vector Network Analyzer (VNA). The simulated and measured return loss agrees well.

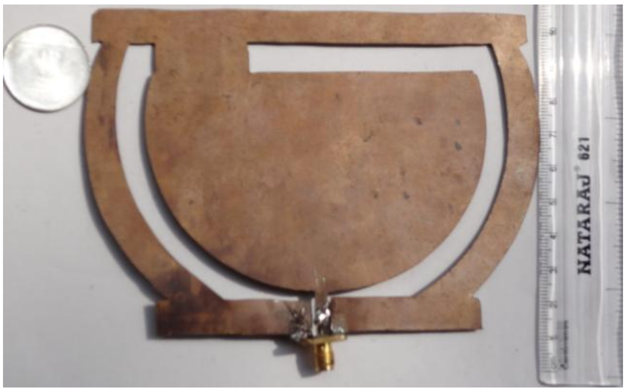


Fig. 14 Photograph of the fabricated SPQSMA

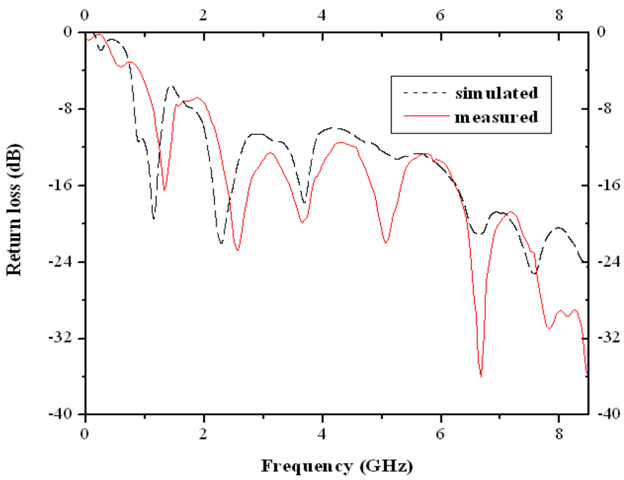


Fig. 15 Simulated and measured return loss characteristic of SPQSMA

V. CONCLUSION

The proposed SPQSMA provides dual band characteristic with smaller size. The bidirectional radiation pattern and other acceptable characteristics demonstrate that this antenna can be used in various wireless communication applications.

A CPW feed is designed to match with 50Ω input impedance line. Also a shorting strip is used to reduce the size of the antenna. Also the semicircular shaped slot reduces the weight, volume and cost of the antenna. The proposed antenna is a completely planar metal antenna that modifies many reported non planar metal antenna.

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