Broadband Shorted 90^0 Sectoral Microstrip Antennae

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ABSTRACT

The compact microstrip antenna is realized by placing shorting post or plate along the zero field line at the fundamental mode of the patch. In this paper, compact variation of circular microstrip antenna, a shorted 90^0 sectoral microstrip antenna is discussed. It gives a bandwidth of more than 300 MHz at center frequency of around 1000 MHz. Further a new 90^0 sectoral microstrip antenna, realized by shorting the curved surface is proposed. It gives simulated and measured bandwidth of more than 1000 MHz in the same frequency band as that given by the above shorted 90^0 sectoral patch. The proposed antenna gives broadside radiation pattern with higher cross polar levels with a gain of more than 6 dBi over most of the bandwidth

Keywords
Circular microstrip antenna, compact microstrip antenna, shorted 90^0 sectoral microstrip antenna, Broadband microstrip antenna, Proximity feeding

1. INTRODUCTION
The simpler method to realize broadband microstrip antenna (MSA) is by fabricating the patch on lower dielectric constant thicker substrate [1, 2]. The lower dielectric constant reduces the quality factor of the cavity below the patch to realize larger bandwidth (BW). In most of the reported configurations the patch is suspended in air thereby realizing dielectric constant of unity. For using substrate with thickness greater than $0.05\lambda_0$, the proximity feeding technique has been used to increase the BW [3]. The compact MSA is realized by placing the shorting post or plate along the zero field line at the fundamental patch mode and thereby it converts half wavelength resonator into a quarter wavelength resonator [1, 2]. The compact variations of circular MSA (CMSA), shorted semi-circular MSA is realized by placing the shorting post or plate along the zero field line at the fundamental TM_{11} mode of the patch and by using only half of the shorted configuration. The compact shorted 90^0 sectoral MSA is realized by using half of the shorted semi-circular MSA and it gives 75% reduction in the patch size as compared to the conventional CMSA.

In this paper, first broadband proximity fed shorted 90^0 sectoral MSA is discussed. It gives bandwidth (BW) of more than 300 MHz (> 35%). Since the shorted patch is used, the radiation pattern shows higher cross-polarization levels with a gain of more than 4 dBi over the entire BW. Further a new proximity fed shorted 90^0 sectoral patch is proposed. In this new shorted sectoral patch, the curve surface (perimeter of the patch) is shorted using the shorting plate. The patch is fed using the coupling strip which is placed below the patch. This configuration gives an increased BW of 1010 MHz (>65%). The proposed antenna gives broadside radiation pattern with higher cross polarization levels and with the gain of more than 6 dBi over the complete BW. The proposed antennas were first optimized using IE3D software [4]. Further to validate the simulated results the antennas were fabricated using copper plate having finite thickness and they were fed using N-type connector of 0.32 cm inner wire diameter. Further the measurement was carried out using finite square ground plane of side length 80 cm using R & S vector network analyzer. The radiation pattern was measured in minimum reflection surroundings with required minimum distance between the reference antenna and the antenna under test [5]. The antenna gain was measured using the three antenna method [5].

2. SHORTED 90^0 SECTORAL MSAs
The proximity fed CMSA is shown in Fig. 1(a, b). The patch radius is calculated such that it operates in its TM_{11} mode at frequency of around 900 MHz. For the proximity feed shown in Fig. 1(a, b), CMSA was simulated using IE3D software and its resonance curve plot is shown in Fig. 1(d). The plot shows three peaks due to TM_{11} (937 MHz), TM_{21} (1637 MHz) and TM_{31} (1842 MHz) modes. The surface current distribution at them is shown in Fig. 1(e – g). At TM_{11} mode, the surface currents show one half wave length variations along half of the patch perimeter and the patch diameter. At TM_{21} mode, surface currents shows two half wavelength variation along half of the patch perimeter and one half wave length along patch diameter. At TM_{31} mode currents show three half wavelength variations along half of the patch perimeter and one half wave length variation along patch diameter. The radiation pattern at TM_{11} mode is in the broadside direction whereas at TM_{21} and TM_{31} mode the pattern is conical, i.e. maximum in the end-fire direction. The above CMSA is also simulated using coaxial probe and the resonance curve plot for the same is shown in Fig. 1(d). It shows three peaks due to above modes, but the frequencies of TM_{21} and TM_{31} are reduced. At TM_{11} mode, a compact shorted 90^0 sectoral MSA is obtained by placing the shorting post along the zero field line and by using only half of the shorted patch as shown in Fig. 1(c). The proximity fed shorted plate 90^0 sectoral MSA is simulated using IE3D software and the resonance curve plot for the same is shown in Fig. 2(a). The first peak in the resonance curve is due to TM_{11} (782 MHz) mode. The peak due to TM_{21} mode is absent as the boundary condition for that mode in shorted patch are not satisfied. The shorted 90^0 sectoral patch is simulated using coaxial feed for the same substrate thickness and its resonance curve plot is shown in Fig. 2(a). It shows peak due to TM_{11} mode. Another peak is present at higher frequency and surface current distribution at the same is shown in Fig. 2(b). This distribution is due to TM_{31} mode.

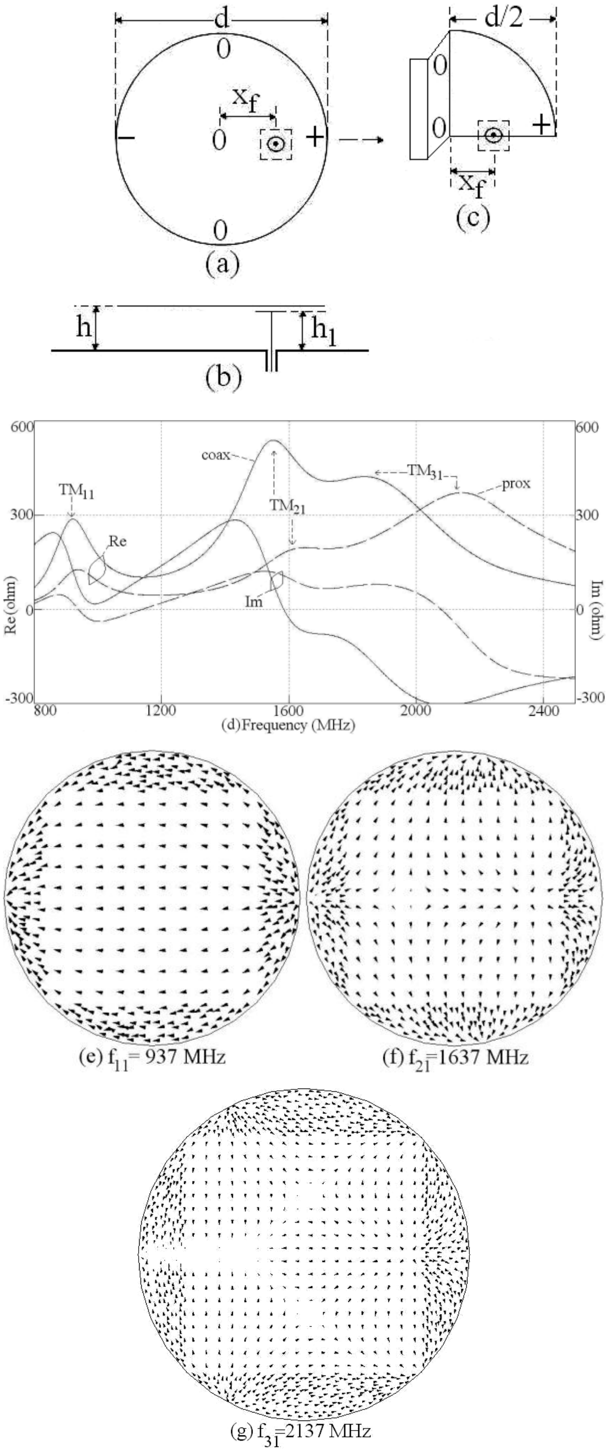

Fig. 1 (a) Top and (b) side views of proximity fed CMSA and (c) proximity fed shorted plate 90^0 sectoral MSA (d) resonance curve plots for CMSA and surface current distribution at (e) TM$_{11}$ (f) TM$_{21}$ (g) TM$_{31}$ modes for proximity fed CMSA

This shorted plate proximity fed 90^0 sectoral MSA is optimized for broader BW by tuning the strip length and its position below the patch and its broadband response is shown in Fig. 2(c). It shows simulated BW from 737 to 1044 MHz (307MHz, 34.5%). The optimum response is realized for square strip of dimension 1.9 cm and for strip position (X_f) of 2.0 cm. The antenna was fabricated using the copper plate having finite thickness (which is also considered in IE3D simulation) and the response was measured using R & S vector network analyzer. The measured BW is from 745 to 1068 MHz (323 MHz, 35.6%) as shown in Fig. 2(c).

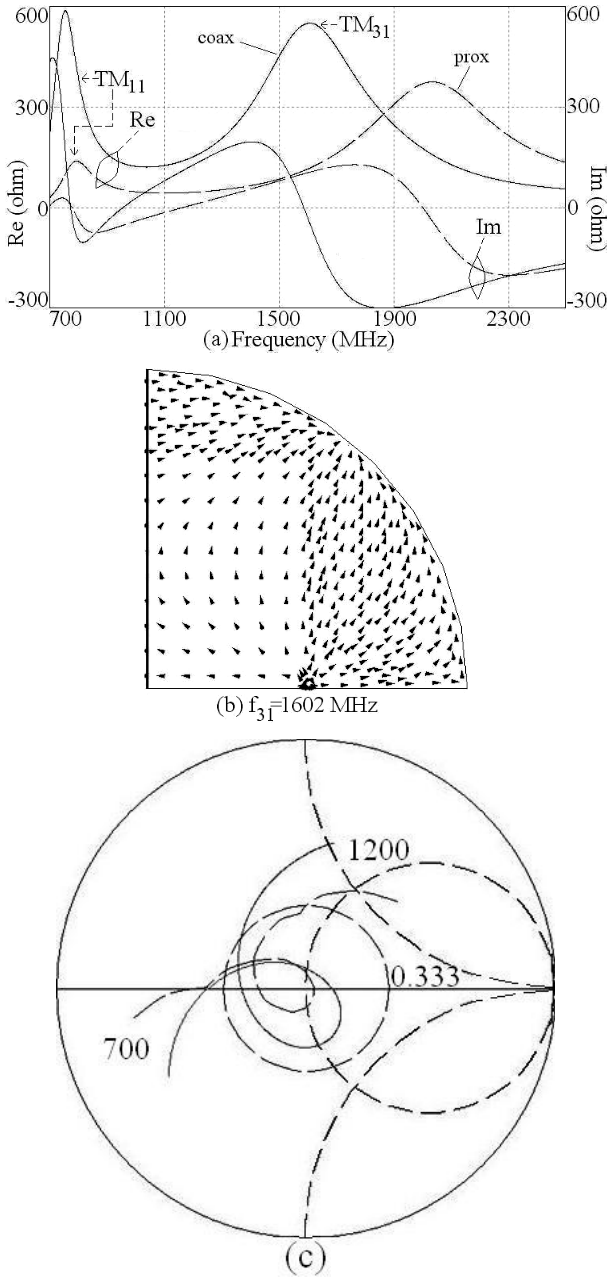

Fig. 2 (a) Resonance curve plot for shorted 90^0 sectoral MSA, its (b) surface current distribution and its optimum (c) input impedance and VSWR plots, (——) simulated, (— —)

Further a new variation of shorted 90^0 sectoral MSA is proposed as shown in Fig. 3(a). In this patch, the curved surface of the patch is shorted. For patch thickness of 3.0 cm and coupling strip thickness of 2.8 cm, the resonance curve plots for the two variations of shorted 90^0 sectoral CMSA is shown in Fig. 3(b). In the new shorted sectoral patch the frequency of fundamental patch mode is increased from 807 to 1011 MHz. By optimizing the strip position below the patch and its dimension, and the substrate thickness for the shorted patch and the coupling strip, a broadband response as shown in Fig. 3(c) is realized. In the optimized configuration, the thickness of shorted patch and coupling strip are, 2.7 and 2.0 cm, respectively.

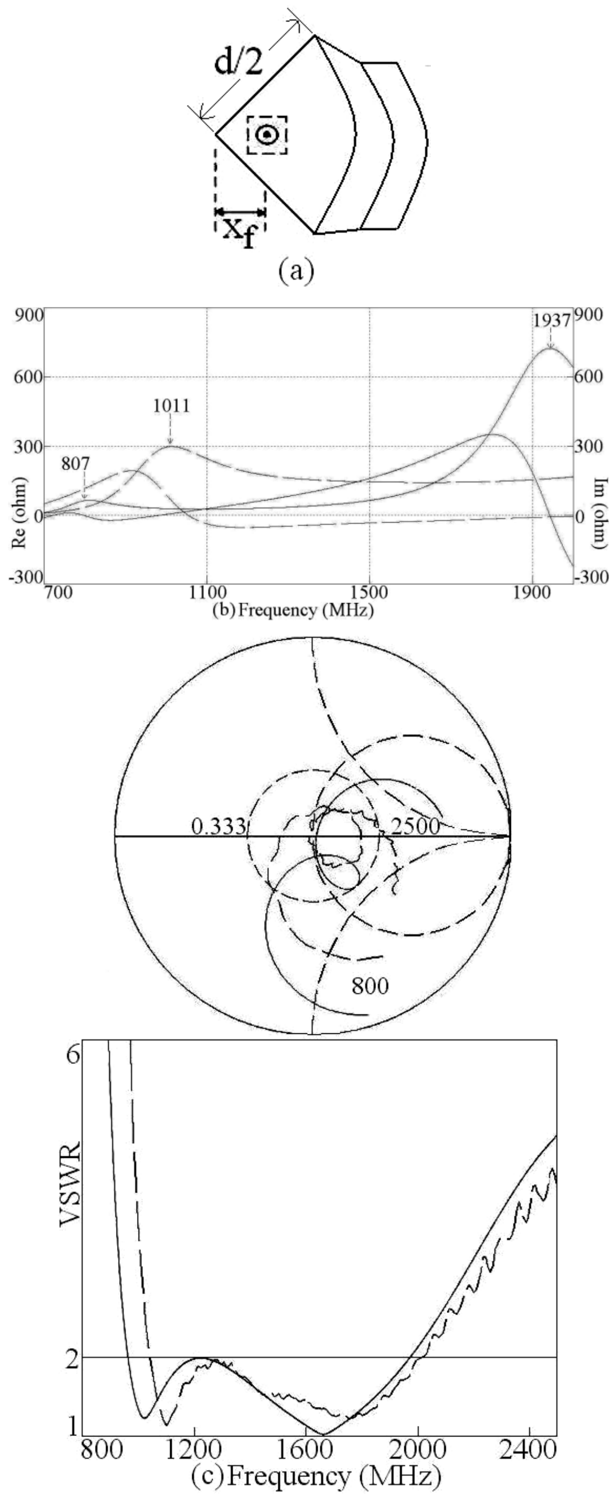

Fig. 3 (a) Curved shorted 90^0 sectoral MSA, (b) resonance curve for shorted MSA shown in, (——) fig. 1(c), (— —) fig. 3(a) and (c) optimized input impedance and VSWR plot for curved shorted 90^0 sectoral MSA

The strip position is optimized at 3.0 cm from the vertex position. The simulated BW is from 964 to 1970 MHz (1006 MHz, 68.6%). The measurement was carried out using larger square ground plane of side length 100 cm. The measured BW is from 1003 to 2010 MHz (1007 MHz, 67%). The result is also validated using finite square ground plane of side length 40 cm and the measured BW is 1027 MHz (68%). The fabricated prototype of the configuration is shown in Fig. 4(a). The radiation pattern over the BW using 40 cm square ground plane is shown in Fig. 4(b, c) and 5(a), respectively.

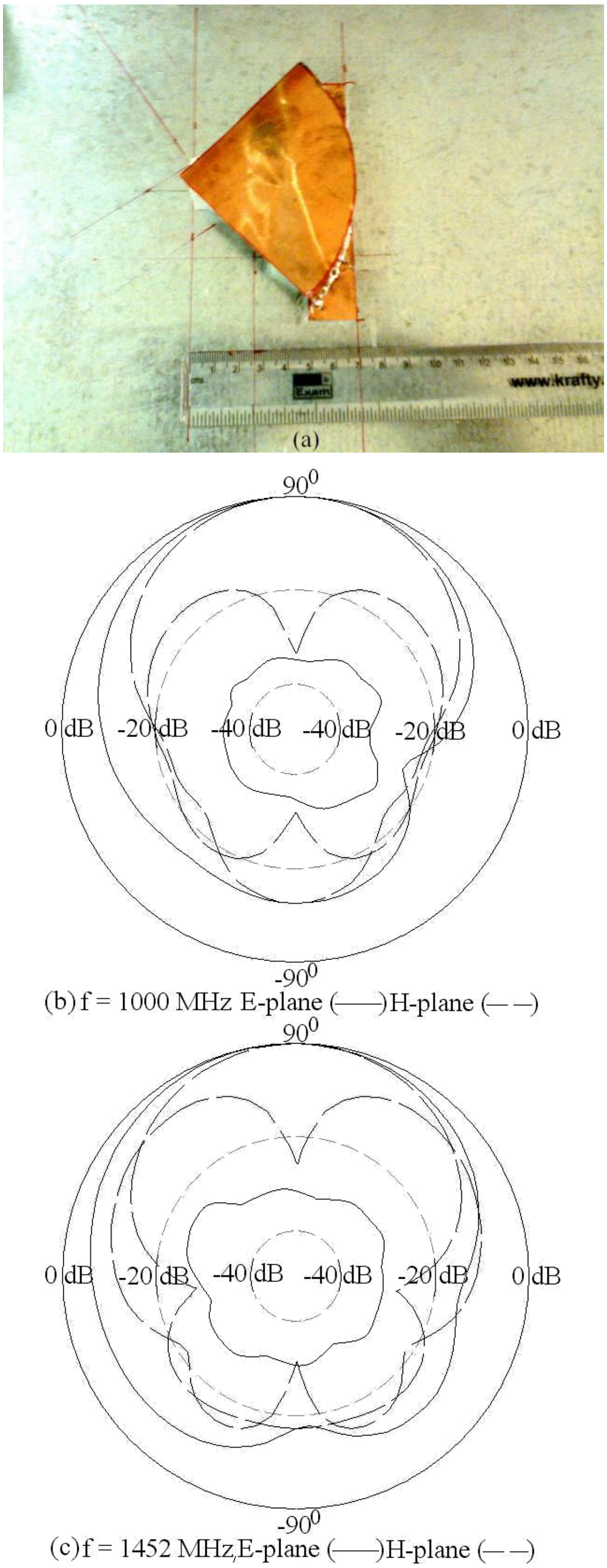

Fig. 4 (a) Fabricated prototype and (b, c) radiation pattern over BW for curved shorted 90^0 sectoral MSA

The pattern is in the broadside direction with higher cross-polarization levels towards higher frequencies of the BW. The back-lobe radiation is less than 10 dB as compared to the main-lobe of radiation over most of the BW. The antenna gain is shown in Fig. 5(b). The proposed antenna shows gain of more 6 dBi over the entire BW with flat gain characteristics.

3. CONCLUSIONs

The fundamental and higher order modes of CMSA and its compact variation shorted 90^0 sectoral MSA for coaxial and proximity feeding are discussed. The broadband proximity fed configuration of shorted 90^0 sectoral MSA is proposed which gives BW of more than 300 MHz (>35%). Further a new curved shorted 90^0 sectoral MSA is proposed. This new configuration yields simulated and measured BW of more than 1000 MHz (>65%) with broadside radiation pattern and gain of more than 6 dBi over the complete BW. The antenna shows higher cross polarization levels towards higher frequencies of BW. The proposed antenna can find applications in mobile communication environment.

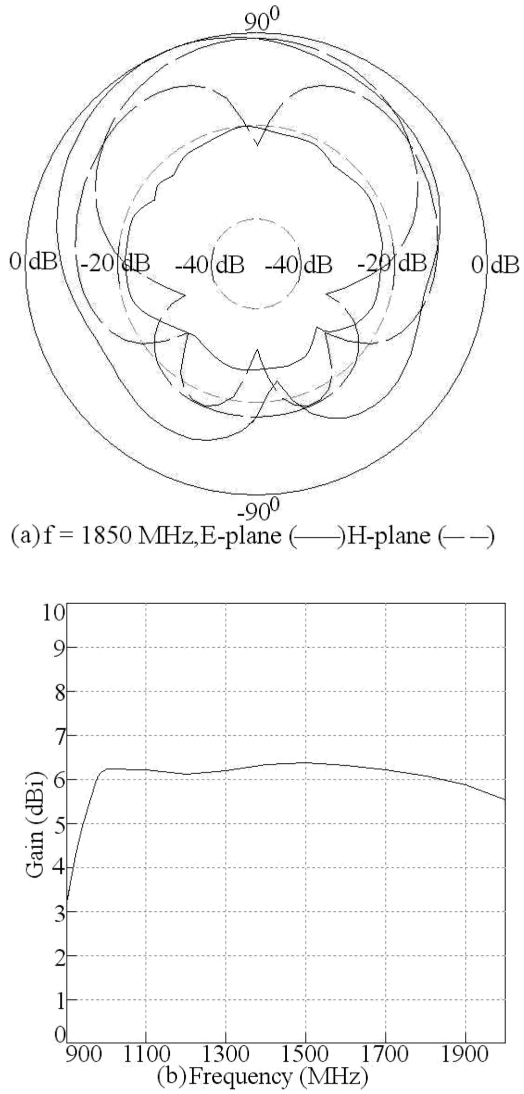

Fig. 5 (a) Radiation pattern at band edge frequency and (b) gain variation over BW for curved shorted 90^0 sectoral MSA

4. REFERENCES

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