# Even Symmetry Multiple Bands CPW Feed Microstrip Spiral Antenna

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***Abstract*—The paper presents an even symmetry CPW feed microstrip spiral antenna that operates in the range of 1 GHz to 15 GHz. The antenna provides multiple band response as well as wideband response. The antenna is fed by an SMA connector from side, which is connected to a monopole i.e. main arm of spiral antenna. Width of this monopole is a one fourth of guided wavelength which provides impedance matching thereby avoiding the need of balun for spiral antenna. The antenna is fabricated on FR-4 substrate with dielectric constant of 4.3 and loss tangent of 0.025. This multiple band antenna is suitable for upcoming cognitive radio systems.**

***Keywords—Cognitive radio; CPW; monopole; spiral antenna.***

## I. INTRODUCTION

Current wireless technologies require wide bands for personal wireless networks and selective bands for applications like WiMax (3.3-3.7 GHz), WLAN (5,15-5.825GHz), GSM(900-1800 GHz). Both wide band and selective band applications require different antennas. Today's wireless communication systems are expecting simple designs, higher data rates and low power consumption. Hence, need of a single antenna that provides selective bands as well as wide band response is becoming need of hour. A single antenna that has both multiple frequency response and wideband response would serve the purpose. Also such antennas are most suitable for the upcoming cognitive radio systems so that, one single antenna can support multiple applications.

Spiral antennas are the one of the suitable choice for wide band applications. The response of spiral antennas can be controlled by deciding their outer and inner radius geometry, since their inner and outer radius decides the upper and lower frequencies.

Spiral antenna was first introduced by J.D. Dyson in 1959 which was based on Rumsey's principle [1] of frequency independent antennas [2]. Later, varieties of spiral antennas were introduced by many authors those were used for various applications [3-6]. Different shapes of spiral antennas like archimedean, rectangular, conical, logarithmic, slot spiral are being used for broad band applications to support high data rates [7-11]. Rectangular spiral antennas are the popular ones because of their geometry. Rectangular spiral antennas are easy to develop in simulation software, easy to fabricate. Many rectangular spiral antennas have been developed by authors that are useful for multiple purposes [12-14]. Coplanar Waveguide has been chosen to feed the proposed spiral antenna due its advantages [15]. Many authors have also used the CPW to feed the monopole antenna since these planar antennas are fed by a probe, which made integration of antennas with other microwave circuits somewhat difficult. A CPW fed planar monopole antenna can be an alternative choice to overcome this problem [16-17]. Many authors have used monopole antenna for obtaining a wideband response as monopole antennas are compact and easy to fabricate [18-19].

The main arm of the proposed symmetric spiral antenna is a monopole antenna of lambda/4 length. A monopole eliminates the need of BALUN in spiral antenna and helps to keep the antenna impedance nearby 50 ohm for wide range of frequencies. The main arm (monopole) is designed for the maximum frequency. The substrate dimensions are taken half wavelength of the lowest operating frequency. This will provide an even symmetry in the modelling of spiral antenna. Adding number of turns ensures multiple bands in the response so that current doesn't decay continuously.



## II. ANTENNA DESIGN

When Square spiral approximates the round Archimedean spiral in this manner and therefore it always has the same distance between its arms [14]. The spiral arms are configured as rectangular monopole of $\lambda g/4$ width to provide impedance matching with standard 50Ω and this eliminates the need of wideband balun design to feed the antenna. For the design of monopole the dimension width is more important and since the antenna is spiral so it's independent of the total length and only depends of spiral rotation. Width of the antenna has been calculated using microstrip transmission line equation [20]. The substrate used is FR4 so dielectric constant is 4.3, with these values guided wavelength comes to be 0.02. Therefore, one fourth of guided wavelength is 5mm.

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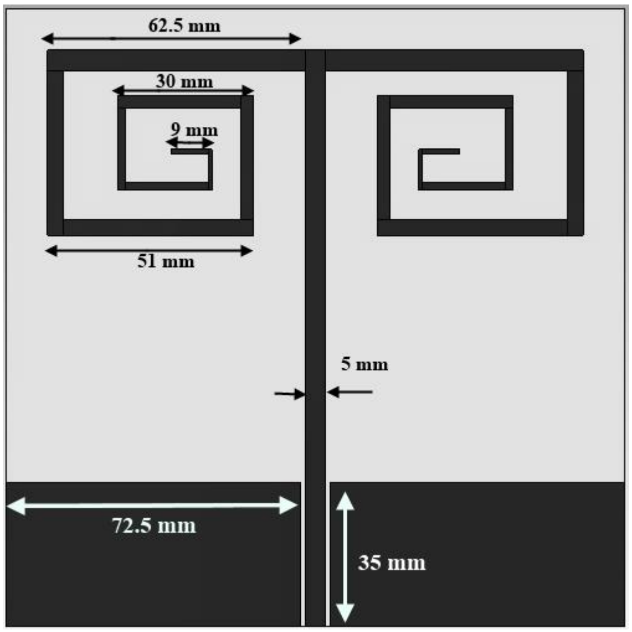



Fig. 1. Geometry and dimensions of even symmetry CPW fed monopole spiral antenna.

substrate dimensions are taken half wavelength of the lowest operating frequency. This will provide an even symmetry in the modelling of spiral antenna. Adding number of turns ensures multiple bands in the response so that current doesn't decay continuously.

The geometry of proposed CPW fed even symmetry spiral antenna is illustrated in fig. 1. An FR4 substrate with thickness 1.6 mm and relative permittivity of 4.4 is used. A 50 ohm CPW-fed line is designed with thickness of 5 mm and a gap width of 1 mm. Two finite ground planes of 71.5 X 35 mm are symmetrically placed on each side of the CPW line.

Each arm length has been reduced in each turn along with its width. The arm A2 has approximately have length than Main arm A1. And then each arm length has been reduced by 10 mm. Thickness has been reduced by 1mm in every two arms. A symmetric structure only allows accommodating more number of turns to provide a multiple band frequency response. The geometry of proposed antenna is shown in Fig. 1.

## III. FABRICATED ANTENNA

The antenna is fabricated on FR4 substrate. The copper material on the substrate is coated with a thin layer of tin to prevent the oxidation of copper due to environmental affect. The fabricated antenna is shown in figure. A Standard 50 Ω SMA connector has been used to feed RF signal to the antenna. Fig. 2 shows the photograph of fabricated antenna.

## IV. RESULTS & DISCUSSION

The simulations are done in Computer Simulation Tool Microwave studio (CST MWS) due to the fact that it provides

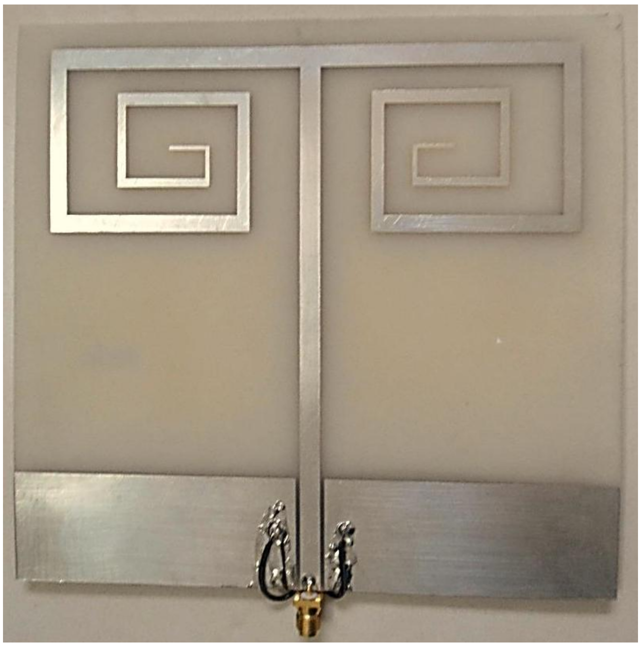


Fig. 2. Photograph of fabricated CPW fed antenna.

a flexible GUI interface, various available numerical techniques like time domain, frequency domain, integral equation, asymptotic modes and Eigen mode. The simulation for proposed antenna are done using time domain solver of the CST MWS which saves the simulation time by using Finite Integral Numerical Technique. Since our main concern is to design a single antenna suitable for multiple applications that requires different frequencies, reflection coefficients are analysed and tested.

The return loss of the antenna is shown in Fig. 3. It can be clearly seen from the reflection coefficient that the proposed antenna resonates at multiple frequencies. The band specifications along with the bandwidth are shown in Table 2. The VSWR is shown in Fig. 4.

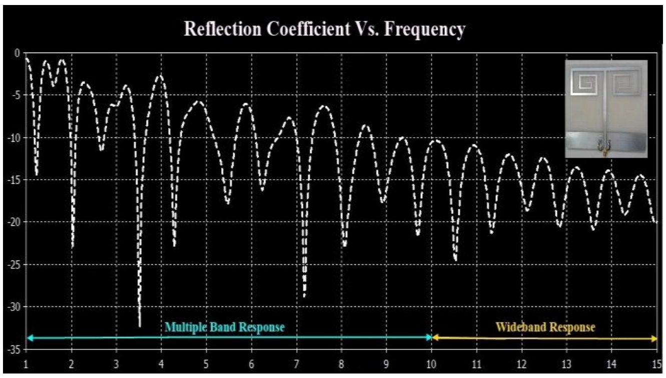



Fig. 3. Reflection coefficient of proposed antenna.

It is seen that the VSWR is well within the limits. It is also seen from Table 1that there are total 10 resonating bands. 9 bands are narrow bands and the last band is wideband. Thus the narrow bands can support the low data rate applications whereas the wideband can be used for high data rate

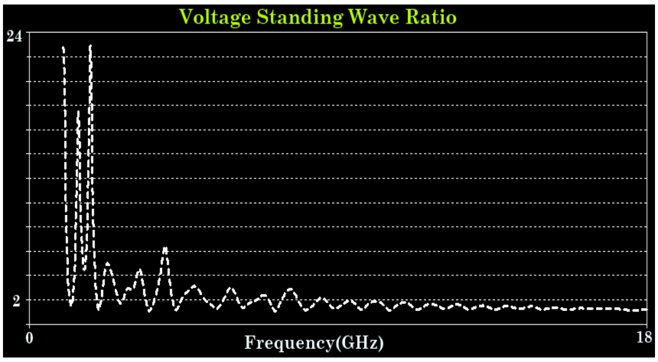


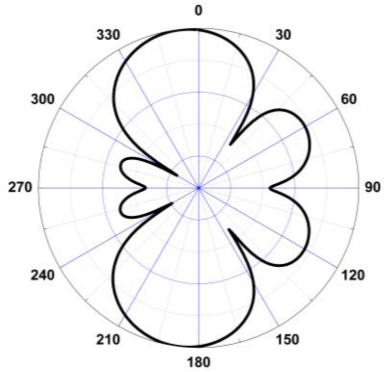

Fig. 4. VSWR of proposed antenna.

applications. The radiation patterns at some of the resonance frequency with main lobe directions are shown in Fig. 5.

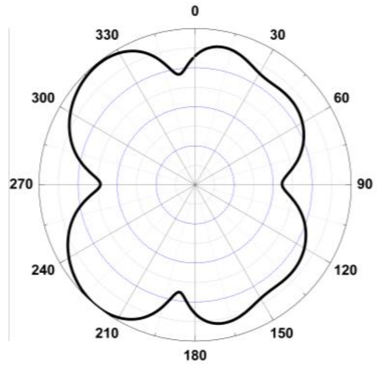
TABLE I. BAND SPECIFICATION FOR EVEN SYMMETRY CPW FED MONOPOLE SPIRAL ANTENNA.

| Sr. No. | Bands Obtained (GHz) | Resonances at (GHz) | Bandwidth of the band (GHz) |
|---|---|---|---|
| 1 | 1.18 to 1.25 | 1.22 | 0.07 |
| 2 | 1.98 to 2.08 | 2.054 | 0.102 |
| 3 | 2.61 to 2.75 | 2.66 | 0.14 |
| 4 | 3.39 to 3.63 | 3.53 | 0.238 |
| 5 | 4.19 to 4.41 | 4.29 | 0.221 |
| 6 | 5.18 to 5.64 | 5.48 | 0.459 |
| 7 | 6.1 to 6.51 | 6.23 | 0.416 |
| 8 | 7 to 7.34 | 7.18 | 0.34 |
| 9 | 7.86 to 8.39 | 8.07 | 0.53 |
| 10 | 8.66 to 15 | wideband | 6.34 |





(a)



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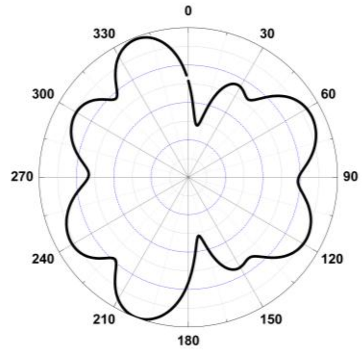
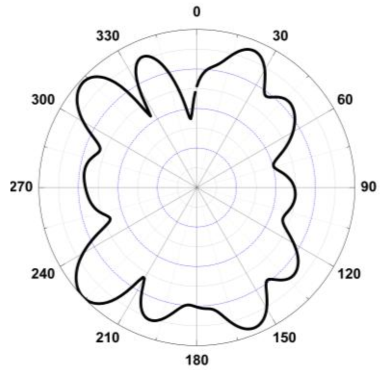
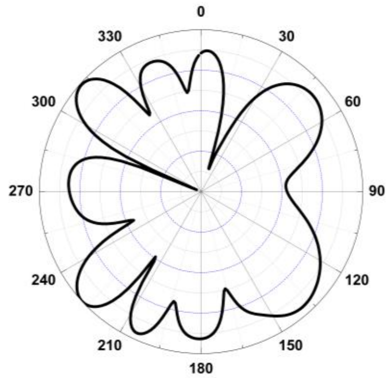


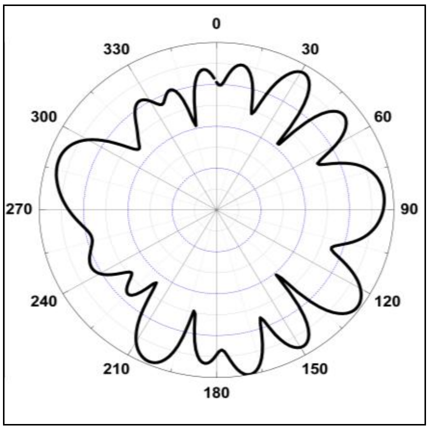
(c)



(d)



(e)




(f)

Fig. 5. Radiation patterns of proposed antenna (a) at frequency 2.03 GHz. (b) at frequency 3.47 GHz. (c) at frequency 4.29 GHz. (d) at frequency 7.19 GHz. (e) at frequency 8.08 GHz. (f) at frequency 9.69 GHz.

For Fig.5 the main lobe directions are $187^0$, $219^0$, $200^0$, $226^0$, $227^0$ and $169^0$ respectively.

## V. CONCLUSION

The proposed antenna works in IEEE C band and IEEE S band as well with multiple resonances. The resonances obtained in result includes UMTS (1.92 -2.71GHz), Local Area Network WLAN (5.15-5.825 GHz), worldwide interoperability for microwave access i.e. WiMax (3.3 -3.7 GHz), IEEE 802.11a in the United States (5.15 – 5.35 GHz, 5.725-5.825 GHz) and HIPERLAN/2 in Europe (5.15 – 5.35 GHz, 5.47 – 5.725 GHz). Since the antenna has multiple band response, the proposed antenna is also suitable to be used in future cognitive radio systems that require the narrowband and wideband responses.

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