Active Coplanar Wave guide Fed Switchable Multimode Antenna Design and Analysis

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Abstract

This article presents the design of reconfigurable multiband antenna fed by coplanar waveguide feeding using commercially available pin diodes. The designed antenna covers S-band, Wi-MAX C-Band, X-band applications. A detail study was performed to characterize the switching operation by considering the wire bound effects. By loading the TSIR (T-shaped stepped impedance resonator) and PSLR (parallel stub loaded resonator) in the circular ring, resonating characteristics are observed. The resonating frequencies of the antenna are 3.26 GHz, 4.16 GHz, 8.04 GHz and 8.9 GHz respectively. The current antenna shows the maximum gain of 5.94 dB at 8.04 GHz. The proposed antenna shows good impedance characteristics, low profile and compact size, which is suitable for wireless communication applications.

Keywords: TSIR (T-shaped Stepped impedance resonator), PSLR (Parallel Stub loaded resonator)

I. Introduction

At present wireless communication has expeditious prosperity so, the subsequent technologies requires compact antenna with the multi band characteristic to reduce the usage of two or more antennas [XIII].

As a result of development in electronics and wireless communications, the demand for mobile wireless devices operating at different standards or different applications. To support an array of applications, such as navigation, communication, and surveillance requires more than one antenna. The use of multiple antennas is absolutely very unsatisfactory as it can boost the system size and material cost which may offer electromagnetic interference. In order

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to reduce the number of antennas is to have one that can be reconfigured to afford a lot of functions and can also accomplish at different frequencies. Such a multifunctional antenna is called as Reconfigurable antenna. Reconfigurable antenna is an antenna which changes its frequency by inimically changing the radiation properties.

Normally the extant method in substantial use can be categorized into two subsequent leagues: First method mainly focuses on burdening parasitic elements on antennas such as stepped impedance resonators or split ring resonators near feed line. Second adequate method is ingraining distinct slots alike Arc shaped slot [XI], U-shaped slot [XV], Square shaped slot [XII], H-shaped slot [II], and Fractal shaped slot [XIV] etc. Though there are some extant narrow-band systems over the designated multi band such as worldwide interoperability for microwave access (WIMAX) operating at 3.4-3.69 GHz, S-band from 2 to 4GHz, C-band from 4 to 8GHz, X-band satellite communication systems working at 7.7-8.5GHz [XVII] which may conflict with the UWB systems. To attenuate these potential conflicts a lot of multi band antennas accommodated with two stage T-shaped stepped impedance resonator (TS-TSIR) and parallel stub loaded resonator (PSLR), through which multi band function is achieved.

The techniques that can be used for reconfigurability in antennas are many such as by using active switches based on MEMS (micro electro mechanical systems), PIN diodes, and Varactor diodes [XVI]. It has many different shapes and sizes, and these are mainly classified into four categories: frequency, pattern, polarization and hybrid reconfigurable antennas. [I,X]

II. Antenna Design

The geometry of basic proposed antenna1 is adorned in Figure 1(a) which is engraved on a substrate Rogers RT/duriod 5880 with relative permittivity of 2.2, with loss tangent 0.0009.

![Figure 1](image_url)

**Figure 1:** Geometry of multimode reconfigurable antennas (a) antenna1 (b) antenna 2 (c) antenna 3 (d) proposed antenna 4
Initially the antenna consists of a circular wide slot in CPW ground plane. Then the TSIR (T-shape stepped impedance resonator) is ingrained vertically on both sides inside the circular ring radiation patch which is illuminated in Figure 1(b). In Figure 1(c) the TSIR is inherent inside the circular ring radiation patch similar to the Figure 1(b) but horizontally. And finally the TSIR is infused in circular ring and also PSLR (parallel stub loaded resonator) is fixed in the CPW transmission line and ground plane with 50ohms. The feed structure of 50ohms CPW consists of a transmission line with width of w4=3.6mm. To provide this multi band antenna reconfigurable four switches s1, s2, s3, s4 are used. Where switch 3 and switch 4 will be turn OFF or ON simultaneously to achieve good radiation pattern. The existence of metal bridge represents ON state and absence of metal bridge represents OFF state. The antenna model is simulated by using simulation software HFSS and the antenna parameters given in Table 1.

| Parameter | Dimension (mm) | Parameter | Dimension (mm) |
|-----------|----------------|-----------|----------------|
| Ls        | 32             | L4        | 4              |
| Ws        | 24             | L5        | 4.5            |
| r1        | 11.6           | w1        | 5              |
| r2        | 6.6            | w2        | 8              |
| r3        | 5.1            | w3        | 2.6            |
| L1        | 3.9            | w4        | 3.6            |
| L2        | 2              | w5        | 1              |
| L3        | 3.1            | w6        | 0.6            |
| g         | 0.3            | g1        | 0.2            |

Table 1: Dimensions of Antenna

### III. Results and Discussion

The attainment of the proposed antenna was examined with the band notched characteristics and multimode reconfigurable function by using HFSS and illustrated. By the design of proposed antenna the multimode function is obtained. From Figure 2 the antenna 1 is a band notched antenna at S-band to reduce the conflicts which ranges from 2.815-4.14GHz with return loss of -30.52dB for some communication satellites and also for surface ship radar. For the case of antenna 2 along vertical TSLR, with a notch at 3.5GHz WiMAX band to mitigate the intrusion from WiMAX communication systems and also dual band is obtained which ranges from 2.823-3.62GHz with return loss of -16.7dB and 4.6-5.1GHz with return loss of -15dB. For antenna 3 with horizontal TSLR triple band is obtained which ranges from 2.815-4.01GHz.
with return loss of -22.25dB, 8.2-8.8GHz with return loss of -20.44dB and 10.09-11.6GHz with return loss of -16.8dB. In case of proposed antenna 4 when switches are in ON condition, multi band is obtained which ranges from 2.8-3.6GHz with return loss at -15.7dB, 4.04-4.42GHz with return loss at -34.5dB, 7.6-8.3GHz with return loss at -37.68dB and 8.7-9.1GHz with return loss at -14.6dB along with a notch at 8GHz X-band to cut down the conflicts for satellite and military communication systems.

Figure.2: Comparison of Simulated return loss of Antenna 1, 2, 3 and antenna 4.

The following Figure represents the return loss when all switches are in ON condition and also when all switches are in OFF condition. To design the switches in proposed model the length of the Switch 1 is 0.7mm and width is 0.6mm. For switch 2 the length is 0.15mm and width is 0.6mm. For switch 3 and switch 4 the length is 0.7mm and width is 0.3mm.

Figure. 3: Simulated return loss for proposed antenna when switches are in ON and OFF conditions

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Figure. 4: Comparison of simulated VSWR for antenna 1, 2, 3 and antenna 4.

The Radiation pattern at resonant frequencies of proposed antenna when all switches are in ON condition is represented in Figure 5. The current distribution at resonant frequencies is represented in the following Figure 6.
Figure 6(a) Current distribution at 3.26GHz (b) 4.16GHz (c) 8.04GHz (d) 8.9GHz

Figure 7(a) polar gain at 3.26GHz (b) 4.16GHz (c) 8.04GHz (d) 8.9GHz
The parametric analysis of the proposed antenna 4 from the Figure 1(d) is performed by varying the radius of the outer circle from 11.6mm to 15.6mm.

**Figure. 8:** Analysis by varying the outer circle radius from 11.6mm to 15.6mm

By changing the radius of the outer circle from 11.6mm to 15.6mm then the resonant frequency values is retrieved at 12.6mm is 7.9, 8.69GHz with maximum return loss is obtained around -22.25dB. At 13.6mm is 4.17, 8.09 GHz with return loss around -13.04dB, and at 14.6mm the resonant frequency is 4.12, 7.9, 8.5GHz with return loss of -20.02dB and at 15.5mm is 4.09, 8.4, 7.8GHz with return loss of -19.9dB.

**Figure. 9:** Analysis by varying the width of L4 from Figure. 1(d)

The width of L4 is changed from 0.3mm to 0.5mm the resonant frequency values is obtained at 0.3mm is 3.3, 4.16GHz with maximum return loss around -29.8dB. At 0.4mm the resonant frequency is around 3.2, 4.14, and 7.98, 8.8GHz with maximum return loss around -31.94dB and at 0.5mm the resonant frequency is around 3.2, 4.16, 7.7and 8.7GHz with maximum return loss at -32.74dB.

**IV. Conclusion**

The presented multiband antenna has frequency reconfigurable property. By loading the PLSR and TSLR with switches there is a change in the frequency bands. The designed antenna has 4 switches, placed to off and
on the connected radiating elements. By placing the pin diode switches at different places antenna able to create more number of narrow band frequencies, the antenna structure provides the good radiation patterns and acceptable gain at different operating frequencies.

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