Frequency Reconfigurable Antenna for WLAN and X-band Applications

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Abstract - *The antenna that we designed is a compact co-planar waveguide-fed flexible antenna. The proposed design uses flexible Rogers RT/duroid 4003 (0.508 mm thickness) as a substrate with small size of 28 × 26.4 mm². Two switches are incorporated on the antenna surface to modify the current distribution which frequently changes the resonance frequency at different conditions of switches, thereby making it a frequency reconfigurable antenna. The antenna design is simulated on CST MWS. The developed antenna exhibits VSWR <1.8 with positive gain over expected frequency bands. On the basis of S-parameters and VSWR, the proposed antenna is envisioned to be established for the following applications; WLAN [3.6GHz and 4.9GHz] and X-Band [7GHz].*

Key Words: Reconfigurable antenna, co-planar waveguide-fed, switches, CST (Computer Simulation Technology), Gain, S-Parameters, VSWR (Voltage Standing Wave Ratio), WLAN (Wireless Local Area Network)

1. INTRODUCTION

Due to the advancement of wireless technology, antenna working with multiple frequency bands gained lot of attention. Every frequency band has its own application; therefore multiband antenna is required to support multiple applications in a single wireless device. Multiband antennas can operate over different frequency bands exhibiting good gain and stable VSWR. Electromagnetic radiations from the wireless device have an adverse effect on human health.The reconfigurable antennas alleviate the above mentioned problems associated with the multiband antennas. Such type of antennas can be reconfigured at the desired frequency band, radiation pattern and polarization. Reconfiguration can be achieved by placing switches within the radiating element of the antenna [1]. A reconfigurable antenna reduces intrusion from adjacent unused bands and minimizes the filter requirements of the front end circuits, thus making the design compact. Frequency reconfigurable antenna with wide bandwidth is chosen because of its miniaturization, cost effectiveness and better tuning ability between different frequency bands without affecting the gain and VSWR.

2.1 Type of Switches With Their Drawbacks

Different type of switches like varactor diodes [2], pin diodes [3], RF MEMS [4] and FET switches [5] are used to perceive the frequency agility. Varactor diodes are used for reconfiguration, but varactor diodes are non-linear and their continuous tuning range is narrow in nature [3]. Switching between multiple bands requires a large number of pin diodes that increases the insertion loss and complicates the biasing circuitry [6]. RF MEMS has a low loss, but its arrangement is expensive [7]. Three pin diodes are employed in U-shaped and L-shaped slots for LTE (Long Term Evolution) and WLAN applications. However, it uses antenna element on both sides of the substrate. Microstrip based frequency and pattern reconfigurable antenna utilizes five pin diodes. It has three operating modes; omnidirectional at 2.4 GHz, unidirectional at 5.4 GHz and both omnidirectional and unidirectional operating concurrently. Frequency reconfigurable antenna using a thick substrate (3.3 mm thickness) is presented in which resonance is controlled by shorting strips; moreover, the conical radiation pattern is maintained even at higher frequencies. A compact frequency reconfigurable antenna proposed which utilizes a simple rectangle shaped radiating patch for Bluetooth, WLAN applications. Three pin diodes are inserted in ground plane that controls switching bands. A frequency reconfigurable antenna using the FR4 substrate that switches between an ultra wide band, narrow band, and dual band mode is proposed in [8]. Using five pin diodes it achieves six switchable bands from 2.2 GHz to 4.75 GHz. However, the above mentioned designs suffer from three main drawbacks; the first is their larger dimension, the second is limited impedance band-width, the third is design complexity in terms of numerous switches.

2.2 Co-Planar Waveguide Feeding

Various feeding techniques have been used in flexible antennas, but co-planar waveguide feeding is preferable as it reduces complication by placing an antenna element and a patch on the same side of the substrate. One pin diode is employed in the T-shaped antenna for WLAN and WiMAX applications. However, its gain is comparatively low and its fabrication is expensive [9]. When it comes to co-planar waveguide feeding gain and bandwidth is amplified using flexible substrate.

In this paper, a compact flexible and frequency reconfigurable antenna is proposed. Both features; flexibility, and reconfiguration are added in this design which makes it attractive for conformal and many other applications. Switches are placed to change the electrical length of the radiator which later changes the resonant frequency. Thus, by applying switches at proper location in the proposed design, frequency reconfiguration is possible for two different applications (WLAN and X-Band).

3. ANTENNA DESIGN AND RECONFIGURATION

The proposed design is shown in Fig. 1. The proposed antenna uses Flexible Rogers RT/Duroid 4003 as a substrate. The dielectric constant of the substrate is 3.38 and loss tangent is 0.0027 with the thickness of 0.508 mm. The proposed antenna has a compact size of 28 mm × 26.4mm.The antenna is fed by a 50 Ω microstrip line.

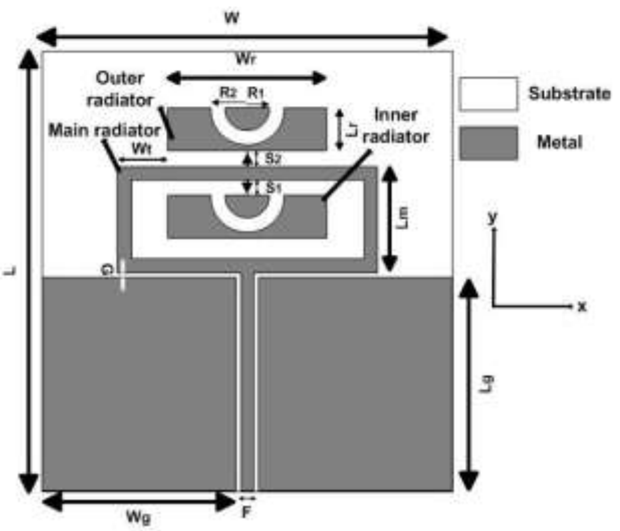

Fig. 1 Antenna configuration (top view)

Tab. 1 Optimized parameters of the proposed design

Parameter	Value (mm)	Parameter	Value (mm)
L	28	Lm	7.1
W	26.4	Lr	2.8
Lg	13.642	Wt	5.0
Wg	12.45	Wr	11
F	1	R1	1.4
G	0.258	R2	2.4

The CPW feed line having the width of 1 mm is connected to the main radiator. The inner and outer radiator is connected to the main radiator via switch S1 and S2. The rectangle is introduced inside and outside the main radiator to acquire more resonance frequencies. The arc-shaped slots are introduced in appropriate locations in the inner and outer rectangle to obtain the desired band. The width of slot controls the current intensity and minimizes the return loss. The lumped element boundary condition is used to implement the switches in CST MWS. With the four states of switches six resonance modes at 3.3 GHz, 3.5 GHz, 4.1 GHz, 4.3 GHz, 6.8 GHz and 7 GHz are excited with good impedance matching. Different parameters are described in Tab. 1.

4. RESULTS AND DISCUSSIONS

The description of states (1 to 4) in terms of the position of the two switches is described in Tab. 2. The status of the switch, i.e. whether the switch is On/off actually defines the electrical length of the antenna structure that contributes for radiating a particular frequency band. S1 and S2 are the switches that are implemented using conductor/conducting wires between two conductors to provide the path. Diodes can be used to provide the path, but this conductor is used because of limitations. When both S1 & S2 are shorted simultaneously, the current circulates in the main radiator as well as in the inner and outer radiator. When both S1 and S2 are open, the current circulates only in the main radiator.

Tab. 2 State of switches.

States	S1	S2	Frequency (GHz)
State 1	ON	ON	3.5&6.8
State 2	ON	OFF	4.1
State 3	OFF	ON	3.5&7
State 4	OFF	OFF	4.3

5. PROPOSED SYSTEM POSSIBILITIES

There are four possibilities for the designed antenna, they are:

a) S1 & S2 in OFF state
b) S1 in ON state & S2 in OFF state
c) S1 in OFF state & S2 in ON state
d) S1 & S2 in ON state

a) When S1 and S2 are opened

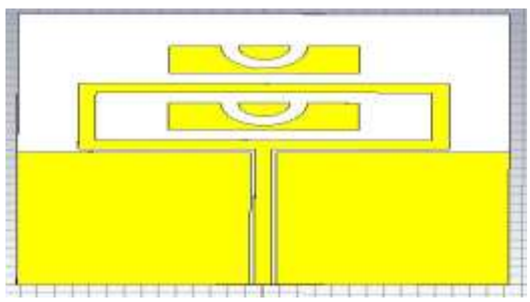

Fig. 2 Final outer structure of antenna with both switches opened

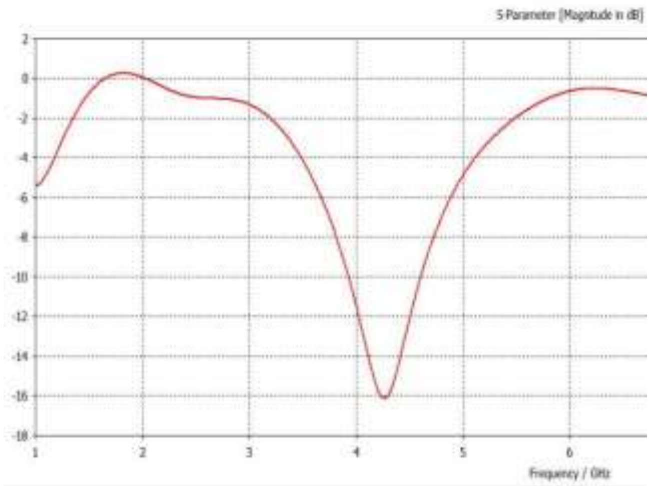

Fig. 3 S-parameter when both switches are open

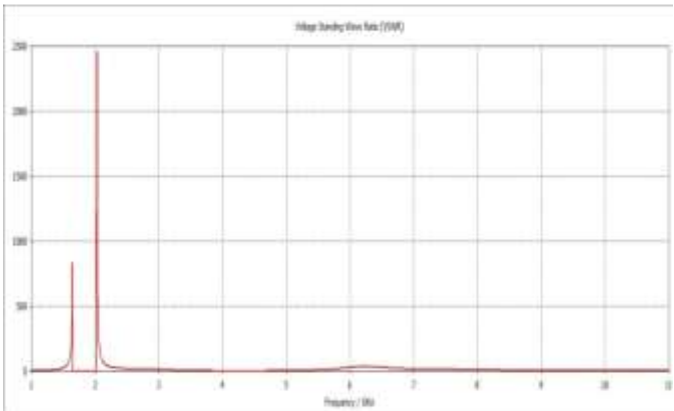

Fig. 4 VSWR at 4.3 GHz when both switches are open

b) When S1 is closed and S2 is opened

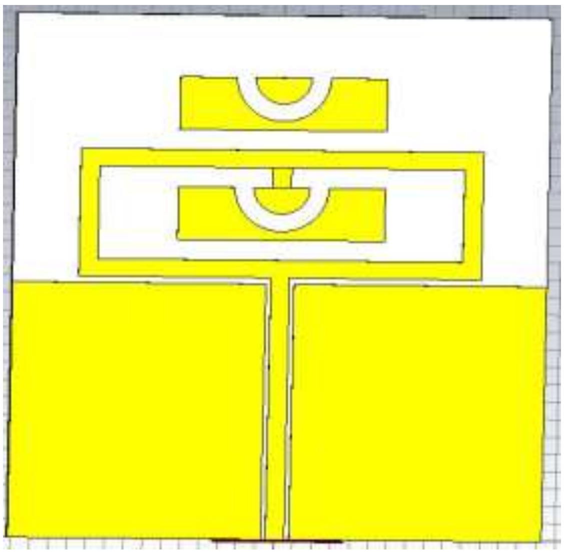

Fig. 5 Final outer structure of antenna when lower switch is closed

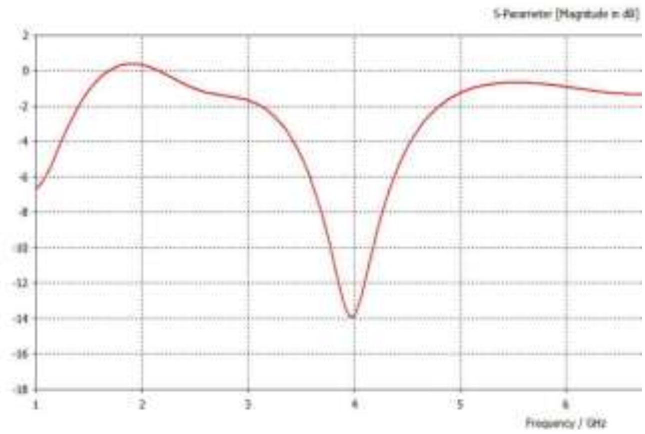

Fig. 6 S-parameter when lower switch is closed

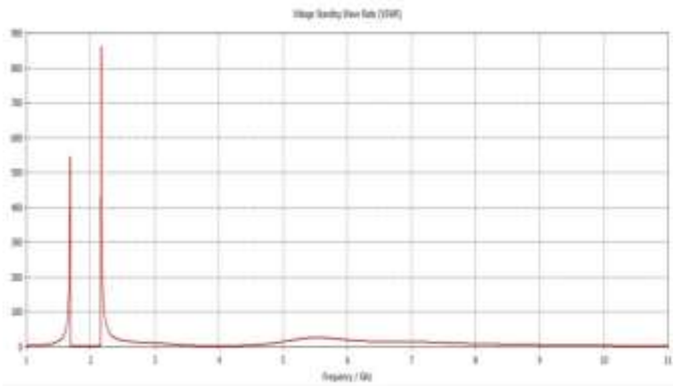

Fig. 7.VSWR at 4.1 GHz when lower switch is closed

c) When S1 is opened and S2 is closed

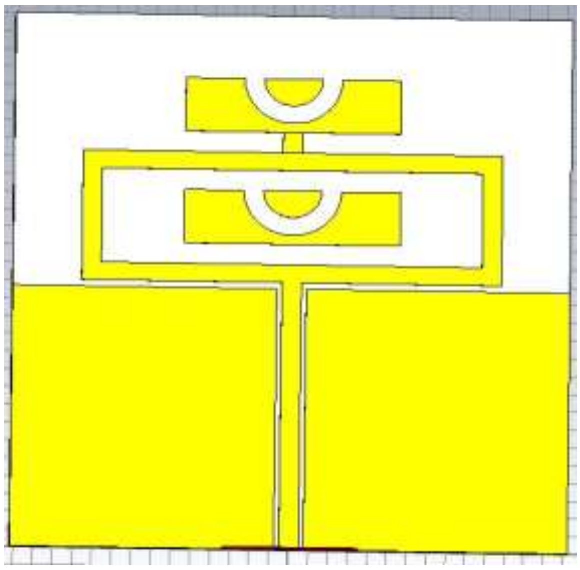

Fig. 8 Final outer structure of antenna when upper switch is closed

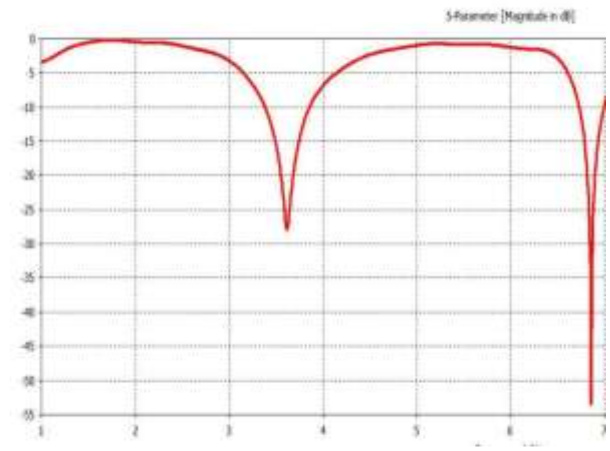

Fig. 9 S-parameter when upper switch is closed

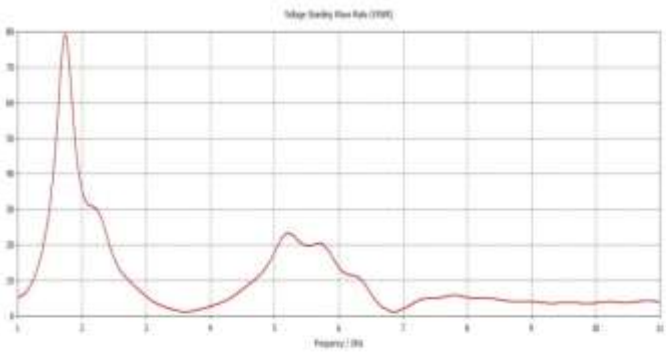

Fig. 10 VSWR at 3.3 and 7 GHz when upper switch is closed

d) When S1 and S2 are closed

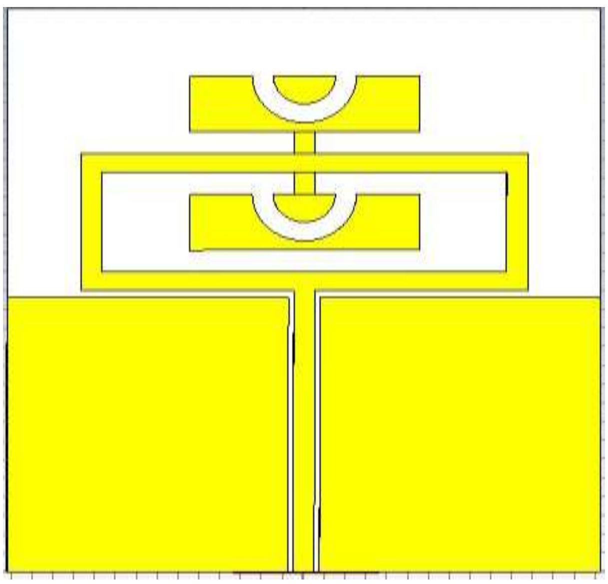

Fig. 11 Final outer structure of antenna with both switches closed

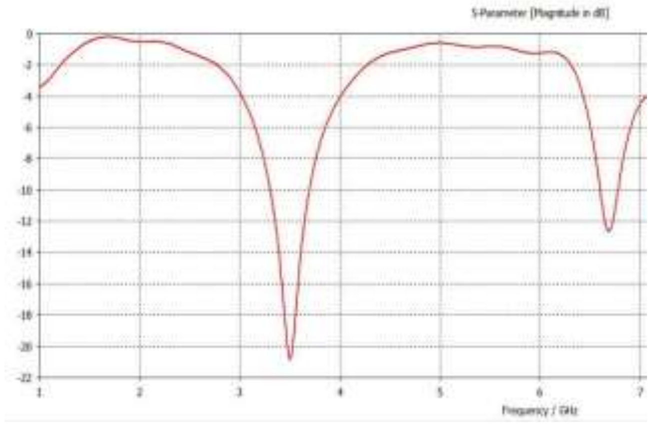

Fig. 12 S-parameter when both switches are closed

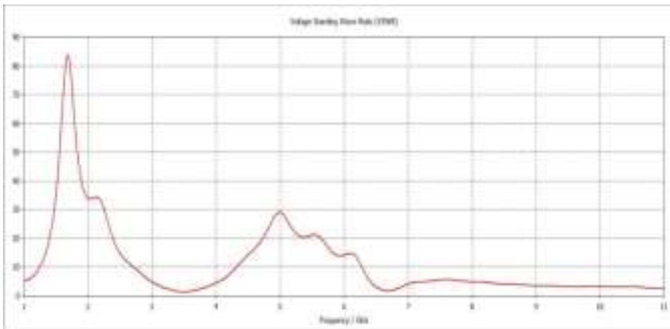

Fig. 13 VSWR at 3.5 and 6.8 GHz when both switches are closed

6. CONCLUSION

A frequency reconfigurable antenna for WLAN and X-band applications is proposed. The effective electrical length of the antenna is changed by applying switches that provide the wide tunability of the operating bands. The antenna operates effectually at desired bands and has good gain. Simplicity, compactness, reconfigurability and flexibility are some features that make it promising for wireless applications.

7. REFERENCES

[1] GE, L., LUK, K. M. Frequency-reconfigurable low-profile circular monopolar patch antenna. IEEE Transactions on Antennas and Propagation, 2014, vol. 62, no. 7, p. 3443–3449. DOI:10.1109/TAP.2014.2318077

[2] CETINER, B. A., CRUSATS, G. R., JOFRE, L., et al. RF MEMS integrated frequency reconfigurable annular slot antenna. IEEE Transactions on Antennas and Propagation, 2010, vol. 58, no. 3, P. 626–632.

[3] YANG, X. L., LIN, J. C., CHEN, G., et al. Frequency reconfigurable antenna for wireless communications using GaAs FET switch. IEEE Antennas and Wireless Propagation Letters, 2015, vol. 14, p. 807–810. DOI: 10.1109/LAWP.2014.2380436

[4] CHEN, G., YANG, X. L., WANG, Y. Dual-band frequency reconfigurable folded slot antenna for wireless communications. IEEE Antennas and Wireless Propagation Letters, 2012, vol. 11, P. 1386–1389. DOI: 10.1109/LAWP.2012.2227293

[5] HAN, L., WANG, C., CHEN, X., et al. Compact frequency-reconfigurable slot antenna for wireless applications. IEEE

[6] BHELLAR, B., TAHIR, F. A. Frequency reconfigurable antenna for handheld wireless devices. IET Microwaves, Antennas & Propagation, 2015, vol. 9, no. 13, p. 1412–1417. DOI: 10.1049/iet-map.2015.0199

[7] CHEN, G., YANG, X. L., WANG, Y. Dual-band frequency reconfigurable folded slot antenna for wireless communications. IEEE Antennas and Wireless Propagation Letters, 2012, vol. 11, p. 1386–1389. DOI: 10.1109/LAWP.2012.2227293

[8] BOUDAGHI, H., AZARMANESH, M., MEHRANPOUR, M. A frequency-reconfigurable monopole antenna using switchable slotted ground structure. IEEE Antennas and Wireless Propagation Letters, 2012, vol. 11, p. 655–658. DOI: 10.1109/LAWP.2012.2204030

[9] SAEED, S. M., BALANIS, C. A., BIRTCHER, C. R. Inkjet printed flexible reconfigurable antenna for conformal WLAN/WiMAX wireless devices. IEEE Antennas and Wireless Propagation Letters, 2016, vol. 15, p. 1979–1982. DOI:10.1109/LAWP.2016.2547338