A Probe Feed Multi-band Reconfigurable Slot Patch Antenna

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Abstract — A novel compact reconfigurable multiband antenna is proposed. The antenna is designed with the 40mm x 40mm substrate with the dielectric constant of 10.2 and the thickness of 1.27mm. the substrate used is Roger RT/Duroid 6010. By achieving the switching multiband functionality, this antenna is almost covering the complete range of X-band and Ku-band with the radiation efficiency >80 % for all the switching combinations. The operating frequencies are Band 1 (8.13-8.8GHz), Band 2 (10.2-11.17GHz, 12.17-12.38GHz, 12.77-13.15GHz, 14.15-14.57GHz, 16.16-16.5GHz, 15.5-15.73GHz), Band 3 (8.13-8.8GHz, 12-12.17GHz, 13.66-14GHz,14.4-14.66GHz, 15.5-15.7GHz, 16-16.38GHz, 18.1-18.84GHz), Band 4 (10.4-11GHz, 12.9-13.2GHz, 13,6-13,85GHz, 14.4-14.6GHz, 17.9-18.3GHz), Band 5 (10.36-11.64GHz, 12.8-13.2GHz, 14.42-14,63Ghz, 15.4-15.6GHz, 16-16.25GHz, 17.96-18.53GHz).

Index Terms — Reconfigurable antenna, multiband antenna, slot antenna, probe feed antenna.

I. INTRODUCTION

In current scenario of antenna development, the need of small size multifunctional antenna is on the rise. However the size reduction causes the poor antenna performance such as low gain and efficiency [8],[9]. The advantage of reconfigurable antenna is that the antenna volume can be reused by reconfiguring the antenna to operate in different or multiband; thus reducing the overall size. A reconfigurable antenna can be used for various surveillance and military communication by dynamically selection of bands via RF switches such as PIN or Varactor diode. For simulation, PIN diode can be modeled using RLC sheet [1]. When diode is in forward or ON state, it behaves like a resistor and in OFF state, work as a capacitor. A reconfigurable antenna has more advantages in terms of increasing antenna capabilities by tuning its performances [2-7]. The designed antenna operates in five bands which are tunable in the range of 8 to19GHz. This will eliminate the need to increase the dimensions or coverage area.

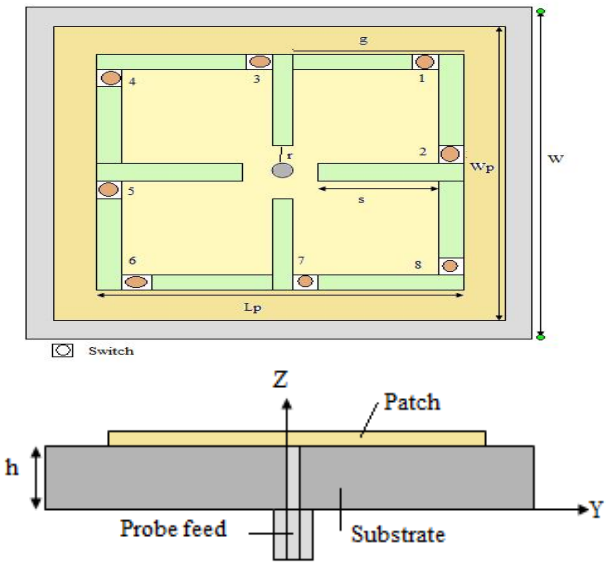

Figure 1. Proposed Structure of Antenna.

II. ANTENNA ANALYSIS AND DISCUSSION

This paper presents a novel small size antenna with reconfigurable multi-bands. The presented antenna is designed on Roger RT/Duroid 6010 substrate with the dielectric of 2.2 and the thickness of 1.27mm and the tangent loss of 0.0023. Antenna consists of 8 switches. For all the switch combinations, the return loss S11 is < -10dB as specified in fig. 3-7. Antenna is designed for the tunable frequency but, antenna is having good characteristics for 11 to 14.5 GHz range. The following graphs are for the central frequency of 14.1 GHz and the operating frequency bands are specified in Table.1.

Dimensions - (L=W=40mm, Wp=Lp= 38 mm, s=11.7mm, g=14mm, r=3mm, width of the slot is 1.5mm.

Dimension wise, the proposed 40 x 40mm antenna is small as compared to the traditional ones. Fig. 1 shows the schematic of antenna. This antenna is excited by a 50Ω probe feed at the center of the patch. The maximum return loss of the antenna is -37.7dB in the frequency band of 12.8-13.2GHz with the efficiency of 88%. The widest bandwidth of the antenna is 1280MHz with a return loss of -31.78dB in the frequency range of 10.36-11.64GHz for Band 5 when switches 1,2,3 &4 are open (ref fig 2(d)). The radiation patterns of the antenna for the different switching

combinations are shown in fig. 8-12. For all the switching combinations, the efficiency ranges from 0.80 to 0.90.

TABLE. 1 SIMULATION RESULTS OF ANTENNA

Switch Position	Frequency Range(GHZ)	Bandwidth (MHz)	Return Loss (dB)	Efficiency
All switches are closed	18.1-18.9	770	-20.1	0.80
All the switches are open (Fig. 2a)	10.2-11.17 12.17-12.38 12.77-13.15 14.15-14.57 15.5-15.73 16.16-16.5	970 210 380 420 230 340	-21.1 -16.1 -17.5 -21.9 -12.79 -16.2	0.87
Switches 1,2, 5 & 6 are open (fig. 2(b))	8.13-8.8 12-12.17 13.66-14 14.4-14.66 15.5-15.7 16-16.38 18.1-18.84	740 380 200 250 350 170 640	-11.2 -12.1 -15.9 -16.6 -12.9 -15.2 -11.0	0.87
Switches 1& 2 are open (fig. 2(c))	10.4-11 12.9-13.2 13.6-13.85 14.4-14.6 17.9-18.3	600 200 250 200 400	-16.56 -16.67 -14.7 -15.5 -12	0.86
Switches 1,2, 3 & 4 are open (fig. 2(d))	10.36-11.64 12.8-13.2 14.63-14.42 15.4-15.6 16-16.25 17.96-18.53	1280 400 210 200 250 570	-31.78 -37.4 -18.2 -17 -14.5 -13.6	0.88

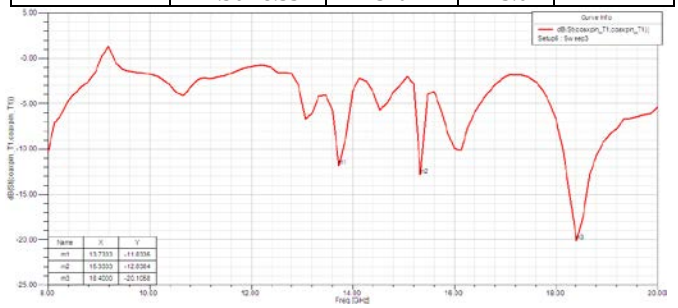

Fig. 3 Return loss (All switches are closed (fig 1(a)))

Fig. 4 Return loss (All switches are open (fig 2(a)))

Fig. 5 Return loss (Switches 1, 2, 5 & 6 are open (fig 2(b)))

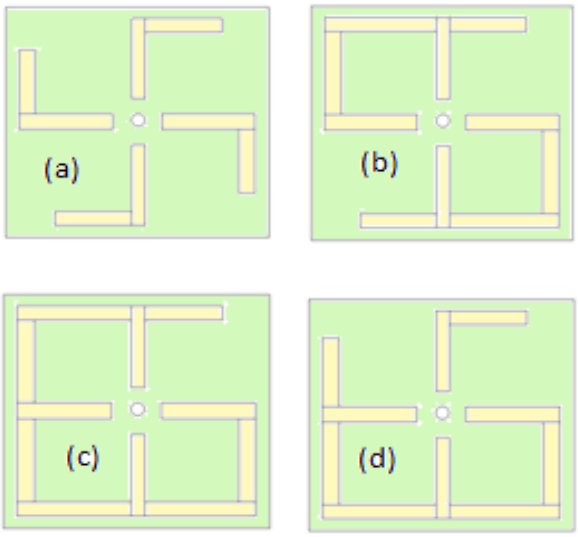

Fig. 2 Antenna structure with different switching combinations

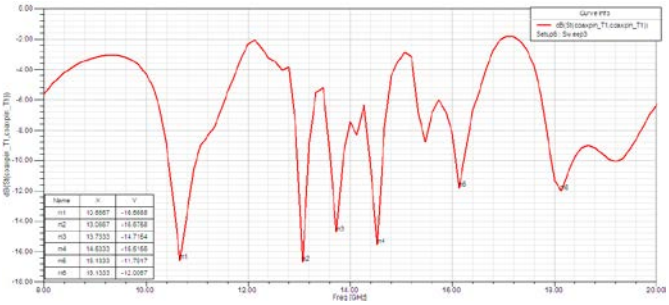

Fig. 6 Return loss (Switches 1 &2 are open (fig 2(c)))

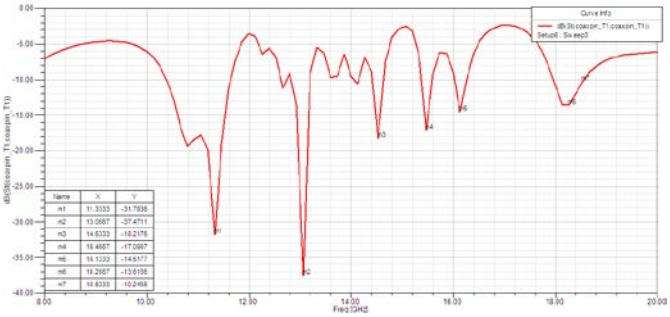

Fig. 7 Return loss (Switches 1, 2, 3 & 4 are open (fig 2(d)))

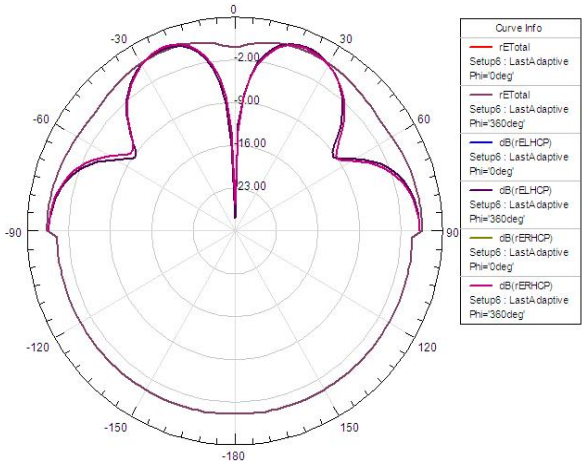

Fig. 8 Radiation Plot (All switches are closed (fig 1(a)))

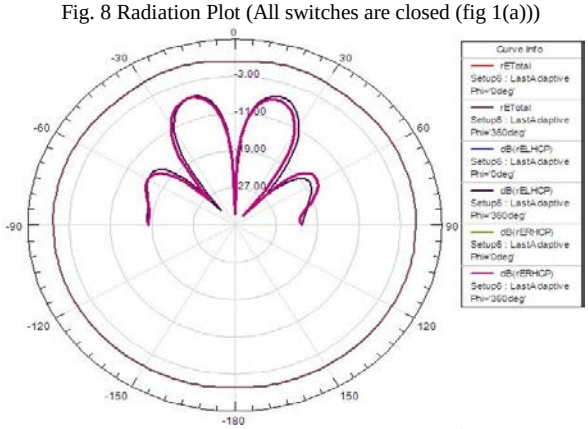

Fig. 9 Radiation Plot (All switches are open (fig 2(a)))

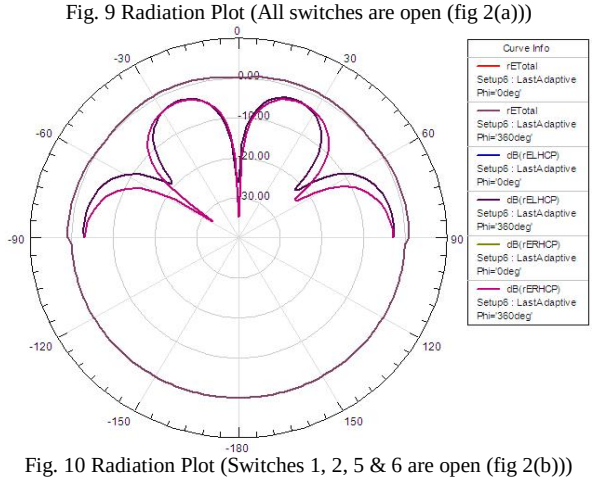

Fig. 10 Radiation Plot (Switches 1, 2, 5 & 6 are open (fig 2(b)))

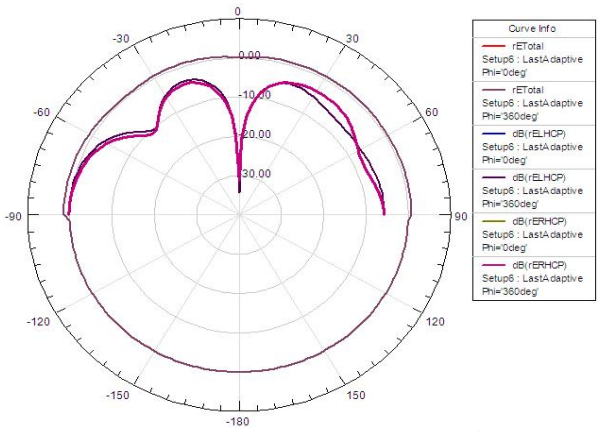

Fig. 11 Radiation Plot (Switches 1 &2 are open (fig 2(c)))

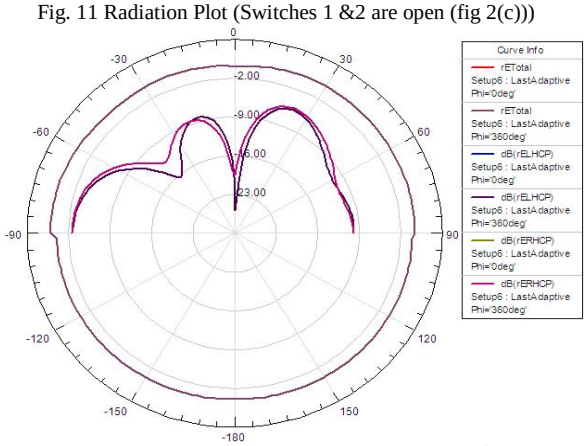

Fig. 12 Radiation Plot (Switches 1, 2, 3 & 4 are open (fig 2(d)))

III. CONCLUSION

A novel small size reconfigurable multiband antenna is designed and simulated using HFSS software [12]. The presented antenna is covering the range of x-Band (8-12GHz) and Ku-Band (12-18GHz). The operating frequency ranges are providing the acceptable reflection coefficient, s11< -10dB, the VSWR ranging from 1.21-1.93(VSWR< 2) in the operating bands and the efficiency > 80 % in all the cases. However, the need of this structure is to optimize and removal of the notch-bands to expand the radiating band. Our future work is to optimize the antenna performance with less switches and to remove the undesired notch-bands of the antenna.

REFERENCES

[1] Hattan F. Abutarboush, "Fixed and reconfigurable Multiband Amtennas," *A thesissubmitted for the degree of Doctor of Philosophy*, July 2011.

[2] M.R. Hamid, P. Gardner, P.S. Hall, F. Ghanem, "Switchable Wideband-Narrowband Tapered Slot Antenna," *Loughborough Antennas & Propagation Conference*, pp. 241-244, 2009.

[3] Qiang Chen, Makoto Kurahashi and Kunio Sawaya, "Dual-mode Patch Antenna Switched by PIN Diode," *IEEE Topical Conference on Wireless Communication Technology*. 148-149, 2003.

[4] S. V. Shynu, G. Augustin, C. K. Aanandan, P. Mohanan, and K. Vasudevan, "Design of Compact Reconfigurable Dual Frequencies Microstrip Antennas Using Varactor Diodes,"

Progress in Electromagnetic Research, PIER 60, 197–205, 2006.
[5] F. Ghanem, J.R. Kelly, and P.S. Hall, "Switched UWB to Narrowband Planar Monopole Antenna," *European Conference on Antennas and Propagation 2010*, 12-16 April 2010, Barcelona.
[6] M. T. Ali, T. A. Rahman, M.R. Kamarudin and M. N. Md Tan, "Reconfigurable Linear Array Antenna with Beam Shaping at 5.8GHz," *Microwave Conference, 2008*. APMC 2008.
[7] M. Jusoh, M. R. Kamarudin, M. F. Jamlos, M. F. Malek, "A Novel Compact Reconfigurable Multi-Band Antenna," *IEEE international RF and Microwave Conference (RFM 2011)*, Seremban, Malaysia 2011.
[8] A. Skrivervik, J.-F. Zurcher, S. O, and J. Mosig, "Pcs antenna design: the challenge of miniaturization," *IEEE Antennas Propagat. Mag.*, vol. 43, no. 4, pp. 12–27, 2001.
[9] R. Azadegan and K. Sarabandi. "A novel approach for miniaturization of slot antennas," *IEEE Antennas Propagat.Mag.*, vol. 51, no. 3, pp. 421–429, 2003.
[10] Constantine A. Balanis, "Antenna theory- Analysis and design," Second edition, John Wiley & sons, Inc., pp. 727-735, 1997.
[11] Thomas A. Milligan, "Modern Antenna Design," Second Edition, John Wiley & Sons, Inc., chapter 5&6, 2005.
[12] Ansoft HFSS 14, Ansoft Corporation.