Active Switchable Band-Notched UWB Patch Antenna

Praveen Kumar Kancherla

***Abstract**: In current study, compact active Ultra Wide band (UWB) antenna ranging from 3.1GHz to 10.6GHz, extendable up to 13GHz with dimensions of 32mm x 36mm x 1.6mm is designed, and its radiation characteristics are presented. Radiating aperture of antenna is provided with two J-shaped slot cuts. PIN diode as a switch is implanted on these two slots in parallel position. During the switching operation of PIN diodes, the operating frequency of proposed antenna is altered (Reconfigured) by notching the band spectrum.*

***Index Terms**: Notched band, Reconfigurable, Ultra-Wideband antenna, WLAN.*

I. INTRODUCTION

In any communication systems, antenna plays key role as transducer. All fundamental antennas have fixed antenna characteristics, so enforce restrictions on overall system performance. To avoid above said problems antenna are provided with tunable systems hence made re-configurable. The UWB systems consumes low-power, its design cost is very low and high data rates. These have wider applications in Wireless Personal Area Networks (WPAN), PC peripherals, mobile computers, etc. By band-notch technique, in-band interfaces in UWB range can be minimized. As per the demand of end user, number of techniques have been proposed for rejection of some frequency bands (notch band) in UWB rang. In this section some switching devices and its incorporation in antennas is presented. In [1], PIN diode is used as switch placed in a rectangular slot cut in E shaped resonating structure. In [2], CPW feed square shaped ring resonator used varactor diodes to reconfigure between wide band and narrow band modes. In [3], reconfigurable antenna is designed that switching between UWB state, and three narrowband states. Similar kind of switching techniques are presented in [4-8].

II. ANTENNA DESIGN

At this stage, truncated, CPW feed patch with two J shaped slots design procedure is explained in four iterations. During first iteration, rectangular patch with CPW feed over a rectangular ground on FR4 epoxy dielectric substrate is designed. A small gap of '*Sp*' maintained between patch and ground as shown in Fig 1(a). During second iteration, to improve antennas impedance band width rectangular patch corners are modified as as shown in Fig. 1(b) and 1(c). During fourth iteration, rectangular ground is changed to semi-elliptical shape as given in Fig 1(d).

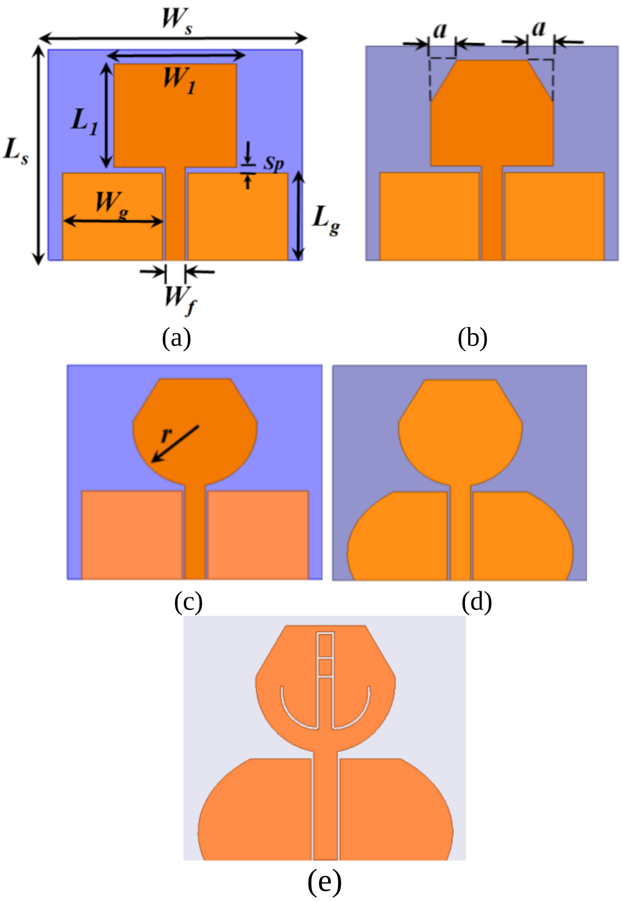

Fig. 1 Geometries of truncated, CPW feed patch with two J shaped slots.

During fourth Iteration, two J shaped slots are etched on radiating patch to have band rejection at required frequencies as shown in Fig. 1(e). Two J-shaped slots are combined by three rectangular narrow slots. First one is combining the upper edges of J slots, other two are combining another two locations at the middle of J slots. This helps to create band notch between 3-4 GHz bands. Three diodes named as D1, D2 and D3 are implanted in the slots lying parallel to each other as shown in Fig. 2(a) then eight combinations are possible.

Table 1: Antenna design parameters

Parameter	L_s	W_s	r	R_r	L_1	W_1
Value (in mm)	32	36	8	3	15	17
Parameter	L_g	S_p	W_f	a	W_g	h
Value (in mm)	13	1.8	3	3.5	14	1.6

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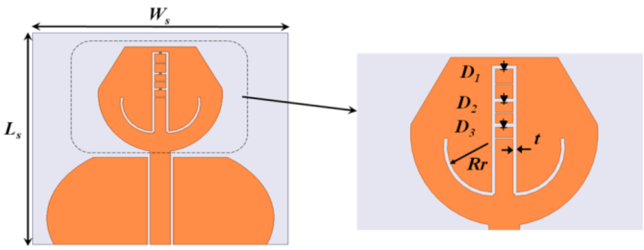
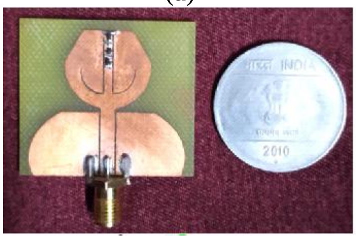


(a)



(b)

Fig. 2 (a) Re-configurable active CPW patch antenna. (b) fabricated design

III. RESULTS AND DISCSSIONS

A. Reflection coefficient at four iterations.

Proposed antenna is designed in HFSS software and simulated for results in four iterations and obtained results are depicted in Fig 3. From figure one can observe that antenna has good impedance matching from 3GHz to 12GHz. During first iteration, antenna is operating at 3.8447GHz with an operating band width ranging from 2.61GHz to 5.7 GHz. During second iteration the antenna is resonating at 3.8894GHz with an operating band width ranging from 2.94GHz to 5.58 GHz. During third iteration, antenna operating at two distant frequencies that is 3.5468GHz and 10.0553GHz with an operating band width ranging from 2.65GHz to 12.92GHz. During final iteration without two J shaped slots, the antenna resonating at three different frequencies they are 3.5021GHz, 7.4191GHz, 10.9787GHz with an operating band width of range 2.62GHz to 13.49 GHz.

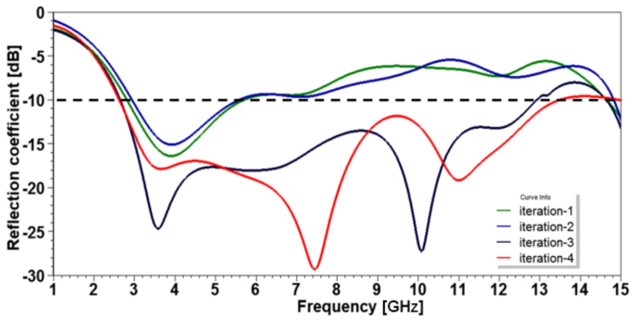


Fig. 3 Return loss characteristics during four iterations.

When J shaped slots are provided on then proposed structure resonating at three different frequencies they are 3.1563GHz, 4.0756GHz, 7.6609GHz and operating bandwidth is ranging from 2.80GHz to 13.62 GHz as depicted in Fig. 4.

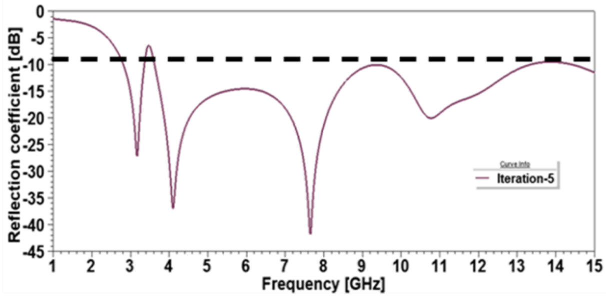


Fig. 4 Coefficient of reflection (S_{11}) characteristics of two J slotted CPW feed truncated patch antenna.

When PIN diodes are implanted on the surface of antenna, and started tuning then obtained reflection characteristics are presented in Fig. 5 and Fig. 6. It is observed that, a small shift in notch band lying during 3GHz - 3.5GHz and 3.5GHz - 4GHz regions and new small notch band is created within the region of 9GHz -10GHz band. The consolidated operating band characteristics are statistically presented in Table 2.

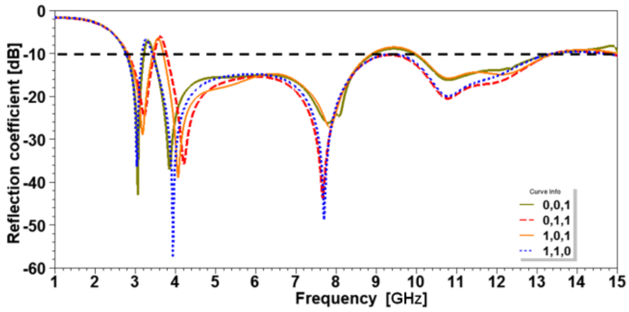


Fig. 5 Reflection characteristics of proposed design at various (001, 011, 101, 110) biasing conditions.

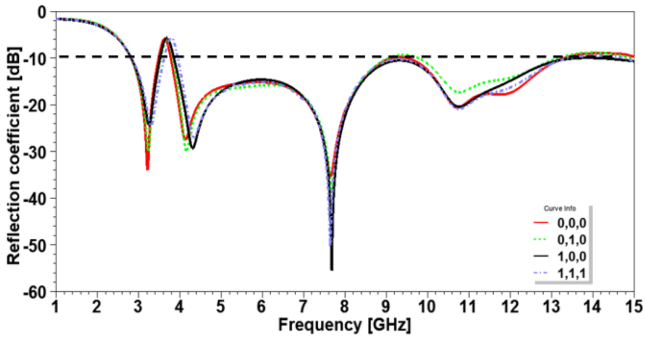


Fig. 6 Reflection characteristics of proposed design at various (000, 010, 100, 111) biasing conditions.

B. Re-configurable Far-field pattern

For better understanding re-configurable radiated patterns of proposed antenna its 2D principle plane patterns and 3D polar plots are used and shown bellow.

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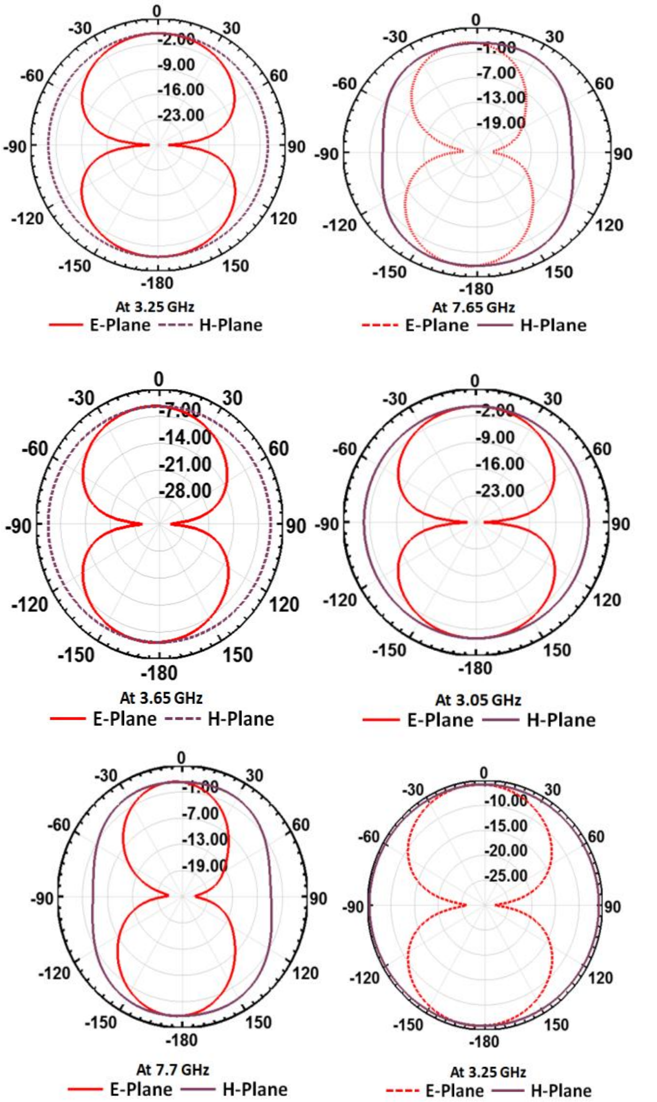
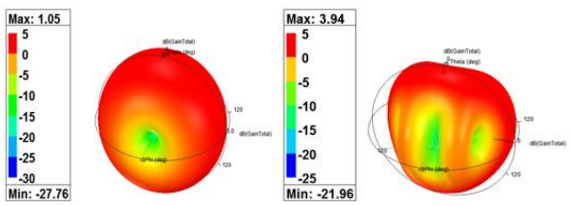
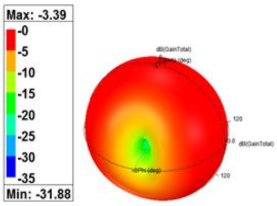


Fig. 7 Radiation patterns of proposed antenna at resonance and notch frequencies.

Radiated patterns at an operating frequency 3.25GHz during switching action of 011 and at an operating frequency 3.05GHz during switching action of 110 are identical and pattern of E-plane are in dumbbell shape, pattern of H-plane are Omni directional. At operating frequency 7.65GHz during switching action of 011 and at an operating frequency of 7.7GHz during switching action of 110, pattern of E-plane are almost dumble in shape during 0^0 to 180^o, pattern of H-plane are nearly Omni directional. At operating frequency 3.65GHz during switching action of 011 and at operating frequency of 3.25 GHz during switching action of 110 pattern of E-plane are almost dumble in shape, pattern of H plane are Omni directional. These radiation patterns are clearly visualized using 3D polar plots, depicted in Fig. 8 and Fig. 9

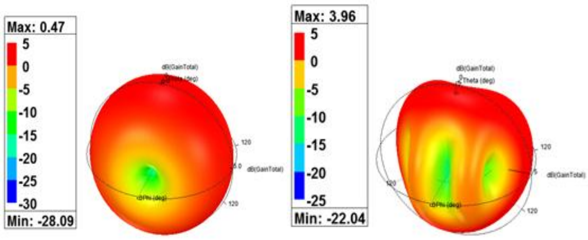


(a) 3.25 GHz (b) 7.65 GHz



(c) 3.65 GHz

Fig. 8 3D polar plots at different frequencies during switching condition of 011.



(a) 3.05GHz (b)7.7GHz

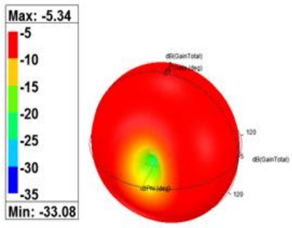


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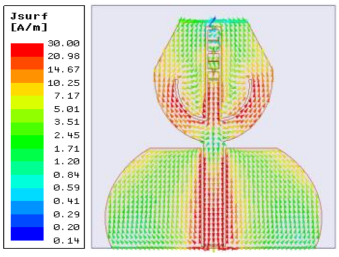
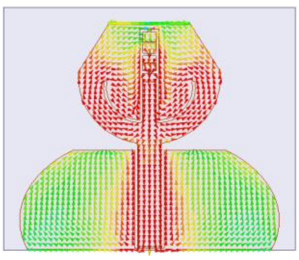
Fig. 9 3D polar plots at different frequencies during switching condition of 110.



(a) 3.25GHz



(b)3.62GHz

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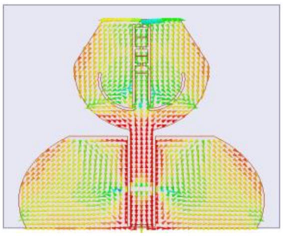
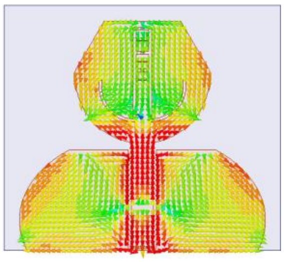


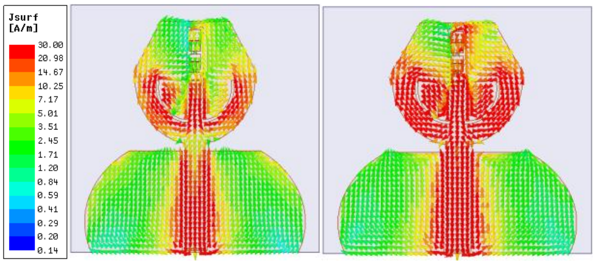
(c)7.67GHz

Fig. 10 Concentration of surface current during switching condition of 011.



(c)7.7GHz

Fig. 11 Concentration of surface current during switching condition of 110.



(a) 3.05GHz (b)3.27GHz

Table 2 Re-configurable radiation pattern of proposed antenna at different switching conditions.

Switching Cases	Operating bands	Notch bands	Peak Gain [in dB] (Operating band)	Radiation Efficiency (Operating band)	Peak Gain [in dB] (Notch band)	Radiation Efficiency (Notch band)
	Resonant Frequencies [GHz]	Notch Center Freq [GHz]				
000	2.82-13.30	3.49-3.79	4.8214	0.9534	-5.5569	0.2451
	3.22/4.15/7.65	3.64				
001	2.772-13.43	3.22-3.45	4.8801	0.9494	-5.7347	0.2291
	3.07/3.85	3.32				
010	2.82-13.16	3.54-3.83	4.7124	0.9551	-5.2050	0.2330
	3.25/4.15/7.69	3.69				
011	2.82-13.42	3.48-3.78	4.9716	0.9527	-5.3388	0.1905
	3.23/4.22/7.67	3.62				
100	2.83-14.08	3.53-3.86	4.8500	0.9539	-4.8533	0.2207
	3.26/4.31/7.67	3.69				
101	2.80-13.44	3.40-3.70	4.8990	0.9519	-4.6789	0.2149
	3.18/4.08/7.87	3.57				
110	2.77-13.39	3.12-3.42	4.9630	0.9514	-5.3415	0.2614
	3.05/3.94/7.70	3.27				
111	2.84-13.41	3.63-3.95	4.8970	0.9558	-4.7088	0.2424
	3.31/4.35/7.64	3.80				

IV. CONCLUSION

Simulated and Measured radiation characteristics of CPW fed truncated patch with triple band notch are presented and its results are discussed. By tuning the switches proposed antenna band notch characteristics are possible to alter. Peak gain of proposed antenna at an operating band is greater than 4.5dB and observed negative gain during notch band this indicates rejection capability of designed antenna.

REFERENCES

1. Mohammad M F et al. (2016). A Wideband and Reconfigurable Filtering Slot Antenna, IEEE Ant. Wirel Prop. Lett, 15, pp1610-1613.
2. Abubakar T el al. (2012). Frequency-Reconfigurable Monopole Antennas, IEEE Trans Ant. Prop, 60, 1, pp44-50.
3. Hamid B, M. et al. (2012). A Frequency-Reconfigurable Monopole Antenna Using Switchable Slotted Ground Structure, IEEE Ant. Wirel Prop. Lett, 11, pp655-658.
4. Lakshmikanth P, Takeshore Kh. (2015). Printed Log Periodic dipole antenna with Notched filter at 2.45 GHz Frequency for wireless communication applications, J. of Engg and Appl. Sciences, ISSN: 1816-949X, 10, 3, pp40-44.
5. K.Praveen Kumar, Dr Habibulla Khan " Surface wave suppression band, In phase reflection band and High Impedance region of 3DEBG Characterization" IJAER, Vol 10, No 11, 2015.
6. K.Praveen Kumar, Dr. Habibulla Khan, "Design and characterization of Optimized stacked electromagnetic band gap ground plane for low profile patch antennas" IJPAM, Vol 118, No. 20, 2018, 4765-4776.
7. K.Praveen Kumar, Dr. Habibulla Khan "Optimization of EBG structure for mutual coupling reduction in antenna arrays; a comparitive study" IJET, Vol-7, No-3.6, Special issue-06, 2018. page 13- 20.
8. K.Praveen Kumar, Dr. Habibulla Khan "Active PSEBG structure design for low profile steerable antenna applications" JARDCS, Vol-10, Special issue-03, 2018.

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