Reconfigurable Micro Strip Patch Antenna Using Single Switch for Wideband Applications

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Abstract – Technique of using the single switch on transmission line to attain reconfigurability for wideband application is presented in the paper. Design is basically influenced from central feeding as well as use of switch on the transmission line. Choice of switch is entirely depend upon its usage and advantages over others. Study of microstrip patch design and its configuration mode with switch states (ON & OFF) is picturized in the paper. This work help to understand the usage of such antenna with different switch states which shows the wide operating range of RF signal providing good bandwidth and notches. By changing the ON and OFF states of switch interference can be blocked and available spectra can be detected. Proposed design is simulated on HFSS software.

Index Terms – Reconfigurable notches, transmission line, wireless local area network (WLAN).

1. INTRODUCTION

The term reconfigurable antenna comes in to the picture when we require more services at times. In this modern world the way traffic of vehicles increasing, in the same way wireless traffic is increasing and as a result of this demand of such antennas increased. Reconfigurable antennas are the types of antennas which help users to attain number of frequency operation with the help of switch. Switches do the work of changing the surface radiation properties by changing the physical size of antenna. There is need to achieve wide impedance bandwidth that we can get it by making switch ON and OFF placing on selected parts of antenna [1]. For achieving the reconfiguration or operating frequencies, there are some switching components which are widely used. PIN diodes, MEMS, and optical switches are normally used [2]. PIN diodes gained popularity as they require low biasing voltages. Optical switches are used where biasing is not required and takes power from optical sources to change the conductivity of silicon switch [3]. Reconfigurable antennas offer several advantages of small size, same radiation patterns for all frequency bands [4]. Some mind blowing features as low power consumption and low power spectral density makes these wideband antennas suitable for application in wireless sensor network, biomedical and health care wireless system [5]. Whenever reconfigurable antenna's designing part with dynamic switches proceeds, collective repetition is to primarily make standard switches as short or open circuits [6]. After this switches are more precisely configured using the corresponding circuit representation. Photodiodes are also used sometimes as a switch based on the power requirement and size of the antenna [7].

In this paper work has been done to bring out more bandwidth and number of notches with compact size. Switch is used in feeding line so as to neglect some interference which can interfere with the radiation properties of antenna. As more number of switches used more is the probability of interference with radiation properties of the antenna. In this design some slot are made to bring out the good return loss characteristics. This work is done to achieve Wi-Fi and WLAN band and to use these band at a times on single antenna. Also with Wi-Fi and WLAN band the unique design of antenna provides the X band which is used for RADAR and space communication. If there is need to notch frequencies then that is also achievable. That's how this whole antenna is designed and proposed antenna shows good simulation result and return loss characteristics. Switch which has been used is PIN diode because of its simplest equivalent circuit and easy installation on fabricated antenna. One more advantages to use PIN diode switch is low biasing voltage requirement. Proposed antenna also shows good gain which is nearly about 3.96 dB.

Keeping compact size in mind, the basic reconfigurable antenna designed in such a way so that it provides simplicity, low cost and desirable characteristics. So many designs came which support notching of frequencies and its wideband transmission. Among all these antennas most suitable and low profile design is selected which is type of planar microstrip central feed line structure. There have been many methods to design a reconfigurable antenna some of which are U shaped, L shaped and J shaped slots which are studied with introduction of slots in radiating patch and the ground. Switch which has used in design is PIN diode for changing the frequency response.

2. RELATED WORK

L.G. Silva et al [8] worked for optically controlled filtenna. Authors proposed integration of broadband printed antenna with a bandpass reconfigurable RF filter which is designed by

applying defected microstrip Structure. DMS technique is applied due to the size limitation. It is also applicable to amplifier harmonic suppression, microstrip size reduction and microstrip longitudinal size reduction. Discrete SMD capacitors were used for making the antenna bandwidth reconfigurable. Two silicon photo conductive switches was used to for ensuring bandwidth reconfigurability. Design which carries frequency reconfigurable microstrip antenna and a frequency reconfigurable rectifying circuit can be configured to receive RF power at 5.2 GHz which is of Wide Local Area Network and converted it to DC power [9]. There are many antennas designed for different frequency of operations. Main problem occurs to minimize the size and to bring out the wide bandwidth with more number of notches without using more switches. Tamer Abou foul et al [10] the paper discussed reconfiguring UWB monopole Antenna for cognitive radio applications by using GaAs FET switches. Four stubs of different lengths are connected with these switches to the main feed line of the monopole. Authors used these switches because of their simple biasing and less effect on antenna performance. In addition to less degradation on the antenna gain and efficiency, it has the less power consumption. Designing of planar reconfigurable UWB circular-disc monopole antenna uses four stubs connected with 50Ω microstrip feed line with thickness of 0.75mm. Design was printed on FR4 substrate. Control voltage of these switches is +3.3V, and DC current consumption is very low. In simulation and measurements results antenna provided satisfactory results for Cognitive radio application. Monika Arora et al [11] the basic structure of the designed antenna is of octagon shape which works for C, X, and Ku- band applications.

3. PROPOSED ANTENNA DESIGN

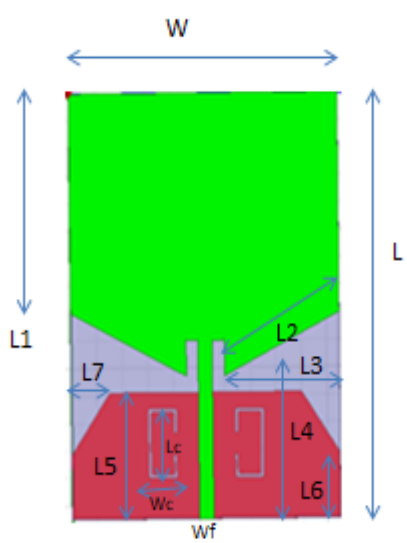

Figure 1 Design of Proposed Antenna Wideband Antenna

Antenna geometry selected is very similar to rectangular microstrip patch antenna. Without dimensions it is quite difficult to design antenna. So first it is very important to go for dimensions which have been calculated by using the formulas used for narrowband patch antenna. The basic design of proposed design is shown in figure 1 and dimensions of proposed antenna are listed in table 1. Designed antenna is simulated on Fire Retardant (FR4) epoxy substrate with dielectric constant ε_r = 4.4, thickness h = 0.8 mm and loss tangent of 0.02. In both dry and humid conditions FR4 shows good behavior and that's why has been selected as a substrate. No doubt at a high frequency there are chances of losses bit it is still the better choice because of its low cost and availability.

Table 1 Antenna Dimensions

Parameters	Dimensions	Parameters	Dimensions
L	31mm	L4	10.4mm
W	20 mm	L5	9.20mm
L1	16mm	L6	4.70mm
L2	9.10mm	L7	3.00mm
L3	7.30 mm	Wf	1.1mm
Wc	2 mm	Lc	5 mm

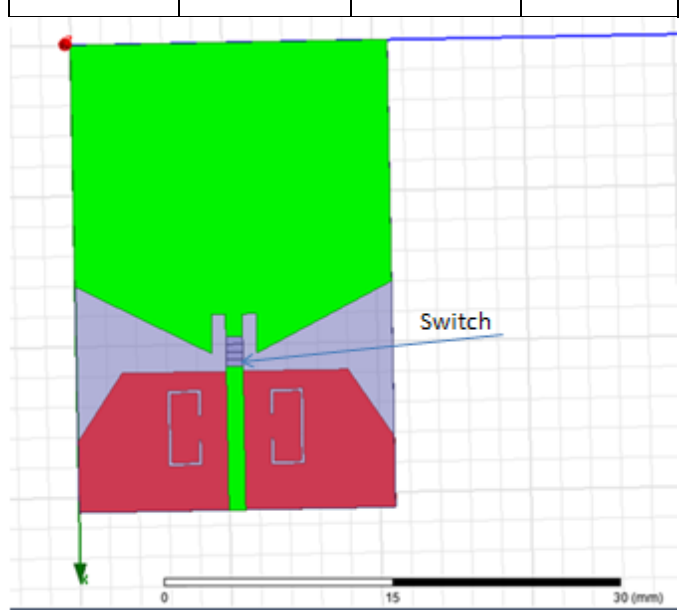

Figure 2 Proposed design with Switch

The antenna impedance is found to be 253Ω. The antenna is fed by 50 Ω microstrip line of width Wf = 1.10 mm. Antenna Consist of radiating patch with central feeding and ground on lower side.

The length of C slot are decided by the formula

$$f_{max} = \frac{c}{2Leff\sqrt{\epsilon eff}}$$

Where

c = speed of light

L_{eff} = total effective length

ϵ_{eff} = effective relative dielectric constant

In the final proposed design the C slot is introduced to notch down the X band (around 7.4 GHz).

4. RESULTS AND DISCUSSIONS

Figure 3 is the simulated return loss of the antenna with C slot. Two bands are achieved one is from 2.5 GHz – 3 GHz and 8.3 GHz – 10.8 GHz. Antenna resonate at 2.4 GHz and 9.6 GHz.

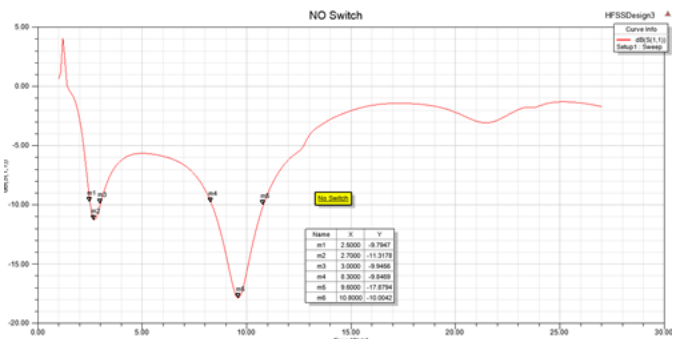

Figure 3 simulated return loss of antenna with C slot

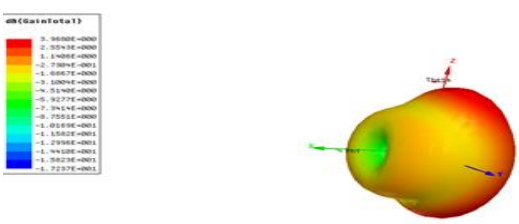

Figure 4 simulated gain of antenna with C slot

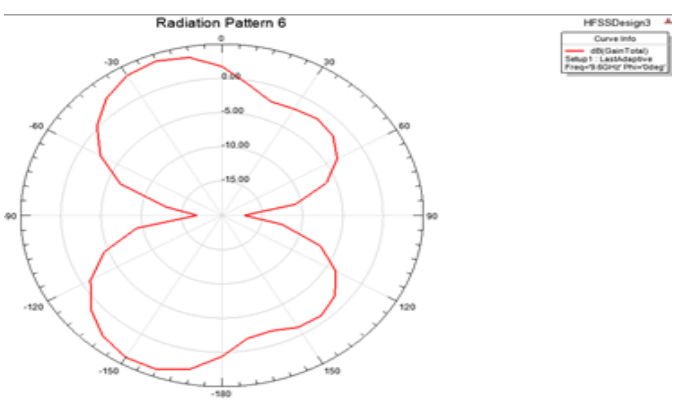

Figure 4 Simulated radiation pattern of antenna at $\emptyset = 0°$

Above figure 4 and 5 is simulated 3-D polar plot and radiation pattern of antenna at 9.6 GHz respectively. Gain is positive and found to be 3 dB at maximum.

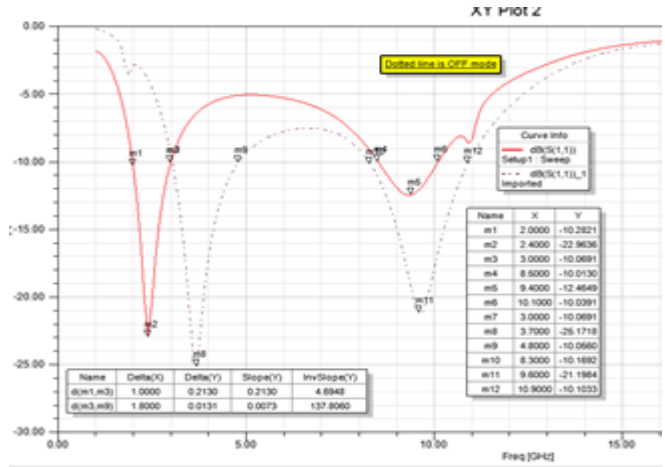

Figure 3 simulated return loss of proposed antenna with switch

Above figure is simulated return loss with switch and C slot. When switch was introduced and put on ON mode then Wi-Fi band was achieved and antenna resonates at 2.4 GHz and Wi-Max band was notched. Second, when switch was OFF the Wi-Fi band is notched and Wi-Max (3.3-3.7 GHz) band was achieved and resonated at 3.7 GHz. With the introduction of C slot it also provides X band which is used for RADAR and satellite communication whether switch is in ON and OFF mode.

Table 3 Antenna with switch operational configuration

Configuration Mode	Operational band	Notched Band
Switch ON	Wi-Fi (2.4 GHz)	Wi-Max
Switch OFF	Wi-Max (3.7 GHz)	Wi-Fi

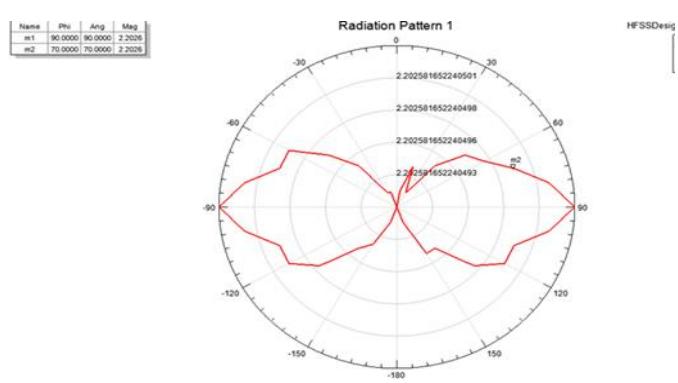

Figure 5 Simulated gain at ON configuration mode

Figure 5 displays gain of the proposed antenna operating at ON mode. It has been observed that antenna has gain ranging from 2-3 dB over allowed wideband. All results are showing that proposed antenna has performed well in the band-notched frequency.

5. CONCLUSION

In this paper, a reconfigurable microstrip patch antenna with switch on transmission line is simulated on HFSS software. Most attractive points of this antenna is that it has capability of providing the reconfigurability over Wi-Fi band and Wi-Max band with single switch.

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