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A Reconfigurable Micro-Strip Antenna Structure Embedded with VariCap for Adaptive Wireless Communication systems

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Abstract: In this paper , a planar frequency reconfigurable meandered microstrip antenna is proposed with variable capacitor for continuous tuning. The proposed design is implemented with a planar monopole structure for frequency reconfigurablity by variation in the capacitance of VariCap diode. The equivalent circuit and electromagnetic(EM) simulation are utilized for the analysis at the variable characteristic design of the antenna, and the same radiation performance.

The implemented frequency adjustable planar monopole antenna has been validated by comparing the fabricated W-slotted Frequency Reconfigurable Micro Strip Antenna(W-FRMSA) prototype with designed capacitors and ones with biased varactor diodes. The proposed W-FRMSAs antenna has presented the resonant frequency variations from 2.35 GHz to 2.44 GHz.

Keywords: Frequency reconfigurable Antennas, Planar monopole antenna, Varactordiode, Cognitive Radio.

I. Introduction

The progress in wireless communication systems and applications and the increased rise in the demand for new protocols have created an unbalance in the spectrum allocation and utilization. The scarcity in the frequency distribution among various wireless applications is due to the spectrum management policies and not due to the lack of available frequencies[1]. It is determined that there is a need for a communication protocol that can detect the various white spaces that exist in the spectrum, as well as communicate over these white spaces. This need is inspired by a recent report filed by the Federal Communications Commission (FCC) that identifies 70% of the spectrum as underutilized and widely idle[2]. These idle gaps in the spectrum are also called white spaces.

Several Micro strip antenna designs have been reported in the literature, however, in many cases they are relatively large in size and mostly incapable of multiband operation. A small printed planar antenna is presented for providing continuous tuning operation with a W shaped meandered structure. A microstripline feed is used for excitation.

A. Cognitve Radio

The Federal Communication Commission(FCC) identified the issue underutilization of spectrum, and It labeled the unused frequencies as white spaces at various time spans as wasteful spectrum allocation[3]. Based on this, several solutions have been proposed to improve the spectrum usage problem. These solutions are divided into three main categories: spectrum reorganization, spectrum leasing, and spectrum distribution, as shown in Figure 1.

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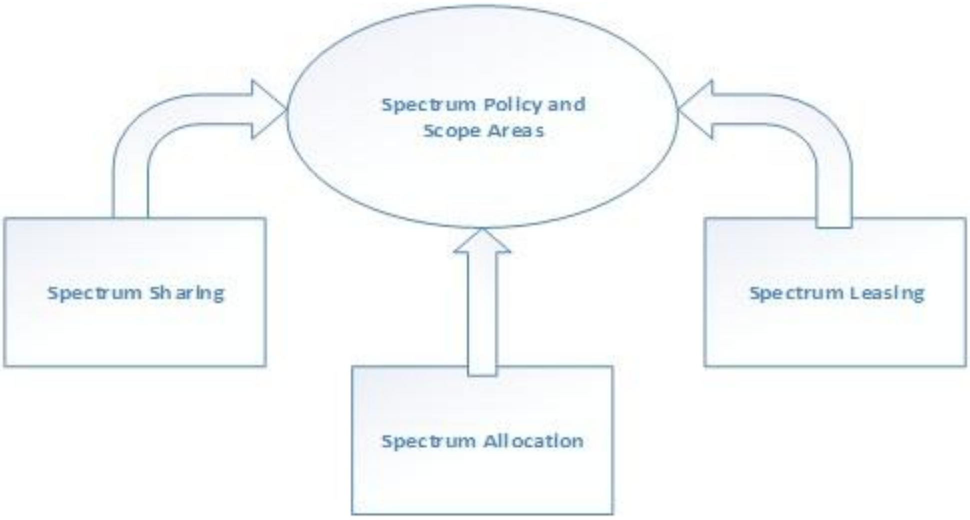

Figure 1: *The Spectrum policy of FCC*

A Cognitive Radio(CR) is built on a Software-Defined Radio(SDR) platform with an additional learning and cognition capability. The cognitive radio(CR) system needs to adapt to the operational parameters of a certain communication channel such as the transmit power, carrier frequency, polarization, modulation scheme, and transmission data rate[4].

II. DESIGN OFW-FRMSA RF STRUCTURE

A frequency tuned antenna structure using a Varactor diode for continuous tuning is designed using HFSS Electromagnetics . The proposed W-shape meandered Frequency reconfigurable Micro strip antenna(W-FRMSA) is designed to resonate in a single band as shown in Figure.2[5].

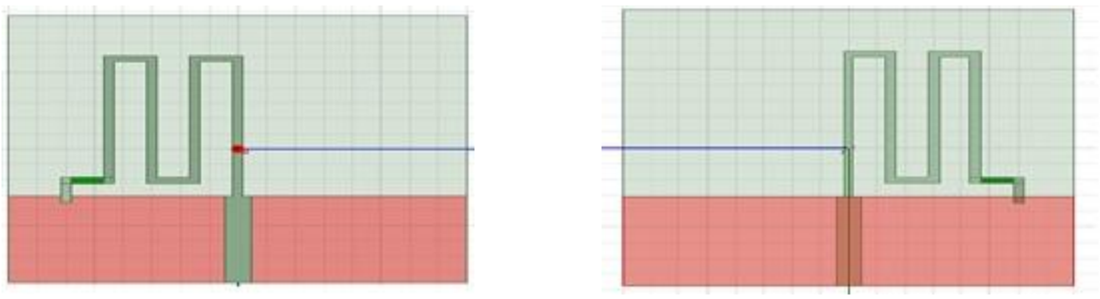

Figure 2a: *Top view of the proposed antenna geometry*

Figure 2b: *Bottom view of the proposed antenna geometry*

Amicrostrip feed line is used to feed the meandered antenna structure[6]. The dimensions of the proposed W-FRMS are shown in the Table I. The Optimetrics tool in the HFSS was used for optimization for dimensions of the FRMSA structure. The FR4 substrate having permittivity of 4.4 and a height of 1.6 mm is used for etching using lithographic process for the proposed FRMSA. The dimensions of the proposed antenna are Lg*Wg*h mm^3.

Table I: Dimensions of the proposed antenna

Parameter	Size in mm
Lg	35 mm
Wg	32 mm
Lf	11.28mm
Wf	1.9 mm
h	1.6 mm

The electrical equivalent circuit of the W-FRMSA is given in the Figure 3.

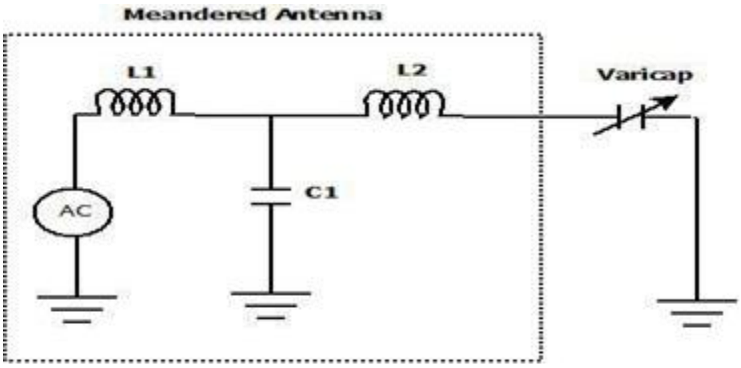

***Figure 3**: Electrical Equivalent of the meandered antenna*

III. Results &Conclusion

The antenna is fed through a microstripline feed line with characteristic impedance of 50 ohmsusing a SMA type microwave connector. The measurement set up for validating the radiation parameters for optimized performance of the designed W-FRMSA is shown inFigure. 4.

***Figure 4**: Measurement set up of the W-FRMSA Micro Strip antenna*

The proposed Micro strip antenna structure is designed & simulated usingelectromagnetic modeling software High Frequency Structure Simulator software(HFSS)to optimize various parameters like Return Loss, Voltage Standing Wave Ratio (VSWR), Bandwidth, Gain and radiation pattern. The designed antenna is tested using Vector Network Analyzer(VNA) model ZVK ,with frequency bandwidth 10 MHz-10 GHz measurement tool.

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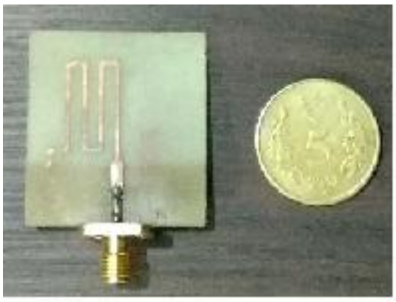

Figure 5a:*Topview of the W-FRMSA*

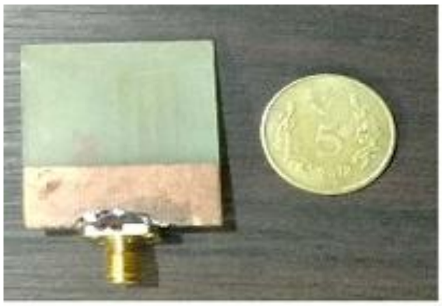

Figure 5b*:Bottom view of the W-FRMSA*

The measurement of the return loss in S11(dB) was simulated and the corresponding radiation pattern was also simulated to verify the pattern integrity across the frequency variation from mode-1 to mode- as shown in the following Figure 6(a)-(h).

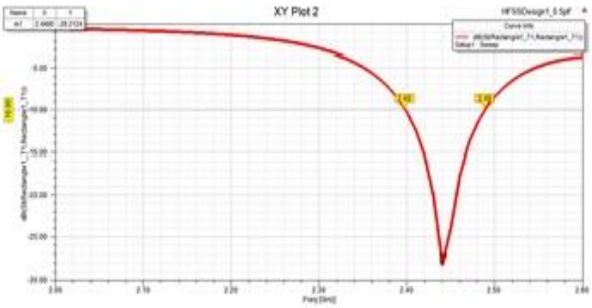

Figure 6-a*:Return loss in Mode-1*

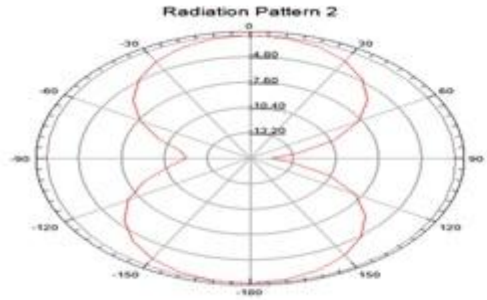

Figure 6-b*: Radiation pattern in Mode-1*

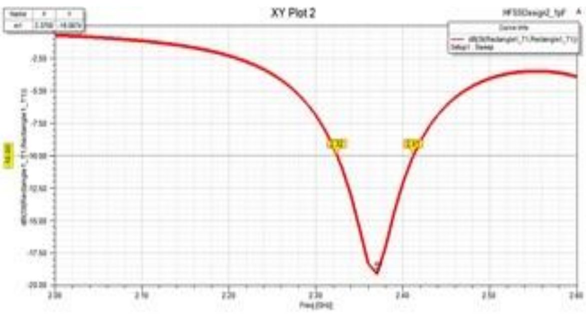

Figure 6-c*:Return loss in Mode-2*

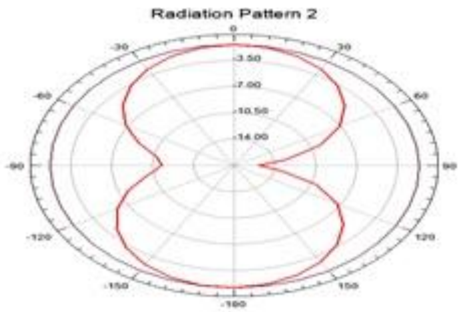

Figure 6-d: *Radiation pattern in Mode-2*

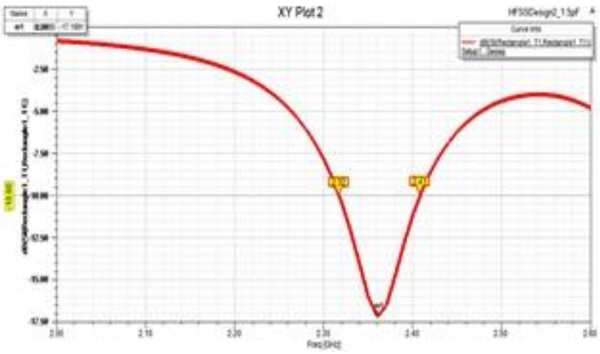

Figure 6-e*:Return loss in Mode-3*

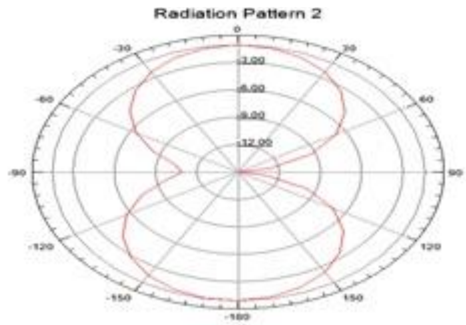

Figure 6-f:*Radiation pattern in Mode-3*

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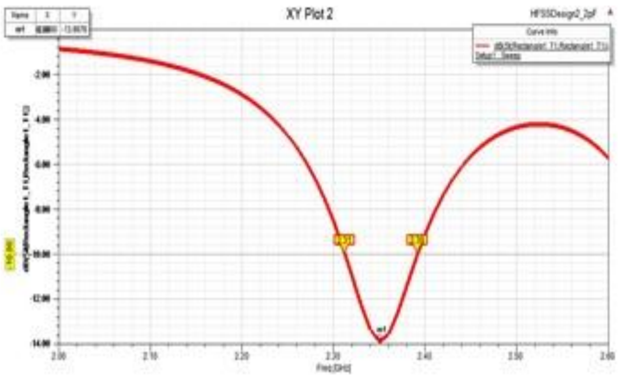

Figure 6-g:*Return loss in Mode-4*

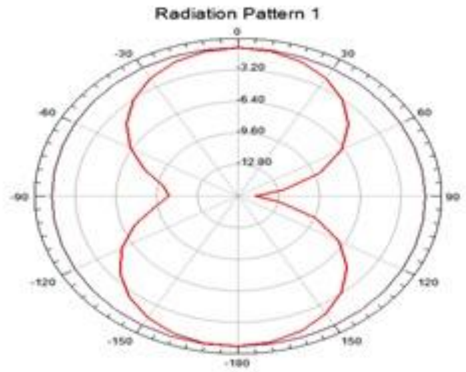

Figure 6-h: *Radiation pattern in Mode-4*

Table II: Simulated Results

Mode	Varicapin pF	Resonant Frequency in GHz	Gain in dB	Bandwidthin %
Mode-1	0.5pF	2.44 GHz	-28.21 dB	3.6 %
Mode-2	1.0 pF	2.37 GHz	-19.08 dB	3.79 %
Mode-3	1.5 pF	2.36 GHz	-17.15 dB	3.81%
Mode-4	2.0 pF	2.35 GHz	-13.86 dB	3.4 %

The return loss S_{11}(in dB) and impedance bandwidthwere simulated and tabulated in the Table II.. The deviations in the return loss was attributed to the capacitive effect introduced in the RF structure using a varicap modelled during the simulation.The results show an acceptable performance for adaptive wireless communication system applications.

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