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Dual Band Miniaturized Patch Antenna for WLAN, WIMAX Applications Using Spiral Meta component

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ABSTRACT

In this paper, the design of a compact, miniaturized, dual band patch antenna for WLAN, WIMAX applications is presented. This model makes use of a spiral resonator (etched on the ground plane of conventional patch). The conventional patch antenna resonates at a frequency of 2.785GHz while the modified antenna resonates at two frequencies of 2.45, 2.57GHz with a gain of 4.19, 4.59dB respectively. The percentage of miniaturisation is found to be 30.2 %, 17.9 % in the two chosen spectras.
Keywords: Rectangular Microstrip Antenna, Metamaterials, Spiral Resonators, Miniaturisation, Dual Band, Linear Polarization, WLAN, WIMAX

I. INTRODUCTION

Metamaterials are artificially synthesized materials which show peculiar features like negative refractive index, artificial magnetism; while the direction of e.m signals are reversed when compared with normal materials. They are often termed Left handed materials. They are classified as Double negative materials (DNG), Mu negative materials (MNG), Epsilon negative materials (ENG) [1]. The idea of Metamaterials was first proposed by Vessalago [2]. These materials are used successfully by many antenna experts in microstrip antenna design ever since it was proposed [3-13]. Spiral resonators are emerging materials that are used for realization of Meta structure samples. Such materials are used in the design of a size reduced dual band printed antenna in the current proposal.

The paper is organized into four sections; Section I, presents the introduction, Section II deals with design of conventional patch & modified patch antenna, Section III elaborates all about the results obtained while the last Section elucidates about the conclusion.

II. METHODS AND MATERIAL

A. Design of Conventional Patch

A Rectangular microstrip patch antenna (which is fed by the inset feed mechanism) is designed to resonate at 2.785GHz. The substrate used is RT Duroid with ε_r of 2.2 and 120 mils thickness. The antenna is fed with a microstrip line of impedance 50 ohms. The feeding is done at 10 mm from edge whose value is computed using the equation from [14]. The design equations are taken from [14]. The dimensions of the antenna are optimized further with the aid of HFSS simulator. The simulated model with its S_{11} plot is shown in Fig.1. The gain of the patch is 7.5675 dB and is shown in Fig. 2. The simulated antenna parameters are shown in Table 1.

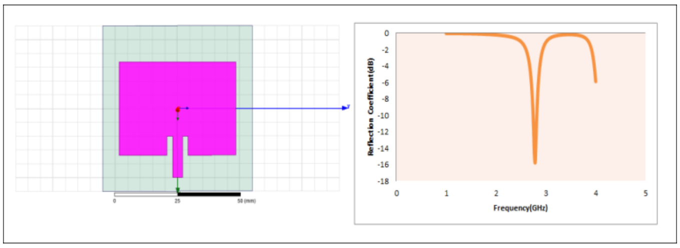

Figure 1. Microstrip patch antenna model & Its Return loss characteristics

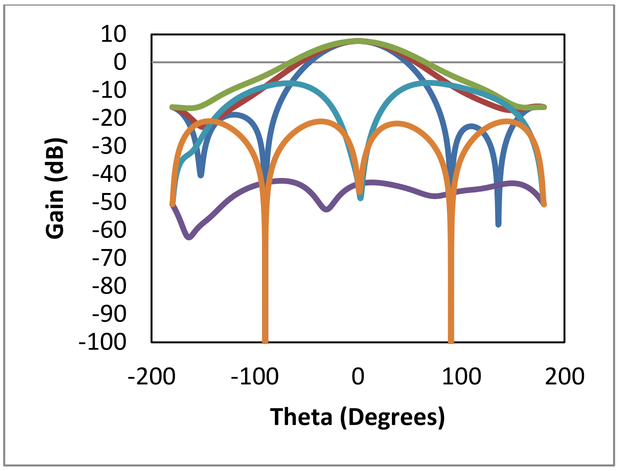

Figure 2. Gain pattern of Conventional patch antenna

Table 1. Antenna parameter of Conventional patch antenna

Antenna Parameter	Value	Unit
Max U	0.45452	W/sr
Gain	7.5675	dB
Radiation Efficiency	99.837%	
Directivity	5.8836	
VSWR	1.388	

B. Design of Modified Patch

The proposed antenna is specially designed for WLAN (2400-2484) MHz and WIMAX (2500-2569) MHz applications. Spiral resonator with two turns is etched on the ground plane of the conventional patch. This model is shown along with its dual resonance characteristics in Fig. 3. The design equations presented holds good, only if the value of *N*, which is the number of turns of resonator, does not exceed a predefined integer value as given below [12]. Where *l,w,s* are length, width and spacing of the resonator. The optimized dimensions of the modified patch antenna are tabulated in Table2.

$$N_{SR\max} = Integer\left[\frac{l-(w+s)}{2(w+s)}\right] \quad \ldots(1)$$

The resonator is designed using the equations given below.

$$L_{SR} = \frac{\mu_0}{2\pi} l_{SRavg}\left[\frac{1}{2}+\ln\left(\frac{l_{SRavg}}{2\omega}\right)\right] \quad \ldots(2)$$

$$C_{SR} = C_o \frac{l}{4(\omega+s)}\frac{N^2}{N^2+1}\sum_{n=1}^{N-1}\left[l-\left(n+\frac{1}{2}\right)(\omega+s)\right] \quad \ldots(3)$$

Table 2. Optimized Dimensions of Modified Patch Antenna

No.	Modified Patch Antenna	Value (mm)
1	Ground	0.55λ×0.55λ
2	Substrate	3.048
3	Patch	0.3942λ × 0.3197λ
4	Spiral turns	2
5	Width of spiral	2
6	Distance	5
7	Thickness of spiral	0.0025

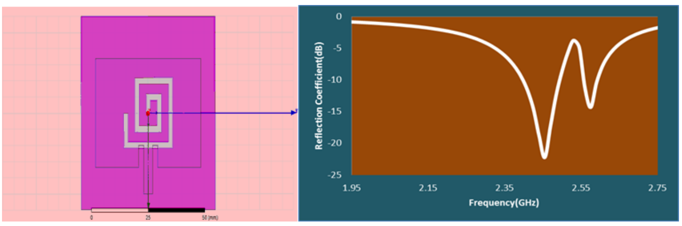

Figure 3. Proposed antenna with Spiral Etch on Ground plane & Its Return loss characteristics

III. RESULTS AND DISCUSSION

The proposed model has miniaturisation, up to 30 % of conventional patch size. This is due to spiral etch on the ground plane; which has made the patch resonate at two different frequencies lesser than the conventional patch resonance. The gain pattern is shown in Fig. 4. The return loss feature is found to be improved while there is a slight reduction in gain.

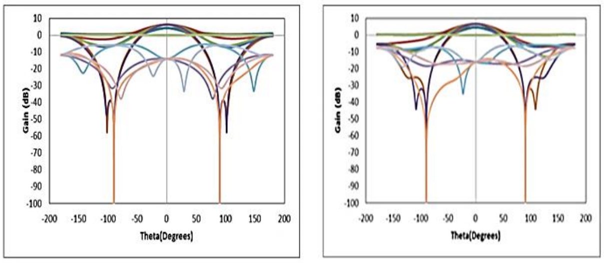

Figure 4. Gain pattern of Proposed antenna at 2.45GHz, 2.57GHz

To understand the phenomenon of miniaturisation, the surface current density plots for conventional patch as well as for modified patch are shown in Figs 5-7. The antenna parameters for the two resonant frequencies are tabulated in Tables 3-4.

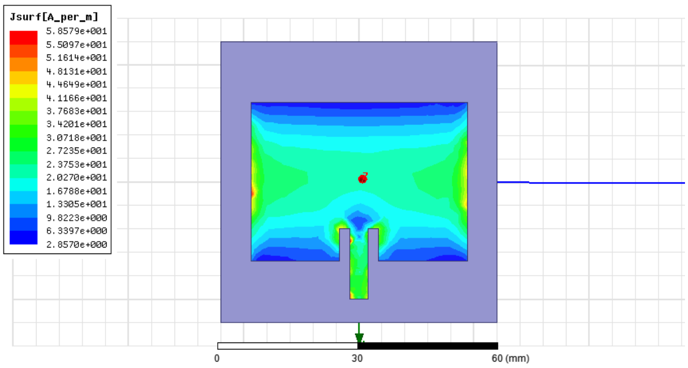

Figure 5. Surface Current Density plot of Conventional patch antenna at 2.785GHz

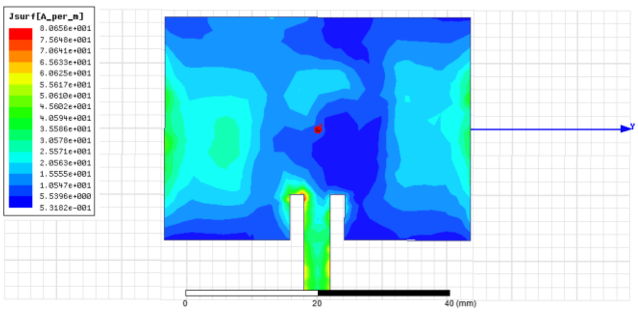

Figure 6. Surface Current Density plot of Proposed antenna at 2.45GHz

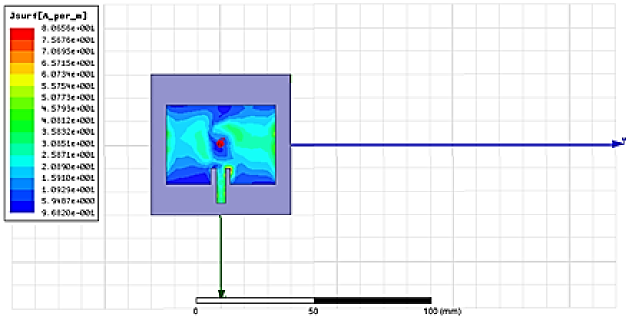

Figure 7. Surface Current Density plot of Proposed antenna at 2.57GHz

Table 3. Simulated Antenna Parameters of Modified Patch Antenna at 2.45GHz

Antenna Parameter	Value	Unit
Max U	0.33791	W/sr
Gain	4.1930	dB
Radiation Efficiency	98.7%	
Directivity	4.338	
VSWR	1.198	

Table 4. Simulated Antenna parameters of Modified Patch Antenna at 2.57GHz

Antenna Parameter	Value	Unit
Max U	0.45452	W/sr
Gain	4.5930	dB
Radiation Efficiency	97.87%	
Directivity	5.031	
VSWR	1.5676	

IV. CONCLUSION

The Proposed patch antenna resonates at WLAN, WIMAX frequency with a broader bandwidth of 72, 34 MHz. The antenna is compact, planar, cheap, with adequate gain, co and cross polarization levels. The suggested antenna has a very good radiating efficiency. This antenna can be further extended for any array application with circular polarization and can be realized easily using photolithography technique.

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