IJIREEICE

ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 4, Issue 6, June 2016

Analysis of Slot Antenna for Satellite Applications

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Abstract: An antenna is an element used for radiating or receiving electromagnetic wave. Although antennas may seem to be available in numerous different shapes and sizes, they all operate according to the same basic principles of electromagnetics. Many types of portable electronic devices, such as cellular phones, GPS receivers, pagers, laptop computers, and telematics unit in vehicles, need an effective and efficient antenna for communicating wirelessly with other fixed or mobile communication units. Wireless communications have been developed widely and rapidly in the modern world especially during the last two decades. The future development of personal communication devices will aim to provide image speech and data communications at any time, and anywhere around the world. The increase in satellite communication has also increased the demand for antennas that are compact and provide reliable transmission. In addition, the expansion of wireless local area networks at home and work has also necessitated the demand for antennas that are compact and inexpensive. The objective of thesis work is to design the circular slot antenna and analysis their performance parameters return loss, VSWR, bandwidth, gain etc. Simulations of antenna design will be done using HFSS simulation software, which is based on the Finite Element Method (FEM). Using High Frequency Structure Simulator (HFSS) software simulation has been carried out to analyze and optimize the antenna's characteristics and performance. In this thesis a small and compact antenna has been proposed which support several bands.

Keywords: Include at least 4 keywords or phrases.

I. INTRODUCTION

The cellular communications become a ubiquitous part of modern life. The desire of people to be able to communicate effectively while being mobile has become an incentive for mobile communications integration in terrestrial and satellite wireless systems. The mobile communication industry has already developed enormously bringing fast and reliable infrastructure to people's disposal. Yet, wireless communication systems are still in the centre of extensive academic and technological research and development, with constant demand of more compact, faster and more reliable devices and services

An antenna is a transducer designed to transmit or receive electromagnetic waves. A microstrip antenna consists of a radiating patch on one side of dielectric substrate ($\varepsilon_r \leq 10$) and ground plane on the other side [1]. A large number of microstrip patch antennas have been studied till date. The rectangular and circular patches are the basic and most commonly used microstrip antennas. Rectangular geometries are separable in nature and their analysis is also simple.

The circular patch antenna has the advantage of their radiation pattern being symmetric [2]. Microstrip patch antennas radiate mainly because of the fringing fields between the ground plane and edges of the patch. In order to achieve good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation [3, 4]. Low dielectric constant substrates are generally preferred for maximum radiation.

Due to low cost, compact size and ease of fabrication slot antennas are attractive for C-Band and UWB applications. Slot antennas fed by microstrip-line were investigated for UWB applications [5].

Because the microstrip-line-fed slot antennas have wide impedance bandwidth, simple structure, easy manufacture and low cost, it can suitable for apply to wireless local area network (WLAN) or Blue-tooth applications communication products [6]. The UWB system covers the frequency range from 3.1-10.6 GHz, which based on narrow pulses to transmit data at extremely low power, and looks like random noise to most conventional radio systems [7, 8]. There is a huge range of applications for UWB technology, which consists of wireless communication systems, radar, sensing and imaging, position and tracking, etc. [9, 10]. In the presented work, a circular slot antenna structure has been employed for UWB and C-Band applications.

II. DESIGN AND STRUCTURE

The proposed antenna consists of a main radiator with, a rectangular slot on radiating part, and a ground plane. The antenna fabricated on Rogers RT/duroid 5880 substrate with a dielectric constant εr=2.2 and a loss tangent of 0.0009 and thickness of the substrate height h= 1.7mm have been used to design microstrip patch antenna. The proposed antenna has a very small size and simple structure.

DOI 10.17148/IJIREEICE.2016.4634

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A. Single Band Mcrostrip antenna

In this section the process of designing of a single band microstrip antenna and its characteristics will be discussed. The designing of this antenna structure helped the author to understand the basic concepts of microstrip antenna, characteristics and various factors that affect the performance of the patch antenna. The geometry and 3-D view of single band antenna shown in Figure 1 and 2.

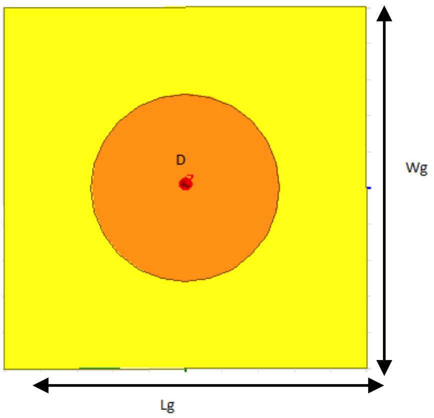

Fig. 1. Top View of proposed antenna

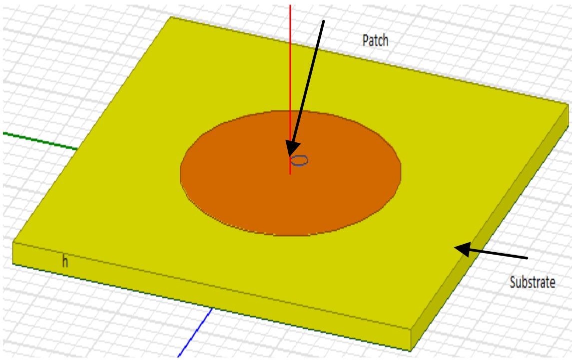

Fig. 2. 3-D View of proposed microstrip antenna in HFSS

TABLE 1 DETAILED DIMENSIONS OF SINGLE BAND ANTENNA

Sr. No.	Parameter	Dimension (mm)
1	Length of ground plane, Lg	50
2	Width of ground plane, Wg	50
3	Diameter of Patch, D	26
4	Height of Substrate, h	1.7

B. Dual Band microstrip patch antenna with a slot on the radiating element

The structure of the proposed dual band microstrip patch antenna with a slot on radiating part is shown in Figure 3. The proposed antenna consists of main radiating patch, a slot on the radiating plane, substrate, coaxial feed and a ground plane

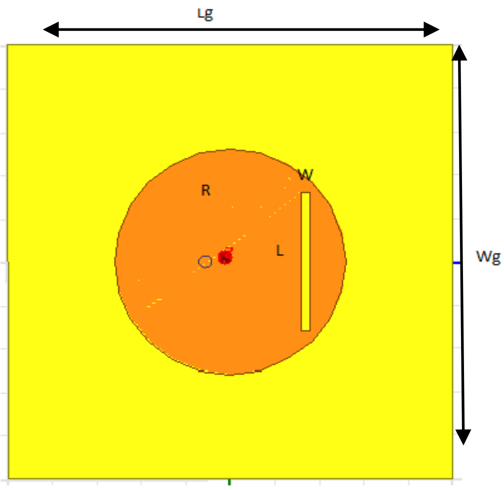

Fig. 3. Top View of proposed dual band antenna

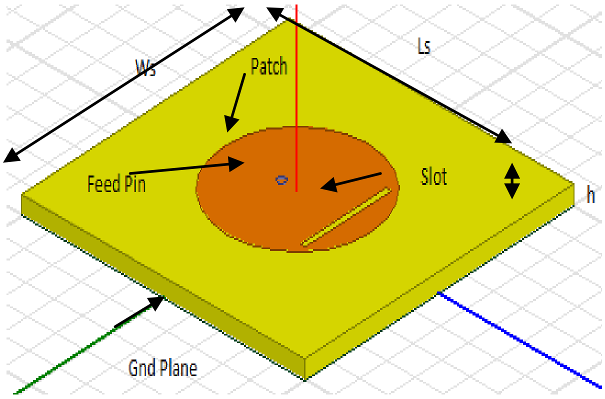

Fig. 4. 3-D view of proposed dual band antenna in HFSS with slot on radiating plane

TABLE 2 DETAILED DIMENSIONS OF PROPOSED DUAL BAND ANTENNA

Sr. No.	Parameter	Dimension (mm)
1	Length of ground plane, Lg	50
2	Width of ground plane, Wg	50
3	Length of substrate, Ls	50
4	Width of substrate, Ws	50
5	Height of Substrate, h	1.7
6	Length of slot , L	16
7	Width of slot, W	1

III. RESULTS AND DISCUSSIONS

C. Return Loss Characteristics of single band antenna

The plot in Figure 5 shows the return loss of single band MSA. It can be seen that a resonant frequency of 4.1 GHz has been achieved. The return loss obtained is -23.12 dB at resonant frequency with the operating bandwidth for $S11 < -10dB$ of 2.64%. The antenna is operating in the frequency range of 4.10 GHz- 4.21 GHz.

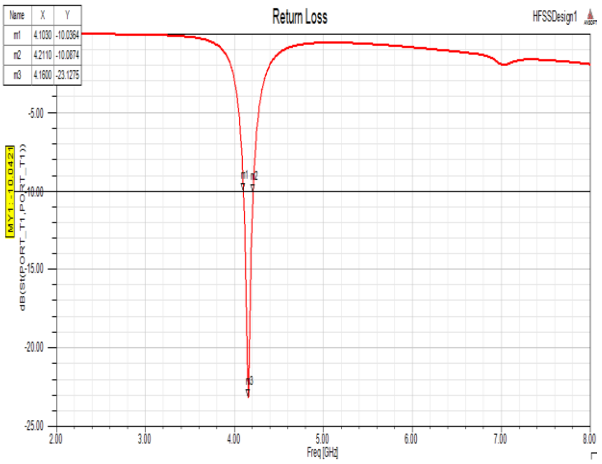

Fig 5. Simulated Return Loss of Single Band antenna

D. Voltage Standing Wave Ratio (VSWR)

The VSWR plot of single band MSA shown in Figure 6. The simulation results for VSWR for the frequency range from 2 to 8 GHz shown in Figure 5.2. The value of VSWR can be seen to be less than 2 dB at resonant frequency which is desirable for most of the WiMAX applications.

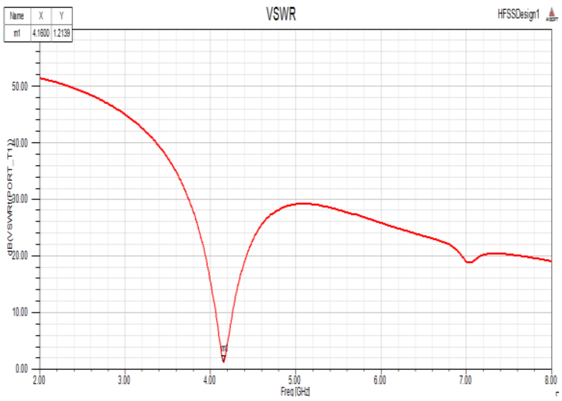

Fig 6. Simulated VSWR plot of Single Band Antenna

E. Return Loss Characteristics of dual band microstrip patch antenna with a slot on radiating element

The following plot in Figure 7. shows the return loss for the dual band MSA. It can be seen that a resonant frequencies 3.7 GHz and 7.6 GHz. The return loss -22.14 dB and -27.90 dB obtained at resonant frequencies with the operating bandwidth 2.11% and 2.73% respectively. The bands covered by proposed antenna are, WiMAX and C-Band.

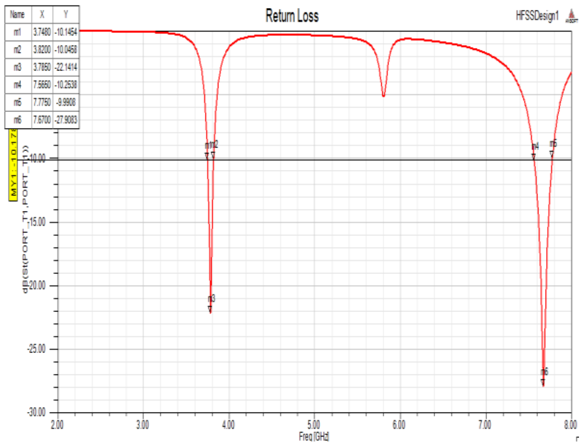

Fig 7. Simulated Return Loss of Dual Band antenna

F. Voltage Standing Wave Ratio (VSWR)

The simulation results for VSWR for the frequency range from 2 to 8 GHz is shown in the Figure 8. The value of VSWR can be seen in the plot and has to be less than 2 dB at two resonant frequencies which is desirable for most of the WiMAX and satellite applications.

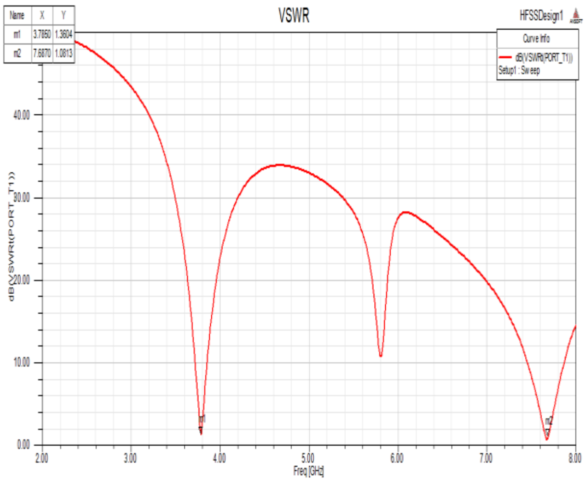

Fig 8. Simulated VSWR of Dual Band MSA

G. Effect of slot length (L) on dual band antenna performance

We will vary the Length of slot (L) we mean all possible cases. We can consider the length of slot 16mm for proposed dualband MSA structure. The different effects of slot by varying the length on resonating frequency, return loss and gain Gain are shown in table below:

TABLE 3 EFFECTS OF SLOT LENGTH(L) ON DIFFERENT PARAMETERS OF DUALBAND MSA

Length of Slot (mm)	**Resonating Frequency (GHz)**	**Return Loss (dB)**	**Bandwidth (%)**	**Gain (dB)**
15	3.92	-20.20	2.04	6.23
	7.71	-19.72	2.98	
13	3.94	-21.37	2.33	4.08
	7.89	-12.10	2.34	
16.5	3.72	-18.18	1.77	5.99
	7.67	-16.51	2.32	
17	3.66	-16.87	1.74	5.89
	7.44	-19.02	2.31	

H. Effect of slot width(W) on dual band antenna performance

We will vary the width of slot(W) from 0.5 to 2.5mm. We will obtain the diffeent results. We can consider the width 1mm for proposed antenna and the most convenient for the bandwidth and the resonant frequency. The effects of slot width on different parameters of antenna are shown in below table:

TABLE 4 EFFECTS OF SLOT WIDTH(W) ON DIFFERENT PARAMETERS OF DUALBAND MSA

Width of Slot (mm)	Resonating Frequency (GHz)	Return Loss (dB)	Bandwidth (%)	Gain (dB)
1.5	3.78	-16.95	1.87	6.18
	7.61	-25.84	2.75	
0.5	3.92	-24.48	2.16	5.75
	7.47	-15.20	2.50	
2	3.74	-14.95	1.63	5.67
	7.68	-19.43	2.58	
2.5				4.58

IV. CONCLUSION

A compact dual band slot antenna for WiMAX and satellite applications is presented. Compared to many antennas proposed earlier, this antenna is designed based on a rather simple structure and suitable for all frequency bands of WiMAX, Wi-Fi, Bluetooth and satellite applications simultaneously. The proposed antenna can be considered to achieve dual band just through etching slots on the radiating plane, so it can be much easier to fabricate. The measured results show that the obtained impedance bandwidths are 2.16% (3.74–3.82 GHz) and 2.74% (7.56–7.77 GHz respectively, good enough for WiMAX and satellite applications. In addition, the proposed antenna has good radiation characteristics and gains in the two operating bands, so it can emerge as an excellent candidate for multiband generation of wireless.

Two configurations of microstrip antenna have been studied in this work. The first is the design of typical single band MSA, second is dual band MSA .The main objective of this work is to design a dual band microstrip patch antenna for WiMAX and satellite applications and study the effect of slot length and slot width. Here coaxial feed method is used to excite the microstrip patch antenna.

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