Design and Fabrication of a Compact U-slot Dual-Band Antenna for WLAN/Wi-MAX and RFID Applications

U.S.Modani, Avinash Garhwal

Abstract— This work deals with the design and fabrication of a U-slot antenna for radio frequency identification (RFID) and WLAN/Wi-MAX operating in the low microwave frequency range. A new antenna design methodology has been developed with the purpose to minimize the amount of both substrate material and patch size. The first goal is achieved by reducing, for a given frequency, the antenna size. The second goal, instead, is pursued by studying the surface current density distribution along the antenna and removing the metal material where such a current density is negligible. The proposed antenna can provide two separate impedance bandwidths of 927MHz(2.071GHz-2.998GHz) and 3.03GHz (5.1760GHz-8.38GHz) respectively. Consistent omnidirectional radiation patterns have been observed in both the frequency bands. The proposed antenna is simple in design and compact in size. It exhibits broadband impedance matching, consistent omnidirectional patterns and appropriate gain characteristics (>2.8 dBi) in the RFID and WLAN/Wi-MAX frequency regions.

Index Terms — Dual band antenna, Wireless, WLAN, Wi-MAX, and RFID.

1 Introduction

Communication using electromagnetic radiation (except for light) began early in the last century. Most of the early systems used very long wavelengths (low frequencies), which traveled great distances. Later it was discovered that higher frequencies could bring other advantages to communications. Microwaves are easier to control (than longer wavelengths) because even small antenna could direct the waves very well. With the increase in demand for data usage, internet connectivity, and networking, new methods have emerged out and are proving their merits. Notable structures among them are: CPW-fed dual frequency monopole antenna [1], dual band CPW-fed strip-sleeve monopole antenna [2], CPW fed L-shaped slot planar monopole antenna for triple band operation [3], internal planar monopole for mobile phones [4], dual-band planar branched monopole antenna [5], etc. Similarly, many compact antennas for RFID application at 5800 MHz are available in the literature such as CPW-fed folded slot [6], T-shaped folded slot monopole antenna [7], F-shaped CPW-fed monopole antenna [8], CPW-fed dual folded strip [9], semi-circular CPW fed folded slot antenna [10], U-slot antenna [15], G-shaped antenna [16] and many more. Our aim here is to design a compact monopole antenna, which can be used simultaneously for WLAN as well as RFID systems. One such emerging technology that we are going to focus here is Wi-MAX, a wireless communication standard (IEEE 802.16 family of network standards), designed to provide a data rate of 30-270Mbps [11]. There is no uniform global licensed published their licensed spectrum profiles: 2.3GHz, 2.5GHz, and 3.5GHz, in an effort to drive standardization and decrease cost.

A simple and compact U-slotted antenna with a shorter strip fed by a coupling microstrip line feed antenna has been presented in, for RFID and WLAN/Wi-MAX applications. The same antenna has been fabricated and tested with industry standard equipment. Comparisons of simulated and measured results are presented in this paper. The proposed antenna exhibit dual band characteristics with the lower resonant band of (2.0-2.367) GHz and the upper band of (5.1335-5.8065)GHz. These bands are suitable to cover the industrial Scientific Medical (ISM 2.4-2.484GHZ), Radio Frequency Identification (RFID 2.45 GHZ), Wireless Local Area Network (WLAN 2.4-2.484 GHZ), and Wi-MAX (5.2-5.8 GHz) [12].

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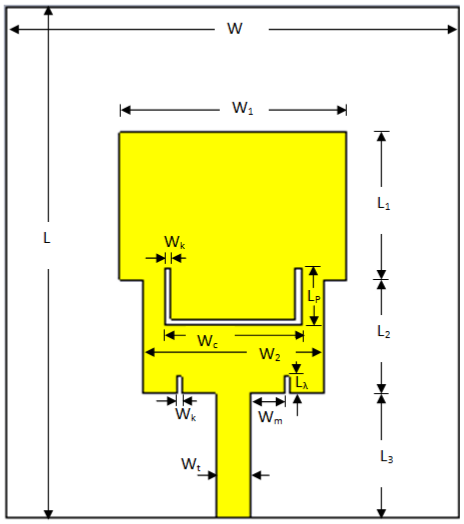
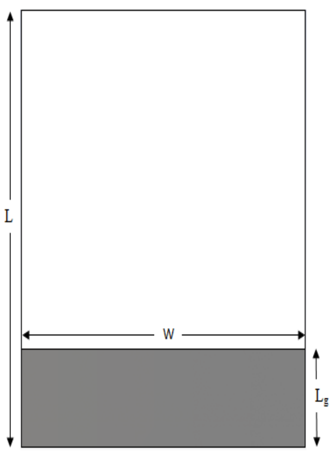
2 The Proposed Antenna Design and Fabrication

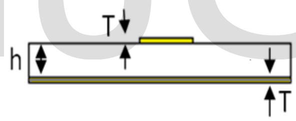
The geometry of patch of the proposed antenna is shown in figure 1(a). The front view of the structure comprises of three elements. The first element is designed as a rectangular with U-slot. Dimensions of rectangular shape are ($W_1 \times L_1$) and dimensions of U-slot is ($W_c \times L_p$), while the dimension of below element is ($W_1 \times l_1$) with a cut of W_k on the both side separated by W_i=1.5mm. The antenna is excited using a 50-ohm microstrip line. The dimensions of the microstrip line are ($W_t \times l_1$). The dimension for ground plane is ($W \times l_g$) refer figure 1(b).



(a)Top view



(b) Back view



(c) Side view

Figure-1 The proposed antenna design

The dimensions of the proposed antenna are presented in Table-1.

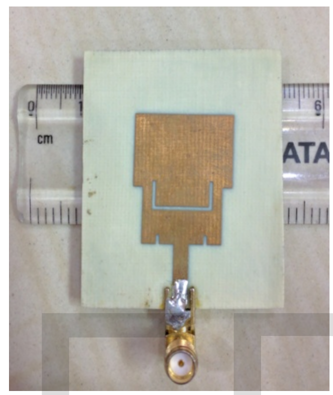
TABLE I
PARAMETERS AND VALUES OF DUAL-BAND ANTENNA GEOMETRY

Parameter	Value(mm)
L_g	10
W_i	1.5
W_u	14
L_u	3
R	5
L_x	1
H	10
L_3	10

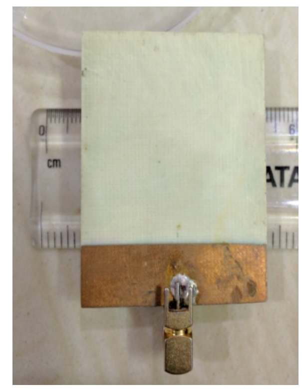
Parameter	Value(mm)
W	40
L	40
W_2	20
W_1	15
L_2	10
W_c	1
W_t	4.75
L_1	8

The antenna studied in the paper was fabricated using the photolithographic technique. This is a chemical etching process by which the unwanted metal regions of the metallic layer are removed so that the intended design is obtained. In figure 2 shows a front view and back view of fabricated U-slot antenna. Depending upon the design of the antenna as a biplane or uniplanar dual or single side substrates are used. The selection of a proper substrate material is the essential part in antenna design. After the proper selection of the substrate material, a computer aided design of the geometry is initially made and a negative mask of the geometry to be generated is printed on a transparent sheet.

A single or double-sided substrate with copper metallization of suitable dimension is properly cleaned using acetone to free from impurities.



(a)



(b)

Figure- 2 Top view and back view of the fabricated antenna

3 SIMULATED RESULTS

Simulation of the antenna structure was performed using the transient solver in CST Microwave Studio software [13]. The proposed U-slotted dual–band antenna has been designed to resonate with the lower frequency at 2.4 GHz and upper frequency at 5.4GHz. After optimizing the different antenna parameters, the proper design has been chosen to get the required results with the dual-band characteristics.

The antenna is fed by a microstrip center lined technique. The radiator and ground plane are on the two opposite faces of flame retarding (FR4) substrate having a thickness of 1.575mm with relative permittivity and loss tangent 4.4 and 0.02 respectively. The simulated return loss of the proposed design is shown in figure 3. Two resonant peaks achieved at 2.4GHz and 6.7GHz demonstrate that the antenna is showing a dual–band characteristic. The simulated return loss of -28.1dB, and -33.5dB is obtained at 2.5GHz and 6.7GHz resonant frequency respectively. The bandwidth obtained for -10dB return loss is about 927 MHz and 3.03 GHz at 2.4GHz and 6.7GHz respectively. In fact, the achieved bandwidths of altogether cover WLAN standards in the 2.4/5.2/5.8 GHz bands, Bluetooth standard in the 2.4 GHz band, and Wi-MAX and RFID standard in the 5.5 GHz band.

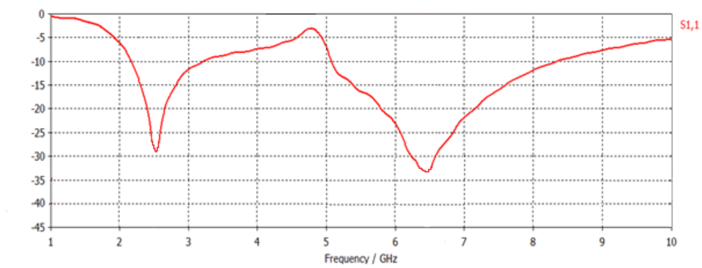


Figure-3 Simulated return loss for the U-slot antenna design

The radiation pattern is a mathematical function or graphical representation of the radiation properties of the antenna as a function of space coordinates. Radiation properties include power flux density, radiation intensity, field strength, directivity phase or polarization. The radiation pattern of the proposed antenna that shows both the E and H-planes patterns for 2.4GHz frequency is represented in fig. 4 and for 5.5GHz in fig. 5. The effect of various dimensions of U-slot on return loss was also examined.

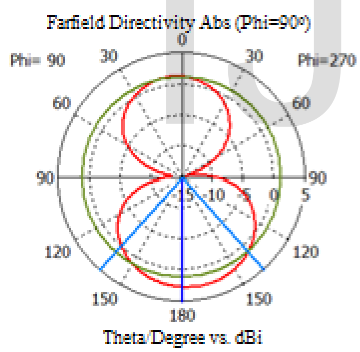


Figure -4 Simulated radiation pattern at 2.4 GHz frequency

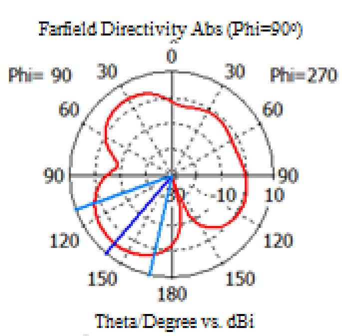


Figure- 5 Simulated radiation pattern at 5.5 GHz frequency

Smith chart pattern for the proposed antenna design is shown in figure 6. It shows the complex reflection coefficient in polar form for arbitrary impedance. The center of the smith chart circle corresponds to reflection coefficient (Γ) which when equals to zero means a perfect impedance match. The smith chart in figure 6 also shows the dual band characteristics of the proposed antenna design.

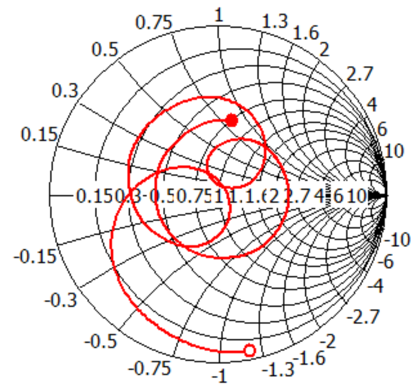


Figure -6 Smith chart for proposed antenna design

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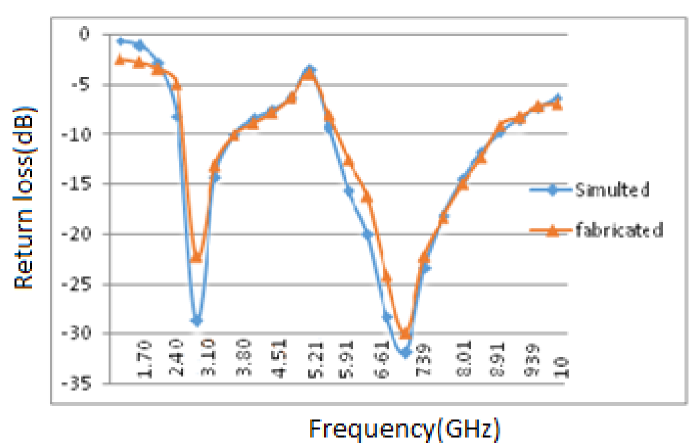
4 COMPARISION OF SIMULATED AND MEASURED RESULTS

The measurement of return loss of the U-slot antenna was carried out using Vector Network Analyzer(VNA). ROHDE and SCHWARZ ZVA 40 VNA used for measurement is sophisticated equipment capable of making rapid and accurate measurements in frequency and time domain [14]. The NWA can measure the magnitude and phase of the S-parameters. It's built in signal processor analyses the transmit and receive data and displays the results in many plot formats. Figure 7 shows simulated and



measured return loss of U-slot antenna.

Figure- 7 Simulated and measured return loss of U-slot Antenna design

5 CONCLUSION

A compact U-slot microstrip feed antenna producing dual resonance frequencies with enhanced frequency diversity has been designed and fabricated. Satisfactory dual-band operations for WLAN/Wi-MAX and RFID applications have been achieved. It provides broadband impedance matching, consistent radiation pattern, and appropriate gain characteristics in the RFID and WLAN/Wi-MAX frequency range.

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