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Design and Fabrication of Double T-monopole Antenna for Dual Band Wireless Communication

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Abstract: A novel printed monopole antenna with dual wideband is presented for simultaneously transmitting as well as receiving in wireless local area network (WLAN). A compact and optimized design of a rectangular printed monopole antenna with FR-4 substrate and coaxial feeding technique is presented. The proposed antenna has a double T shape structure mainly designed for dual-band operation at 2.4 GHz and 5.2 GHz for Wireless Local Area Network (WLAN) applications which is in ISM band. This antenna has good impedance matching, return loss (> than -10dB), radiation patterns and consistent gain in required frequency band. The calculated and measured results in terms of return loss and VSWR shows good agreement and the results also shows good wideband characteristics.

Keywords: Dual Band, Monopole, WLAN, Coaxial, ISM.

I. INTRODUCTION

Antenna is defined as a device or a transducer which transforms an RF signal into electromagnetic waves and acts as a means to transmit and receive radio waves. Micro strip antennas have gained a lot of popularity due to their salient features such as low profile, simple and inexpensive to design and manufacture, flexible in terms of configuration, polarization, pattern, resonant frequency and impedance when a particular shape and mode are selected. These antennas are used in various applications for example, in satellite communication, in handsets and base stations for mobile communication, in telemetry antennas for missiles and so on. Micro strip antennas cover a broad frequency spectrum from 100 MHz to 100 GHz, thus possess several advantages as compared to conventional antennas. A micro strip antenna consists of a conducting patch of any geometry on a ground plane and separated by a dielectric substrate. The rectangular and circular patches are most common geometry used in micro strip antennas. Rectangular patches are chosen as they are very simple to analyse and circular patches are chosen due to their symmetric radiation pattern.

Many printed monopole antennas are developed in last few years for WLAN applications such as double L shaped slot [9], U shaped slot [10], straight radiating strip [3], But it has been seen that they are able to radiate in single band with single frequency only. The proposed T shaped antenna [1] can radiate in dual band monopoles (2.4 GHz and 5.2 GHz).

Here, we propose a new and simple dual band printed monopole antenna for wireless communication system. The antenna consists of two rectangular T shaped monopole elements; stacked at the top of each other, and with a ground plane at the back of the substrate (see Fig. 1). The main resonators of the antenna are two rectangular T shaped elements [1]. Furthermore slits are introduced to improve the S11 response and impedance bandwidth. In order to satisfy the IEEE 802.11 WLAN standards in the 2.4 GHz (2400–2484 MHz) and 5.2GHz (5150–5350 MHz) bands, dual-band operations of the printed monopole antennas are required [2] with 50 Ω microstrip line.

Although, the restriction to use a certain frequency band limits (except ISM band) the bandwidth of operation, but complete use of bandwidth cannot be achieved until proper and efficient design is maintained within the whole system design. Proper antenna design is a critical task that must be accomplished to achieve most from what is required. Main features that are to be looked in an antenna design are its gain and efficiency.

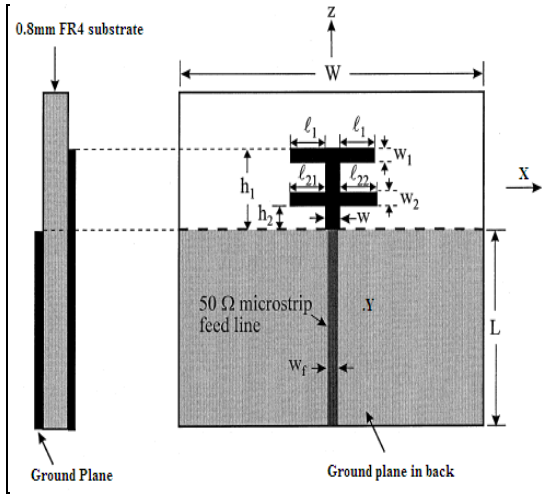

Figure.1. Geometry of the proposed dual-band double-T monopole antenna.

Before this work, "A Printed double T-monopole antenna for 2.4/5.2 GHz dual band WLAN operation" was developed by Yen-Liang Kuo and Kin-Lu Wong in 2003[1]. Which generate two separate resonant modes for the desired dual-band operation. The proposed antenna has

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a low profile and can easily be fed by using a 50Ω coaxial feed line.

II. ANTENNA DESIGN PROCEDURE

Micro strip antenna is a microwave antenna which consisting of desired shape metal ground conductor patches or attached to the floor of the dielectric substrate, typically by a micro strip transmission line or a coaxial probe fed, so that between the conductor patches and the ground plate excite high-frequency electromagnetic fields, and electromagnetic waves radiate outward through the gap between the patch around the ground plate. The proposed antenna can be considered as T-shaped monopoles, operated as quarter wavelength structures, and is easily fed by a coaxial feeding technique. The T- shaped monopoles is printed on the same side of the dielectric substrate (FR4 substrate of thickness 1.6 mm and relative permittivity 4.4 was used.).
In this design, the larger T-shaped monopole patch comprises a vertical strip (width w and height h1) in the centre and a horizontal strip (width w1 and length l1+l1+w) on the top. This larger T-shaped monopole controls the first or lower operating band of the proposed antenna. On the other hand, a lower horizontal strip (width w2 and length l21+w+l22) and a portion (length h2) of the vertical strip form the smaller T-shaped monopole, which controls the antenna's second or upper operating band. Notice that the two portions of the lower horizontal strip protruded from the vertical strip have unequal lengths of l21 and l22.
To design a rectangular micro strip patch antenna following parameters such as dielectric constant (Ɛr), resonant frequency (fr), and height (h) are considered for calculating the length and the width of the patch.

- Width of patch (W):

$$W = \frac{c}{2f_0\sqrt{\frac{\varepsilon r + 1}{2}}}$$

- Effective dielectric constant of antenna (ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{-1}{2}}$$

- Effective dielectric length of antenna (L_{eff}):

$$L_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}}$$

- The extended length of antenna (ΔL):

$$\Delta L = 0.421h\frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)}$$

- The length is (L):

$$L = L_{eff} - 2\Delta L$$

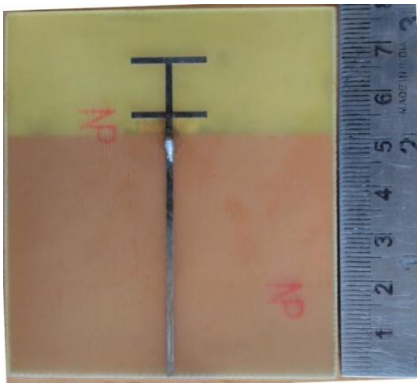

Figure.2. Fabrication of Double T-monopole Antenna

III. SIMULATED AND EXPERIMENTAL RESULTS

The proposed antenna was simulated for dual band operation in frequency band of 2.4 GHz (2.19 – 2.484 GHz) and 5.2 GHz (5.15 – 5.35 GHz) in application to WLAN. The simulated results are shown here:

a) Return Loss:
The return loss is a measuring parameter in which the backward reflection of power is observed. This reflected power should be minimum. It is a loss of transmitted energy. It should be always >-10 dB. The designed antenna resonates at 2.4 and 5.2 GHz frequency. The return loss for 2.4 and 5.2 GHz is -24.10dB and -32dB respectively, which covers the minimum required value of return loss of -10 dB. The plot for Return Loss is shown in below Fig.3.

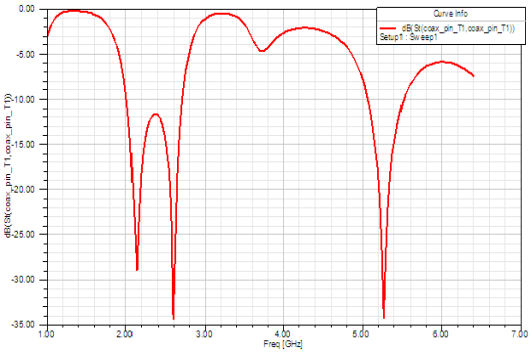

Figure.3. Simulated Return Loss of Double T monopole Antenna

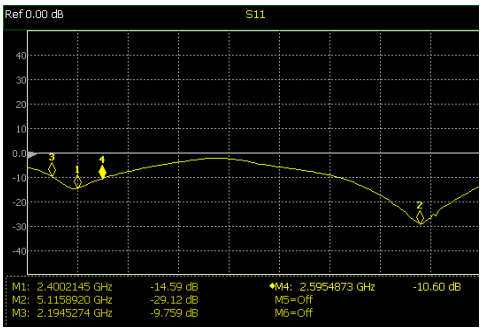

Figure.4. Measured Return Loss of Double T monopole Antenna

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b) VSWR:

The VSWR (voltage standing wave ratio) plot for the proposed antenna (Coaxial feed) is shown in Fig.4. A VSWR is of 1:1, means that there is no power being reflected back to the source. At a VSWR of 2.0, approximately 10% of the power is reflected back to the source. The value of VSWR should be always < 2. The proposed antenna shows value of VSWR for resonating frequencies 2.4 and 5.2 GHz are 1.65 and 1.03 respectively. This is within the desired limit value.

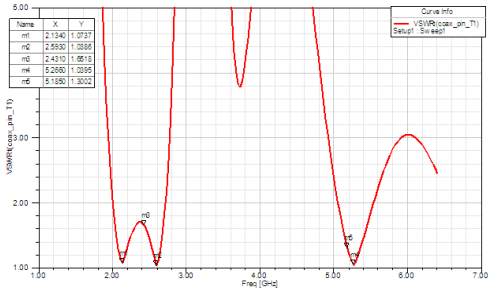

Figure.5. Simulated VSWR of Double T monopole Antenna

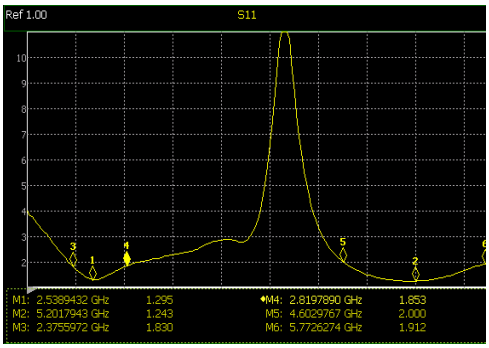

Figure.6. Measured VSWR of Double T monopole Antenna

c) Radiation Pattern:

The radiation characteristic is shown Fig.7. The measured two dimensional (2-D) patterns at 2.4 and 5.2 GHz resonance frequencies with respect to total power in azimuthal plane (x–y planes). It is observed that these radiation patterns are nearly omni directional for proposed antenna. Maximum radiation in forward direction.

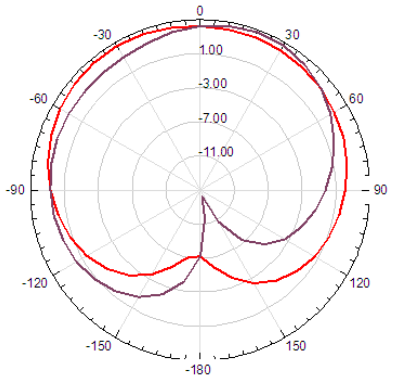

Figure.7. Radiation Pattern of Double T monopole Antenna

d) Current Distribution:

E-Field distribution is maximum along the feed and distributed along the edges of the patches.

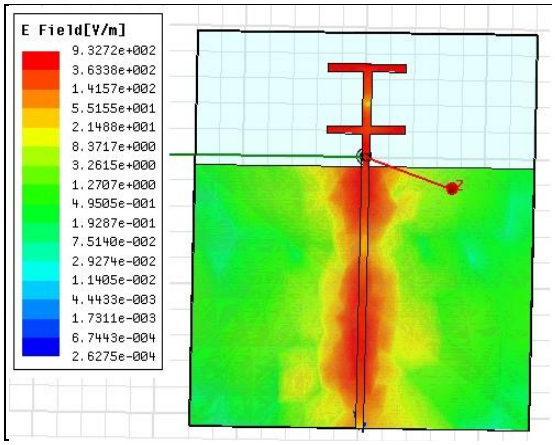

Figure.8. E-Field Distribution

All the simulated results are practically measured in the lab using Vector Network Analyzer (VNA) tool as shown in the below table 1.

Table 1 Comparison Between Simulated And Measured Results

Parameters	For 2.4 GHz		For 5.2 GHz	
	Simulated	Measured	Simulated	Measured
Return Loss(dB)	-24.10	-15	-32	-29
VSWR	1.65	1.7	1.03	1.24

IV. CONCLUSION

The double T-monopole antenna has been simulated, fabricated and tested practically, using such results like return loss, VSWR, radiation pattern and gain, we concludes that; this antenna is suitable for 2.4 GHz and 5.2 GHz dual band wireless communication. The good agreement obtained between the experimental and simulated data. Constructed prototype is suitable for WLAN operations.

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BIOGRAPHIES

Markad A. R. was born in Maharashtra, India in 1991. He received the B.E. degree in Electronics and Telecommunication from University of Pune, 2013. He is currently working towards PG degree at Dr. BAMU University. He has ISTE life time membership. He was recipient of Best paper award in International conference at Malkapur, India. His research interest is on Microwave communication, Antennas and Wireless communication.

Patel A. S. was born in Maharashtra, India in 1972. He received the B.E. degree in Electronics and Telecommunication from University of Dr. BAMU, 1994 and his M.E. degree in Electronics and Telecommunication from Dr. BAMU University in 2011. He is currently working as an Assistant Professor at MSSCET, Jalna, India. His research interest is in Wireless and communication, Networking and Wireless sensor networks.