Design of Single and Dual-Band U-Slot Rectangular Patch Micro-strip Antenna for Wireless LAN at 5 GHz

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Abstract- This paper presents design and analysis of an efficient Single and Dual Band U-Slot Rectangular micro strip patch antenna frequency of 2.45 GHz. U-shaped slot increase the bandwidth. Performance parameters like VSWR, RFC & Impedance etc are very god in argument. Various tables, graph showing comparison with detailed analysis in this paper.
This paper is also available on GitHub:-

Keywords – Micro-strip, U-Slot, Reflection Coefficient, VSWR, Mesh, PCB Stack, Impedance, Beam width, Current Distribution, Pattern, s Parameter, MATLAB Antenna Design

INTRODUCTION

An antenna is defined by Webster's Dictionary as "a usually metallic device (as a rod or wire) for radiating or receiving radio waves." The IEEE Standard Definitions of Terms for Antenna s (IEEE Std 145-1983)[1] define the antenna or aerial as "a means for radiating or receiving radio waves." In other words the antenna is the transitional structure between free-space and a guiding device. These antennas are knows as Low-Profile antennas and PCA (personal communication antennas). Some examples= applications are cellular telephone communications, Wi-Fi, Bluetooth, RFID etc.

The micro-strip antenna is a special type of printed antenna, which is constructed using methods similar to those used for printed circuits. Micro-strip antennas have been widely used in many modern communication system, because of its planer profile, and low cost.

There are two type of slot feed antenna i.e. Centre-Feed Slot Antenna and Off-Centre-Feed Slot Antenna.

The U-slot introduces a capacitive component to counteract the large input inductance when thick substrate is used [2.] In this paper intermediate features of Micro-strip U-Slot patch antenna was taken under design consideration. Micro-strip patch antenna uses a radiating patch of perfectly conducting material separated from the copper ground plane using dielectric substrate material. Coaxial probe feed method, being easy and flexible, was considered for our design.

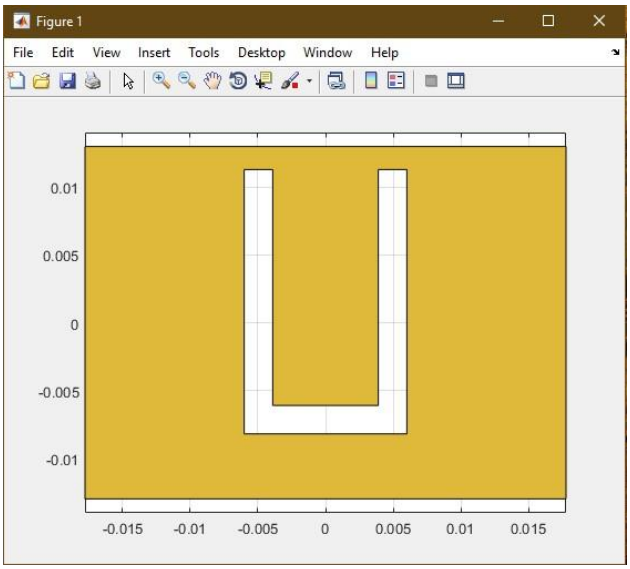

Fig. 1 MATLAB model of Single U-Slot rectangular Patch Antenna

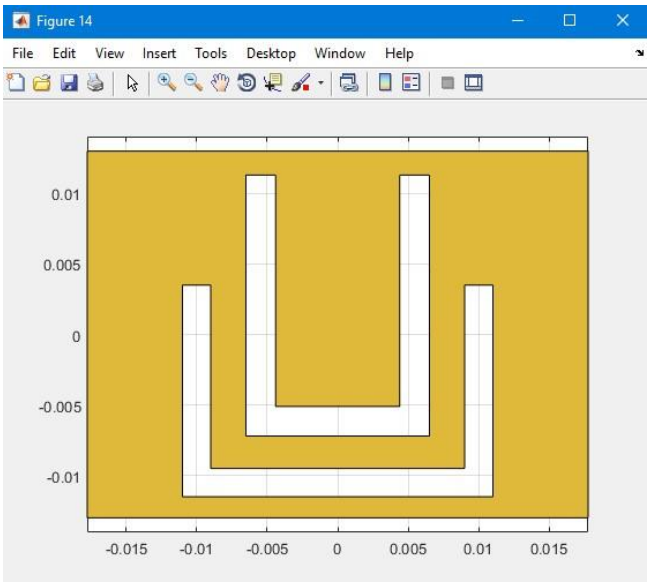

Fig. 2 MATLAB model of Dual Band rectangular patch Antenna

DESIGN OF THE ANTENNA

The geometry of the above proposed U-slot rectangular patch antenna is show below Fig 2.

Length (L)	26mm
Width (W)	35.5mm
Uy1	19.5mm
Ux1	12mm
Ua1	2.1mm
Ud1	4.8mm
d	13.5mm
Length (gp)	71.88mm
Width (gp)	52.6mm
Dielectric	'FR4'
Ux2	22mm
Uy2	15mm
Ua2	2.1mm
Ud2	1.5mm

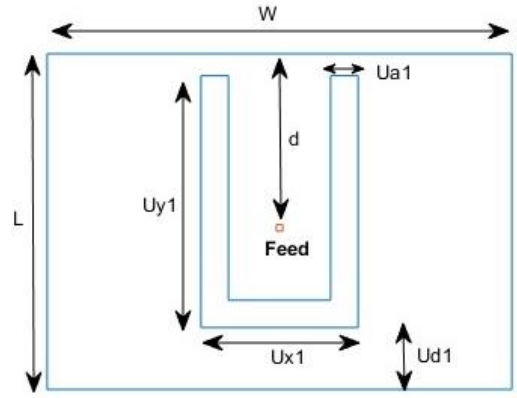

Fig.2 Dimension details of U-Slot Rectangular Patch Antenna

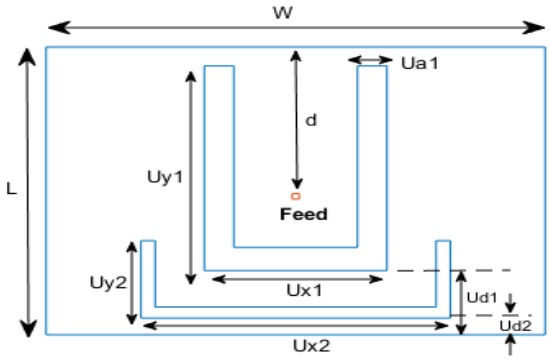

Fig 3. Dimension details of Dual Band U-Slot Rectangular Patch Antenna

DESIGN CONSIDERATIONS

Here the centre frequency f_o is taken as 5 GHz with lower bound frequency F_{low} as 3.00 GHz and upper bound frequency f_{high} as 6.00 Ghz. The antenna was designed for the application of wireless LAN that uses operating frequency as per **IEEE 802.11ac standards.**[4]

In this document it has been stated that - "IEEE 802.11ac is the fifth generation in Wi-Fi networking standards released December 2013[5-6]. This standard operating frequency is 5GHz, and bandwidth of 20, 40, 80, 160MHz sectors. The stream rates ranges for these bandwidth sectors are 7.2 - 96.3Mbps for 20MHz, and 15 – 200Mbps for 40MHz, 32.5 - 433.3Mbps for 80MHz, and 65 - 866.7Mbps for 160MHz. This standard exhibits better performance, and better coverage compared to IEEE 802.11a,b,g and n standards. The 802.11ac standard uses a wider channel and an improved modulation scheme that also supports more clients. The IEEE 802.11ac standard utilizes a modulation technique known as multi-user MIMO. This technique allows a set of users or wireless terminals, each with one or more antennas, o communicate with each other. The indoor range is 35m, and there is no recorded max for outdoor range."

Dielectric material FR4 with dielectric constant 4.800 and loss tangent 0.0260 was used.

Calculation of Patch Dimensions

Width of the patch of conducting patch material can be calculated using the below formula –

$$W = \frac{Co}{2fo}\sqrt{\frac{2}{[1+\varepsilon r]}}$$

Where c0 is the free-space velocity of light i.e. 3×108 m/s and εr is the dielectric constant of material here 4.8.

$$\varepsilon_{e_{ff}} = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-1/2}$$

Calculation of Ground Dimensions

The ground dimension for the antenna can be calculated as below:

Width of the ground is given as: Wg = W + 6h

Length of ground is given as: Lg = L + 6h

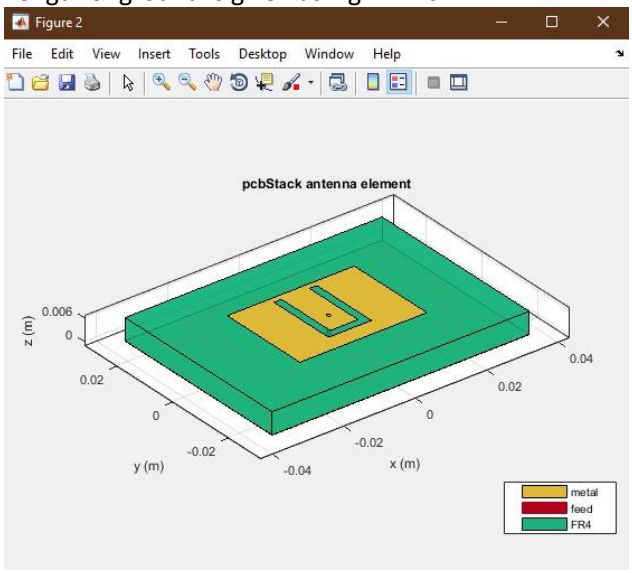

Fig. 4 PCB Stack

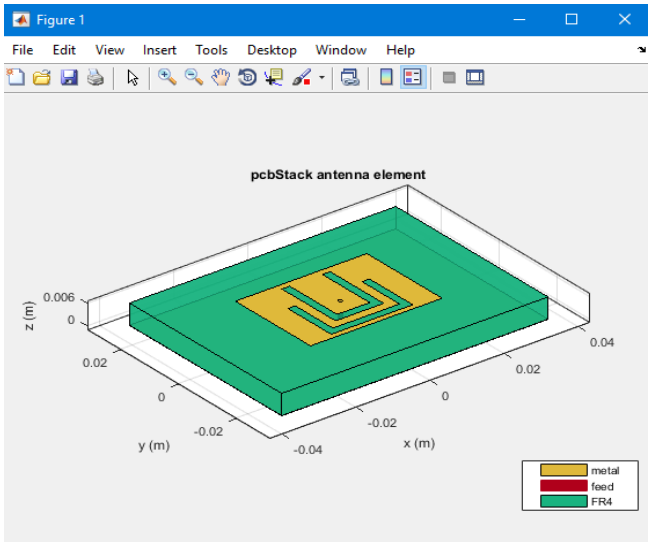

Fig 4. Dual Band PCB Stack

SIMULATION AND RESULTS

This antenna was designed and simulated using Antenna Designer MATLAB MATHWORKS software. The feed point was located at [0 0.5 1 3]. At this point impedance found to be 40-50 Ω. Various results are shown below:

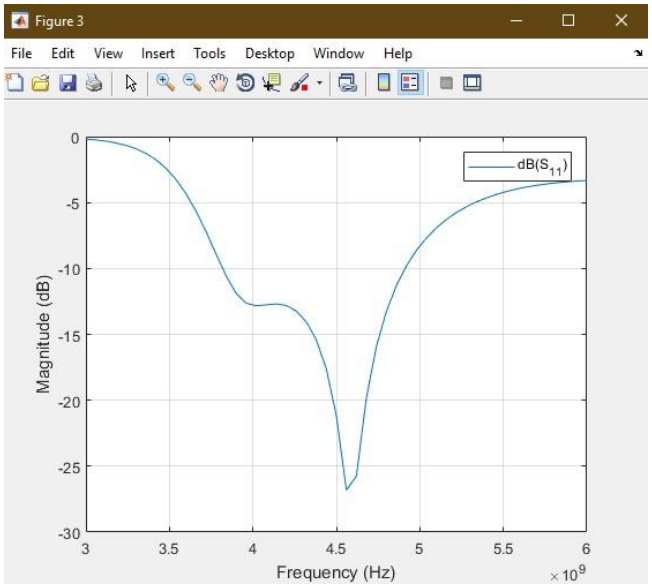

Fig 4. Reflection Coefficient

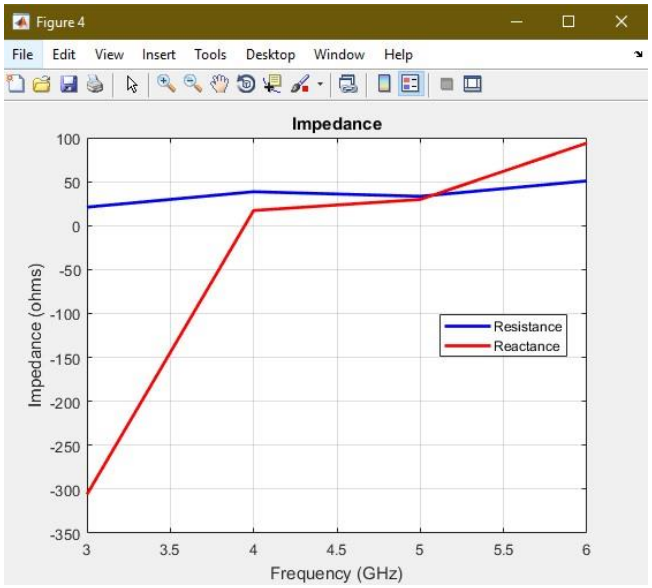

Fig 5. Impedance

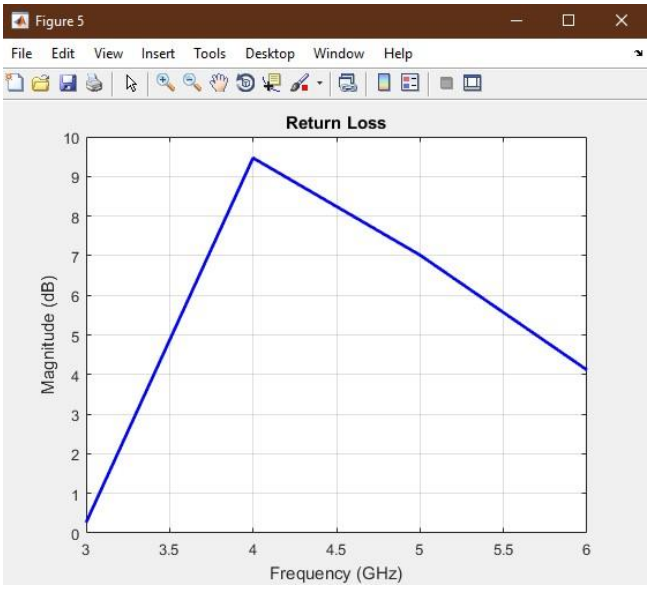

Fig 6. Return Loss

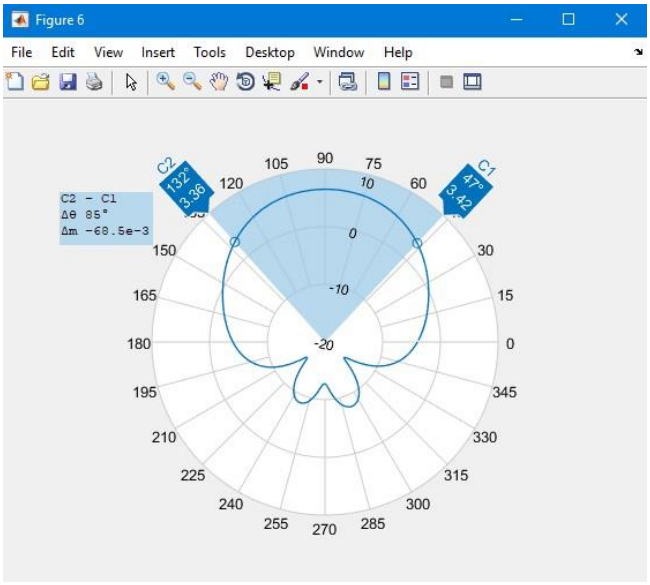

Fig 7. Beamwidth

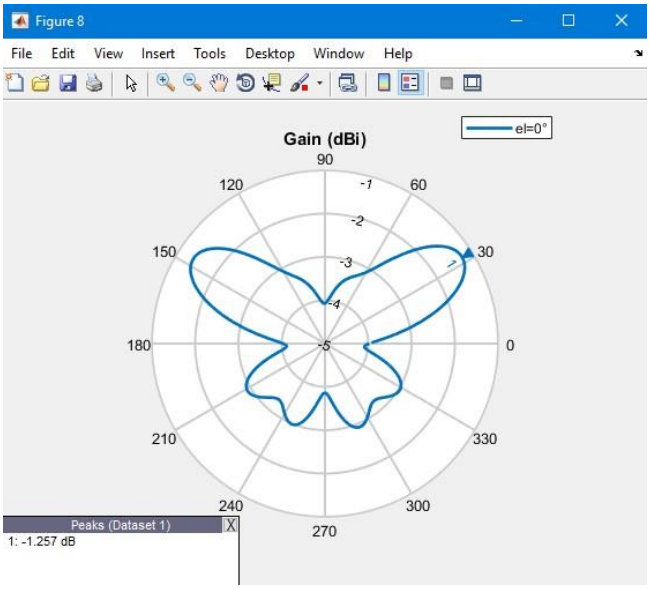

Fig 8. Elevation

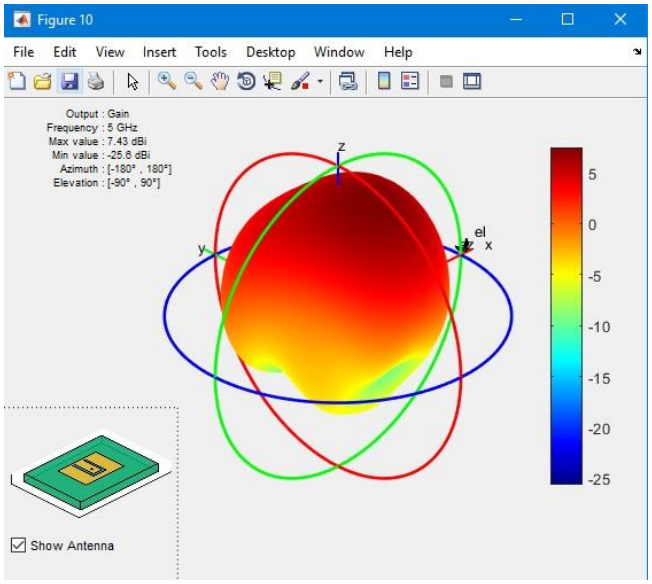

Fig 9. Radiation Pattern

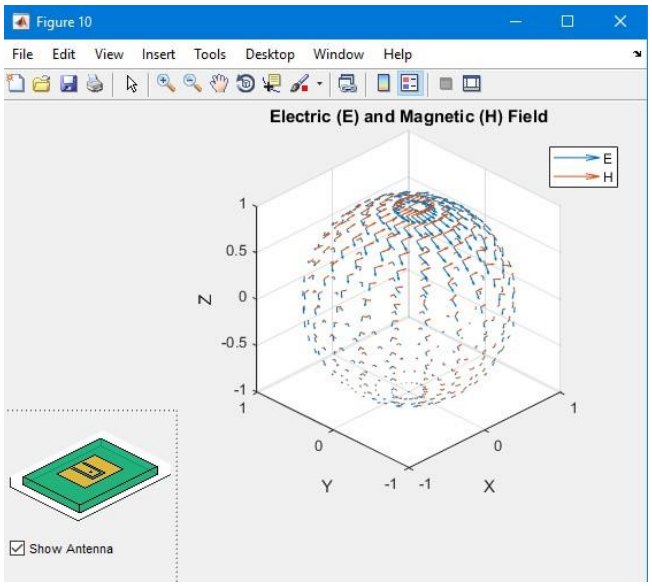

Fig. 10 Electric and Magnetic Field

CONCLUSION

Nowadays micro-strip antenna is an attractive candidate with low profile and very easy fabrications properties. The designed antenna is very compact in size and can be used for various applications. At last we have also designed on PCB for same i.e Single U-Slot antenna. Hugely, U-slot antennas are designed for wideband, multiband or frequency tuning operations.

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