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Design of Meander Line Antenna for Operating Frequency of 2.5 GHz

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ABSTRACT
In this paper, the meander line antenna which operates at 2.5 GHz was designed and analyzed. The tool named High Frequency Structure Simulator was used for design and simulate antenna. The antenna was designed on a Rogers Ultralam 1250 (tm) substrate with dielectric constant with relative permittivity of 2.5 and dielectric loss tangent of 0.0015 with a thickness of 2 mm. The performance of antenna was evaluated based on return loss, operational bandwidth, gain, VSWR and radiation pattern characteristics. During measurement return loss was measured by reading the S(1,1) port reflection constant parameter and it was found to be -20 dB.

Keywords
Antenna, Meander line antenna, VSWR, wireless, S-parameter.

1. INTRODUCTION
In the recent years, there has been rapid growth in the field of wireless communication . With the rising number of users and limited bandwidth available, operators are trying hard to optimize the network for larger capacity and improved quality coverage. This led to the field of antenna engineering to constantly evolve and accommodate the need for wideband, low cost, miniaturized and easily integrated antennas. There are various techniques to miniaturize the size of microstrip antennas: use of high primitive substrates, shorting pins and meander line antennas designs. For wireless communication, applications such as radio frequency identification tags, USB Dongle, Bluetooth headset, Mobile phone etc. meander line is the optimum solution for this type of implementation. Meander line antenna is a type of printed antenna that can achieves miniaturization in size by embedding a wire structure onto a dielectric substrate. The basics of meander line antenna, is to fold the conductors back and forth to make the overall length of antenna shorter than the original length of straight wire. The design of meander line antenna is a set of horizontal and vertical lines which forms turns. As number of turns increases, efficiency increases. In case of meander line if meander spacing increases with respect to that the resonant frequency decreases [1]. In basic form meander line antenna is a combination of conventional wire and planar strip line which includes the benefits of configuration simplicity, easy integration to wireless devices and potential for low specific absorption rate features.

2. DESIGN METHODOLOGY
The parametric study was carried out in the designing of the proposed antenna. The design of the meander line antenna will begin from the single element. It is then developed into the 5 elements and finally the S- parameter, gain and total radiation pattern is computed through HFSS Design model.

2.1 Substrate and patch analysis
From past Research analysis, the height of the substrate was found by [2]:

$$h_s \le \frac{0.3c}{2\pi f\sqrt{\varepsilon_r}} \quad (1)$$

Where,

h_s = height of the substrate.

f = frequency in GHz.

c = velocity of light in m/s.

ε_r = substrate dielectric constant.

The width of the patch can be determined through the following equation [3]:

$$w_p = \frac{c}{f}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (2)$$

Also, the length of the patch can be calculated from the specified equation [3]:

$$L = \frac{c}{2f\sqrt{\varepsilon_{eff}}} - 2\Delta L \quad (3)$$

Where, ε_{eff} = effective permittivity which is given by [3]:

$$\varepsilon_{eff} = \left(\frac{\varepsilon_r + 1}{2}\right) + \left(\frac{\varepsilon_r - 1}{2}\right)\left(\frac{1}{\sqrt{1 + \frac{12h_s}{w_p}}}\right) \quad (4)$$

Or, ΔL = physical length can be calculated from the below equation [3]:

$$\Delta L = h_s\left[\frac{0.412h_s\left(\varepsilon_{eff} + 0.3\right)\left(\frac{w_p}{h_s} + 0.264\right)}{\left(\varepsilon_{eff} - 0.258\right)\left(\frac{w_p}{h_s} + 0.8\right)}\right] \quad (5)$$

The length of the substrate is found by:

$$L_s = L_p + 6h_s \qquad (6)$$

Finally, the width of substrate is found by:

$$w_s = w_p + 6h_s \qquad (7)$$

2.2 Microstrip Width to depth ratio

The conductor width d, and the substrate width w, can be determined as a ratio of w/d and given the characteristic impedance and substrate dielectric constant. The microstrip width to depth ratio is determined through the following equation [2]:

$$\frac{w}{d} = \frac{8e^{A}}{e^{2A} - 2} \qquad (8)$$

Where, A is the effective area given by:

$$A = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right) \qquad (9)$$

and Z_0 = characteristic impedance in ohms.

3. ANTENNA DESIGN AND SIMULATION

The single element meander line antenna is designed which operates at 2.5 GHz. The antenna substrate is made on Rogers Ultaralam (1250) tm with dimensions (72.625 mm* 72.612mm * 2mm) and coplanar waveguide is of dimensions (32.77mm*20.8345 mm). The design of meander line antenna with coplanar waveguide is shown in Fig.1.

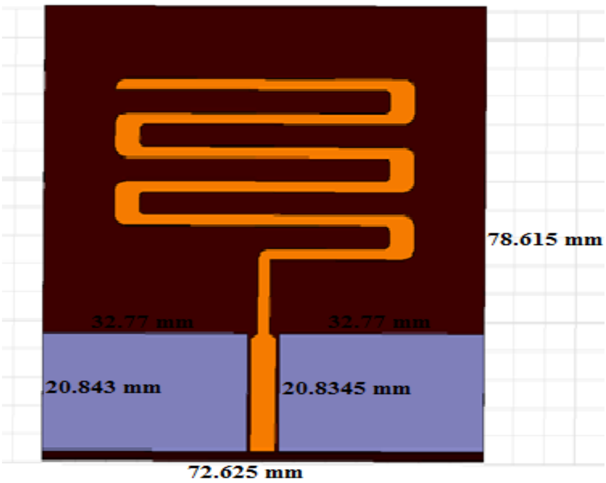

Fig1.Meander line antenna with CoplanarWaveguide

This figure shows the meander line antenna with coplanar waveguide and the feeding which is used in meander elements is 50Ω transmission line. Coplanar waveguide consists of a single conducting circuit printed onto a dielectric substrate ,together with a pair of return conductors, one to either side of the circuit. All three conductors are on the same side of the substrate, and hence are coplanar. The advantage of coplanar waveguide is that active devices can be mounted on top of the circuit. More importantly, it can provide extremely high frequency response since connecting to coplanar waveguide does not require any parasitic discontinuities in the ground plane. It has a good characteristic such as low radiation loss, low dispersion, good control of characteristics impedance and uniplanar configuration and it is used in the field of integration of active solid-state devices with antenna.

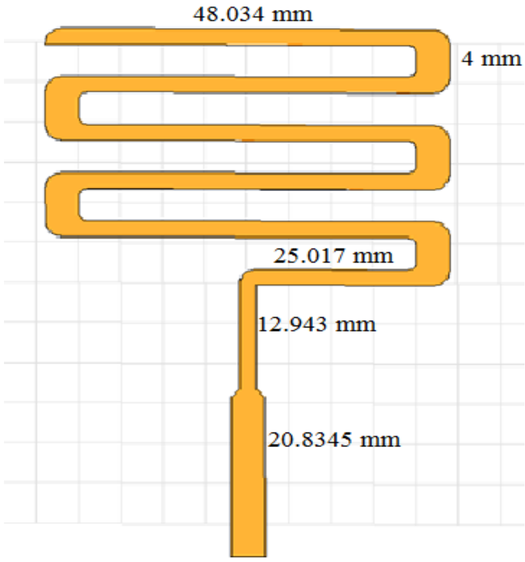

Fig 2. Meander line elements with feed

The meander line element dimensions is 48.034 mm*4 mm with thickness of 0.05 mm using the dielectric substrate having relative permittivity of 2.5 with a diameter of 2 mm and the distance between the two meander line elements is 4mm. The gap between the feed and the coplanar waveguide is 0.532 mm. The dimensions of feed are 4 mm*20.8345 mm with the thickness of 0.05 mm. The design of meander line elements of the meander line antenna is shown in Fig.2.

The meander line antenna is fed with a 50Ω lumped port of dimensions 15 mm * 7.724 mm with thickness of 0.45 mm. The Fig.3 shows the proposed antenna with lumped port depicted in colored portion.

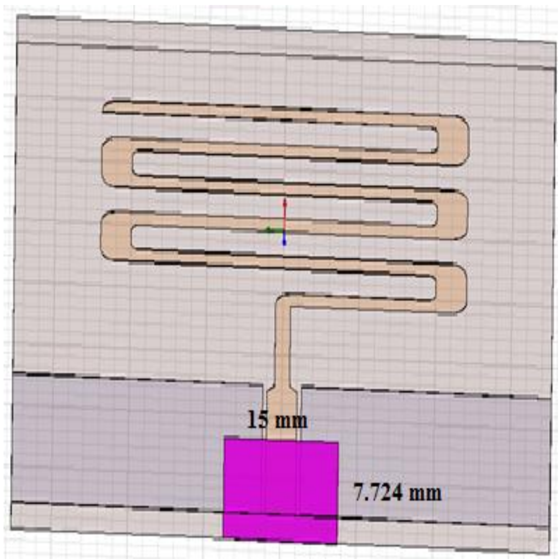

Fig 3. Meander line antenna with Lump port in coloured portion

4. SIMULATION RESULT

The antenna performance with the coplanar waveguide has examined through simulation via HFSS program. It is a simulation tool for 3D full wave electromagnetic field simulation. HFSS provides E-Fields, H-Fields, currents, S-parameters and near and far field radiation field results. The core of HFSS is based on the finite element method (FEM) where it is numerical technique for finding approximate solutions to partial differential equations (PDE) and their systems. The simulation results of the proposed antenna are is shown in Fig.4.

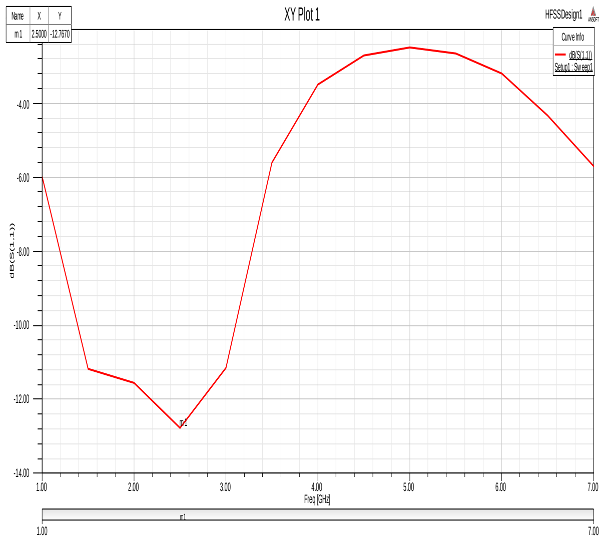

Fig 4. Return loss of Meander Line antenna

The Fig.4. shows the return loss i.e, S(1,1) parameter also known as scattering parameter of meander line antenna. The simulated result of the antenna design shows the return loss of -20dB. The graph is plotted S(1,1) parameter versus frequency. The antenna which was designed confirm the return loss at 2.5 GHz.

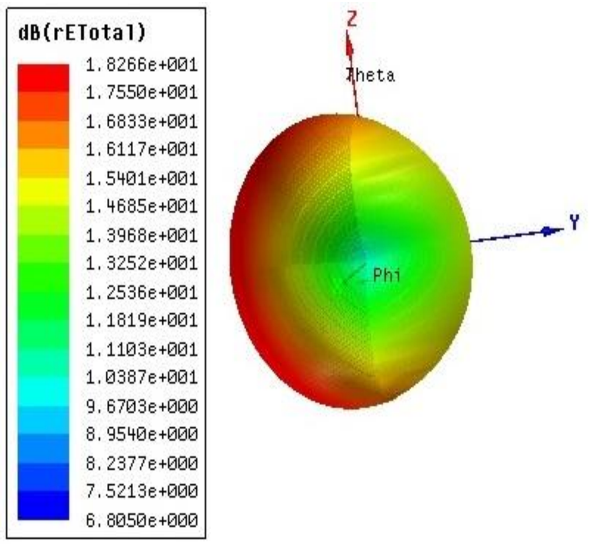

Fig 5. 3D polar plot of antenna for 2.5GHz

The 3D view for gain of Meander line antenna is also shown in Fig.5. for 2.5GHz. The gain of the antenna is efficient for meander line antenna to operate well at 2.5GHz.

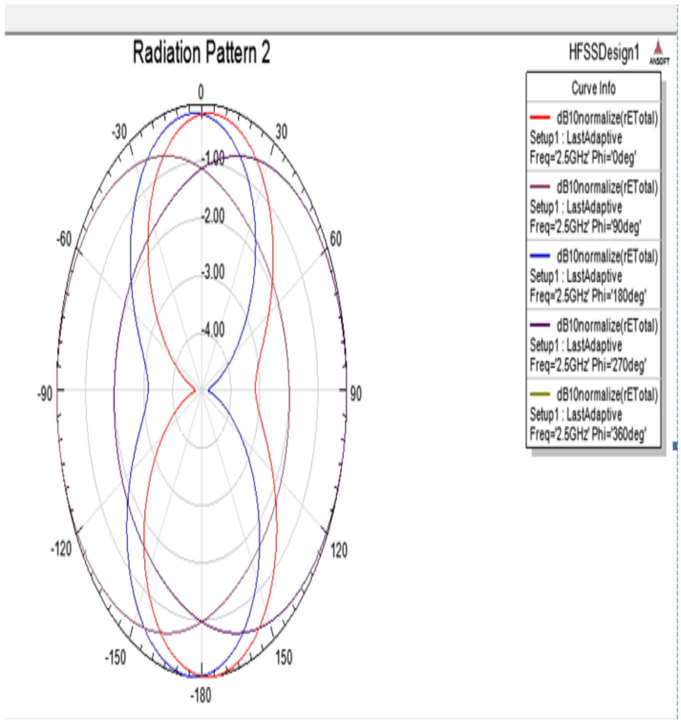

Fig 6. Radiation pattern of antenna at 2.5GHz.

The radiation pattern of the Meander line antenna was shown in Fig.6 in which the fields were presented for high frequency of operation for Antenna.

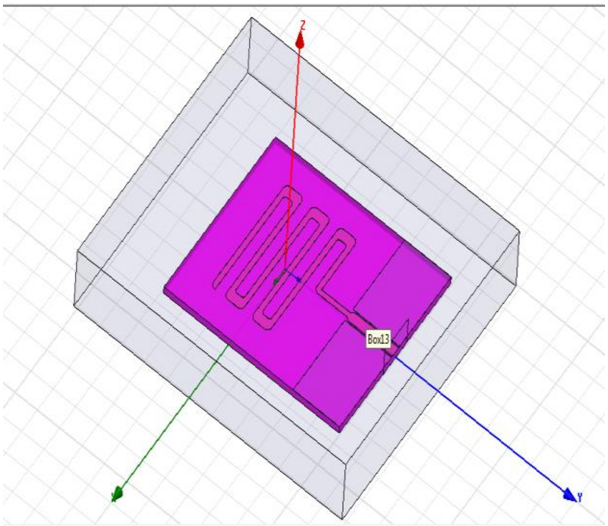

Fig 7. The view of final Meander line antenna.

In Fig.7 we can see the final Meander line antenna with air box (colored as pink color) built of vacuum is designed.

5. CONCLUSIONS

An electrically small meander line antenna operating at 2.5GHz was designed. The antenna provide us a good reflection coefficient, fair radiation pattern and a good gain enhancement of 7.2 dB and return loss of -20 dB. The simulated antenna can found to be useful in the mobile handsets which will run on the long term evolution (LTE) technology, wireless dongles and work efficiently for Bluetooth devices also.

6. ACKNOWLEDGMENTS
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7. REFERENCES
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