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Design and Simulation of Meander Line Antenna for Wireless Applications

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Abstract— The aim of this paper is to design the Meander line antenna (MLA) for the operating frequency of 3.4Ghz for wireless applications like WiMAX. The tool named FEKO from the product of Altair Hyper Works which is used to design the antenna. Basically, the designing part is done by using CADFEKO and simulated results are shown in POSTFEKO. The antenna was designed on the substrate called FR4 with dielectric constant with anepsilon ε value of 4 andloss tangent of 0.02 with a thickness of 1 mm. In order to design the proposed antenna, the optimal dimensions of the antenna and the effective di-electric of the microstrip line should not be over then 5 lines. The antenna performance was evolved based on the reflection coefficient of the antenna, VSWR, radiation pattern and return loss. The return loss was measured by reading the S (1,1) port of reflection coefficient and it was founded to be -14db.

Keywords—CADFEKO, dielectric constant, FEKO, FR4, MLA, POSTFEKO, reflection coefficient, S-parameter, VSWR, WiMAX, Wireless.

I. INTRODUCTION

In recent year's technology has grown vastly in all directions of the world. An antenna is the main useful device for wireless communication. If we speak about wireless communication definitely cell phone holds a major role. There are different kinds of mobile operator in all over the world. The main reason to evolve and improve the antenna engineering in the wireless communication system is the increased a number of users in a smaller bandwidth. This reason which causes the antenna to be manufactured with low cost, miniature in size, wide bandwidth and easily integrated with thick or thinnest communication devices. It is a type of patch antenna but the speciality about MLA is straight conductor line is folded one by another to make the overall length of antenna shorter than the original length, in other words a set of horizontal and vertical lines which forms turns. This makes the MLA look like a zig-zag pattern. The folded lines are print and embedded to the dielectric substrate easily.

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If the number of conductive turns increases the output efficiency of the meander line will be more. This makes the antenna to cheaper cost, lighter weight, high efficiency, better electrical characteristics and easy to manufacture in printed technology.

II. LITERATURE SURVEY

In [1], D. Misman, M. z. A. Abd. Aziz, M. N. Husain and P.J Soh designed a planer meander line antenna to operate in a frequency of 2.4GHz for WLAN application. In this, they have fabricated the double side PCB board using an FR4 etching technique. The meander line design from 1 to 4 possess a larger bandwidth. The best return loss for the planar antenna designed is -19.66dB with gain 4dB.
In [2], V.B. Ambhore and A.P. Dhande were designed the compact single element Meander line antenna for USB and wireless applications. The antenna designed to be operated in the frequency of 2.44 – 2.68GHz with 240MHz bandwidth. In this, they have optimized the parameters to achieve high gain, less than two VSWR, wide impedance B.W and unidirectional radiation pattern.
In [3], ShivshankarTondare and Navale V S have proposed the Meander Line Antenna LTE communication. The antenna is operated under a 2.4GHz bandwidth at -35.5dB and is designed for WLAN applications. The tool which they have used to design the antenna was HFSS. The designed antenna has been fabricated on the FR4 substrate. Network analyser has been used to test the fabricated design. In [4], X.L.Travassos, A.C.Lisboa and D.A.G.Vieira designed the MLA antennas for RFID based on multi-objective optimization. The purpose of this design is to made effective meanderline antenna for RFID purpose. The multi-objective system is faster to converge than the single-goal one. However, considering that SWRs of 1 and 40 at pattern frequencies can be considered Pareto most useful for the former method, the solution of the worst-case components may be appeared more meaningful, that is, an excellent decision rule, even though it is either ruled or protected in the optimal Pareto set. In [5], Md. Mustafizur Rahman and Ajay Krishno Sarkar have proposed the method for calculating the resonant frequency of meander line antenna. The designed antenna is for RFID tag. The simulation has been done in FEKO software. Two methods have been proposed one is T. Endo and another is proposed method. The results show that the increase in half dipole of the resonant frequency in antenna decrease in physical length of the antenna.

The proposed antenna frequency range is 860 to 960MHz. In [6], Bedir Yousif, Mohammed Sadiq and Maher Abdelrazzak were designed the meander line antenna for LTE communications based on defected ground structure. The performance has been analysed and observed good efficiency up to 82%. The bandwidth of the proposed antenna is approximately 57MHz.

The antenna can operate at 2.4GHz with < -10dB and the return loss of -38dB. In [7], Calla, Alok Singh, Amit Kumar Singhtheorized the empirical relation of MLA antenna. By adjusting the H-segments of the antenna to have divergent phase. The design was fabricated with the glassy epoxy (FR4) substrate with 3.2 thickness and dielectric constant of 4.4. The wavelength of the substrate at the centre frequency is obtained as 1060MHz then it has to be simulated at a frequency of 1030MHz and 1090MHz. Two methods have been proposed one by empirical relation and another is they have compared and calculated. With this empirical relation, they have designed the antenna.

In [8], D. Misman, M.Z. Abd Aziz, M.N. Husain, M.K.A. Rahim and P.J. Soh were designed a dual beam meander line antenna. In this paper, they have investigated the parasitic element of the meander line antenna. The design is to operate the antenna in the frequency of 2.4GHz. This specific design is for WLAN applications. They have used microwave office software to design and then the fabrication is made in double-sided FR4 PCB. The results have been compared between hardware and software.

In [9], Pingan Liu, Yanlin Zou, BaorongXiewere proposed the tri-band printed antenna with Meandering Split-Ring using compact CPW-Fed.This design structure is mainly focused on inverted L strips, rectangular slot,& Y shaped single pole radiator with meandering split rings. The antenna has been fabricated by using this structure. The fabricated antenna results show that the WLAN works in a frequency of 2.4 or 5.8GHz and the WiMAX can work in a frequency range of 2.5 or 3.5GHz.

In [10], Samridhi Manchanda, MithunHatwar and Bharani Abhishek were proposed the meander line antenna design for thefrequency of 2.5 GHz. The application for the design is LTE, dongle and also for Bluetooth devices. The simulations were done in tool names HFSS. The antenna was designed on a substrate called rogers with a relative permittivity of 2.5 and tangent loss of -20dB and 7.2dB gain.

In [11], Chien-Hsuan Liu, Ruey-Lue Wang, Chia-Yu Chen and Yan-KuinSu were proposed A multi-band current-reused VCO for 3.4 GHz WiMAX applications. The eight switched sub-bands and covers 2.438-2.971 GHz and 3.104-3.786 GHz which is the operating frequency of VCO. The power consumed by the VCO is 2.886 milli watt. The fabrication has done under CMOS fabrication method by TSMC 0.18 μm.

III. SOFTWARE OVERVIEW

FEKO is the computational electromagnetic (CEM) software which allows the user to design in 3 dimensional. This software is very useful in telecommunications, automotive, aerospace and defence industries. The name FEKO is derived from the German word “FEldberechnungbeiKörpernmitbeliebigerOberfläche”.

A. GPU Acceleration

FFEKO helps the usage of a couple of GPUs for simulation acceleration making use of the unified gadget architecture (CUDA) framework from NVIDIA. The computational phases specified for execution on CUDA-centered GPUs exhibit an enormous speedup when in comparison with normal CPU-based execution.

B. Optimization

FEKO offers state-of-the-art optimisation engines based on generic algorithm (GA) and other methods, which can be used to automatically optimise the design and determine the optimum solution. Furthermore, for advanced design exploration, the interface to Altair Hyper Study offers a comprehensive post-processing functionality (including trade off analysis and stochastics).

C. User Interface

The FEKO components with a graphical user interface (CADFEKO, EDITFEKO and POSTFEKO) make use of a ribbon driven interface that focusses on improved efficiency of workflow. CADFEKO supports parametric model construction. Complex geometry models and mesh models can be imported or exported in a wide range of industry standard formats. Use the application programming interface (API) to control CADFEKO or POSTFEKO from an external script or to automate repetitive and mundane tasks. Figure: 1 represents the workflow of the software.

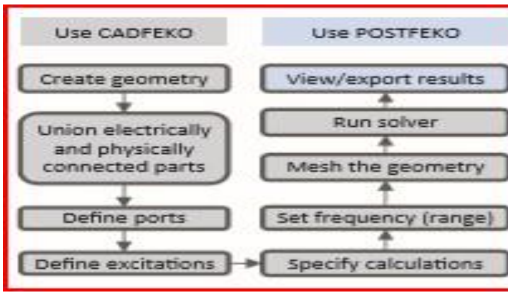


Figure 1: FEKO Software Workflow

IV. ANTENNA DESIGN AND ANALYSIS

The MLA begins from the 1 wire elementto the 5 wire elements and finally, the reflection coefficient, S- parameter, gain (db) and the radiation pattern is computed through POSTFEKOdesign model. The first step of the design begins with selecting the substrate and appropriate operating frequency. In this case, FR4 is the substrate material with relative permeability (epsr) of 4 which we have used. The step 2 is to choose the appropriate length andwidth (W) of the substrate. The step 3 is to choose appropriate length and width of the trace.

The height of the substrate was found by using

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

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 trace was determined by using

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

The length of the trace was determined by using

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

Where,

ε_{eff}= effective permittivity.

$$\varepsilon_{eff}=(\varepsilon_{r+1/2}) + (\varepsilon_{r-1/2})\,(1/(\sqrt{1+12h_s/(w_p)})) \quad (4)$$

ΔL = physical length

$$\Delta = hs\left[\frac{0.412hs(\varepsilon_{eff}+0.3)(\frac{wp}{hs}+0.264)}{(\varepsilon_{eff}-0.258)(\frac{wp}{hs}+0.8)}\right]$$

(5)

Length of the substrate is given by

$$L_S = L_P + 6h_S \quad (6)$$

The width of the substrate is found by

$$w_S = w_P + 6\,h_S \quad (7)$$

The microstrip width to depth ratio is determined by

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

Where,

d = width of the trace,

w = width of the substrate

A = effective area.

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

Where,

Z_0 = characteristic impedance in ohms.

V. ANTENNA SIMULATION

The simulation has been starting with single element meander line antenna to operate in the frequency of 3.4GHz. The substrate is made up of FR4 with the espr value of 4. Mathematical values for the meander line antenna are,

w_S=58.01mm,

L_S = 38.39mm,

h_s = 1mm,

w_t = 0.8mm,

h_t = 4.9mm.

Initially create all the required variables. After creating variables need to create a dielectric substance (FR4 is the dielectric substance). Then the single set conducting lines are created and then it is developed into five sets conducting lines which in the form of one by another like in figure:2. The top right corner there is small rectangular shaped box which is called patch feeder. Which gives the output through the SMA feeder. The dimensions of the feeder patch are 1.9*1.2mm. The small square shaped box in the bottom left corner which is used to correct the impedance matching in the design. The look alikeof one impedance to another impedance is called impedance matching. Input impedance of the antenna must be equal to the transmitting output in order to receive the expected output power this shows that the impedance matching is more important. The transmitter output is usually related to the antenna through a transmission line, that's normally coaxial cable. The high VSWR (voltage standing wave ratio) is the proof that the quality impedance matching.

The port impedance of the MLA antenna is given by the

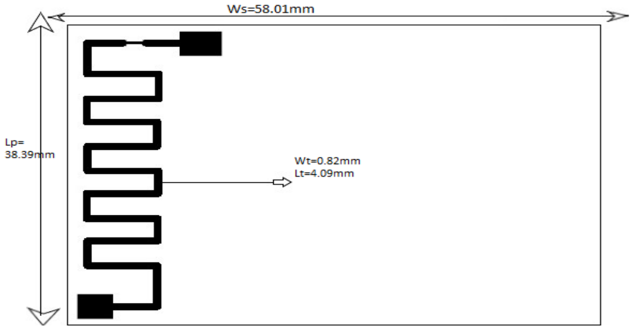


Figure 2: Circuit Schematic of MLA

50Ω. There are two ports which we have used in this antenna design, port inductance and port generator, these two are the wire ports. Wire ports can be applied to wires (geometry), mesh segments or on a vertex between segments. Apply a wire port to a vertex when a wire or mesh segment is connected to a structure and the phase difference from the end point to the first segment centre results in a significance effect on the input impedance reference figure: 3.

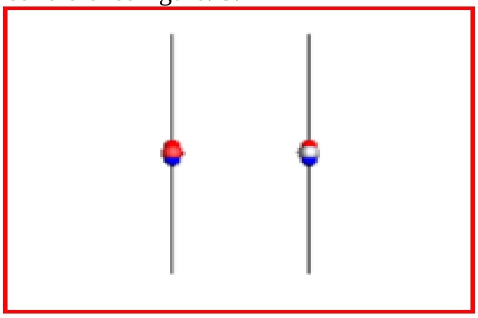
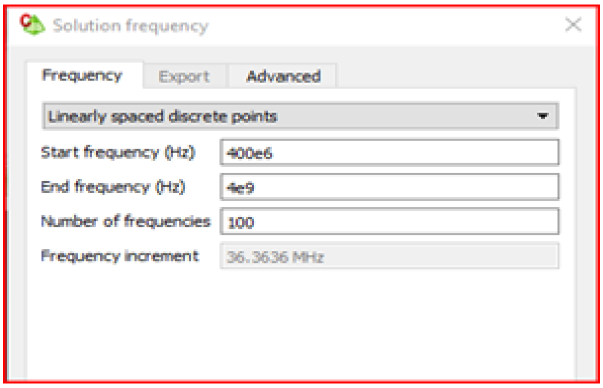


Figure 3: A Wire Port on a Segment (on the left) and a Wire Port on a Vertex (to the right) in the 3DView

a wire or mesh segment is connected between an infinite ground plane and an UTD plate.
The starting frequency which is given to the circuit is 400MHz, the post increment for every frequency during the cycle is36.364MHz, the end frequency given as 4GHz. The total number of frequencies during the cycle is 100. The circuit schematic of starting and ending frequencies are shown in figure 4.



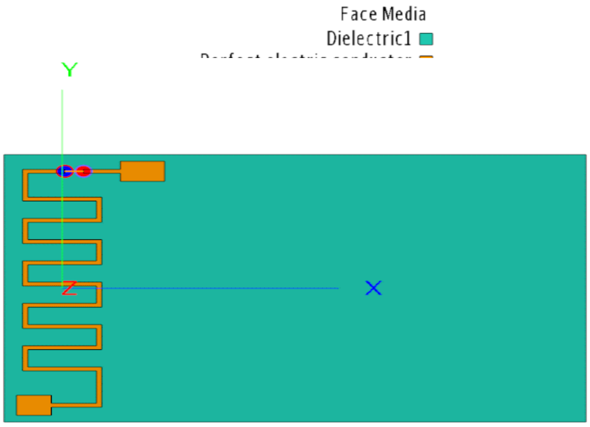


Figure 5: Circuit Schematic of MEANDER LINE

Figure 4: Circuit Schematic of Starting and Ending Frequency

VI. SIMULATION AND RESULTS

The final simulation of the MLA antenna in FEKO is shown in figure 5. The figure that shows the 3D model of the antenna. The blue colour which represents the substrate and orange colour shows te conducting meander line.

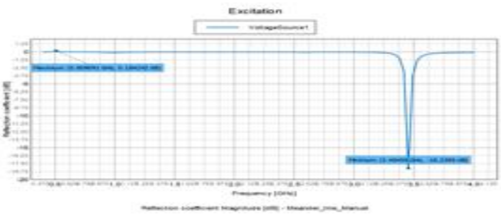


Figure 6: Circuit Schematic of RETURN LOSS of Reflection Coefficient

The above figure 6 shows the Return Loss (in S_{11} Parameters) of the antenna where the antenna can operate in less than -14dB.

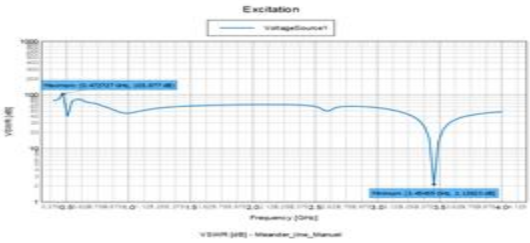


Figure 7: Circuit Schematic of VSWR

The VSWR (Voltage Standing Wave Ratio) is shown in the abovefigure 7 were at the frequency of 3.45GHz and VSWR of 2.14dB.
The above shown figure 8 represents the real impedance ismeasured at 17.14 k*Ω* at a frequency of 3.13GHz.

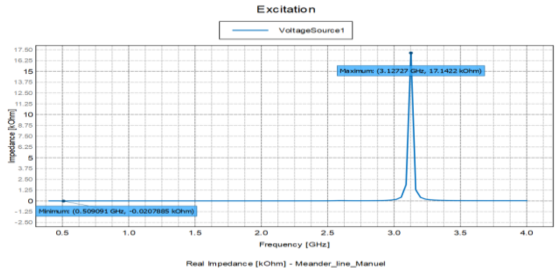


Figure 8: Circuit Schematic of Real Impedance

The Imaginary Impedance and the radiation pattern of the antenna are displayed in the below figure 9 and 10 respectively. The imaginary impedance of the antenna was measured at 6.57 k*Ω*at a frequency of 3.09GHz.

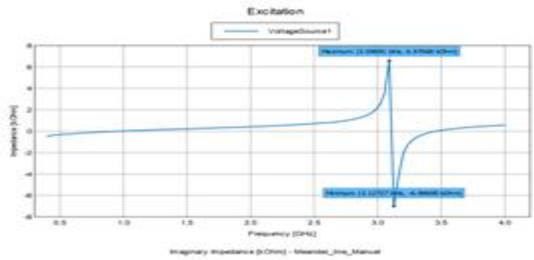


Figure 9: Circuit Schematic of Imaginary Impedance

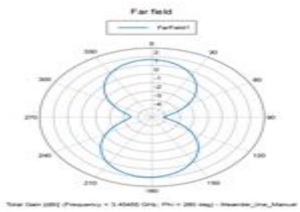


Figure 10: Circuit Schematic of Radiation Pattern

The radiation pattern as simulated in 3D is shown in figure 11.

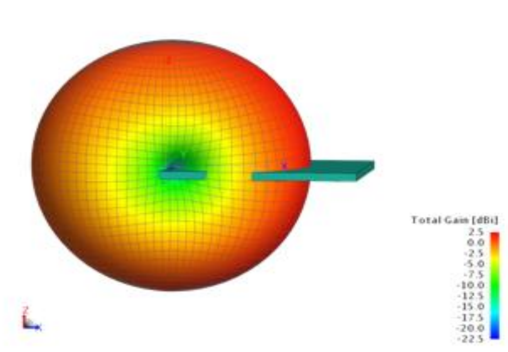


Figure 11: Circuit Schematic of Radiation Pattern in 3D

The resulted Parameters of Meander line antenna founded in the simulation are showed in the below table-1.

S.NO	PARAMETERS	VALUES
1.	Frequency	3.4GHz
2.	Gain obtained	2.5dB
3.	Return loss	-18dB
4.	VSWR	2.13823dB

VII. FUTURE SCOPE

The proposed antenna is used for wireless communication. The length of the Meander lines is directly proportional to the return loss. So, decreasing the Meander lines of the antenna may help toreduce the return loss of the antenna. This may reduce the size of the antenna to even smaller than the existing antenna.

VIII. CONCLUSION

In this work, the design of the meander line antenna for wireless application was presented. Due to the size reduction proposed antenna useful for wireless communication. The antenna system operates in the 3.4GHz frequency band. Therefore, the Meander line Antenna parametric reviews are acknowledged which involved the height of substrate and gap between the number of turns of meander traces. Due to the miniature in size, the proposed antenna is very useful to implement in many wireless applications.

IX. ACKNOWLEDGEMENT

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