Log Periodic Dipole Antenna For ISM Applications

Prof. Kiran Nandi[1], Mr. Mallikarjun D. Hiremath[2], Miss. Rajiyabi Awati[2], Miss. Sanjeevini Rudrapur[2], Mr. Mahesh Sanadi(Navalagi)[2]

[1]Assistant Professor, Dept. Electronics & Communication engineering, S.G. Balekundri Institute of Technology, Belagavi, Karnataka, India.
[2]Undergraduate Students, Dept. Electronics & Communication engineering, S.G. Balekundri Institute of Technology, Belagavi, Karnataka, India.

Abstract - *Antenna is widely used in many applications like Bluetooth, Wi-Fi, WiMAX, WLAN. In this paper, the Log periodic dipole antenna is designed for Industrial Scientific and Medical (ISM) band applications, which resonates at 2.4GHz. The size of the structure is comparatively smaller and line feed is used as the feed method. The different output parameters of the antenna such as S-parameter, directivity, gain, return loss and VSWR. Commonly, it's desirable for a UWB antenna to quilt a huge bandwidth spanning the whole range of 2.4GHz to provide an omni-directional radiation pattern and to have a compact size as well as an easy configuration.*

***Key Words*: Log Periodic Dipole antenna, Directional Antenna, Chip base antenna, 2.4Ghz antenna, ISM Applications, PCB Antenna.**

1.INTRODUCTION

Current media transmission systems are inclined towards antenna having more extensive data transfer capacity with Omni-directional attributes and smaller measurements. In this way, dipole antennas are extremely well-known contender for their uniform Omni-directional scope, sensible pick up and generally low assembling cost.

Log-periodic antennas are intended for the particular reason for having a wide data transmission. The actual data transmission of a log periodic antenna is reliant on its frequency range.

In telecommunication, the frequency spectrum is rare commodity and each band is assigned for a specific application. A log-periodic antenna is a broadband, multi-element, unidirectional, narrow-beam antenna that has impedance and radiation characteristics that are regularly repetitive as a logarithmic function of the excitation frequency. The measurements including input impedance, gain, radiation pattern and simulations are observed.

1.1 LPDA

LPDA is a multi-element directional aerial that is intended to function over wide band frequencies which were made up by Dwight Isbell and Raymond DuHamel in 1958 in Illinois University that exhibit uniform impedance, VSWR and energy characteristics. It has numeral semi signal dipole driven fundamentals with increasing in length which are allied to a feed-line in alternating phase. LPDA shifts with frequency by radiating or receiving in the active region thus is called log periodic

2. METHODOLOGY

The goal of this project is to design and build high gain, low cost, Log Periodic Antenna at 2.4GHz. The LPA is designed using CST studio software. One of the most important parameters that describe log periodic antenna is scaling factor. This scaling factor allows the antenna dimensions to remain constant in terms of wavelength λ. The condition is necessary to maintain the same impedance and radiation characteristics over a wide range of frequencies. Spacing factor and reflection coefficients are the other two parameters. The designing steps for the log periodic antenna are shown in Figure 1, it consists of 5 dipole elements and the wideband transition between micro strip. It is designed based on the technique of HMSIW (half mode substrate integrated waveguide). The substrate used is FR-4. The shortest dipole element determines the highest frequency range and the largest dipole element determines the shortest frequency range.

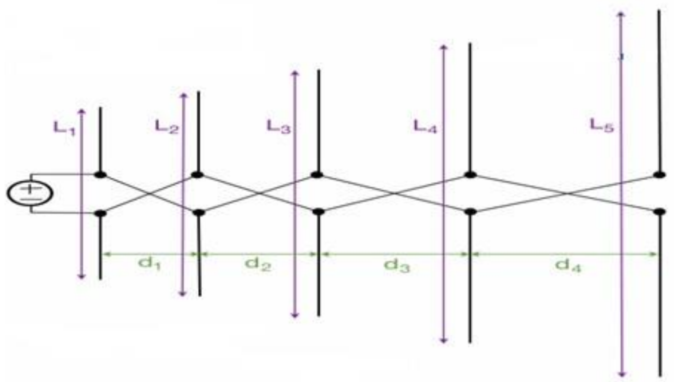


Fig -1: LPDA with 5 arms

Depending on the frequency range various parameters such as S-parameter, directivity, gain, return loss and VSWR can be achieved. LPDA designed for its very widest bandwidth. The possible Bandwidth is theoretically beyond measure and genuine Bandwidth reliant on structure range. Key property of LPDA is that, if it radiates at fn primarily due to Ln facet, then it also radiates at f(n+1) and f(n-1). Thus, it is called log periodicity.

The antenna structure is made by frequently increasing factor (*k*). If antenna radiate at various frequencies it will emit at multiples of *k*. The basic 5 element LPDA is shown, For the array in Figure 1, EF *k*=1.25 is used. Each dipole is 25% longer the other in left side and the distance (*d*) between dipole increases by 25. The feed is illustrated by the crisscrossing feed pattern in Figure 1. This antenna is often characterized by active and passive regions. it can be seen that the elements near the half-wavelength dipole which contribute to LPDA radiation, while other elements will not involve for the contribution.

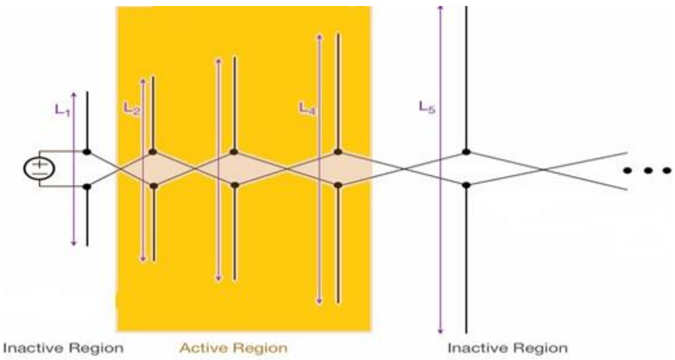


Fig -2: Illustration of LPDA active and inactive regions

The short elements are more capable to radiate. The longer elements will not radiate well. If an assumption is made that there are 3 active elements as in Figure 2. One can say that it resembles like Yagi-Uda antenna with three elements. The center one is the driven section, longer dipole is the reflector element and the shorter dipole is called director as in Figure. The radiation direction is towards left.

The LPDA comprises of collection of elements having different lengths and spacing's. It is important to know that the antenna elements will be lesser when the spacing decreases between them through back to font. The polarity of feeder will be reversed between elements which are adjacent. The antenna operates in the middle operating range that is in the active region.

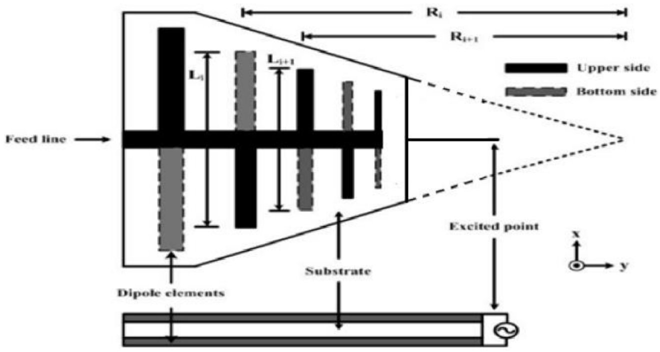


Fig -3: Printed design of LPDA

2.1 Design Formula

1. Specify the center frequency and select a substrate permittivity ε_r and a substrate thickness h

$$h \geq 0.06 \frac{\lambda_{eff}}{\sqrt{\varepsilon_r}}$$

2. Calculate width

$$w = \frac{v_o}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

3. Calculate ε_r using the following common equations

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}}$$

4. $\Delta L$is the normalized extension of the length and given as

$$\frac{\Delta L}{h} = 0.412\frac{(\varepsilon_{reff} + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{W}{h} + 0.8\right)}$$

5. Calculate the value of L and Z as

$$L = \frac{V_O}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

2.2 Software

The CST (computer simulation technology) best solutions for electromagnetic design and analysis. CST 3D EM simulation software is user-friendly and enables to choose the most appropriate method for the design and optimization of devices operating in a wide range of frequencies. Passive microwave & RF component design is a major application of this software and supporting it is one of CST's core competencies. CST DESIGN STUDIO™ (CST DS) allows the hybrid co-simulation of the effect of an attached circuit on the antenna performance. The System Assembly and Modelling framework in CST DS allows the user to set up coupled simulations which can combine different solvers automatically by making use of field sources. A network analyzer is an instrument that measures the network parameters of electrical networks. Network analyzers are used mostly at high frequencies, operating frequency at2.4 GHz. Special types of network analyzers can also cover lower frequency ranges down to 1 Hz. These network analyzers can be used for example for the stability analysis of open loops or for the measurement of audio and ultrasonic components.

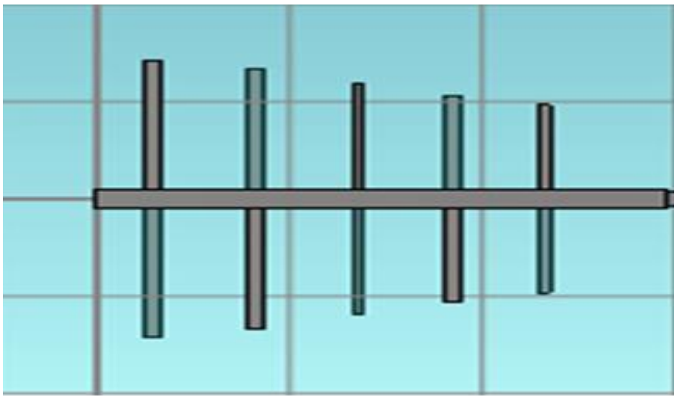


Fig -4: Software design overview

2.3 Parameters

Return loss (RL)is defined as how miniature the reflection or return is. The rebound back signal is known as return. It would < negatives of 10 hence antenna performance will not degrade

$$S_{11} = \frac{V_1^-}{V_1^+}$$

VSWR (voltage standard wave ratio) is the power in what way efficiently transferred from input to output. It has no units and also referred as ratio of Vmax to Vmin in transmitted signal.

$$VSWR = \frac{1 + |S_{11}|}{1 - |S_{11}|}$$

2.4 Steps

Step 1: Initially start with the applications and advantages of the antenna that has to be designed for the particular requirements. Here LPDA for the frequencies is designed for the ISM applications particularly for the Wi-Fi applications using software called CST studio suite.

Step 2: In the second step the type of antenna that has to be designed for the particular applications according to the requirements is known. For anything to be designed the most significant thing is to know dimensions and the parameters of interest. The Dimensions of the LPDA are calculated here for the 2.4GHz For ISM bands.

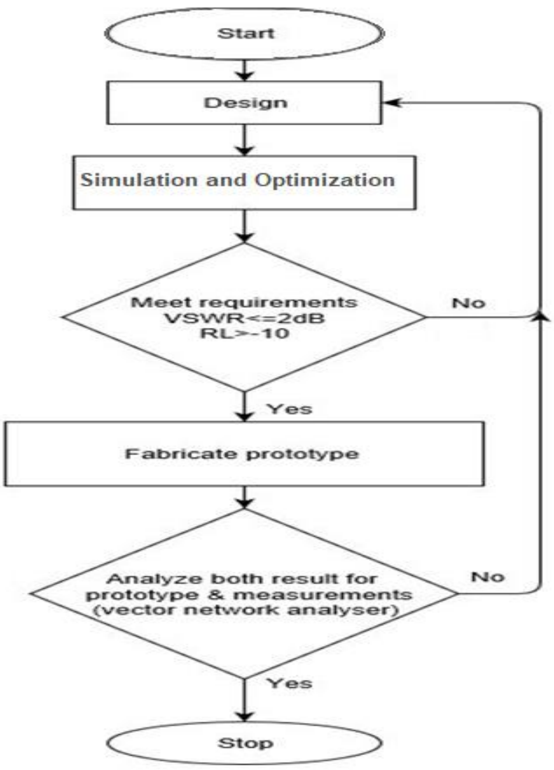
Step 3: In the third step the LPDA is designed using the dimensions calculated in CST Tool.

Step 4: Verification After designing LPDA for the calculated dimensions simulation will be started in CST software and checked for the required results. Here in this project an antenna is designed for the parameters like VSWR, RL and the Gain. The Return loss should be < -10dB and VSWR should be < 2.

Step 5: Prototyping After verifying the required results, the LPDA is fabricated by Standard PCB process.

Step6: Testing Once the fabrication of the designed antenna is complete it has to be tested for its correct functioning and obtained results are compared with that of the software results.

3. FLOW CHART



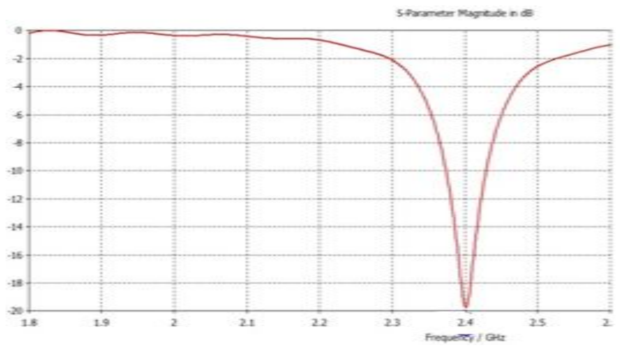


Chart-1: Scattering parameter Result

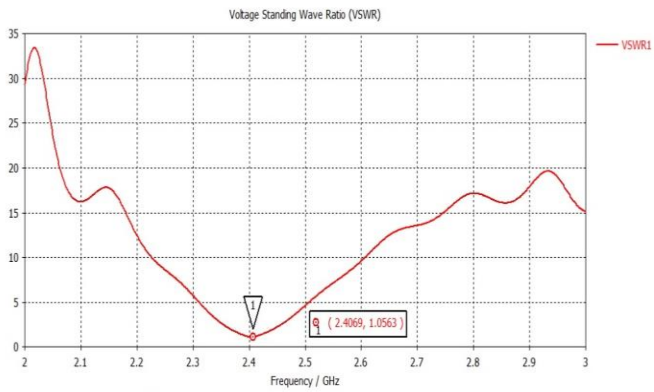


Chart -2: Voltage Standard Wave Ratio Result

4. CONCLUSIONS

After following all these designing steps one by one LPDA is designed in which both software results and the hardware results are in consistence. The simulation of the designed antenna and the results are Shown and perfectly match for the purpose of designing for ISM application.

REFERENCES

[1] Jian Yang, “On Conditions for Constant Radiation Characteristics for Log-Periodic Array Antennas”, MAY 2010.

[2] Lei Chang, Shuai He, Jian Qiang Zhang and Dan Li “A Compact Dielectric-Loaded Log-Periodic Dipole Array (LPDA) Antenna”,2017.

[3] Dr.R.Prabha, K.Madhubala, G.R.Sai Pranathi and S.Lavanya “Smart Log Periodic Dipole Array Antenna (3.1 GHz-11.6 GHz) for UWB Applications”, April-June 2018.

[4] Kyei Anim and Young-Bae Jung, Member, “Shortened Log-Periodic Dipole Antenna using Printed Dual-band Dipole Elements”, 2018.

[5] CST Microwave Studio 2016.