EEM487 Fundamentals of ANTENNA THEORY Term Project(Fall 2022 - 2023)

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***Abstract* - A transmission line equivalent circuit of the proposed MLPDA is developed to give physical insight of the structure and validation. Log periodic nature of the proposed antenna array is verified by plotting input impedance with logarithm of frequency over the specified range. To validate the results, prototype of proposed antenna is realized in the high frequency laboratory and results are verified with few experimentally measured values.**

# INTRODUCTION

## Antennas

In radio engineering, an antenna or aerial is the interface between radio waves propagating through space and electric currents moving in metal conductors, used with a transmitter or receiver. In transmission, a radio transmitter supplies an electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of a radio wave in order to produce an electric current at its terminals, that is applied to a receiver to be amplified. Antennas are essential components of all radio equipment.

Antennas can be designed to transmit and receive radio waves in all horizontal directions equally (omnidirectional antennas), or preferentially in a particular direction (directional, or high-gain, or “beam” antennas). An antenna may include components not connected to the transmitter, parabolic reflectors, horns, or parasitic elements, which serve to direct the radio waves into a beam or other desired radiation pattern. Strong directivity and good efficiency when transmitting are hard to achieve with antennas with dimensions that are much smaller than a half wavelength.

## Log Periodic Antennas

The conventional Log Periodic Dipole Array antenna design was proposed by R.H. Du Hamel and D.E Isbell in 1957 for broadband applications. The Printed Log Periodic Dipole Array (PLPDA) antenna was presented by Campbell et al. in 1977. A microstrip based structure of log periodic dipole array was introduced first time using modified Carell’s method. Later on the basic geometry of a strip line Log periodic dipole antenna introduced by Campbell et al. has been modified sequentially by several researchers to achieve better antenna performance in terms of large bandwidth, reduced size, improved front to back ratio, low cross polarization level and better gain.

A wide variety of techniques have been proposed for size reduction, bandwidth enhancement, gain improvement, feeding techniques and cross polarization of PLPDA

## Microstrip Log Periodic Dipole Array Antenna

In the Microstrip Log Periodic Dipole Array the length , width of the each dipoles depends on the scale and spacing factor values.

Chart

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Fig 1. The relationship between spacing factor and scale factor.

The antenna functions as a directional antenna radiating a beam off the ends of the MLPDA, along the feed length axis. These are used for transmitting antenna in high power shortwave broadcasting stations.

## Project

Calculations will be made for the antenna type to be used as the beginning of the project, then the antenna design will be made using the CST Studio Suite program with reference to these calculations, and finally the project will be concluded with the project report right after the project is implemented and the tests are done.

## Aim

The aim of this project is to design a Log Periodic Antenna with 150 MHz bandwidth at 1.1 GHz frequency with S11 (Reflection) value below -10 dB and Realized / IEEE Gain above 6 dBi as minimum success.

## Attributes of Antenna

Since we want to design a directional antenna in this problem, we will design MLPDA antenna that can be used in Bluetooth, phone, Zigbee etc.

# CALCULATIONS

In addition the calculations were not done by using formulas that found in the internet which is specifically for log periodic antenna however we need the formulas of microstrip log periodic antenna so there is no any calculations from any websites each calculation done by using calculator.

## Formulas

We will start to project by collecting the formulas that will be used to begin mathematical calculations. During the process we have used this article [1].

First of all, four basic parameters to be used in the calculations should be chosen according to the problem. These parameters can be given as: Frequency (f as megahertz), spacing factor (σ), scale factor (τ) and number of dipoles(n).

The frequency is already defined in the problem and will be used as 2.4 GHz in the calculations. While choosing the scale factor and spacing factor we have used the graph in Fig 2.

Diagram

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Fig 2. The relationship between spacing factor and scale factor.

To design an microstrip log periodic antenna , each length width and the distance between each dipole’s center, must be calculated in order to get results. The design formulas can be given as:

1. , operating wavelength (c as speed of light),
2. , maximum length of the dipole
3. Where is τ
4. , where is lowest operating frequency.
5. Where  is the values of and is given in Math section
6. , maximum length of the dipole
7. Where is τ – 7.3
8. , where is highest operating frequency.
9. Number of dipoles can be calculated from

1. is explained carefully in Math section
2. After determining the length and width of the first dipole element from Eq 2 and Eq 10 we can calculate other dipoles by knowing scale factor value.
3. Where is

## Math

While calculating the width of each dipole we have used the theory of the line dipole antenna which is as we know from the basic antenna theory when calculating the of a dipole array antenna we assume that it is not a volume but an infinite dipole wire which is . Since it is an infinite dipole wire, we can approximately say that a width of a dipole wire is . For instance after calculating the lambda() It is divided by 10 and multiplied by pi(π). An example calculation is give below.

then

The given value of and are calculated from the substrate which is FR4 substrate (εr = 4.4 and width h = 1.6 mm). The value is calculated from this article [2].

From the graph given in Fig 1 the base parameters of microstrip log periodic dipole array antenna are given below

Graphical user interface, text, application

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Fig 3. Parameters of MLPDA antenna

Table

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Fig 4. Each dipole’s length , widths and the distance between center of dipoles values

## Optimizing Calculations

While some of the parameters were changed due to the problems about the relationship between spacing factor and scale factor. Firstly the values are chosen as 0,78 for scale factor and 0,135 for spacing factor but it has been seen that while doing simulation the S11 graph didn’t satisfy our goal.

# SIMULATION

The design will be realized by finding the best design values in line with the simulation results of the drawing made using mathematically calculated values and optimization tools in the CST Studio Suite program.

## Designing Stage

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Fig 5. Log Periodic Antenna Design at CST Studio Suite 2021.

As can be seen on from the figure , each parameters that calculated in math section is used while designing the antenna.

## Graphics

After designing the antenna with the most suitable values for the problem, we simulated the operation of our antenna and obtained S11 (reflection) graphs and far-field graphs.

Table

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Fig 6. S11 Graph of the Log Periodic Antenna Design.

As can be seen from the graph, our antenna design provides the -10 dB condition determined for our problem in the simulation results, and gives the S11 result at -40 dB values.

Chart, radar chart

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Fig 7. Far-Field Graph of the Log Periodic Antenna Design.

Far-field graph also has been formed in a direction suitable for the MLPDA antenna graphs and is suitable for our purpose.

# REALIZATION

We will implement and test our antenna design that performs successfully in the simulation results.

## Antenna

The realized antenna hasn’t tested yet. The results will be added after testing with Prof. Dr. Selçuk Helhel.

A close-up of some papers

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Fig 8. Implementation of the Log Periodic Antenna Design.

## Test Results

Before testing the antenna we can we can easily predict that the result will not be same as in simulation. The reason of that the realization of the project made by hand. Since it is a handmade realization, we can see that from Fig 8. there are some troubles at the end of some dipoles. That caused by the usage of iron and the type of the paper when printing.

# CONCLUSION and DISCUSSION

As seen from the antenna design and implementation stages, mathematical calculations, simulation, and realization will not give the same results even if they are done carefully in the problem-solving process, however mathematical calculations and simulation steps are required to reach our goal for a successful application.

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