

Design of Log Periodic T-Antenna for Operation in S Band

V. Nagaraju, B. R. Tapas Babu and B. Janani*

S.A. Engineering College, Chennai - 77, Tamil Nadu, India; jananibhaskaran@gmail.com

Abstract

In this paper, the design and simulation of a Log Periodic T Antenna is presented. T antennas are generally small sized antennas used in VLF, LF and shortwave bands. These antennas can be used in a wide variety of applications due to their ease of designing and simplicity but are restricted to small bandwidth, low efficiency and low frequency band applications. To overcome the deficiencies of this antenna, Log Periodic T antenna (LPTA) is proposed. The proposed antenna can be used in higher frequency band applications (S band) and has a broad bandwidth. The proposed T-antenna is implemented by means of a patch. The substrate is chosen to be RT Duroid. The antenna dimensions are calculated using Transmission Line model. The antenna layout is simulated in Agilent's Advanced Design System (ADS) simulator.

Keywords: S band, Shortwave band, T-Antenna

1. Introduction

T antennas or T aerial or flat top antennas are small, light-weight, simple wire radio wave antenna that is used in applications such as VLF and LF bands. These antennas are easy to handle, robust and easy to design and manufacture⁵. They are gaining applications in a wide variety of fields due to their compactness but are restricted to narrow bandwidth and low efficiency. A T-antenna configuration is shown in Figure 1.

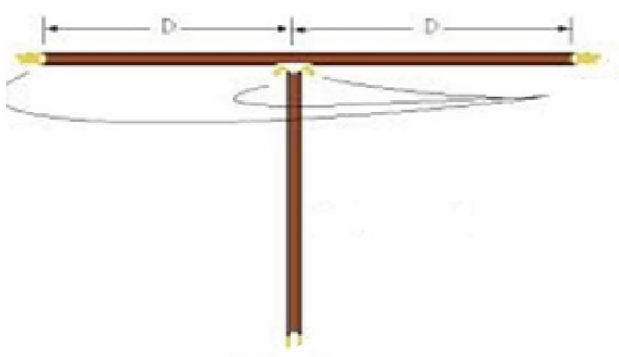


Figure 1. T-antenna configuration⁵.

Due to their deficiencies the T-antenna is restricted to minimal applications. These problems can be overcome by log periodic style^{6,9}. To overcome the above listed shortcomings, a Log Periodic T Antenna (LPTA) is modeled. T-antennas can be improvised to a better version by using Log Periodic technique. The Log Periodic technique provides larger bandwidth, improved efficiency and gain⁵. By using Log Periodic Technique, a single T is designed and the other T's are scaled using a scaling factor τ . τ is chosen to be 1.25^{16,17}. This T-antenna is implemented by means of a patch⁹ and analyzed using the transmission line model.

S band has the frequency range from 2 GHz to 4 GHz defined by the IEEE standard. It is used for weather radar, surface ship radar and communication satellites⁵.

The paper construction is as follows: Section II gives a brief note on Patch Antennas. In section III Log Periodic Style of T-Antennas (LPTA) is discussed. In section IV simulation software is discussed. In section V design and simulation of LPTA is discussed. In VI simulation results are shown and finally concluded with section VII and in section VIII the future work is described.

*Author for correspondence

2. Patch Antennas

Micro strip patch antennas have gained application in a wide variety of fields including wireless fields, laptops, mobile phones, tablets, mobile radios, pagers, base stations for personal communication etc because of their ease of fabrication¹. However there are certain limitations in printed antennas such as narrow bandwidth, low efficiency, low gain and low power handling capability^{1,2}. The patch antenna configuration is shown in Figure 2².

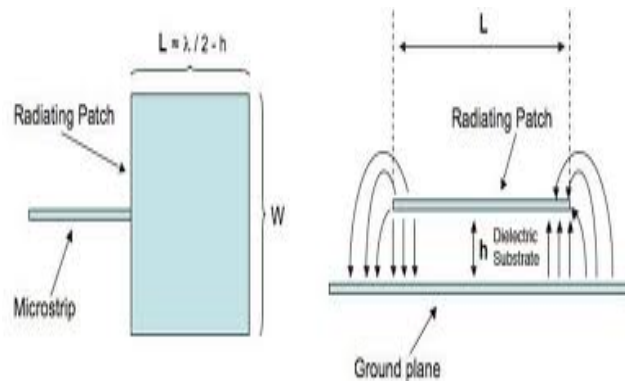


Figure 2. Patch antenna^{2,4}.

The substrate, patch and micro strip transmission line are made of high conductivity material. The patches can be in a variety of shapes^{1,2}. For easy computation, rectangular and circular patches are preferred. These patches are analysed using Transmission Line Model or Cavity Model. The patch antenna can be fed using² general techniques i.e. either by contacting or non-contacting scheme^{11,12,14}.

3. Log Periodic Style of T Antennas (LPTA)

Log Periodic Antennas are designed for specific purpose of having very high bandwidth. The achievable bandwidth is said to be theoretically infinite. The actual bandwidth depends on how large the structure is and how precise the finer features are on the antenna⁴. The demerits of the T antennas such as low bandwidth, low efficiency, low gain, low frequency applications etc. can be overcome by Log Periodic technique^{8,9}. In this technique a single T antenna is first designed using transmission line model and the parameters for the other elements are scaled by a factor τ in log periodic style.

Now L_n be the length of the n th patch and L_{n+1} be the length of $(n+1)$ patch, then by log-periodic style:

$$\ln\left(\frac{L_n}{L_{n+1}}\right) = \ln\tau \quad (1)$$

Now W_n be the width of n th patch and W_{n+1} be the width of $(n+1)$ th patch, then

$$\ln\left(\frac{W_n}{W_{n+1}}\right) = \ln\tau \quad (2)$$

τ is called the scaling constant. It is chosen to be either 1.02 or 1.25^{16,17}. The choice of higher value for the scaling factor provides better bandwidth. The log periodic fashion tells that the antenna radiates well at frequencies that are multiples of the resonant frequencies.

4. Simulation Software

Advanced Design System (ADS) is Agilent's software used for RF, microwave and high speed applications⁵. It is a powerful and easy to use interface for innovative and commercially successful technologies such as X-parameters used by leading companies in wireless communication and networking and aerospace and defence industries. It is a 2D design tool and uses Method of Momentum (MOM) technique. It can be used for combining schematic, layout, circuit, electro-thermal co-simulation and three full wave 3D EM technologies⁵.

5. Design and Simulation of LPTA

The substrate selection is the basic step¹¹ in designing LPTA. RT Duroid is chosen as the substrate and the antenna parameters are determined based on substrate's dielectric constant. The substrate parameters are mentioned in the Table 1 given below.

Table 1. Substrate Parameters

Substrate	RT Duroid
Dielectric Constant	2.2
Loss Tangent	0.002

The thickness of the substrate is chosen to be 1.5 mm. The first patch is designed with 2.6GHz frequency and the other patches are scaled with a scaling factor τ . The τ is chosen as 1.25¹⁶.

The parameters of a single element of LPTA designed using Transmission Line Model are given in Table 2.

Table 2. Parameters of single element of LPTA

Frequency GHz	L mm	W mm	W(t) Mm
2.6	3.5	9.598	3.0838

Where in Table 2, L denotes length of the T, W is the width of the T, W(t) denotes the width of the transmission line. W(t) is calculated using the Line calc tool of ADS.

The parameters of other T antennas are scaled by a factor 1.25. This provides better bandwidth and efficiency. The layout of the designed antenna is shown in Figure 3.

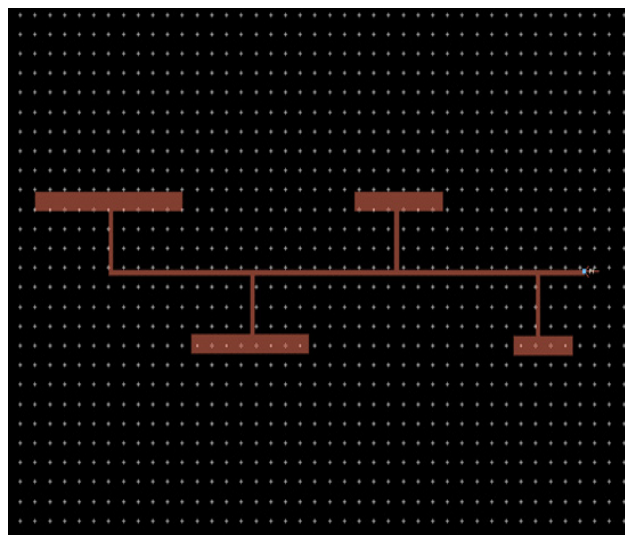


Figure 3. ADS Layout of LPTA.

The 3D view of designed LPTA generated using ADS is shown in Figure 4.

6. Simulation Results

The most important antenna parameter is the Return Loss (S_{11}) or S Parameter. The simulation result for return loss is shown in Figure 5. The return loss is much below -4 dB and this reveals that almost less than only 5% of the

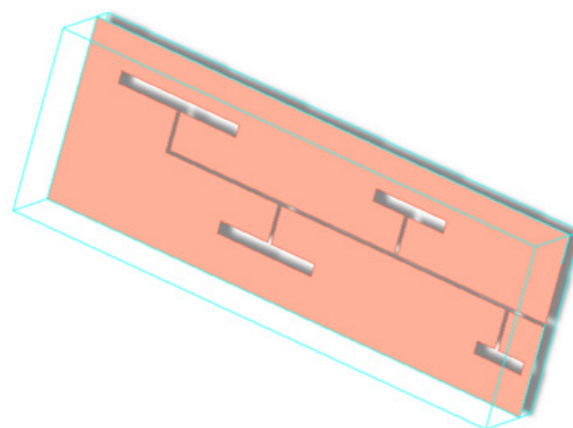


Figure 4. 3D view of Designed LPTA.

transmitted signal is reflected. This shows that the LPTA has improved efficiency than the T-antennas.

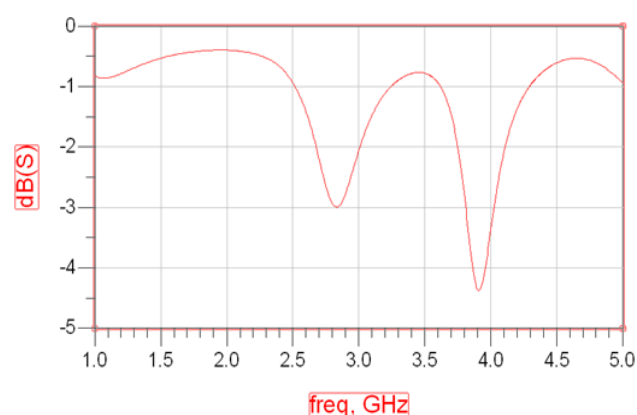


Figure 5. S Parameter of LPTA.

The resonant frequencies are between 2-4 GHz (which infers S Band frequency) which is due to the log-periodic character of the antenna. One of the most important characteristics of the antenna is its radiation pattern. The simulated radiation pattern is shown in Figure 6.

The radiation pattern is another important parameter indicating the antenna's performance. The Figure 6 shows that the LPTA has a uniform and standard radiation pattern.

Gain and Directivity of the antenna are other important characteristics indicating the performance of the antenna. The gain and directivity of the simulated antenna is depicted in Figure 7. It reveals that the gain is almost 8 dB which is much better and improved than the ordinary T-antenna because of the Log periodic style. Also the effi-

ciency of the simulated antenna is found to be 94% which is much improved than the T-antenna. Also by increasing the number of T elements the gain of the antenna can be much improved to a better value

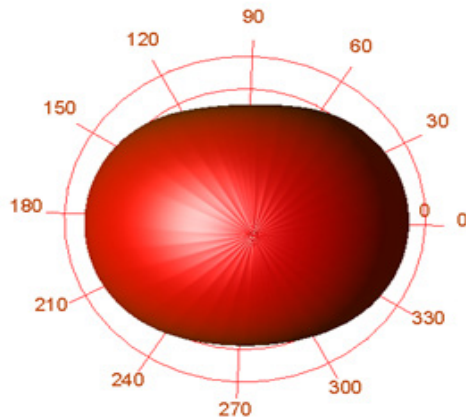


Figure 6. 3D radiation pattern of LPTA.

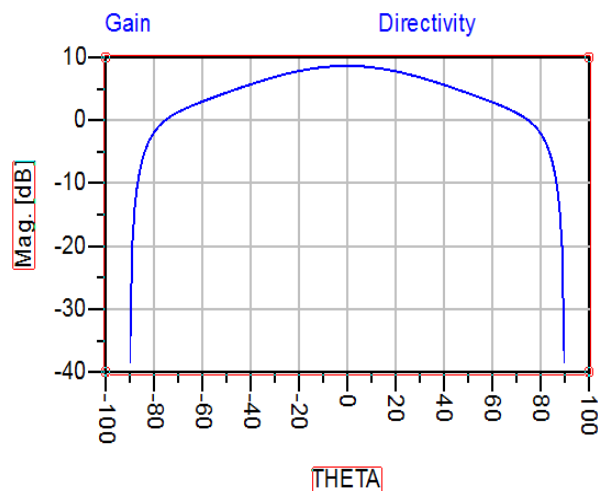


Figure 7. Gain and Directivity of LPTA.

7. Conclusion

This paper reveals the fact that LPTA can be used as a multi band antenna because it resonates at multiple frequencies inherited with the log periodic style. Increasing the number of elements increases its bandwidth¹⁰ and increasing the scaling constant also provides better band-

width. This can also be used for C band applications, satellite communications and UWB applications.

8. Future Work

The fabrication of LPTA using RT Duroid substrate has to be done and this is subject to future work.

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