ON THE PARAMETRIC CURVES FOR THE DESIGN, PERFORMANCE OPTIMIZATION AND CHARACTERIZATION OF THE LPDA ANTENNA

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Abstract: This paper attempts to overcome the limitations of the parametric curves that characterize the performance of the Log Periodic Dipole Array Antenna (hereafter referred to as the LPDA). For instance, the parametric curves in design handbooks e.g. ARRL antenna handbook and other relevant literature e.g. Peixeiro do not contain those giving the relationship between the boom-length 'L' and the number of dipole element 'N' for any given bandwidth, even when it is known that these two parameters are the main cost determinants of a LPDA Antenna. The concept of convergence is introduced to aid cost optimization of the LPDA Antenna in terms of number of dipole element 'N'. Although 'N' is used as the minimization criterion, the criteria for establishing convergence encompass all the main electrical characteristics of the LPDA antenna, such as VSWR, gain and radiation patterns.

Key words: LPDA, convergence, sparse, optimization criterion.

1. INTRODUCTION

The log periodic dipole antenna hereafter referred to as LPDA antenna was invented in 1958 by Isbell [1], of the University of Illinois, United States of America. This antenna is a system of driven elements designed to operate over a wide range of frequencies. The LPDA antenna exhibits constant electrical characteristics (i.e. fairly constant gain, pattern and VSWR etc), over the designed bandwidth [2], [3]. The basic concept guiding the operation of the LPDA antenna is that a gradually expanding periodic arrays, radiates most effectively when the array elements (dipoles) are near resonance, so that with frequency variation, the radiating or active region moves along the array. [4, 5].

Structurally speaking, the LPDA antenna consists of a sequence of dipoles with successively increasing lengths outwards from the feed point at apex as figure1 depicts. The feed lines cross over between adjacent elements, so as to give an 180° phase reversal between any two adjacent elements; this ensures that the radiated fields from the resonant elements are in phase at the far field (broadside radiation pattern) [6]. The active or radiating region moves along the structure with changing frequency. The active region is comprised of dipole elements whose wavelengths are \( \lambda/2 \) at the resonant frequency and most of the antenna currents are concentrated within this region. The remaining elements of the array are then considered as parasitic being comprised of directors and reflectors. Consequent to the actions of the directors and reflectors, the LPDA antenna is highly directional in its radiating and receiving patterns. In addition the phase reversal of currents in adjacent elements, ultimately results in highly directive broadside beam pattern emerging from the direction of the smallest element in the array.

![Figure 1: The LPDA Antenna](image)

The behaviour of the LPDA antenna is fairly well modelled, mathematically speaking. The elements are shortened by a factor \( \tau \) (tau) as we move towards the source of excitation, where \( \tau \) is known as the scaling factor and is one of the key parameters of the LPDA antenna. The scale factor is defined by,

\[
\tau = \frac{L_{n+1}}{L_n} = \frac{d_{n+1}}{d_n} = \frac{D_{n+1}}{D_n} = \frac{X_{n+1}}{X_n} \ldots \ (1)
\]

(Where \( D_n \) is the diameter of the \( n^{th} \) dipole element and \( L_n \) is the length of the \( n^{th} \) dipole element.) The scaling factor specifies the dimensional relationship between any two adjacent dipole elements. Another important
parameter of the LPDA antenna is the space constant \( \sigma \) (sigma), which is given by

\[
\sigma = \frac{d_n}{2L_n} = (1- \tau)/4\cot \alpha \quad (2)
\]

Where \( \alpha \) is the apex angle and \( d_n \) is the distance of the \( n \)th dipole element from the preceding element. The number of dipole elements \( N \), which is another parameter of the LPDA Antenna is specified in terms of both the scaling factor and spacing constant and is given by,

\[
N = 1 + \log \left( \frac{L_1}{L_N} \right)/\log (1/\tau) \quad (3)
\]

\( Z_0 \) in Ohms is the impedance of the Antenna boom and must be specified during design. The boom-length \( L \) in meters is given as;

\[
L = 2\sigma(L_1 - L_N)/(1- \tau) \quad (4)
\]

where \( L_1 \) and \( L_N \) are the longest and the shortest dipole elements respectively.

Carrel [2] published a simple design procedure for designing LPDA antennas. The only draw back to his procedure is that it neglects the effects of the boom-impedance and length to diameter ratio on the gain performance characteristics of the LPDA antennas. This though does not detract from the elegance and simplicity of this design technique. Subsequent works by De vito and Stracca [7], [8], Peixeiro [9] and others have taken advantage of the availability of computers to numerically model the LPDA antenna, thereby introducing more accurate design curves (although still limiting in scope).

Despite the attractiveness and popularity of the LPDA antenna, much information is still lacking regarding its performance characteristics, hence the justification for this research. The parametric curves giving the performance characteristics of the LPDA antennas, currently available in design books and other literature are those of Carrel [2], De vito and Stracca [7], [8], and Peixeiro [9]. Each of these researchers though having essentially the same objective, which is the design of a functional LPDA antenna, placed emphasis on different aspects of the design problems. Carrel [2], one of the many pioneer researchers of the LPDA antenna, though recognising the effects of the length to diameter ratio \( (L_n/D_n) \) and the boom-impedance \( (Z_0) \) on the gain performance of the LPDA antenna, took the view that these effects are negligibly small. Carrel's design curves therefore did not incorporate these effects. De vito and Stracca [7], [8], on the other hand, considered Carrel's miscalculation of the gain a major problem and therefore sought to correct it. In looking at the problem, Peixeiro [9] was of the view that not only is carrel's gain prediction overly optimistic, his neglect of the effects of the length to diameter ratio and the boom-impedance on the performance characteristics of the LPDA antenna was unacceptable. His design curves therefore contained LPDA antenna performance characteristics for values of length to diameter ratio and boom-impedance. Butson and Thompson [10], also considered the incorrect gain values as given by Carrel [2], but differed with Peixeiro [9] as to the origin of the error. These arguments are indications that the performance characteristics of the LPDA antenna are still incomplete.

The aim of this paper is to take advantage of the immense computational capability inherent in the hybrid method of moments (mom)/geometric theory of diffraction (GTD) based Super-Nec [11], combined with the graphical capabilities of Matlab, to achieve the following:

- Extend the range of the parametric curves beyond those given by Peixeiro [9]. This is necessitated by the fact that the design curves as given by Peixeiro are limiting in scope as it does not cover the range of scale factor \( \tau \), below 0.7 and space \( \sigma \), beyond the range of values between 0.05 and 0.22. This limitation of the parametric curves was also investigated by Bantin and Balmain [12]. Their paper concentrated on different aspect of this problem though.
- Find a means of minimising the number of element \( N \) as a means of cost optimising LPDA antenna. The justification for minimising \( N \) is propelled by the need to keep the cost down as the number of elements and the boom-length are the main cost determinants of the LPDA antenna, De vito and Stracca [7], [8]. This minimisation criterion is referred to in this paper as convergence and it will enable the Engineer to ascertain the minimum number of elements necessary for a LPDA antenna of given length and operating bandwidth, to yield acceptable performance.
- Give cognisance to the effects of boom-length \( L \) in meters) and operating bandwidth \( B \) on the gain performance characteristics of LPDA antennas by presenting parametric curves in terms of these parameters.

The investigations in this paper were performed in three stages. Firstly, in order to perform computational investigation of the LPDA antenna, measured impedance and VSWR are compared with theoretical predictions of them. Favourable comparison between the two sets of values will serve as a validation of the numerical modelling tool (in this instance Super-Nec) used in obtaining the theoretical results. Secondly, once the numerical model is validated, the generalised performance characteristics of the LPDA antenna for various lengths and operating bandwidths are then presented without cognisance to whether the Antenna is convergent or not. Thirdly, trends in the variation patterns of the average and standard deviation of the gain are used, as the basis for optimising LPDA antennas in terms of the number of element \( N \). Thereafter, the...
performance characteristics of converged LPDA antennas are presented.

In all, four hundred and ten LPDA antennas were investigated and the total outcomes of this investigation are presented as ‘result’. The simulations were done such that, for any operating bandwidth, the number of frequency steps will be the same, to ensure same average values. In the same vain, for any boom-length and operating band-width, the number of element is doubled for each incremental step, starting with \( N = 4 \) where possible.

This paper does not cover all varieties of Log Periodic Array Antennas, as there are an infinite number of such antennas. This paper investigates LPDA Antennas within the bandwidth of 300MHz – 3GHz, [except for one of the built models where validation of Super NEC was the main aim], with boom lengths ranging from \( 0.5\lambda_{\text{max}} \) to \( 2\lambda_{\text{max}} \) (where \( \lambda_{\text{max}} \) is the wavelength at the lowest operating frequency). The variations of these parameters are limited to ranges, which are of practical interest. It is to be noted here that Super NEC [11] is not an infallible tool. It does have its own limitations and rules, which, if not well followed, can yield erroneous results. Finally, these investigations are limited to free space environment only.

2. DESCRIPTION AND VALIDATION OF NUMERICAL MODELLING TOOL (SUPERNEC)

2.1 The modelling tool

The numerical modelling tool used in these investigations is Super numeric electromagnetic code version 2 (SuperNec). SuperNec [11] is an enhanced version of the numeric electromagnetic code 2 by G. Foggio et al [13]. It is an object oriented program with C++ at its core. It is a hybrid tool combining the methods of moment (MOM) [14] with optical theories such as geometric theory of diffraction (GTD) for simulation of antennas and structures. SuperNec requires Matlab to run, thus it combines the immense computational and graphical capabilities inherent in Matlab with the user friendliness of object oriented based C++ environment.

SuperNec models wire antennas and large structures and have rules which if not strictly adhered to, can yield embarrassing results. The modelling platform is interactive and prompts the user for key parameters of the antenna like operating band widths, characteristic impedance of the boom, space, scaling constants and length to diameter ratio. The simulated output is weighed against known performance characteristic of the antenna and a decision is then required as to accept the output or make some adjustments and simulate again. These parameter adjustment and repeated simulations is part of what this paper seeks to overcome by presenting all probable performances in form of parametric curves. In order to simulate the large number of antennas investigated here, group of antennas with similar characteristics were run as batch files and their outputs combined and viewed in SuperNec output engine [11].

2.2 Tests on Practical LPDA Antennas

Four pairs of antennas were built and measured for three antenna output parameters: impedance, voltage standing wave ratio and gain. Certain parameters of the antennas were varied such as length to diameter ratios, operating bandwidth and boom-length. Fixed boom impedance ‘\( Z_0 \)’ of 75\( \Omega \) was used for all the four models. This is because the transmission line (stripe line) is lossy, resulting in average feed point resistance of about 50\( \Omega \), which can easily be matched to a coaxial cable of the same characteristic impedance value. For each pair of antennas, dipole elements of fixed diameters were used. The antenna was fed directly using coaxial cables in all models. This involved passing 50\( \Omega \), RG 58 coaxial cable through aluminium tubes to the smallest dipole elements of each model. The measurement was performed in a shielded anechoic chamber using HP8753C network analyser. Table 1 below, gives the simulated and measured values of the antenna models built. The simulated values are denoted with an extension ‘out’, while the measured values are denoted as ‘models’.

<table>
<thead>
<tr>
<th>FILE NAME</th>
<th>REAL INPUT IMPEDANCE</th>
<th>IMAGINARY IMPEDANCE</th>
<th>G(dBi)_av</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEAN</td>
<td>STD</td>
<td>MEAN</td>
</tr>
<tr>
<td>C1.out</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 1a</td>
<td>52.78</td>
<td>8.87</td>
<td>-1.73</td>
</tr>
<tr>
<td>Model 1b</td>
<td>51.29</td>
<td>7.83</td>
<td>3.36</td>
</tr>
<tr>
<td></td>
<td>54.19</td>
<td>9.32</td>
<td>4.86</td>
</tr>
<tr>
<td>C2.out</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2a</td>
<td>50.65</td>
<td>8.94</td>
<td>-2.34</td>
</tr>
<tr>
<td>Model 2b</td>
<td>57.13</td>
<td>12.87</td>
<td>6.13</td>
</tr>
<tr>
<td></td>
<td>55.83</td>
<td>11.68</td>
<td>5.73</td>
</tr>
<tr>
<td>C3.out</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 3a</td>
<td>49.50</td>
<td>8.81</td>
<td>-2.59</td>
</tr>
<tr>
<td>Model 3b</td>
<td>58.69</td>
<td>14.43</td>
<td>7.39</td>
</tr>
<tr>
<td></td>
<td>60.00</td>
<td>18.05</td>
<td>8.94</td>
</tr>
</tbody>
</table>

A fair agreement between the predicted values from simulations and measured values is evident as can be seen in table 1 (last page). In all instances, real, imaginary impedance and VSWR are compared for simulated and measured results. The numerical means and standard deviations of input resistance, VSWR and gain were presented as opposed to parametric curve presentation of the same parameters. The reason for this format of presentation is justified on the basis that trends in the variation of numerical values of these parameters form the criteria for determining the convergence or otherwise of a LPDA Antenna which is introduced in the
next section. In order to maintain a balanced presentation, one of the LPDA Antenna models designed to operate from 30MHz to 120 MHz with a boom-length of 1.5m and number of elements = 15 is presented in graphical format as can be seen in figures 2 & 3.

Figure 2: Plot of real input impedance variation with frequency, L=1.5m, N=15

Figure 3: Variation of imaginary Zin with frequency N = 15, L=1.5m

The fair agreement between measured values and the theoretical prediction of the values by the modelling tool is enough validation of the modelling tool. Hence forth, it is to be assumed that the modelling tool has been validated and can then be used as the basis for extensive theoretical investigations.

3. CONVERGENT AND SPARSE LPDA ANTENNAS

The need to classify LPDA antennas arose due to the following reasons:

- It has been observed that some values of scale and design constants (and by extension number of elements) for a given boom-length (L) and operating bandwidth (B), do not yield meaningful gain, VSWR and radiation pattern characteristics. That is, for these values of \( \tau \) and \( \sigma \), (or N) the antenna gain, VSWR and radiation pattern characteristics are often not so good. There is therefore the need to avoid these values when designing LPDA antennas.

- One of the main objectives of this paper is that the number of dipole element (N) should be the optimisation criteria. This is because, as pointed out by De Vito and Stracca [7], [8], the cost of the LPDA antenna is determined by the boom-length and the number of dipole elements. For this reason, it has become imperative to find a means of designating LPDA antennas, so that one can see at a glance, the minimum number of elements for any given Boom-length and operating bandwidth required for the antenna to yield acceptable performance characteristics. This delineation is therefore a means of minimising 'N' so as to produce a cost optimised LPDA antenna.

To achieve these objectives, LPDA antennas are designed such that every other parameter remains constant except the number of elements, which are doubled in every step. Thus depending on the boom-length and operating bandwidth, the number of elements are given as N = [4 8 16 32 64 128]. The Boom-lengths are given as L = [0.5\( \lambda_{\text{max}} \), \( \lambda_{\text{max}} \), 1.5\( \lambda_{\text{max}} \), 2\( \lambda_{\text{max}} \)] where \( \lambda_{\text{max}} \) is the wavelength at the lowest frequency of operation. The operating bandwidth is investigated in the range B = [1:2 1:5 1:10]. The boom-impedance \( Z_o = 75\Omega \) and \( L_n/D_n = 100 \). The antennas were simulated and the average and standard deviation of the gains are extracted from the simulated batch files.

Trends in the patterns of variation of the average and standard deviations of the gain are used as the basis for deciding the element density, at which the antenna yields acceptable performance. Once this optimisation is done, the standard deviation of the gain has no further use and will not be referred to again.

The justification for using the mean and standard deviation of the gain as the basis for determining the usefulness or otherwise of a LPDA antenna is that the mean (or average) value of a set of data (in this instance gain) is a measure of central tendency. It is a measure of the tendency of the gains of LPDA antenna to converge to a central value for variations of frequency within the operating bandwidth. The standard deviation of the gain on the other hand is a measure of dispersion of the gain values around the mean value. It gives an indication of how close a given gain value is to the mean. In looking at the trends in the variation in the standard deviation of the gain, a low standard deviation value is an indication of LPDA antenna convergence (or optimised performance). It is to be seen that once convergence is attained the STD values do not differ widely for doubling of 'N'. It is also seen that for the mean gain, once convergence is attained, the mean values remain within a narrow band of values. As an example, consider a LPDA Antenna of length L = 1.5\( \lambda_{\text{max}} \), with operating bandwidth of 1:5. The number of
elements is doubled per step as 4, 8, 16, 32 and 64. Trends in the pattern of variations of the VSWR, gain and radiation patterns will be investigated with the aim of establishing the criteria for convergence or Sparse LPDA Antennas.

As can be seen from figure 4 below, this antenna does not yield acceptable VSWR (1:2 or below) performance for all frequencies within the operating bandwidth until the number of dipole elements became at least greater than 16. The same conclusion can also be reached, when the variations of gain and radiation pattern with frequency for fixed values of number of elements is investigated. The azimuth radiation pattern was taken at a mid- frequency of 900MHz (figures not included due to size). It can be shown that, the variation of gain with frequency was not acceptable until the number of dipole element 'N' became greater than 16.

The radiation pattern is not acceptably directive until the number of dipole element became greater than 16 and for N greater than 32, the radiation pattern does not show marked improvement (as would have been expected) to justify using more than 16 elements. The implication of this is that even though increasing the number of elements beyond the convergence point does sometimes increase the average gain, the pattern of variation of gain with frequency may render this increased gain useless. Since the aim here is minimisation of 'N', using values of N greater than N at convergence does not necessarily result in improved performance of the LPDA as to justify the cost implications.

The mean VSWR does not meet acceptable value until N greater than 16. This suggests a convergent value of N of about \((16+32)/2 = 24\). The reason for this approach is based on the fact that the mean VSWR approaches 1:1 between N=16 and 32 and the mean gain appears to stabilize between these values. Also for N=16, the STD of gain =1.99 and for N=32, STD of gain =1.52. Now, if N exceeds 32, the STD of gain increases, suggesting that the point of convergence lies between N = 16 and 32, hence the justification for averaging. After convergence, doubling the number of elements does not result in any appreciable change in the VSWR. With respect to standard deviation of the VSWR, once the number of elements became greater than 16, the value of STD dropped drastically suggesting little dispersal from the central value. After convergence, the STD values do not vary greatly. Looking at the trends in the pattern of variation of the mean gain, it was also observed that for N greater than 16, the Antenna for the first time yields acceptable mean gain and doubling the number of elements does not result in appreciable change in gain values. The same is true for the STD of the gain.

Figure 4 is a representative case of the graphical illustration of convergence and sparse LPDA antennas. In other to define LPDA Antenna convergence in detail, there is the need for numerical presentation of the trends in the variation patterns of VSWR and gain for fixed N as can be seen from table 2 below.

![Figure 4: SWR versus frequencies for values of N, L =1.5λ_{max}](image-url)
Table 2: Trends in pattern of variations of VSWR and gain for fixed values of $N, L = 1.5\lambda_{max}, B = 1.5$.

<table>
<thead>
<tr>
<th>$N$</th>
<th>$(\text{VSWR})_{\text{avg}}$</th>
<th>$(\text{VSWR})_{\text{STD}}$</th>
<th>$(\text{Gain})_{\text{avg}}$ (dBi)</th>
<th>$(\text{Gain})_{\text{STD}}$ (dBi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5.29</td>
<td>9.37</td>
<td>-0.39</td>
<td>3.75</td>
</tr>
<tr>
<td>8</td>
<td>3.06</td>
<td>4.12</td>
<td>-3.31</td>
<td>4.55</td>
</tr>
<tr>
<td>16</td>
<td>1.08</td>
<td>0.08</td>
<td>6.40</td>
<td>1.99</td>
</tr>
<tr>
<td>32</td>
<td>1.12</td>
<td>0.15</td>
<td>6.81</td>
<td>1.52</td>
</tr>
<tr>
<td>64</td>
<td>1.32</td>
<td>0.60</td>
<td>6.80</td>
<td>1.64</td>
</tr>
</tbody>
</table>

This was the procedure adopted for all four hundred and ten LPDA Antennas (410) and information gathered from this is used for setting the convergence criterion, which follows next.

3.1 Convergence (Optimisation) Criteria for LPDA Antennas.

A log periodic dipole array antenna shall be considered converged if it meets the following requirements:

I. It must yield a mean gain of at least 5dBi for a pair of scale factor '$\tau$' and spacing constant 'r' (and by extension for a given value of number of dipole elements 'N') and for any given boom-length 'L' and operating band-width 'B'. A gain of 5dBi indicates that the LPDA Antenna radiates at least three times more in the direction of maximum field compared to that of an isotropic radiator.

II. Doubling the number of dipole elements 'N' results in at most average increase in mean gain of about 1dBi and the STD averages 1.15dBi (deduced from observation).

III. It must maintain a VSWR value of 2:1 and below within the designed operating bandwidth.

IV. Its electrical characteristics such as input impedance, radiation pattern and gain must vary periodically as the logarithm of the operating frequency. This Antenna must therefore yield acceptable radiation pattern within its operating bandwidth.

A log periodic dipole array antenna that does not meet the requirements I to IV above is considered unconverged. Although the criteria for convergence have been stated in terms of the VSWR, radiation pattern and gain characteristics of the LPDA antenna, the latter will be used as the basis for establishing convergence. Any of the electrical characteristics can be used but I have chosen the gain for the sake of uniformity; also, the effect of boom-impedance ‘$Z_o$’ and length to diameter ratio on the gain of LPDA antenna are the subject matters of a later paper. It is to be noted however, that a converged antenna must meet all of the requirements.

It is necessary at this stage to point out that the convergent value is not absolute. It is however more sensitive at the lower values than at higher values. Thus, if for a given boom-length and operating bandwidth, a given LPDA Antenna converges for $N = 8$. If the elements were reduced by 2 elements, the convergence of that Antenna may no longer be guaranteed. On the other hand, if convergence was attained at $N=12$, reducing the number of elements by two might not affect the convergence drastically. Convergence provides a means of using the number of elements as the optimisation criteria while maintaining the electrical characteristics of the LPDA antenna.

4. RESULTS

In this section, results of investigations are presented in the order in which they were carried out. First generalised (figures 5-16), extended parametric plots are presented for both convergent and sparse LPDA antennas (i.e. for both minimised and non-minimised LPDA Antennas). Next, minimised (or convergent) LPDA antennas are presented as in figures 17, 18 and 19.

4.1 Probable Gain Performance Characteristics of LPDA Antennas (Convergent/Sparse)

In figures 5-16, extended parametric plots are presented for both convergent and sparse LPDA antennas. The convergent and sparse antennas are represented in figures 17, 18 and 19.
Fig 7: N versus $\tau$ for L and varying B

Fig 8: N versus $\tau$ for L & varying B

Fig 9: N versus $\tau$ for L and varying B

Fig 10: N versus $\tau$ for L and varying B

Fig 11: N versus $\sigma$ for L & varying B

Fig 12: N versus $\sigma$ for L & varying B

Fig 13: N versus $\sigma$ for L & varying B

Fig 14: N versus $\sigma$ for L & varying B
4.2 Convergent LPDA Antennas

The convergence table 3 from figure 5 to 16 above by applying the convergent criteria. A look at the table clearly indicates that the values of tau and sigma are all within the optimum region. Therefore convergent antennas are somewhat also optimised LPDA antennas. In this region tau ranges from 0.85 to 0.98, while sigma ranges from 0.08 to 0.13.

It is to be noted that the convergent table given here is not absolute. The values are extendable to about \( \pm2 \) or 3 elements depending on boom-length and operating bandwidth. Figures 17 to 19 give the convergent curves.

5. CONCLUSION

The main theme throughout this paper has been the design of a functional LPDA antenna. In other to do this, there is a need to know all the various trade-offs available to better optimise the probable performance characteristics of the antenna given a set of situations.
These include:

(i) The need to be able to approximate the probable gain of a LPDA Antenna for a given length and operating bandwidth.

(ii) Approximate the number of dipole elements which will result in a desired gain value.

(iii) Determine what values of tau and sigma would result in that gain.

(iv) Determine what effect(s) if any, a given antenna parameter have on the performance of the antenna.

Attempt has been made in this paper to provide these answers. It is therefore anticipated that, the use of the parametric curves (listed as figures 5 to 19) in conjunction with traditional design curves such as Peixeiro [9], would provide an easy means of designing a functional and cost optimised LPDA antenna given any set of requirements.

Parametric curves beyond the ranges provided by Peixeiro [9] have been provided. In addition, parametric curves in terms of boom-length (L) and number of elements (N) for any given operating bandwidth has been provided so as to keep the cost of producing any LPDA Antenna acceptable, as these two parameters determine the cost of the Antenna, De vito and Stracca [7, 8].

A means of optimising LPDA Antenna in terms of performance, using minimised number of dipole element (N) as the criterion was introduced. The interesting thing about this technique is that although the minimisation is based on N, The value of N at which the LPDA Antenna is considered converged, is based on trends in the pattern of variation of the gain, VSWR and radiation pattern. The implication of this is that although minimisation is given in terms of N, the methodology used in obtaining N includes every practically useful performance evaluating parameter of the LPDA Antenna. The minimisation process ultimately results in optimised performance of the LPDA Antenna [15].

It is important to note here that all the parametric curves given in this paper are valid only for a transmission line of characteristic impedance 50Ω and length to diameter ratio of 100. A follow up paper attempts at studying the effects of boom impedance and length to diameter ratios on the gain performance of an LPDA antenna. It aims to model these effects numerically and if successful will present correction factors, which takes cognisance of the impact of these parameters on the gain performance of an LPDA antenna.

In conclusion, the paper met its aims of: (i) Extending the range of parametric curves beyond those of Peixeiro [9]. (ii) Finding means of minimising ‘N’, leading to cost optimisation of the LPDA Antenna. (iii) Presentation of the parametric curves in terms of the main cost determinants namely L and N for values of operating bandwidths ‘B’.

6. REFERENCES


Super Numeric Electromagnetic code (SuperNec) version 2 user's guide.


