DESIGN AND MANUFACTURED OF LPDA ANTENNA AT 400 MHz - 800 MHz FREQUENCY AND ITS IMPLEMENTATION ON TELEVISION ANTENNA

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Abstract— **In this study the designed Log-Periodic Dipole Array antenna (LPDA) in the frequency range 400 MHz up to 800 MHz with 7 dBi Gain. For the purpose of point to point communication required antenna that has directivity and for wideband telecommunication system required a wideband type antenna. At a gain of 7 dBi, the wider the frequency range then the total length of the Log-Periodic Dipole Array (LPDA) antenna structure is also longer. The design of the Log-Periodic Dipole Array (LPDA) antenna operates at λ / 2 in the 400 MHz - 800 MHz frequency range and has the ideal VSWR value (VSWR ≈ 1) so that the antenna and transmission line are matched. The advantages of the Log-Periodic Dipole Array (LPDA) antenna itself is to have a wide bandwidth and geometry value following a certain comparison...**

Index Terms— **Antenna, Frequency, Gain, LPDA, VSWR.**

I. Introduction

In a System of wireless communication, Electromagnetic waves propagate from the transmitter through free space, where the system itself uses an antenna. An antenna which attached on a transmitter is called (Transmitting Antenna). And the antenna attached to the receiver is called (Receiving Antenna). For Point –to-point communications a directional antenna is required (directivity) and for wideband telecommunication system it required a Wideband type antenna.

For LPDA or log-periodic dipole array antenna it has an ideal operating frequency depends on the area. One of many LPDA antenna types is the LPDA antenna with coaxial cable connection, where this antenna can be operated on a wide bandwidth.[1]

The LPDA antenna is expected to function on UHF frequencies with its own frequency range of 300 MHz to 3 GHz. Some parameters affect the total length of the antenna structure log-periodic dipole array is like the geometry factor ( ), the distance factor (σ), the peak angle (α), and the frequency range. At the gain 7 dBi, the wider the desired frequency range to the total length of the antenna structure log-periodic dipole array the longer and more expensive it becomes. One of many ways to solve this problem is by designing a log-periodic dipole array which operates with λ/2 from 400 MHz frequency until 800 MHz.

Layers of log-periodik dipol (log-periodik dipole array, LPDA) consist of system from driven elements, but not all elements in the systems are active at an operating frequency. Depending on the design parameters, LPDA can operate in a frequency range that has a 2:1 or higher ratio.

The LPDA antenna is designed to be able to receive UHF frequency signals, so it can be applied as a television antenna. This antenna has a several advantages over other antennas in the same application, which is:

1. Has a wider bandwidth.
2. Has a larger gain of 7 dBi.
3. It has 8 elements of array elements

II. Design of Log-Periodic Dipole Array Antenna (LPDA)

In designing an LPDA antenna, there are several factors that must be considered, which is the material making factor, the signal amplifier frequency allocation, and the selection of the antenna connecting channel with the system.

1. Antenna material

In the process of making an LPDA antenna, there are several choices of materials (conductors) for the arrangement and boom that can be used. Among them are copper, gold, brazen, aluminum, and brass. In the process of making this antenna, aluminum pipe material (5 mm diameter) is used as conductor for each element and for boom also use the same material that is aluminum pipe.

2. Frequency allocation

The radio frequencies used for television broadcasts are VHF and UHF. Where the radio frequency range of VHF ranges from 30 MHz up to 300 MHz, and for UHF radio frequency ranges from 300 MHz up to 3 GHz. In Indonesia, the frequency used by

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the television requires the permission of the local regulator.

After knowing the design procedure of the antenna, now it will described the design process until the manufacture of the antenna.

The first step is to determine the operating bandwidth of the equation f_l = 400 MHz, f_n = 800 MHz, and B = 800 / 400 = 2. (Note: Since log-periodic decreases gain at low frequencies, some designers decrease f_l A few percent to get the gain satisfaction at low operating frequency. Increasing fn, In frequency design does not provide advantages rather than widening the frequency coverage.). Due to get a compact design, researchers chose not to enlarge the low frequency coverage.

Next, choose a value τ and σ with reference to Figure 2.8 based on the basic theory where the greater the value σ Means the longer the boom size, chosen value that is not too big than 0.150. Also note that the compact size will not give a large gain, the researchers chose the gain being, 7 dBi. For the value of the gain and σ Selected, Figure 2.8 shows the need τ with the value 0.826.

Step number 2, determine the value cot α :

$$\cot\alpha = \frac{4\sigma}{1-\tau} = \frac{4\times 0.150}{1-0.826} = 3{,}45$$

$$\alpha = \tan^{-1}\left[\frac{1-\tau}{4\sigma}\right] = \tan^{-1}\left(\frac{1-0{,}826}{4\times 0{,}150}\right) = 16{,}17^{o}$$

This means the top corner of the arrangement is $2\times 16{,}17^{o} = 32{,}34^{o}$.

Step number 3, Calculate the value B_{ar}:

$$B_{ar} = 1.1 + 7.7(1-\tau)^2 \cot\alpha$$

$$B_{ar} = 1.1 + 7.7(1-0.826)^2 \times 3.45$$

$$B_{ar} = 1.904$$

Next, from step number 4, Specify the bandwidth structure B_s:

$$B_s = B \times B_{ar} = 2\times 1{,}904 = 3{,}808$$

From step number 4 and the relate equations determine the length of the boom, number of elements, and length of the longest element.

$$\lambda_{max} = 2l_{max} = \frac{c}{f_{min}} = \frac{3\times 10^8}{4\times 10^8} = 0.75\text{m}$$

$$L = \frac{\lambda_{max}}{4}\left(1-\frac{1}{B_s}\right)\cot\alpha$$

$$L = \frac{0.75}{4}\left(1-\frac{1}{3.808}\right)3.45$$

$$L = 0.477\ m$$

$$N = 1 + \frac{\ln(B_s)}{\ln(1/\tau)} = 1 + \frac{\ln 3{,}808}{\ln 1/0{,}826} = 7{,}99$$ (summarize to 8 element)

(Since the ratio of the logarithm values is given here, both common and natural logarithms can be used in equations, as long as both numerator and denominator values are of the same type; The result is the same.)

$$l_1 = 0.75/2 = 0.375\text{m}$$

Next on step number 5, determine Z_t (terminating stub):

$$Z_t = \frac{\lambda_{max}}{8} = \frac{0{,}75}{8} = 0.09375 \text{ m}$$

Z_t is a measure that determines the distance of the first element of the boom end.

Step number 6, determine the value Z_0 By first determining the value R_0 and Z_a:

$$R_0 = 50\,\Omega$$

$$Z_a = 120\left[\ln\left(\frac{h}{a}\right) - 2.25\right]$$

$$Z_a = 120\left[\ln\left(\frac{0.375}{0.005}\right) - 2.25\right]$$

$$Z_a = 248.098\ \Omega$$

$$\sigma' = \frac{\sigma}{\sqrt{\tau}} = \frac{0.150}{\sqrt{0.826}} = 0.165$$

$$Z_0 = \frac{R_0{}^2}{8\sigma' Z_a} + R_0\sqrt{\left(\frac{R_0}{8\sigma' Z_a}\right)^2 + 1}$$

$$Z_0 = \frac{(50)^2}{8(0.165)(248.0986)} + 50\sqrt{\left(\frac{50}{8(0.165)(248.0986)}\right)^2 + 1}$$

$$Z_0 = 58.21\ \Omega$$

Next on step number 7,Specify the length of the element:

$$l_1 = 0.375\text{m}$$

$$l_2 = \tau l_1 = 0{,}826\times 0.375 = 0.31\text{m}$$

$$l_3 = \tau l_2 = 0{,}826\times 0.31 = 0.256\text{m}$$

$$l_4 = \tau l_3 = 0{,}826\times 0.256 = 0.211\text{m}$$

$$l_5 = \tau l_4 = 0{,}826\times 0.211 = 0.174\text{m}$$

$$l_6 = \tau l_5 = 0{,}826\times 0.174 = 0.144\text{m}$$

$$l_7 = \tau l_6 = 0{,}826\times 0.144 = 0.119\text{m}$$

$$l_8 = \tau l_7 = 0{,}826\times 0.119 = 0.098\text{m}$$

Next, step 8 is calculating the distance between elements:

$$d_{1\leftrightarrow 2} = \tfrac{1}{2}(l_1 - l_2)\cot\alpha = \tfrac{1}{2}(0.375 - 0.31)\times 3{,}45 = 0.112\text{m}$$

$$d_{2\leftrightarrow 3} = \tfrac{1}{2}(l_2 - l_3)\cot\alpha = \tfrac{1}{2}(0.31 - 0.256)\times 3{,}45 = 0.093\text{m}$$

$$d_{3\leftrightarrow 4} = \tfrac{1}{2}(l_3 - l_4)\cot\alpha = \tfrac{1}{2}(0.256 - 0.211)\times 3{,}45 = 0.077\text{m}$$

$$d_{4\leftrightarrow 5} = \tfrac{1}{2}(l_4 - l_5)\cot\alpha = \tfrac{1}{2}(0.211 - 0{,}174)\times 3{,}45 = 0.064\text{m}$$

$$d_{5\leftrightarrow 6} = \tfrac{1}{2}(l_5 - l_6)\cot\alpha = \tfrac{1}{2}(0.174 - 0.144)\times 3{,}45 = 0.052\text{m}$$

$$d_{6\leftrightarrow 7} = \tfrac{1}{2}(l_6 - l_7)\cot\alpha = \tfrac{1}{2}(0.144 - 0.119)\times 3{,}45 = 0.043\text{m}$$

$$d_{7\leftrightarrow 8} = \tfrac{1}{2}(l_7 - l_8)\cot\alpha = \tfrac{1}{2}(0.119 - 0.098)\times 3{,}45 = 0.036\text{m}$$

From the calculation result in step 1 to step 8, can be concluded in the following table:

Table 1 Design Parameters for LPDA UHF.

f_1 = 400 MHz	Element lenght:
f_2 = 800 MHz	l_1 = 0.375 m
B = 2	l_2 = 0.31 m
τ = 0.826	l_3 = 0.256 m
σ = 0.150	l_4 = 0.211 m
Gain = 7 dBi	l_5 = 0.174 m
cot α = 3,45	l_6 = 0.144 m
B_{ar} = 1,904	l_7 = 0.119 m
B_s = 3,808	l_8 = 0.098 m
L = 0.477 m	Distance between element:
N = 7,99 (summarize to 8)	$d_{1\leftrightarrow 2}$ = 0.112 m
	$d_{2\leftrightarrow 3}$ = 0.093m
Z_t = 0.09375 m	$d_{3\leftrightarrow 4}$ = 0.077m
R_0 = 50 Ω	$d_{4\leftrightarrow 5}$ = 0.064 m
Z_{av} = 248,0986 Ω	$d_{5\leftrightarrow 6}$ = 0.052 m
σ' = 0.165	$d_{6\leftrightarrow 7}$ = 0.043 m
Z_0 = 58,21 Ω	$d_{7\leftrightarrow 8}$ = 0.036 m
Balun: 1:1	element diameter:
Feed line: 50 Ω coax	all element = 5mm
RG58	(Solid aluminium pipe)

III. RESULT AND ANALYSIS

A. Measurement Results

3.1 Measurement of VSWR Log-Periodic Dipole Array (LPDA)

Antenna VSWR measurement Log-Periodic Dipole Array (LPDA) has been done in the frequency range of 400 MHz to 800 MHz then get VSWR values in the figure 1 below

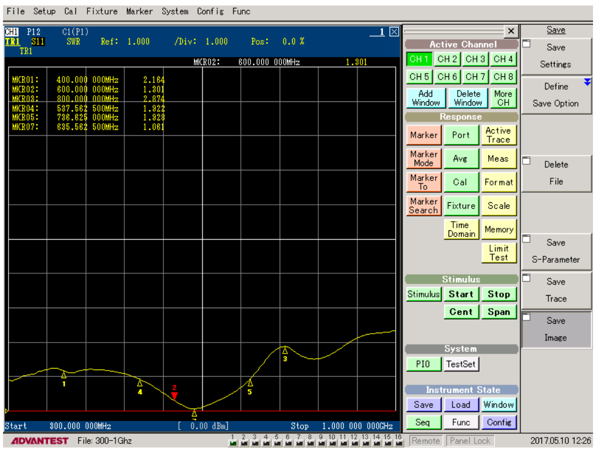

Figure 1. Measurement of VSWR Log-Periodic Dipole Array (LPDA).

From the figure can be seen the value of VSWR provided:
Marker 1 : 2.164 to frequency 400 MHz.
Marker 2 : 1.301 to frequency 600 MHz.
Marker 3 : 2.874 to frequency 800 MHz.
Marker 4 : 1.922 to frequency 537.562 MHz.
Marker 5 : 1.928 to frequency 736.625 MHz.
Marker 6 : 1.061 to frequency 635.562 MHz.

3.2 Measurement of Return Loss Log-Periodic Dipole Array (LPDA)

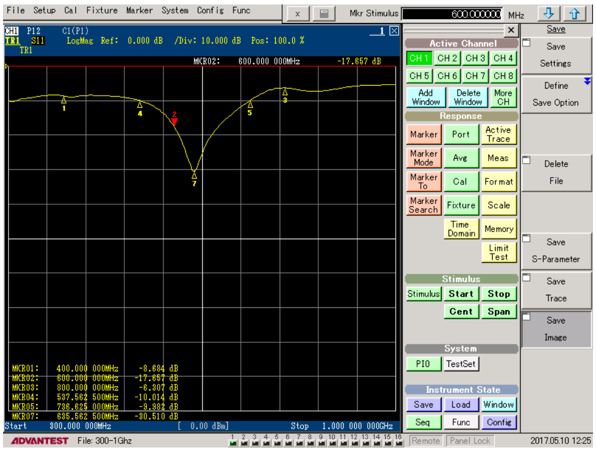

Figure 2. Measurement of Return Loss Log-Periodic Dipole Array (LPDA).

From the figure can be seen the value of a given return loss:
Marker 1 : -8.684 dB to frequency 400 MHz.
Marker 2 :- 17.657 dB to frequency 600 MHz.
Marker 3 : -6.307 dB to frequency 800 MHz.
Marker 4 : -10.014 dB to frequency 537.562 MHz.
Marker 5 : -9.982 dB to frequency 736.625 MHz.
Marker 6 : -30.510 dB to frequency 635.562 MHz.

3.3 Measurement of Input Impedance Log-Periodic Dipole Array (LPDA)

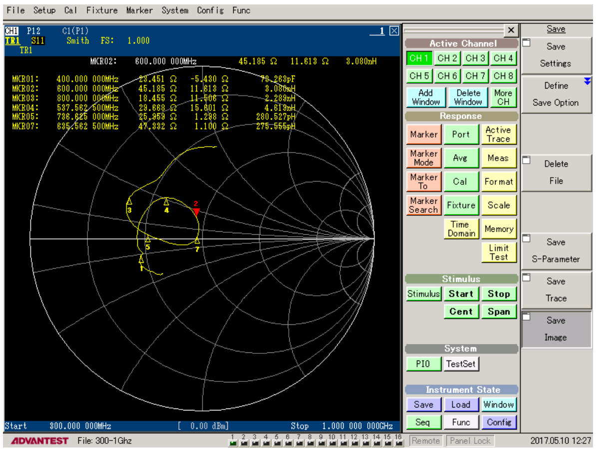

Figure 3. Measurement of Input Impedance Log-Periodic Dipole Array (LPDA).

From the figure can be seen the value of a given input impedance:
Marker 1 : Impedance given at frequency 400 MHz is 23.451 Ω - 5.430 Ω.
Marker 2 : Impedance given at frequency 600 MHz is 45.185 Ω + 11.613 Ω.
Marker 3 : Impedance given at frequency 800 MHz is 18.455 Ω + 11.506 Ω.
Marker 4 : Impedance given at frequency 537.562 MHz is 29.668 Ω +15.601 Ω.
Marker 5 : Impedance given at frequency 736.625 MHz is 25.959 Ω + 1.298 Ω.

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Marker 6 : Impedance given at frequency 635.562 MHz is 47.332 Ω + 1.100 Ω.

3.4 Measurement of Gain Log-Periodic Dipole Array (LPDA)

Table 2 Measurement of Antenna Gain Log-Periodic Dipole Array (LPDA)

P1 (RX)	**-37.48 dB**
P2 (TX)	**-32.69 dB**
Gain	**7.21 dB**

3.5 Measurement of Radiation Pattern Log-Periodic Dipole Array (LPDA)

After going through the steps of measuring the Log-Periodic Dipole Array (LPDA) antenna pattern of 600 MHz and done at an angle of 0 ° to 360 °, it can be seen the radiation pattern form obtained from the measurement of the antenna signal level. The measurement data as well as the complete normalization are as follows:

Table 3 Measurement of azimuth radiation pattern, elevation radiation pattern, and polarization of Log-Periodic Dipole Array (LPDA) Antenna.

ANGLE (°)	Azimuth radiation pattern Level (dB)	Elevation radiation pattern Level (dB)	Polarization level (dB)
0	-37.48	-39.43	-41.27
10	-38.29	-40.49	-43.30
20	-36.53	-40.42	-44.71
30	-37.85	-41.64	-45.59
40	-38.16	-42.61	-46.30
50	-37.23	-43.89	-47.68
60	-39.48	-45.43	-47.21
70	-39.59	-46.73	-48.43
80	-40.88	-44.36	-49.28
90	-42.96	-48.58	-50.94
100	-41.96	-49.94	-51.68
110	-40.65	-46.73	-52.83
120	-39.33	-45.18	-53.34
130	-35.18	-43.91	-54.17
140	-33.20	-44.78	-57.34
150	-27.31	-37.90	-58.65
160	-30.33	-.41.43	-59.64
170	-33.78	-39.35	-59.35
180	-29.20	-33.10	-60.79
190	-32.67	-39.29	-59.84
200	-31.43	-40.54	-58.69
210	-27.33	-36.87	-57.44
220	-34.12	-41.75	-54.54
230	-35.40	-42.81	-53.48
240	-38.39	-37.11	-52.72
250	-40.67	-38.79	-51.59
260	-41.48	-40.95	-50.74
270	-43.27	-40.52	-49.41
280	-40.83	-39.33	-48.90
290	-39.41	-38.80	-47.23
300	-38.99	-37.64	-47.82
310	-37.64	-37.32	-46.42
320	-38.34	-36.77	-47.95
330	-37.53	-35.24	-46.17
340	-37.92	-37.05	-43.39
350	-36.18	-38.33	-43.04
360	-37.49	-39.41	-41.51

B. Testing

The Log-Periodic Dipole Array (LPDA) antenna works in the frequency range between 400 MHz - 800 MHz. In the application of an LPDA antenna as a television signal receiving antenna, some television broadcasts are clear, slightly clear, and blurry. Here are some TV Channels in Indonesia, especially in DKI Jakarta area that can be reached by LPDA Antenna.

Table 4 List of TV stations in Indonesia especially DKI Jakarta that successfully received the Log-Periodic Dipole Array Antenna (LPDA).

No.	Names of TV station	Frequency (MHz)	Observation results
1	INTV	479.25	Blur
2	RTV	487.25	Slightly Blur
3	Kompas TV	503.25	Slightly Blur
4	CTV	511.25	Slightly Blur
5	NET TV	519.25	Slightly Clear
6	KTV	527.25	Slightly Clear
7	Trans TV	535.25	Slightly Clear
8	iNews TV	543.25	Clear
9	TVRI	551.25	Slightly Clear
10	O Channel	567.25	Slightly Clear
11	Elshinta	583.25	Clear
12	MNC TV	599.25	Clear
13	TVRI Nasional	615.25	Slightly Clear
14	Indosiar	631.25	Clear
15	RCTI	647.25	Clear
16	SCTV	663.25	Clear
17	ANTV	679.25	Slightly Clear
18	Trans 7	695.25	Slightly Clear
19	Global TV	711.25	Clear
20	TV One	727.25	Slightly Clear
21	Jak TV	743.25	Slightly Clear
22	Metro TV	759.25	Slightly Clear
23	DAAI TV	775.25	Slightly Blur
24	Jawapos TV	783.25	Blur

After doing an observation, the results is there are several channels that look blurry. This is caused by several factors, namely:

a) Location of observation

The location of the observation in the open space (outdoor).

b) The direction of the Log-Periodic Dipole Array antenna (LPDA).

If the desired channel want to look more clearly then the antenna needs to be directed towards appropriate direction.

IV. CONCLUSION

1. LPDA antenna that design based on calculation of antenna parameters then realized with a prototype of LPDA antenna by using coaxial cable as connector of LPDA antenna to television in the frequency range 400 MHz to 800 MHz.
2. In performing measurements of VSWR, Return loss, and input impedance by using the Vector Network Analyzer device, the researcher uses six markers. Namely in the frequency range 400 MHz to 800 MHz, the first marker at 400 MHz, second marker at 600 MHz frequency, third marker at 800 MHz frequency, fourth marker at 537.562 MHz, fifth marker at 736.625 MHz frequency, and the sixth marker on frequency 635,562 MHz. In measuring the radiation pattern using a signal generator device, spectrum analyzer, cross-section position, and DRG Horn Antenna conducted in the range 400 MHz - 800 MHz, the measurement is done at an angle of 0 ° - 360 °. Measurement with outdoor method is done in indoor anechoic chamber.
3. From the result of the researcher above, by using Log-Periodic Dipole Array (LPDA) Antenna can detain 24 TV stations located in Indonesia especially DKI Jakarta with 18 number of TV stations that have clear and slightly clear quality, and only 6 TV stations that have blur and slightly blur

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