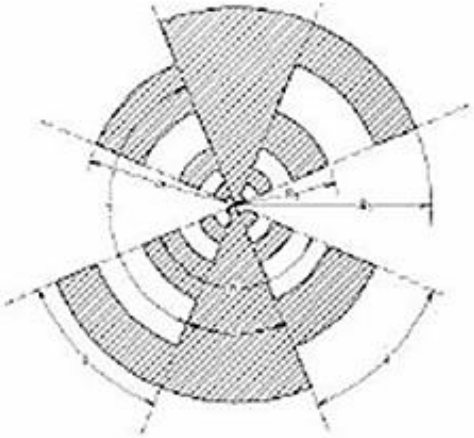
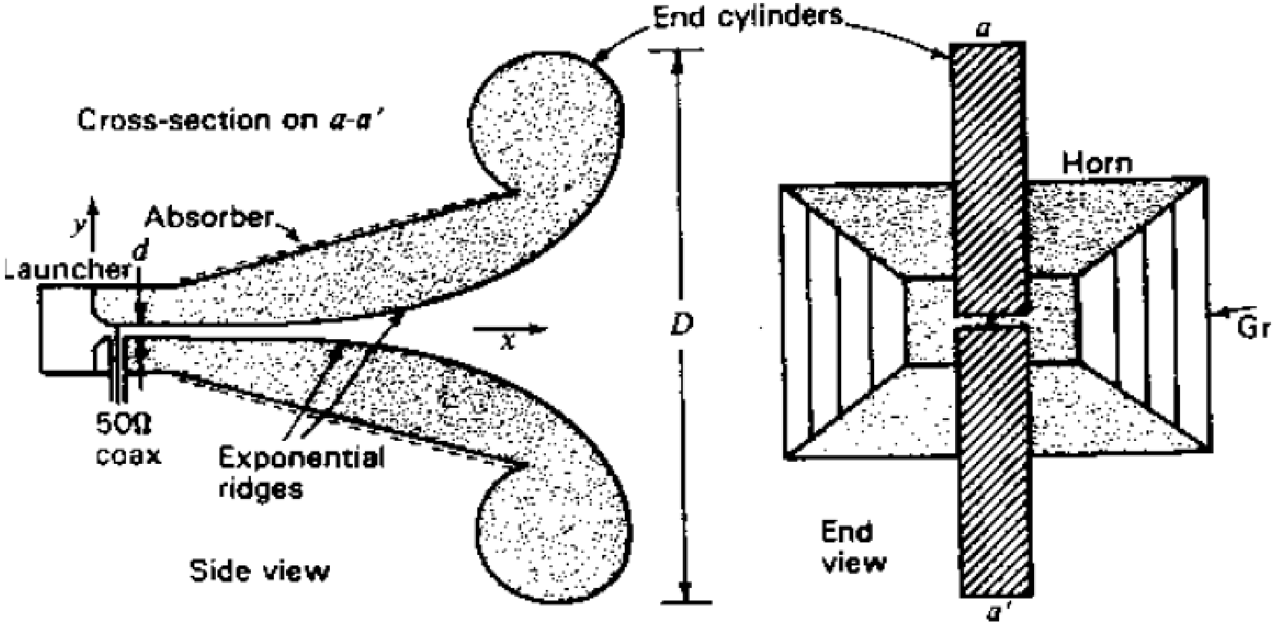
Log Periodic Dipole Antenna
LPDA



microstrip
version

Broadband antennas

- The definition of a broadband antenna :"If the impendence and pattern of an antenna do not change significantly over about an octave ($f_u / f_l = 2$) or more, it will classified as a broadband antenna".
- Broadband antennas usually require structures that do not change abruptly in its physical dimensions, but instead utilize materials with smooth boundaries. Smooth physical structures tend to produce patterns and input impedance that also change smoothly with frequency. This simple concept is very important in broadband antennas
- The gradual Smooth transition from feed to radiating portions can provide almost **constant impedance over very wide bandwidths.**



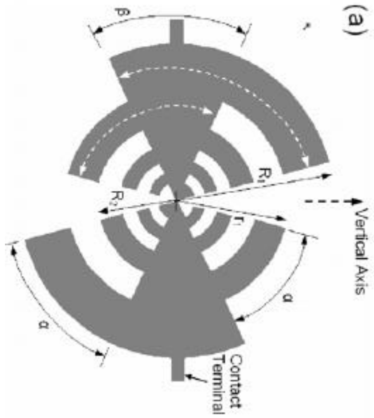
(c)

(d)

Broadband antennas

example

- Bow-tie antenna
- Spiral antenna: circularly polarized
- Log-periodic antenna: linearly polarized, but the direction of polarization depends on frequency
- Parabolic reflectors, its useful bandwidth restricted by bandwidth of its feed
- Helical antenna
- Fractal antennas



a self-complementary antenna have constant Feed point impedance

$$Z=\eta/2=188.5\ \Omega$$

The frequency independent concept: Rumsey’s principle

Rumsey’s principle is that the impedance and pattern properties of an antenna will be frequency independent if the antenna shape is specified only in terms of angles.

Self complementary antennas were developed at University of Illinois, further work they found that self complementary condition may not be used and by 1960 they demonstrate the first log periodic dipole array.

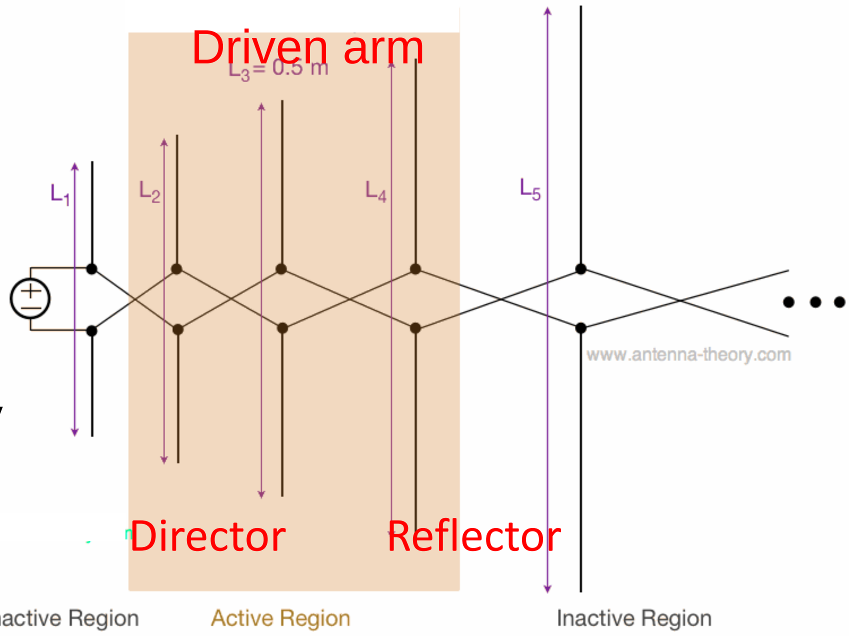
log periodic dipole antenna

The basic concept is that a gradually expanding periodic structure array radiates when the array elements are near resonance

- LP antenna is often characterized by "active" and "passive" regions. This means that if we are discussing the radiation mechanism at f=300 MHz, then the bulk of the radiation from this antenna will come from the dipoles with lengths near half a wavelength at 300 MHz (so L=0.5 meters). This is illustrated in Figure

- If we assume 3 active elements as in Figure, then one could argue that this antenna resembles somewhat a 3-element [Yagi-Uda Antenna](). That is, the driven arm is in the center, the reflector element is the longer dipole to the right, and the director is the shorter dipole to the left as seen in Figure .

- Log periodic is a broadband multi element, directional, narrow beam antenna that has impedance and radiation characteristics that are regularly repetitive as a logarithmic function of the excitation frequency. That is why it is known as log-periodic



- Impedance and radiation characteristics repeat periodically. In practice, the variations over the frequency band of operation are minor, and log-periodic antennas are usually considered to be frequency-independent antennas.

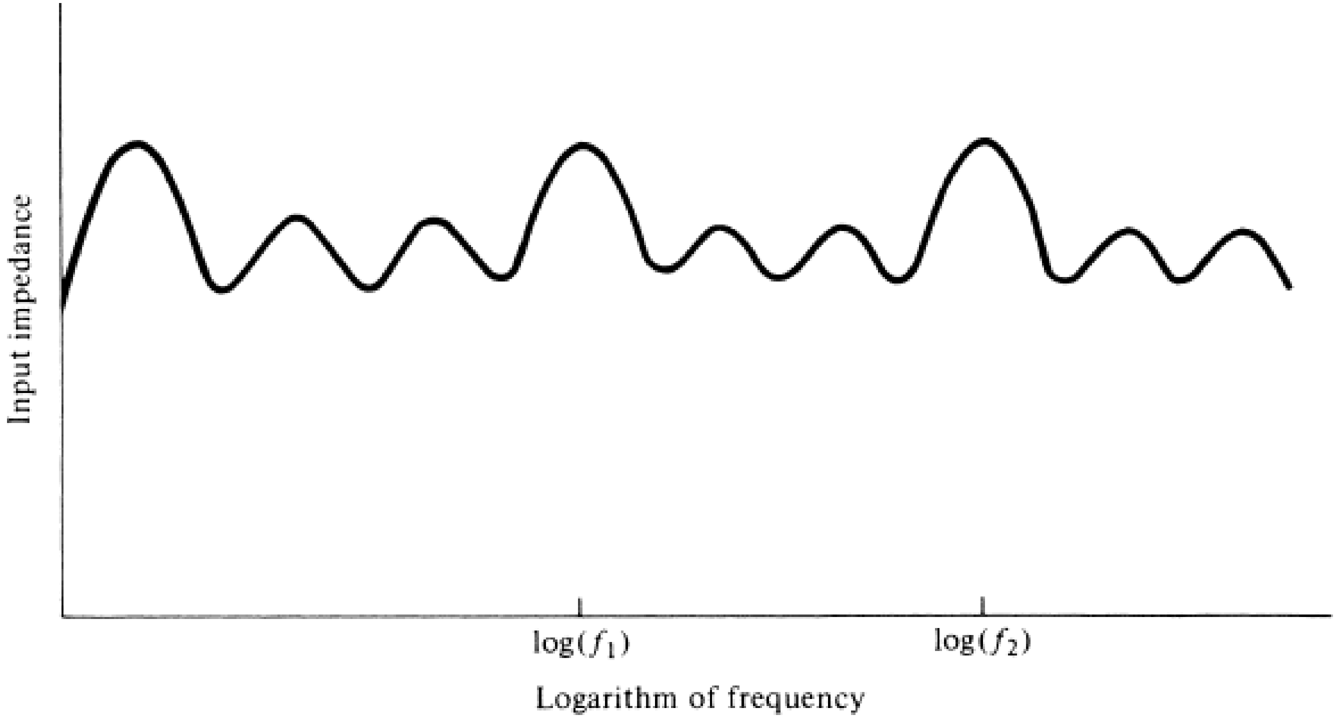


Figure 11.11 Typical input impedance variation of a log-periodic antenna as a function of the logarithm of the frequency.

- An antenna with **a bandwidth of about 10:1** or more is referred to as a frequency-independent antenna. The purest form of a frequency-independent antenna has constant pattern, impedance, and polarization with frequency. Few antennas meet all these criteria.
- Log-periodic antennas are mainly used at the high frequency band (HF 3-30MHz) of the spectrum. They are also used at very high frequency band(VHF 30-300MHz) and some of ultra high frequency bands (UHF 300MHz-3GHz) as TV antennas (VHF 41-250Mhz and UHF 470-960MHz) .
- Angle α is const. and the length and spacing of elements in a log-periodic antenna increase logarithmically from one end of the dipole to the other

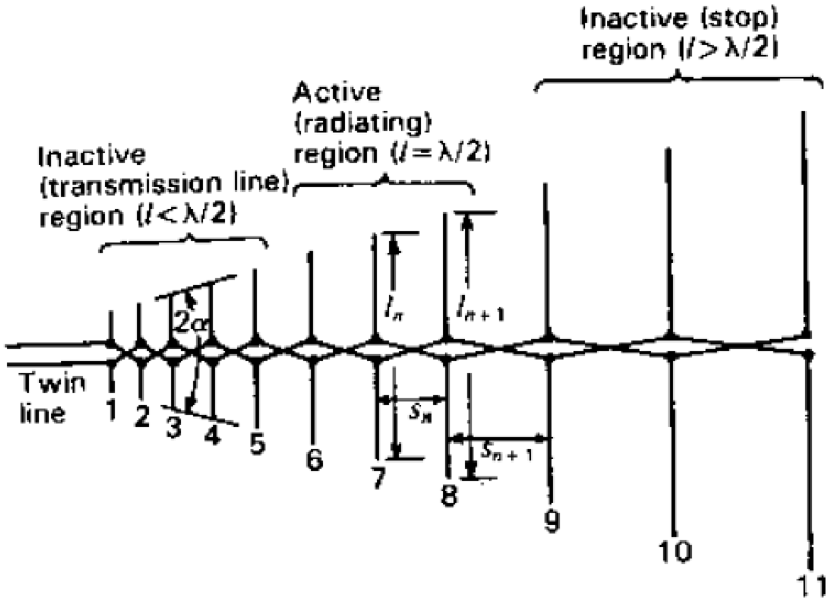
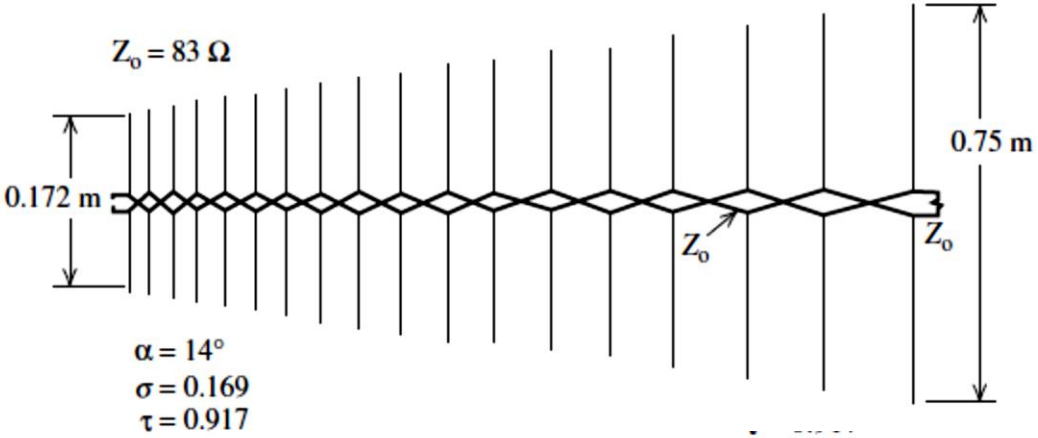
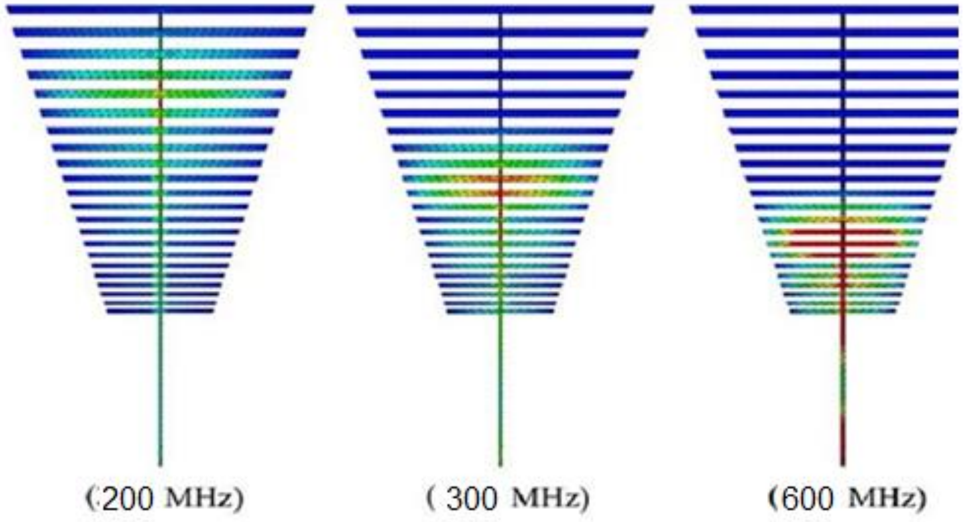


Figure Isbell log-periodic frequency-independent type of dipole array of 7 dBi gain with 11 dipoles showing active central region and inactive regions (left and right ends).





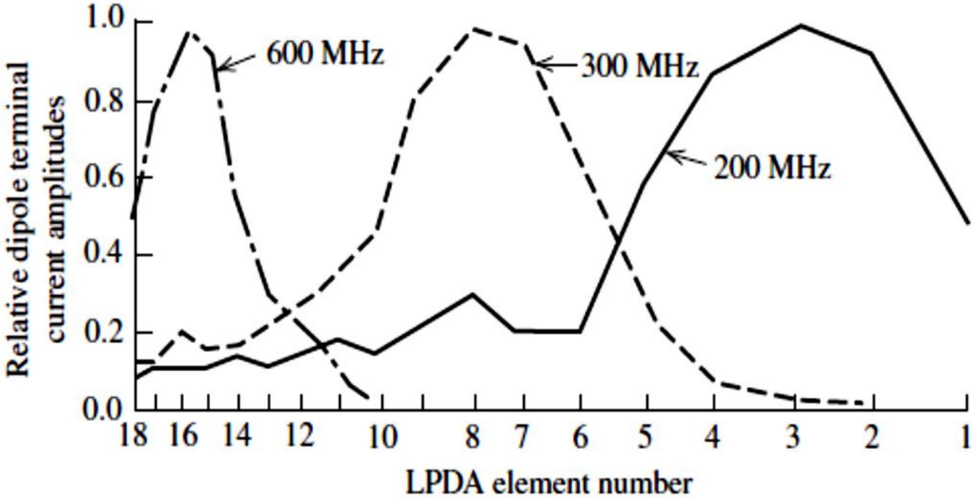
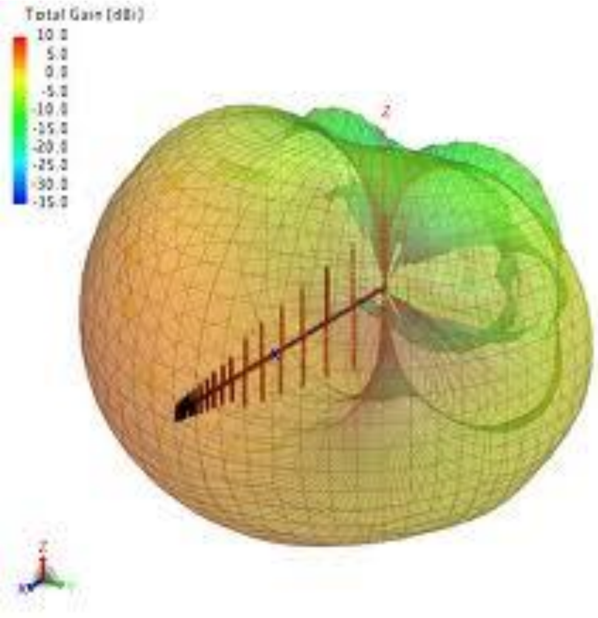
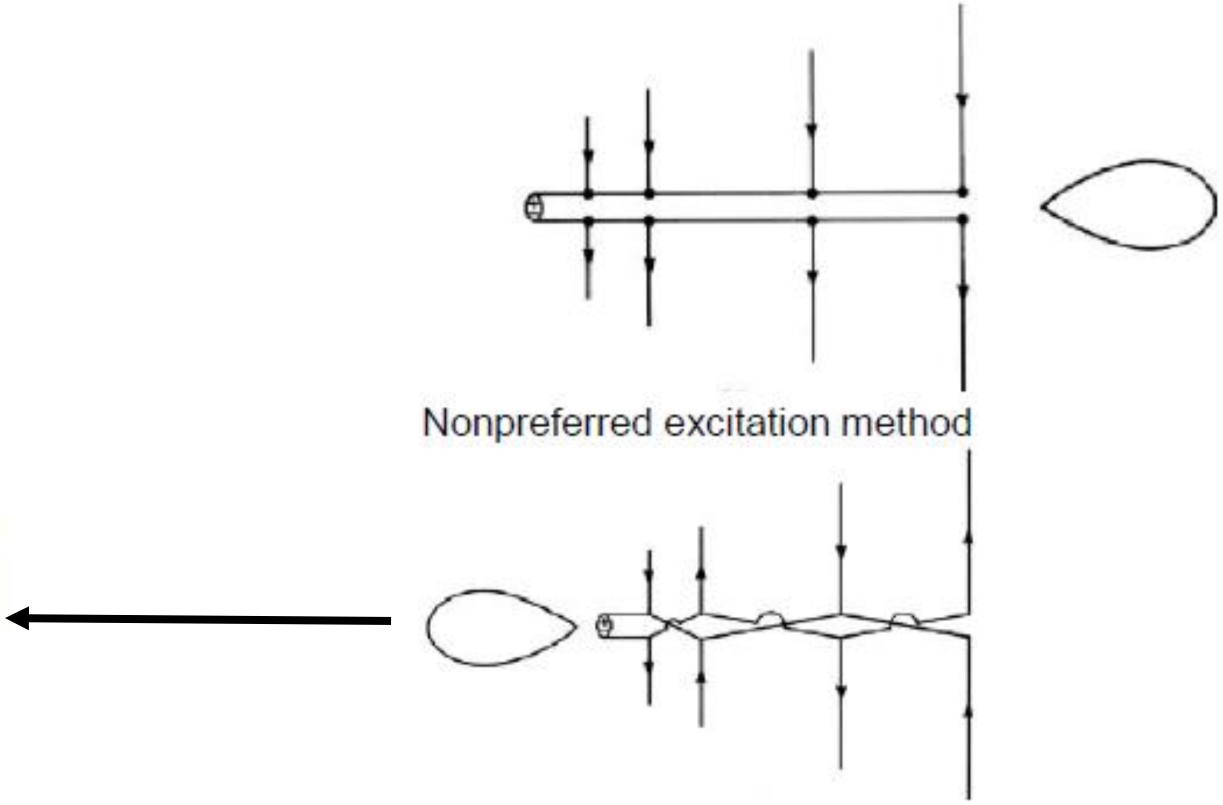


Figure 7-42 An optimum log-periodic dipole antenna for operation in the 200- to 600-MHz band (Example 7-3). (Top) Voltage distribution on the 83-Ω transmission line. (Middle) The geometry. (Bottom) Relative dipole terminal current amplitudes.

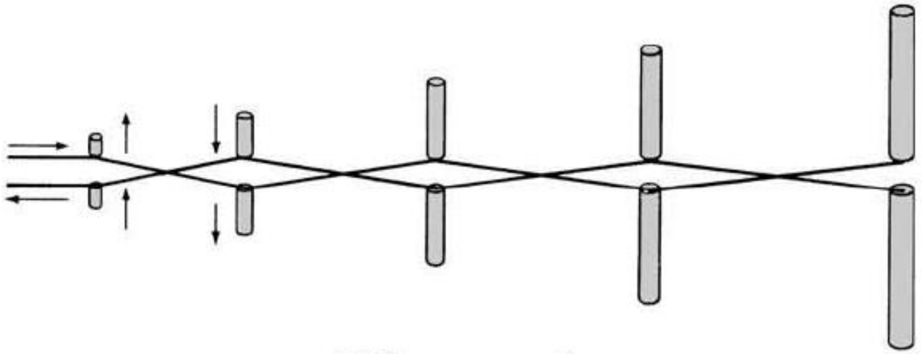
LPDA radiation pattern

Phase reversal between dipoles required to make Radiation in back fire direction (toward smaller elements)

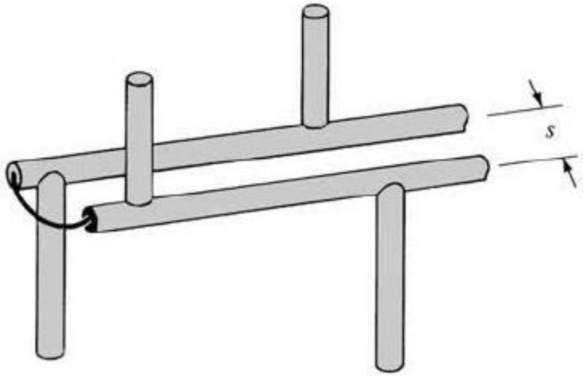




LPDA feed



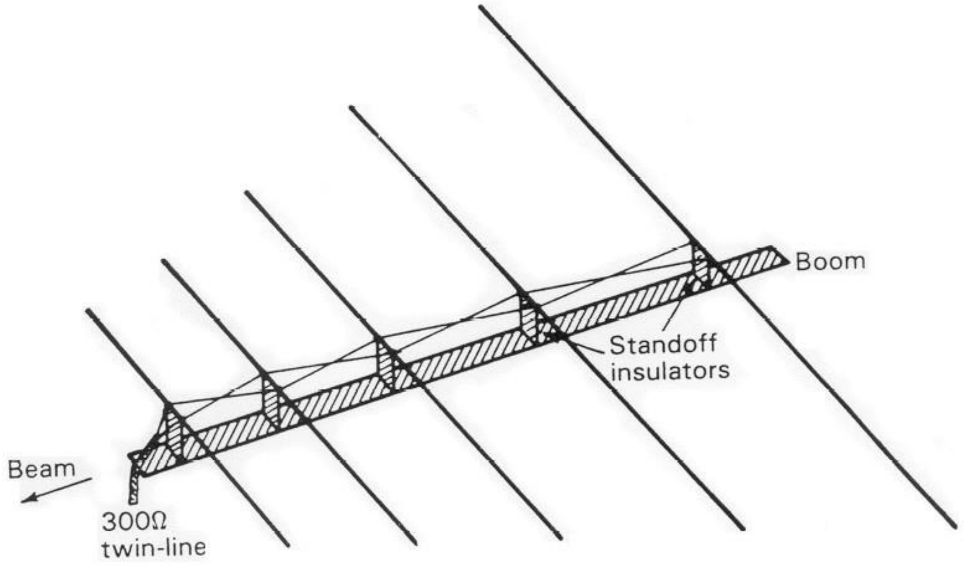
(c) Crisscross connection



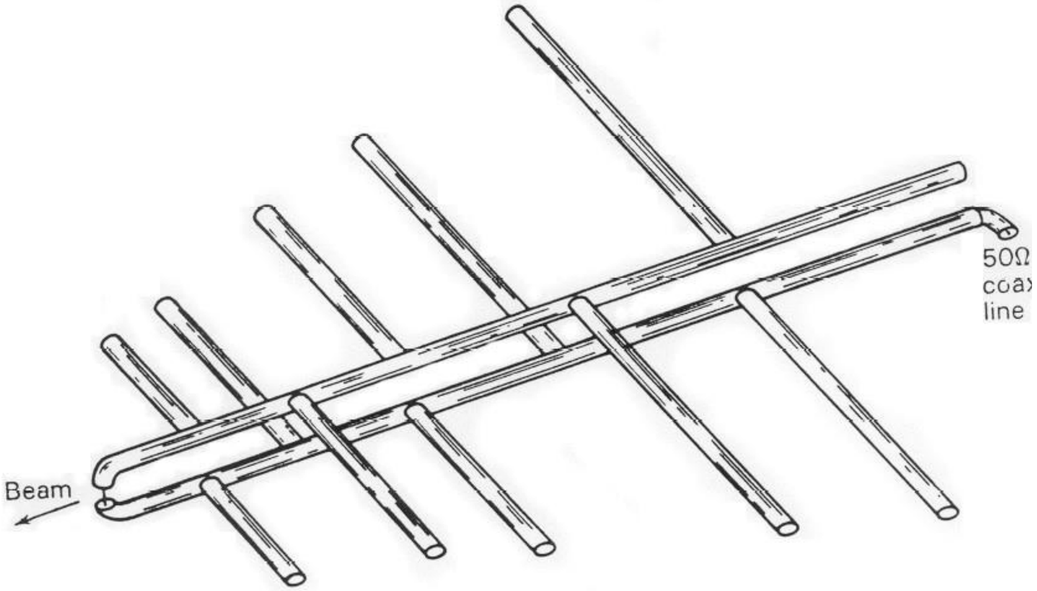
(d) Coaxial connection

Figure 11.9 Log-periodic dipole array and associated connections.

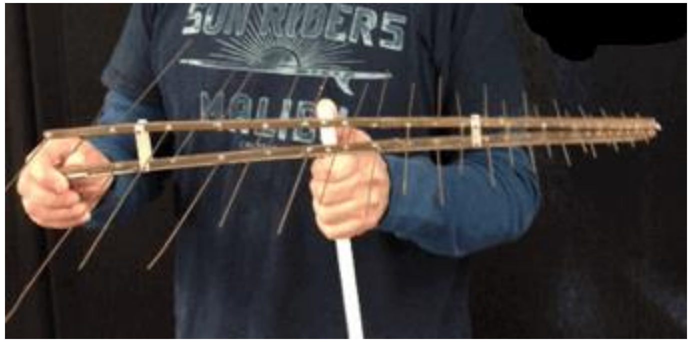
(*a*)

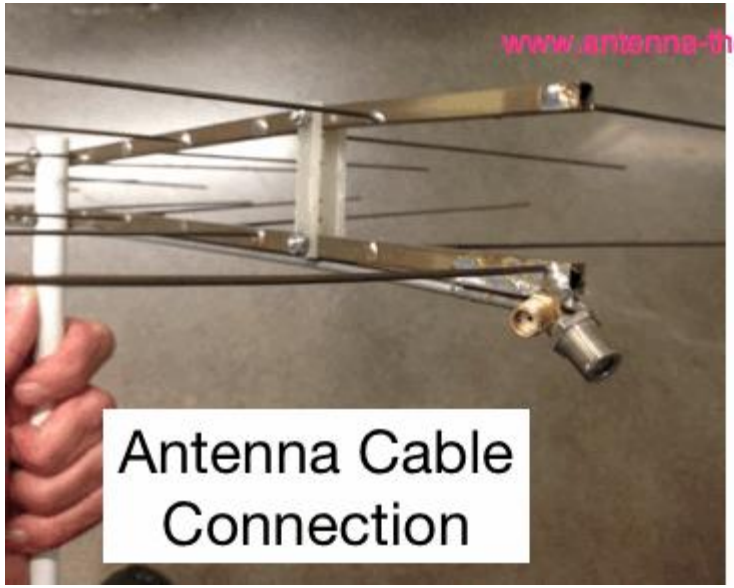


(*b*)



Log periodic dipole antenna array





A particularly successful method of constructing an LPDA is shown in Fig. 7-40.

A coaxial transmission line is run through the inside of one of the feed conductors. The outer conductor of the coax is attached to that conductor and the inner conductor of the coax is connected to the other conductor of the LPDA transmission line.

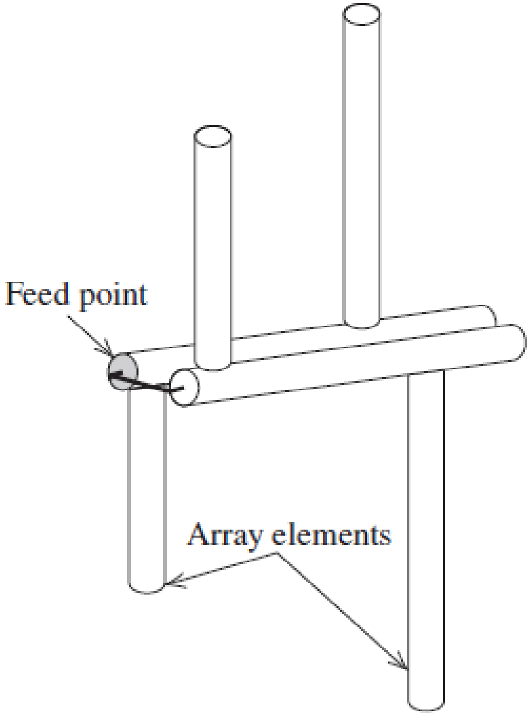


Figure 7-40 Construction details of the log-periodic dipole array.

The lengths Ln, location Rn from apex, gap spacing dn of dipole elements decrease logarithmically

$$\tau = \frac{R_{n+1}}{R_n} = \frac{L_{n+1}}{L_n} = \frac{d_{n+1}}{d_n}$$

(we count from left to right)

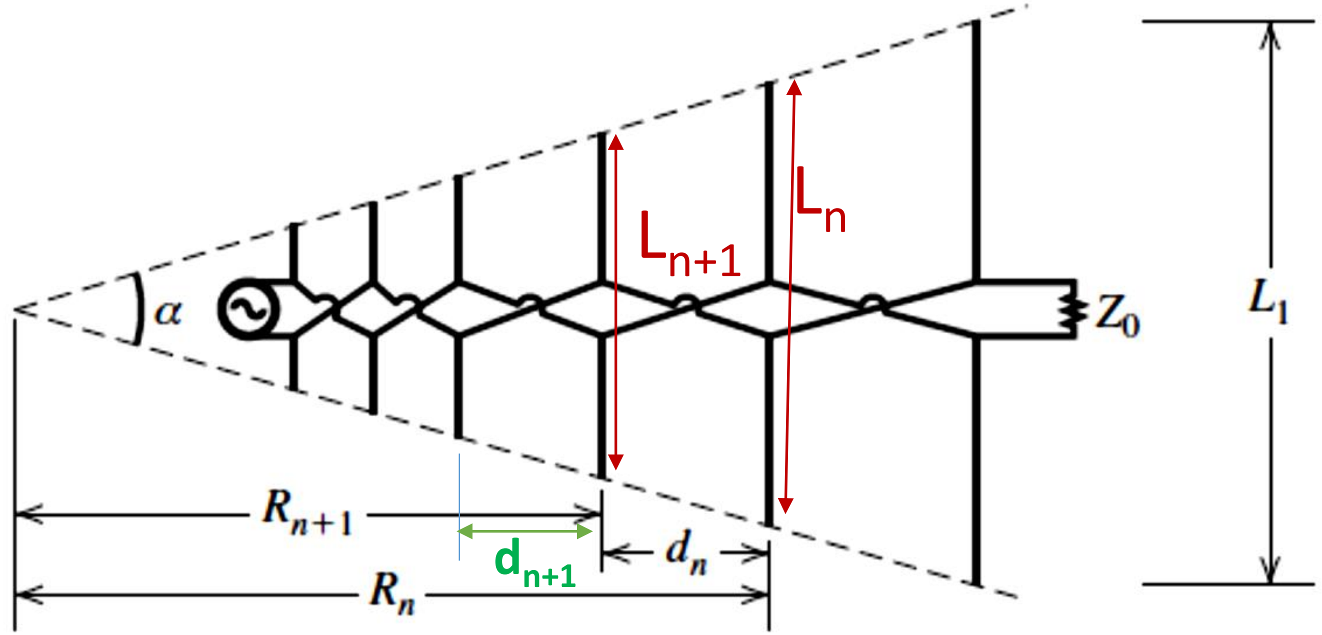


Figure 7-39 Log-periodic dipole array geometry.

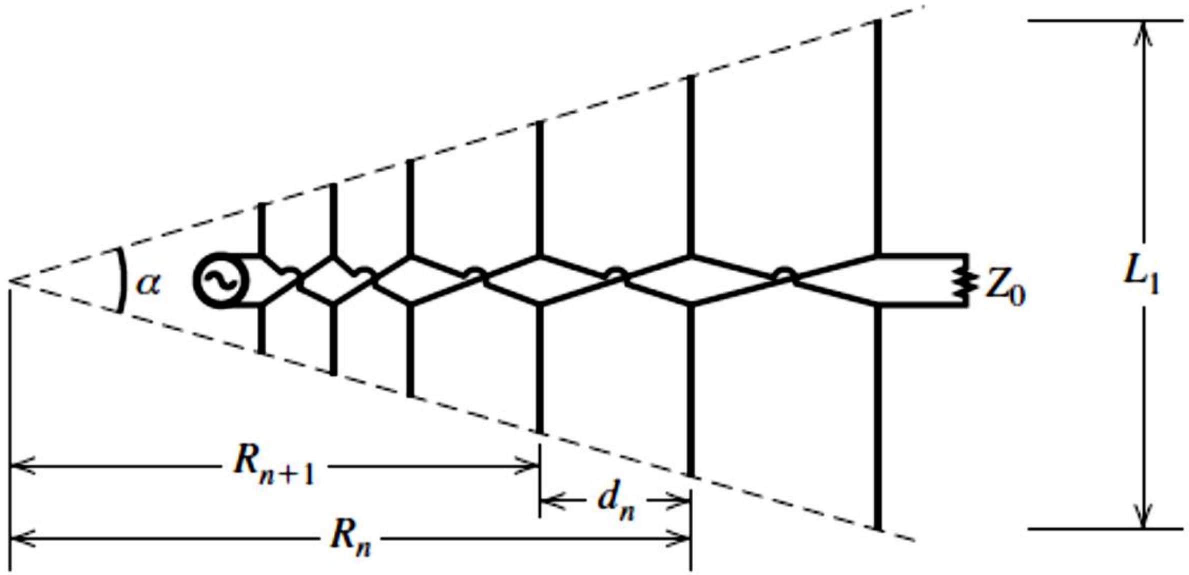


Figure 7-39 Log-periodic dipole array geometry.

As shown in Fig. 7-38, a wedge of enclosed angle α bounds the dipole lengths. The scale factor τ for the LPDA is

$$\tau = \frac{R_{n+1}}{R_n} < 1 \tag{7-73}$$

Right triangles of enclosed angle $\alpha/2$ reveal that

$$\tan\frac{\alpha}{2} = \frac{L_n/2}{R_n} = \frac{L_{n+1}/2}{R_{n+1}} \tag{7-74}$$

$$\frac{L_1}{R_1} = \cdots = \frac{L_n}{R_n} = \frac{L_{n+1}}{R_{n+1}} = \cdots = \frac{L_N}{R_N} \tag{7-75}$$

Using this result in (7-73) gives

$$\tau = \frac{R_{n+1}}{R_n} = \frac{L_{n+1}}{L_n} \tag{7-76}$$

Thus, the ratio of successive element positions equals the ratio of successive dipole lengths.

The spacing factor for the LPDA is defined as

$$\sigma = \frac{d_n}{2L_n} \tag{7-77}$$

where the element spacings as shown in Fig. 7-39 are given by

$$d_n = R_n - R_{n+1} \tag{7-78}$$

But $R_{n+1} = \tau R_n$, so

$$d_n = R_n - \tau R_n = (1 - \tau) R_n \tag{7-79}$$

From (7-74), $R_n = L_n/2 \tan\,(\alpha/2)$. Using this in (7-79) yields

$$d_n = (1 - \tau) \frac{L_n}{2 \tan\,(\alpha/2)} \tag{7-80}$$

Substituting this in (7-77) gives

$$\sigma = \frac{d_n}{2L_n} = \frac{1-\tau}{4\tan(\alpha/2)} \tag{7-81}$$

or

$$\alpha = 2\tan^{-1}\left(\frac{1-\tau}{4\sigma}\right) \tag{7-82}$$

Combining (7-81) with (7-76), we note that all dimensions are scaled by

$$\tau = \frac{R_{n+1}}{R_n} = \frac{L_{n+1}}{L_n} = \frac{d_{n+1}}{d_n} \tag{7-83}$$

$$L_1 \approx \frac{\lambda_L}{2} \quad \text{and} \quad L_N \approx \frac{\lambda_U}{2} \tag{7-84}$$

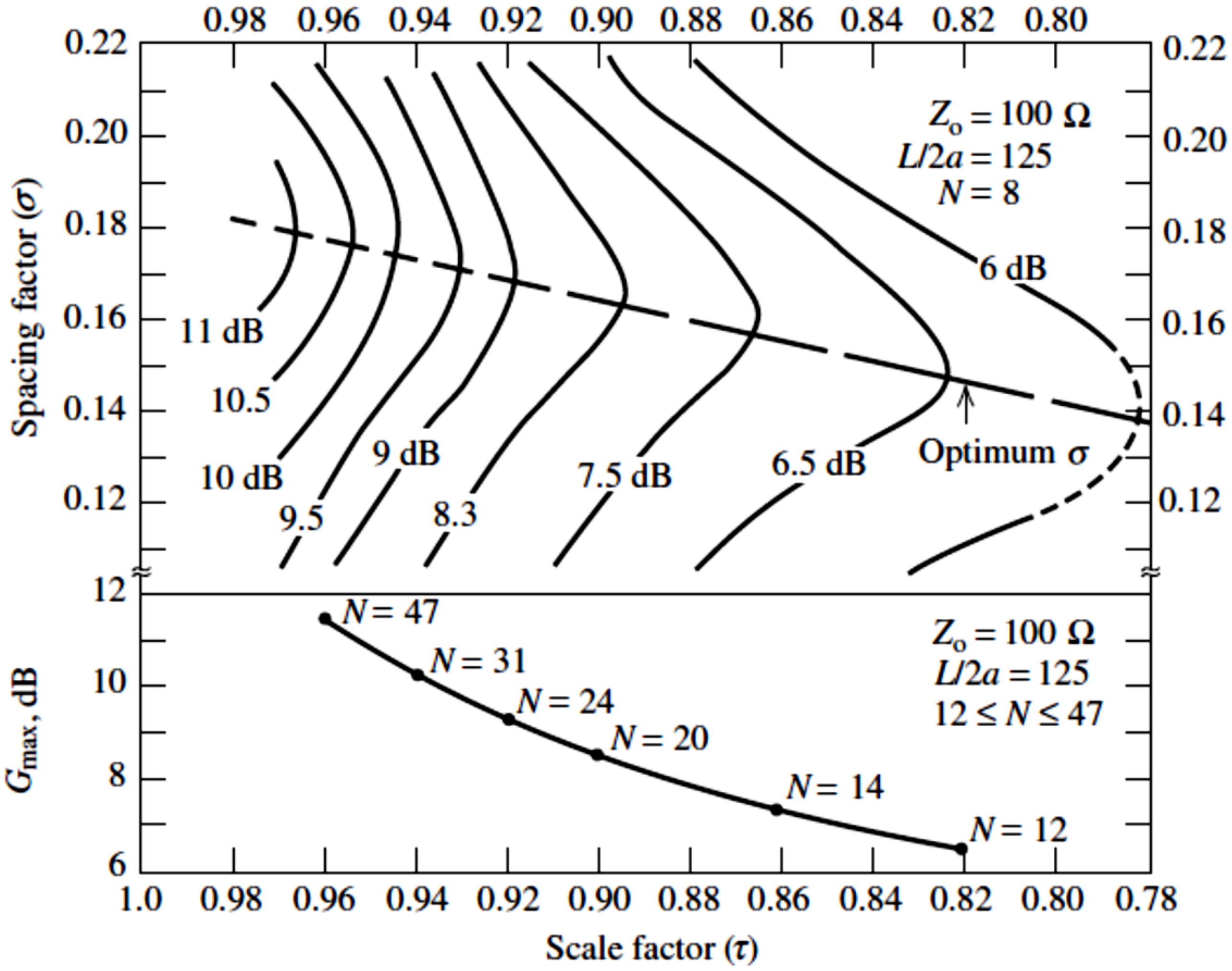


Figure 7-41 Gain of a log-periodic dipole array. (Contours, at top, adapted from Carrel [31]. Maximum gain curve, at bottom, derived from data in [32].)

EXAMPLE 7-3 *Optimum Design of a 54- to 216-MHz Log-Periodic Dipole Antenna*

An antenna that operates over the entire VHF-TV and FM broadcast bands, which span the 54- to 216-MHz frequency range for a 4:1 bandwidth, is desired. Suppose the design gain is chosen to be 6.5 dB. The corresponding values of τ and σ for optimum design from Fig. 7-40 are

$$\tau = 0.822 \quad \text{and} \quad \sigma = 0.149 \tag{7-85}$$

Then from (7-82), we have

$$\alpha = 2\tan^{-1}\left[\frac{1-0.822}{4(0.149)}\right] = 33.3^\circ \tag{7-86}$$

The length of the longest dipole is determined first. At the lowest frequency of operation (54 MHz), the dipole length from (7-84) should be near a half-wavelength, so

$$L_1 = 0.5\lambda_L = 0.5(5.55) = 2.78 \text{ m} \tag{7-87}$$

The shortest dipole length should be on the order of $L_U = 0.5\lambda_U = 0.694$ m at 216 MHz. The LPDA element lengths are computed until a length on the order of 0.694 m is reached. To be specific, element lengths are found from L_1 using $L_{n+1} = \tau L_n$. For example,

$$L_2 = \tau L_1 = (0.822)(2.78) = 2.29 \text{ m}$$

and

$$L_3 = \tau L_2 = (0.822)(2.29) = 1.88 \text{ m}$$

Completing this process leads to

$$\begin{aligned} &L_1 = 2.78 \text{ m}, \quad L_2 = 2.29 \text{ m}, \quad L_3 = 2.78 \text{ m}, \quad L_4 = 1.54 \text{ m} \\ &L_5 = 1.27 \text{ m}, \quad L_6 = 1.04 \text{ m}, \quad L_7 = 0.858 \text{ m}, \quad L_8 = 0.705 \text{ m} \\ &L_9 = 0.579 \text{ m} \end{aligned} \tag{7-88}$$

The array was terminated with nine elements since $L_9 = 0.579$ m is less than the 0.694 m length for the highest operating frequency. Elements could be added to either end to improve performance at the band edges.

The element spacings for this example are found from (7-81) as

$$d_n = 2\sigma L_n = 2(0.149)L_n = 0.298L_n \tag{7-89}$$

Using the element lengths of (7-88) gives

$$\begin{aligned} &d_1 = 0.828\ \text{m}, \quad d_2 = 0.682\ \text{m}, \quad d_3 = 0.560\ \text{m}, \quad d_4 = 0.459\ \text{m} \\ &d_5 = 0.378\ \text{m}, \quad d_6 = 0.310\ \text{m}, \quad d_7 = 0.256\ \text{m}, \quad d_8 = 0.210\ \text{m} \end{aligned} \tag{7-90}$$

These dipole lengths and spacings completely specify the LPDA, as shown in Fig. 7-39. The total length of the array is the sum of the spacings in (7-90), which gives a 3.683 m. The outline of the antenna fits into an angular sector of angle $\alpha = 33.3^\circ$.