EE 483/583 Antennas for Wireless Communications Quiz #5 (Spring 2025)

Name ___KEY____

Instructions: Open homework. Place answers in indicated spaces and **show/indicate all work** for credit.

A Yagi-Uda antenna is desired that will give a minimum directivity of 9 dBi and operate at 255 MHz. Design the **smallest** possible standard Yagi-Uda antenna that meets these specifications using a brass boom of diameter 1.41 cm and elements with diameters of 0.705 cm. Provide all indicated quantities. Sketch your design, including all relevant dimensions in the box provided. Assume boom extends 5 cm beyond center of last director and 30 cm beyond center of reflector. **Assume $c = 2.998 \times 10^8$ m/s.**

Design Steps:

1) Select or specify design parameters:
   a. The directivity of a **3 element** Yagi-Uda antenna, from Table 10.6, is 7.1 dBd = 7.1 + 2.15 = **9.25 dBi**. [Note: For a Yagi-Uda antenna, gain ≈ directivity.]

   b. Design Frequency- ***f* = 255 MHz**.

2) Select diameter d of elements and diameter D of metallic supporting boom

   Given: Element diameter- **d = 0.705 cm** Boom diameter- **D = 1.41 cm**

3) Calculate design wavelength λ. Use λ to calculate s_{12} (reflector-driven element spacing) & s_{23} [driven element-director] using Table 10.6 values.

$$\lambda = \frac{c}{f} = \frac{2.998 \times 10^8}{255 \times 10^6} = 1.175686 \text{ m} \quad \Rightarrow \quad \boldsymbol{\lambda = 117.5686 \text{ cm}}$$

$$\boldsymbol{s_{12} = s_{23} = 0.2\lambda = 23.51373 \text{ cm}}$$

4) Calculate d/λ. Is $0.001 \le d/\lambda \le 0.04$?

$$d/\lambda = 0.705/117.5686 = \boldsymbol{0.0059965} \quad \Rightarrow \text{ Within } 0.001 \le d/\lambda \le 0.04 \text{ range.}$$

5) If a metal boom is used, calculate D/λ. Is $0.001 \le D/\lambda \le 0.04$?

$$D/\lambda = 1.41/117.5686 = \boldsymbol{0.011993} \quad \Rightarrow \text{ Within } 0.001 \le D/\lambda \le 0.04 \text{ range.}$$

6) Since $d/\lambda \neq 0.0085$, the elements lengths must be corrected. Plot the lengths of the reflector (element 1) and first director (element 3) from Table 10.6 on the appropriate design curves on Figure 10.25 (should fall on or near vertical line drawn from $d/\lambda = 0.0085$). Label these points l_1'' and l_3'' respectively.

\# of elements = _**3**_ Directivity = **9.25 dBi** λ = **117.5669 cm** d/λ = **0.0060**

D/λ = _**0.0120**_ s_{12} = _**23.5137 cm**_ s_{ij} = _**23.5137 cm**_

Table 10.6 OPTIMIZED UNCOMPENSATED LENGTHS OF PARASITIC ELEMENTS FOR YAGI-UDA ANTENNAS OF SIX DIFFERENT LENGTHS

$d/\lambda = 0.0085$, $s_{12} = 0.2\lambda$		LENGTH OF YAGI-UDA (IN WAVELENGTHS)					
		0.4	0.8	1.20	2.2	3.2	4.2
LENGTH OF REFLECTOR (l_1/λ)		**0.482**	0.482	0.482	0.482	0.482	0.475
LENGTH OF DIRECTORS, λ	l_3	**0.442**	0.428	0.428	0.432	0.428	0.424
	l_4		0.424	0.420	0.415	0.420	0.424
	l_5		0.428	0.420	0.407	0.407	0.420
	l_6			0.428	0.398	0.398	0.407
	l_7				0.390	0.394	0.403
	l_8				0.390	0.390	0.398
	l_9				0.390	0.386	0.394
	l_{10}				0.390	0.386	0.390
	l_{11}				0.398	0.386	0.390
	l_{12}				0.407	0.386	0.390
	l_{13}					0.386	0.390
	l_{14}					0.386	0.390
	l_{15}					0.386	0.390
	l_{16}					0.386	
	l_{17}					0.386	
SPACING BETWEEN DIRECTORS (s_{ij}/λ)		**0.20**	0.20	0.25	0.20	0.20	0.308
DIRECTIVITY RELATIVE TO HALF-WAVE DIPOLE (dBd)		**7.1**	9.2	10.2	12.25	13.4	14.2
DESIGN CURVE (SEE FIGURE 10.25)		**(*A*)**	(*B*)	(*B*)	(*C*)	(*B*)	(*D*)

SOURCE: Peter P. Viezbicke, *Yagi Antenna Design*, NBS Technical Note 688, December 1976.

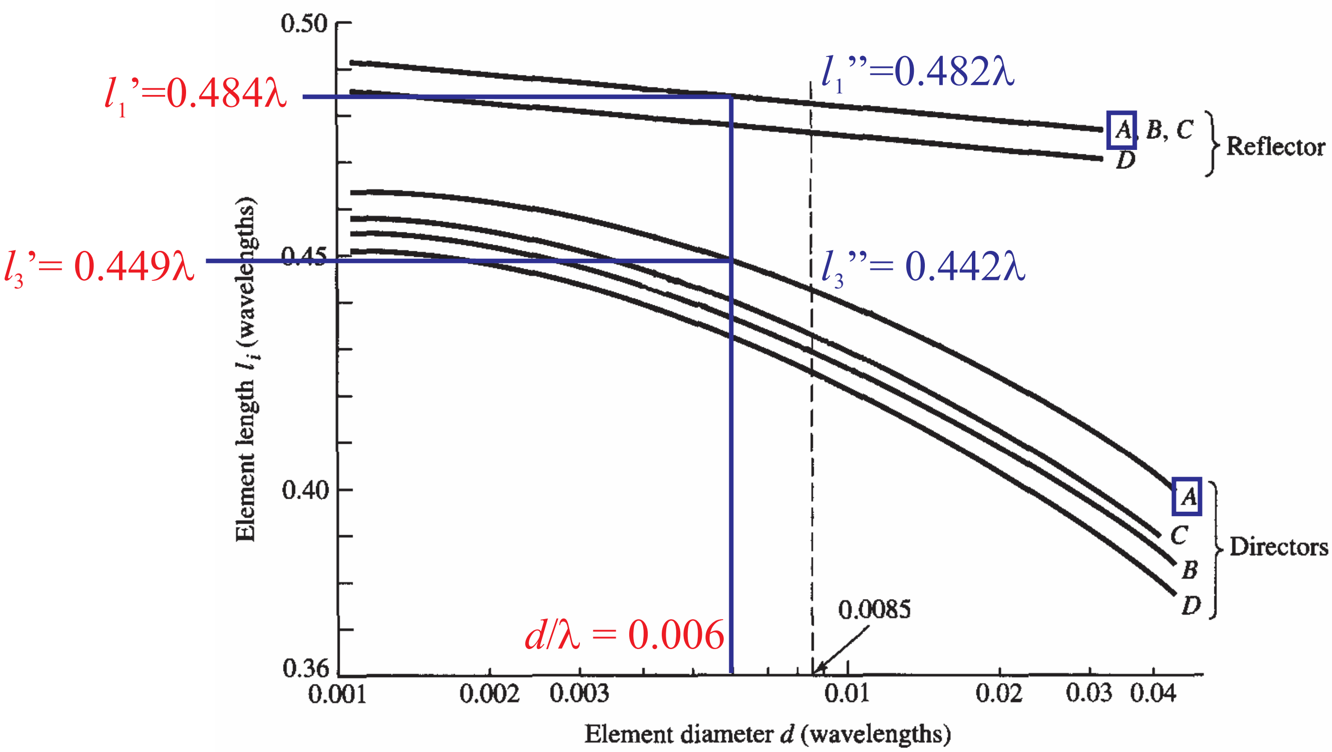

Figure 10.25 Design curves to determine element lengths of Yagi-Uda arrays. (SOURCE: P. P. Viezbicke, ''Yagi Antenna Design,'' NBS Technical Note 688, U.S. Department of Commerce/National Bureau of Standards, December 1976)

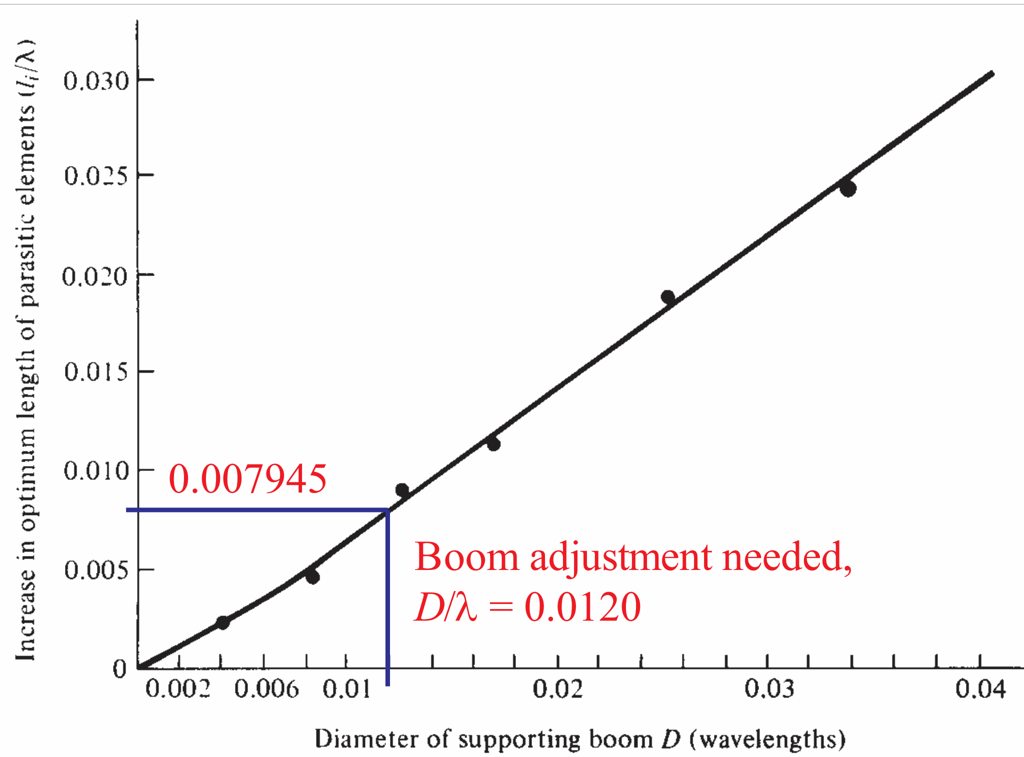

Figure 10.26 Increase in optimum length of parasitic elements as a function of metal boom diameter. (SOURCE: P. P. Viezbicke,'' Yagi Antenna Design,'' NBS Technical Note 688, U.S. Department of Commerce/National Bureau of Standards, December 1976)

7) Draw a vertical line from d/λ through reflector and director design curves (A), where this line intersects the curves is the corrected lengths of the reflector l_1' and director l_3'. To read the values, draw horizontal lines from the intersections to the left axis of the figure.

$l_1' = 0.484\lambda$ and $l_3' = 0.449\lambda$

For 3-element design, steps 8 through 10 are not necessary

11) The element lengths must be lengthened to compensate for a metal boom. On Figure 10.26, draw a vertical line from <u>$D/\lambda = 0.012$</u> through the curve. Read

<u>Boom compensation length = 0.008λ</u>

$l_1 = 0.484\lambda + 0.008\lambda = 0.492\lambda =$ 57.84376 cm

$l_3 = 0.449\lambda + 0.008\lambda = 0.457\lambda =$ 53.72886 cm

$l_3 < l_2 < l_1$