

**Example:** Use a Gamma-Match to drive the previously designed 5-element UHF Channel 43 Yagi-Uda antenna without boom with a  $50 \Omega$  coaxial transmission line. The matching specification is that the  $VSWR \leq 1.1$ .

### Yagi-Uda antenna design summary

$f_c = 647$  MHz and  $\lambda = 46.3$  cm

element diameters  $d = 2a = 0.25'' = 0.635$  cm  $\Rightarrow a = 0.125'' = 0.3175$  cm

element spacings  $s_{ij} = 0.2\lambda = 9.274$  cm

reflector length  $l_1' = 0.48\lambda = 22.24$  cm

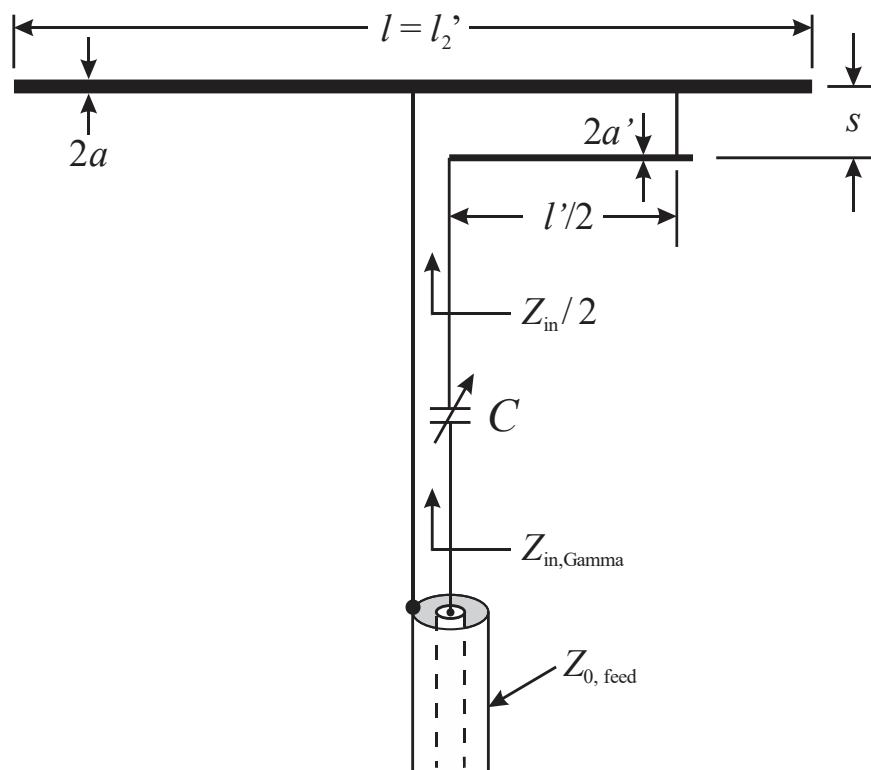
director lengths  $l_3' = l_5' = 0.419\lambda = 19.41$  cm

director length  $l_4' = 0.412\lambda = 19.09$  cm

selected driven element length  $l_2' = (l_1' + l_3')/2 = 0.45\lambda = 20.85$  cm

From NEC-2,  $Z_a = 17.35 + j 20.59 \Omega$  and Gain = 11.265 dBi w/ no match

### **Gamma-Match:**



## First attempt at Gamma-Match ( $\Gamma$ -Match)

Select  $\Gamma$ -Match diameter  $2a' = 0.125'' = 0.3175 \text{ cm} \Rightarrow a' = 0.15875 \text{ cm}$

Select  $\Gamma$ -Match spacing  $s = 2 \text{ cm}$  and length  $l'/2 = 5 \text{ cm}$

Select driven element length  $l_2' = 0.47\lambda = 21.8 \text{ cm}$  (want inductive reactance)

Using NEC-2 and MathCad (see attached pages)-

- Using MathCad for  $\Gamma$ -match:  $Z_0 = 260.329 \Omega$ , current division factor  $\alpha = 1.36748$ , effective radius  $a_e = 0.666 \text{ cm}$ , & transmission line mode input impedance  $Z_t = j209.663 \Omega$
- From NEC:  $Z_a = 18.356 + j25.3879 \Omega$  & Gain = 11.6122 dBi
- Using MathCad:  $Z_{in}/2 = 27.746 + j58.205 \Omega$ . After adding series capacitor  $C = 4.226 \text{ pF}$ ,  $Z_{in, \Gamma} = 27.746 \Omega$ . With this input impedance,  $|\Gamma| = 0.286$ , and VSWR = 1.802 > 1.1 (high).

## NEC input file for first $\Gamma$ -Match attempt

```

CM Yagi-Uda Antenna for UHF channel 43 (NO BOOM)
CM
CM THIS FILE IS USED TO DETERMINE THE INPUT IMPEDANCE OF THE DRIVEN
CM ELEMENT OF A 5 ELEMENT YAGI-UDA ANTENNA. CENTER FREQUENCY IS 647 MHz
CM W/ WAVELENGTH OF 0.46335 m.
CM
CM THE DIMENSIONS ARE:
CM element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in,
CM equivalent radius of Gamma-Match portion of driven element
CM is ae=0.00666 m which has a length of l'/2=0.05 m < l2
CM
CM l1=0.48 l=0.2224m, l3=l5=0.419 l=0.1941m, l4=0.412 l=0.1909m,
CM driven element l2=0.47 l= 0.218m
CM ELEMENT SPACINGS Sij=0.2 l=0.09267m
CM SELECT SEGMENT LENGTH OF APPROX. 1.25cm=0.025 l
CE THE DRIVEN SEGMENT IS #1 on l2 Tag 3/GW 3.
GW 1 17 -0.1112 0.0 0.0 0.1112 0.0 0.0 0.003175 !Reflector
GW 2 9 -0.109 0.0 0.09267 0.0 0.0 0.09267 0.003175 !Driven tip
GW 3 4 0.0 0.0 0.09267 0.05 0.0 0.09267 0.00666 !Driven middle
GW 4 5 0.05 0.0 0.09267 0.109 0.0 0.09267 0.003175 !Driven tip
GW 5 15 -0.09705 0.0 0.18534 0.09705 0.0 0.18534 0.003175 !Director 1
GW 6 15 -0.09545 0.0 0.27801 0.09545 0.0 0.27801 0.003175 !Director 2
GW 7 15 -0.09705 0.0 0.37068 0.09705 0.0 0.37068 0.003175 !Director 3
GE 0 0
FR 0 1 0 0 647 0
EX 0 3 1 0 1.0 0.0
RP 0 2 3 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0
EN

```

### NEC output file for first $\Gamma$ -Match attempt

Yagi-Uda Antenna for UHF channel 43 (NO BOOM)

THIS FILE IS USED TO DETERMINE THE INPUT IMPEDANCE OF THE DRIVEN ELEMENT OF A 5 ELEMENT ANTENNA. CENTER FREQUENCY IS 647 MHz W/ WAVELENGTH OF 0.46335 m.

THE DIMENSIONS ARE:

element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in, equivalent radius of Gamma-Match portion of driven element is ae=0.00666 m which has a length of l'/2=0.05 m < l2

l1=0.48 l=0.2224m, l3=l5=0.419 l=0.1941m, l4=0.412 l=0.1909m, driven element l2=0.47 l= 0.218m

ELEMENT SPACINGS Sij=0.2 l=0.09267m

SELECT SEGMENT LENGTH OF APPROX. 1.25cm=0.025 l

THE DRIVEN SEGMENT IS #9 on l2.

\*\*\*\*\*

- - - STRUCTURE SPECIFICATION - - -

COORDINATES MUST BE INPUT IN METERS OR BE SCALED TO METERS BEFORE STRUCTURE INPUT IS ENDED

WIRE NO.	X1	Y1	Z1	X2	Y2	Z2	RADIUS	NO. OF SEG.	FIRST SEG.	LAST SEG.	TAG NO.
1	-0.11120	0.0	0.00000	0.11120	0.0	0.00000	0.00317	17	1	17	1
2	-0.10900	0.0	0.09267	0.00000	0.0	0.09267	0.00317	9	18	26	2
3	0.00000	0.0	0.09267	0.05000	0.0	0.09267	0.00666	4	27	30	3
4	0.05000	0.0	0.09267	0.10900	0.0	0.09267	0.00317	5	31	35	4
5	-0.09705	0.0	0.18534	0.09705	0.0	0.18534	0.00317	15	36	50	5
6	-0.09545	0.0	0.27801	0.09545	0.0	0.27801	0.00317	15	51	65	6
7	-0.09705	0.0	0.37068	0.09705	0.0	0.37068	0.00317	15	66	80	7

TOTAL SEGMENTS USED=80 NO. SEG. IN A SYMMETRIC CELL=80 SYMMETRY FLAG= 0

\*\*\*\*\* INPUT LINE 1 FR 0 1 0 0 6.470E+02 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 2 EX 0 3 1 0 1.00000E+00 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 3 RP 0 2 3 0 0.0 0.0 1.800E+02 9.000E+01 0.0 0.0

FREQUENCY= 6.4700E+02 MHZ WAVELENGTH= 4.6337E-01 METERS

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE REAL	VOLTAGE IMAG.	IMPEDANCE (OHMS) REAL	IMPEDANCE (OHMS) IMAG.	ADMITTANCE (MHOS) REAL	ADMITTANCE (MHOS) IMAG.
3	27	1.0	0.0	1.83560E+01	2.53879E+01	1.87022E-02	-2.58667E-023

- - - RADIATION PATTERNS - - -

THETA DEGREES	PHI DEGREES	Gain DB
0.00	0.00	11.61220
180.00	0.00	-0.14719

\*\*\*\*\* INPUT LINE 4 PT -1 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 5 XQ 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 6 EN 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

## MathCad file for first $\Gamma$ -Match attempt

### Gamma-Match equations

$$c := 2.9979 \cdot 10^8 \text{ m/s} \quad f_c := 647 \cdot 10^6 \text{ Hz} \quad \lambda := \frac{c}{f_c} \quad \lambda = 0.46335 \text{ m} \quad k := \frac{2 \cdot \pi}{\lambda} \quad k = 13.56023 \text{ rad/m}$$

$$Z_{\text{desired}} := 50 \quad \Omega \quad d := 0.635 \cdot 10^{-2} \text{ m} \quad a := d \cdot 0.5 \quad a = 0.003175 \text{ m}$$

$$d_{\text{prime}} := 0.3175 \cdot 10^{-2} \text{ m} \quad a_{\text{prime}} := d_{\text{prime}} \cdot 0.5 \quad a_{\text{prime}} = 0.0015875 \text{ m} \quad s := 2 \cdot 10^{-2} \text{ m}$$

$$Z_0 := \frac{376.73}{2 \cdot \pi} \cdot \operatorname{acosh} \left[ \frac{(s^2 - a^2 - a_{\text{prime}}^2)}{2 \cdot a \cdot a_{\text{prime}}} \right] \quad Z_0 = 260.329 \quad \Omega \quad u := \frac{a}{a_{\text{prime}}} \quad v := \frac{s}{a_{\text{prime}}}$$

$$u = 2 \quad v = 12.5984$$

$$\alpha := \frac{\operatorname{acosh} \left[ \frac{(v^2 - u^2 + 1)}{2 \cdot v} \right]}{\operatorname{acosh} \left[ \frac{(v^2 + u^2 - 1)}{2 \cdot v \cdot u} \right]} \quad \alpha = 1.36748 \quad ae := a_{\text{prime}} \cdot e^{\frac{1}{(1+u)^2} \cdot (u^2 \cdot \ln(u) + 2 \cdot u \cdot \ln(v))}$$

$$ae = 0.00666 \quad ae \cdot 100 = 0.66609 \text{ cm}$$

$$l_{\text{prime}} := 10 \cdot 10^{-2} \text{ m} \quad l_{\text{prime}} \cdot 0.5 = 0.05 \text{ m}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 209.66289i \quad \Omega \quad Y_t := \frac{1}{Z_t} \quad Y_t = -4.77i \times 10^{-3}$$

### Za from NEC (a MoM program)

$$Z_a := 18.356 + j \cdot 25.3879 \quad \Omega \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.0187 - 0.02587i \quad \text{Mhos}$$

$$Y_{\text{in}2} := Y_t + \frac{Y_a \cdot 2}{(1 + \alpha)^2} \quad Y_{\text{in}2} = 6.673 \times 10^{-3} - 0.014i \quad \frac{1}{Z_{\text{desired}}} = 0.02 \text{ Mhos}$$

$$Z_{\text{in}2} := \frac{1}{Y_{\text{in}2}} \quad Z_{\text{in}2} = 27.746 + 58.205i \quad \Omega \quad Z_{\text{desired}} = 50 \quad \Omega$$

$$C := \operatorname{if} \left( \operatorname{Im}(Z_{\text{in}2}) > 0, \frac{1}{2 \cdot \pi \cdot f_c \cdot \operatorname{Im}(Z_{\text{in}2})}, 0 \right) \quad C = 4.226 \times 10^{-12} \quad C \cdot 10^{12} = 4.226 \quad \text{pF}$$

$$Z_{\text{cap}} := \operatorname{if} \left( C > 0, \frac{1}{j \cdot 2 \cdot \pi \cdot f_c \cdot C}, 0 \right) \quad Z_{\text{cap}} = -58.205i \quad \Omega$$

$$Z_{\text{in}g} := Z_{\text{cap}} + Z_{\text{in}2} \quad \boxed{Z_{\text{in}g} = 27.746} \quad \Omega$$

$$\Gamma := \frac{(Z_{\text{in}g} - Z_{\text{desired}})}{Z_{\text{in}g} + Z_{\text{desired}}} \quad \Gamma = -0.286 \quad |\Gamma| = 0.286$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \text{VSWR} = 1.802$$

**First try**

## Second attempt at $\Gamma$ -Match

Keep  $\Gamma$ -Match diameter  $2a' = 0.125'' = 0.3175 \text{ cm} \Rightarrow a' = 0.15875 \text{ cm}$

Keep  $\Gamma$ -Match spacing  $s = 2 \text{ cm}$  and length  $l'/2 = 5 \text{ cm}$

Change driven element length to  $l_2' = 20.8 \text{ cm}$  (shorten from 21.8 cm)

Using NEC-2 and MathCad (see attached pages)-

- Using MathCad for  $\Gamma$ -match:  $Z_0 = 260.329 \Omega$ ,  $\alpha = 1.36748$ ,  $a_e = 0.666 \text{ cm}$ , &  $Z_t = j209.663 \Omega$  (no changes)
- From NEC:  $Z_a = 14.9299 + j1.27235 \Omega$  & Gain = 11.56149 dBi
- Using MathCad:  $Z_{in}/2 = 38.953 + j11.15 \Omega$ . After adding series capacitor  $C = 22.06 \text{ pF}$ ,  $Z_{in, \Gamma} = 38.953 \Omega$ . With this input impedance,  $|\Gamma| = 0.124$ , and VSWR = 1.284 > 1.1 (high).

## NEC input file for second $\Gamma$ -Match attempt

```

CM Yagi-Uda Antenna for UHF channel 43 (NO BOOM)
CM
CM THIS FILE IS USED TO DETERMINE THE INPUT IMPEDANCE OF THE DRIVEN
CM ELEMENT OF A 5 ELEMENT YAGI-UDA ANTENNA. CENTER FREQUENCY IS 647 MHz
CM W/ WAVELENGTH OF 0.46335 m.
CM
CM THE DIMENSIONS ARE:
CM element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in,
CM equivalent radius of Gamma-Match portion of driven element
CM is ae=0.00666 m which has a length of l'/2=0.05 m < l2
CM
CM l1=0.48 l=0.2224m, l3=l5=0.419 l=0.1941m, l4=0.412 l=0.1909m,
CM driven element l2=0.4489 l= 0.208m
CM ELEMENT SPACINGS Sij=0.2 l=0.09267m
CM SELECT SEGMENT LENGTH OF APPROX. 1.25cm=0.025 l
CE THE DRIVEN SEGMENT IS #1 on l2 Tag 3/GW 3.
GW 1 17 -0.1112 0.0 0.0 0.1112 0.0 0.0 0.003175 !Reflector
GW 2 9 -0.104 0.0 0.09267 0.0 0.0 0.09267 0.003175 !Driven tip
GW 3 4 0.0 0.0 0.09267 0.05 0.0 0.09267 0.00666 !Driven middle
GW 4 5 0.05 0.0 0.09267 0.104 0.0 0.09267 0.003175 !Driven tip
GW 5 15 -0.09705 0.0 0.18534 0.09705 0.0 0.18534 0.003175 !Director 1
GW 6 15 -0.09545 0.0 0.27801 0.09545 0.0 0.27801 0.003175 !Director 2
GW 7 15 -0.09705 0.0 0.37068 0.09705 0.0 0.37068 0.003175 !Director 3
GE 0 0
FR 0 1 0 0 647 0
EX 0 3 1 0 1.0 0.0
RP 0 2 3 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0
EN

```

### NEC output file for second $\Gamma$ -Match attempt

Yagi-Uda Antenna for UHF channel 43 (NO BOOM)

THIS FILE IS USED TO DETERMINE THE INPUT IMPEDANCE OF THE DRIVEN ELEMENT OF A 5 ELEMENT ANTENNA. CENTER FREQUENCY IS 647 MHz W/ WAVELENGTH OF 0.46335 m.

THE DIMENSIONS ARE:

element diameter  $d=0.635\text{cm}=0.25\text{in}$ , radius  $a=d/2=0.3175\text{cm}=0.125\text{in}$ ,  
equivalent radius of Gamma-Match portion of driven element  
is  $a_e=0.00666\text{ m}$  which has a length of  $l'/2=0.05\text{ m} < l_2$

$l_1=0.48\text{ m}$   $l_2=0.2224\text{m}$ ,  $l_3=l_5=0.419\text{ m}$   $l_4=0.1941\text{m}$ ,  $l_6=0.412\text{ m}$   $l_7=0.1909\text{m}$ ,  
driven element  $l_8=0.4489\text{ m}$   $l_9=0.208\text{m}$

ELEMENT SPACINGS  $S_{ij}=0.2\text{ m}$   $l_{10}=0.09267\text{m}$

SELECT SEGMENT LENGTH OF APPROX.  $1.25\text{cm}=0.025\text{ m}$

THE DRIVEN SEGMENT IS #9 on  $l_2$ .

\*\*\*\*\*

- - - STRUCTURE SPECIFICATION - - -

COORDINATES MUST BE INPUT IN METERS OR BE SCALED TO METERS  
BEFORE STRUCTURE INPUT IS ENDED

WIRE NO.	X1	Y1	Z1	X2	Y2	Z2	RADIUS	NO. OF SEG.	FIRST SEG.	LAST SEG.	TAG NO.
1	-0.11120	0.0	0.0	0.11120	0.0	0.0	0.00317	17	1	17	1
2	-0.10400	0.0	0.09267	0.0	0.0	0.09267	0.00317	9	18	26	2
3	0.0	0.0	0.09267	0.05000	0.0	0.09267	0.00666	4	27	30	3
4	0.05000	0.0	0.09267	0.10400	0.0	0.09267	0.00317	5	31	35	4
5	-0.09705	0.0	0.18534	0.09705	0.0	0.18534	0.00317	15	36	50	5
6	-0.09545	0.0	0.27801	0.09545	0.0	0.27801	0.00317	15	51	65	6
7	-0.09705	0.0	0.37068	0.09705	0.0	0.37068	0.00317	15	66	80	7

TOTAL SEGMENTS USED= 80 NO. SEG. IN A SYMMETRIC CELL= 80 SYMMETRY FLAG= 0

\*\*\*\*\* INPUT LINE 1 FR 0 1 0 0 6.47000E+02 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 2 EX 0 3 1 0 1.00000E+00 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 3 RP 0 2 3 0 0.0 0.0 1.800E+02 9.00E+01 0.0 0.0

FREQUENCY= 6.4700E+02 MHZ WAVELENGTH= 4.6337E-01 METERS

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE REAL	IMAG.	IMPEDANCE REAL	IMAG.	ADMITTANCE REAL	IMAG.
3	27	1.0	0.0	1.49299E+01	1.27235E+00	6.64966E-02	-5.66692E-03

- - - RADIATION PATTERNS - - -

THETA DEGREES	PHI DEGREES	MAJOR DB
0.00	0.00	11.56149
180.00	0.00	-0.12704

\*\*\*\*\* INPUT LINE 4 PT -1 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 5 XQ 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 6 EN 0 0 0 0 0.0 0.0 0.0 0.0 0.0 0.0

**MathCad file for second  $\Gamma$ -Match attempt****Gamma-Match**

$$c := 2.9979 \cdot 10^8 \quad f_c := 647 \cdot 10^6 \quad \lambda := \frac{c}{f_c} \quad \lambda = 0.46335 \quad k := \frac{2 \cdot \pi}{\lambda} \quad k = 13.56023$$

$$Z_{\text{desired}} := 50 \quad \Omega \quad d := 0.635 \cdot 10^{-2} \text{ m} \quad a := d \cdot 0.5 \quad a = 0.003175 \text{ m}$$

$$d_{\text{prime}} := 0.3175 \cdot 10^{-2} \text{ m} \quad a_{\text{prime}} := d_{\text{prime}} \cdot 0.5 \quad a_{\text{prime}} = 0.0015875 \text{ m} \quad s := 2 \cdot 10^{-2} \text{ m}$$

$$Z_0 := \frac{376.73}{2 \cdot \pi} \cdot \operatorname{acosh} \left[ \frac{(s^2 - a^2 - a_{\text{prime}}^2)}{2 \cdot a \cdot a_{\text{prime}}} \right] \quad Z_0 = 260.329 \quad \Omega \quad u := \frac{a}{a_{\text{prime}}} \quad v := \frac{s}{a_{\text{prime}}}$$

$$u = 2 \quad v = 12.5984$$

$$\alpha := \frac{\operatorname{acosh} \left[ \frac{(v^2 - u^2 + 1)}{2 \cdot v} \right]}{\operatorname{acosh} \left[ \frac{(v^2 + u^2 - 1)}{2 \cdot v \cdot u} \right]} \quad \alpha = 1.36748 \quad ae := a_{\text{prime}} \cdot e^{\frac{1}{(1+u)^2} \cdot (u^2 \cdot \ln(u) + 2 \cdot u \cdot \ln(v))}$$

$$ae = 0.00666 \quad ae \cdot 100 = 0.66609 \text{ cm}$$

$$l_{\text{prime}} := 10 \cdot 10^{-2} \text{ m} \quad l_{\text{prime}} \cdot 0.5 = 0.05 \text{ m}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 209.66289i \quad \Omega \quad Y_t := \frac{1}{Z_t} \quad Y_t = -4.77i \times 10^{-3}$$

**Za from NEC (a MoM program)**

$$Z_a := 14.9299 + j \cdot 1.27253 \quad \Omega \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.0665 - 0.00567i \quad \text{Mho}_s$$

$$Y_{\text{in}2} := Y_t + \frac{Y_a \cdot 2}{(1 + \alpha)^2} \quad Y_{\text{in}2} = 0.024 - 6.792i \times 10^{-3} \quad \frac{1}{Z_{\text{desired}}} = 0.02 \text{ Mho}_s$$

$$Z_{\text{in}2} := \frac{1}{Y_{\text{in}2}} \quad Z_{\text{in}2} = 38.953 + 11.15i \quad \Omega \quad Z_{\text{desired}} = 50 \quad \Omega$$

$$C := \text{if} \left( \operatorname{Im}(Z_{\text{in}2}) > 0, \frac{1}{2 \cdot \pi \cdot f_c \cdot \operatorname{Im}(Z_{\text{in}2})}, 0 \right) \quad C = 2.206 \times 10^{-11} \quad C \cdot 10^{12} = 22.061 \text{ pF}$$

$$Z_{\text{cap}} := \text{if} \left( C > 0, \frac{1}{j \cdot 2 \cdot \pi \cdot f_c \cdot C}, 0 \right) \quad Z_{\text{cap}} = -11.15i \quad \Omega$$

$$Z_{\text{ing}} := Z_{\text{cap}} + Z_{\text{in}2} \quad \boxed{Z_{\text{ing}} = 38.953} \quad \Omega$$

$$\Gamma := \frac{(Z_{\text{ing}} - Z_{\text{desired}})}{Z_{\text{ing}} + Z_{\text{desired}}} \quad \Gamma = -0.124 \quad |\Gamma| = 0.124$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \text{VSWR} = 1.284$$

**Second try**

### Third attempt at $\Gamma$ -Match

Keep  $\Gamma$ -Match diameter  $2a' = 0.125'' = 0.3175 \text{ cm} \Rightarrow a' = 0.15875 \text{ cm}$

Keep  $\Gamma$ -Match spacing  $s = 2 \text{ cm}$  and length  $l'/2 = 5 \text{ cm}$

Keep driven element length  $l_2' = 20.8 \text{ cm}$

Increase reflector length  $l_1' = 22.4 \text{ cm}$  (from 22.24 cm) & decrease first director length  $l_3' = 19.1 \text{ cm}$  (from 19.41 cm)

Using NEC-2 and MathCad (see attached pages)-

- Using MathCad for  $\Gamma$ -match:  $Z_0 = 260.329 \Omega$ ,  $\alpha = 1.36748$ ,  $a_e = 0.666 \text{ cm}$ , &  $Z_t = j209.663 \Omega$  (no changes)
- From NEC:  $Z_a = 18.2632 - j0.2054 \Omega$  & Gain = 11.45567 dBi
- Using MathCad:  $Z_{in}/2 = 48.555 + j 11.309 \Omega$ . After adding series capacitor  $C = 21.752 \text{ pF}$ ,  $Z_{in, \Gamma} = 48.555 \Omega$ . With this input impedance,  $|\Gamma| = 0.015$ , and **VSWR = 1.03 < 1.1 (DONE!)**.

### NEC input file for third $\Gamma$ -Match attempt

```

CM Yagi-Uda Antenna for UHF channel 43 (NO BOOM)
CM
CM THIS FILE IS USED TO DETERMINE THE INPUT IMPEDANCE OF THE DRIVEN
CM ELEMENT OF A 5 ELEMENT ANTENNA. CENTER FREQUENCY IS 647 MHz
CM W/ WAVELENGTH OF 0.46335 m.
CM
CM THE DIMENSIONS ARE:
CM element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in,
CM equivalent radius of Gamma-Match portion of driven element
CM is ae=0.00666 m which has a length of l'/2=0.05 m < l2
CM l1=0.483 l=0.224m, l3=0.4122 l=0.191 m, l4=0.412 l=0.1909m,
CM l5=0.419 l=0.1941m
CM driven element l2=0.4489 l= 0.208m
CM ELEMENT SPACINGS Sij=0.2 l=0.09267m
CM SELECT SEGMENT LENGTH OF APPROX. 1.25cm=0.025 l
CE THE DRIVEN SEGMENT IS #1 on l2 Tag 3.
GW 1 17 -0.112 0.0 0.0 0.112 0.0 0.0 0.003175 !Reflector
GW 2 9 -0.104 0.0 0.09267 0.0 0.0 0.09267 0.003175 !Driven tip
GW 3 4 0.0 0.0 0.09267 0.05 0.0 0.09267 0.00666 !Driven middle
GW 4 5 0.05 0.0 0.09267 0.104 0.0 0.09267 0.003175 !Driven tip
GW 5 15 -0.09505 0.0 0.18534 0.09505 0.0 0.18534 0.003175 !Director 1
GW 6 15 -0.09545 0.0 0.27801 0.09545 0.0 0.27801 0.003175 !Director 2
GW 7 15 -0.09705 0.0 0.37068 0.09705 0.0 0.37068 0.003175 !Director 3
GE 0 0
FR 0 1 0 0 647 0
EX 0 3 1 0 1.0 0.0
RP 0 2 3 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0

```

3/7/2024



EN

**NEC output file for third  $\Gamma$ -Match attempt**

Yagi-Uda Antenna for UHF channel 43 (NO BOOM)

THIS FILE IS USED TO DETERMINE THE INPUT IMPEDANCE OF THE DRIVEN ELEMENT OF A 5 ELEMENT ANTENNA. CENTER FREQUENCY IS 647 MHz W/ WAVELENGTH OF 0.46335 m.

THE DIMENSIONS ARE:

element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in, equivalent radius of Gamma-Match portion of driven element is ae=0.00666 m which has a length of l'/2=0.05 m < l2

l1=0.483 l=0.224m, l3=0.4122 l=0.191 m, l4=0.412 l=0.1909m, l5=0.419 l=0.1941m

driven element l2=0.4489 l= 0.208m

ELEMENT SPACINGS  $S_{ij}$ =0.2 l=0.09267m

SELECT SEGMENT LENGTH OF APPROX. 1.25cm=0.025 l

THE DRIVEN SEGMENT IS #9 on l2.

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- - - STRUCTURE SPECIFICATION - - -

COORDINATES MUST BE INPUT IN METERS OR BE SCALED TO METERS BEFORE STRUCTURE INPUT IS ENDED

WIRE NO.	X1	Y1	Z1	X2	Y2	Z2	RADIUS	NO. OF SEG.	FIRST SEG.	LAST SEG.	TAG NO.
1	-0.11200	0.0	0.00000	0.11200	0.0	0.00000	0.00317	17	1	17	1
2	-0.10400	0.0	0.09267	0.00000	0.0	0.09267	0.00317	9	18	26	2
3	0.00000	0.0	0.09267	0.05000	0.0	0.09267	0.00666	4	27	30	3
4	0.05000	0.0	0.09267	0.10400	0.0	0.09267	0.00317	5	31	35	4
5	-0.09505	0.0	0.18534	0.09505	0.0	0.18534	0.00317	15	36	50	5
6	-0.09545	0.0	0.27801	0.09545	0.0	0.27801	0.00317	15	51	65	6
7	-0.09705	0.0	0.37068	0.09705	0.0	0.37068	0.00317	15	66	80	7

TOTAL SEGMENTS USED= 80 NO. SEG. IN A SYMMETRIC CELL= 80 SYMMETRY FLAG= 0

*****	INPUT LINE	1	FR	0	1	0	0	6.47000E+02	0.0	0.0	0.0	0.0
*****	INPUT LINE	2	EX	0	3	1	0	1.00000E+00	0.0	0.0	0.0	0.0
*****	INPUT LINE	3	RP	0	2	3	0	0.0 0.0 1.80E+02	9.00E+01	0.0	0.0	0.0

FREQUENCY= 6.4700E+02 MHZ WAVELENGTH= 4.6337E-01 METERS

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE (V) REAL	IMAG.	CURRENT (AMPS) REAL	IMAG.	IMPEDANCE (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.
3	27	1.0	0.0	5.48E-02	6.16E-04	1.82632E+01	-2.05397E-01	5.48E-02	6.16E-04

- - - RADIATION PATTERNS - - -

THETA DEGREES	PHI DEGREES	Gain DB
0.00	0.00	11.45567
180.00	0.00	-1.78089

*****	INPUT LINE	4	PT	-1	0	0	0	0.0	0.0	0.0	0.0	0.0
*****	INPUT LINE	5	XQ	0	0	0	0	0.0	0.0	0.0	0.0	0.0
*****	INPUT LINE	6	EN	0	0	0	0	0.0	0.0	0.0	0.0	0.0

**MathCad file for third  $\Gamma$ -Match attempt****Gamma-Match equations**

$$c := 2.9979 \cdot 10^8 \quad f_c := 647 \cdot 10^6 \quad \lambda := \frac{c}{f_c} \quad \lambda = 0.46335 \quad k := \frac{2 \cdot \pi}{\lambda} \quad k = 13.56023$$

$$Z_{\text{desired}} := 50 \quad \Omega \quad d := 0.635 \cdot 10^{-2} \quad \text{m} \quad a := d \cdot 0.5 \quad a = 0.003175 \quad \text{m}$$

$$d_{\text{prime}} := 0.3175 \cdot 10^{-2} \quad \text{m} \quad a_{\text{prime}} := d_{\text{prime}} \cdot 0.5 \quad a_{\text{prime}} = 0.0015875 \quad \text{m} \quad s := 2 \cdot 10^{-2} \quad \text{m}$$

$$Z_0 := \frac{376.73}{2 \cdot \pi} \cdot \operatorname{acosh} \left[ \frac{(s^2 - a^2 - a_{\text{prime}}^2)}{2 \cdot a \cdot a_{\text{prime}}} \right] \quad Z_0 = 260.329 \quad \Omega \quad u := \frac{a}{a_{\text{prime}}} \quad v := \frac{s}{a_{\text{prime}}}$$

$$u = 2 \quad v = 12.5984$$

$$\alpha := \frac{\operatorname{acosh} \left[ \frac{(v^2 - u^2 + 1)}{2 \cdot v} \right]}{\operatorname{acosh} \left[ \frac{(v^2 + u^2 - 1)}{2 \cdot v \cdot u} \right]} \quad \alpha = 1.36748 \quad ae := a_{\text{prime}} \cdot e^{\frac{1}{(1+u)^2} \cdot (u^2 \cdot \ln(u) + 2 \cdot u \cdot \ln(v))}$$

$$ae = 0.00666 \quad ae \cdot 100 = 0.66609 \quad \text{cm}$$

$$l_{\text{prime}} := 10 \cdot 10^{-2} \quad \text{m} \quad l_{\text{prime}} \cdot 0.5 = 0.05 \quad \text{m}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 209.66289i \quad \Omega \quad Y_t := \frac{1}{Z_t} \quad Y_t = -4.77i \times 10^{-3}$$

**Za from NEC (a MoM program)**

$$Z_a := 18.2632 - j \cdot 0.205397 \quad \Omega \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.05475 + 0.00062i \quad \text{Mhos}$$

$$Y_{\text{in}2} := Y_t + \frac{Y_a \cdot 2}{(1 + \alpha)^2} \quad Y_{\text{in}2} = 0.02 - 4.55i \times 10^{-3} \quad \frac{1}{Z_{\text{desired}}} = 0.02 \quad \text{Mhos}$$

$$Z_{\text{in}2} := \frac{1}{Y_{\text{in}2}} \quad Z_{\text{in}2} = 48.555 + 11.309i \quad \Omega \quad Z_{\text{desired}} = 50 \quad \Omega$$

$$C := \operatorname{if} \left( \operatorname{Im}(Z_{\text{in}2}) > 0, \frac{1}{2 \cdot \pi \cdot f_c \cdot \operatorname{Im}(Z_{\text{in}2})}, 0 \right) \quad C = 2.175 \times 10^{-11} \quad C \cdot 10^{12} = 21.752 \quad \text{pF}$$

$$Z_{\text{cap}} := \operatorname{if} \left( C > 0, \frac{1}{j \cdot 2 \cdot \pi \cdot f_c \cdot C}, 0 \right) \quad Z_{\text{cap}} = -11.309i \quad \Omega$$

$$Z_{\text{in}g} := Z_{\text{cap}} + Z_{\text{in}2} \quad \boxed{Z_{\text{in}g} = 48.555} \quad \Omega$$

$$\Gamma := \frac{(Z_{\text{in}g} - Z_{\text{desired}})}{Z_{\text{in}g} + Z_{\text{desired}}} \quad \Gamma = -0.015 \quad |\Gamma| = 0.015$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \boxed{\text{VSWR} = 1.03}$$

**Third try, DONE!**

**Yagi-Uda antenna CH 13 final design** ( $f_c = 647 \text{ MHz}$  &  $\lambda = 46.3 \text{ cm}$ )

element diameters  $d = 2a = 0.25'' = 0.635 \text{ cm} \Rightarrow a = 0.125'' = 0.3175 \text{ cm}$

element spacings  $s_{ij} = 0.2\lambda = 9.274 \text{ cm}$

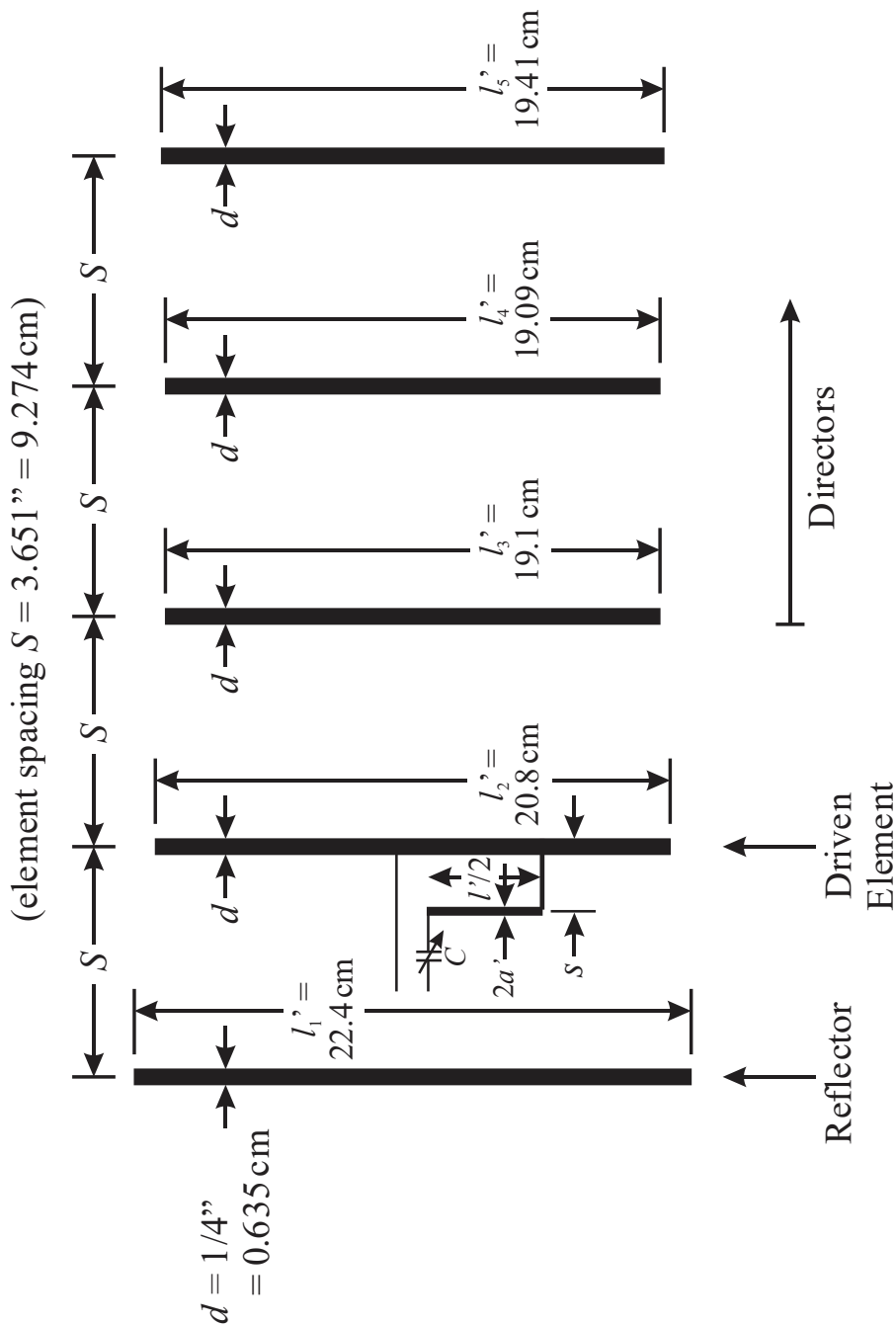
$\Gamma$ -Match diameter  $2a' = 0.3175 \text{ cm}$ , spacing  $s = 2 \text{ cm}$ , & length  $l'/2 = 5 \text{ cm}$

reflector length  $l_1' = 22.4 \text{ cm}$  & driven element length  $l_2' = 20.8 \text{ cm}$

director lengths  $l_3' = 19.1 \text{ cm}$ ,  $l_4' = 19.09 \text{ cm}$ , &  $l_5' = 19.41 \text{ cm}$

$C = 21.752 \text{ pF} \Rightarrow Z_{in, \Gamma} = 48.555 \Omega$ , and Gain = 11.456 dBi

**5 element, channel 43 Yagi-Uda antenna w/  $\Gamma$ -Match**



$\Gamma$ -Match Dimensions:  $2a' = 1/8'' = 0.3175 \text{ cm}$ ,  $s = 2.0 \text{ cm}$ ,  $l'/2 = 5 \text{ cm}$ , &  $C = 21.75 \text{ pF}$