

**Example:** Use a T-Match to drive the 5 element UHF Channel 43 Yagi-Uda antenna without boom that was previously designed with a  $100 \Omega$  twin-lead transmission line. The matching specification is that the  $VSWR \leq 1.1$ .

**Yagi-Uda antenna design summary:**

$$f_c = 647 \text{ MHz and } \lambda = 46.3 \text{ cm}$$

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

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

$$\text{reflector length } l_1' = 0.48\lambda = 22.24 \text{ cm}$$

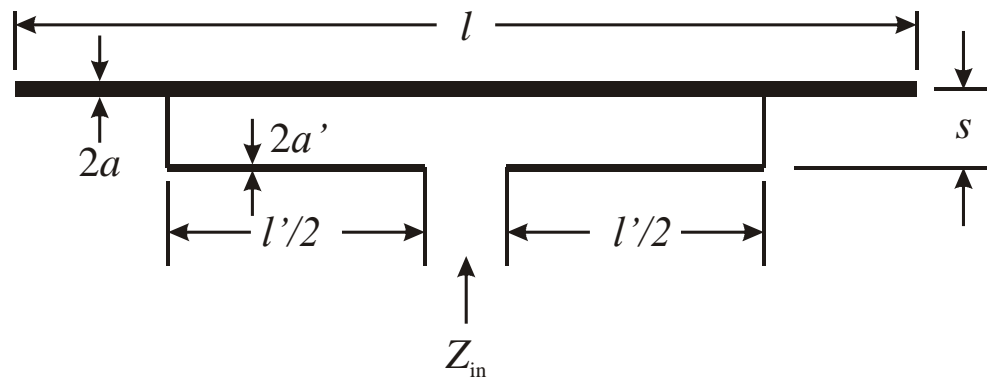
$$\text{director lengths } l_3' = l_5' = 0.419\lambda = 19.41 \text{ cm}$$

$$\text{director length } l_4' = 0.412\lambda = 19.09 \text{ cm}$$

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

From NEC-2,  $Z_a = 17.35 + j 20.59 \Omega$  and Gain = 11.265 dBi

**T-Match:**



**First attempt at T-Match:**

Select T-Match diameter  $2a' = 0.125'' = 0.3175 \text{ cm} \Rightarrow a' = 0.15875 \text{ cm}$

Select T-Match spacing  $s = 2 \text{ cm}$  and length  $l' = 9 \text{ cm}$

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

$$Z_a = 14.1 - j 12.86 \Omega \quad \& \quad \text{Gain} = 11.33 \text{ dBi}$$

$Z_0 = 260.3 \Omega$ ,  $\alpha = 1.367$ ,  $a_e = 0.667 \text{ cm}$ ,  $Z_{in} = 114.7 - j 58.7 \Omega$  which yields  $|\Gamma| = 0.27$ ,  $VSWR = 1.75 > 1.1$  (high), & suggested  $l' = 4.4 \text{ cm}$

**NEC input file for first T-Match attempt:**

```

CM Yagi-Uda Antenna for UHF channel 43
CM THIS PROGRAM ASSUMES THAT THERE IS 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 0.4634m.
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 center portion of driven element (T-Match)
CM is ae=0.00666 m which has a length of
CM l'=0.09m < 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=(l1+l3)/2=0.45 l= 0.2085m
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 #9 on l2.
GW 1 17 -0.1112 0.0 0.0 0.1112 0.0 0.0 0.003175 ← Reflector
GW 2 5 -0.10425 0.0 0.09267 -0.045 0.0 0.09267 0.003175
GW 3 7 -0.045 0.0 0.09267 0.045 0.0 0.09267 0.00666 } Driven
GW 4 5 0.045 0.0 0.09267 0.10425 0.0 0.09267 0.003175
GW 5 15 -0.09705 0.0 0.18534 0.09705 0.0 0.18534 0.003175
GW 6 15 -0.09545 0.0 0.27801 0.09545 0.0 0.27801 0.003175 } Directors
GW 7 15 -0.09705 0.0 0.37068 0.09705 0.0 0.37068 0.003175
GE 0 0
FR 0 1 0 0 647 0
EX 0 3 4 0 1.0 0.0
RP 0 2 2 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0
EN

```

### NEC output file for first T-Match attempt:

\*\*\*\*\*

Yagi-Uda Antenna for UHF channel 43  
THIS PROGRAM ASSUMES THAT THERE IS 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 0.4634m.

THE DIMENSIONS ARE:

element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in,  
equivalent radius of center portion of driven element (T-Match)  
is ae=0.00666 m which has a length of  
l'=0.09 < l2

l1=0.48 l=0.2224m, l3=l5=0.419 l=0.1941m, l4=0.412 l=0.1909m,  
driven element l2=(l1+l3)/2=0.45 l= 0.2085m  
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 - - -

WIRE NO.	X1	Y1	Z1	X2	Y2	Z2	RADIUS	SEG.	SEG.	SEG.	NO.
1	-0.11120	0.0	0.0	0.11120	0.0	0.0	0.00317	17	1	17	1
2	-0.10425	0.0	0.09267	-0.04500	0.0	0.09267	0.00317	5	18	22	2
3	-0.04500	0.0	0.09267	0.04500	0.0	0.09267	0.00666	7	23	29	3
4	0.04500	0.0	0.09267	0.10425	0.0	0.09267	0.00317	5	30	34	4
5	-0.09705	0.0	0.18534	0.09705	0.0	0.18534	0.00317	15	35	49	5
6	-0.09545	0.0	0.27801	0.09545	0.0	0.27801	0.00317	15	50	64	6
7	-0.09705	0.0	0.37068	0.09705	0.0	0.37068	0.00317	15	65	79	7

TOTAL SEGMENTS USED= 79 NO. SEG. IN A SYMMETRIC CELL= 79 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 4 0 1.0 0.0 0.0 0.0 0.0 0.0

\*\*\*\*\* INPUT LINE 3 RP 0 2 2 0 0.0 0.0 1.80E+02 9.00000E+01 0.0 0.0

- - - FREQUENCY - - -

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

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE		IMPEDANCE (OHMS)		ADMITTANCE (MHOS)	
		REAL	IMAG.	REAL	IMAG.	REAL	IMAG.
3	26	1.0	0.0	1.41289E+01	-1.29563E+01	3.87189E-02	3.52313E-02

- - - RADIATION PATTERNS - - -

THETA DEG	PHI DEG	Gain DB
0.00	0.00	11.32992
180.00	0.00	-0.33110

*Z<sub>a</sub> = 14.13 - j17.86 Ω*

\*\*\*\*\* 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 T-Match attempt:****T-Match equations**

$$c := 2.9979 \cdot 10^8 \quad fc := 647 \cdot 10^6 \quad \lambda := \frac{c}{fc} \quad \lambda = 0.46335$$

$$k := \frac{2 \cdot \pi}{\lambda} \quad k = 13.56023 \quad Z_{\text{desired}} := 100 \quad \text{Ohms}$$

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

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

$$s := 2 \cdot 10^{-2} \quad \text{m}$$

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

$$u := \frac{a}{a_{\text{prime}}} \quad u = 2 \quad v := \frac{s}{a_{\text{prime}}} \quad v = 12.59843$$

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

$$ae := a_{\text{prime}} \cdot e^{\frac{1}{(1+u)^2} \cdot \left( u^2 \cdot \ln(u) + 2 \cdot u \cdot \ln(v) \right)}$$

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

$$l_{\text{prime}} := 9.0 \cdot 10^{-2}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 182.03011i \quad \approx \quad Y_t := \frac{1}{Z_t} \quad Y_t = -5.494 \cdot 10^{-3}i$$

$$\frac{Y_t}{2} = -2.747 \cdot 10^{-3}i$$

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

$$Z_a := 14.1289 - j \cdot 12.8563 \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.03872 + 0.03523i$$

$$Y_{\text{in}} := \frac{Y_t}{2} + \frac{Y_a}{(1+\alpha)^2} \quad Y_{\text{in}} = 6.908 \cdot 10^{-3} + 3.539 \cdot 10^{-3}i \quad \frac{1}{Z_{\text{desired}}} = 0.01$$

$$Z_{\text{in}} := \frac{1}{Y_{\text{in}}} \quad Z_{\text{in}} = 114.666 - 58.744i \quad Z_{\text{desired}} = 100$$

$$\Gamma := \frac{(Z_{\text{in}} - Z_{\text{desired}})}{Z_{\text{in}} + Z_{\text{desired}}} \quad \Gamma = 0.133 - 0.237i \quad |\Gamma| = 0.272$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \text{VSWR} = 1.747 \quad \leftarrow \text{Too High}$$

$$l_{\text{suggested}} := \frac{2}{k} \cdot \text{atan} \left[ \frac{1}{2 \cdot Z_0 \cdot \text{Im} \left[ \frac{Y_a}{(1+\alpha)^2} \right]} \right]$$

$$l_{\text{suggested}} = 0.04374 \quad l_{\text{suggested}} \cdot 0.5 = 0.022$$

*↑ shorten l'*

**Second attempt at T-Match:**

Leave T-Match diameter  $2a' = 0.125'' = 0.3175 \text{ cm} \Rightarrow a' = 0.15875 \text{ cm}$

Leave T-Match spacing  $s = 2 \text{ cm}$

Change T-Match length to  $l' = 6.5 \text{ cm}$

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

$Z_a = 14.84 - j 8.397 \Omega$  & Gain = 11.37 dBi

$Z_0 = 260.3 \Omega$ ,  $\alpha = 1.367$ ,  $a_e = 0.667 \text{ cm}$ ,  $Z_{in} = 108.3 - j 12.85 \Omega$  which yields  $|\Gamma| = 0.073$ , VSWR = 1.16 > 1.1 (high), & suggested  $l' = 5.3 \text{ cm}$

**NEC input file for second T-Match attempt:**

```

CM Yagi-Uda Antenna for UHF channel 43
CM THIS PROGRAM ASSUMES THAT THERE IS 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 0.4634m.
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 center portion of driven element (T-Match)
CM is ae=0.00666 m which has a length of
CM l'=0.065m < 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=(l1+l3)/2=0.45 l= 0.2085m
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 #9 on l2.
GW 1 17 -0.1112 0.0 0.0 0.1112 0.0 0.0 0.003175
GW 2 6 -0.10425 0.0 0.09267 -0.0325 0.0 0.09267 0.003175
GW 3 5 -0.0325 0.0 0.09267 0.0325 0.0 0.09267 0.00666
GW 4 6 0.0325 0.0 0.09267 0.10425 0.0 0.09267 0.003175
GW 5 15 -0.09705 0.0 0.18534 0.09705 0.0 0.18534 0.003175
GW 6 15 -0.09545 0.0 0.27801 0.09545 0.0 0.27801 0.003175
GW 7 15 -0.09705 0.0 0.37068 0.09705 0.0 0.37068 0.003175
GE 0 0
FR 0 1 0 0 647 0
EX 0 3 3 0 1.0 0.0
RP 0 2 2 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0
EN

```

### NEC output file for second T-Match attempt:

\*\*\*\*\*

Yagi-Uda Antenna for UHF channel 43  
THIS PROGRAM ASSUMES THAT THERE IS 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 0.4634m.

THE DIMENSIONS ARE:  
element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in,  
equivalent radius of center portion of driven element (T-Match)  
is ae=0.00666 m which has a length of l'=0.065 < l2

l1=0.48 l=0.2224m, l3=l5=0.419 l=0.1941m, l4=0.412 l=0.1909m,  
driven element l2=(l1+l3)/2=0.45 l= 0.2085m  
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	SEG.	SEG.	SEG.	NO.
1	-0.11120	0.0	0.0	0.11120	0.0	0.0	0.00317	17	1	17	1
2	-0.10425	0.0	0.09267	-0.03250	0.0	0.09267	0.00317	6	18	23	2
3	-0.03250	0.0	0.09267	0.03250	0.0	0.09267	0.00666	5	24	28	3
4	0.03250	0.0	0.09267	0.10425	0.0	0.09267	0.00317	6	29	34	4
5	-0.09705	0.0	0.18534	0.09705	0.0	0.18534	0.00317	15	35	49	5
6	-0.09545	0.0	0.27801	0.09545	0.0	0.27801	0.00317	15	50	64	6
7	-0.09705	0.0	0.37068	0.09705	0.0	0.37068	0.00317	15	65	79	7

TOTAL SEGMENTS USED=79 NO. SEG. IN A SYMMETRIC CELL=79 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 3 0 1.0 0.0 0.0 0.0 0.0 0.0
**** INPUT LINE 3 RP 0 2 2 0 0.0 0.0 1.80E+02 9.0E+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 (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.
3	26	1.0	0.0	1.48402E+01	-8.39722E+00	5.10421E-02	2.88818E-02

- - - RADIATION PATTERNS - - -

THETA DEG	PHI DEG	Gain DB
0.00	0.00	11.37197
180.00	0.00	-0.31343

```

**** 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 T-Match attempt:

### T-Match equations

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

$$k := \frac{2 \cdot \pi}{\lambda} \quad k = 13.56023 \quad Z_{\text{desired}} := 100 \quad \text{Ohms}$$

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

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

$$s := 2 \cdot 10^{-2} \quad \text{m}$$

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

$$u := \frac{a}{a_{\text{prime}}} \quad u = 2 \quad v := \frac{s}{a_{\text{prime}}} \quad v = 12.59843$$

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

$$ae := a_{\text{prime}} \cdot e^{\frac{1}{(1+u)^2} \cdot (u^2 \cdot \ln(u) + 2 \cdot u \cdot \ln(v))}$$

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

$$l_{\text{prime}} := 6.5 \cdot 10^{-2} \quad \text{m}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 122.78272i \quad Y_t := \frac{1}{Z_t} \quad Y_t = -8.144 \cdot 10^{-3} i$$

$$\frac{Y_t}{2} = -4.072 \cdot 10^{-3} i$$

### Za from NEC (a MoM program)

$$Z_a := 14.8402 - j \cdot 8.39722 \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.05104 + 0.02888i \quad Z_{\text{desired}} = 100$$

$$Y_{\text{in}} := \frac{Y_t}{2} + \frac{Y_a}{(1+u)^2} \quad Y_{\text{in}} = 9.107 \cdot 10^{-3} + 1.081 \cdot 10^{-3} i \quad \frac{1}{Z_{\text{desired}}} = 0.01$$

$$Z_{\text{in}} := \frac{1}{Y_{\text{in}}} \quad Z_{\text{in}} = 108.286 - 12.85i \quad \text{Ohms} \quad Z_{\text{desired}} = 100 \quad \text{Ohms}$$

$$\Gamma := \frac{(Z_{\text{in}} - Z_{\text{desired}})}{Z_{\text{in}} + Z_{\text{desired}}} \quad \Gamma = 0.043 - 0.059i \quad |\Gamma| = 0.073$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \text{VSWR} = 1.158 \quad \leftarrow \text{Too High}$$

$$l_{\text{suggested}} := \frac{2}{k} \cdot \text{atan} \left[ \frac{1}{2 \cdot Z_0 \cdot \text{Im} \left[ \frac{Y_a}{(1+u)^2} \right]} \right]$$

$$l_{\text{suggested}} = 0.05262 \quad l_{\text{suggested}} \cdot 0.5 = 0.026$$

↑  
Shorten l'

### Third attempt at T-Match:

Leave T-Match diameter  $2a' = 0.125'' = 0.3175 \text{ cm} \Rightarrow a' = 0.15875 \text{ cm}$

Leave T-Match spacing  $s = 2 \text{ cm}$

Change T-Match length to  $l' = 6 \text{ cm}$

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

$Z_a = 14.97 - j 7.08 \Omega$  & Gain = 11.4 dBi

$Z_0 = 260.3 \Omega$ ,  $\alpha = 1.367$ ,  $a_e = 0.667 \text{ cm}$ ,  $Z_{in} = 102.7 - j 1.5 \Omega$  which yields  $|\Gamma| = 0.015$ , VSWR = 1.03 < 1.1 **Meets spec!**

### NEC input file for third T-Match attempt:

```

CM Yagi-Uda Antenna for UHF channel 43
CM THIS PROGRAM ASSUMES THAT THERE IS 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 0.4634m.
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 center portion of driven element (T-Match)
CM is ae=0.00666 m which has a length of
CM l'=0.06m < 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=(l1+l3)/2=0.45 l= 0.2085m
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 #9 on l2.
GW 1 17 -0.1112 0.0 0.0 0.1112 0.0 0.0 0.003175
GW 2 6 -0.10425 0.0 0.09267 -0.03 0.0 0.09267 0.003175
GW 3 5 -0.03 0.0 0.09267 0.03 0.0 0.09267 0.00666
GW 4 6 0.03 0.0 0.09267 0.10425 0.0 0.09267 0.003175
GW 5 15 -0.09705 0.0 0.18534 0.09705 0.0 0.18534 0.003175
GW 6 15 -0.09545 0.0 0.27801 0.09545 0.0 0.27801 0.003175
GW 7 15 -0.09705 0.0 0.37068 0.09705 0.0 0.37068 0.003175
GE 0 0
FR 0 1 0 0 647 0
EX 0 3 3 0 1.0 0.0
RP 0 2 2 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0
EN

```



### NEC output file for third T-Match attempt:

\*\*\*\*\*

Yagi-Uda Antenna for UHF channel 43  
THIS PROGRAM ASSUMES THAT THERE IS 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 0.4634m.

THE DIMENSIONS ARE:  
element diameter d=0.635cm=0.25in, radius a=d/2=0.3175cm=0.125in,  
equivalent radius of center portion of driven element (T-Match)  
is ae=0.00666 m which has a length of l'=0.06 < l2

l1=0.48 l=0.2224m, l3=l5=0.419 l=0.1941m, l4=0.412 l=0.1909m,  
driven element l2=(l1+l3)/2=0.45 l= 0.2085m  
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	SEG.	SEG.	SEG.	NO.
1	-0.11120	0.0	0.0	0.11120	0.0	0.0	0.0	0.00317	17	1	17
2	-0.10425	0.0	0.09267	-0.03000	0.0	0.0	0.0	0.09267	0.00317	6	18
3	-0.03000	0.0	0.09267	0.03000	0.0	0.0	0.0	0.09267	0.00666	5	24
4	0.03000	0.0	0.09267	0.10425	0.0	0.0	0.0	0.09267	0.00317	6	29
5	-0.09705	0.0	0.18534	0.09705	0.0	0.0	0.0	0.18534	0.00317	15	35
6	-0.09545	0.0	0.27801	0.09545	0.0	0.0	0.0	0.27801	0.00317	15	50
7	-0.09705	0.0	0.37068	0.09705	0.0	0.0	0.0	0.37068	0.00317	15	65

TOTAL SEGMENTS USED= 79 NO. SEG. IN A SYMMETRIC CELL= 79 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 3 0 1.00 0.0 0.0 0.0 0.0 0.0
**** INPUT LINE 3 RP 0 2 2 0 0.0 0.0 1.80E+02 9.0E+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 (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.
3	26	1.0	0.0	1.49736E+01	-7.07901	5.45842E-02	2.58056E-02

- - - RADIATION PATTERNS - - -

```

THETA PHI Gain
DEGREES DEGREES DB
0.00 0.00 11.38537
180.00 0.00 -0.30466

```

```

**** 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 third T-Match attempt:

T-Match equations

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

$$k := \frac{2 \cdot \pi}{\lambda} \quad k = 13.56023 \quad Z_{\text{desired}} := 100 \quad \text{Ohms}$$

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

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

$$s := 2 \cdot 10^{-2} \quad \text{m}$$

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

$$u := \frac{a}{a_{\text{prime}}} \quad u = 2 \quad v := \frac{s}{a_{\text{prime}}} \quad v = 12.59843$$

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

$$ae := a_{\text{prime}} \cdot e^{\frac{1}{(1+u)^2} \cdot (u^2 \cdot \ln(u) + 2 \cdot u \cdot \ln(v))}$$

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

$$l_{\text{prime}} := 6.0 \cdot 10^{-2} \quad \text{m}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 112.16003i \quad Y_t := \frac{1}{Z_t} \quad Y_t = -8.916 \cdot 10^{-3} i$$

$$\frac{Y_t}{2} = -4.458 \cdot 10^{-3} i$$

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

$$Z_a := 14.9736 - j \cdot 7.07901 \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.05458 + 0.02581i$$

$$Y_{\text{in}} := \frac{Y_t}{2} + \frac{Y_a}{(1 + \alpha)^2} \quad Y_{\text{in}} = 9.739 \cdot 10^{-3} + 1.461 \cdot 10^{-4} i \quad \frac{1}{Z_{\text{desired}}} = 0.01$$

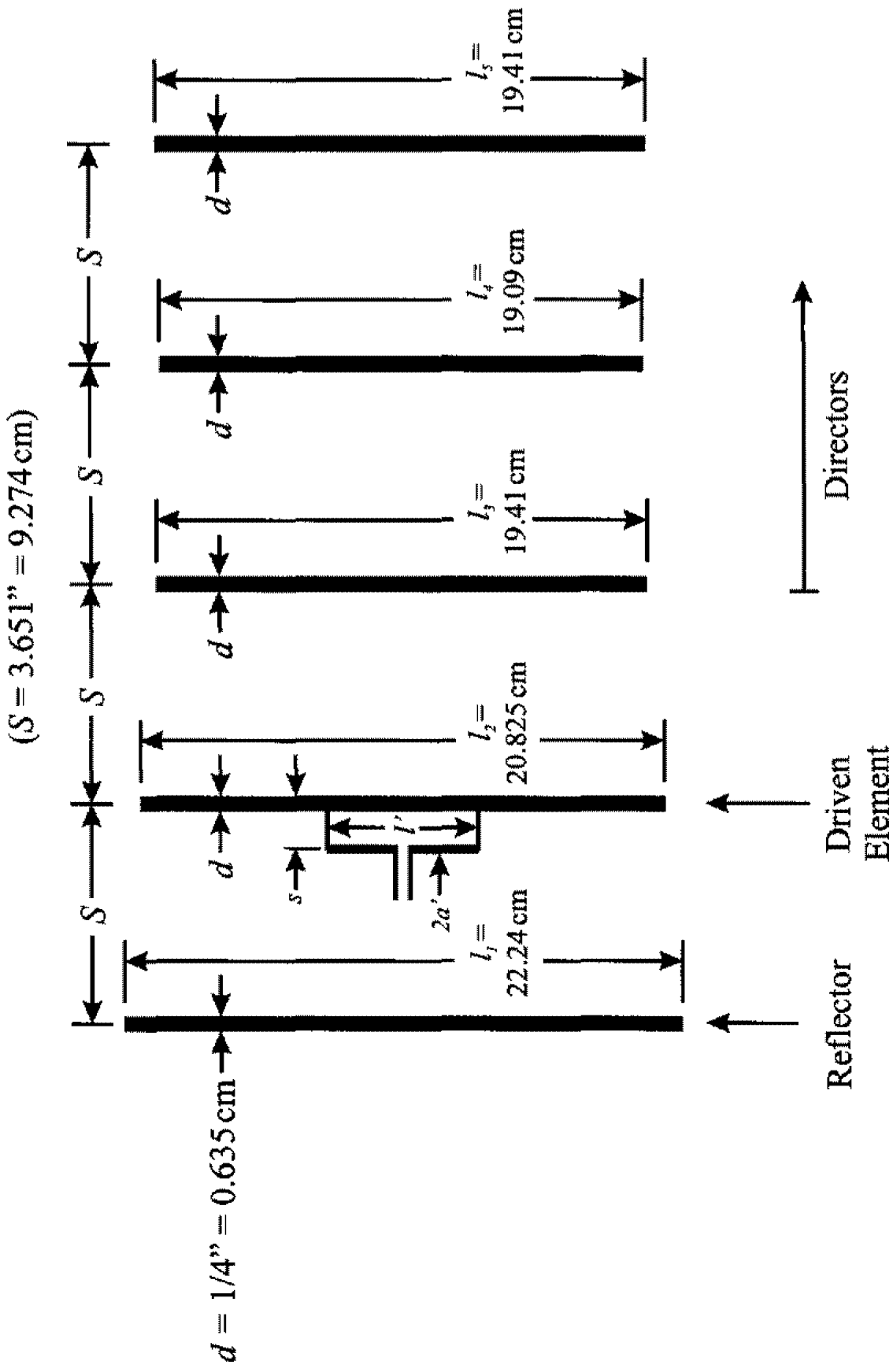
$$Z_{\text{in}} := \frac{1}{Y_{\text{in}}} \quad Z_{\text{in}} = 102.662 - 1.541i \quad \text{Ohms} \quad Z_{\text{desired}} = 100 \quad \text{Ohms}$$

$$\Gamma := \frac{(Z_{\text{in}} - Z_{\text{desired}})}{Z_{\text{in}} + Z_{\text{desired}}} \quad \Gamma = 0.013 - 7.501 \cdot 10^{-3} i \quad |\Gamma| = 0.015$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \text{VSWR} = 1.031 \quad \leftarrow \text{Good Enough}$$

$$l_{\text{suggested}} := \frac{2}{k} \cdot \text{atan} \left[ \frac{1}{2 \cdot Z_0 \cdot \text{Im} \left[ \frac{Y_a}{(1 + \alpha)^2} \right]} \right] \quad l_{\text{suggested}} = 0.05829 \quad l_{\text{suggested}} \cdot 0.5 = 0.029$$

# 5 element, channel 43 Yagi-Uda antenna w/ T-Match



T-Match Dimensions:  $2a' = 1/8'' = 0.3175 \text{ cm}$ ,  $s = 2 \text{ cm}$ ,  $l' = 6 \text{ cm}$