

**Example:** Use a modified 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:**

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

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

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

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

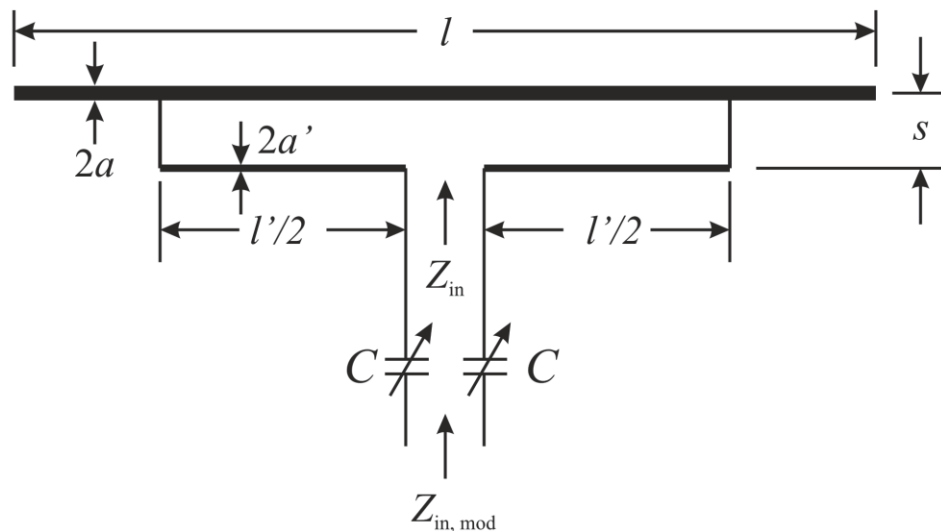
$$\text{director lengths } l_3' = l_5' = 0.419\lambda = 19.41 \text{ cm}$$

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

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

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

**Modified or Resonant 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  $s = 1'' = 2.54 \text{ cm}$  and length  $l' = 3.5'' = 9 \text{ cm}$

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

- For T-match (MathCad):  $Z_0 = 289.734 \Omega$ , current division factor  $\alpha = 1.32867$ , effective radius  $a_e = 0.74075 \text{ cm}$ , & transmission line mode input impedance  $Z_t = j202.591 \Omega$
- From NEC:  $Z_a = 15.4971 - j 15.544 \Omega$  & Gain = 11.14 dBi
- Using MathCad:  $Z_{in, T-match} = 125.325 - j 73.579 \Omega$ . Since the reactance is capacitive, using a modified T-match would make things worse, i.e., do NOT add series capacitors. With this input impedance,  $|\Gamma| = 0.328$ , VSWR = 1.977 > 1.1 (high), & suggested  $l' = 4.4 \text{ cm}$

**NEC input file for first modified 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 l=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=0.00741 m which has a length of l'=0.09m < l2
CM l1=0.481=0.2224m, l3=l5=0.4191=0.1941m, l4=0.4121=0.1909m,
CM driven element l2=0.46 l= 0.211m
CM ELEMENT SPACINGS Sij=0.2 l=0.09267m
CM SELECT SEGMENT LENGTH OF APPROX. 1.25cm=0.025 l
CM THE DRIVEN SEGMENT IS #9 on l2.
CE
GW 1 17 -0.115 0.0 0.0 0.115 0.0 0.0 0.003175
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 0.00741
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
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 3 0000 0.0 0.0 180.0 90.0
PT -1
XQ 0
EN

```

# NEC output file for first modified 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  $d=0.635\text{cm}=0.25\text{in}$ , radius  $a=d/2=0.3175\text{cm}=0.125\text{in}$ ,  
equivalent radius of center portion of driven element (T-Match)  
is  $a_e=0.00741\text{ m}$  which has a length of  $l'=0.09\text{ m} < l_2$

$l_1=0.48\text{ m}$   $l_2=0.2224\text{m}$ ,  $l_3=l_5=0.419\text{ m}$   $l_4=0.1941\text{m}$ ,  $l_6=0.412\text{ m}$   $l_7=0.1909\text{m}$ ,

driven element  $l_8=0.46\text{ m}$   $l_9=0.211\text{m}$

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  $l_2$ .

*Handwritten note in a box: "1st TRY"*

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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	SEG. NO.	SEG. NO.	SEG. NO.	NO.
1	-0.11500	0.0	0.0	0.11500	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	0.00741	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 6.470E+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 3 0 0.0 0.0 1.80E+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 (VOLTS) REAL	IMAG.	IMPEDANCE (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.
3	26	1.0	0.0	1.54971E+01	-1.55440E+01	3.21666E-02	3.22640E-02

- - - RADIATION PATTERNS - - -

THETA DEGREES	PHI DEGREES	Gain DB
0.00	0.00	11.14139
180.00	0.00	0.77669

*Z<sub>ant</sub>*

\*\*\*\*\* 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 modified T-Match attempt:**

**Modified T-Match equations**

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

$Z_{desired} := 100 \text{ Ohms}$      $d := 0.635 \cdot 10^{-2} \text{ m}$      $a := d \cdot 0.5$      $a = 0.003175 \text{ m}$

$d_{prime} := 0.3175 \cdot 10^{-2} \text{ m}$      $a_{prime} := d_{prime} \cdot 0.5$      $a_{prime} = 0.0015875 \text{ m}$      $s := 2.54 \cdot 10^{-2} \text{ m}$

$Z_0 := \frac{376.73}{2 \cdot \pi} \cdot \text{acosh} \left[ \frac{(s^2 - a^2 - a_{prime}^2)}{2 \cdot a \cdot a_{prime}} \right]$      $Z_0 = 289.734 \text{ Ohms}$      $u := \frac{a}{a_{prime}}$      $v := \frac{s}{a_{prime}}$

$u = 2$      $v = 16$

$\alpha := \frac{\text{acosh} \left[ \frac{(v^2 - u^2 + 1)}{2 \cdot v} \right]}{\text{acosh} \left[ \frac{(v^2 + u^2 - 1)}{2 \cdot v \cdot u} \right]}$      $\alpha = 1.32827$      $ae := a_{prime} \cdot e^{\frac{1}{(1+u)^2} \cdot (u^2 \cdot \ln(u) + 2 \cdot v \cdot \ln(v))}$

$ae = 0.00741$      $ae \cdot 100 = 0.74075 \text{ cm}$

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

$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{prime}}{2} \right)$      $Z_t = 202.59106i$      $Y_t := \frac{1}{Z_t}$      $Y_t = -4.936 \cdot 10^{-3} i$

$\frac{Y_t}{2} = -2.468 \cdot 10^{-3} i$

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

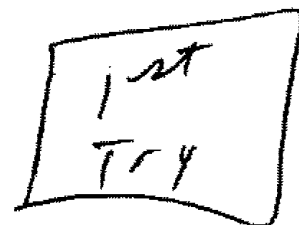
$Z_a := 15.4971 + j \cdot -15.544 \text{ Ohms}$      $Y_a := \frac{1}{Z_a}$      $Y_a = 0.03217 + 0.03226i \text{ Mhos}$

$Y_{int} := \frac{Y_t}{2} + \frac{Y_a}{(1 + \alpha)^2}$      $Y_{int} = 5.934 \cdot 10^{-3} + 3.484 \cdot 10^{-3} i$      $\frac{1}{Z_{desired}} = 0.01 \text{ Mhos}$

$Z_{int} := \frac{1}{Y_{int}}$      $Z_{int} = 125.325 - 73.579i \text{ Ohms}$      $Z_{desired} = 100 \text{ Ohms}$

$C := \text{if} \left( \text{Im}(Z_{int}) > 0, \frac{1}{\pi \cdot f_c \cdot \text{Im}(Z_{int})}, 0 \right)$      $C = 0$

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



$Z_{in} := 2 \cdot Z_{cap} + Z_{int}$      $Z_{in} = 125.325 - 73.579i \text{ Ohms}$

$\Gamma := \frac{(Z_{in} - Z_{desired})}{Z_{in} + Z_{desired}}$      $\Gamma = 0.198 - 0.262i$      $|\Gamma| = 0.328$

$VSWR := \frac{(1 + |\Gamma|)}{1 - |\Gamma|}$      $VSWR = 1.977$

## Second attempt at modified T-Match:

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

Leave T-Match spacing  $s = 2.54 \text{ cm}$

Change T-Match length to  $l' = 10 \text{ cm}$  **and** change driven element length to  $l_2' = 21.8 \text{ cm} = 0.47\lambda$  in hope of giving  $Z_{\text{in,T-match}}$  an inductive reactance.

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

- For T-match (MathCad):  $Z_0 = 289.734 \Omega$ ,  $\alpha = 1.32867$ ,  $a_e = 0.741 \text{ cm}$ , & transmission line mode input impedance  $Z_i = j233.345 \Omega$
- From NEC:  $Z_a = 16.4017 + j 1.7047 \Omega$  & Gain = 11.335 dBi
- Using MathCad:  $Z_{\text{in,T-match}} = 82.609 + j 24.494 \Omega$ . Since the reactance is inductive, add series capacitors with  $2Z_{\text{cap}} = -j 24.494 \Omega$  ( $C = 20.1 \text{ pF}$ ).  
Now,  $Z_{\text{in,MT-match}} = 82.609$ ,  $|\Gamma| = 0.095$ , and VSWR = 1.211 > 1.1 (high).

## NEC input file for second modified 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=0.00741 m which has a length of l'=0.1m < l2
CM
CM l1=0.481=0.2224m, l3=l5=0.419 l=0.1941m, l4=0.4121=0.1909m,
CM driven element l2=0.471= 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 #9 on l2.
GW 1 17 -0.1112 0.0 0.0 0.1112 0.0 0.0 0.003175
GW 2 5 -0.109 0.0 0.09267 -0.05 0.0 0.09267 0.003175
GW 3 7 -0.05 0.0 0.09267 0.05 0.0 0.09267 0.00741
GW 4 5 0.05 0.0 0.09267 0.109 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 4 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 modified 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  $d=0.635\text{cm}=0.25\text{in}$ , radius  $a=d/2=0.3175\text{cm}=0.125\text{in}$ ,  
equivalent radius of center portion of driven element (T-Match)  
is  $a_e=0.00741\text{ m}$  which has a length of  $l'=0.1\text{ m} < l_2$

$l_1=0.48\text{ m}$   $l=0.2224\text{m}$ ,  $l_3=l_5=0.419\text{ m}$   $l=0.1941\text{m}$ ,  $l_4=0.412\text{ m}$   $l=0.1909\text{m}$ ,  
driven element  $l_2=0.47\text{ m}$   $l=0.218\text{m}$

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

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

THE DRIVEN SEGMENT IS #9 on 12.

Try 2

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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	FIRST X2	LAST Y2	TAG 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	-0.10900	0.0	0.09267	-0.05000	0.0	0.09267	0.00317	5	18	22	2
3	-0.05000	0.0	0.09267	0.05000	0.0	0.09267	0.00741	7	23	29	3
4	0.05000	0.0	0.09267	0.10900	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  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 (VOLTS) REAL	IMAG.	IMPEDANCE (OHMS) REAL	IMAG.	ADMITTANCE (MHOS) REAL	IMAG.
3	26	1.0	0.0	1.64017E+01	1.70470E+00	6.03178E-02	-6.26911E-03

- - - RADIATION PATTERNS - - -

THETA DEGREES	PHI DEGREES	Gain DB
0.00	0.00	11.33515
180.00	0.00	-0.36647

```

***** 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 modified T-Match attempt:****Modified T-Match equations**

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

$$Z_{\text{desired}} := 100 \text{ Ohms} \quad d := 0.635 \cdot 10^{-2} \text{ m} \quad a := d \cdot 0.5 \quad a = 0.003175 \text{ m}$$

$$d_{\text{prime}} := 0.3175 \cdot 10^{-2} \text{ m} \quad a_{\text{prime}} := d_{\text{prime}} \cdot 0.5 \quad a_{\text{prime}} = 0.0015875 \text{ m} \quad s := 2.54 \cdot 10^{-2} \text{ m}$$

$$Z_0 := \frac{376.73}{2 \cdot \pi} \cdot \operatorname{acosh} \left[ \frac{(s^2 - a^2 - a_{\text{prime}}^2)}{2 \cdot a \cdot a_{\text{prime}}} \right] \quad Z_0 = 289.734 \text{ Ohms} \quad u := \frac{a}{a_{\text{prime}}} \quad v := \frac{s}{a_{\text{prime}}}$$

$$u = 2 \quad v = 16$$

$$\alpha := \frac{\operatorname{acosh} \left[ \frac{(v^2 - u^2 + 1)}{2 \cdot v} \right]}{\operatorname{acosh} \left[ \frac{(v^2 + u^2 - 1)}{2 \cdot v \cdot u} \right]} \quad \alpha = 1.32827 \quad ae := a_{\text{prime}} \cdot e^{\frac{1}{(1+u)^2} \cdot (u^2 \cdot \ln(u) + 2 \cdot u \cdot \ln(v))}$$

$$ae = 0.00741 \quad ae \cdot 100 = 0.74075 \text{ cm}$$

$$l_{\text{prime}} := 10.0 \cdot 10^{-2} \text{ m}$$

$$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{\text{prime}}}{2} \right) \quad Z_t = 233.34507i \quad Y_t := \frac{1}{Z_t} \quad Y_t = -4.285 \cdot 10^{-3} i$$

$$\frac{Y_t}{2} = -2.143 \cdot 10^{-3} i$$

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

$$Z_a := 16.4017 + j \cdot 1.7047 \text{ Ohms} \quad Y_a := \frac{1}{Z_a} \quad Y_a = 0.06032 - 0.00627i \text{ Mhos}$$

$$Y_{\text{int}} := \frac{Y_t}{2} + \frac{Y_a}{(1 + \alpha)^2} \quad Y_{\text{int}} = 0.011 - 3.299 \cdot 10^{-3} i \quad \frac{1}{Z_{\text{desired}}} = 0.01 \text{ Mhos}$$

$$Z_{\text{int}} := \frac{1}{Y_{\text{int}}} \quad Z_{\text{int}} = 82.609 + 24.494i \text{ Ohms} \quad Z_{\text{desired}} = 100 \text{ Ohms}$$

$$C := \operatorname{if} \left( \operatorname{Im}(Z_{\text{int}}) > 0, \frac{1}{\pi \cdot fc \cdot \operatorname{Im}(Z_{\text{int}})}, 0 \right) \quad C = 2.009 \cdot 10^{-11}$$

$$Z_{\text{cap}} := \operatorname{if} \left( C > 0, \frac{1}{j \cdot 2 \cdot \pi \cdot fc \cdot C}, 0 \right) \quad Z_{\text{cap}} = -12.247i \text{ Ohms}$$

Zad  
T/Y

$$Z_{\text{in}} := 2 \cdot Z_{\text{cap}} + Z_{\text{int}} \quad Z_{\text{in}} = 82.609 \text{ Ohms}$$

$$\Gamma := \frac{(Z_{\text{in}} - Z_{\text{desired}})}{Z_{\text{in}} + Z_{\text{desired}}} \quad \Gamma = -0.095 \quad |\Gamma| = 0.095$$

$$\text{VSWR} := \frac{(1 + |\Gamma|)}{1 - |\Gamma|} \quad \text{VSWR} = 1.211$$

### Third attempt at modified T-Match:

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

Leave T-Match spacing  $s = 2.54 \text{ cm}$  and T-Match length  $l' = 10 \text{ cm}$

Change driven element length to  $l_2' = 21.7 \text{ cm} = 0.4683\lambda$  **and** reflector length  $l_1' = 23 \text{ cm}$  in hopes of increasing real part of  $Z_a$ .

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

- For T-match (MathCad):  $Z_0 = 289.734 \Omega$ ,  $\alpha = 1.32867$ ,  $a_e = 0.741 \text{ cm}$ , & transmission line mode input impedance  $Z_i = j233.345 \Omega$
- From NEC:  $Z_a = 18.3917 + j0.86962 \Omega$  & Gain = 11.155 dBi
- Using MathCad:  $Z_{in,T-match} = 93.531 + j24.448 \Omega$ . Since the reactance is inductive, add series capacitors with  $2Z_{cap} = -j24.448 \Omega$  ( $C = 20.12 \text{ pF}$ ).  
Now,  $Z_{in,MT-match} = 93.531$ ,  $|\Gamma| = 0.033$ , & VSWR = 1.069 < 1.1 (DONE).

### NEC input file for third modified 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=0.00741 m which has a length of l'=0.1m < l2
CM l1=0.23m, l3=l5=0.419 l=0.1941m, l4=0.412 l=0.1909m, and
CM driven element l2= 0.217m
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 -0.115 0.0 0.0 0.115 0.0 0.0 0.003175
GW 2 5 -0.1084 0.0 0.09267 -0.05 0.0 0.09267 0.003175
GW 3 7 -0.05 0.0 0.09267 0.05 0.0 0.09267 0.00741
GW 4 5 0.05 0.0 0.09267 0.1084 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 4 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 third modified 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  $d=0.635\text{cm}=0.25\text{in}$ , radius  $a=d/2=0.3175\text{cm}=0.125\text{in}$ ,  
equivalent radius of center portion of driven element (T-Match)  
is  $a_e=0.00741\text{ m}$  which has a length of  $l'=0.1\text{ m} < l_2$

$l_1=0.23\text{ m}$  ,  $l_3=l_5=0.419\text{ m}$   $l=0.1941\text{m}$ ,  $l_4=0.412\text{ m}$   $l=0.1909\text{m}$ ,  
driven element  $l_2=0.211\text{m}$

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

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

THE DRIVEN SEGMENT IS #9 on  $l_2$ .

3rd Try

\*\*\*\*\*

- - - 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	-0.11500	0.0	0.0	0.11500	0.0	0.0	0.00317	17	1	17	1
2	-0.10840	0.0	0.09267	-0.05000	0.0	0.0	0.09267	0.00317	5	18	22 2
3	-0.05000	0.0	0.09267	0.05000	0.0	0.0	0.09267	0.00741	7	23	29 3
4	0.05000	0.0	0.09267	0.10840	0.0	0.0	0.09267	0.00317	5	30	34 4
5	-0.09705	0.0	0.18534	0.09705	0.0	0.0	0.18534	0.00317	15	35	49 5
6	-0.09545	0.0	0.27801	0.09545	0.0	0.0	0.27801	0.00317	15	50	64 6
7	-0.09705	0.0	0.37068	0.09705	0.0	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 3 0 0.0 0.0 1.800E+02 9.0E+01 0.0 0.0

- - - FREQUENCY - - -

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

- - - ANTENNA INPUT PARAMETERS - - -

TAG NO.	SEG. NO.	VOLTAGE (VOLTS)	IMPEDANCE (OHMS)	ADMITTANCE (MHOS)			
		REAL	IMAG.	REAL	IMAG.		
3	26	1.0	0.0	1.83917E+01	8.69629E-01	5.42509E-02	-2.56518E-03

- - - RADIATION PATTERNS - - -

THETA DEGREES	PHI DEGREES	Gain DB
0.00	0.00	11.15446
180.00	0.00	0.71645

z<sub>ant</sub>

\*\*\*\*\* 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 modified T-Match attempt:**

**Modified T-Match equations**

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

$Z_{desired} := 100$  Ohms     $d := 0.635 \cdot 10^{-2}$  m     $a := d \cdot 0.5$      $a = 0.003175$  m

$d_{prime} := 0.3175 \cdot 10^{-2}$  m     $a_{prime} := d_{prime} \cdot 0.5$      $a_{prime} = 0.0015875$  m     $s := 2.54 \cdot 10^{-2}$  m

$Z_0 := \frac{376.73}{2 \cdot \pi} \cdot \operatorname{acosh} \left[ \frac{(s^2 - a^2 - a_{prime}^2)}{2 \cdot a \cdot a_{prime}} \right]$      $Z_0 = 289.734$  Ohms     $u := \frac{a}{a_{prime}}$      $v := \frac{s}{a_{prime}}$

$u = 2$      $v = 16$

$\alpha := \frac{\operatorname{acosh} \left[ \frac{(v^2 - u^2 + 1)}{2 \cdot v} \right]}{\operatorname{acosh} \left[ \frac{(v^2 + u^2 - 1)}{2 \cdot v \cdot u} \right]}$      $\alpha = 1.32827$      $ae := a_{prime} \cdot e^{\frac{1}{(1+u)^2} \cdot (u^2 \ln(u) + 2 \cdot u \cdot \ln(v))}$      $ae = 0.00741$      $ae \cdot 100 = 0.74075$  cm

$l_{prime} := 10.0 \cdot 10^{-2}$  m

$Z_t := j \cdot Z_0 \cdot \tan \left( \frac{k \cdot l_{prime}}{2} \right)$      $Z_t = 233.34507i$      $Y_t := \frac{1}{Z_t}$      $Y_t = -4.285 \cdot 10^{-3} i$

$\frac{Y_t}{2} = -2.143 \cdot 10^{-3} i$

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

$Z_a := 18.3917 + j \cdot 0.86962$  Ohms     $Y_a := \frac{1}{Z_a}$      $Y_a = 0.05425 - 0.00257i$  Mhos

$Y_{int} := \frac{Y_t}{2} + \frac{Y_a}{(1 + \alpha)^2}$      $Y_{int} = 0.01 - 2.616 \cdot 10^{-3} i$      $\frac{1}{Z_{desired}} = 0.01$  Mhos

$Z_{int} := \frac{1}{Y_{int}}$      $Z_{int} = 93.531 + 24.448i$  Ohms     $Z_{desired} = 100$  Ohms

$C := \operatorname{if} \left( \operatorname{Im}(Z_{int}) > 0, \frac{1}{\pi \cdot f_c \cdot \operatorname{Im}(Z_{int})}, 0 \right)$      $C = 2.012 \cdot 10^{-11}$

$Z_{cap} := \operatorname{if} \left( C > 0, \frac{1}{j \cdot 2 \cdot \pi \cdot f_c \cdot C}, 0 \right)$      $Z_{cap} = -12.224i$  Ohms

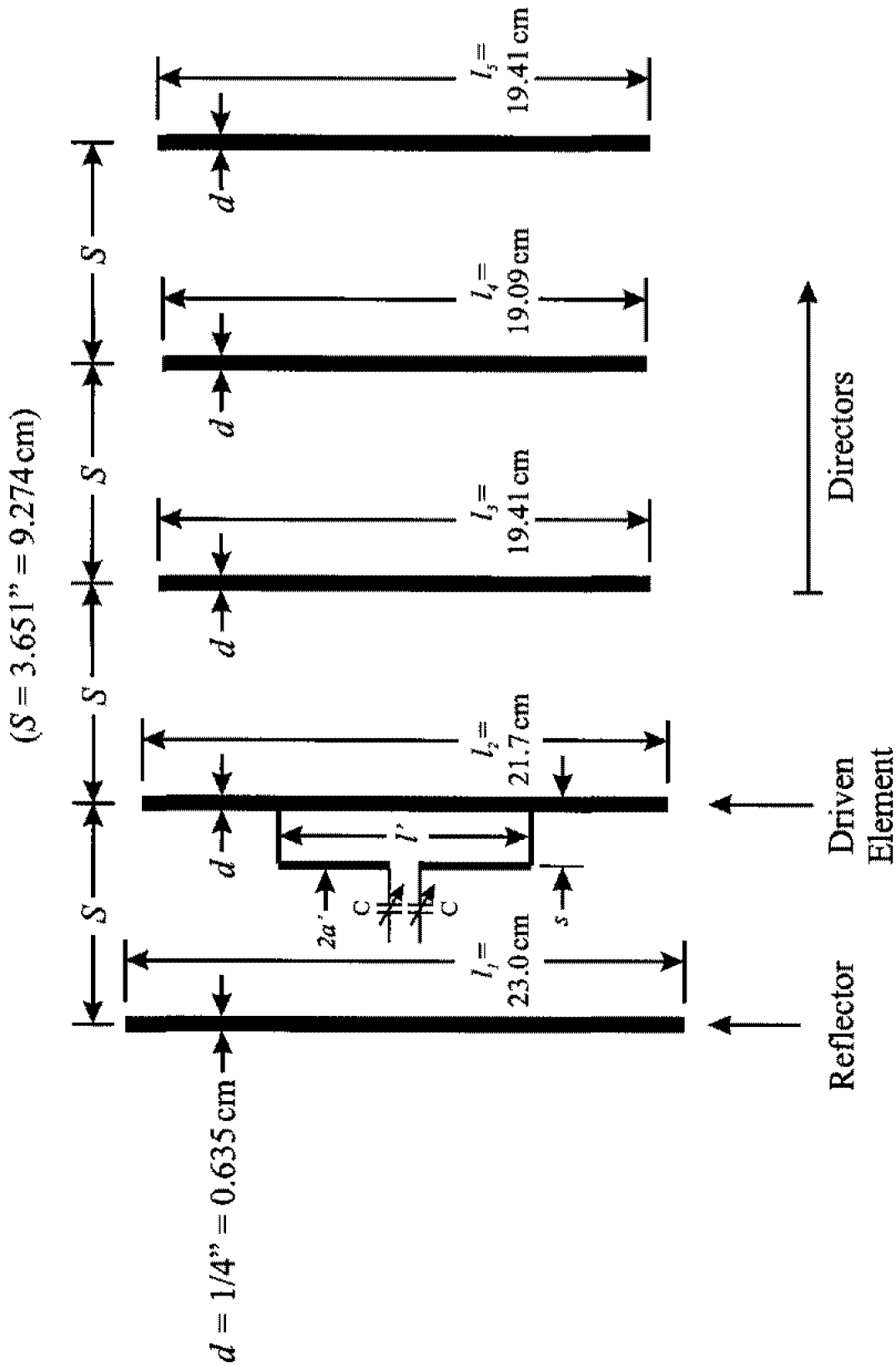
$Z_{in} := 2 \cdot Z_{cap} + Z_{int}$      $Z_{in} = 93.531$  Ohms

$\Gamma := \frac{(Z_{in} - Z_{desired})}{Z_{in} + Z_{desired}}$      $\Gamma = -0.033$      $|\Gamma| = 0.033$

$VSWR := \frac{(1 + |\Gamma|)}{1 - |\Gamma|}$      $VSWR = 1.069$     Done !

3rd  
TRY

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



Modified T-Match Dimensions:  $2a' = 1/8'' = 0.3175 \text{ cm}$ ,  $s = 2.54 \text{ cm}$ ,  $l' = 10 \text{ cm}$ , and  $C = 20.12 \text{ pF}$