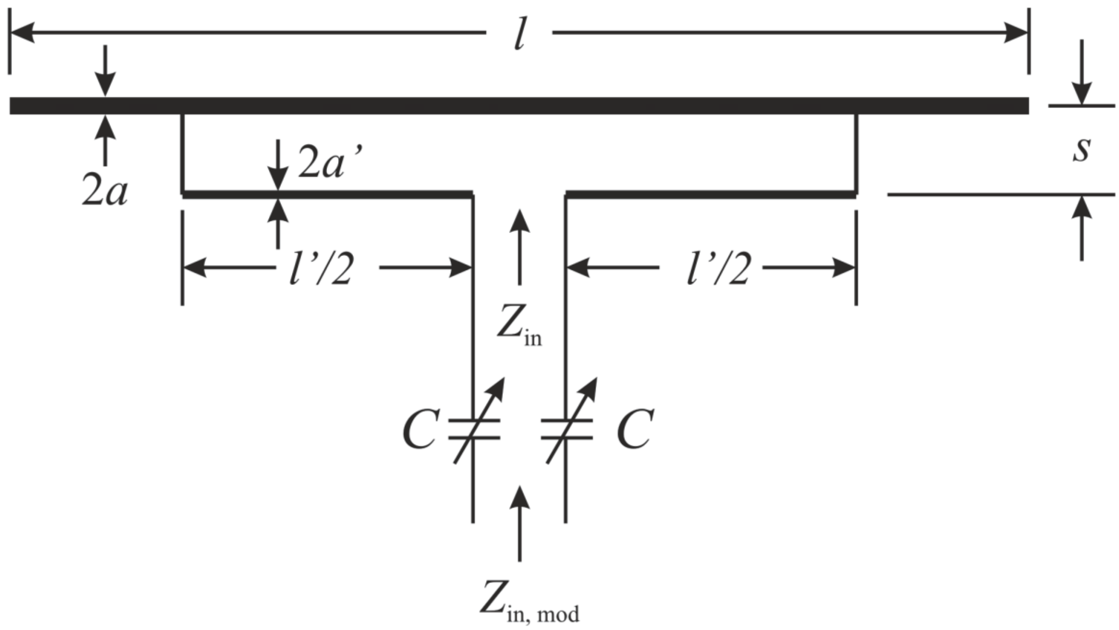
Matching Techniques For Driving Yagi-Uda Antennas: Modified T-Match

(Sections 9.5 & 9.8 of Balanis)

Modified or Resonant T-Match:



- The modified or resonant T-Match is another shunt-matching technique that can be used to feed the driven element of a Yagi-Uda antenna.

- As it is symmetrical and balanced, it is typically used to connect twin-lead transmission lines to Yagi-Uda antennas.

- Here, a pair of variable/tunable capacitors has been added in series with the T-Match as shown.

- This is done because $Z_{\text{in}} = R_{\text{in}} + j\,X_{\text{in}}$ for the unmodified T-Match can have an inductive reactance X_{in}, a consequence of $l'/2$ usually being small in terms of the wavelength λ ($l'/2 < l_2/2 < \lambda/4$).

- The input impedance of the modified T-Match is

$$\begin{aligned} Z_{\text{in, mod}} &= 2Z_{\text{cap}} + Z_{\text{in}} \\ &= \frac{2}{j\omega C} + \frac{2(1+\alpha)^2 Z_a Z_t}{(1+\alpha)^2 Z_a + 2Z_t} \\ &= R_{\text{in}} = R_{\text{in, mod}} \end{aligned}$$

where C is the series capacitance required to counteract the inductive reactance of Z_{in}. In order to achieve a real input impedance $Z_{\text{in, mod}}$ for the modified T-match, the capacitance is calculated as

$$C = \frac{1}{\pi f X_{\text{in}}}.$$

<u>Design Process:</u>

- We desire to match a given Yagi-Uda antenna to a transmission line characteristic impedance $Z_{0,\text{feed}}$. Usually a specification in terms of the VSWR is given.

1) Select a driven element length l_2 so that $l_1 < l_2 < l_3$, a', s, and l' (usually $l' < l_2/2$). These values may be changed later.

2) Calculate the characteristic impedance Z_0 of the transmission line mode of the T-Match.

3) Calculate the transmission line mode input impedance Z_t.

4) Calculate the parameters u, v, and α.

5) Calculate the equivalent radius a_e of the T-Match section.

6) Find input impedance of antenna mode Z_a.

7) Find overall T-Match input impedance Z_{in}.

8) Determine if Z_{in} meets your specification, i.e., will a regular T-match work? If so, stop design process (don't need the capacitors). If not, check if $X_{in} > 0$ (inductive reactance). If so, go to next step, else back to step 1) to adjust l_1, l_2, l_3, a', s, and/or l'.

9) If $X_{in} > 0$, calculate C and $Z_{in, mod} = R_{in} = R_{in, mod}$. Determine if $Z_{in, mod}$ meets your specification. If not, back to step 1) to adjust l_1, l_2, l_3, a', s, and/or l'.

Note: Remember, the magnitude of the input impedance is greatly influenced by α (i.e., when α increases $|Z_{in, mod} = R_{in} = R_{in, mod}|$ increases and vice versa). In turn, α is inversely related to the spacing s (i.e., if s decreases α increases and vice versa).