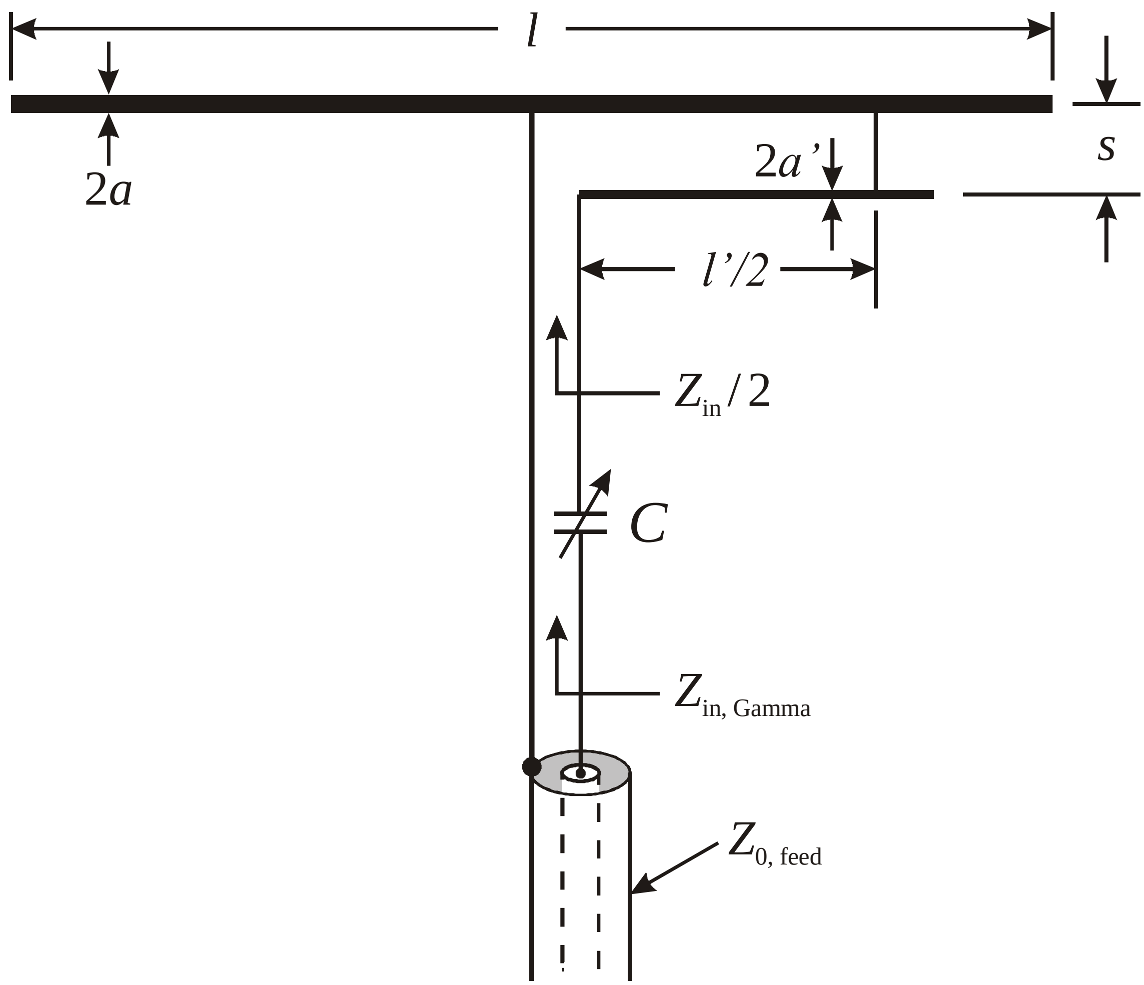
Matching Techniques for Driving Yagi-Uda Antennas: Gamma-Match

(Sections 9.5 & 9.8 of Balanis)

Gamma-Match:



- The Gamma-Match allows the driven element of Yagi-Uda antennas to be fed by coaxial transmission lines (unbalanced). The shield of the coaxial line is connected to the center of the driven element (the axis of symmetry) by “pigtailing” the shield braid. Whereas, the center conductor is connected to the Gamma-Match.

- Note that the Gamma-Match is simply the modified T-Match split down the middle. Therefore, the analysis follows that for the modified T-Match and T-Match.

- Further, the input impedance is half that of the modified T-Match.

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

where $Z_{\text{in}} = R_{\text{in}} + j\,X_{\text{in}}$ is the input impedance for a T-Match of length l', and C is the series capacitance required to counteract the inductive reactance of $Z_{\text{in}}/2$. In order to achieve a real input impedance $Z_{\text{in, Gamma}}$ for the Gamma-Match, the capacitance is calculated as

$$C = \frac{1}{2\pi f X_{\text{in}}}.$$

Note the factor of 2 in the denominator versus the equation for the capacitance required for the modified T-Match.

Design Process:

- 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 $l'/2$ (usually $l'/2 < l_2/4 < \lambda/4$). These values may be changed later.

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

6) Find input impedance of antenna mode Z_a.

7) Calculate the T-Match input impedance Z_{in} using α, Z_a, and Z_t.

8) Determine if $Z_{\text{in}} / 2$ meets your matching specification. If so, stop the design process (the capacitor is not needed). If not, check if $X_{\text{in}} > 0$ (inductive reactance). If so, go to the next step, else back to step 1) and adjust l_1, l_2, l_3, a', s, and/or $l'/2$.

9) If $X_{\text{in}} > 0$, calculate C and $Z_{\text{in, Gamma}} = R_{\text{in, Gamma}}$. Then, determine if $Z_{\text{in, Gamma}}$ meets your matching specification. If not, back to step 1) and adjust l_1, l_2, l_3, a', s, and/or $l'/2$

   Note: Remember, the magnitude of $Z_{\text{in, Gamma}}$ is greatly influenced by α (i.e., when α increases $|Z_{\text{in, Gamma}} = R_{\text{in}}/2 = R_{\text{in, Gamma}}|$ increases and vice versa). In turn, α is inversely related to the spacing s (i.e., if s decreases α increases and vice versa).