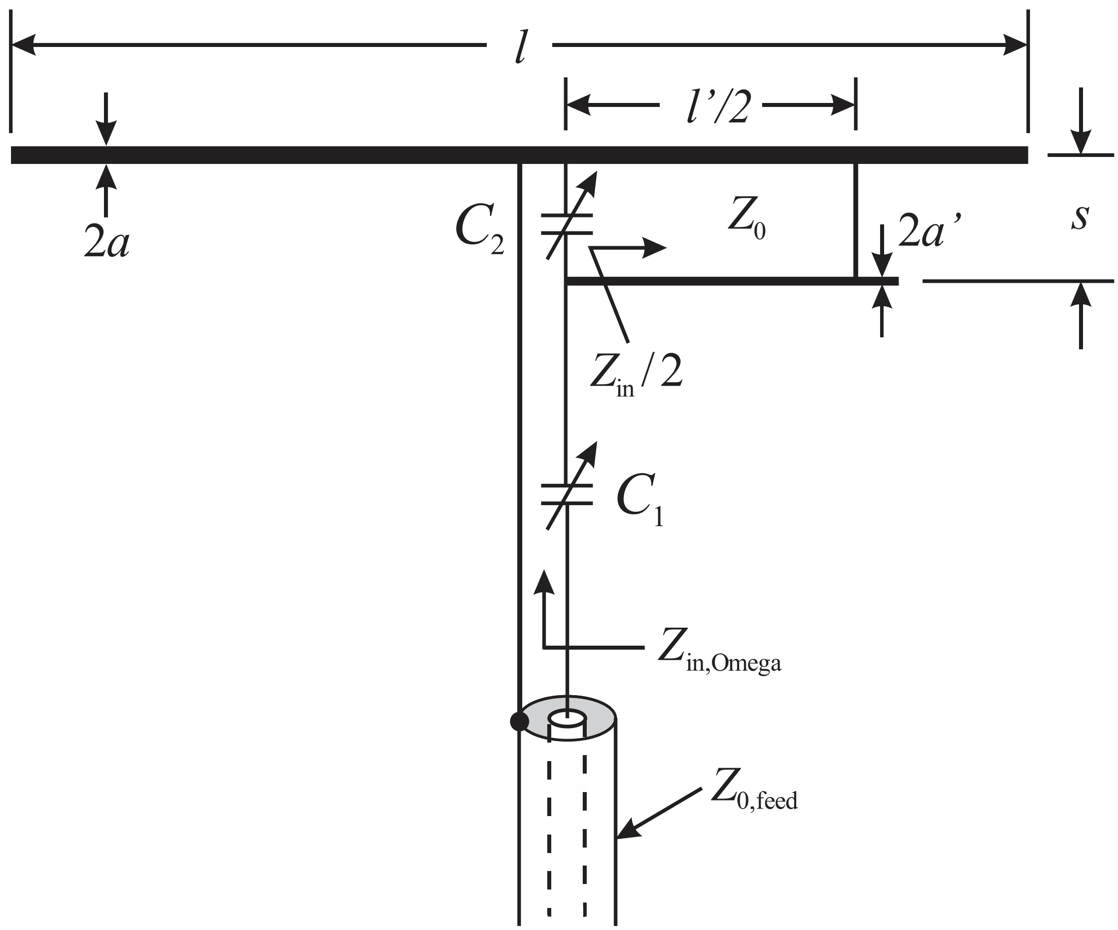
Matching Techniques for Driving Yagi-Uda Antennas: Omega-Match

[Sections 9.5, 9.6, & 9.8 of *Antenna Theory, Analysis and Design* (4e) by Balanis)]

Omega-Match:



- The Omega-Match is another matching technique that allows dipoles or the driven element of Yagi-Uda antennas to be fed by coaxial transmission lines (unbalanced).
- As can be seen, the Omega-Match is a variation on the Gamma-Match (Γ-Match) where C is now C_1 <u>and</u> a second capacitor C_2 has been placed in <u>parallel</u> to the transmission line component of the Γ-Match. This allows for an additional degree of freedom in trying to match a dipole or driven element of a Yagi-Uda antenna to the transmission line.

- The process for finding the input impedance to the Omega-Match is like that for the Γ-Match.
- Calculate the characteristic impedance Z_0 of the transmission line mode of the Omega-Match –

$$Z_0 = \frac{\eta}{2\pi}\cosh^{-1}\left(\frac{s^2 - a^2 - a'^2}{2aa'}\right)$$

where $\eta = \sqrt{\mu/\varepsilon_{\text{eff}}}$ is the intrinsic impedance of the material wherein the Omega-Match exists.

- Calculate the transmission line mode input impedance Z_t –

$$Z_t = jZ_0 \tan\left(kl'/2\right) \text{ where } k = \beta = 2\pi/\lambda.$$

- Calculate the parameters u, v, and α –

$$u = \frac{a}{a'},\quad v = \frac{s}{a'},\quad \text{and}\quad \alpha = \frac{\cosh^{-1}\left(\dfrac{v^2 - u^2 + 1}{2v}\right)}{\cosh^{-1}\left(\dfrac{v^2 + u^2 - 1}{2vu}\right)} \quad \begin{array}{l} \alpha > 1 \text{ when } a > a' \\ \alpha = 1 \text{ when } a = a'. \\ \alpha < 1 \text{ when } a < a' \end{array}$$

- Calculate the equivalent radius a_e of the transmission line section of the Omega-Match –

$$a_e \approx a' e^{\frac{u^2 \ln u + 2u \ln v}{(1+u)^2}}.$$

- Find input impedance of antenna mode Z_a (i.e., use NEC-2) of the dipole or driven element as part of the overall Yagi-Uda antenna. Remember to modify the dipole or driven element to have an equivalent radius of a_e over the length $l'/2$ corresponding to the position of the Omega-Match and radius a for the remainder.

- To find the input impedance of the Omega-Match, we can simply modify the expression for the input impedance of the Γ-Match by replacing C with C_1 and Z_{cap} with Z_{C1}. Also, the second term in the Γ-Match input impedance equation ($Z_{\text{in}}/2$) is modified by placing it in parallel with the impedance Z_{C2} of C_2 yielding –

$$Z_{\text{in,Omega}} = Z_{C1} + Z_{C2} \,\|\, \left(\frac{Z_{\text{in}}}{2}\right)$$

where

$$Z_{\text{in}} = \frac{2(1+\alpha)^2 Z_a Z_t}{(1+\alpha)^2 Z_a + 2Z_t}$$

is the input impedance for a T-Match of length l', $Z_{C1} = \dfrac{1}{j\omega C_1}$, and $Z_{C2} = \dfrac{1}{j\omega C_2}$. This yields –

$$Z_{\text{in,Omega}} = Z_{C1} + \frac{Z_{C2}\left[\dfrac{(1+\alpha)^2 Z_a Z_t}{(1+\alpha)^2 Z_a + 2Z_t}\right]}{Z_{C2} + \dfrac{(1+\alpha)^2 Z_a Z_t}{(1+\alpha)^2 Z_a + 2Z_t}}$$

$$= \frac{1}{j\omega C_1} + \frac{\dfrac{1}{j\omega C_2}\left[\dfrac{(1+\alpha)^2 Z_a Z_t}{(1+\alpha)^2 Z_a + 2Z_t}\right]}{\dfrac{1}{j\omega C_2} + \dfrac{(1+\alpha)^2 Z_a Z_t}{(1+\alpha)^2 Z_a + 2Z_t}}.$$

- Given the complexity of the equation for $Z_{\text{in,Omega}}$, the Omega-Match is more likely to be used to empirically match a dipole or driven element of a Yagi-Uda antenna to a feeding coaxial transmission line rather than follow a design process, i.e., manually adjust C_1 and C_2 until a match is achieved.