① An open wire r.f. transmission line, which may be regarded as loss free has a characteristics impedance $Z_0 = 600\,\Omega$ & is connected to a resistive load of $75\,\Omega$. Find the position & the length of a short-circuited stub, of the same construction as the line, which would enable the main length of the line to be correctly terminated at a frequency of 150 MHz.

Soln $Z_0 = 600\,\Omega$, $Z_L = 75\,\Omega$, $f = 150\,MHz$

$l_s = ?$, $l_t = ?$

$$l_s = \frac{\lambda}{2\pi} \tan^{-1}\sqrt{\frac{Z_L}{Z_0}} = \frac{1}{\beta} \tan^{-1}\sqrt{\frac{Z_L}{Z_0}}$$

$$l_s = \frac{\lambda}{2\pi} \tan^{-1}\sqrt{\frac{1}{8}} \qquad \lambda = \frac{c}{f} = \frac{300}{150} = 2\,m.$$

$$= \frac{2}{2\pi} \tan^{-1}\sqrt{1/8} = \frac{2}{2\pi} \times 19.44^\circ \times \frac{\pi}{180} = 0.108\,m$$

$l_s = 10.8\,cm$.

$$l_t = \frac{\lambda}{2\pi} \tan^{-1} \frac{\sqrt{Z_L Z_0}}{Z_L - Z_0} = \frac{1}{\pi} \tan^{-1}\left(-\frac{8.484}{21}\right) = \frac{1}{\pi} \tan^{-1}(-0.404)$$

$$= \frac{1}{\pi} \cdot (-22^\circ) = \frac{1}{\pi} \times +158 \times \frac{\pi}{180} = \frac{158}{180} = 0.8790\,m = \underline{87.9\,cm}.$$

② Calculate the position & length of a short circuited stub designed to match a $200\,\Omega$ load to a transmission line whose characteristic impedance is $300\,\Omega$

$Z_0 = 300\,\Omega$, $Z_L = 200\,\Omega$

$l_s = ?$, $l_t = ?$

$$l_s = \frac{\lambda}{2\pi} \tan^{-1}(0.8164) = \frac{\lambda}{2\pi} \cdot 39.22^\circ \times \frac{\pi}{180} = \frac{39.22\lambda}{360} = 0.10894\lambda\ m.$$

$= 10.894\lambda\ cm$.

$$l_t = \frac{\lambda}{2\pi} \tan^{-1}(-2.4495) = \frac{\lambda}{2\pi} \cdot (-67.8^\circ)$$

$$= \frac{\lambda}{2\pi} (180 - 67.8^\circ) \times \frac{\pi}{180^\circ} = \frac{\lambda}{2\pi} \cdot 112.2 \times \frac{\pi}{180}$$

$= 0.3116\lambda$ metre

$= \underline{31.16\lambda\ cm}$

(1) A two wire line has a chara. imp. of 300Ω. It is used at 100MHz. Find the minimum length required of a short circuited line that can be used to simulate an inductive reactance of 200Ω.

$Z_L = 200\Omega$, $Z_0 = 300\ \Omega$ $f = 100\ MHz$

$\lambda = \frac{c}{f}$ $3\times10^8\ m/sec$

$= \frac{300\times10^6}{100\times10^6}$

$= 3$

$\lambda = \frac{300}{100} = 3m$. ✓

The min. length of short ckt. line

$$l_t = \frac{\lambda}{2\pi}\tan^{-1}\frac{\sqrt{Z_L Z_0}}{Z_L - Z_0} = \frac{3}{2\pi}\tan^{-1}\frac{\sqrt{200\times300}}{200-300}$$

$$= \frac{3}{2\pi}\tan^{-1}\frac{\sqrt{60000}}{-100} = \frac{3}{2\pi}\tan^{-1}(-2.4495)$$

$$= \frac{3}{2\pi}(-67.8^\circ) = \frac{3}{2\pi}(+112.2^\circ)\times\frac{\pi}{180}$$

$$= \frac{112.2}{120} = \underline{0.935m}.$$

(2) At what distance from the aerial end of a line of Ch. imp 500Ω should a stub be introduced on it so as to match the line with the aerial of 80Ω input imp., radiating wavelength 100m.

$Z_0 = 500\Omega$, $Z_L = 80\Omega$, $\lambda = 100m$ $l_s = ?$

$$l_s = \frac{\lambda}{2\pi}\tan^{-1}\sqrt{Z_L/Z_0} = \frac{100}{2\pi}\tan^{-1}\sqrt{\frac{80}{500}}$$

$$= \frac{50}{\pi}\tan^{-1}\sqrt{0.16} = \frac{50}{\pi}\tan^{-1}0.400$$

$$= \frac{50}{\pi}\times21.8^\circ\times\frac{\pi}{180} = \frac{5\times21.8}{18} = \frac{109}{18} = \underline{6.055m}.$$

1) An UHF lossless T. L. working at 1GHz is connected to an unmatched load producing a voltage reflection coefficient of 0.5 ∠30°. Calculate, after deriving necessary relations, length & position of a single stub to match the line.

→ $f = 1\text{GHz}$. $\Gamma_L = 0.5$ $\phi = 30°$

$l_s = ?$, $l_t = ?$

$\lambda = \frac{300}{1000} = \frac{c}{f} = 0.3\,m.$

$\phi = 30° = 30 \times \frac{\pi}{180°} = \frac{\pi}{6}$ radians.

$$l_s = \frac{\lambda}{4\pi}\left[\phi + \pi - \cos^{-1}|\Gamma_L|\right] = \frac{\lambda}{4\pi}\left[\frac{\pi}{6} + \pi - \cos^{-1}(0.5)\right]$$

$$l_s = \frac{\lambda}{4\pi}\left[\frac{\pi}{6} + \pi - 60°\right] = \frac{\lambda}{4\pi}\left[\frac{\pi}{6} + \pi - 60 \cdot \frac{\pi}{180}\right] = \frac{\lambda}{4\pi}\left[\frac{\pi}{6} + \pi - \frac{\pi}{3}\right]$$

$$\left[\frac{7\pi}{6} - \pi/3\right]$$

$$l_s = \frac{\lambda}{4\pi}\left[\frac{7\pi - 2\pi}{6}\right] = \frac{\lambda}{4\pi}\left[\frac{5\pi}{6}\right] = \frac{0.3}{4} \times \frac{5}{6} = \frac{1.5}{24}$$

$$\boxed{l_s = 0.0625 \text{ meters.}}$$

$$l_t = \frac{\lambda}{2\pi}\tan^{-1}\frac{\sqrt{1 - |\Gamma_L|^2}}{2|\Gamma_L|} = \frac{\lambda}{2\pi}\tan^{-1}\frac{\sqrt{1-(0.5)^2}}{2 \times 0.5}$$

$$l_t = \frac{\lambda}{2\pi}\tan^{-1}\sqrt{0.75} = \frac{\lambda}{2\pi}\tan^{-1}(0.8660) = \frac{\lambda}{2\pi} \times 40.9°$$

$$l_t = \frac{\lambda}{2\pi} \times 40.9 \times \frac{\pi}{180°}$$

$$l_t = \frac{0.3}{2\cancel{\pi}} \times \frac{40.9 \times \cancel{\pi}}{180} = \frac{12.27}{360}$$

$$\boxed{l_t = 0.03408 \text{ meters.}}$$

$\frac{10.51}{1040}$, $\frac{10.38}{1031}$

A 300 Ω T.L. feeding an antenna has a standing wave ratio of 4. & the distance from the load of the first voltage minima is 28cm. If the frequency is 150MHz, design a single stub matching system to eleminate standing wave ratio from the maximum possible length of the line.

→ $Z_0 = 300\Omega$ $\quad f = 150\text{MHz}$

$VSWR = 4$ $\quad l_s = ?$

$y_{min} = 28\text{cm}$ $\quad l_t = ?$

The first voltage minima is $\quad \lambda = \frac{c}{f} = \frac{300}{150}$

$\lambda = 2$ meter

$$2\beta y_{min} - \phi = \pi$$

$$2 \times \frac{2\pi}{\lambda} \cdot \frac{28}{100} - \phi = \pi$$

$$2 \times \frac{2\pi}{\lambda} \cdot \frac{28}{100} - \pi = \phi$$

$$\frac{4\pi}{2} \cdot \frac{28}{100} - \pi = \phi$$

$$\pi\left(\frac{28}{50} - 1\right) = \phi$$

$$\phi = \pi\left(-\frac{11}{25}\right) = -3.14 \times 0.44 \text{ or } \underline{-0.44\pi} \text{ radian.}$$
$$= \underline{-79.16^\circ}$$

$$\Gamma_L = \frac{VSWR - 1}{VSWR + 1} = \frac{4-1}{4+1} = \frac{3}{5} = 0.6$$

$\cos^{-1}|0.6| = 53.1^\circ$

$\frac{53.1 \times \pi}{180} = \underline{\underline{0.295\pi}}$

$$l_s = \frac{\lambda}{4\pi}\left(\phi + \pi - \cos^{-1}|\Gamma_L|\right) = \frac{2}{4\pi}\left(-0.44\pi + \pi - \cos^{-1}|0.6|\right) = \frac{2}{4\pi}\left(0.56\pi - 0.295\pi\right)$$
$$= \frac{\cancel{2}}{{}_2\cancel{4}\pi} = \frac{1}{2\cancel{\pi}}\left(0.265\cancel{\pi}\right) = 0.1325$$

$$\boxed{l_s = 0.1325 \text{ meter}}$$

$$l_t = \frac{\lambda}{2\pi}\tan^{-1}\frac{\sqrt{1-|\Gamma_L|^2}}{2|\Gamma_L|} = \frac{2}{2\pi}\tan^{-1}\frac{\sqrt{1-(0.6)^2}}{2 \times 0.6} = \frac{1}{\pi}\tan^{-1}\frac{\sqrt{0.64}}{1.2} = \frac{1}{\pi}\tan^{-1}\frac{0.8}{1.2}$$

$$= \frac{1}{\pi}\tan^{-1}(0.666) = \frac{1}{\pi} \cdot 33.65^\circ = \frac{1}{\pi} \cdot 33.65 \times \frac{\pi}{180} = \frac{33.65}{180}$$

$$\boxed{l_t = 0.1869 \text{ meters}}$$

(1) find the input impedance of a transmission line $Z_0 = 50\Omega$ that has a length of $\lambda/8$ & is connected to a load impedance $Z_L = (50+j50)\Omega$

step 1 locate $(Z_L)_N = Z_L/Z_0 = 1+j1$ on Smith chart

2. Draw a constant VSWR circle as shown in fig.

3. Now, move towards gen. on const. VSWR circle a distance of $\lambda/8$ to obtain

$$(Z_{IN})_N = 2-j1$$

$$Z_{IN} = 50(2-j1) = (100-j50)\Omega$$

(2) find the admittance value for an impedance value of $Z = (50+j50)$ in a 50Ω system.

$Z_0 = 50\Omega$

Step: Locate $Z_{IN,N} = 1+j1$ on smith chart.

2. Draw constant VSWR circle.

3. Read $180°$ away on the const. VSWR circle.

$$Y_N = 0.5-j0.5$$

$$Y_0 = 1/Z_0 = 1/50 = 0.02$$

$$Y = Y_0 Y_N = 0.02(0.5-j0.5)$$

$$Y = 0.01-j0.01$$

(3) A transmission line with charg. prop. of $Z_0 = 50\Omega$ is terminated into the following load impedances

$Z_L = 0$ (short ckt.), $Z_L = \infty$ (open ckt.), $Z_L = 50\Omega$

$Z_L = (16.67-j16.67)\Omega$, $Z_L = (50+j150)\Omega$

Find the individual ref. coefficient & display them on Smith Chart

1) $\Gamma = -1$

2) $\Gamma = +1$

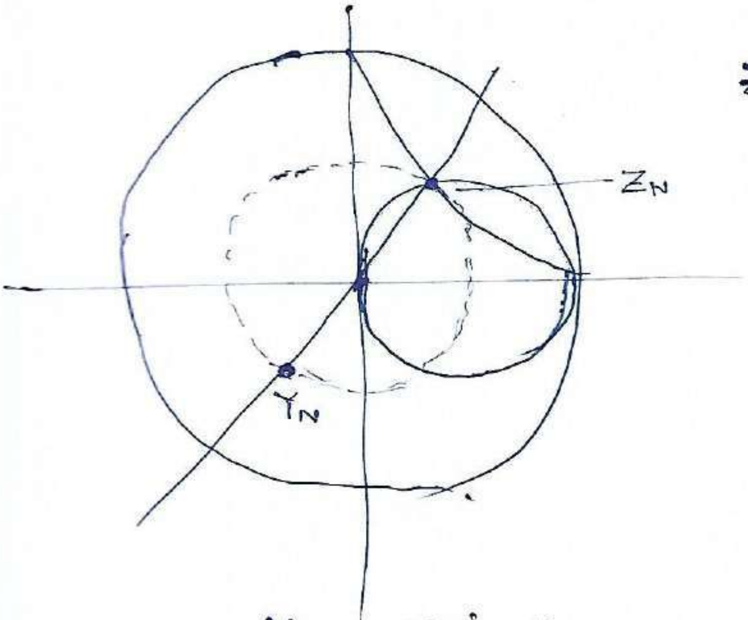
3) $\Gamma = 0$

4) $\Gamma = 0.54\angle 221°$.

5) $\Gamma = 0.83\angle 34°$.

① Determination of Admittance from Impedance.

$Z = (50+j50)\,\Omega$, $Z_0 = 50\,\Omega$



$Z_N = 1+j1$

$Y_0 = \frac{1}{Z_0} = \frac{1}{50} = 0.02\,S$

$Y_N = 0.5 - j0.5$

$Y = Y_0 Y_N = (0.5-j0.5) \times 0.02$

② A T.L. with chara imp. of $Z_0 = 50\,\Omega$ is terminated into the following load impedances.

i) $Z_L = 0$ (short ckt.)

ii) $Z_L = \infty$ (open ckt.)

3) $Z_L = 50\,\Omega$

4) $Z_L = 16.67 - j16.67$

5) $Z_L = 50 + j150\,\Omega$

Find individual ref coefficients Γ & display them on smith chart.

$\frac{Z_L - Z_0}{Z_L + Z_0}$

i) $\Gamma = -1$

2) $\Gamma = 1$

3) $\Gamma = 0$

4) $\Gamma = 0.54 \angle 221^\circ$

5) $\Gamma = 0.83 \angle 34^\circ$.