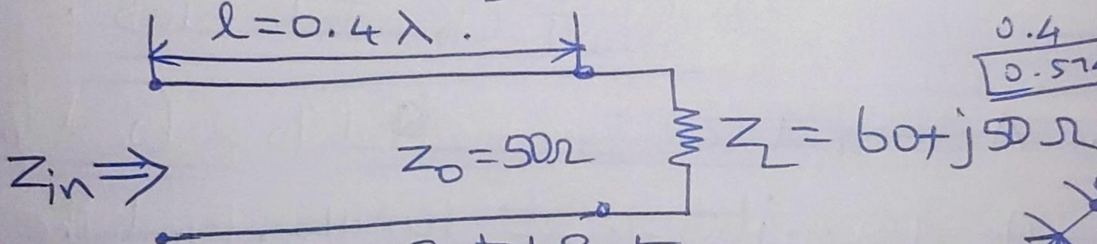
$\lambda/2$ ①

1. Use the smith chart to find the following Quantities for the transmission line Circuit, shown in the figure (i) VSWR, (ii) Reflection Coefficient at load (Γ_L), (iii) Load Admittance Y_L, (iv) Input Impedance (v) Distance from the load to the first Voltage minimum (dV_{min}) (vi) Distance from the load to the first voltage maximum (dV_{max}).

$$\begin{aligned}&0.25\\ &+0.076\\ &=0.326\end{aligned}$$

0.076

$$\begin{aligned}&0.174\lambda\\ &0.4\\ &\boxed{0.574\lambda}\end{aligned}$$



Solution:

$Z_{in} = \bar{Z}_{in} \cdot Z_0$

$= 25 + j21$

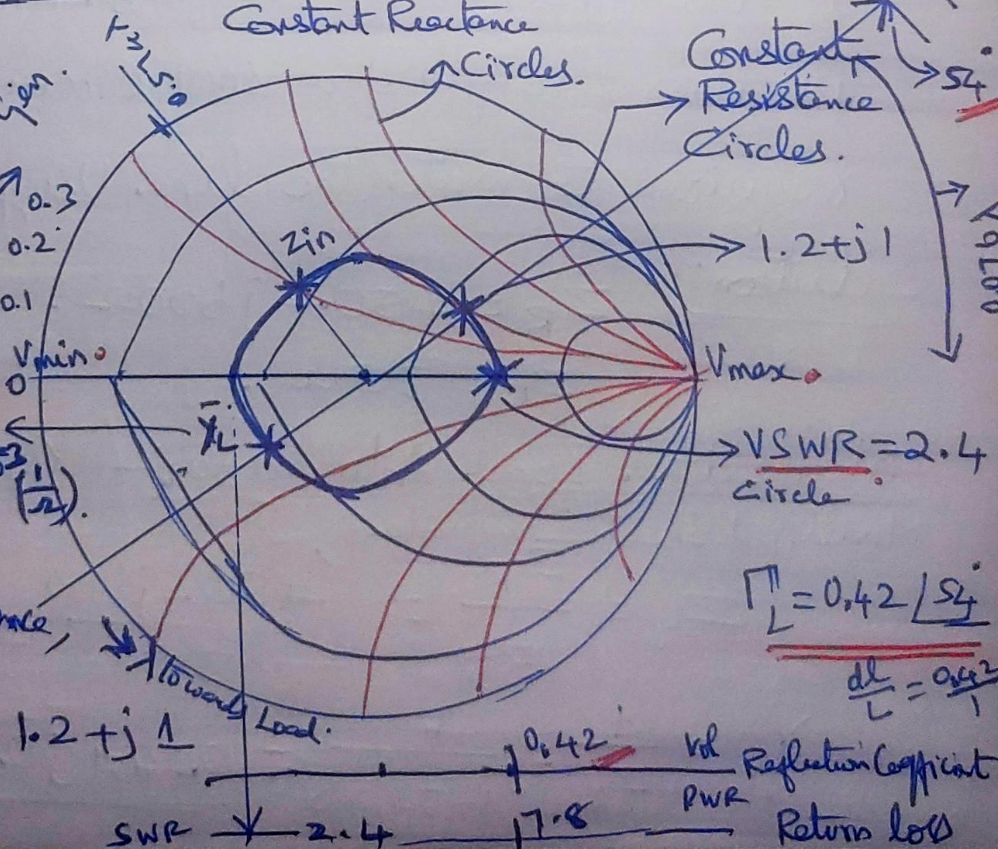
$\bar{Z}_{in} = 0.5 + 0.42j$

$\bar{Y}_L = 0.5 - 0.42j$

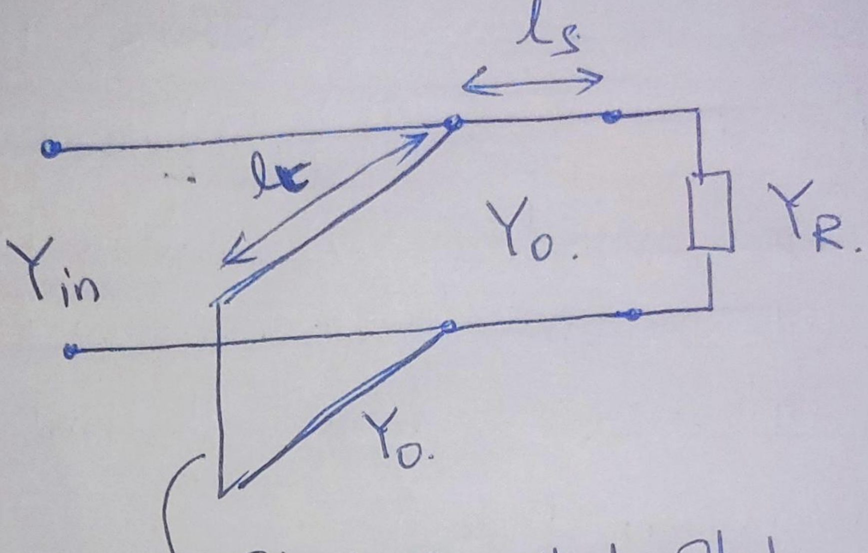
$Y_L = 0.01 - j8.4\times10^{-3}\,(\frac{1}{\Omega})$.

Normalized Load Impedance,

$\bar{Z}_L = \frac{Z_L}{Z_0} = 1.2 + j1$



Single Stub Matching



Short Circuited Stub.

1. A 300Ω T. line is connected to a load Impedance of $450-j600\Omega$ at 10 MHz. Find the position & length of a short circuited stub required to match the line using Smith chart.

Solution:- $Z_R = 450 - j600\Omega$.

$Z_0 = 300\Omega$.

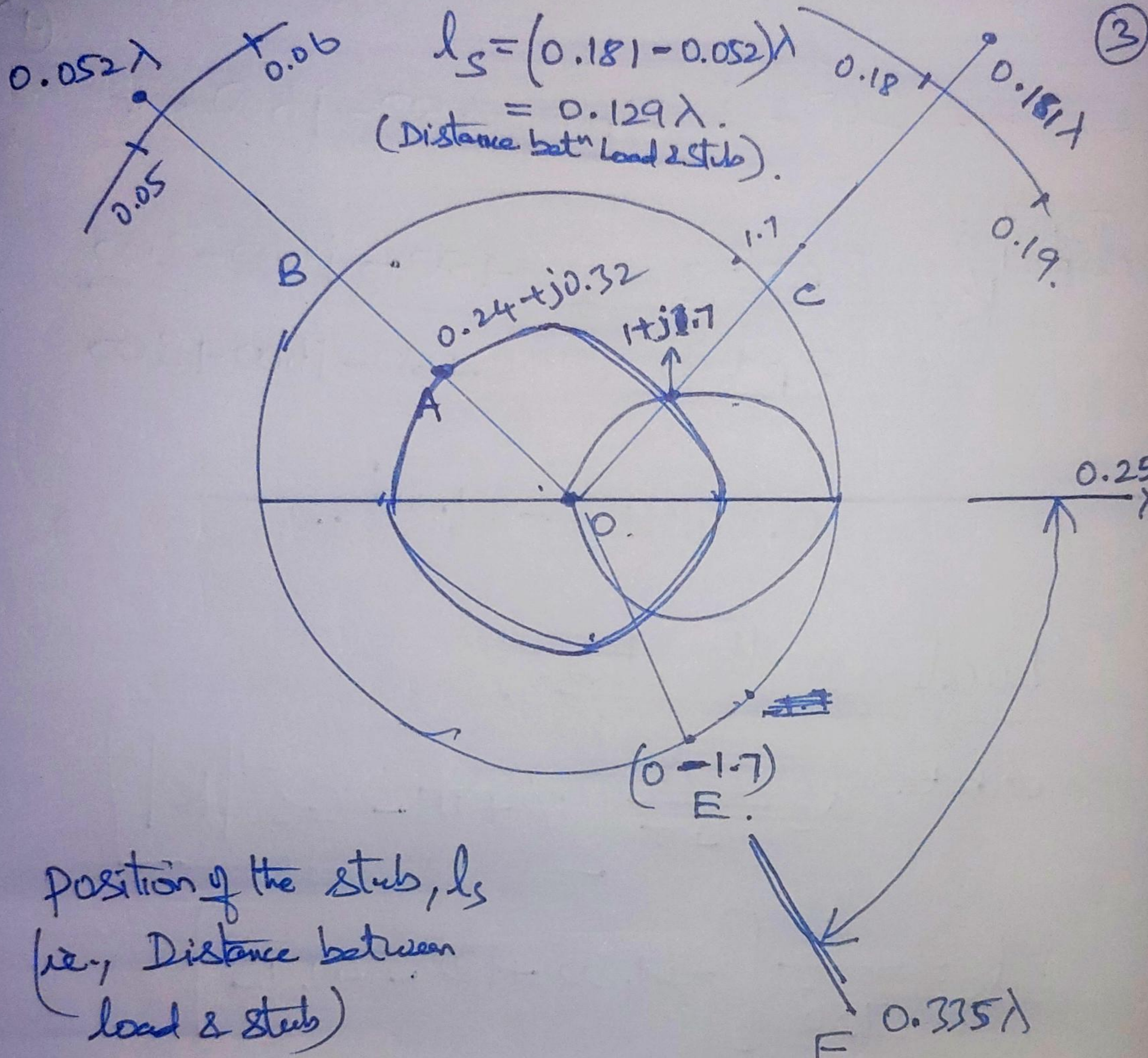
Normalized Load Admittance:- Y_r.

Normalized Load Impedance,

$$Z_r = \frac{Z_R}{Z_0} = \frac{450-j600}{300} = 1.5 - j2.0.$$

$$Y_r = \frac{1}{Z_r} = \frac{1}{1.5-j2.0} = \underline{0.24 + j0.32}.$$

$l_s = (0.181 - 0.052)\lambda$
$= 0.129\lambda.$
(Distance betn Load & Stub).



position of the stub, l_s
(i.e., Distance between load & stub)

$\underline{l_s = 0.129\lambda}.$

$(0.355 - 0.250)\lambda$

$\boxed{l_t = 0.085\lambda}$

Length of the short Circuited stub, $\underline{l_t = 0.085\lambda}$.

$Z_0 = 300\Omega$; $Z_R = 450 - j600\Omega$.

Reflection Coefficient,

$$K = \frac{Z_R - Z_0}{Z_R + Z_0} = \frac{450 - j600 - 300}{450 - j600 + 300}$$

$$= 0.6439 \angle -37.30^\circ.$$

Location of the stub

w.k.t. $l_s = \frac{\lambda}{4\pi}\left[\phi + \pi - \cos^{-1}|K|\right]$

$$l_s = \frac{\lambda}{720^\circ}\left[-37.30^\circ + 180^\circ - 49.92^\circ\right]$$

$$l_s = \frac{\lambda}{720^\circ}\left[92.783\right] \Rightarrow \boxed{l_s = 0.1289\lambda}$$

$$l_s' = \frac{\lambda}{4\pi}\left[\phi + \pi + \cos^{-1}|K|\right] \Rightarrow \boxed{l_s' = 0.2675\lambda}$$

Length of the stub :- $l_t = \frac{\lambda}{2\pi}\tan^{-1}\left(\frac{\sqrt{1-|K|^2}}{2|K|}\right)$

$$\boxed{l_t = 0.085\lambda}$$

$$l_t' = \frac{\lambda}{2\pi}\tan^{-1}\left(\frac{\sqrt{1-|K|^2}}{-2|K|}\right) = 0.414\lambda.$$

Location of the stub should be nearer to the Load

Stub Matching :-

1. Reflection Coefficient :-

$$K = \frac{Z_R - Z_0}{Z_R + Z_0} \; ; \quad K = |K| \angle \phi .$$

2. Position of the stub:-

$$d = l_s = \frac{\lambda}{2\pi} \cdot \tan^{-1} \sqrt{\frac{Z_R}{Z_0}} .$$

(or)

Angle of Reflection Coefficient.

$$l_s = \frac{\lambda}{4\pi} \left[\phi + \pi - \cos^{-1} |K| \right] .$$

Magnitude of Reflection Coefficient.

3. Length of the stub :-

$$l_t = \frac{\lambda}{2\pi} \tan^{-1} \left[\frac{\sqrt{Z_0 Z_R}}{Z_R - Z_0} \right]$$

$$l_t = \frac{\lambda}{2\pi} \tan^{-1} \left[\frac{\sqrt{1 + |K|^2}}{2|K|} \right]$$

1. A dipole antenna whose Input Impedance is 100Ω to be matched at a frequency of $100MHz$ to a transmission line having characteristic Impedance of 600Ω by means of short Circuited stub. Determine the location and length of the stub.

Solution :-

Given, $Z_R = 100\Omega$; $Z_0 = 600\Omega$; $f = 100MHz$.

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{100\times10^6} = 3m.$$

Location of the Stub :-

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

$$= \frac{3}{2\pi}\tan^{-1}\sqrt{\frac{100}{600}}$$

$$= \frac{3}{2\pi} \times 22.2^{\circ} \times \left(\frac{\pi}{180^{\circ}}\right)$$ {Converting from degree to radians}

$$\boxed{l_s = 0.185\,m}$$

Length of the stub :-

$$l_t = \frac{\lambda}{2\pi} \tan^{-1}\left[\frac{\sqrt{Z_0 Z_R}}{Z_R - Z_0}\right]$$

$$= \frac{3}{2\pi} \tan^{-1}\left[\frac{\sqrt{(100)(600)}}{100-600}\right] \Rightarrow \frac{3}{2\pi} \tan^{-1}\left(\frac{244.95}{-5}\right)$$

$$= \frac{3}{2\pi}(-26.1^{\circ}) \Rightarrow \frac{3}{2\pi}(180^{\circ} - 26.1^{\circ}).$$

$$= \frac{3}{2\pi} \times 153.9^{\circ}.$$ {Converting from degree to radians}

$$\Rightarrow \frac{3}{2\pi} \times 153.9^{\circ} \times \frac{\pi}{180^{\circ}}$$

$$\boxed{l_t = 1.28\,m}$$

2. A load $(50+j100)\Omega$ is connected across a 50Ω line. Design a short circuited stub to provide matching between the Z_S & Z_L at a signal frequency of 30 MHz.

Solution:-

Given :- $Z_0 = 50\Omega$; $Z_R = (50+j100)\Omega$

$f = 30\,MHz$.

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{30\times10^6} = 10m. \quad \boxed{\lambda = 10m}.$$

Reflection Coefficient :-

$$K = \frac{Z_R - Z_0}{Z_R + Z_0} \Rightarrow \frac{(50+j100)-50}{(50+j100)+50} \Rightarrow \frac{j100}{100+j100}.$$

$$K = \frac{100\angle 90^\circ}{141.4\angle 45^\circ} \Rightarrow \boxed{K = 0.707\angle 45^\circ}$$

$$\boxed{|K| = 0.707 \; ; \; \phi = 45^\circ = \frac{\pi}{4}.}$$

Location of the stub :-

$$l_s = \frac{\lambda}{4\pi}\left[\phi + \pi - \cos^{-1}|K|\right]$$

$$= \frac{10}{4\pi}\left[\frac{\pi}{4} + \pi - \underbrace{\cos^{-1}(0.707)}_{45^\circ = \frac{\pi}{4}}\right] \Rightarrow \underline{\underline{2.5\,m}}$$

3. A UHF lossless transmission line working at 1 GHz is connected to an unmatched line producing a reflection coefficient of $0.5(0.866 + j0.5)$. Calculate the length & position of the stub used to match the line.

Solution :-

Given :- Reflection coefficient, $K = 0.5(0.866 + j0.5)$

$f = 1\,GHz$.

$K = 0.433 + j0.25 = 0.5\angle 30^\circ$.

$\lambda = \frac{c}{f}$

$\boxed{\lambda = 0.3m}$.

$|K| = 0.5$ & $\phi = 30^\circ = \frac{\pi}{6}$.

Position of the stub :-

$$l_s = \frac{\lambda}{4\pi}\left[\phi + \pi - \cos^{-1}|K|\right].$$

$$= \frac{0.3}{4\pi}\left[\frac{\pi}{6} + \pi - \cos^{-1}|0.5|\right].$$ $\left\{\cos^{-1}(0.5) = 60^\circ = \pi/3\right\}$

$$= \frac{0.3}{4\pi}\left[\frac{5\pi}{6}\right].$$ $\boxed{l_s = 0.625\,m}$

Length of the stub :-

$$l_t = \frac{\lambda}{2\pi}\tan^{-1}\left\{\frac{\sqrt{1+|K|^2}}{2|K|}\right\}.$$

$$= \frac{0.3}{2\pi}\tan^{-1}\left\{\frac{\sqrt{1+0.5^2}}{2(0.5)}\right\}$$

$$= \frac{0.3}{2\pi}\tan^{-1}(0.866) = \frac{0.3}{2\pi}\cdot(40.8925^\circ).$$

$$= \frac{0.3}{2\pi}\left[40.8925 \times \frac{\pi}{180^\circ}\right] \Rightarrow 0.0341\,m$$

$$\boxed{l_t = 3.41\ cm}$$