(15/09/20)

Stub → piece of wire.

we got ~~the~~ fos s.c, lin o.c lots of energy gets wasted.

S.C two types of connection (1) series (II) Parallel.

→ Electrical length (wavelength) (~~will go~~ Physical length. (serially we are not going to connect the sub bcoz of these two problems)

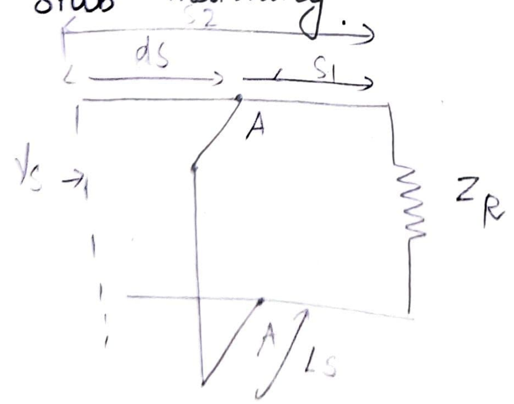
→ Mechanical problem.

So we are going to connect the sub parallel.

Single - stub. Matching → use single sub for matching purposes

Double - stub: Matching → uses 2 subs for matching purposes

Single Stub matching:



L_s → length of the stub

S_2 → dist from load to source end.

At AA' we are placing the stub.

(i) What is the length (Electrical length)

(ii) Where to locate the stub Physical length

(Because when frequency ↑, Electrical length radiation will come into account)

I/p admittance at pt before the stub

$$Y_s = \underset{\substack{\cup \\ \text{conductance.}}}{G_0} \pm jB_0 \rightarrow \text{susceptance of the line.}$$

(at A)

Point A is located such that at that point

$G_0 = 1/R_0$.

The stub is selected such that its I/p susptance is $\mp jB_0$. (stub must cancel the susceptance of the line)

Admittance at pt A after the stub

$$Y_s \text{ at } A = G_0 \pm jB_0 \mp jB_0.$$

$$\boxed{Y_s = G_0}$$

$$\boxed{Z_s = R_0}$$

~~When~~

Thus the line from source to pt A acts as a smooth line. When line is terminated at $Z_s = R_0$ (then no standing wave) ⇒ so we called it as smooth line. (or) reflected waves

This characteristic is valid from source to the point A, not from A to load.

So to calculate (location, length) we measure standing wave ratio & voltage min nearest to load.

$$Z_B = \frac{R_0 \left(1 + |K| \angle \phi - 2\beta s\right)}{1 - |K| \angle \phi - 2\beta s)}$$

$$Y_s = \frac{G_0 \left(1 - |K| \angle \phi - 2\beta s\right)}{1 + |K| \angle \phi - 2\beta s}$$

$$G_S + jB_S = \frac{G_0\left[1 - |K| \angle \phi - 2\beta S\right]}{\left[1 + |K| \angle \phi - 2\beta S\right]}$$

$$\frac{G_S + jB_S}{G_0} = \frac{1 - |K| \angle \phi - 2\beta S}{1 + |K| \angle \phi - 2\beta S.}$$

$$\Rightarrow \frac{G_S}{G_0} + \frac{jB_S}{G_0} = \frac{1 - |K| e^{j\phi} e^{-j2\beta S}}{1 + |K| e^{j\phi} e^{-j2\beta S}}$$

$\Downarrow$

Normalised conductance.

$$= \frac{1 - |K|\left[\cos\phi + j\sin\phi\right]\left[\cos 2\beta S - j\sin 2\beta S\right]}{1 + |K|\left[\cos\phi + j\sin\phi\right]\left[\cos 2\beta S - j\sin 2\beta S\right]}$$

$$= -2|K| \left(\cos(\phi - 2\beta s) + j\sin(\phi - 2\beta s) \right)$$

$$= \frac{1 - |K| \left[\cos(\phi - 2\beta s) + j\sin(\phi - 2\beta s) \right]}{1 + |K| \left[\cos(\phi - 2\beta s) + j\sin(\phi - 2\beta s) \right]}$$

$$= \frac{\left(\underbrace{1 - (|K| \cos(\phi - 2\beta s))}_{a} - \underbrace{j\sin(\phi - 2\beta s) K}_{b} \right) \left(1 + K\cos(\phi - 2\beta s) - j\sin(\phi - 2\beta s) K \right)}{\left(1 + K\cos(\phi - 2\beta s) + jK\sin(\phi - 2\beta s) \right) \left(1 + K\cos(\phi - 2\beta s) - jK\sin(\phi - 2\beta s) \right)}$$

$$= \frac{\cancel{1} - K^2\cos^2(\phi - 2\beta s) - j^2 \quad (1 - jK\sin(\phi - 2\beta s))^2 - (K^2\cos^2(\phi - 2\beta s)}{(1 + K\cos(\phi - 2\beta s))^2 - (j^2K^2\sin^2(\phi - 2\beta s))}$$

$$= \frac{(1 - 2jK\sin(\phi - 2\beta s + - K^2\sin^2(\phi - 2\beta s) - K^2\cos^2(\phi - 2\beta s)}{1 + K^2\cos^2(\phi - 2\beta s) + 2K\cos(\phi - 2\beta s) + K^2\sin^2(\phi - 2\beta s)}$$

$$= \frac{1 - K^2 - 2jK\sin(\phi - 2\beta s)}{1 + 2K\cos(\phi - 2\beta s) + K^2} = \frac{1 - K^2}{1 + 2K\cos(\phi - 2\beta s) + K^2} + j\frac{(-2K\sin(\phi - 2\beta s))}{1 + K^2 + 2K\cos(\phi - 2\beta s)}$$

$$\frac{G_s}{G_0} = \frac{1 - K^2}{1 + K^2 + 2K\cos(\phi - 2\beta s)}$$

$$\frac{B_s}{G_0} = \frac{-2K\sin(\phi - 2\beta s)}{1 + K^2 + 2K\cos(\phi - 2\beta s)}$$

To find the particular pt.

$G_s = G_0 = 1/R_0$

$\frac{G_s}{G_0} = 1 \rightarrow$ location of point A.

$$\cancel{1} + K^2 + 2K\cos(\phi - 2\beta s) = \cancel{1} - K^2$$

$$2\left[K^2 + K\cos(\phi - 2\beta s)\right] = 0$$

$$K + \cos(\phi - 2\beta s) = 0.$$

$$\cos(\phi - 2\beta s) = -K.$$

$$\cos^{-1}(K) - \pi = x.$$

$$\cos^{-1}(K) = (x + \pi)$$

$$K = \cos(x + \pi)$$

$$= -\cos x \implies x = \cos^{-1}(-K) \rightarrow (1)$$

But $x = \cos^{-1}|K| - \pi.$

$$\cos^{-1}(-K) = \cos^{-1}|K| - \pi$$

$$(\phi - 2\beta s) = \cos^{-1}(-K)$$

$$\phi - 2\beta s = \cos^{-1}|K| - \pi.$$

The point A lies at a distance of s_1 from load

$$\Rightarrow \phi - 2\beta s_1 = \cos^{-1}|K| - \pi$$

$$s_1 = \frac{\pi - \cos^{-1}|K| + \phi}{2\beta}.$$

Thus the distance d from voltage minimum to the point of stub connection is given by $d = s_2 - s_1$.

Let the 1st voltage minima part at s_2 and d is given by

$$s_2 = \frac{\phi + \pi}{2\beta}.$$

$$d = \frac{\phi + \pi}{2\beta} - \frac{\pi + \cos^{-1}|K| - \phi}{2\beta}$$

$$d = \frac{\cos^{-1}|K|}{2\beta}$$

$$= \frac{1 - [K\cos\phi + j\sin\phi][\cos 2\beta s - j\sin 2\beta s]}{1 + |K|[\cos\phi\cos 2\beta s - j\cos\phi\sin 2\beta s + j\sin\phi\cos 2\beta s + \sin\phi\sin 2\beta s]}$$

$$= \frac{1 - |K|[\cos(\phi - 2\beta s) + j\sin(\phi - 2\beta s)]}{1 + |K|[\cos(\phi - 2\beta s) + j\sin(\phi - 2\beta s)]}$$

$$= \frac{1 - |K|[\cos(\phi - 2\beta s) + j\sin(\phi - 2\beta s)]}{1 + |K|[\cos(\phi - 2\beta s) + j\sin(\phi - 2\beta s))}$$

$$= \frac{1 - K\cos(\phi - 2\beta s) - j\sin(\phi - 2\beta s)K \times (1 + K\cos(\phi - 2\beta s) - j\sin(\phi - 2\beta s)K}{(1 + K\cos(\phi - 2\beta s) + (j\sin(\phi - 2\beta s))K)(1 + K\cos(\phi - 2\beta s) - j\sin(\phi - 2\beta s)K}$$

$$= \frac{1^2 + K\cos(\phi - 2\beta s) - j\sin(\phi - 2\beta s)K - K\cos(\phi - 2\beta s) - K^2\cos^2(\phi - 2\beta s) - jK^2\cos(\phi - 2\beta s)\sin(\phi - 2\beta s) + jK\sin(\phi - 2\beta s) + K^2 j\cos(\phi - 2\beta s)\sin(\phi - 2\beta s) + K^2\sin^2(\phi - 2\beta s)}{+K\cos(\phi - 2\beta s) - j\sin(\phi - 2\beta s)K + K\cos(\phi - 2\beta s) + K^2\cos^2(\phi - 2}$$

7/09/20

To find length of line:

$$\frac{\beta s}{G_{10}} = \frac{-2K\sin(\phi - 2\beta s)}{1 + |K|^2 + 2K\cos(\phi - 2\beta s)}$$

The point A is at distance S_1 from load $S = S_1$

$$S_1 = \frac{\pi + \phi - \cos^{-1}|K|}{2\beta}$$

$\sin(\phi - 2\beta s_1) = \sin(-\pi + \cos^{-1}|K|) = \sqrt{1-K^2}$

$\cos(\phi - 2\beta s_1) = \cos(\cos^{-1}|K| - \pi) = -K.$

$$\frac{B_s}{G_0} = \frac{+2K\sqrt{1-K^2}}{1+K^2-2K^2} = \frac{+2K\sqrt{1-K^2}}{1-K^2}$$

$$= \frac{+2K}{\sqrt{1-K^2}}.$$

$$B_{s_1} = \left[\frac{2K}{\sqrt{1 \cancel{+} K^2}}\right] G_0$$

To cancel this susceptance, susceptance of stub should be equal to

$$B_{stub} = \left(-\frac{2K}{\sqrt{1-K^2}}\right) G_0.$$

In general the i/p impedance of shorted line is given by $Z_{SC} = jR_0 \tan(\beta s)$

$$B_{SC} = \frac{-jG_0}{\tan \beta s}.$$

The stub connected is also a short-circuited TL and at a length of 'L'.

$$B_{SC} = \frac{-jG_0}{\tan \beta L}.$$

$$G_0\left[\frac{\mp 2K}{\sqrt{1-K^2}}\right] = \frac{G_0}{\tan \beta L}$$

$$\tan \beta L = \frac{\mp\sqrt{1-K^2}}{2K}$$

$$\beta L = \tan^{-1}\left(\frac{\pm\sqrt{1-K^2}}{2K}\right)$$

$$L = \frac{\lambda}{2\pi} \tan^{-1}\left[\frac{\pm\sqrt{1-K^2}}{2K}\right]$$

In terms of S, $S = \frac{1-K}{1+K} \Rightarrow \cancel{K = \frac{1+S}{-1+S}}$

$S + SK = 1 - K$

$S - 1 = -K - SK$

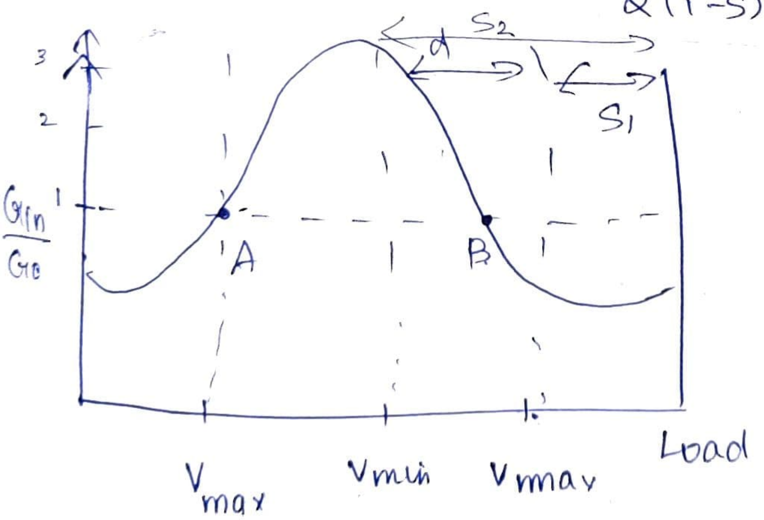
$S - 1 = K(-1-S)$

$$\boxed{K = \frac{1-S}{1+S}}$$

$K = \frac{1-S}{1+S}$

$$L = \frac{\lambda}{2\pi}\tan^{-1}\left[\frac{\pm\sqrt{1-\left(\frac{1-S}{1+S}\right)^2}}{2\left(\frac{1-S}{1+S}\right)}\right]$$

$$= \frac{\lambda}{2\pi}\tan^{-1}\left[\frac{\pm\sqrt{1-(1-S)^2}}{2(1-S)}\right]$$



We'll have two possible solutions.

PROB:

$Z_0 = 50\,\Omega$ $Z_L = 40 + j10\,\Omega$. $f = 750$ MHz

Find the length & distance of stub.

$K = \frac{Z_R - Z_0}{Z_R + Z_0}$ $d = \frac{\cos^{-1}|K|}{2\beta}$ $\beta = \frac{2\pi}{\lambda}$ $f = c\lambda$, $\lambda = \frac{f}{c}$

$= \frac{2\pi}{2.5}$ $= \frac{750 \times 10^6}{3 \times 10^8}$

$= 2.512$ $= 250 \times 10^{-2}$

$= 2.5$ m

$= \frac{40 + 10j - 50}{90 + j10}$ $= \cancel{-0.1 + 0.1j}$

$= -0.097 + 0.121j$

$= \frac{-10 + 10j}{90 + j10} = \frac{-1+j}{9+j} = \frac{(-1+j)(9-j)}{81+1} = \frac{-9+j+9j+1}{82} = \frac{-8+10j}{82}$

$$d = \frac{\cos^{-1}(-0.097 + 0.121j)}{2\beta}$$

$$|k| = \sqrt{(0.097)^2 + (0.121)^2}$$

$2\beta d = \cos^{-1}$

$$= \sqrt{(9.409 \times 10^{-3})^2 + (0.0146)}$$

$$= 0.1550.$$

$$d = \frac{\cos^{-1}(0.1550)}{2\beta}$$

× Not needed

$$= \cancel{81.07^\circ} \; \frac{1.415}{2\beta} = \frac{1.415}{2 \times \frac{2\pi}{\lambda}}$$

$$= \frac{1.415}{2 \times 2.512} = 0.281 \qquad = \frac{1.415}{4\pi} = 0.112\lambda$$

~~Location~~:

$$L = \frac{\lambda}{2\pi} \tan^{-1}\left(\frac{\pm\sqrt{1-K^2}}{2K}\right)$$

$$= \frac{\lambda}{2\pi} \tan^{-1}\left(\frac{\pm\sqrt{1-(0.1550)^2}}{2 \times (0.1550)}\right) \Rightarrow \text{Length}$$

$$= \frac{\lambda}{2\pi} \tan^{-1}(3.186)$$

$$= \frac{\lambda}{2\pi} \times 1.266 = 0.201\lambda m$$

$$S_1 = \frac{\pi - \cos^{-1}|K| + \phi}{2\beta}$$

0.316 λ

Ans

$$= \frac{\pi - 1.415 - 0.895}{2 \times \frac{2\pi}{\lambda}}$$

$$= \lambda \left(1 \right. \qquad \Rightarrow \text{location}$$