USN - 1MS19EC017

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SUBJECT - Field lines and Waves

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CIE - 2

SEM - IV

PAGE - 9

SIGN - Anirud

①

$$\Gamma = \frac{Z_1[Z_L - Z_0]}{(Z_L + Z_0) Z_1 + 2Z_1^2 jt}$$

$$\Gamma = \frac{Z_L - Z_0}{(Z_L + Z_0) + 2Z_1 jt}$$

$$|\Gamma| = \frac{1}{\sqrt{\frac{(Z_L+Z_0)^2}{(Z_L-Z_0)^2} + \frac{4Z_1^2 t^2}{(Z_L-Z_0)^2}}}$$

$$(Z_L + Z_0)^2 = (Z_L - Z_0)^2 + 4Z_L Z_0$$

So,
$$\frac{(Z_L+Z_0)^2}{(Z_L-Z_0)^2} = \frac{(Z_L-Z_0)^2 + 4Z_L Z_0}{(Z_L-Z_0)^2}$$

$$= 1 + \frac{4Z_L Z_0}{(Z_L-Z_0)^2}$$

$$= 1 + \frac{4Z_1^2}{(Z_L-Z_0)^2}$$

$$\boxed{|\Gamma| = \frac{1}{\sqrt{1 + \frac{4Z_L Z_0}{(Z_L-Z_0)^2}\sec^2\theta}}}$$

$$\boxed{\theta = \frac{\pi}{2}\frac{\lambda_0}{\lambda}}$$

Let max. threshold on reflection coefficient $|\Gamma|$ where bandwidth design for certain ranges of frequency must be done

$$\theta_m = \cos^{-1}\left(\frac{(t_m)\, 2\sqrt{Z_L Z_0}}{\sqrt{1-|t_m|^2}\,(Z_L - Z_0)}\right)$$

$$\frac{\Delta f}{f_0} = 2 - \frac{4\cos^{-1}}{\pi}\left(\frac{|t_m|}{\sqrt{1-(t_m)^2}}\,\frac{2\sqrt{Z_L Z_0}}{Z_L - Z_0}\right)$$

②

1b.) SWR = 6 ; V_{max} at 0.721 λ

$Z_0 = 150\,\Omega$; $l = 3.2\lambda$

Moving at 0.721 λ anti-clockwise

$|\Gamma| = 0.7$

$z_L = 0.165 + j1.85$

i) $Z_i = 24.75 + j\,27.75$

ii.) $\Gamma_L = 0.7\angle 158$

iii.) $\Gamma_m = 0.7\angle 87$

iv.) return loss = 3 dB

v.) distance = $(4\times 0.5 + 0.479)\lambda$

$= 2.479\lambda$.

3b.) $Z_L = (150 - j75)\,\Omega$ $Z_0 = 100$ $f = 1.5\,GHz$

SSSS

$d_1 = \lambda_2 - \lambda_{y_L}$

$= 0.155 - 0.056$

$= (0.101)\lambda$

$l_1 = \lambda_1' - 0.25$

$= 0.398 - 0.25$

$= 0.148\lambda$

$$\lambda = \frac{c}{f} = \frac{3\times 10^8}{1.5\times 10^9} = 0.5\,m$$

$d_1 = 0.101 \times 0.5$

$= 0.0505$

$l_1 = 0.148 \times 0.5$

$= 0.074\,m$.

1 c.) Bandwidth performance of quarter wave line (8M)

From definition impedance seen into junction of quarter wave line

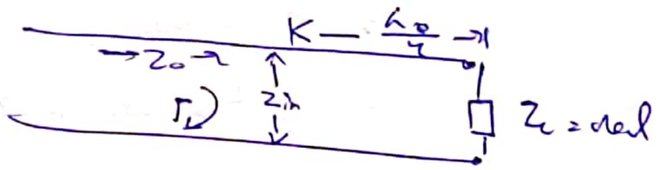
$$Z_{in} = Z_1 \left[\frac{Z_L + jZ_1 \tan \beta L}{Z_1 + jZ_L \tan \beta L} \right]$$

when $\beta L = \frac{2\pi}{\lambda} \left(\frac{\lambda_0}{4} \right)$

when $\lambda = \lambda_0$, $\beta L = \theta = \frac{\pi}{2}$

$Z_1 = \sqrt{Z_0 Z_L}$, $\Gamma = 0 =$ reflection at junction.

If there is small change in operating freq. when $f \neq f_0$ there is mismatch at junction result in reflection



$$\Gamma = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$ when $\lambda \neq \lambda_0$ or $f \neq f_0$ $Z_{in} \neq Z_0$

$$\Gamma = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

$$\Gamma = \frac{Z_1 \left[\frac{Z_1 + jZ_1 t}{Z_1 + jZ_L t} \right] - Z_0}{Z_1 \left[\frac{Z_L + jZ_0 t}{Z_1 + jZ_L t} \right] + Z_0}$$ $t = \tan\beta L$

$$\Gamma = \frac{Z_1 Z_L + jZ_1^2 t - Z_0 Z_0 - Z_0 j Z_L t}{Z_1 Z_L + jZ_1^2 t + Z_0 Z_1 + jZ_0 Z_1 t +}$$

$$\Gamma = \frac{Z_1 [Z_L - Z_0] + j[Z_1^2 - Z_1^2] + t}{Z_1 [Z_1 + Z_0] + j[Z_1^2 + Z_1^2] t}.$$

④

$$\Gamma = \frac{Z_1[Z_L - Z_0]}{(Z_L+Z_0)Z_1 + 2Z_1^2 jt}$$

$$\Gamma = \frac{Z_L - Z_0}{(Z_L+Z_0) + 2Z_1 jt}$$

$$|\Gamma| = \frac{1}{\sqrt{\frac{(Z_L+Z_0)^2}{(Z_L-Z_0)^2} + \frac{4Z_1^2 t^2}{(Z_L-Z_0)^2}}}$$

$$(Z_L+Z_0)^2 = (Z_L-Z_0)^2 + 4Z_L Z_0$$

So, $$\frac{(Z_L+Z_0)^2}{(Z_L-Z_0)^2} = \frac{(Z_L-Z_0)^2 + 4Z_L Z_0}{(Z_L-Z_0)^2}$$

$$= 1 + \frac{4Z_L Z_0}{(Z_L-Z_0)^2}$$

$$= 1 + \frac{4Z_1^2}{(Z_L-Z_0)^2}$$

$$\boxed{|\Gamma| = \frac{1}{\sqrt{1 + \frac{4Z_L Z_0}{(Z_L-Z_0)^2}\sec^2\theta}}}$$

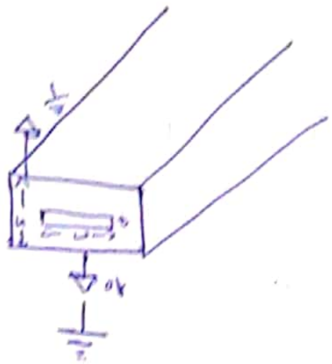
$$\boxed{\theta = \frac{\pi}{2}\frac{\lambda_0}{\lambda}}$$

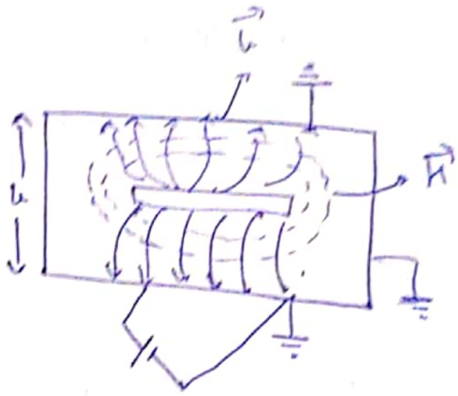
Let max. threshold on reflection coefficient $|\Gamma|$ where bandwith design for certain ranges of frequency must be done

$$\theta_m = \cos^{-1}\left(\frac{(\Gamma_m)\, 2\sqrt{Z_L Z_0}}{\sqrt{1-|\Gamma_m|^2}\,(Z_L - Z_0)}\right)$$

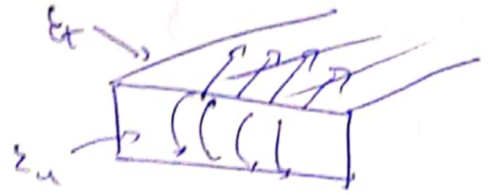
$$\frac{\Delta f}{f_0} = \frac{2 - 4\cos^{-1}}{\pi}\left(\frac{|\Gamma_m|}{\sqrt{1-(\Gamma_m)^2}}\,\frac{2\sqrt{Z_L Z_0}}{Z_L - Z_0}\right)$$

5a.) Strip lines - Transmission lines like two wire open lines are bulky in size and costly. Hence miniaturized transmission lines are designed and they are called planar transmission where size is small so that it is used in MMIC.

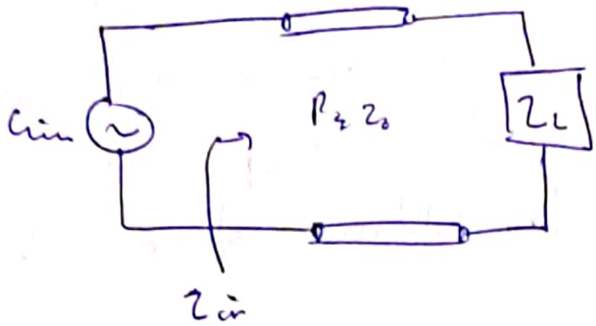




Microstrip line - Microstrip line consist of conductor strip of width thickness such that $t \ll w$ is mounted on a dielectric substrate of thickness and width permittivity. When signal propagates through lines electrified emerges from positive conductor strip and converges with magnetic field is in circulation around strip.



3c) Input impedance of lossless line ⑥



$$Z_{in} = \frac{V(z)}{I(z)} = \frac{V(-l)}{I(-l)} \quad \text{— (1)}$$

w.k.t

$$V(z) = V_0^+ e^{-j\beta z} + V_0^- e^{j\beta z}$$

$$I(z) = \frac{V_0^+}{Z_0} e^{-j\beta z} - \frac{V_0^-}{Z_0} e^{j\beta z}$$

$$V(z) = V_0^+ \left(e^{-j\beta z} + \Gamma e^{j\beta z}\right) = V_0^+ \left(e^{j\beta l} + \Gamma e^{-j\beta l}\right)$$

$$I(z) = \frac{V_0^+}{Z_0} \left(e^{-j\beta z} - \Gamma e^{j\beta z}\right) = \frac{V_0^+}{Z}\left(e^{j\beta l} - \Gamma e^{-j\beta l}\right)$$

$z = (-l)$

$$Z_{in} = \frac{Z_0\left(e^{j\beta l} + \Gamma\left(e^{-j\beta l}\right)\right)}{\left(e^{j\beta l} - \Gamma e^{-j\beta l}\right)}$$

$$= \frac{Z_0\left(e^{j\beta l} + \frac{Z_L - Z_0}{Z_L + Z_0} e^{-j\beta l}\right)}{e^{j\beta l} - \left(\frac{Z_L - Z_0}{Z_L + Z_0}\right) e^{-j\beta l}}$$

$$= Z_0 \left[\frac{(Z_L + Z_0)e^{j\beta l} + (Z_L - Z_0) e^{-j\beta l}}{(Z_L + Z_0) e^{+j\beta l} - (Z_L - Z_0) e^{-j\beta l}}\right]$$

$$Z_{in} = Z_0 \left[\frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l}\right]$$

$$Z_{max} = \frac{V_{max}}{I_{min}} = |V_0^+| \frac{(1 + |\Gamma|)}{(1 - |\Gamma|)} = Z_0 j$$

$$Z_{in\,min} = \frac{V_{min}}{I_{max}} = \frac{(V_0^+)(1-|\Gamma|)}{\frac{V_0^+}{Z_0}(1+|\Gamma|)} = \frac{Z_0}{\rho}$$ (7)

END

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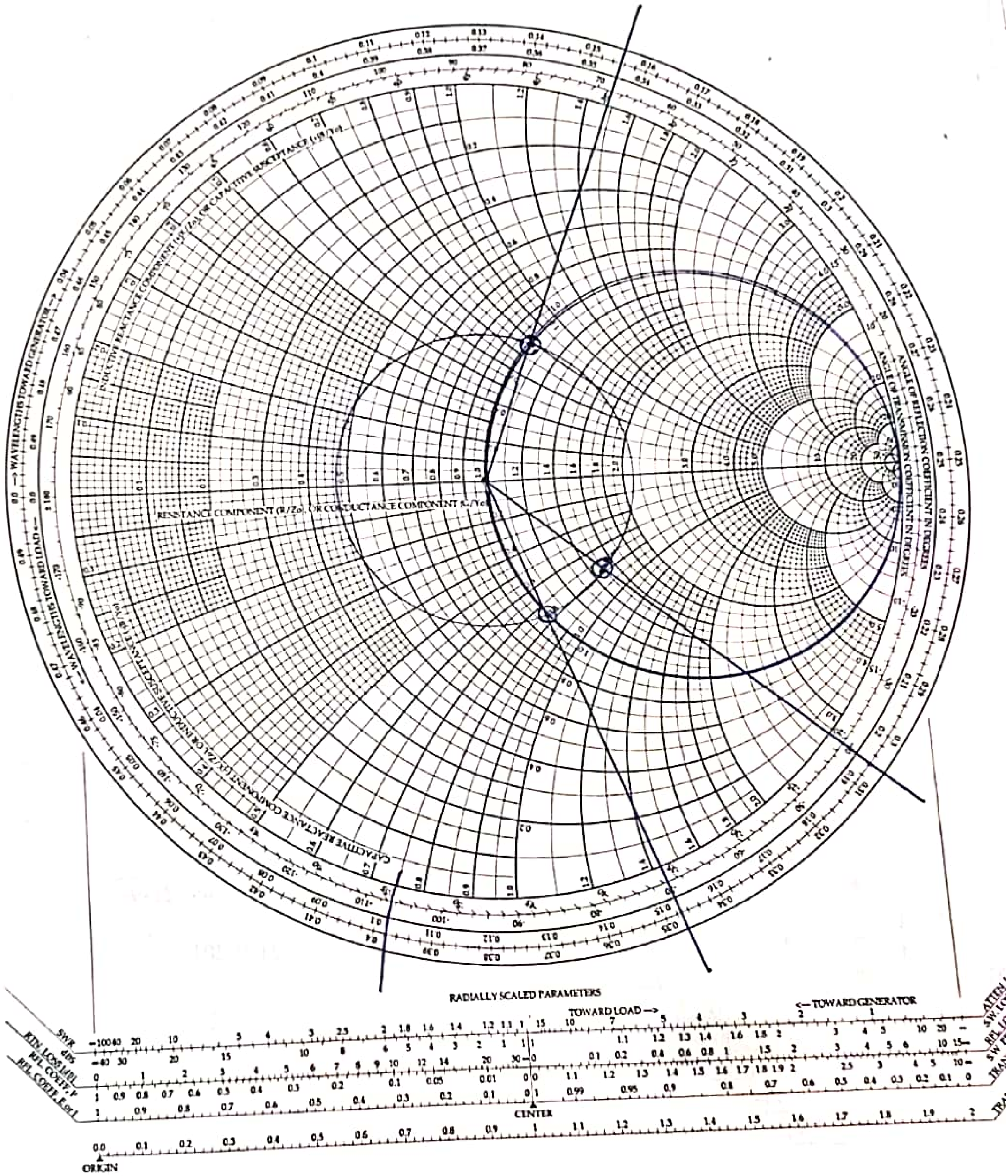
Smith Chart



Smith Chart

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