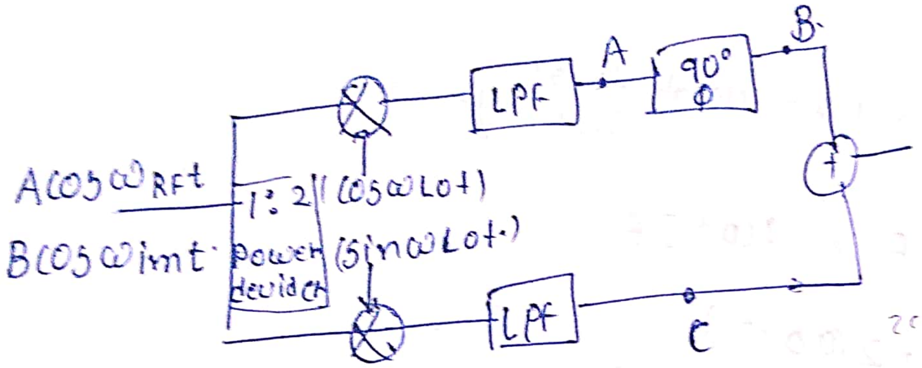
* Hartly & Weaver

DT - 02/09/2019
friday - ~~4th~~ 3rd oct - at 12 noon
CEP-103

* Hartly Architecture for image rejection



Signal at A after LPF

$= A\cos\omega_{RF}t \cdot \cos\omega_{LO}t + B\cos\omega_{im}t \cdot \cos\omega_{LO}t$

$= \frac{A}{2}\left(\cos(\omega_{RF}-\omega_{LO})t\right) + \cancel{\cos} + \frac{B}{2}\left(\cos(\omega_{im}-\omega_{LO})t\right)$

$= \frac{A}{2}\cos(\omega_{IF})t + \frac{B}{2}\cos(\omega_{IF})t$

Signal at B

$= \frac{A}{2}\cos(\omega_{IF}t+90°) + \frac{B}{2}\cos(\omega_{IF}+90°)$

$= -\frac{A}{2}\sin\omega_{IF}t - \frac{B}{2}\sin(\omega_{IF})t$

signal at C.

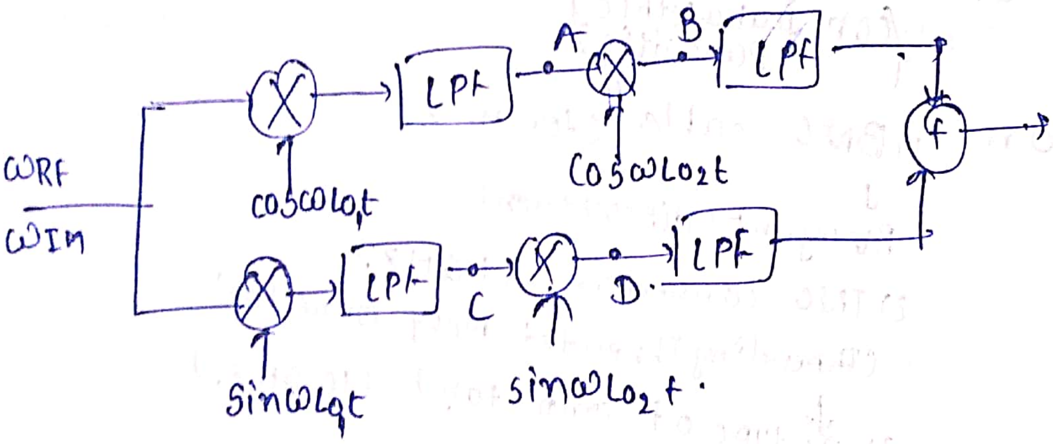
$= -\frac{A}{2}\sin(\omega_{RF}-\omega_{LO})t + \frac{B}{2}\sin(\omega_{im}-\omega_{LO})t$

$= -\frac{A}{2}\sin\omega_{IF}t + \frac{B}{2}\sin\omega_{IF}t$

signal at (D) o/p

$A + C = -A\sin\omega_{IF}t$

Weaver architecture (introduced to avoid phase shifter, as it is difficult to design)



signal at A $= \frac{A}{2}\cos\omega_{IF}t + \frac{B}{2}\cos\omega_{IF}t$

signal at C $= \frac{-A}{2}\sin\omega_{IF}t + \frac{B}{2}\sin\omega_{IF}t$

signal at B $= \frac{A}{2}\cos(\omega_{IF}-\omega_{LO_2})t + \frac{B}{4}\cos(\omega_{IF}-\omega_{LO_2})t$

after LPF

signal at D $= -\frac{A}{4}\cos(\omega_{IF}-\omega_{LO})t + \frac{B}{4}\cos(\omega_{IF}-\omega_{LO})t$

after LPF

at O/P ⇒ B − D

$$= \frac{A}{2} \cos(\omega_{IF} - \omega_{LO2} t)$$

1 Phase shifter is replaced by 2 Mixer & 2 LPF.

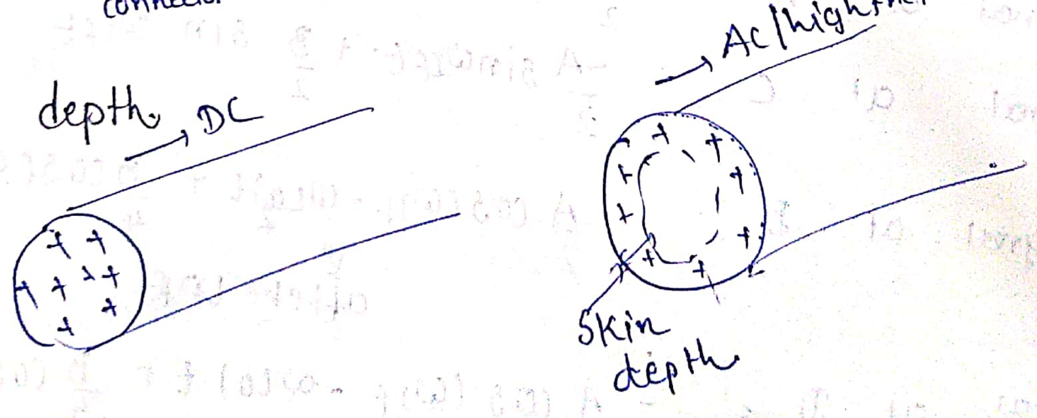
1st Insem course.

* Basics of RF electronics.

1) Presence of stray elements (or ~~paraeethic~~ parasitic)

2) Radiation : 1) BNC cable (few MHz)
Bvoyant (discoverer)
2) TNC connector (1 GHz)
(~~Threading~~ Threaded Nevy connector)
3) N type of connector) (10 GHz)
Gold connector. 4) SMA (Sub miniature A) (20 GHz)

→ Skin depth



$$\delta = \sqrt{\frac{2}{\omega\mu\sigma}} = \sqrt{\frac{1}{\pi f \mu\sigma}}$$

$\uparrow f \rightarrow \downarrow \delta$ (skin depth)

$$Skin\ Depth = \delta = \sqrt{\frac{\rho}{\pi f \mu}} = \sqrt{\frac{\rho}{\pi f \mu_r \mu_o}}$$

coper wire

Where,

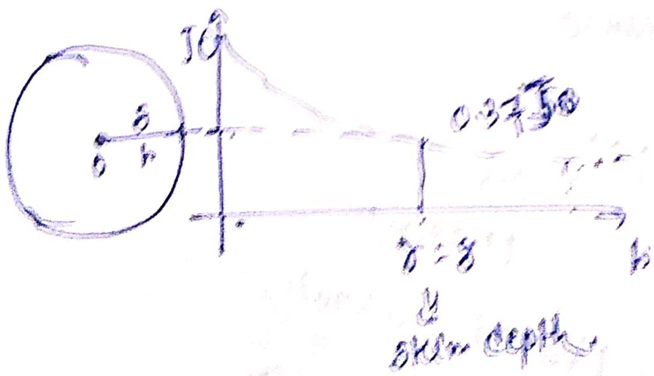
ρ = Resistivity of the Material

f = Frequency

μ_r = Relative Permeability (usually 1)

μ_o = Permeability Constant = $4\pi \times 10^{-7}$

→ For AC signals, current density falls exponentially from surface to center of the conductivity are at critical depth, δ called skin depth, signal amplitude falls to $1/e$ or 36.8% of its maximum value.



1 mil → $\frac{1 \text{ inch}}{1000}$

$= \frac{2.54 \text{ cm}}{1000}$

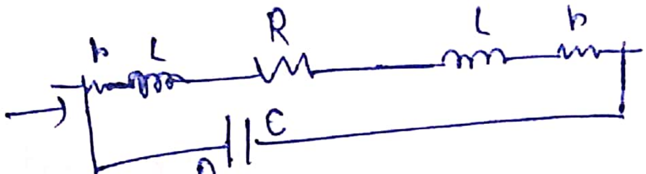
$= \frac{25.4 \text{ m}}{1000}$

50
44

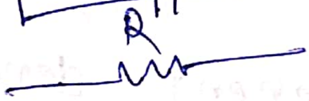
SWG
(Standard wire guage.)

(AC equivalent circuit)
wire (circuit)

Resistor (R)
(AC equivalant)



Resistor(R)
(DC equivalant)

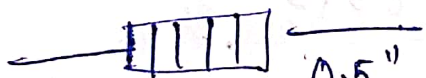


10KΩ (colour code)

d

200MHZ (~~Ammitter~~)

To Measure resistance.



0.5" (1.27 cm)   0.5" (1.27cm)

~~L = 0.002~~ d = 14SWG = 64mil

= × 0.254 cm

= 0.1628 cm.)

L (μH) = 0.002.

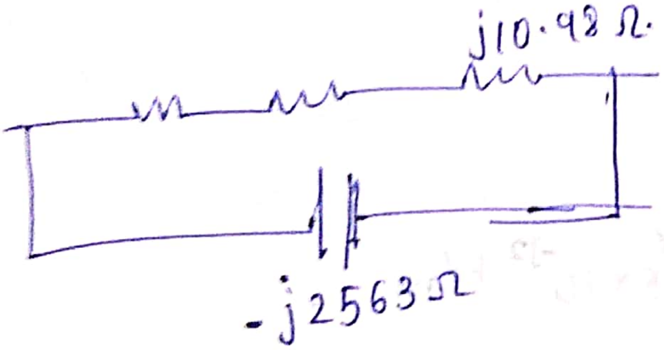
87 (nH) (nano Henry)

$j\omega L = 2\pi \times \underline{200 \times 10^{6}} \times 8.7 \times 10^{-9}$

$= 2\pi f L \qquad = j10.93\,\Omega$

$. 14\,PF$ ~~10^{-1}~~
(10^{-12})

$$X_C = \frac{1}{j\omega C} = \frac{1}{2\pi \times 200 \times 10^{-6} \times 0.3 \times 10^{-12}}$$



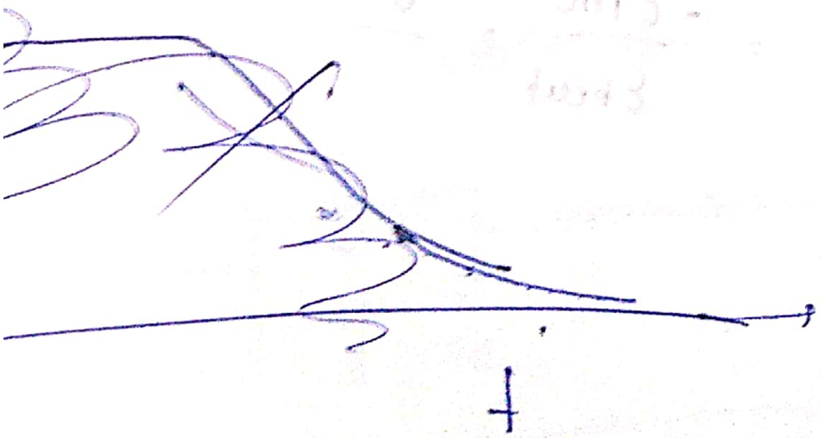
$$Z = \frac{R\,X_C}{\sqrt{R^2 + X_C^2}}$$

$\downarrow$

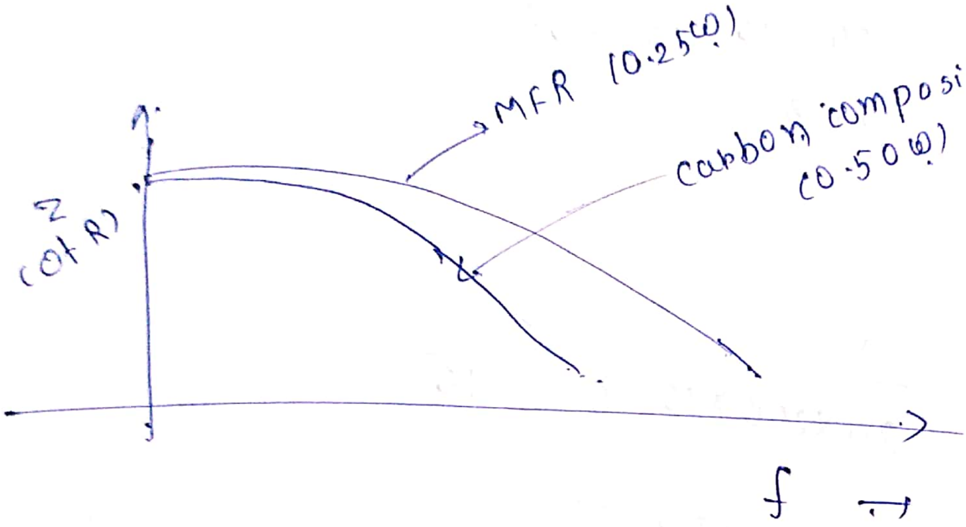
$1890\,\Omega$

$\Downarrow$

10 kΩ resistor behaves as 2 kΩ resistor at 200MHZ



13/09/2019



* Capacitor

→ $\varepsilon = \varepsilon_r \varepsilon_0$

ε_r — relative Permittivity

ε_0 — free space 8.85×10^{-12} F/m

ε_r · dielectric constant - ability to retain the charge

$\varepsilon_r = \varepsilon_r' + j\varepsilon_r''$ (can be real / complex)

not skin depth

$\tan\delta = \frac{-\varepsilon_r''}{\varepsilon_r'} = \frac{-\varepsilon_{im}}{\varepsilon_{real}} = \frac{\sigma}{}$

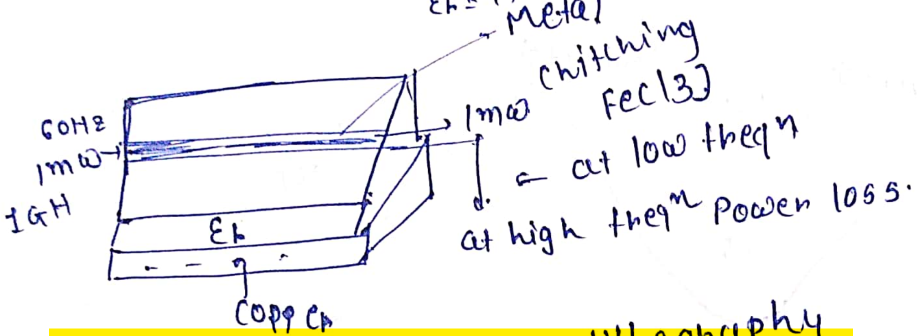
↓

lost tangent

Scanned by CamScanner

Normal PCB (FR-4) → ~~tanδ~~ :
$\varepsilon_r = 4$)

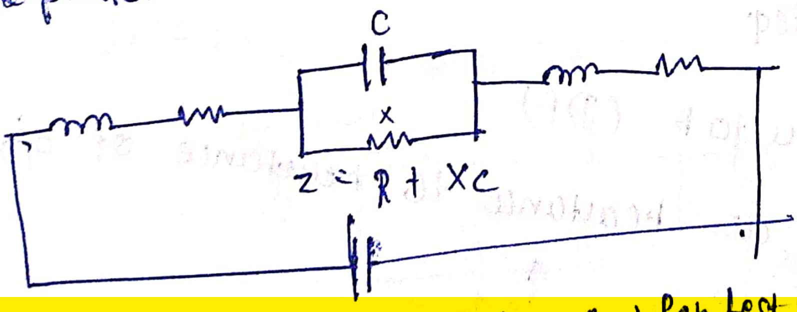
CIVIL



at high freq^n → photolithography.
⇓
use special PCB
(RF substrate } → very costly
μwave "
Dielectric ")

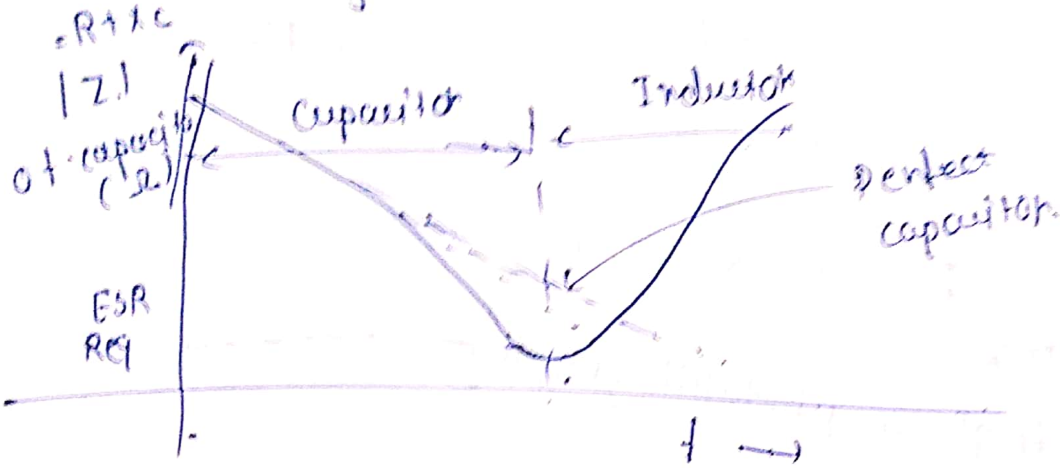
→ $\tan\delta$ = 0.0009 at 60 HZ
= 0.009 at 1MHZ
= 0.09 at 1GHZ

capacitor → used to block dc



current leads voltage by 90° → Perfect capacitor

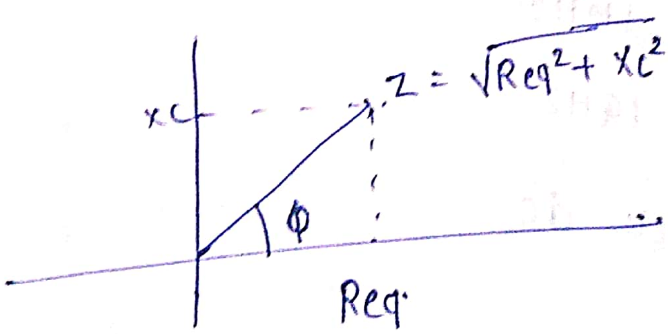
$x_c = \frac{1}{j\omega c}$



- ESR or Req or ac resistor of capacitor

effect $= R_S + R_P$

2) Power factor (PF) : $\cos\phi = \frac{Req}{X_c}$



$= \frac{Req}{\sqrt{X_c^2 + Req^2}}$

$\approx \frac{Req}{X_c}$

3) Discipation factor (DF)

ratio of ac reactance to reactance of o/p

$= \frac{Req}{X_c}$

100 % $DF = \frac{R_{eq}}{X_C} \times 100\%$.

4) Q - factor $= \frac{X_C}{R_{eq}} = \frac{1}{\omega C R_{eq}} \approx \frac{1}{PF}$

~~for~~ perfector.

⇒ for perfect capacitor

$ESR = R_{eq} = 0$

$PF = 0$

$DF = 0$

$Q = \infty$

$\tan\delta = 0$

* Inductor

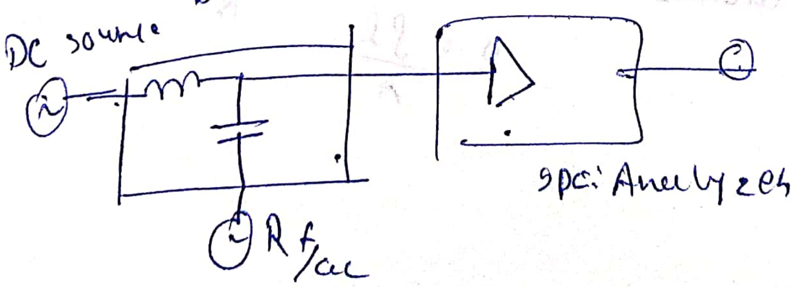
(Inductor application)

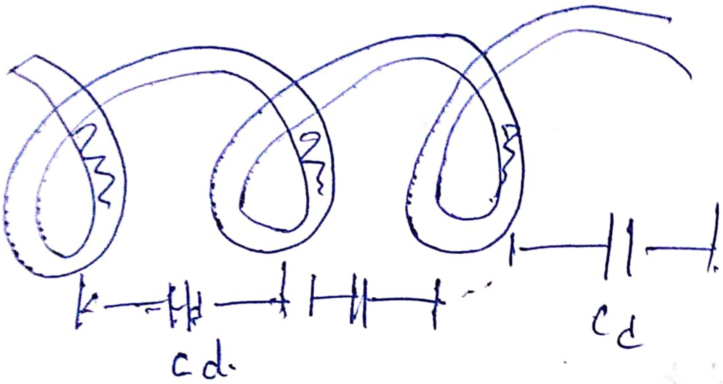
RF chock, → Inductor

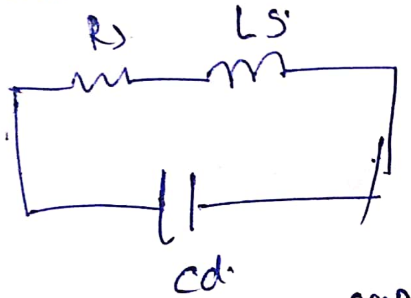
tunning,

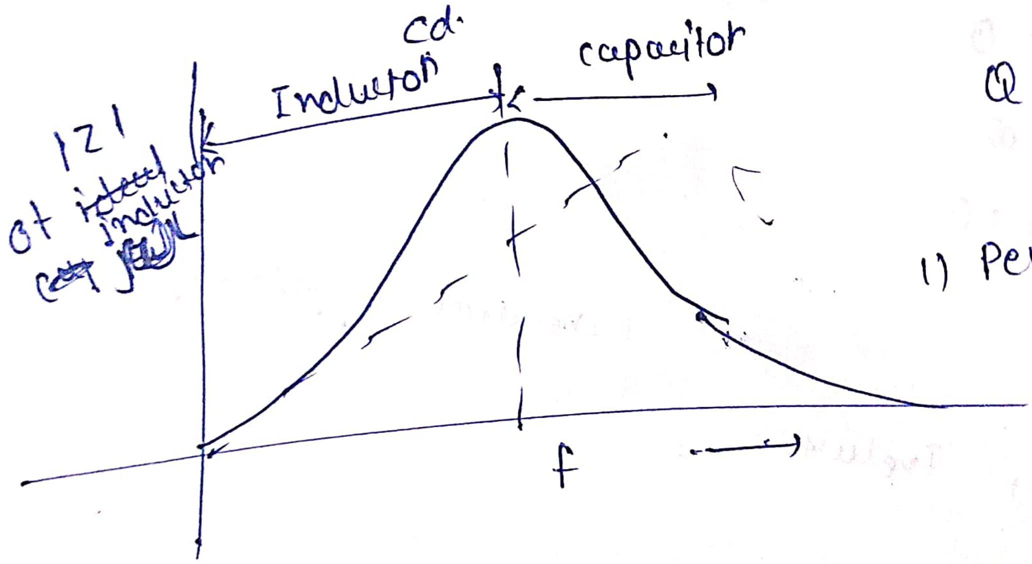
delay,

Bias Tee









$Q = \frac{X_L}{R_S} = \frac{\omega L}{R_S}$

1) Perfect inductor

$R_S = 0$

$Q = \infty$

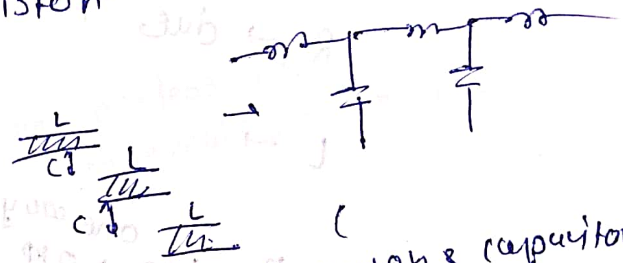
2) large diameter → large area

$R = \frac{\rho l}{A}$ $\quad R \to 0$

3). Increase space betn ~~[illegible]~~ winding (A)

$C = \frac{\varepsilon A}{d}$ A ↑ C ↑

220R ← chip ~~resistense~~ resistor



mils mils

0402 : 40 × 20

0603 : 60 × 30

0805 : 80 × 50

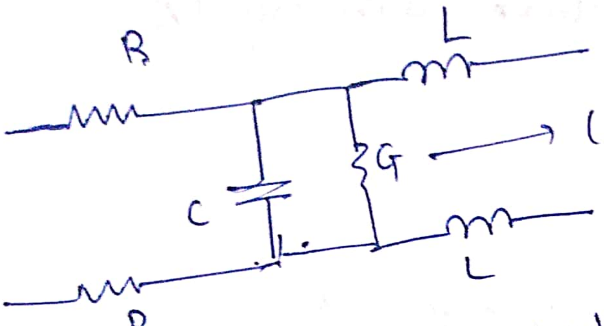
1206 : 120 × 60

1218 : 120 × 180

(inductor & capacitor on PCB)

Ω.

DT - 16/09/2019

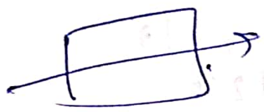


G → (conductance)

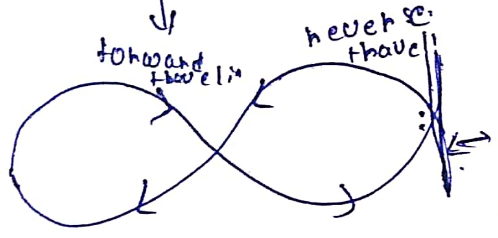
R → due to Material by conductor (~~conductor~~ .)

L →

at low freqn → i/p → o/p (one way)



at 'RF freqn



V & C changes → Z impedance changes.

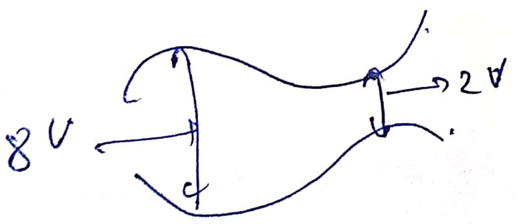
→ load at every point

↓

Reflection depends on

↓

SW



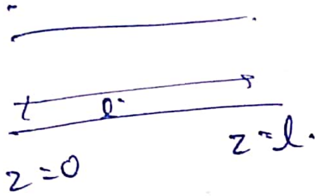
maxima
minima

↓

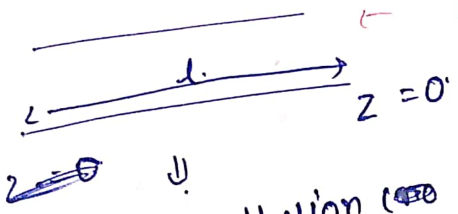
standing wave (Super Position of forward & reverse travelling waves)

by

at low freq^e z=0 -



at RF freq^n



← always talks in terms of ~~V(z)~~ V(z)

⇓ no-reflection (lossless line impossible) → bcz R, G, ...

⇓ every thing depends on load.

characteristic impedance. ($Z_0 = 50\Omega$) (standard) (i/p & o/p impedance always $Z_0 = 50\Omega$)

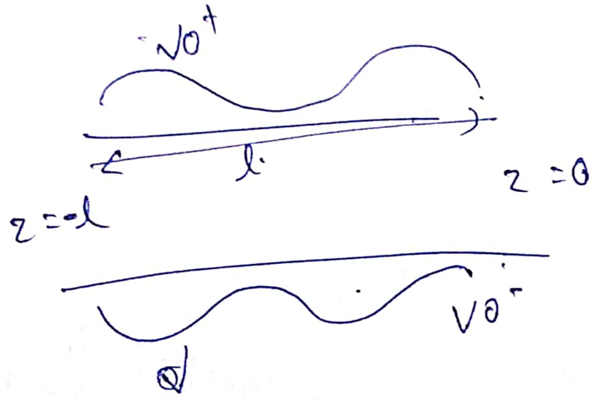
Broadcasting
↓ at
75Ω (India)

→ To avoid impedance mismatch, ~~fr~~ impedance transform is used.

Voltage along transmission line.

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

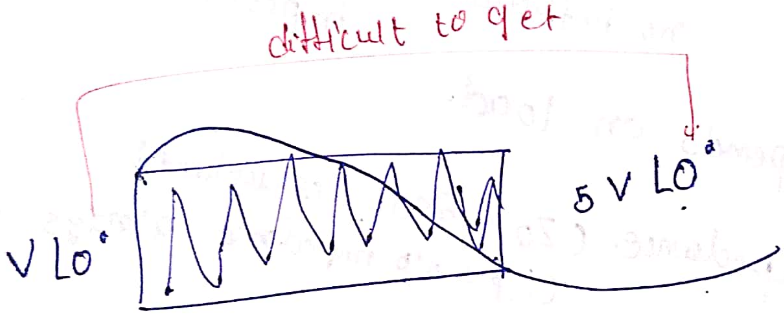
→ forward wave



γ = Propogation const.

$= \alpha + j\beta \rightarrow$ phase constant (rad/m)

α ↓ attenuation constant (NP/m)



1 NP = 8.686 dB

$$Z_0 = \underbrace{\cancel{\alpha + j\beta}}_{R_0 + jX_0} = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

Ω

$$\gamma = \alpha + j\beta = \sqrt{(R + j\omega L)(G + j\omega C)}$$

γ ↓ m, α ↓ NP/m, β ↓ rad/m

Case - I lossless line (ideal), $R = 0$, $G = 0$

$$\gamma = j\omega\sqrt{LC} = \alpha + j\beta$$

$$\boxed{\beta = \omega\sqrt{LC}}$$

$\alpha = 0 \Rightarrow$ lossless line.

$Z_0 = R_0 + jX_0 = \sqrt{\frac{L}{C}}$

$R_0 = \sqrt{\frac{L}{C}}$

$X_0 = 0$

phase velocity v_p

$$\boxed{v_p = \frac{1}{\sqrt{LC}} = \frac{\omega}{\beta}}$$

case-II) Low loss line

$$\boxed{(R << \omega L, \ G << \omega C)}$$

$\gamma, \alpha, \beta, v_p, Z_0, R_0, X_0$

$$\gamma = \alpha + j\beta = \sqrt{(R + j\omega L)(G + j\omega C)}$$

$$\approx j\omega\sqrt{LC}\left(1 + \frac{R}{j\omega L}\right)^{1/2}\left(1 + \frac{G}{j\omega C}\right)^{1/2}$$

$$(1+x)^n = 1 + nx + \ldots$$

$$= j\omega\sqrt{LC}\left(1 + \frac{R}{2j\omega L}\right)\left(1 + \frac{G}{2j\omega C}\right) + \ldots$$

$$= j\omega\sqrt{LC}\left(1 + \ldots\right.$$

$$= \underbrace{j\omega\sqrt{LC}}_{\beta} + \underbrace{\frac{1}{2}R\sqrt{\frac{C}{L}} + \frac{1}{2}G\sqrt{\frac{L}{C}}}_{\alpha}$$

$$Z_0 = R_0 + jX_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$= \sqrt{\frac{\frac{R}{j\omega L} + 1}{\frac{G}{j\omega C} + 1} \cdot \frac{j\omega L}{j\omega C}}$$

$$= \sqrt{\frac{L}{C}}\left(1 + \frac{R}{j\omega L}\right)^{1/2}\left(1 + \frac{R}{j\omega L}\right)^{-1/2}$$

$$= \sqrt{\frac{L}{C}}\left[1 + \frac{1}{2j\omega}\left(\frac{R}{L} - \frac{G}{C}\right)\right]$$

$$R_0 = \sqrt{\frac{L}{C}}$$

$$X_0 = \sqrt{\frac{L}{C}} \cdot \frac{1}{2j\omega}\left[\frac{R}{L} - \frac{G}{C}\right]$$

$$\approx 0.$$

$$v_p = \frac{\omega}{\beta} = \frac{1}{\sqrt{LC}}$$

Distortionless

↓

losses of electric field = losses of Magnetic field.

$$\boxed{RC = GL}$$

$$\boxed{\frac{R}{L} = \frac{G}{C}}$$

γ, α, β, R_0, Z_0, X_0, V_p

$$\gamma = \alpha + j\omega = \sqrt{(R + j\omega L)(G + j\omega C)}$$

$$= \sqrt{(R + j\omega L)\left(\frac{RC}{L} + j\omega C\right)}$$

$$= \sqrt{\frac{R^2 C}{L} + j\omega RC + j\omega RC - \omega^2 LC}$$

$$= \sqrt{\frac{R^2 C}{L} + -\omega^2 LC + 2j\omega RC}$$

$$= \sqrt{\frac{C}{L}(R^2 - \omega^2 L^2) + 2j\omega RL}$$

$$= \sqrt{\frac{C}{L}(R+j\omega L)^2}$$

$$= \sqrt{\frac{C}{L}}\,(R+j\omega L) = \gamma = \alpha + j\beta$$

$$\alpha = R\sqrt{\frac{C}{L}} = \sqrt{RG} \quad \left(\because \frac{C}{G} = \frac{R}{L},\ G = \frac{RC}{L}\right)$$

$$\beta = \omega\sqrt{LC}$$

$$v_p = \frac{\omega}{\beta} = \frac{1}{\sqrt{LC}}$$

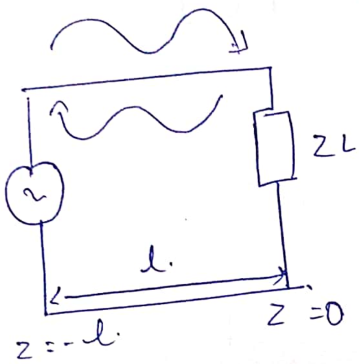
$$Z_0 = R_0 + jX_0 = \sqrt{\frac{(R+j\omega L)}{(G+j\omega C)}}$$

$$= \sqrt{\frac{R+j\omega L}{\frac{RC}{L}+j\omega C}}$$

$$R_0 = \sqrt{\frac{C}{L}} = \sqrt{\frac{R}{G}}$$

$$X_0 \simeq 0$$

Scanned by CamScanner



$\gamma = \underbrace{\alpha}_{\text{attenuat const (Np/m)}} + j\underbrace{\beta}_{\text{phase con. (rad/m)}}$

$V(z) = \underbrace{V_0^+ e^{-\gamma z}}_{\text{forward (incident)}} + \underbrace{V_0^- e^{+\gamma z}}_{\text{backward (reflected)}}$

$I(z) = I_0^+ e^{-\gamma z} + I_0^- e^{+\gamma z}$

$= \frac{V_0^+}{Z_0} e^{-\gamma z} + \cancel{V_0} I_0^- e^{\gamma z}$ $\left(\because Z_0 = \frac{V_0^+}{I_0^+} = \frac{V_0^-}{I_0^-} \right]$

Assumption :- line is lossless $(\alpha = 0)$

(reflection due to impedence mismatch)

$\gamma = \alpha + j\beta = j\beta$

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

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

Voltage reflection coefficient [Γ or C]

Ⓐ V_L. (voltage at load.) $= V(z=0)$

$= V_0^+ + V_0^-$

Ⓑ I_L (current at load) $= I(z=0)$

$= \frac{1}{Z_0}[V_0^+ - V_0^-]$

$$Z_L = \frac{V_L}{I_L} = \frac{V_0^+ + V_0^-}{\frac{1}{Z_0}[V_0^+ - V_0^-]}$$

$Z_L = Z_0 (V_0^+$

$$V_0^- = \left(\frac{Z_L - Z_0}{Z_L + Z_0}\right) V_0^+$$

reflection co-efficient

$$\boxed{\Gamma = \frac{V_0^-}{V_0^+} = \frac{Z_L - Z_0}{Z_L + Z_0}}$$

. perfect.
$Z_0 = 50 + j0$.

complex quantity.
(by default take voltage co-efficient)

$$\cancel{I_0^+} \quad \frac{I_0^-}{I_0^+} = \frac{-V_0^-}{V_0^+} = -\Gamma$$

Γ = complex quantity ($\because$ Z_L is complex)

$= |\Gamma| e^{j\theta_r} = |\Gamma| \angle \theta_r$

→ Matched ~~impedence~~ line ($Z_L = Z_0$)
$\Downarrow$
Perfect Match

$\Gamma = 0 = \frac{Z_L - Z_0}{Z_L + Z_0}$ (no reflection)

→ short-circuited ~~impedance~~ line ($Z_L = 0$)

$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = -1 = 1 \angle 180°$ (phase reversal)

→ Open-circuited line ($Z_L = \infty$)

$\Gamma = 1 = 1 \angle 0°$ × (reflection with no phase change)

OTDR (Optical Time domain Reflectometer)
$\Downarrow$
measure reflected signal in time domain

$-1 \leq \Gamma \leq 1$

$0 \leq |\Gamma| \leq 1$

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* VSWR (Voltage standing wave Ratio)

$$VSWR = \frac{1+|\Gamma|}{1-|\Gamma|}$$ less VSWR (for good system)

ML 1 (1 < VSWR < ∞)

SC ∞

OC ∞

* Standing wave (. lossless $\alpha = 0$, $\gamma = j\beta$)

eqn

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

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

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

$I(z) = Y_0^+ \left(e^{-j\beta z} - \Gamma e^{j\beta z} \right)$

$\left(\because \frac{V_0^-}{V_0^+} = \Gamma \Rightarrow V_0^- = \Gamma V_0^+ \right)$

$|V(z)| = \left[V(z) \cdot V^*(z) \right]^{1/2}$

complex conjugate

$$= \left[V_0^{+} \left(e^{-j\beta z} + \Gamma e^{j\beta z} \right) \cdot (V_0^{+})^{*} \left(e^{j\beta z} + \Gamma e^{-j\beta z} \right) \right]^{1/2}$$

$$= \left[V_0^{+} \left(e^{-j\beta z} + |\Gamma| e^{j\theta_r} e^{j\beta z} \right) \right] \cdot \left[(V_0^{+})^{*} \left(e^{j\beta z} + |\Gamma| e^{-j\theta_r} e^{-j\beta z} \right) \right]^{1/2}$$

$$(\because \Gamma = |\Gamma| e^{j\theta_r})$$

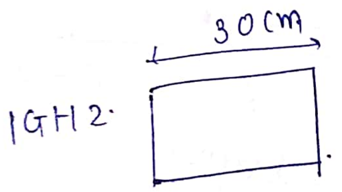
$$= |V_0^{+}| \left[1 + |\Gamma|^2 + |\Gamma| e^{j(2\beta z + \theta_r)} + e^{-j(2\beta z + \theta_r)} \right]^{1/2} \quad (\because e^{jx} + e^{-jx} = 2\cos x.)$$

$$\boxed{|V(z)| = |V_0^{+}| \cdot \left[1 + |\Gamma|^2 + 2|\Gamma| \cos(2\beta z + \theta_r) \right]^{1/2}}$$

©

$\lambda = c/f$

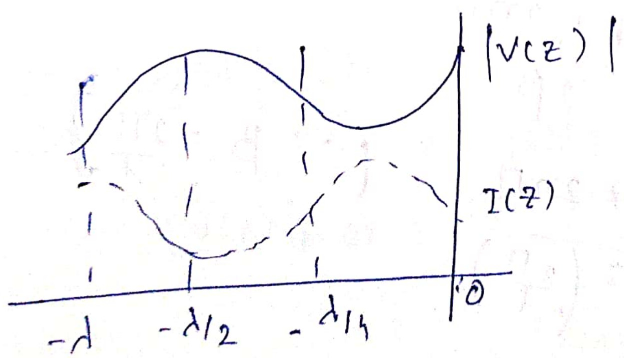
electrical length $\rightarrow \lambda = c/f = \frac{3 \times 10^{8}}{1 \times 10^{9}} = 30$



$l = \lambda$ @ 1GHz

$l = 7.5 \Rightarrow \frac{\lambda}{4}$ @ 1GHz

$l = 15 \Rightarrow \frac{\lambda}{2}$ @ 1GHz



* Our objective

1) To find Position of Maxima & minima
2) " " Amp " "

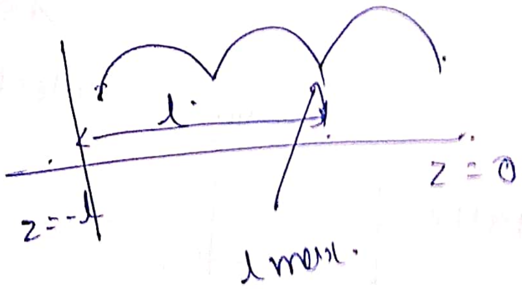
Maxima: The Maxima value of standing wave retain. of $|V(z)|$. corresponds to positions ~~on~~ of line at which ~~inci~~ incident & reflected waves are in phase.

$(2\beta z + \theta_r) = 2n\pi$, $n = 0$, -ve or +ve in phase.

↓

~~$z = l_{max}$~~

$z = l_{max}$ (Position of Maxi



$2\beta l_{max} = 2n\pi$

$-2\beta l_{max} + \theta_r = -2n\pi$

~~l_{max}~~ $l_{max} = \dfrac{\theta_r + 2n\pi}{2\beta}$

$= \dfrac{\theta_r + 2n\pi}{2\left(\frac{2\pi}{\lambda}\right)}$ $\left(\because \beta = \frac{2\pi}{\lambda}\right)$

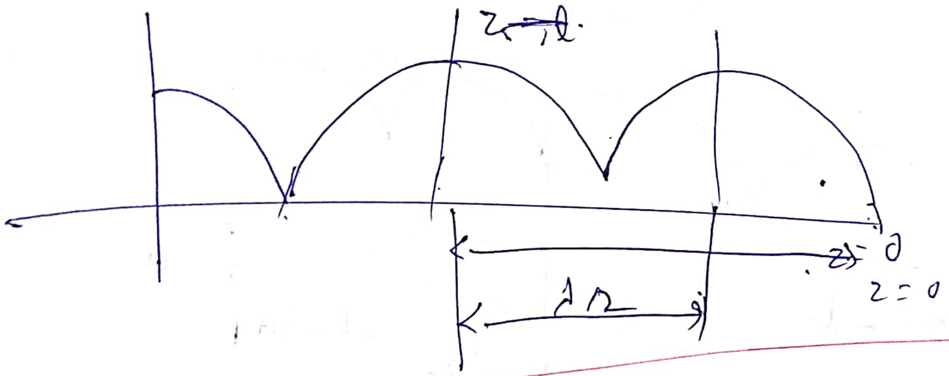
$$l_{max} = \frac{\theta_r \lambda}{4\pi} + \frac{n\lambda}{2} \quad ; \quad n = 0, 1, 2 \ldots$$

First Maxima will occure at.

1st " " $\frac{\theta_r \lambda}{4\pi}$ $(n=0)$.

2nd " " $\frac{\theta_r \lambda}{4\pi} + \frac{\lambda}{2}$ $(n=1)$

3rd " " $\frac{\theta_r \lambda}{4\pi} + \lambda$ $(n=2)$



$\boxed{\text{Dest. bet}^n \text{ 2 successive Matrix} = \frac{\lambda}{2}}$

(c) $\cancel{V_0^+}$ $|V(z)| = |V_0^+| [1 + |\Gamma|^2 + 2|\Gamma| \cos(2\beta z + \theta_r)]^{1/2}$

$= |V_0^+| [(1 + |\Gamma|)^2]^{1/2}$

$|V(z)|_{max} = |V_0^+| [1 + |\Gamma|]$

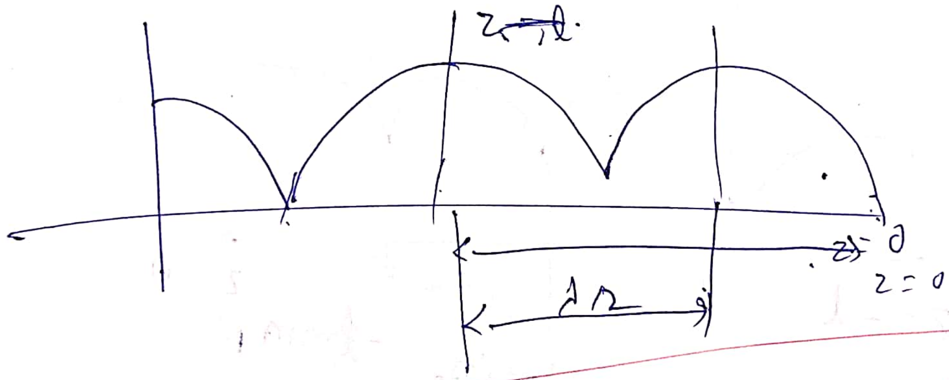
$\ell_{max} = \frac{\theta_r \lambda}{4\pi} + \frac{n\lambda}{2}$; $n = 0, 1, 2 \ldots$

First Maxima will occure at.

1^{st} " " $\frac{\theta_r \lambda}{4\pi}$ $(n=0)$.

2^{nd} " " $\frac{\theta_r \lambda}{4\pi} + \frac{\lambda}{2}$ $(n=1)$

3^{rd} , " $\frac{\theta_r \lambda}{4\pi} + \lambda$ $(n=2)$



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$= |V_0^+| [(1 + |\Gamma|)^2]^{1/2}$

$|V(z)|_{max} = |V_0^+| [1 + |\Gamma|]$

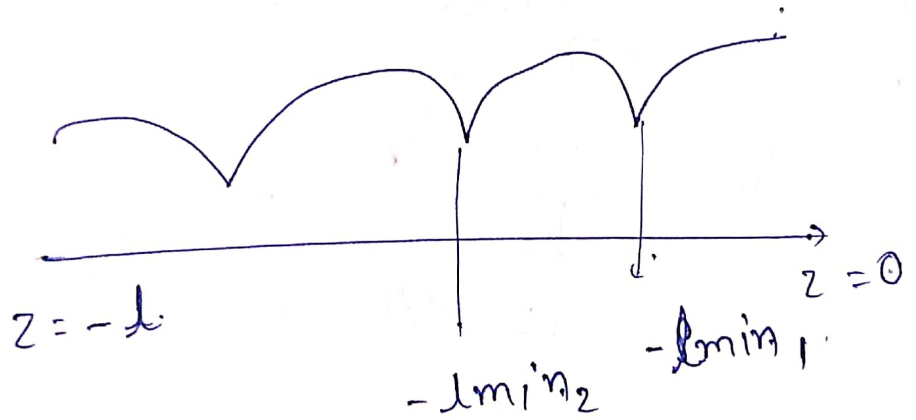
⇒ Minima.

$(2\beta z + \theta_r) = (2n+1)\pi \quad ; \quad n = 0, 1, 2$

$z = l_{min}$

$-2\beta l_{min} + \theta_r = (2n+1)\pi. \quad n = 0, 1, 2 ..$

$z = -l_{min}$



$$l_{min} = \frac{\theta_r + (2n+1)\pi}{2\beta}$$

$$\boxed{l_{min} = \frac{\theta_r + (2n+1)\pi}{2\left(\frac{2\pi}{\lambda}\right)}}$$

1st min

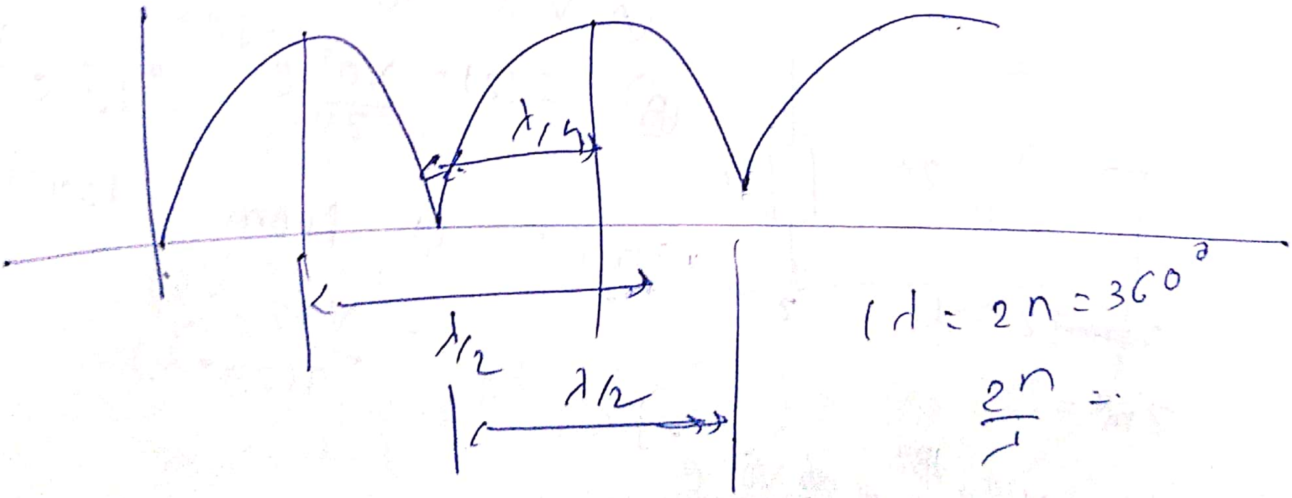
$$P_{min_1} = \frac{\theta_r \lambda}{4\pi} + \frac{\pi}{4\pi/\lambda} \quad (n=0)$$

$$P_{min_1} = \frac{\theta_r \lambda}{4\pi} + \frac{\lambda}{4} \quad (n=0)$$

$$P_{min_2} = \frac{\theta_r \lambda}{4\pi} + \frac{3\lambda}{4} \quad (n=1)$$

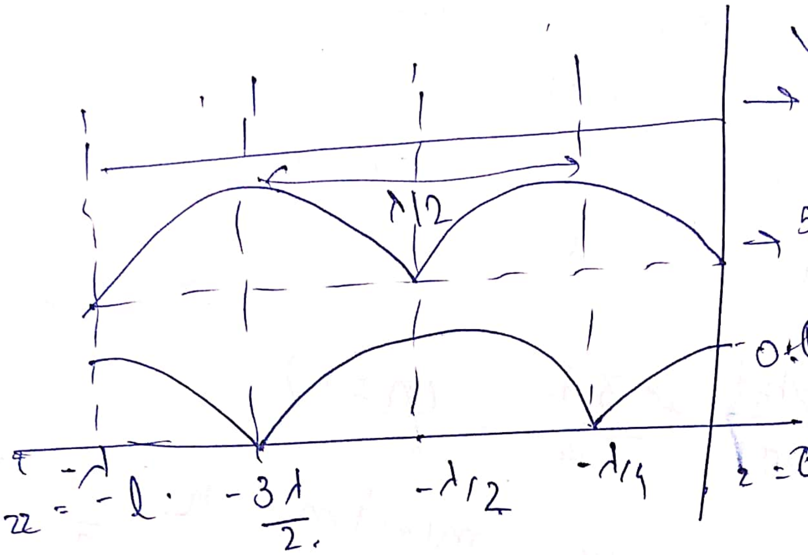
Dist. betn 2 successive minimum $= \frac{\lambda}{2}$

Dist betn max. & subsequence min $= \frac{\lambda}{4}$.



$1\lambda = 2\pi = 360°$

$\frac{2\pi}{\lambda} =$

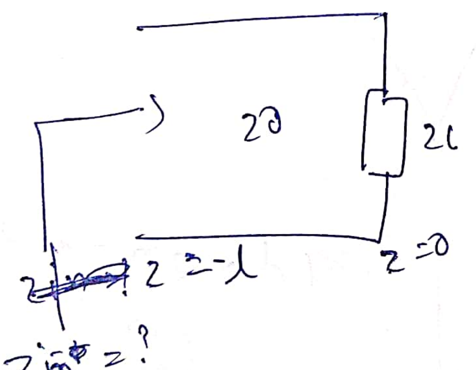


$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

an ion collision avoid system

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

Ⓑ $I(z) = \frac{V_0^+}{Z_0} e^{-j\beta z} - I_0^- e^{+j\beta z}$



$Z_{in}(z = -l)$ from load

$$= \frac{V(z=-l)}{I(z=-l)}$$

$Z_{in} = Z_0 \, V_0^+ e^{j\beta z} + V_0^- e^{-j}$

$$Z_{in} = Z_0 \cdot \frac{V_0^+ e^{j\beta l} + \frac{V_0^-}{V_0^+} e^{-j\beta l}}{V_0^+ e^{j\beta l} - \frac{V_0^-}{V_0^+} e^{-j\beta l}}$$

$\cancel{z_{in} = e^{4j}}$ e^{GRBS}

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

$$\left(\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} \right)$$

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

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

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

$$e^{j\beta l} = \cos(\beta l) + j\sin(\beta l)$$

$$e^{-j\beta l} = \cos(\beta l) - j\sin(\beta l)$$

$$Z_{in} = Z_0 \cdot \frac{Z_L\cos(\beta l) + jZ_0\sin(\beta l)}{jZ_L\sin(\beta l) + Z_0\cos(\beta l)}$$

$Z_{in}\,(z = -l$

$$Z_{in}(z = -l) = Z_0 \cdot \frac{(Z_L + jZ_0\tan(\beta l))}{Z_0 + jZ_L\tan(\beta l)} \qquad \because \beta = \frac{2\pi}{\lambda}$$

$R \rightarrow \Omega/m$

$L \rightarrow nH/m$

(∵ at every point elements (as per length) ~~the~~ value changed. so distributed element

If line is lossy. ($\alpha \neq 0$, $\gamma = \alpha + j\beta$)

$Z_{in}(\Omega) = Z_0 \cdot \frac{Z_L + Z_0 \tanh(\gamma l)}{Z_0 + Z_L \tanh(\gamma l)}$

$$\boxed{Z_{in}(\Omega) = Z_0 \cdot \frac{Z_L + Z_0 \tanh(\gamma l)}{Z_0 + Z_L \tanh(\gamma l)}}$$

$\tanh(\gamma l) = \tanh(j\beta l) = j\tan(\beta l)$

for lossless line ($\gamma = j\beta$)

Dt - 23/9/19

?

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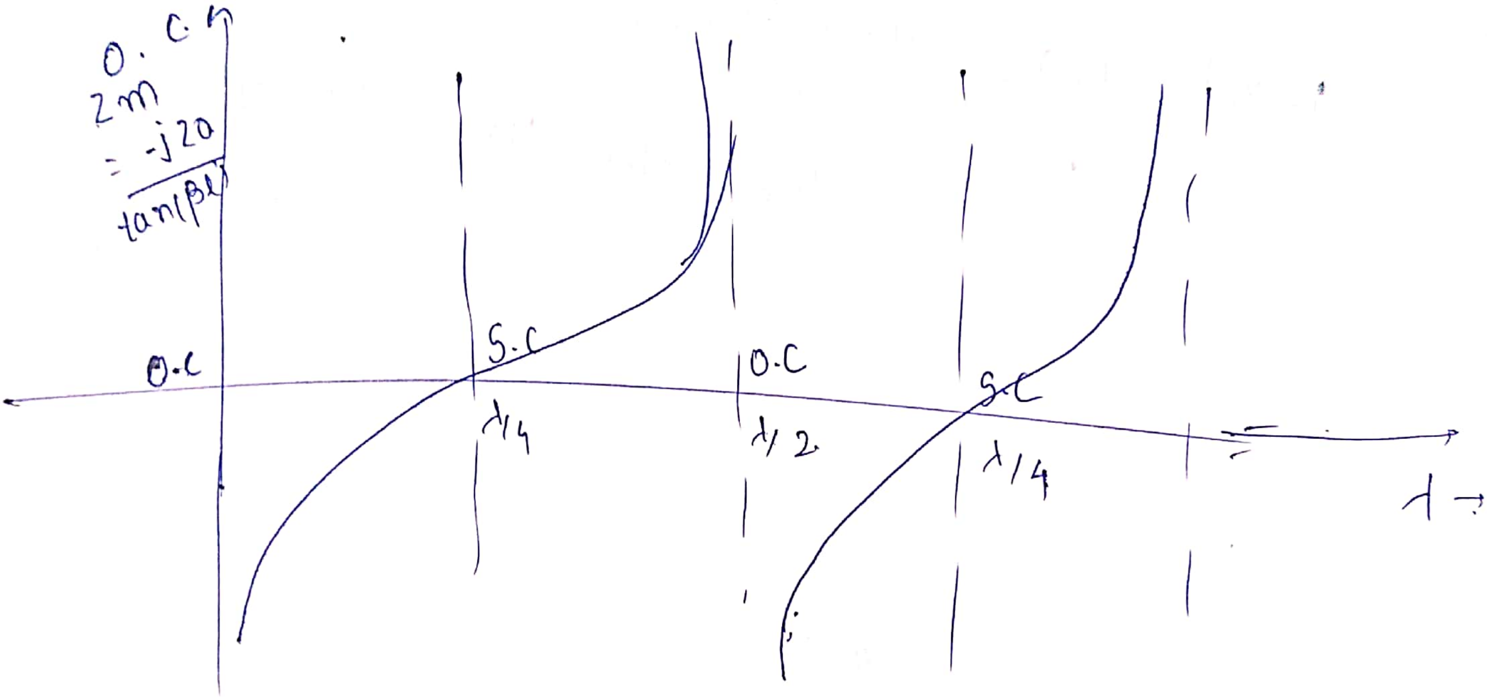
case - II   lossless   O.C. line.

① eqn $\frac{Z_L}{Z_{in}} = \infty$

$$Z_{in}^{x} = \frac{-jz_0}{\tan(\beta l)} = -jz_0\cot(\beta l)$$

lossless $\Rightarrow \coth(\gamma l)$ $(-jz_0\cot(\beta l) = \coth(\gamma l))$



case - III $l = \lambda/4$

① eqn $\Rightarrow \beta l = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{4} = \frac{\pi}{2}$

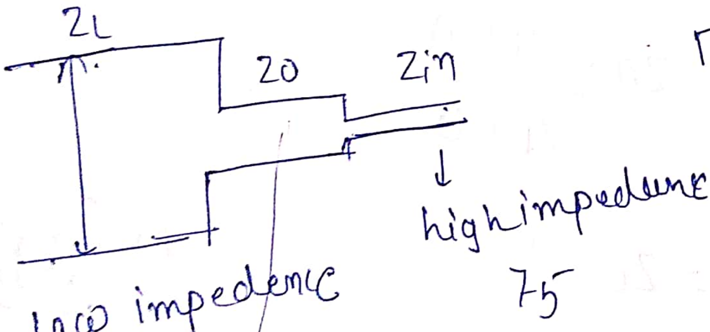
$$\tan(\beta l) = \tan\left(\frac{\pi}{2}\right) = \infty$$

(i): $Z_{in} = Z_0 \left[\dfrac{\dfrac{Z_L}{\tan\beta l} + jZ_0}{\dfrac{Z_0}{\tan\beta l} + jZ_L} \right]$

$$Z_{in}^{\lambda/4} = Z_0 \left[\frac{jZ_0}{jZ_L}\right] \quad \left(\because \frac{1}{\tan\beta} = \frac{1}{\infty} \to 0\right)$$

$$\boxed{Z_{in}^{\lambda/4} = \frac{Z_0^2}{Z_L}}$$ → quarter wave transformer.

*



$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{75-50}{75+50} = \frac{1}{5} = 20\%$$ (power cutted) disast (ri)

$Z_0 = \sqrt{Z_{in} Z_L}$ → This is for real impedance.

$= \sqrt{50 \times 75}$

$= 6550$ (impedance transformer)

$\frac{\lambda}{4}$ → Quater wave transformer

⇓

for impedance matching

&

impedance inverter

(after every $\lambda/4$ SC ⟷ O.C. that's why impedance inverter)

Case - IV

$l = \lambda/2.$

$$\beta l = \frac{2\pi}{\lambda} \times \frac{\lambda}{2} = \pi$$

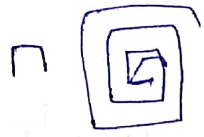
$$\tan(\beta l) = \tan\pi = 0$$

$$Z_{in}^{\lambda/2} = Z_0 \cdot \frac{Z_L + 0}{Z_L + 0}$$

$$\boxed{Z_{in}^{\lambda/2} = Z_L}$$

⇓

Half wave transformer



↑

Meander line (~~ten~~ always length $= \lambda/2$)

if I wan $z_{in} = z_L$ then length must be $\frac{\lambda}{2}$ (depends upon frequency)

30/09/2019

?

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tan -ve, angle is in 2nd or 4th quadrant.
soln in 2nd quadrant.

$$\beta l_2 = \cancel{5} 5.94 \text{ rad}$$

$$l_2 = \frac{5.94}{6.28} = 9.46$$

$l_2 > l_1 = .5\,cm \left(\frac{\lambda}{2}\right)$

$\lambda = 10\,cm$

$$\boxed{l = 4.46\,cm + \frac{n\lambda}{2}} \quad n = 0, 1, \ldots$$

* Analysis of short circuit & open circuit measure.

$$Z_{in}^{SC} = jZ_0 \tan\beta l \quad \text{—(1)}$$

$$Z_{in}^{OC} = -jZ_0 \cot\beta l = \frac{-jZ_0}{\tan\beta l} \quad \text{—(2)}$$

1×2 $\quad Z_0 = \sqrt{Z_{in}^{OC} \cdot Z_{in}^{SC}}$

1÷2 $\quad \tan\beta l = \sqrt{\frac{jZ_0 \tan\beta l^2}{-jZ_0 \tan}}$

$$\tan\beta l = \tan\beta l.$$

→ S.C & O.C are always purely reactive so j terms

$$Z_{in}^{sc} = j\,40.42\,\Omega$$

$$Z_{in}^{oc} = -j\,121.24\,\Omega$$

$$Z_0 = \sqrt{Z_{in}^{sc} \cdot Z_{in}^{oc}} = 70\,\Omega$$

$$\tan\beta l = \sqrt{\frac{-Z_{in}^{sc}}{Z_{in}^{o.c}}} = \sqrt{\frac{1}{3}}$$

$$\beta = \frac{2\pi}{\lambda}$$

$|\Gamma|$ = for purly reactive load (inductive)

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{jX_L - Z_0}{jX_L + Z_0}$$

$$= \frac{-(Z_0 - jX_L)}{Z_0 + jX_L}$$

$$\Gamma = \frac{-\sqrt{Z_0^2 + X_L^2}\, e^{-j\theta}}{\sqrt{Z_0^2 + X_L^2}\, e^{j\theta}}$$

$$|\Gamma| = |e^{-j2\theta}|$$

$$= \left[e^{-j2\theta} \left(e^{-j2\theta}\right)^* \right]^{1/2}$$

$$\boxed{|\Gamma| = 1}$$

Q A $100\,\Omega$ trans. line is connected (terminated) to a load lossy of $50\,\Omega$ required in series a 10 pF. open. find Γ for 100 MHz. e.

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

$Z_0 = 100\,\Omega$ (transmission line impedance)

$Z_L = 50\,\Omega$ (in serie with 10PF.) jX_C

$Z_L = \cancel{R_L} - \frac{j}{\omega C_L} \quad R_L - jX_C$

$jX_L = j\omega L$

$\frac{j}{X_C} = \frac{-j}{\omega C}$

$= R_L - \frac{j}{\omega C_L}$

$= R_L - \frac{j}{2\pi \times 10^8 \times 10^{-11}}$

$= 50 - j159\,\Omega$

$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} \Rightarrow$ $-ve \Rightarrow$ is not good

as $+ve$ is good

$\Gamma = 0.79\, e^{j119.3} \cdot e^{-j180°}$ $(\because -\Gamma\phi = \Gamma$
$-\Gamma = \Gamma e^{j\pi})$

$= 0.76 \angle -60.7°$

$|\Gamma| = 0.76$

Power flow in a Tx line.

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

$\Downarrow$ forward

$I(z) = \underbrace{\frac{V_0^{+}}{Z_0} e^{-j\beta z}}_{\substack{\Downarrow \\ \text{forward} \\ \text{incident.}}} \underbrace{- \frac{V_0^{-}}{Z_0} e^{j\beta z}}_{\substack{\Downarrow \\ \text{backward.} \\ \text{reflected}}}$ //

At load $(z=0)$, incident & reflected voltage & current

$\frac{V_0^{-}}{V_0^{+}} = \Gamma \Rightarrow V_0^{-} = \Gamma V_0^{+}$

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

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

At load $(z=0)$

$V_{in} = V_0^{+}$ $\quad V_{ref} = \Gamma V_0^{+}$

$I_{in} = \frac{V_0^{+}}{Z_0}$ $\quad I_{ref} = -\frac{\Gamma V_0^{+}}{Z_0}$

Def of Time average Power is

$P_{av} = \frac{1}{2} Re[V \cdot I^*]$ complex current.

$P_{av}^{incidnt} = \frac{1}{2} Re\left[V_0^+ \cdot \frac{V_0^{+*}}{Z_0} \right]$

$= \frac{|V_0^+|^2}{2Z_0}$

$P_{av}^{reflected} = \frac{1}{2} Re\left[\Gamma V_0^+ \cdot \left(\frac{-\Gamma V_0^+}{Z_0} \right)^* \right]$

$P_{av}^{ref} = -|\Gamma|^2 \frac{|V_0^+|^2}{2Z_0}$

$P_{av} = P_{av}^{in} + P_{av}^{Ref}$

$$\boxed{P_{av} = \frac{1}{2} \frac{|V_0^+|^2}{Z_0} (1 - |\Gamma|^2)}$$

red → impedance
blue → addmittance.

$Z_0 = 50$
↓
$z = \frac{Z_0}{Z_0} = 1$
⇓
normalized
value (small z) (no unit)
(devide it by same Z_0)

*. Smith chart
step-1 ⇒ normalization.

$Z_1 = 50 + j50$
$z = 1 + j$

$z =$

$100 + j50$
$2 + j$

$75 - j100 \Omega$.
$1.5 - j2$

$184 - j900$
$3.68 - j18$

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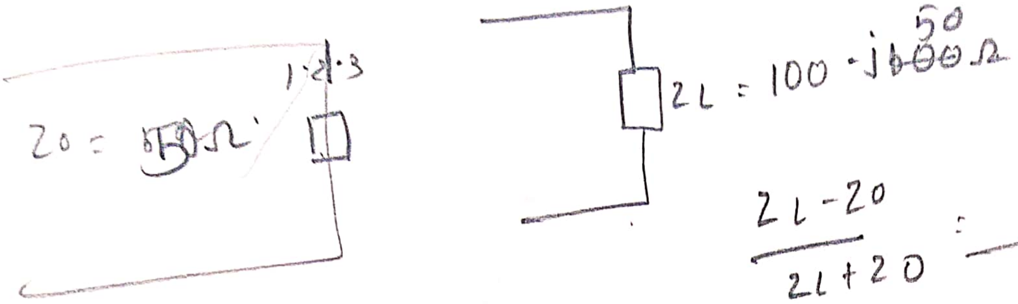
$Z_L = 100 - j\,50\Omega.$



$$\frac{Z_L - Z_0}{Z_L + Z_0} = \frac{100 - j50 - 50}{100 + j50 - 50}$$

$= 0.42 - j\,0.19$

$x + iy$

$= 0.45 \angle -26.6°.$

$R = \sqrt{x^2 + y^2}$

$\theta = \tan^{-1}\left(\frac{y}{x}\right)$

$x = R\cos\theta$

$y = R\sin\theta$

Γ: $z = \infty \Rightarrow$ 100% Reflection

O.C

$z = 0$?

7/08/2019

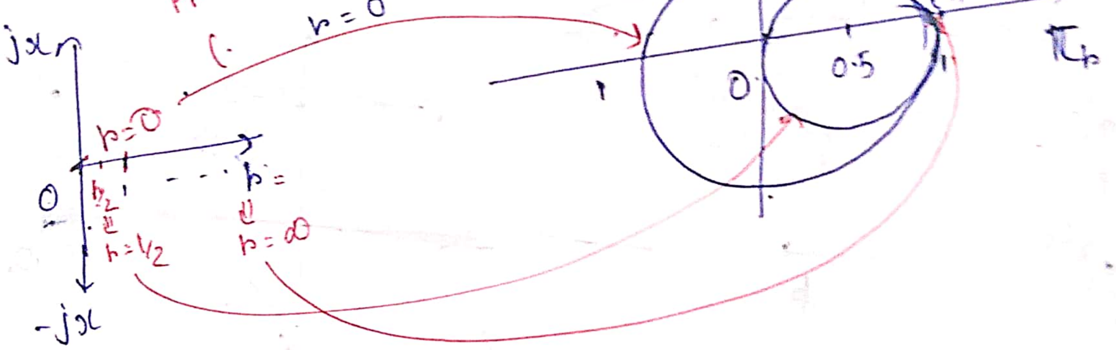
$$\left(\Gamma_r - \frac{r}{r+1}\right)^2 + \Gamma_i^2 = \frac{1-r}{1+r} + \frac{r^2}{(1+r)^2}$$

$$\boxed{\left(\Gamma_r - \frac{r}{r+1}\right)^2 + \Gamma_i^2 = \frac{1}{(1+r)^2}} \quad \text{—— (A)}$$

$\Downarrow$

Equation of circle

Fr. eqn (A) becomes



x (imag.)

$$x = \frac{2\Gamma_i}{1 + \Gamma_r^2 \cancel{+} - 2\Gamma_r + \Gamma_i^2}$$

$$x + x\Gamma_r^2 - 2x\Gamma_r + x\Gamma_i^2 = 2\Gamma_i$$

$$x\Gamma_r^2 - 2x\Gamma_r + x\Gamma_i^2 - 2\Gamma_i = -x.$$

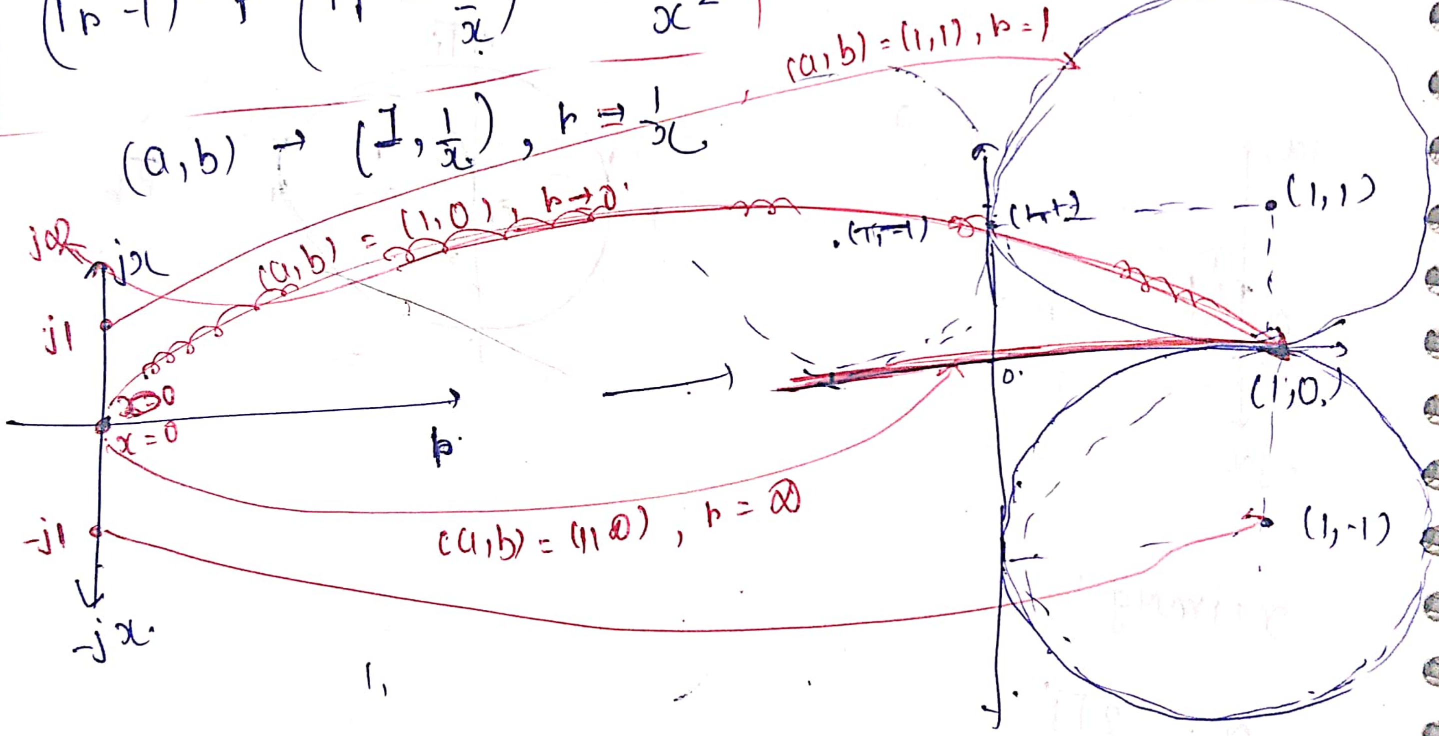
$$1 + \Gamma_r^2 - 2\Gamma_r + \Gamma_i^2 = 2\Gamma_i / x$$

$$\Gamma_r^2 - 2\Gamma_r + 1 + \Gamma_i^2 - \frac{2\Gamma_i}{x} = 0$$

$$\Gamma_r^2 - 2\Gamma_r + 1 + \Gamma_i^2 - \frac{2\Gamma_i}{x} + \underbrace{\frac{1}{x^2}}_{\text{Add}} - \underbrace{\frac{1}{x^2}}_{\text{substhuct.}} = 0$$

$$\boxed{(\Gamma_r - 1)^2 + \left(\Gamma_i - \frac{1}{x}\right)^2 = \frac{1}{x^2}} \longrightarrow (B)$$

$(a,b) \to \left(1, \frac{1}{x}\right)$, $r = \frac{1}{x}$



for

$$z_L = \frac{1+\Gamma}{1-\Gamma}$$

$$y_L = \frac{1}{z_L} = \frac{1-\Gamma}{1+\Gamma}$$

$[-\Gamma = |\Gamma| \exp(j\Gamma)]$

* Designing of Matching n/w :

(To match load impedance Z_L to source impedance Z_S)

$$Z_L = R_L + jX_L$$

$$Z_S = R_S + jX_S$$

for maximum power transfer

$Z_L = Z_S^*$ (complex conjugate)

i.e. $R_L = R_S$ & $jX_L = -jX_S$

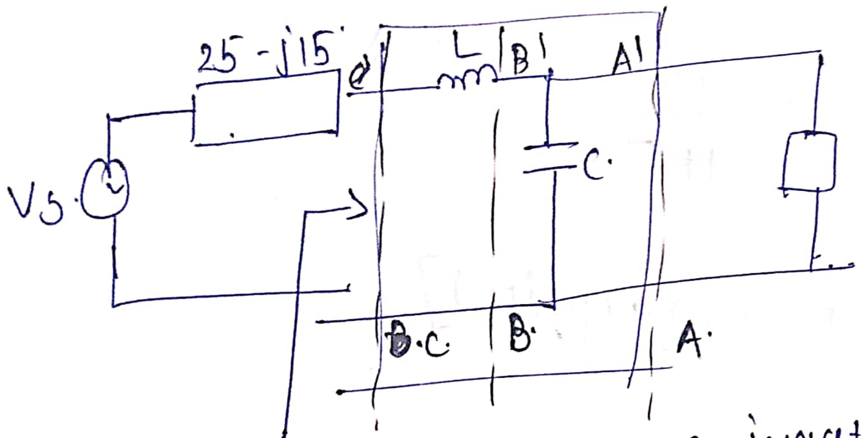
* Impedance Matching steps.

$$Z_S = 25 - j15\,\Omega$$

$$Z_L = 100 - j25\,\Omega.$$

(for maximum power transfer ~~Max~~ impedance matching steps)

$\Gamma = \dfrac{Z_L - Z_S}{Z_L + Z_S}$. Matching n/w



$Z_L = 100 - j\cancel{50}\ \Omega$

$= \dfrac{}{25}\ \ 2 - j0.5$

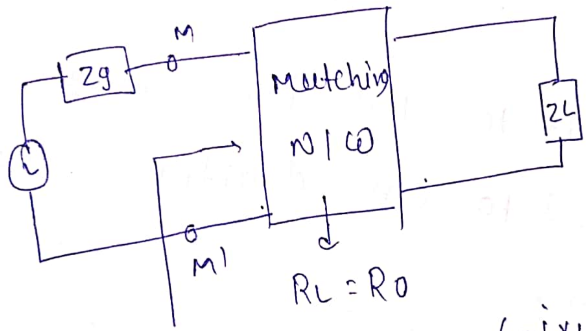
$Z_S = 25 + j15\ \Omega$. (conjugate of i/p r I have

1) 0.5 + j0.3 seen from this side.

common
wealth scholarship
(U.K., canada)
Austeralia,

min
M.Tech (2 years work exper)
5 year

Q. Stub Matching
↓
Small section of Tx line.



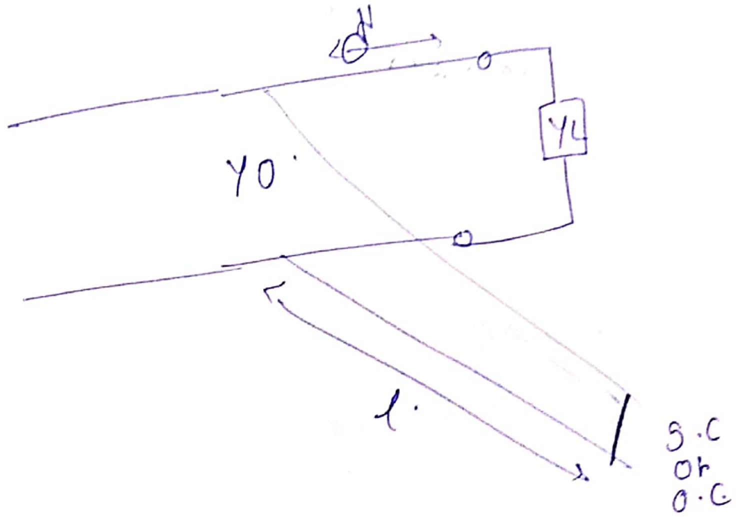
$R_L = R_0$

$jX_L = 0$ ($-jX_L \Rightarrow$ have to add)

→ To achieve there two transfor. of ~~motion~~ matching N/W,
we need ~~to deg~~ two degree of freedom

MN : Small section of Tx. of length l (S.C. or O.C) (shunt)

→ Matching Procedure (2 steps.)
↳ shunt stub → Y.



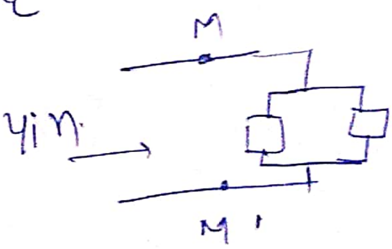
1) Select distance d so as to ~~thans for~~ transfer load admittance $Y_L \left(= \frac{1}{Z_L}\right)$ into an addmittance of form

$$Y_d = Y_0 + jB$$

when looking toward load at ~~MMF~~ MM'

2) Select the length of stub so that its input admittance Y_S at MM' is equal to $-jB$

Parallel sum of two admittance Y_d & Y_S given Y_0



$$Y_{in} = Y_0 + jB - jB$$

$$\boxed{Y_{in} = Y_0}$$

Ex $Z_L = 25 - j50\,\Omega \rightarrow Z_0 = 50\,\Omega$

* Maximum power transfer condition.

→ Impedence Matching

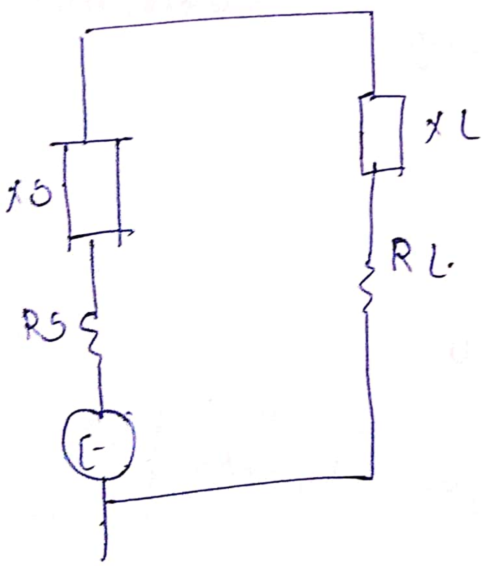
$Z_S = R_S + jX_S$

$Z_L = R_L + jX_L$

$R_L + jX_L = R_S - jX_S$

Conjugate Matching $R_L = R_S$

$jX_L = -jX_S$



Average power delivered to load Z_L is.

$$P_L = V_R \cdot I = \frac{E R_L}{\sqrt{(R_S + R_L)^2 + (X_S + X_L)^2}} \times \frac{E}{\sqrt{}}$$

$$R_L = \frac{E^2 R_L}{(R_S+R_L)^2 + (X_S + X_L)^2}$$

Looking first at effect of X_L on P_L, it will be given that by making $\boxed{X_L = -X_S}$, P_L will at maxim[illegible] P is given by

$$P_L = \frac{E^2 R_L}{(R_S+R_L)^2}.$$

R_L can now be ~~Power~~ range to maximum this.

(i) $\frac{dP_L}{dR_L} = 0$

$$\Rightarrow E^2 \frac{[(R_S+R_L) - 2R_L]}{(R_S+R_L)^2} = 0$$

$$\boxed{R_L + jX_L = R_S - jX_S}$$

$$\boxed{R_S = R_L}$$

Scanned by CamScanner

Near Field comm
((((NFC) → credit / debit card.

Yagi-Uda
Patch / Microstrip / Printed.
Parabolic

(Driveless car)

Radiation equation.

$$\dot{I}L = Q\dot{V}$$

$\dot{I}$ ↓ current time changing (A/s)

L ↓ length of Ant. (m)

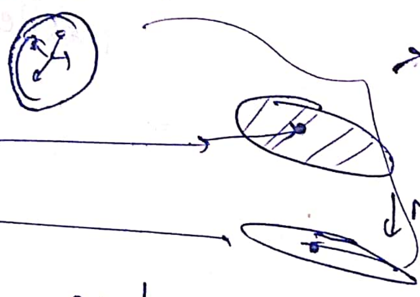
Q ↓ charge (Q) C

$\dot{V}$ → Accelaration of charges. (m/s^2)

→ time varying current
→ Accelaration of charge.

For Missile Ant. (3 Ant.) (require.)

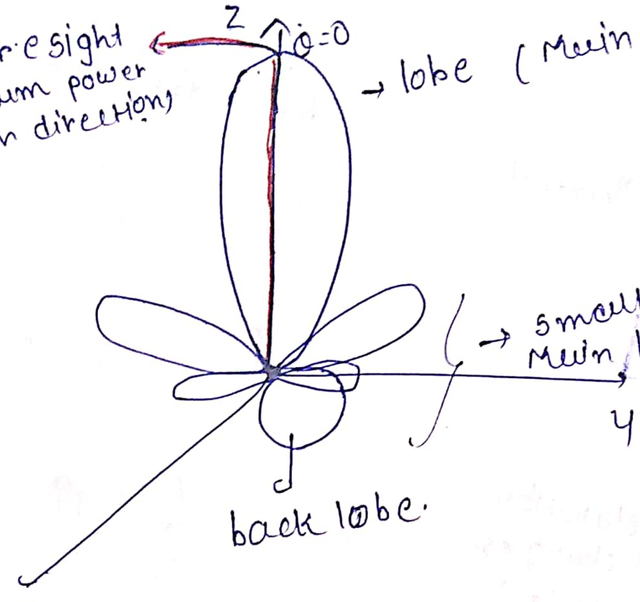
1) Search
2) detect
4) Track



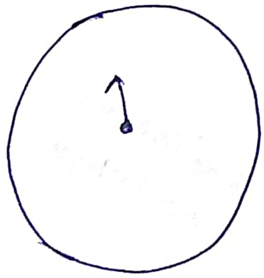
→ Radiation pattern

make beam much more sharped compared to detect ant.

Antna Radiation w.r.t V, P → Radiation pattern.



Omnidirectional Ata (Perfect Ata)
(isotropic Ata)

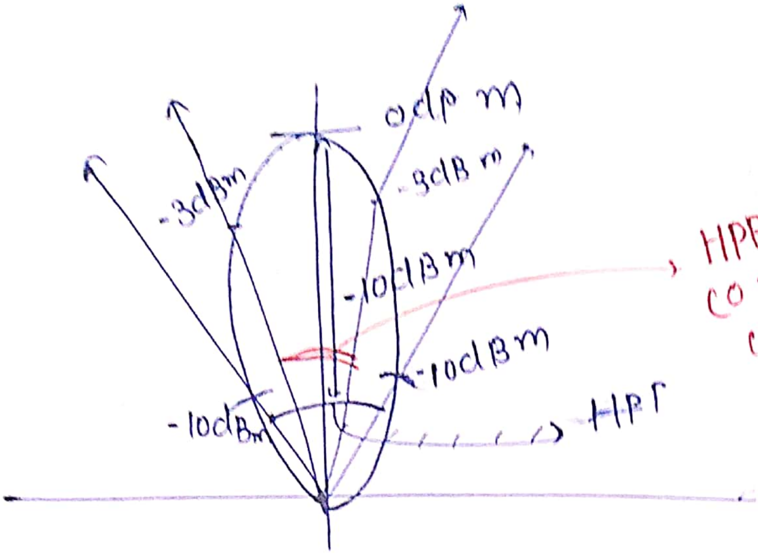


~~Ata → very narro~~ band

Ata → very narrow band devices.

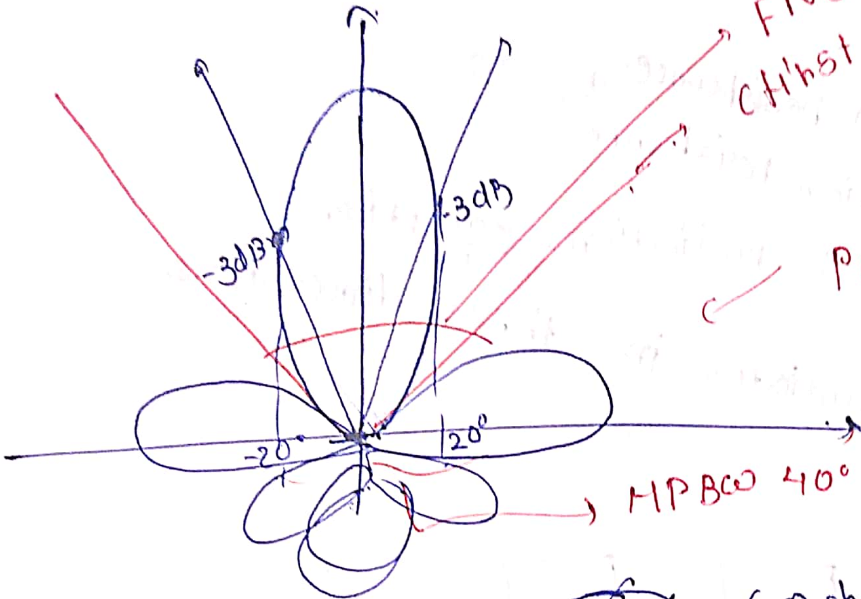
Mobile $\xrightarrow{\text{Ata}}$ wifi, CDMA, GSM, Blutooth → all ata but at different freq^n & no interface bet^n them.

Beam width



HPBW
(0 to -3dBm)
(angle substanted by -3dBm is Half Power Beam width)

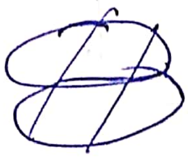
FNBW ≃ 2HPBW
(First null Beam width)



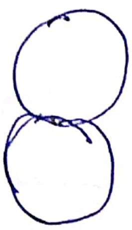
Power Pattern.

HPBW 40°

ideal Ata



(8 shape / dumble shap)



(neurest perfect Ata)

(Mutiple

Antennas

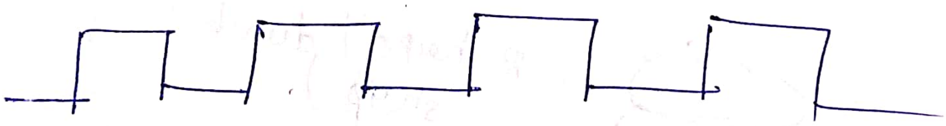
→ radiators
→ sensors (temperature)
→ transducers
→ impedance Matching
→ coupler

$120\pi = 377\,\Omega$.

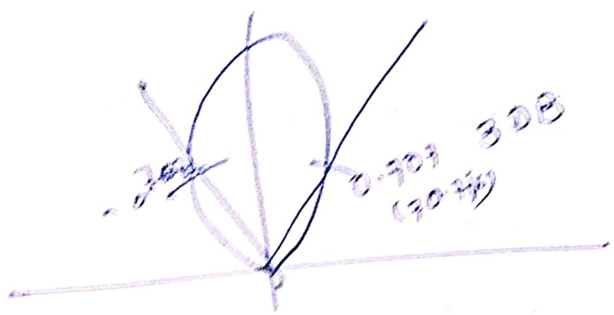
fiction resistance
↓
radiation resistance

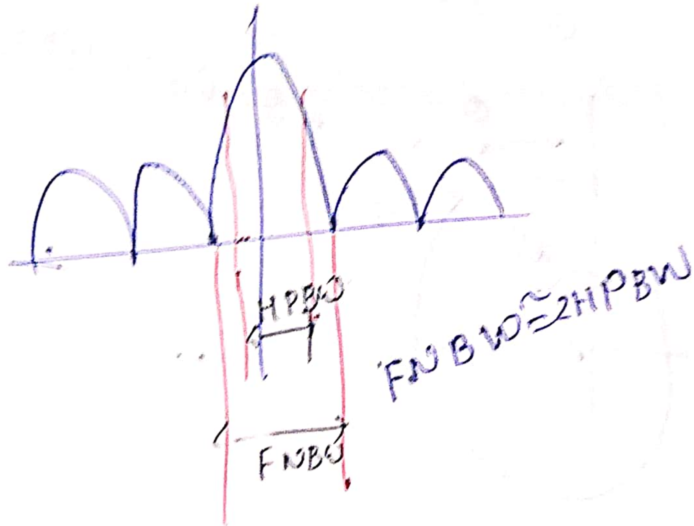
$\dot{I}L = Q\dot{v}$ → Basic radiation equation

Antenna always radiates in three dimensions.



Staggered PRF





iso
always take isotropic ata ~~As base~~ ,
~~only one port~~ is
as Ata is only one port device so measure
w.r.t to isotropic Ata.

Ex

votay e → $E(\theta) = \cos^2\theta$ for $0^\circ \leq \theta \leq 90^\circ$
field.

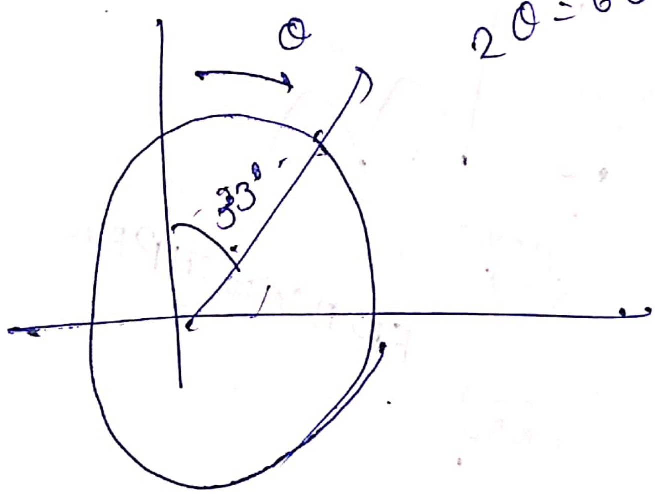
HPBW = ?

first find voltage patter / power pattern.

$\cos^2\theta = 0.707$

→ for voltage $\cos\theta = \sqrt{0.707}$

$\theta = 33^\circ$ → $2\theta = 66^\circ = HPBW$



⇒ for power pattern.

$\cos^2\theta = 0.5$

$\cos\theta =$

2) Sol.

$E(\theta) = \cos\theta \cos 2\theta$

for $0° \le \theta \le 90°$

HPBW = ?

$\cos\theta \cdot \cos 2\theta = 0.707$

$= \frac{1}{\sqrt{2}}$

$\cos 2\theta = \frac{1}{\sqrt{2}\cos\theta}$

$2\theta = \cos^{-1}\left(\frac{1}{\sqrt{2}\cos\theta}\right)$

$\theta = \frac{1}{2}\cos^{-1}\left(\frac{1}{\sqrt{2}\cos\theta'}\right)$

$\theta' = 0 \Rightarrow \theta = 22.5$

$\theta' = 22.5 \Rightarrow \theta = 20°$

$\theta'' = 20.57 \Rightarrow \theta \cdot 20.7$

nearly eqn

$HPBW = 2\theta$

Beam Area. (beam solid angle)

As angle is measured in 3D

so ~~Unit~~

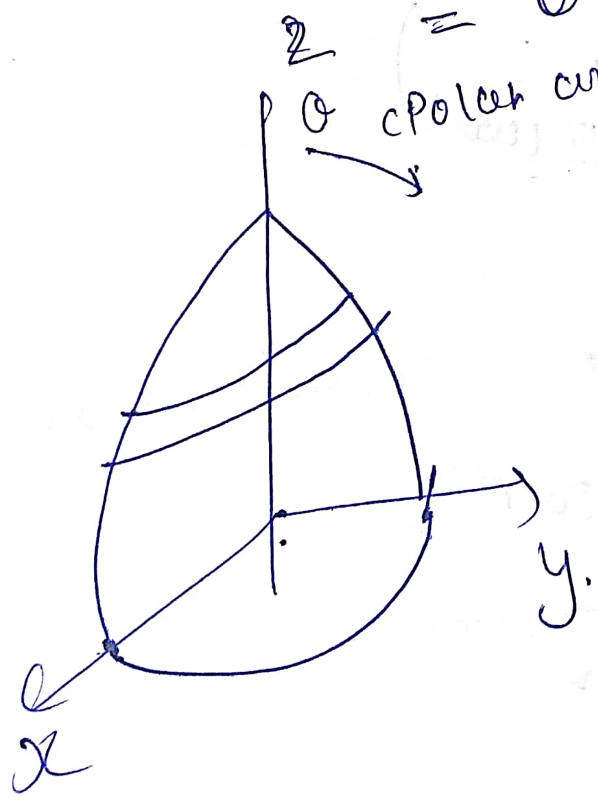
steradian (Sr) = ~~solined~~ solid angle subtended by sin.

$$\frac{\text{by sin}}{4\pi}$$

$= 1 \, rad^2$

$= \left(\frac{180}{\pi}\right)^2 deg^2 \rightarrow \square$

$= \Theta^{\square}$



~~Area of sp^re = 4~~

Area of sphere $= 2\pi r^2 \int_0^{\pi} \sin\theta \, d\theta$

$= \cancel{2\pi r^2 [-\cos\theta]}$

$= 2\pi r^2 \left(-\cos\theta\right)_0^{\pi}$

$= 4\pi r^2$

~~1 rad² = 1 sr = 3283 3283~~

$\boxed{1 \text{ rad}^2 = 1 \text{ sr} = 3283^{\square} \quad (3283 \text{ sq. degree})}$

$4\pi \text{ sr} = 3283^{\square} \times 4\pi$

$4\pi \text{ sr} = 41{,}253^{\square}$

= solid angle in ~~sphe~~ sphere.

Beam area.

$$\Omega_A = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{A} P_n(\theta,\phi) \cdot \sin\theta \, d\theta \, d\phi$$

$$\Omega_A = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} P_n(\theta,\phi) \, d\Omega$$

~~$d\Omega = \sin\theta \, d\theta \, d\phi$~~

$d\Omega = \sin\theta \, d\theta \, d\phi$

Beam Area $= \Omega_A$

$= \theta_{HP} \phi_{HP}$

* Beam Area

Ex $E(\theta) = \cos^2\theta$ for $0^\circ \leq \theta \leq 90^\circ$

$HPBW = 33^\circ \times 2 = 66^\circ$

Beam Area $\Omega_A = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi} \cos^4\theta \sin\theta \, d\theta \, d\phi$

$P(\theta) = E^2(\theta)$

$= \cos^4\theta$

$= -2\pi \left[\frac{1}{25} \cos^5\theta \right]_0^{\pi/2}$

$= \frac{2\pi}{5}$ Sr.

$\Omega_A = 1.26$ Sr

HPBW $= 33 \times 2 = 66^\circ$

$\Omega_A = \theta_{HP} \phi_{HP}$

$= 66^\circ \times 66^\circ$

$= 4356$ (sq. deg)

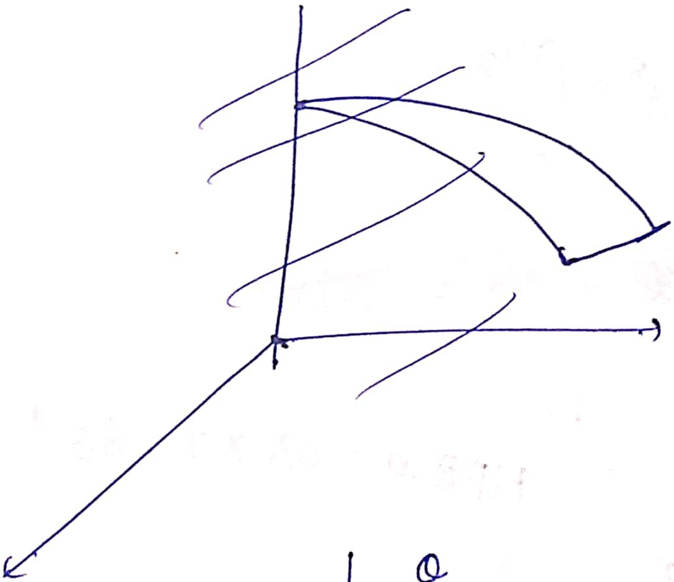
1 sq rad $= 3283$ sq degree

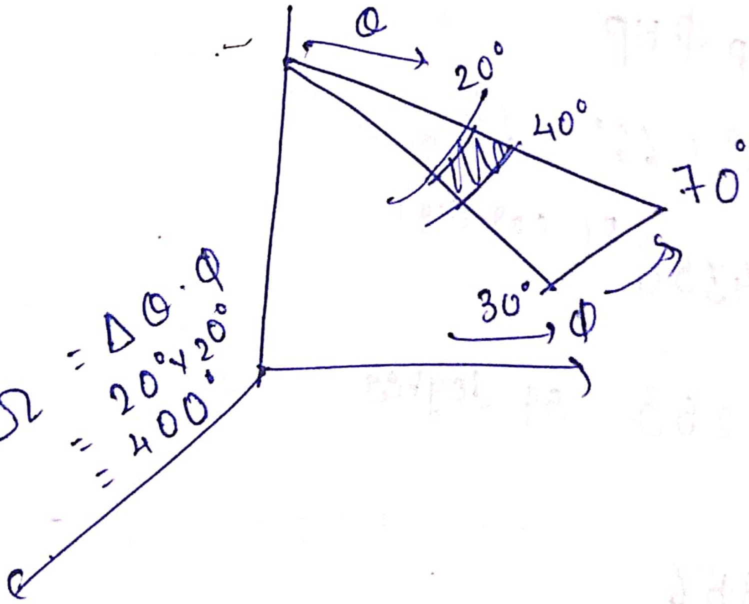
$\Omega_A = \frac{4356}{3283}$

$\boxed{\Omega_A = 1.33 \text{ Sr.}}$

Solid angle Ω_A on a ~~square~~ sphere surface betn $\theta = 20° \,\&\, 40°$ and

$\phi = 30° \,\&\, 70°$





oximate → $\left\{ \begin{aligned} \Omega &= \Delta\theta \cdot \phi \\ &= 20° \times 20° \\ &= 400° \end{aligned} \right.$

ay)

$$\Omega_A = \int_{\phi=30^\circ}^{70^\circ} d\phi \int_{\theta=20^\circ}^{40^\circ} \sin\theta \, d\theta$$

$$= \frac{40}{360} \cdot 2\pi \left[-\cos\theta\right]_{20}^{40}$$

$$= 0.222\pi \times 0.173 \text{ Sr}$$

$$= 0.121 \text{ Sr}$$

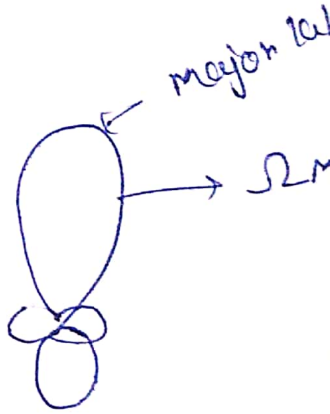
$$= 0.121 \times 3283 \text{ sq. degree} = 397^{\square}$$

Exact way

* Beam efficiency

$\Omega \rightarrow$ solid angle

$\Omega_A \Rightarrow$ beam Area



$$\text{Beam efficiency} = \frac{\Omega_M}{\Omega_A} \times 100\ \%$$

~~Directivi~~ * Directivity (dB)

→ Ratio of Maximum power density $P_n(\theta, \phi)_{max}$ (watts/m²) to its average value over a sphere

$$D = \frac{P(\theta,\phi)_{max}}{P(\theta,\phi)_{avg}} \geq 1 \qquad D = 1 \ (0\,dB)$$

$$P(\theta,\phi)_{av} = \frac{1}{4\pi}\int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi} P(\theta,\phi)\,\underbrace{\sin\theta\, d\theta\, d\phi}_{d\Omega}$$

$$= \frac{1}{4\pi}\int_{4\pi} P(\theta,\phi)\, d\Omega \quad (W/sr.)$$

$$D = \frac{P(\theta,\phi)_{max}}{\frac{1}{4\pi}\iint_{4\pi} P(\theta,\phi)\, d\Omega}$$

$$= \frac{1}{\frac{1}{4\pi}\iint_{4\pi}\left[\frac{P(\theta,\phi)}{P(\theta,\phi)_{max}}\right] d\Omega}$$

$P_n(\theta,\phi)$ normalized value.

$$= \frac{4\pi}{\iint_{4\pi} P_n(\theta,\phi)\, d\Omega}$$

$$P_n(\theta,\phi) = \frac{P(\theta,\phi)}{P(\theta,\phi)_{max}}$$

for an antenna radiation over only half a sphere

$\Omega_A = 2\pi \ Sr$

$D = \frac{4\pi}{2\pi} = 2$

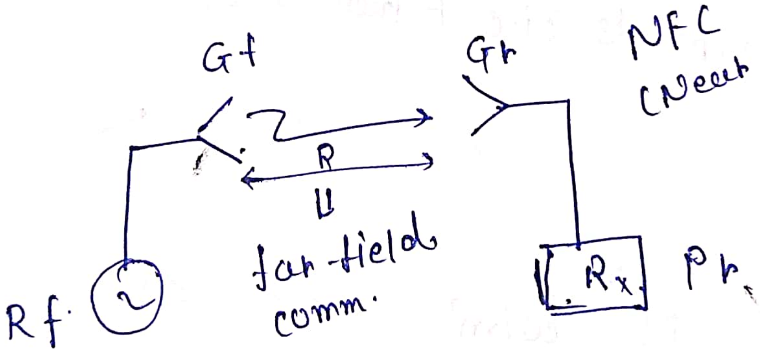
↓

3 dB

3 dBi (~~A~~ for Ata)

* RF or radio link (Free space)

NFC (Near Field communication)



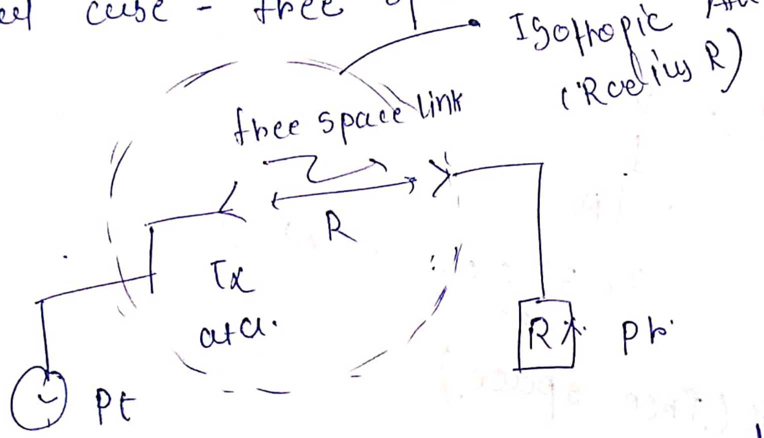
Anechoic change

11/11/2019

How to Measure the Gain ?

RF link / communication link / M.W link / satellite

→ Ideal case - free space (no buildings, nice atmosphere)



Surface area of sphere at radius R is

$$A = 4\pi R^2$$

But as sphere expands (i.e., R increases.) power

$$S_{av} = \frac{P_t}{A} = \frac{P_t}{4\pi R^2} \ \omega/m^2 \quad \text{——— (1)}$$

If G_t is the gain of Tx. ata. Power density radiated by Tx. ata is given by

$$S_{av} = \frac{P_t G_t}{4\pi R^2} \ \omega/m^2 \quad \text{——— (2)}$$

This power is incident on Rx ant (of gain G_r), we use concept of effective aperture area of antenna. (Capture Area) (A_e)

→ A_e is related to gain by expression

$$G_r = \frac{4\pi A_e}{\lambda^2}$$

$$A_e = \frac{G_r \lambda^2}{4\pi} \quad \text{--- (3)}$$

$P_r = ?$

$P_r = A_e \cdot S_{av}$ (2) & (3).

$$P_r = \frac{P_t \cdot G_t}{4\pi R^2} \cdot \frac{G_r \cdot \lambda^2}{4\pi}$$

$$\boxed{P_r = P_t G_t \cdot G_r \left(\frac{\lambda}{4\pi R}\right)^2}$$ ⇒ received Power

friis. equation. $P_r \propto \frac{1}{R^2}$ ⇒ $P_r \propto \frac{1}{f^2}$ ⇒ $\left(\because \lambda = \frac{c}{f}\right)$

(∵ in ~~wirless~~ cable exponential decay in Power so here wireless has advantage as $P_r \propto \frac{1}{R^2}$)

geo. stationary → 36000 km frome earth

aircraft → 10 km from earth.

Geo - stationary orbit

$R = 36000$ km

$$P_r = \frac{P_t \cdot G_t \cdot G_r}{(4\pi)^2 R^2} \frac{c^2}{f^2}$$

$$= \frac{P_t \cdot G_t \cdot G_r \, (3 \times 10^8)^2}{158 \times (10^3)^2 \times R^2 \times (10^6)^2 f^2}$$

$f \rightarrow$ MHz

$R \rightarrow$ km

$$P_r = P_t G_t G_r \left[\frac{0.057 \times 10^{-2}}{\underbrace{f^2}_{\text{MHz}} \underbrace{R^2}_{\text{km}}} \right]$$

$$P_r|_{dBm} = P_t|_{dBm} + G_t|_{dB} + G_r|_{dB} + 10\log(0.057 \times 10^{-2}) - 10\log(F^2) - 10\log(R^2)$$

$Pr|dBm = Pt|dBm + Gt|dB + Gr|dB - \underbrace{32.5 + 20\log f + 20\log R}$

free space Path loss (dB)
$20\log D$ ~~loss~~ loss
or
$20\log R$ ~~loss~~ loss.

If f (in GHz), R (km)
Free space Path loss (FSPL) $= 92.5 + 20\log f + 20\log R$

⇒ Geo - stationary

$R = 36,900$ km

$Pt = 2W = 33$ dBm

$Gt = 37$ dB

$Gr = 45.8$ dB

$Pr = ?$

$Pr(dBm) = Pt(dBm) + Gt(dB) + Gr(dB) - 32.5) - - -$

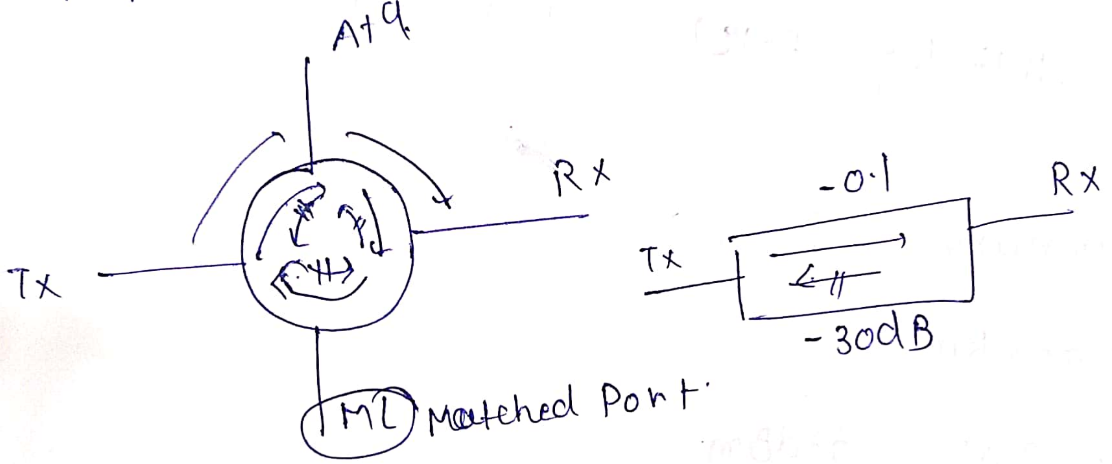
$= 33 + 37 + 45.8 - 209.8$

$\Rightarrow \approx -94$ dBm

$\approx 3.98 \times 10^{-10}$ mW

$P_t G_t \rightarrow$ EIRP
↓
effective Isotropic Radiated Power

Duplexer → It facilitates a single Ant. for the ~~Tx~~ Rx.
↓
single ant for Tx & ant
it prevents transmitter from Receiver leakage



Ex

$f = 6GHz = 6000\ MHz$

$R = 50\ km = 50\ km$

$FSPL = ?$

$FSPL = -32.4 + 20\log(6000) + 20\log(50)$

$= -32.4 + 75.6 + 34$

$\boxed{FSPL = 142\ dB}$

$FSPL = 32.4 + 20\log(6000) + 20\log(50)$
$= 32.4 + 75.6 + 34$
$= 142 \text{ dB}$

~~Fade~~
* Fade Margin.

$F_d = 30\log D + 10\log(\quad) - 10\log(1-R) - 70$

D → distance (km)

f → freq (GHz)

R → ~~realiab~~ reliability factor = 99.99%

A → roughness fact.
= 4 for very smoth ~~sp~~ free on earth

= 1

= 0.25

B = climate factor
= 0.5 for humidity area.
= 0.25 for avarage G
= 0.125 for V - -

Ex D : 40 km

f = 1.8 GHz

R = 99.99 %

~~Humid~~ Humidty a. B =

~~st~~ smooth surface A = 4

$F_M = 30\log(40) + 10\log(6 \times 4 \times 0.5 \times 1.8) - 10\log(1 - 0.9999) - 70$

$= 48.06 + 13.34$

$F_M = 31.4$ dB

$$P_r = P_t G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2$$

$\Downarrow$ free space. Path loss.

$EIRP = P_t \cdot G_t$

$\Downarrow$

Effective Isotropic Radiated Power

$$EIRP|_{dBm} = P_t|_{dBm} + G_t|_{dB}$$

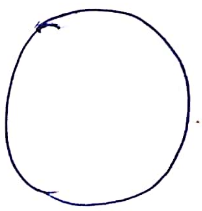
$$D = \frac{4\pi}{\Omega_A} = \frac{4\pi}{\int_0^{2\pi}\int_0^{\pi} P_n(\theta,\phi)\sin\theta \, d\theta \, d\phi}$$

$$D = \frac{4\pi \cdot A_e}{\lambda^2} \qquad G = \frac{4\pi A_e}{\lambda^2}$$

$$\boxed{G = k D}$$

k: efficiency.

→ A_e for an ideal isotropic A|a.



$$A_e = \frac{D\lambda^2}{4\pi} = \frac{\lambda^2}{4\pi} = 0.0796\lambda^2$$

→ 2 identical Ata.

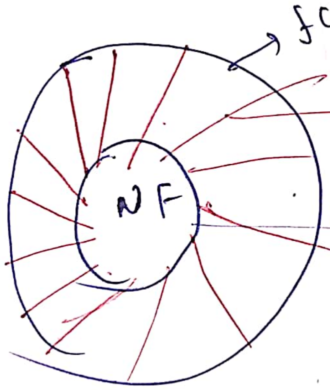
$G_t = G_r = G$

$$P_r = P_t \cdot G^2 \left(\frac{\lambda}{4\pi R}\right)^2$$

Near field   NFC   Far field (distance)

Near field = reactive in nature.
(non-radiative)

far-field = radiative in nature.



* Micro
Plan
Pr

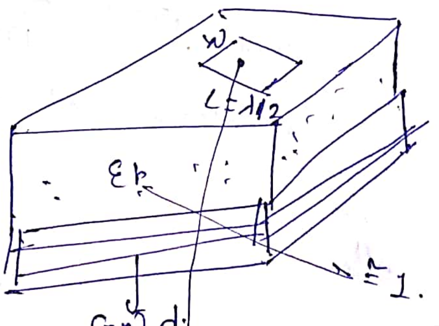
* Microstrip Antenna (radiator)
(Patch Ant)

⇓

Planner

⇓

Printed

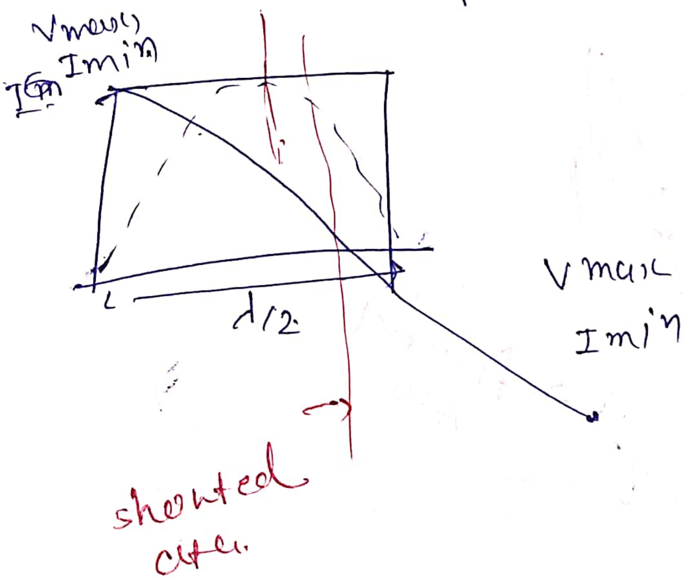


⇒ for

for circuit design εr to be high

→ for Ant design SNR as small as possible ≅ 1

connect pin from top to ground | cut Ant. = shorted ant



1) limited bandwidth (1-3 %)

Limitations of microstrip antenna

2) Low power handling

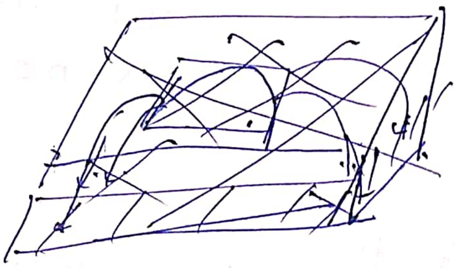
3) Low power gain.

(radiate in half ~~way~~ plane)

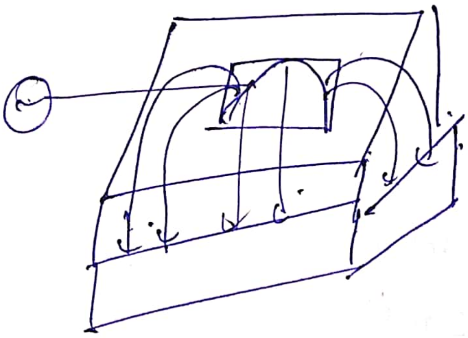
Solution for it

to increase bandwidth increased ~~~~ increase.

thickness of the substrate



ADS TOOLS



→ Fractal Ata.