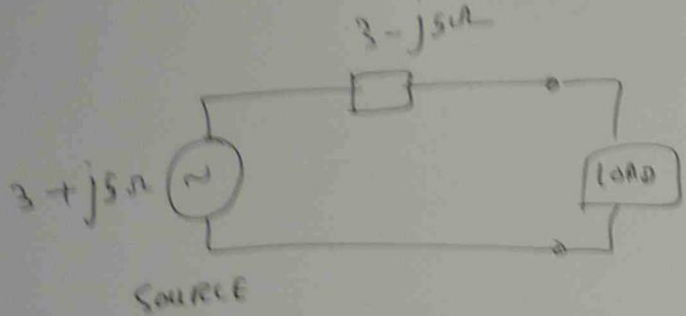
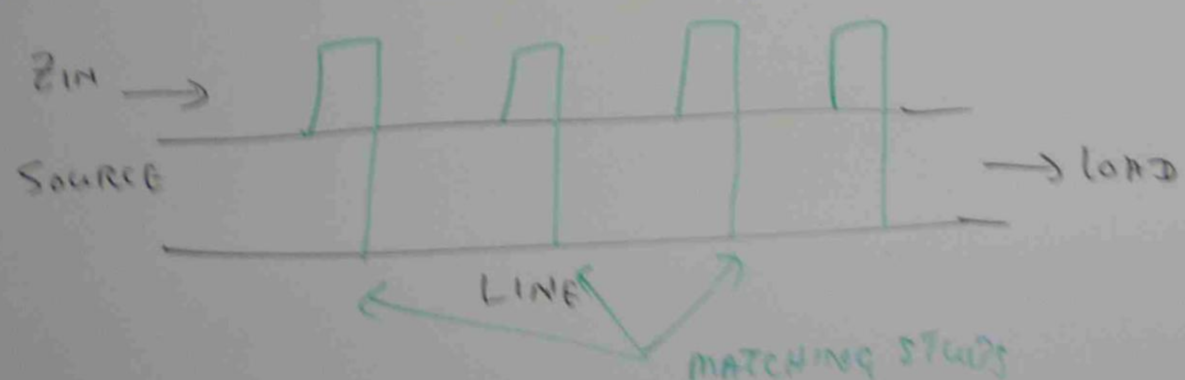
TRANSMISSION LINE MATCHING

A GIVEN GENERATOR WITH A SPECIFIED IMPEDANCE TRANSFERS THE MAXIMUM POWER TO LOAD WHEN THE LOAD IMPEDANCE IS THE CONJUGATE WITH SOURCE IMPEDANCE.



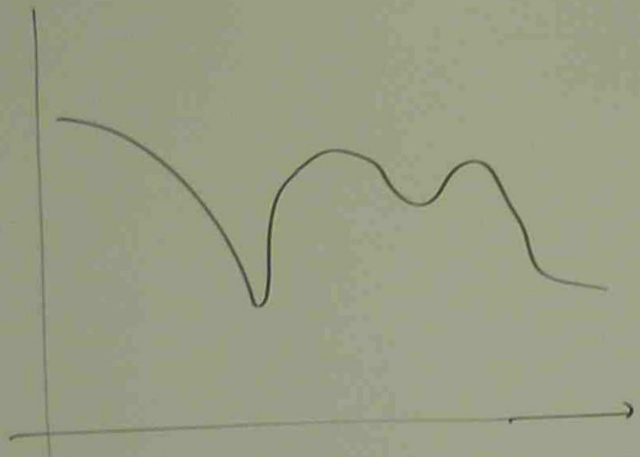
AN IDEAL MATCHING NETWORK IS A SERIES OF TRANSMISSION LINE STUBS PLACED PRIOR TO THE LOAD SUCH THAT INPUT IMPEDANCE EXACTLY MATCHES THE TRANSMISSION LINE IMPEDANCES FOR ALL DESIRED FREQUENCIES



IT MATCHES 1, 2, 3, 4 GHz

MATCHING STUBS

Z MATCH CREATES THE MATCHING WITH SHORTED STUBS IN PARALLEL WITH THE TRANSMISSION LINE. IF ONLY ONE FREQUENCY IS DEFINED, TWO UNIQUE MATCHING SOLUTIONS ARE AVAILABLE.



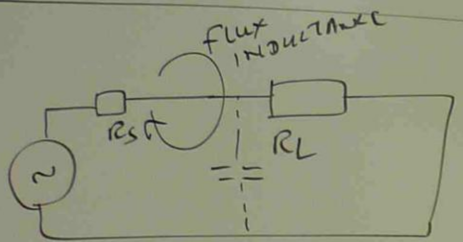
TRANSMISSION LINE REFLECTION

REFLECTION COEFFICIENT MINIMIZED OVER THE SELECTED SPECTRUM

REFLECTION COEFFICIENT

PERFECTLY MATCHED AT SELECTED POINT

POWER TRANSFER MAXIMIZING

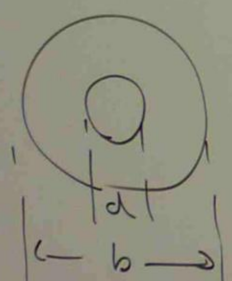


$R_S = R_L \longrightarrow$ MAXIMUM POWER TRANSFER

RESONANT FREQUENCY

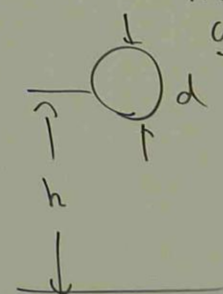
$$f_r = \frac{1}{\sqrt{LC}}$$

CONCENTRIC



$$C = \frac{2\pi\varepsilon}{\ln \frac{D}{d}}$$

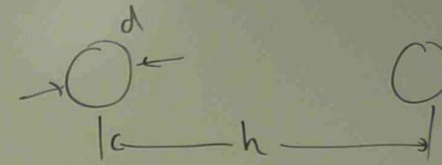
ABOVE GROUND



GROUND

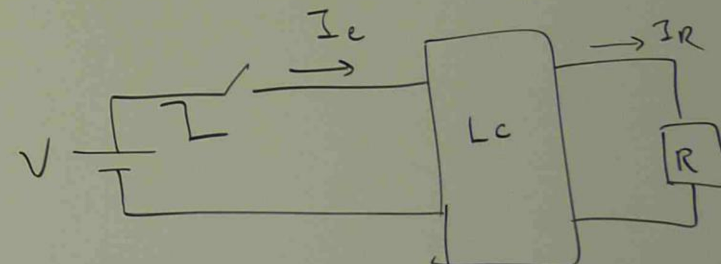
$$C = \frac{2\pi\varepsilon}{\ln \frac{4h}{d}}$$

TWO WIRES



$$C = \frac{\pi\varepsilon}{\ln \frac{4h}{d}}$$

VOLTAGE REFLECTION EQUATION



$$V = V_{\text{INCIDENT}} + V_{\text{REFLECTED}}$$

$$I = I_{\text{INCIDENT}} + I_{\text{REFLECTED}}$$

REFLECTION COEFFICIENT

$$\rho = \frac{\frac{R}{R_0} - 1}{\frac{R}{R_0} + 1}$$

GENERALIZATION / NORMALIZATION

$$\rho = \frac{Z/Z_0 - 1}{Z/Z_0 + 1}$$

LINE IMPEDANCE IS DIVIDED BY SOURCE IMPEDANCE (Z_0) AND USE THIS VALUE TO READ ON THE SMITH CHART.

WAVE PROPAGATION

THE COMPLEX AMPLITUDE OF WAVE MAY BE DEFINED IN 3 WAYS

- VOLTAGE AMPLITUDE
- CURRENT AMPLITUDE
- NORMALIZED AMPLITUDE WHOSE SQUARED MODULUS EQUALS TO THE POWER CONVEYED BY THE WAVE.

WAVE CAN BE REPRESENTED BY COMPLEX PHASOR WHOSE LENGTH IS PROPORTIONAL TO THE SIZE OF WAVE AND WHOSE PHASE ANGLE TELLS THE RELATIVE PHASE WITH RESPECT TO THE ORIGIN (OR) ZERO OF TIME VARIABLE.

PHASE ANGLE OF THE WAVE COMPLEX AMPLITUDE VARIES AS MOVING ALONG THE TRANSMISSION LINE.

POSITIVE TRAVELLING WAVE - THE PHASE DECREASES WITH INCREASING DISTANCE FROM GENERATOR

NEGATIVE TRAVELLING WAVE - PHASE ADVANCES WITH INCREASING DISTANCE FROM GENERATOR.

DIRECTION OF PROPAGATION

THE DIRECTION OF PROPAGATION IS THE DIRECTION OF POWER FLOW EITHER FROM GENERATOR TO LOAD (FORWARD) OR FROM LOAD TO GENERATOR (REVERSE)

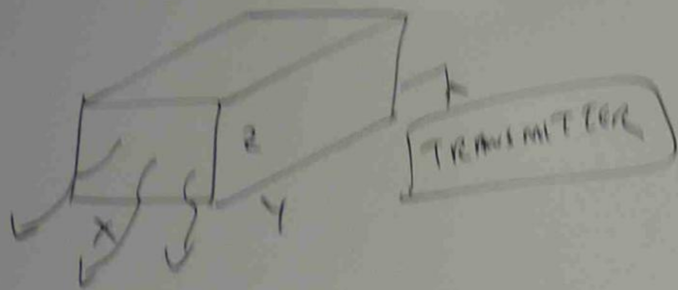
WAVE GUIDE

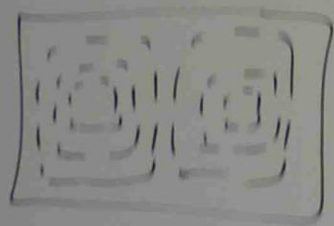
A WAVE GUIDE RESTRICTS THE 3 DIMENSIONAL "FREE SPACE" PROPAGATION OF THE ELECTROMAGNETIC WAVE TO A SINGLE DIRECTION.

USUALLY WAVE GUIDES ARE

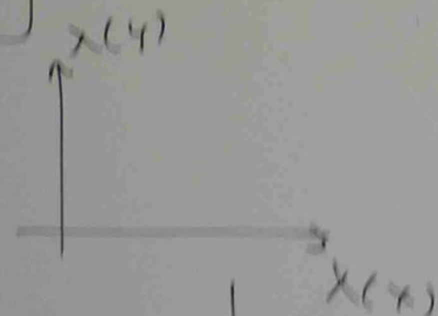
- LOW LOSS, THE WAVE TRAVELS ALONG THE GUIDE WITHOUT GREATLY ATTENUATING AS IT GOES.
- ROTABLE. WE CAN GENTLY BEND THE GUIDING STRUCTURE WITHOUT LOSING CONTACT WITH THE WAVE AND WITHOUT GENERATING REFLECTION.

RECTANGULAR METAL PIPE WAVE GUIDE





λ = WAVE LENGTH



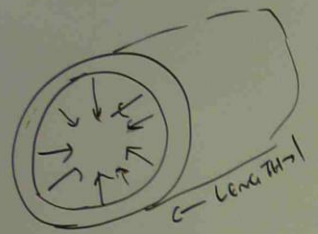
$$\frac{1}{\lambda^2} = \frac{1}{(\lambda(x))^2} + \frac{1}{(\lambda(y))^2}$$

$$\lambda(x) = \frac{\lambda}{\cos\alpha}$$

ALL ELECTRIC FIELDS MEET THE CONDUCTORS AT RIGHT ANGLE TO THE SURFACE.

THE ASSOCIATED CHARGES MOVE ALONG THE GUIDE AND SET UP CURRENTS WHICH ARE LINKED TO THE MAGNETIC FIELD, PARALLEL TO THE GUIDE METAL SURFACE AND PERPENDICULAR TO THE ELECTRIC FIELD.

CIRCULAR GUIDE MODE



GROUP VELOCITY × PHASE VELOCITY = C^2

↑ ENERGY TRANSFER IN WAVE

↑ PATTERN TRANSFER IN WAVE

$\lambda(g)$ = LENGTH OF WAVE GUIDE

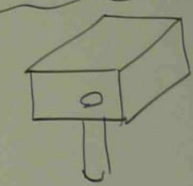
$$\frac{1}{\lambda^2} = \left(\frac{m}{2a}\right)^2 + \left(\frac{n}{2b}\right)^2 + \frac{1}{(\lambda(g))^2}$$

m, 2a, n, b = CONSTANT

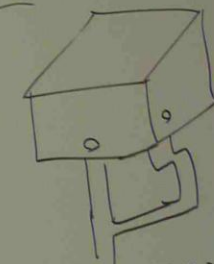
$$\text{PHASE VELOCITY} = \frac{c}{\cos\alpha}$$

C = SPEED OF LIGHT

TE – (TRANSVERSED ELECTRIC MODE)



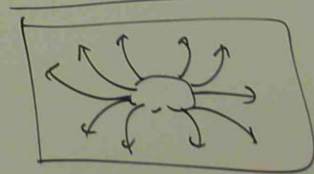
TE 10



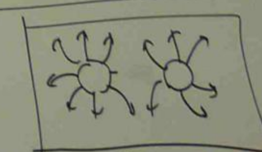
TE 20

NO ELECTRIC FIELD IN DIRECTION OF PROPAGATION

TM – (TRANSVERSED MAGNETIC MODE)



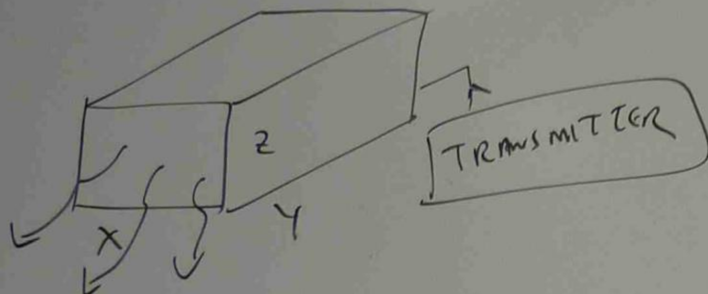
TM11

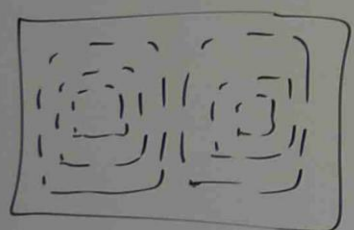


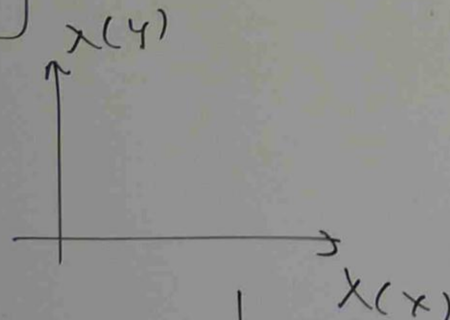
TM21

NO MAGNETIC FILED IN THE DIRECTION OF PROPAGATION

RECTANGULAR METAL PIPE WAVE GUIDE







λ = WAVE LENGTH

$$\frac{1}{\lambda^2} = \frac{1}{(\lambda(x))^2} + \frac{1}{(\lambda(y))^2}$$

$$\lambda(x) = \frac{\lambda}{\cos\alpha}$$

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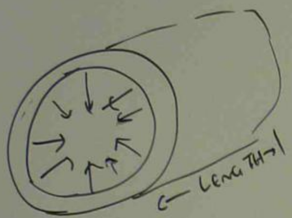
CIRCULAR GUIDE MODE



$\lambda(g)$ = LENGTH OF WAVE GUIDE

$$\frac{1}{\lambda^2} = \left(\frac{m}{2a}\right)^2 + \left(\frac{n}{2b}\right)^2 + \frac{1}{(\lambda(g))^2}$$

m, 2a, n, b = CONSTANT

$$\text{PHASE VELOCITY} = \frac{c}{\cos\alpha}$$

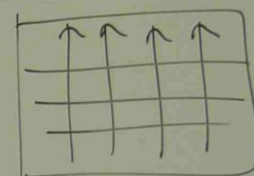
C = SPEED OF LIGHT

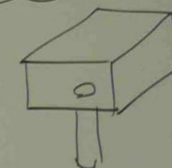
GROUP VELOCITY × PHASE VELOCITY = C^2

GROUP VELOCITY: ENERGY TRANSFER IN WAVE

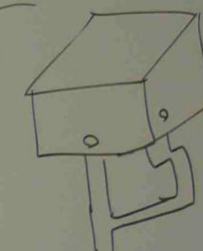
PHASE VELOCITY: PATTERN TRANSFER IN WAVE

TE – (TRANSVERSED ELECTRIC MODE)





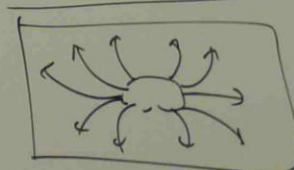
TE10



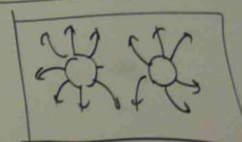
TE20

NO ELECTRIC FIELD IN DIRECTION OF PROPAGATION

TM – (TRANSVERSED MAGNETIC MODE)



TM11



TM21

NO MAGNETIC FILED IN THE DIRECTION OF PROPAGATION

TEM (TRANSVERSED ELECTROMAGNETIC)

NO ELECTRIC OR MAGNETIC FIELD IN THE DIRECTION OF PROPAGATION

HYBRID

IT HAS BOTH ELECTRIC AND MAGNETIC COMPONENTS IN THE DIRECTION OF PROPAGATION.

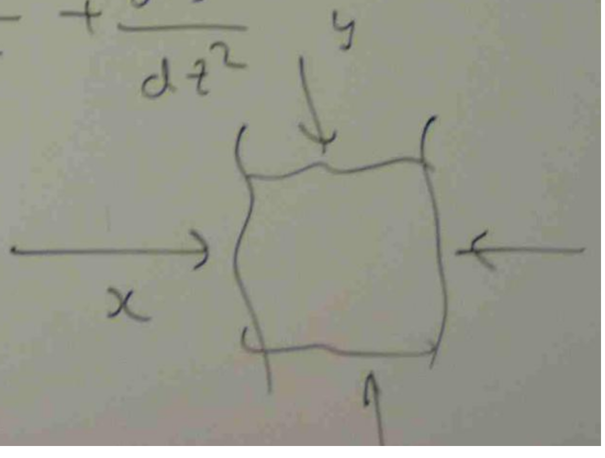
$$\gamma = \sqrt{\frac{k}{\rho}}$$

γ = WAVE SPEED

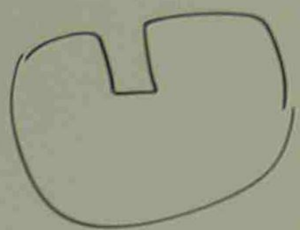
ρ = DENSITY OF FIELD

k = BULK MODULUS (CONSTANT)

$$\frac{1}{\gamma^2}\frac{d^2\rho}{dt^2} = \frac{d^2\rho}{dx^2} + \frac{d^2\rho}{dy^2} + \frac{d^2\rho}{dz^2}$$



SLOTTED WAVE GUIDE IS UTILIZED FOR RADAR.



CLOSED WAVE GUIDE - CIRCULAR / RECTANGULAR

HOLLOW FILLED WITH DIELECTRIC