Unit - IV:- 27/1/09

Ferrites :-

Ferrites are non-metalic meterial whoes resistivity is nearly 10^{14} times greater than metals, di-Electric Constants is of 10 - 15 and relative Permiabilities is of order 1000.

They are oxide based Components its general Composition is in the form of $MeO \cdot Fe_2O_3$ i.e a mixture of metalic oxides and ferric oxides.

MnO, ZnO, CdO, NiO, are used as ferrites.

Properties of ~~ferrites~~ Metalic oxides:-

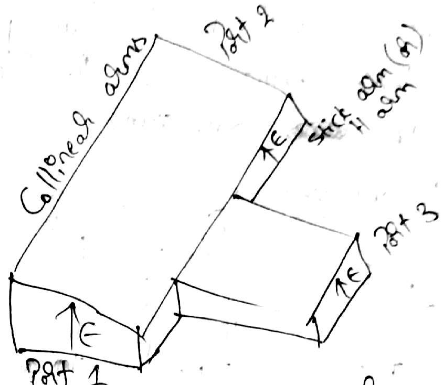
*) Ferrites Posess strong magnetic Properties

*) Ferrites are most suitable for using micro wave devices in order to reduce reflected Power, for modulation Perposes and in switching circuits.

*) Ferrites Pocess high resistivity to noise hence they can be used up to 100 GHz.

*) Ferrites Pocess non-reciprocal Property.

H-Plane Tee :-



A rectangular slot is cut along the border dimension wall of a main 'wg' and a side arm called H-arm is attached.

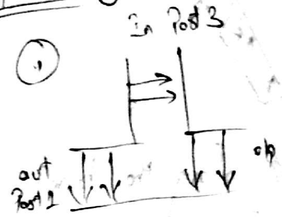
A H-plane Tee is defined as the acess of the side arm is ‖le to magnetic feild of the main 'wg'.

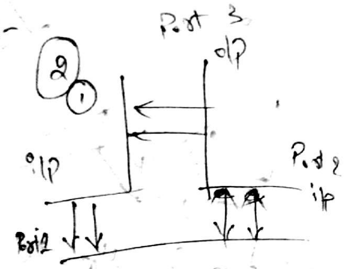
Port 1 and Port 2 are the Collinear arms. and Port 3 is the side arm (or) H-arm.

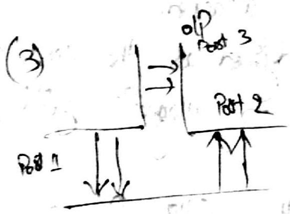
H-Plane is also called Shunt Tee why because in a H-T tension high amount of energy is delivered to a branch line Connected to a main transmission line if this branch line is Connected in Shunt with the main 'wg' transmission line at a Point of high voltage

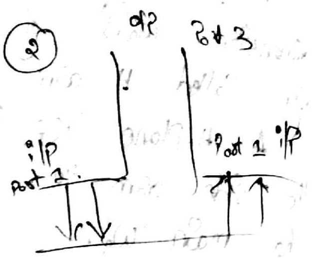
and low Current.
If two i/p's are feed at Port 1 & Port 2 i.e Collinear arms then the o/p will be obtain at Port '3'. will be in same phase and additive. hence some times the 3-Port is also called as ~~[illegible]~~ sum arm.

Properties of H-Plane Tee :-









1) When the i/p is applied at the side arm. i.e Port '3'. then o/p's are obtained from Collinear arms Port 1 & Port 2'. are equal in magnitude and in same phase.

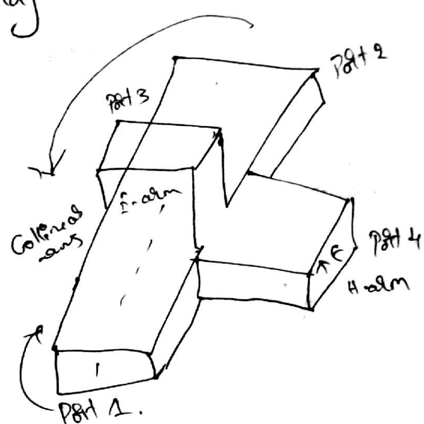
2) When the i/p is applied at collinear arms i.e Port 1 and Port 2 then o/p obtained from the side arm depends on the phase of the i/p's applied at collinear arms.

a) if phased i/p's are applied at Port 1 and Port 2 then maximum power is obtained at Port 3.

b) if 180° phase shift is applied b/w Port 1 and Port 2. then o/p at Port 3 is zero.

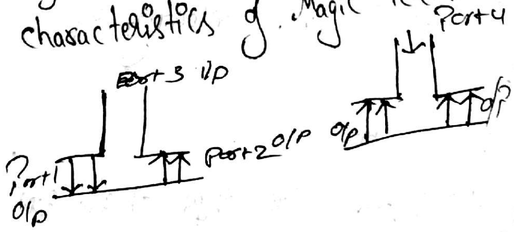
3) When an i/p is feed at Port 1 (or) Port 2 then o/p's are obtained at Port 2 (or) Port 1 and side arm i.e Port 3.

* Magic - Tee :-



A magic Tee is a Combination of both E-plane Tee and H-Plane Tee it is also called as hybrid Tee.

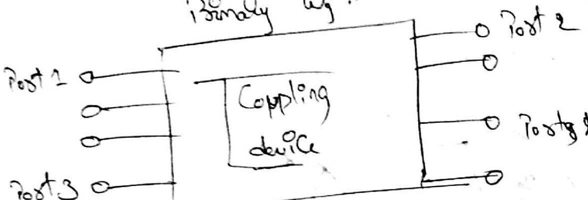
Characteristics of Magic Tee :-



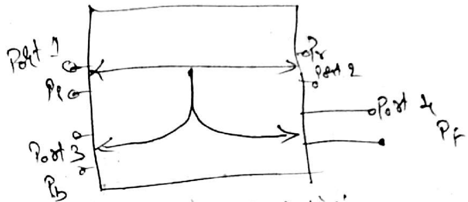
Directional Couplers:- 7/2/21

Directional Coupler's may be designed for measuring incident Powers (or) reflected Powers, standing wave ratio values. and Provides a signal path to a receiver.

main (or) Primary 'wg' :-



Directional Coupler is a 4-Port 'wg' Junction. it Consists of Primary 'wg' or main 'wg' i.e Ports 1 & Port '2' and secondary 'wg' are axillary 'wg' i.e. Port 3 & Port '4'. When Ports are terminated with their characteristic impedance there is free transmission exits b/w Port 1 and Port 2. and no transmission exits b/w Port 1 and Port '3'. and Port 2 & 4, because no coupling exits b/w these Pairs of ports.



P_i → incident Power at Port '1'.
P_r → received Power at Port '2'.
P_f → Forward Power at Port '4'.
P_b → back Power at Port '3'.

When an i/p Power is fed at Port '1'. then the resulting Power is Equally divided at Port '2' and Port '4'. but no o/p will be obtained at Port '3'. Similarly when an i/p is fed at Port '2'. then the resulting Power exits b/w Port 1 and Port '4'. and no o/p at Port '3'.

The characteristics of a directional Coupler:-
Can be depends on its Coupling factor, directivity and isolation.

Coupling factor:- It is defined as the ratio of incident to the forward Power (P_f) it is measured in dB it is Expressed as $C = 10\log_{10}\left(\frac{P_i}{P_f}\right)$

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Directivity :- It is defined as the ratio of P_f to P_b

$$D = 10 \log_{10}\left(\frac{P_f}{P_b}\right) dB$$

It is measured in dB.

Isolation :- It is defined as the ratio of incident Power P_i to back Power P_b.

It is also measured in dB.

It is expressed as $I = 10 \log_{10}\left(\frac{P_i}{P_b}\right)$.

isolation is also defined as coupling factor + Directivity.

$$I = C.F + D$$

$$= 10 \log_{10}\left(\frac{P_i}{P_F}\right) + 10 \log_{10}\left(\frac{P_F}{P_b}\right).$$

2-hole directional Coupler :- 9/2/09

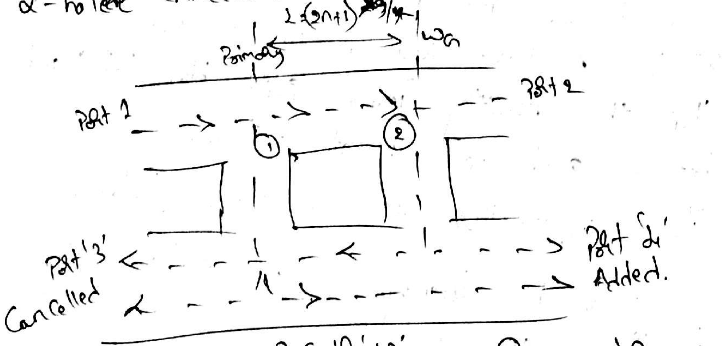


figure shows a 2-hole directional Coupler. It consists of 2 - wg's namely primary (or) main 'wg' and secondary 'wg'. with 2 - tiny holes common b/w them is facing b/w centre of 2 - holes must be $l = (2n+1) \lambda_g/4$

where λ_g -> guide wavelength

n -> any positive integer

when an incident Power is feed at Port 1 then the received Power will be obtain at Port '2'.

The incident Power which is coming out from holes 1 & 2 are in same phase at the position of second hole.

hence they are added at Port '4'. which produces a forward power (P_f) but the incident Power which is coming out from Port 1 & 2 are out of phase by 180° at the position of first hole. hence they are cancelled at Port '3' and produces a zero back power (P_b) = 0 because the incident power will have to travell a distance of $\lambda/4 + \lambda/4 = \lambda/2$ when it compares from Port '2' resulting in 180° Phase shift.

The degree of coupling is determined by size and location of holes in wg walls.

The magnitude of the Power Coming out of 2 holes depends up on the dimensions of the holes

It is difficult to produce high directivity over a band of frequencies.

3. the (or) single hole DC :-

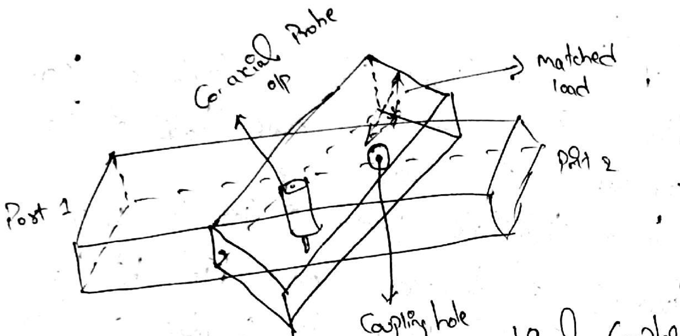


figure shows a single hole directional coupler the directivity which is produced by a single hole directional coupler is high rather than 2-hole directional coupler. is the power entering at port 1 is the coupled by co-axial probe o/p and the power entering at port 2 is absorbed by matched load. In order to produce high directivity the secondary guide is placed at the magnitude of magnetic wave is equal to that of electric wave.

In this coupler the wave in secondary w/g are generated trough single hole which includes both electric and magnetic waves.

Because of phase relation ship the signal generated by coupling cancells in forward direction and they are added in reverse direction.

Applications :-

Directional couplers are the tools used in RF and micro wave signal's rooting for seperating (or) combining signals. the various measurement applications are

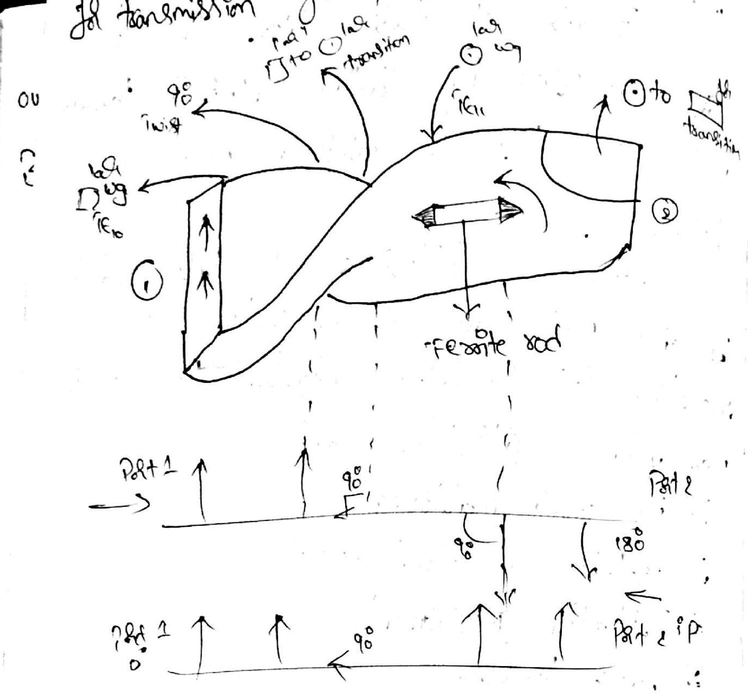
1) for power monitoring
2) Isolation of signal sources
3) Reflection measurments
4) source leveling.

Faraday rotation :- The rotation of a plane of polarization of a wave with respect to distance is known as faraday rotation.

Gyrator :-

It is a 2-port device which produces a phase difference of 180° for transmission from port 1 to port 2. and it produces no phase shift

For transmission from Port 2 to Port 1.



It consist's of piece of circular wg carrying with dominant TE_{11} mode with transitions in to rectangular 'wg' carrying with dominant TE_{10} mode a thin ferrite rod tappered at both ends is placed inside circular 'wg' and 'wg' is surrounded by permanent magnet which produces dc magnetic feild for proper operation of ferrite rod. A ferrite rod is tappered at both ends because in order to reduce attenuation and also for smooth rotation of polarized wave

Operation:- When power entering from port 1 its plane of polarized rotates by 90° in anti clock wise direction because of twist of 'wg'. again it undergoes faraday rotation through 90° in anti clock wise direction because of ferrite rod. Then the wave which comes out of port 2 will have a phase shift of 180° as compared to wave entering from port 1.

But same wave enter's from port 2 it undergoes faraday rotation through 90° in anti clock wise direction because of ferrite rod. Then it will gets back by 90° in clock wise direction because of twist of 'wg'. Then the wave which will comes out of port 1 will be in same phase. ~~compared to the~~

Isolators:- An isolator is a 2-port device which provides a very small amount of attenuation for transmission from port 1 to port '2' and it provides maximum attenuation from transmission from port 2 to port 1.

This requirement is very much diserable when we want to match a source

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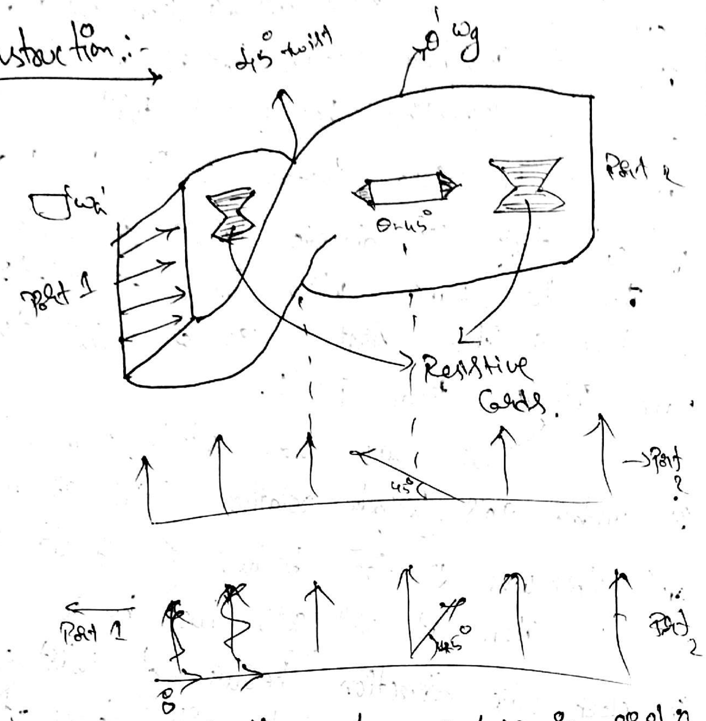
with a load.

Construction :-



The Construction of an isolator is similar to that of gyrator except that here isolator uses 45° twisted 'wg' instead of 90° twist in gyrator and 45° faraday rotation ferrite rod instead of 90°.

A resistive chord is placed along the ~~border~~ broader dimension of the 'wg' at both ends.

A resistive chord can be absorbed any wave when the plane of polarization is parallel to plane of resistive card and it does not observe when the plane of polarization is $\perp$ to plane of resistive card.

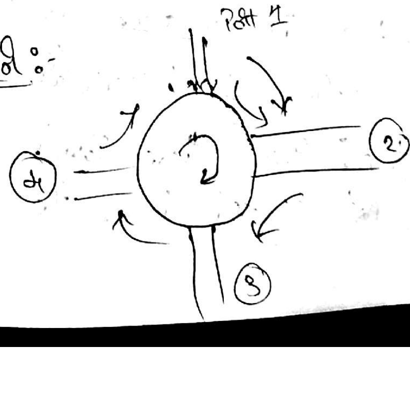
Operation :- When a wave entering port 1 trough resistive chord does not attenuated. After coming out of resistive card the wave rotates by 45° in anti clock wise direction because of the twist.

The wave again rotates 45° in clock wise direction because of ferrite rod which will comes out of port '2' is same as port 1 with less attenuation. But the wave is fed from port '2'. it rotates 45° in clock wise direction because of ferrite rod. and again it rotates 45° in clock wise direction because of twist.

Here the plane of polarization is $\parallel$ to plane of resistive card.

hence the o/p is zero at port 1.

Circulator :-



A Circulator is a 4-Port microwave Component it has a Peculiar Property i.e Each terminal must be Connected to a next clock wise terminal only.
ie Port 1 is Connected to 2 only but not Port 3 and 4 and Port 2 is Connected to 3 only, ... Etc;

Port 4 . Circulators are most Commonly used at μwave frequencies there are used in amplifiers, Parametric amplifiers, tunnel diodes and as a duplexer in radar antennas.

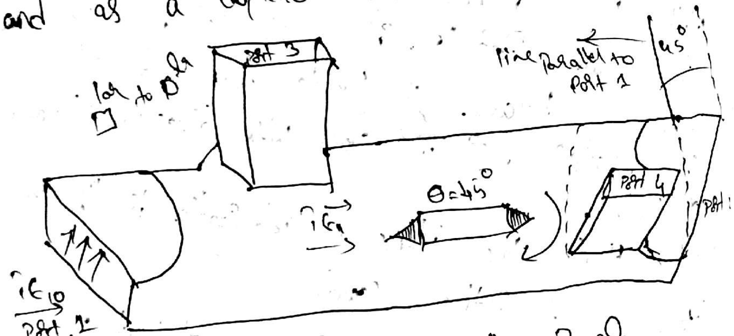


Figure shows:- A 4-Port Circulator the Power Entering Port 1 i.e TE_{10} ~~mode~~ is Converted to TE_{11} mode because of rectangular to Circular transmission these Power Passes Port '3' is not affected because the Electric field is not cut and rotates trough 45° in clock wise direction due to ferrite rod. and it passes 4th Port is not affected again because the Electric field is not cut and ~~Power from Port 2~~. Passes to Port '2'.

Power from Port 2. whose Plane of Polarization is already tilted by 45° with respect to Port 1 and again this Power passes 4th Port it is also not effected this wave again rotates trough 45° in clock wise direction due to ferrite rod. this wave whose Plane of Polarization is tilted trough 90° finds Port '3'. suitably and emerges out in order to Couple Port '4'. and emerges out in order to Couple Port '4'. is Coupled to Port 1. Similarly, Port '4' is Coupled to Port 1.

Circulator and Gyrator has low Power.

Scattering Matrix :-

Low freq Ckt Can be defined by two Port n/w by Parameters Y, Z, H, ABCD Parameters

As Per n/w theory. Here n/w Parameter related to total currents and total voltages at Each Port of n/w terminal.

* At micro wave freq ranges these parameter's (such as Y, Z, H ABCD are can not be used due to following regions.

1) Equipment is not available to measure total currents and total voltages and each of 2-Port.

2) Short and open circuits are difficult to achieve over a broad band of frequencies

3) Active devices such as transistors and diodes frequently will not have stability for short and open circuits.

4) In order to over come these problem. some new method of characterisation is needed.

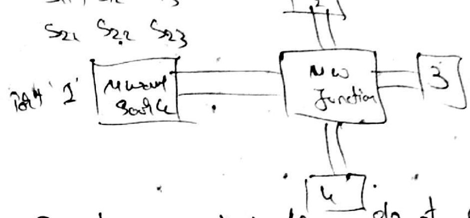
* The logical variable to use are propagating waves are associated with Powers instead of total voltages and total currents. and a micro wave junction defined by scattering parameters (or) S-Parameters.

* Here we analyse a micro wave junction as a traffic junction in which number of roads are meet on which vechicles enters and leaves from a traffic junction.

In a similar manner when a Power is feed at Port 1 some part of Power comes out of Port 2 some Part of Power comes out at Port 3 and the other part comes out of Port 4 and the remaing Part will comes out of Port 1 itself. because a Path b/w micro wave junction and source

S_{11}, S_{12}, S_{13}

S_{21}, S_{22}, S_{23}



It can be seen that for an i/p at one Port we have 4 o/p. similarly if we apply i/ps to all Ports we will have 16 combinations which is represented in a matrix form and this matrix is called scattering matrix.

It is a square matrix which gives the combinations of Power relation ship b/w various i/p and o/p's. The elements of this matrix is called as scattering co-efficients (or) S-co-efficients.

in matrix form

$$\begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ \vdots & & & \\ S_{n1} & \cdots & & S_{nn} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix}$$

Here a . represents i/p's at Particular Ports.
b. represents o/p's out from various Ports.

S_{ij} - denotes Scattering Co-efficients resulting due to i/p at i-port and o/p comes out of j^{th} Port.

S_{ii} - denotes when an i/p is applied at i^{th} port how much amount of Power is reflected back in to the i^{th} port itself.

Properties of S-matrix :- [S]

1) S-Matrix is square matrix of order m×n

[S] is symmetric matrix

$S_{ij} = S_{ji}$

[S] is an unitary matrix.

$$[S][S]^* = [I]$$

$[S]^*$ denotes -> Complex Conjugate of [S].

[I] -> identity matrix of same order as S-matrix.

4) The sum of the product of each term of any row (or) column is multiplied by complex conjugate of co-responding terms of other row (or) column is zero.

i.e: $\begin{bmatrix} k = 1,2,3 \ldots n \\ j = 1,2,3 \ldots n \end{bmatrix}$ for k≠j

$$\left[\sum_{i=1}^{n} S_{ij} S^*_{jk} = 0 \text{ for } k \neq j \right]$$

5) For an ideal n-Port n/w with matched termination

i.e $S_{ii} = 0$ since there is no reflection from any Port

∴ under Perfect matched Conditions the diagonal elements of [S] is zero.

2-Port n/w Junction:-

S_{11} transforms to the reflection co-efficient at Port 1 and when i/p Port is applied at Port 1

S_{21} denotes (or) co-responds transmission coffiient Port 1 when an i/p applied at Port '2'.

S_{22} denotes the reflection cofficient at Port 2

S-Matrix Calculations for H-Plane Tee :-

1) [S] is a 3×3

i.e ; $[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{21} & S_{22} & S_{23} \\ S_{31} & S_{32} & S_{33} \end{bmatrix}$

2) $S_{23} = S_{13} \rightarrow (1)$

3) $S_{33} = 0 \rightarrow (2)$

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4) $S_{ij} = S_{ji}$

$S_{12} = S_{21}$; $S_{23} = S_{32} = S_{13}$

$S_{13} = S_{31} \rightarrow (3)$.

$$= \begin{pmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & S_{13} \\ S_{13} & S_{13} & 0 \end{pmatrix} \rightarrow (4)$$

5) $[S][S^*] = [I]$

$$\begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{22} & S_{13} \\ S_{13} & S_{23} & 0 \end{bmatrix} \begin{bmatrix} S_{11}^* & S_{12}^* & S_{13}^* \\ S_{12}^* & S_{22}^* & S_{13}^* \\ S_{13}^* & S_{13}^* & 0 \end{bmatrix}$$

$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$R_1C_1 = |S_{11}|^2 + |S_{12}|^2 + |S_{13}|^2 = 1 \rightarrow (5)$

$R_2C_2 = |S_{12}|^2 + |S_{22}|^2 + |S_{13}|^2 = 1 \rightarrow (6)$

$R_3C_3 = |S_{13}|^2 + |S_{13}|^2 = 1 \rightarrow (7)$

$R_3C_1 = S_{13}S_{11}^* + S_{13}S_{12}^* = 0 \rightarrow (8)$

By Equating Eq (5) & (6)

$R_1C_1 = R_2C_2$

$|S_{11}|^2 + |S_{12}|^2 + \cancel{|S_{13}|^2} = |S_{12}|^2 + |S_{22}|^2 + \cancel{|S_{13}|^2}$

$|S_{11}|^2 + |S_{12}|^2 = |S_{12}|^2 + |S_{22}|^2$.

$S_{11} = S_{22} \rightarrow (9)$

$S_{13} = 1/\sqrt{2} \rightarrow (10)$

$S_{13}(S_{11}^* + S_{12}^*) = 0$.

$S_{11} = -S_{12}$

(or)

$S_{12} = -S_{11} = S_{22} \rightarrow (11)$

$|S_{11}|^2 + |S_{12}|^2 + |S_{13}|^2 = 1$

$|S_{11}|^2 + |S_{11}|^2 + 1/2 = 1$

$S_{11} = 1/2$

$$[S] = \begin{bmatrix} 1/2 & -1/2 & 1/\sqrt{2} \\ -1/2 & 1/2 & 1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} & 0 \end{bmatrix} = 0$$

WKT

$[B] = [S][a]$

$$\begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix} = \begin{bmatrix} 1/2 & -1/2 & 1/\sqrt{2} \\ -1/2 & 1/2 & 1/\sqrt{2} \\ 1/\sqrt{2} & 1/\sqrt{2} & 0 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix}$$

$$b_1 = \frac{a_1}{2} - \frac{a_2}{2} + \frac{a_3}{\sqrt{2}}$$

$$b_2 = \frac{-a_1}{2} + \frac{a_2}{2} + \frac{a_3}{\sqrt{2}}$$

$$b_3 = \frac{a_1}{\sqrt{2}} + \frac{a_2}{\sqrt{2}}.$$

Case '1' :- $a_3 \neq 0$; $a_1 = a_2 = 0$

$b_1 = \frac{a_3}{\sqrt{2}}$; $b_2 = \frac{a_3}{\sqrt{2}}$; $b_3 = 0$.

Case 2:- $a_1 = a_2 = a$; $a_3 = 0$

$b_1 = 0$; $b_2 = 0$; $b_3 = \sqrt{2}\,a$

Case 3:- $a_1 = a$; $a_2 = -a$; $a_3 = 0$

~~b x a~~

Case 4:- $a_1 \neq 0$; $a_2 = 0$; $a_3 = 0$

$b_1 = \frac{a}{\sqrt{2}}$; $b_2 = \frac{a}{\sqrt{2}}$; $b_3 = \frac{a}{2}$.

S-matrix Calculations for Magic Tee:-

1) $[S]$ is a 4×4

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

2) $S_{23} = -S_{13}$.

3) $S_{24} = S_{14}$

4) $S_{ij} = S_{ji}$

$S_{12} = S_{21}$; $S_{23} = S_{32}$, $S_{34} = S_{43}$

$S_{13} = S_{31}$; $S_{24} = S_{42}$; $S_{14} = S_{41}$

5) $S_{33} = 0$; $S_{44} = 0$.

6) $S_{34} = S_{43} = 0$,

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{13} & S_{14} \\ S_{13} & -S_{13} & 0 & 0 \\ S_{14} & S_{14} & 0 & 0 \end{bmatrix}$$

From unitary matrix

$$[S] \times [S^*] = [I]$$

$R_1C_1 = |S_{11}|^2 + |S_{12}|^2 + |S_{13}|^2 + |S_{14}|^2$

$R_2C_2 = |S_{12}|^2 + |S_{22}|^2 + |S_{13}|^2 + |S_{14}|^2$

S-Matrix of Directional Coupler :-

1) $[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$

2) $S_{11} = S_{22} = S_{33} = S_{44} = 0$

3) $S_{ij} = S_{ji}$ $\quad S_{12} = S_{21}$; $S_{23} = S_{32}$ $\pm S_{13}$ $\cancel{S_{31}}$

$S_{13} = S_{31} \rightarrow (3)$

4) $S_{13} = S_{31} = 0$ (∵

$S_{24} = S_{42} = 0$

$[S] = \begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{21} & 0 & S_{23} & 0 \\ 0 & S_{23} & 0 & S_{34} \\ S_{14} & 0 & S_{34} & 0 \end{bmatrix}$

5) $[S][S^*] = [I]$

$= \begin{bmatrix} \cancel{S_{12} S_{21}} + S_{14} \cancel{S_{14}} \\ \cancel{S_{21} S_{21}} + S_{23} \end{bmatrix}$

$\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix} \begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{21} & 0 & S_{23} & 0 \\ 0 & S_{23} & 0 & S_{34} \\ S_{14} & 0 & S_{34} & 0 \end{bmatrix}$

$= \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

$\therefore R_1C_1 = |S_{12}^2| + |S_{14}^2|$

$R_2C_2 = |S_{12} \cdot S_{21}| + |S_{23}^2|$

$R_3C_3 = |S_{34}^2| + |S_{32} \cdot S_{23}|$

$R_4C_4 = |S_{14} \cdot S_{41}| + |S_{34}$

$S_{14} = S_{23}$; $S_{12} = S_{34}$

$R_1C_3 = S_{12} \cdot S_{23}^* + S_{14} S_{34}^* = 0 \rightarrow (a)$

$S_{12} = P = S_{34} = S_{34}^*$

from eq (a)

$P \cdot S_{23}^* + S_{23} \cdot P = 0$

$P(S_{23}^* + S_{23}) = 0$

let $S_{23}^* = -jq$

$S_{23} = jq$

$P \neq 0$;

$$[S] = \begin{bmatrix} 0 & P & 0 & jq \\ P & 0 & jq & 0 \\ 0 & jq & 0 & P \\ jq & 0 & P & 0 \end{bmatrix}$$

S. Matrix of a Circulator :-

$$[S] = \begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

A/c Carline theorm :- four Port Circulator is a low loss, Perfectly matched and non reciprocal transmission device.

$$[S] = \begin{bmatrix} 0 & S_{12} & S_{13} & S_{14} \\ S_{21} & 0 & S_{23} & S_{24} \\ S_{31} & S_{32} & 0 & S_{34} \\ S_{41} & S_{42} & S_{43} & 0 \end{bmatrix}$$

$$\Rightarrow \; = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

S. Matrix of an isolator :-

it is 2-Port device

$$[S] = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

A/c Carline therm Perfectly matched reciprocal transmission

$$[S] = \begin{bmatrix} 0 & S_{12} \\ S_{21} & 0 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix},$$

$$[b] = [S][a]$$

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

$b_1 = 0$; $b_2 = a_1$

Insertion loss :- $-20 \log |S_{21}|$

Isolation $= -20 \log |S_{12}|$

A matched isolator has insertion loss of 0.5 ilp and isolation of 25dB find the scattering Co-efficient.

$25 = -20 \cdot \log |S_{12}|$

$S_{11} = S_{22} = 0$

$0.5 = -20 \log |S_{21}|$.

Scanned by CamScanner

$$S_{21} = 10^{-0.5/20}$$

$$S_{21} = 10^{-0.025}$$

$$S_{12} = 10^{-25/20} = 10^{-5/4}$$

$$= 10^{-1.25}$$

$$S = \begin{bmatrix} 0 & 10^{-1.25} \\ 10^{-0.025} & 0 \end{bmatrix}$$

Unit - VII.

μW solid state devices:.

classification :-

- Micro wave Transistors
  - MWBJT
  - HBT
  - Tunnel diodes
- FET's
  - JFET
  - MOSFET
  - MESFET, HEMT
  - NMOS, PMOS, CMOS
  - memories
  - CCD's.
- Transferred electron Devices
  - Gunn diode
  - LSA Diode
  - InP diode
  - CdTe Diode
- Avalanch transit time device

Metal semi Conductor field transistor.

HBT -> High Electron mobility transistor.

NMOS -> N - Channel metal oxide semi Conductors

P. MOS -> P - " " " " "

C.MOS -> Complentary " " " "

Memory :-

RAM - ?

SRAM - Static

DRAM -

BS RAM - Bi-Polar Static RAM.

ROM :-

P-ROM ; EP ROM ; EEPROM

CCD: Charge coupled devices ((array of several metal oxide semi conductors))

LSA → Limited space charge accumulation diode.

InP D → Indium phosphide diode

CdTe → Cadmium telluride diode

Trapped plasma avalanche device.

Barrier injected transit time device.

MASER → Convert atomic Energy into ε

micro wave amplification by stimulated Emission of Radiation

LASER :-

Light amplification " " "

of Radiation.

TED's	μW transistors :-
1) These are bulk devices	
2) These devices are Constructed from compound InP, CdTe.	2) These devices are Constructed from germanium, silicon.