Unit - III

Wave Guide Components & applications:-

Micro wave systems normally consists of several micro wave components including the source and load being connected to each other by w/g & co-axial line & transmission line systems.

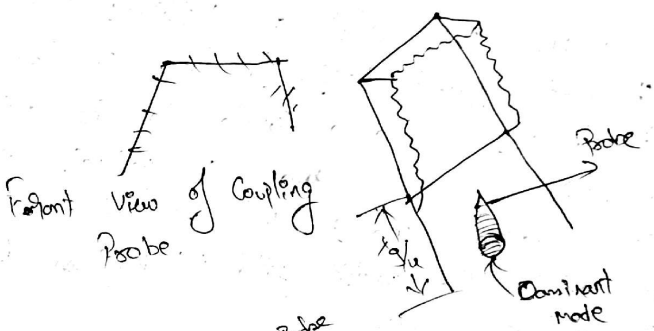
* All these components must be built with low standing wave ratio lower attenuation, lower insertion losses and other desirable characteristics to achieve the desired transmission of micro wave signal.

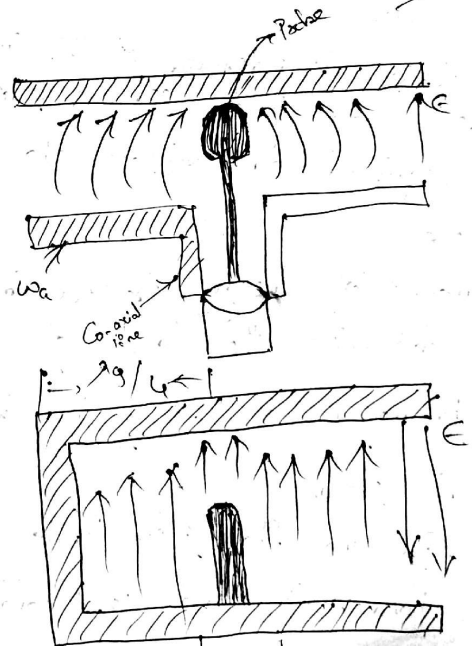
We have already seen that rectangular w/g circular w/g and cavity resonators are also micro wave components now we will see some other micro wave components like probes, screws, direction couplers, ferrite devices, attenuators, phase shifters, etc;

1) Coupling Probes:-

A co-axial line may be coupled to a w/g by means of either a probe parallel to electric field or near a point where its electric field has its maximum value.

2) A coupling probe consists of an extension of the centre conductor of co-axial line at the mid point of one of the w/g and when it is supplied by micro wave energy then it acts as quarter wave antenna. Currents flows in probe and sets up an electric field.





when a short antenna in the form of a probe is inserted in to a w/g it will radiate when it is placed correctly then the wanted mode will be set up.

The electric lines seperates them selves from the probe. when the probe is located at the point of height efficience electric lines set up an electric field of considerable intensity the most efficent plates to locate the probe is in centre of conducted parallel to the narrow dimensional wall and one quarter wave length from shorted end of w/g this is the point at which the electric field is maximum in the dominat mode.

∴ Energy transfer is maximum at this point. the quarter wave length spacing is at the freq required to propagate the dominant mode.

The amount of Energy transfer can be reduced by decreasing the length of the probe of by moving in out of the centre of the electric field.

The size and shape of the probe determine freq, band width and power handling capacity. As diameter of probe increases then B.w increases.

A probe similar in shape to a door knob is capable of handling much higher power and a larger B.w than a conventional probe.

When a miss match occurs reflections are produced in any w/g system. in order to minimise reflections at the junction. the probe must be matched to w/g

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Coupling loops :-

In micro waves systems some time it is more convinient desirable to couple a co-axial line to a w/g (or) cavity resonator by means of a coupling loop than by a coupling probe.

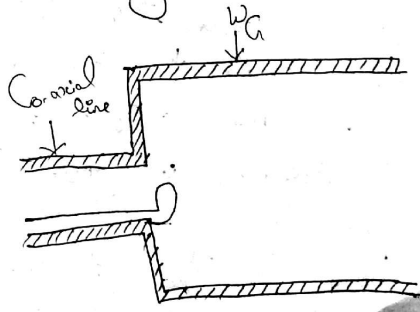
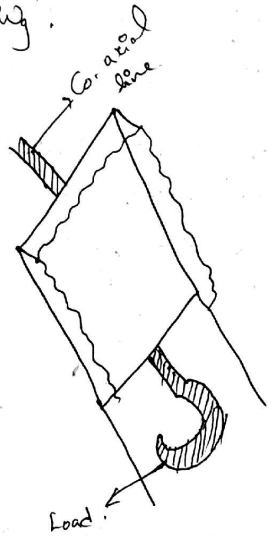


figure shows the use of Coupling loop in a junction the Co-axial line and 'wg'.

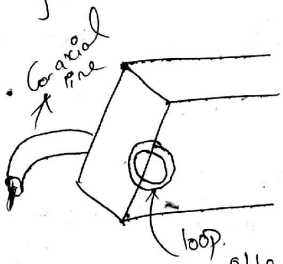


A Coupling loop is placed at the Centre of Shorted end of the 'wg' and can also be used to interrupt the dominant mode i.e Coupling is achived by means of a loop antenna located in a plane ⊥r to the plane of the probe. Since Coupling loop is primarily magnetic the loop must be placed at (or) near a point of high magnetic field strength. and torn in such a position that its plane is normal to flux line. hence the plane of the loop should be ⊥r to magnetic field. for maximum

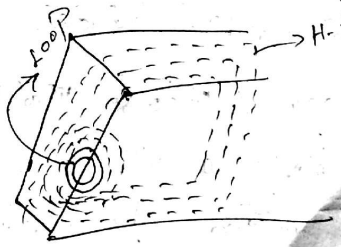
Coupling.

* thus it is seen that Coupling probes Couples primarily to the electric field and Coupling loops to the magnetic field but in each Case both are setup because the electric and magnetic fields are inseparable.

The magnetic field is setup by injecting energy in to a 'wg' Can be accomplish by inserting a small loop. that carries a high current in to the 'wg'.



A magnetic field builds up around the loop and Expands to fit the 'wg'. if the freq of the Current in the loop is with in the B.W of 'wg' then Energy will be transfered to the 'wg'.



the power handling capacity of coupling loop ↑ as its diameter is ↑ by increasing the size of wire used to make the loop. the Bw can be increased automatically.

When a loop is introduced in to a 'wg' in which an magnetic field is present hence current is induced in the loop automatically

Wave Guide discontinuities:-

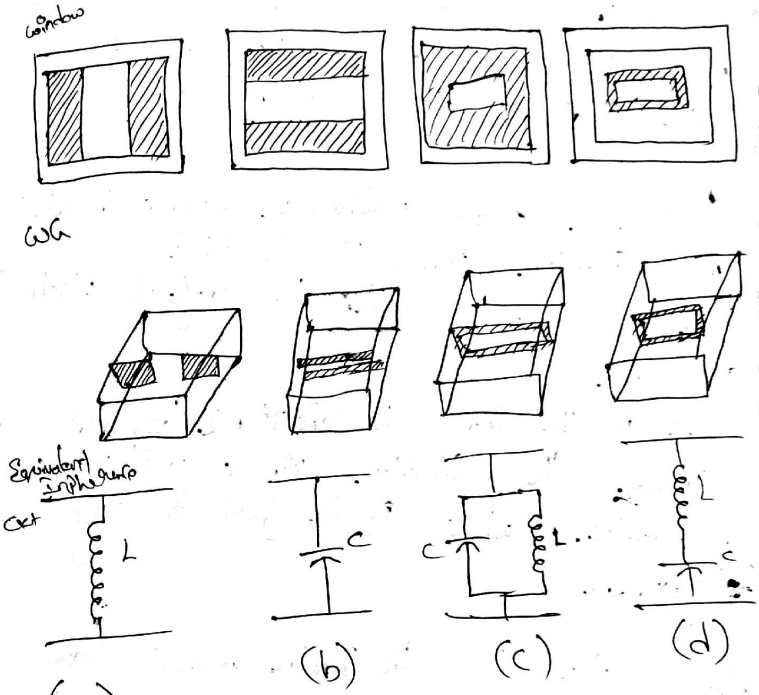
1) 'wg' arises:- Reflections are produced when miss matches occurs in any 'wg' system in transmission lines in order to over come this miss match impedances & stubes of required value & place at Pre calculated points.

Irises:- (a) Wg windows:-

Similarly in wg also some discontinuities are used for matching Purposes.

1) when any susceptance appearing across the guide causing a miss match. hence it needs to be cancelled by introducing another susceptance of same magnitude but of same opposite nature which is done by irises.

Irises are also called as windows apertures, diaphragm. (or) obstacles.



In fig (a) shows an inductive iris (or) window which allows a current to flow where none flowed before the window is placed in a position where the magnetic field is strong.

Since the plane of polarization of electric

field is parallel to plane of window hence the current flows due to window causes a magnetic field.

The increase of inductance will take place where the energy of magnetic field is stored at that point of the 'wg'.

figure (b) shows a capacitive window in which the potential exits b/w the top & bottom walls of 'wg'. now exits b/w surfaces which are closer

∴ At that point the capacitance has been increased the capacitive window is placed in a position where electric field is strong (or) maximum.

figure (c):- shows the parallel resonant window the inductive and capacitive window combined suitablely which produces equal reactance of capacitor and inductor. the parallel resonant window supports only dominant modes by providing a high impedance and other modes are completly attenuated on the resonant window acts as a band pass filter to suppress un wanted modes.

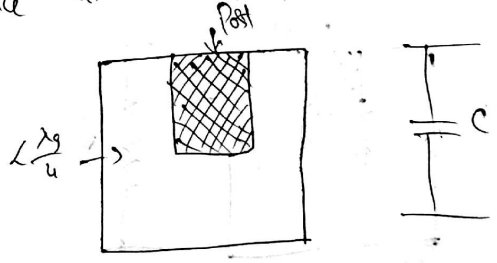
figure (d):- shows a series resonant window it is supported by a non metalic meterial and it is used to transfer the flow of micro wave energy transperently.

Dis - advantages:-

The dis-advantage of inductive and capacitive window is they are not readily adjustable due to the imperfect contact b/w window and the walls of 'wg'.

Posts and tunning screws:-

Posts :- The main advantage of posts is that it is readily adjustable. when a metalic cylindrical posts is introduced in the border side of 'wg'. it produced same effect as an window in providing lumped reactance at that point.



The figure shows a basic capacitive post the post behaves as a capacitive post when extends (or) moves only a short distance ie $< \lambda/4$ in to a 'wg' where 'λg' is the guide wave length, the capacitive susceptance increases with ↑ depth of penetration.

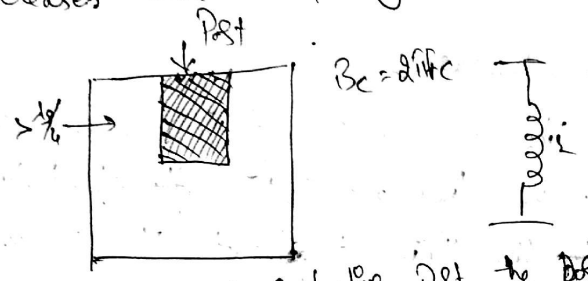
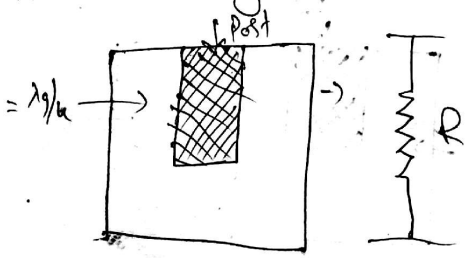
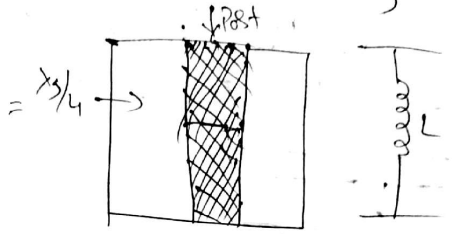


figure shows a basic inductive post the post behaves as an inductive post when it extends or moves to a larger distance ie $> \lambda_g/4$ in to the 'wg'. when the post is moved further away from the centre of 'wg' the inductive susceptance decreases.

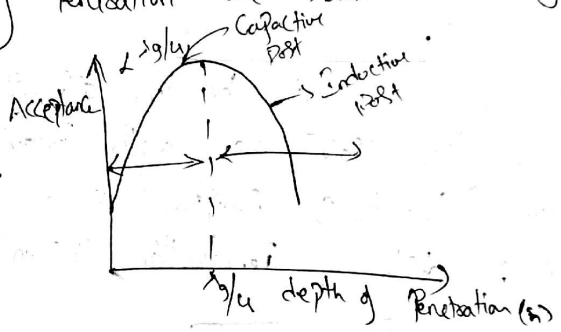
When the depth of penetration is equal to $\lambda_g/4$ then post acts as a series resonant ckt i.e like a purely resistive ckt.



When the post is extended completly across the 'wg' the post becomes 'wg' purely



The characteristic b/w the susceptons and depth of penetration are shown in below figure



The amount of susceptons decreases as the diameter of post is decreased.

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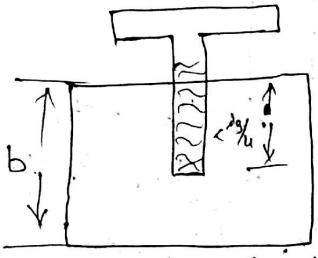
Tuning screw:- An adjustable post is known as screw (or) slug

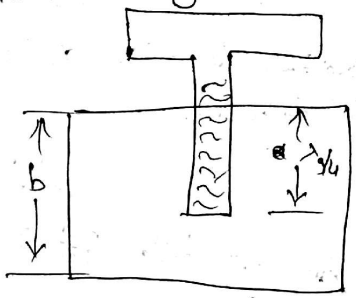
The dis advantage of inductive and capacitive windows is that they are not steadly adjustable due to the imperfect contact blw the 'wg'

window and the walls of 'wg'.

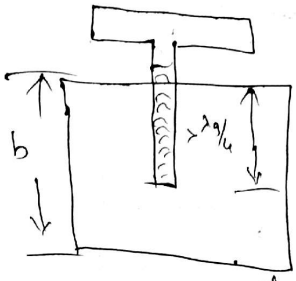
By inserting a screw at the top & bottom of the 'wg'. Elec. to Electric field. hence we obtain the susceptance value



A screw of length less than approximately a quater free space wave length produces an effective capacitance susceptance value then the value of depth of penetration increases.



A screw of length is approximately equal to a quater free space wave length then screw acts as a series resonant circuit



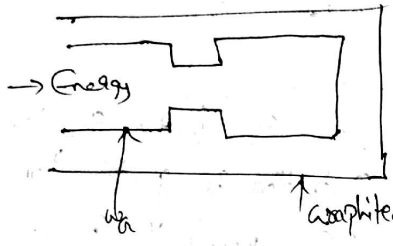
When the screw is further inserted that is the depth of penetration is greater than that of the quater free space wavelength produces an effective inductive susceptance.

The use of screws is to produce a wide range of susceptance value but it is not possible because the 'b' dimensional of 'wg' is too small.

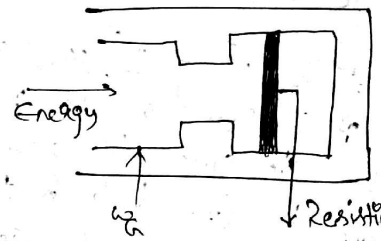
A disadvantage of the use of the single screw in impedance matching is that it requires a slot in the walls of the 'wg' the above disadvantage can be over come by using double & triple screws. in which 2 & 3 adjustable screws (&) space at an 8th (&) quarter of the guide wave length.

'Wg' terminations :- in many applications a need exits for a termination i.e capable of absorbing the incident energy with out reflections.

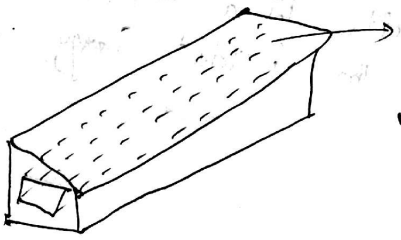
In a 'wg' system it is not possible to attach a fixed resistive load as a resistive termination.



At the end of 'wg' as shown in the figure can dispate energy to achieve standing wave ratio.



A resistive load placed at a point in the 'wg' where the electric field strength is maximum can also dercipate energy.



A bridge of resistive material in the form of a tapper as shown in the figure that can acts as a termination. All these are matched terminations and almost no reflections occurs know reflection occurs by using these transmissions.

Wg attenuator :-

Some times for perfect matching we require that the micro power in a wg would be observed completly with out any reflections for this we use attenuators.

Attenuators are commonly used measuring Power gain (or) loss in db's for providing isolation btw instruments, for reducing the op Power to a particular stage to prevent over loading and also for providing the signal generators. with a means of calculating there dps accurately.

Attenuators are classified in 2- Categiroes.

1) fixed attenuator.
2) Variable "

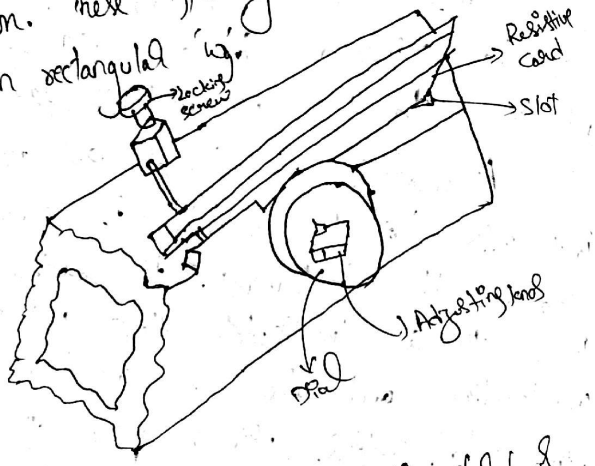
1) fixed attenuators are used for providing fixed amount of attenuation.

Variable attenuators provides continous are step wise variable attenuation. for rectangular wg these attenuators can be flap attenuator.

for circular 'wg' Rotary vane attenuator is used.

1) Flap attenuators:-

is a type of variable attenuators which provides continous are & step wise variable attenuation. these type of variable attenuators are used in rectangular 'wg'.



Flap attenuator consists of resistive sheet of element is inserted in to a longitudinal slot cut along the centre of the broader dimensions of the 'wg' the flap is mounted on the insulating hinged arm in to centre of wg

the degree of attenuation is determined by the depth of penetration of flap.

flap attenuator is also called as resistive sheet type attenuator (or) dissipative attenuator

the flap attenuator is not a precision attenuator hence it should be calculated against a standard value.

Rotary vane type attenuator:-

is a type of variable attenuator which provides continous & step wise variable attenuation. these type of attenuators are used in circular 'wg'.

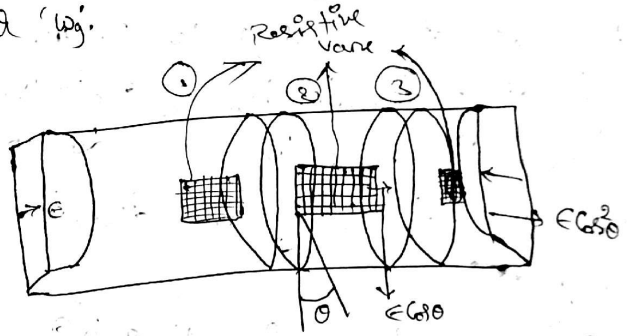


figure shows a resistive rotary vane attenuator which provides

figure shows precision attenuation of $\pm 2.1\%$ of the indication attenuation over the operation freq range it consists of 3 vanes the central vane rotating type is placed in the central section of circular 'wg'. the other 2 vanes

are placed in rectangular 'wg'. when all the 3-vanes are allined these planes are at 90° to the direction of electric field hence there is no attenuation.

vane 1 prevents any horizontal attenuation electric field at the o/p vane 1 is

the centre vane 2 is rotating type and if it as it rotated by an angle 'θ' the $E\sin\theta$ component is attenuated and $E\cos\theta$ component is present at the o/p of vane 2. and the final o/p of attenuator becomes. $E\cos^2\theta$ which is having the same to due to this then attenuation rotary vane attenuator is given by.

$$\alpha = 20\log\cos\theta = 40\log\cos\theta$$

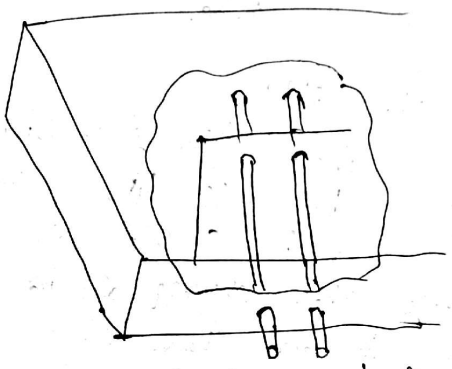
from the above Eq. we can say that attenuation is independent of frequency hence it means to a prefixed attenuator

Via Phase shifter:-

Phase shifter is a device which is used to change the phase relation ships b/w 2-signal is known as wg phase shifter

i) Di-Electric Phase shifter:-

is a type of variable phase shifter these type of phase shifters are used in rectangular wg.



A variable phase shift is to insert a slab of low loss di-electric material such as polistry in to a wg as shown in the figure. the slab is attached to metal supporting which may be moved across the wall in broder dimension wall.

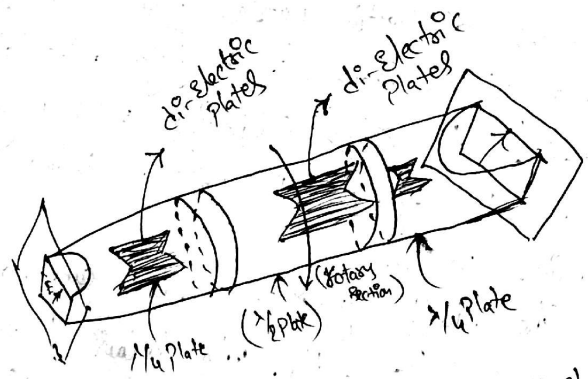
the spacing of metal rods and slab are chosen correctly. why because in order to give minimum reflection. the maximum effect of slab is produced when it is placed at the centre of 'wg' where the electric field is maximum.

hence di-electric reduces phase velocity in the section of the wg. when the slab is placed at the centre of wg.

the electrical length of section appears to increase as the slab is moved towards the centre of the guide.

Rotary vane phase shifter :-

It is also a type of variable phase shifter but these type of phase shifters are used in circular wg. These phase shifters are more accurate than di-electric phase shifter



Except for the centre and the 2-outer most resistive cards. its construction is similar to that of the rotary vane attenuator.

these outer and centre resistive cards are replaced by dielectric half wave and quater wave plates the phase shift produced by the half wave plate is equal to twice the angle of which it is rotated. a linearly polarised mode is converted in to a circular polarised mode by the quater wave plates. and similarly it converts a circular polarized mode in to a linearly polarised mode.

The electric field components of the circularly polarized wave obtained ie x & y components are equal in magnitude but 90° apart in time phase. the construction of quater wave plate is possible from a slab of di-electric material. when the TE$_{10}$ mode is polarised perpendicular to slab then β_1 is the propagation constant for the polarization. and the mode is polarised ∥le to the slab and β_2 is the propagation constant for ⊥le polarisation.

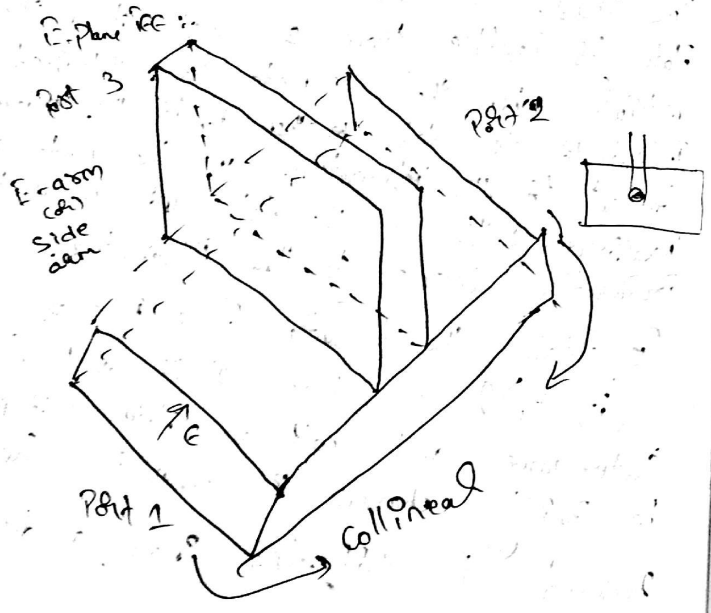
to obtain the differential phase shift as

$(\beta_2 - \beta_1)l = 90°$ where 'l' is length b/w quater wave and half wave plates it must be properly choosen. the reflection can be reduced by tappering ends of di-electric slab.

The Construction of half wave plate is similar to that of quater wave plate except that its length is increased to Produce a 180° differential phase shift

Wave guide TEES :- (or) multiport Junction T'ng

E-plane TEE :-



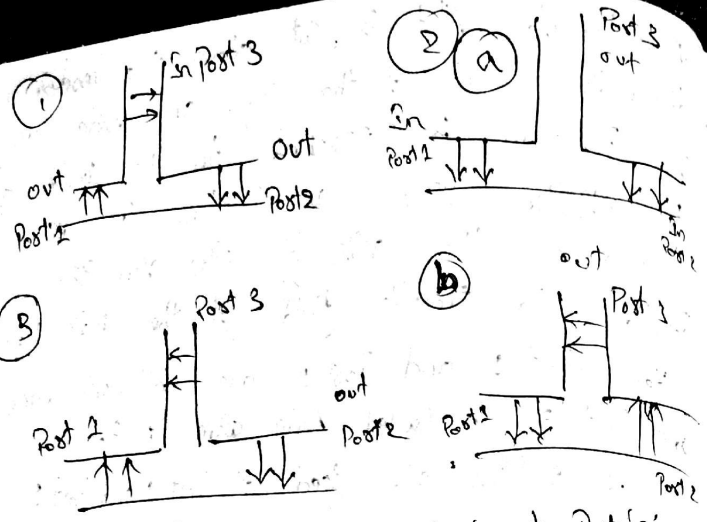
A rectangular slot is cut along the broader dimension wall of the w/g. and side arm (or) E-arm is attached to the main w/g transmission line. an E-plane TEE is defined as the axis of side arm is Parallel to Electric field of the main w/g.

Here Port 1 and Port 2 are Collineal arms and Port 3 is Called side arm. (or) E-arm

if 2-i/p's are feed at Port 1 and Port 2 of Collineal arm's then o/p will be obtained at Port 3. will be opposite in phase and subtractive. that's why some times Port 3 is also Called as difference arm

E-plane TEE is also Called as series TEE why because in the E-plane TEE Junction high amount of Energy is delivered to a branch line which is Connected to a main transmission line if this branch line is Connected in series with w/g transmission line at transition of low voltage and high Current.

Properties of E-plane TEE :-



1) When the i/p waves are feed at Port '3'. then the o/p waves will be obtained at Port '1' & Port '2' i.e Collineals arms will be in opposite phase and Equal in magnitude

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

a) If Phased o/p are applied at Port 1 and Port 2 then o/p will be zero at Port '3'.

b) If 180° phase shift is ~~un Equal o/p~~ applied b/w port 1 and port 2 then o/p will be maximum at Port '3'.

3) When i/p is applied at one of the Collineal arms Port 1 (or) Port 2 the o/p's are obtained at Port 1 and Port 2 side arm Port 3.