Subject → Microwave Engg.
Branch → ECE (3rd Yr)
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Microwave Hybrid Circuits —

- Waveguide Tees -

Waveguide tees may consist of the E-plane tee, H-plane tee, magic tee, hybrid rings, corners, bends and twists.

Tee junctions —* In microwave circuits a waveguide or coaxial line junction with three independent ports is commonly referred to as a tee junction.

* A tee junction should be characterized by a matrix of third order containing nine elements, six of which should be independent. (From the S-parameter theory of a microwave junction.)

* The characteristics of a three port junction can be explained by three theorems of the tee junction which are derived from the equivalent-circuit representation of the tee junction.

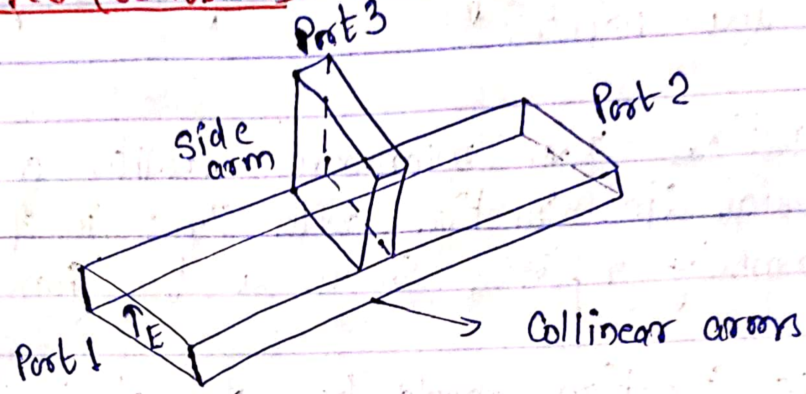
Their statement follows -

① A short circuit may always be placed in one of the arms of a three port junction in such a way that no power can be transferred through the other two arms.

② If the junction is symmetric about one of it's arm, a short circuit can always be placed in that arm so that no reflections occur in power transmission between the other two arms.

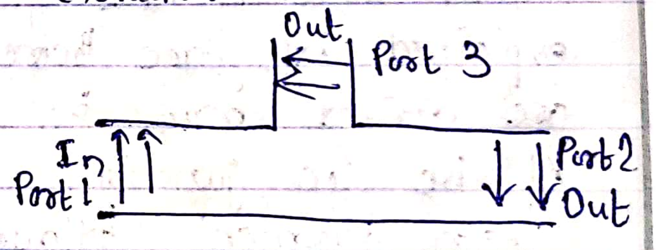
③ It is impossible for a general three port junction of arbitrary symmetry to present matched impedances at all three arms.

E-Plane tee (series tee)

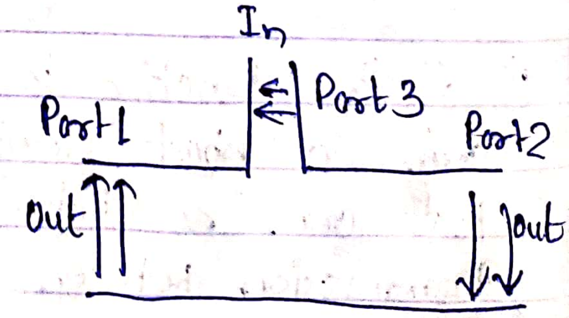


* An E-plane tee is a waveguide tee in which the axis of it's side arm is parallel to the E field of the main guide.

Two different transmission characteristics –



① If the E-plane tee is perfectly matched with the aid of screw tuners or inductive or capacitive windows at the junction, the diagonal components of the scattering matrix, S_{11}, S_{22}, S_{33} are zero because there will be no reflection.



② when the waves are fed into the side arm (Port 3), the waves appearing at port 1 and port 2 of the collinear arm will be in opposite phase and in the same magnitude. ∴ $S_{13} = -S_{23}$

The negative sign merely means that S_{13} and S_{23} have opposite signs.

For a matched junction, the S matrix is given by—

$$S = \begin{bmatrix} 0 & S_{12} & S_{13} \\ S_{21} & 0 & S_{23} \\ S_{31} & S_{32} & 0 \end{bmatrix}$$

From the symmetry property of S-matrix -

$$S_{12} = S_{21}, \quad S_{13} = S_{31}, \quad S_{23} = S_{32} \quad \text{—} (1)$$

From the zero property of S-matrix -

$$S_{11} S_{12}^* + S_{21} S_{22}^* + S_{31} S_{32}^* = 0$$

Hence, $S_{13} S_{23}^* = 0$ ⇒ Either S_{13} or S_{23}^* or both should be zero.

From unity property of S-matrix -

$$S_{21} S_{21}^* + S_{31} S_{31}^* = 1 \quad \text{—} (2)$$

$$S_{12} S_{12}^* + S_{32} S_{32}^* = 1 \quad \text{—} (3)$$

$$S_{13} S_{13}^* + S_{23} S_{23}^* = 1 \quad \text{—} (4)$$

Subs.ⁿ eqⁿ (1) in (2) —

$$|S_{12}|^2 = 1 - |S_{13}|^2 = 1 - |S_{23}|^2 \quad \text{—} (5)$$

Eqⁿ (4) & eqⁿ (5) are contradictory, for if $S_{13} = 0$ then S_{23} is also 0, then eqⁿ (4) is false. Similarly, if $S_{23} = 0$ then $S_{13} = 0$, ∴ eqⁿ (5) is not true.

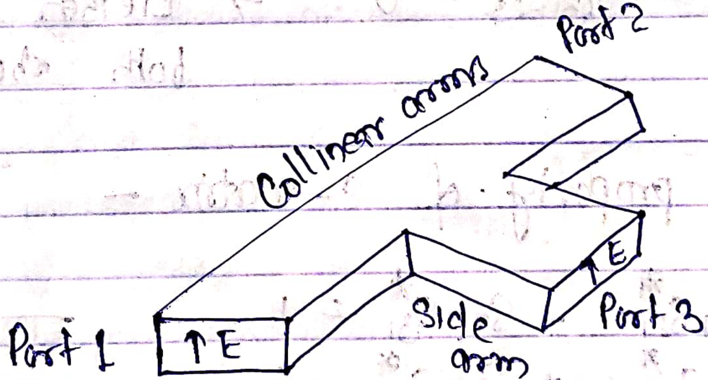
This inconsistency proves the statement that the tee junction cannot be matched to the three arms. i.e the diagonal elements of S-matrix of a tee junction are not all zeros.

The S-matrix can be simplified to :

$$S = \begin{bmatrix} S_{11} & S_{12} & S_{13} \\ S_{12} & S_{11} & -S_{13} \\ S_{13} & -S_{13} & S_{33} \end{bmatrix}$$

H - Plane tee (Shunt tee) -

An H-plane tee is a waveguide tee in which the axis of it's side arm is shunting the E field or parallel to the H field of the main guide.



* If two input waves are fed into port 1 and port 2 of the collinear arm, the output wave at port 3 will be in phase and additive.

* If the input is fed into the port 3, the wave will split equally into port 1 and port 2 in phase and in the same magnitude.

∴ The S-matrix of the H-plane tee is similar to E-plane except that $S_{13} = S_{23}$.