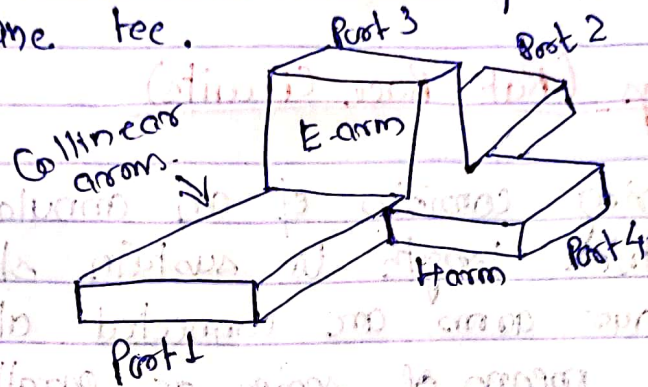


Magic Tees (Hybrid Tees) -

- * The magic tee is commonly used for mixing, duplexing and impedance measurements.
- * A magic tee is a combination of the E-plane tee and H-plane tee.



* Characteristics of Magic Tee -

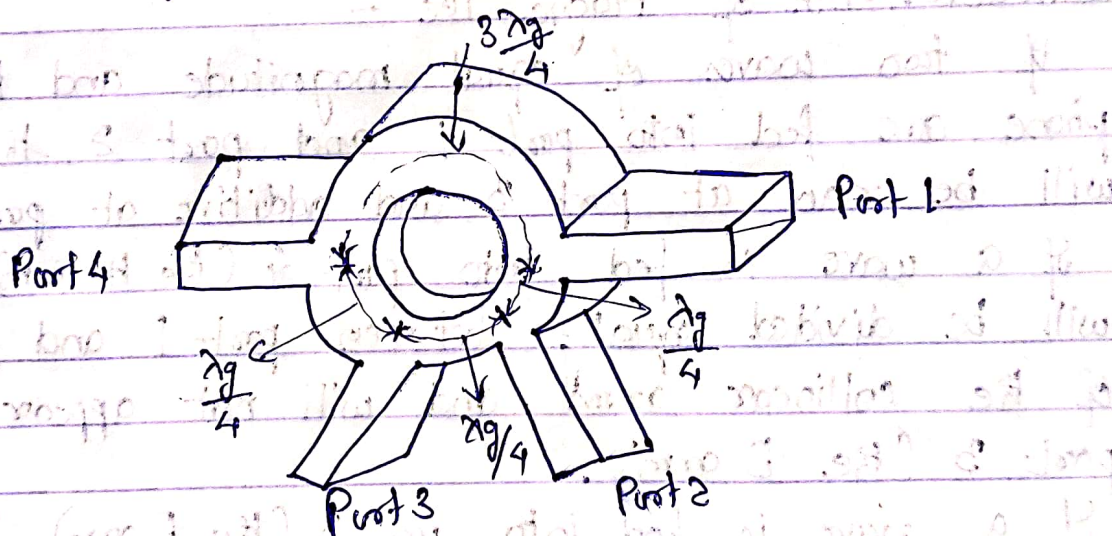
- ① If two waves of equal magnitude and the same phase are fed into port 1 and port 2, the output will be zero at port 3 and additive at port 4.
- ② If a wave is fed into port 4 (the H arm), it will be divided equally between port 1 and port 2 of the collinear arms and will not appear at port 3 (the E arm).
- ③ If a wave is fed into port 3 (the E arm), it will produce an output of equal magnitude and opposite phase at port 1 and port 2. The output at port 4 is zero, i.e. $S_{43} = S_{34} = 0$.
- ④ If a wave is fed into one of the collinear arms at port 1 or port 2, it will not appear in the other collinear arm at port 2 or port 1 because the E arm causes a phase delay while the H arm causes a phase advance.
i.e. $S_{12} = S_{21} = 0$.

∴ The S matrix of a magic tee can be expressed as

$$S = \begin{bmatrix} 0 & 0 & S_{13} & S_{14} \\ 0 & 0 & S_{23} & S_{24} \\ S_{31} & S_{32} & 0 & 0 \\ S_{41} & S_{42} & 0 & 0 \end{bmatrix}$$

Hybrid Rings (Rat - Race Circuits)

* A Hybrid ring consists of an annular line of proper electrical length to sustain standing waves, to which four arms are connected at proper intervals by means of series or parallel junctions.



* When a wave is fed into port 1, it will not appear at port 3 because the difference of phase shifts for the waves traveling in the clockwise and counterclockwise directions is 180° . Thus the waves are canceled at port 3. For the same reason, the waves fed into port 2 will not emerge at port 4 and so on.

The S matrix for an ideal hybrid ring can be expressed as -

$$S = \begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{21} & 0 & S_{23} & 0 \\ 0 & S_{32} & 0 & S_{34} \\ S_{41} & 0 & S_{43} & 0 \end{bmatrix}$$