

Lecture – 11 (Dt. 18th April 2020)

Microwave Engineering (EC- 6th Sem)

Termination (Circulator & Isolator)

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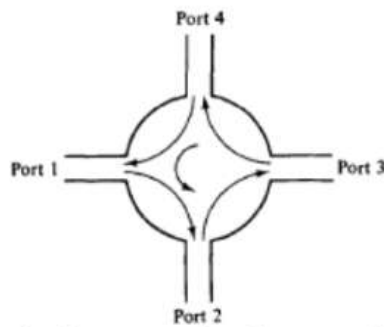
Acknowledgement

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TERMINATION:

A *microwave circulator* is a multiport waveguide junction in which the wave can flow only from the n th port to the $(n + 1)$ th port in one direction

Although there is no restriction on the number of ports, the four-port microwave circulator is the most common. One type of four-port microwave circulator is a combination of two 3-dB side-hole directional couplers and a rectangular waveguide with two nonreciprocal phase shifters as shown in Fig



The operating principle of a typical microwave circulator can be analyzed with the aid of Fig. Each of the two 3-dB couplers in the circulator introduces a phase shift of 90° , and each of the two phase shifters produces a certain amount of phase change in a certain direction as indicated.

When a wave is incident to port 1, the wave is split into two components by coupler **1**. The wave in the primary guide arrives at port 2 with a relative phase change of 180° . The second wave propagates through the two couplers and the secondary guide and arrives at port 2 with a relative phase shift of 180° . Since the two waves reaching port 2 are in phase, the power transmission is obtained from port 1 to port 2.

However, the wave propagates through the primary guide, phase shifter, and coupler 2 and arrives at port 4 with a phase change of 270° . The wave travels through coupler 1 and the secondary guide, and it arrives at port 4 with a phase shift of 90° . Since the two waves reaching port 4 are out of phase by 180° , the power transmission from port 1 to port 4 is zero. In general, the differential propagation constants in the two directions of propagation in a waveguide containing ferrite phase shifters should be

$$\omega_1 - \omega_3 = (2m + 1)\pi \quad \text{rad/s}$$

$$\omega_2 - \omega_4 = 2n\pi \quad \text{rad/s}$$

ISOLATOR CIRCULATOR:

An *isolator* is a nonreciprocal transmission device that is used to isolate one component from reflections of other components in the transmission line. An ideal isolator completely absorbs the power for propagation in one direction and provides lossless transmission in the opposite direction. Thus the isolator is usually called *uniline*.

Isolators are generally used to improve the frequency stability of microwave generators, such as klystrons and magnetrons, in which the reflection from the load affects the generating frequency. In such cases, the isolator placed between the generator and load prevents the reflected power from the unmatched load from returning to the generator. As a result, the isolator maintains the frequency stability of the generator. Isolators can be constructed in many ways. They can be made by terminating ports 3 and 4 of a four-port circulator with matched loads. On the other hand, isolators can be made by inserting a ferrite rod along the axis of a rectangular waveguide.

The isolator here is a Faraday-rotation isolator. Its operating principle can be explained as follows [5]. The input resistive card is in the y - z plane, and the output resistive card is displaced 45° with respect to the input card. The de magnetic field, which is applied longitudinally to the ferrite rod, rotates the wave plane of polarization by 45° . The degrees of rotation depend on the length and diameter of the rod and on the applied de magnetic field. An input TE₁₀ dominant mode is incident to the left end of the isolator. Since the TE₁₀ mode wave is perpendicular to the input resistive card, the wave passes through the ferrite rod without attenuation.

The wave in the ferrite rod section is rotated clockwise by 45° and is normal to the output resistive card. As a result of rotation, the wave arrives at the output end without attenuation at all. On the contrary, a reflected wave from the output end is similarly rotated clockwise 45° by the ferrite rod.

However, since the reflected wave is parallel to the input resistive card, the wave is thereby absorbed by the input card. The typical performance of these isolators is

