CLASS: B.E. E &TC **SUBJECT: RMT**
EXPT. NO.: 6 **DATE:**
Roll No.: 42428

TITLE: To measure and verify port characteristics of isolator and circulator and calculate insertion loss and isolation in dB.

OBJECTIVE:

1. To study the characteristics of Circulator/ Isolator.
2. To measure Insertion Loss, Isolation.

EQUIPMENTS: Microwave oscillator with power supply,
Attenuator,
Isolator,
Circulator,
Detector mounts,
Frequency meter,
Matched loads,
CRO

THEORY:

ISOLATOR:

An **isolator** is a two-port device that transmits microwave or radio frequency power in one direction only. It is used to shield equipment on its input side, from the effects of conditions on its output side; for example, to prevent a microwave source being detuned by a mismatched load.

An isolator is a non-reciprocal device with a non-symmetric scattering matrix. An ideal isolator transmits all the power entering port 1 to port 2, while absorbing all the power entering port 2, so that to within a phase-factor its S-matrix is

$$S = \begin{pmatrix} 0 & 0 \\ 1 & 0 \end{pmatrix}$$

To achieve non-reciprocity, an isolator must necessarily incorporate a non-reciprocal material. At microwave frequencies this material is invariably a ferrite which is biased by a static magnetic field. The ferrite is positioned within the isolator such that the microwave signal presents it with a rotating magnetic field, with the rotation axis aligned with the direction of the static bias field. The behavior of the ferrite depends on the sense of rotation with respect to the bias field, and hence is different for microwave signals travelling in opposite directions. Depending on the exact operating conditions, the signal travelling in one direction may either be phase-shifted, displaced from the ferrite or absorbed.

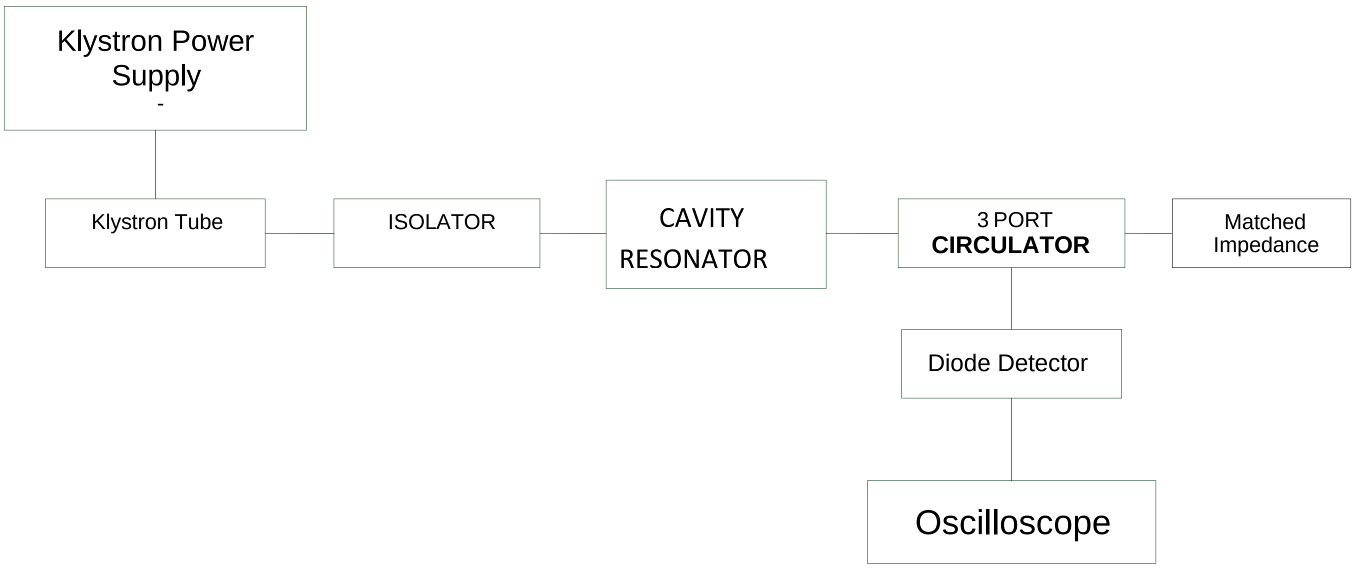
CIRCULATOR:

A **circulator** is a non-reciprocal three- or four-port device, in which power entering any port is transmitted to the next port in rotation (only). So to within a phase-factor, the scattering matrix for a three-port circulator is

$$S = \begin{pmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{pmatrix}$$

A two-port isolator is obtained simply by terminating one of the three ports with a matched load, which absorbs all the power entering it. The biased ferrite is part of the circulator. The bias field is lower than that needed for resonance absorption, and so this type of isolator does not require such a heavy permanent magnet. Because the power is absorbed in an external load, cooling is less of a problem than with a resonance absorption isolator.

SETUP_DIAGRAM:



PROCEDURE:

1. Energize the microwave source for particular operation. Adjust the repeller voltage to get maximum signal voltage at the output. Tune the detector mount for maximum output. [Without circulator connected in set up]
2. Feed this known power to port 1 of 3 ports circulator.
3. Connect a matched load at port 3 and then measure the voltage at port 2, by connecting the diode detector.
4. Then measure the voltage at port 3 by interchanging the detector and matched load.
5. Repeat the procedure by applying the inputs at port 2 and then to port-3. Tabulate the readings. Verify their port characteristics.
6. Similarly, verify the port characteristics of Isolator also. (When port which is not coupled to input port is terminated by matched termination, it makes an isolator)

OBSERVATION TABLE:

CIRCULATOR:

Input	Output	Output	Insertion Loss(dB) $L = 20\log_{10}(\frac{i/p_{-nport}}{o/p_{-n+1port}})db$	Isolation (dB) $I = 20\log_{10}(\frac{i/p_{-nport}}{o/p_{-n+2port}})db$
Port 1 =2.20V	Port 2 =1.92V	Port 3 =31mV	1.182429	37.021219
Port 2 =2.20V	Port 3 =1.90V	Port 1 =14.8mV	1.273381	43.443219
Port 3 =2.20V	Port 1 =1.91V	Port 2 =22.9mV	1.227786	39.651743

ISOLATOR:

Input	Output	Insertion Loss(dB) $L = 20\log_{10}(\frac{i/p_{-nport}}{o/p_{-n+1port}})db$	Isolation (dB) $I = 20\log_{10}(\frac{i/p_{-nport}}{o/p_{-n+2port}})db$
Port 1 =2.20V	Port 2 =1.96V	1.003332	-
Port 2 =2.20V	Port 1 =44mV	-	33.979400

CALCULATIONS:-

For Circulator:

For input at port 1

$L = 20\log_{10}(2.2/1.92) = 20\log_{10}(1.14583) = 1.182429\text{dB}$

$I = 20\log_{10}(2.2/0.031) = 20\log_{10}(70.967742) = 37.021219\text{dB}$

For input at port 2

$L = 20\log_{10}(2.2/1.90) = 20\log_{10}(1.1578947) = 1.273381\text{dB}$

$I = 20\log_{10}(2.2/0.0148) = 20\log_{10}(148.64864) = 43.443219\text{dB}$

For input at port 1

$L = 20\log_{10}(2.2/1.91) = 20\log_{10}(1.151832461) = 1.227786\text{dB}$

$I = 20\log_{10}(2.2/0.0229) = 20\log_{10}(96.069869) = 39.651743\text{dB}$

For Isolator:

$L = 20\log_{10}(2.2/1.96) = 20\log_{10}(1.12244898) = 1.003332\text{dB}$

$I = 20\log_{10}(2.2/0.044) = 20\log_{10}(50) = 33.979400\text{dB}$

CONCLUSION:-

In this experiment we studied the characteristics of Circulator and Isolator and measured Insertion Loss and Isolation for both. In case of circulator, when we apply input at port 1, we observe output at port 2 and port 3 gets isolated. When we apply input at port 2, we observe output at port 3 and port 1 gets isolated. When we apply input at port 3, we observe output at port 1 and port 2 gets isolated. In case of isolator when we apply input at port 1 then we observe full output at port 2 but in case of vice versa we observe negligible output. From this we can say that both are following their working principles.

REFERENCES:-

1. Microwave and Radar Engineering—M.Kulkarni
2. Basic Microwave Lab Manual—Sisodia