APPLICATION NOTE
ANV003

# ISOLATION MEASUREMENT

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## Introduction:

A measure of the separation of signal levels on adjacent ports of a Circulator is called as Isolation. It is measured in *dB*. The greater the isolation value lesser will be the interference from a signal on one port relative to an adjacent port.

This isolation is due to a matched termination attached to one of the three ports of the Circulator. The isolation of Circulator is mainly dependent on following two parameters:

- Termination match level
- VSWR of terminated port

The VSWR value on terminated Circulator port represents the absolute maximum amount of energy that will reflect off from the port when a *50Ω* load is connected on it. In order to dissipate this reflected energy safely, Circulator isolation value always needs to be equal to or higher than VSWR value for a given bandwidth.

In case of the poor match on terminated port, expected isolation is below *10 dB*. When terminated port match is improved to VSWR of *1.10:1* by using a good termination, then the isolation would improve to over *20 dB*. For the same quality of termination and VSWR values (*1.05:1* or better) comparatively better isolation(around *25 dB*) can be achieved for narrowband units than that for broadband units (around *15-20 dB*).

## Isolation Measurement Principle:

When measuring the isolation of a 3-port-Circulator we connect one port with the source, on the next port in the sense of circulation we put a matched load and the third port is connected to a detecting device (*Figure 1*). This technique can be done with low signal level but also with high power. For low level measurements we can use also a network analyzer, connecting two ports to it and the remaining port gets a matched load.

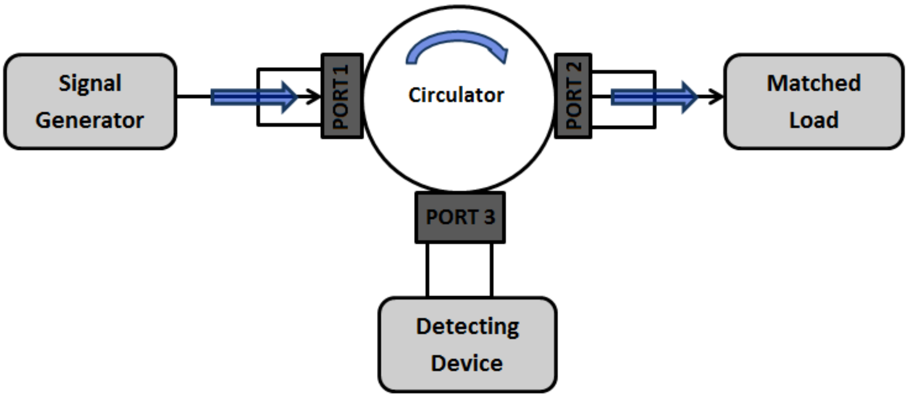


*Figure 1: Isolation Measurement Principle*

The matched load used for terminating one port is not an ideal matching but has a small $VSWR_{load}$. This small reflection superimposes the signal caused by the not ideal isolation of the Circulator. Therefore we measure a combination of the Circulator isolation and the VSWR of the connected load, the value of which depends on the phase between the two signals. The minimum value of isolation is measured when both signals add, the maximum when the signals subtract one from the other.

For calculation the isolation value *D* of the Circulator is converted into an equivalent $VSWR_{Circulator}$. Then we combine the VSWR of the load $VSWR_{load}$ and $VSWR_{Circulator}$ to determine the maximum ($VSWR_{max}$) and minimum ($VSWR_{min}$). We convert these back to the extremes of the measured isolation $D_{meas\_max}$ and $D_{meas\_min}$.

Circulator VSWR in terms of isolation is given by:

$$(VSWR_{Circulator}) = \frac{1+\frac{1}{10^{\left[\frac{D}{20}\right]}}}{1-\frac{1}{10^{\left[\frac{D}{20}\right]}}} \qquad \textit{(Eq. 1)}$$

The minimum value of VSWR can be calculated as:

$$VSWR_{min} = VSWR_{Circulator} * VSWR_{load} \qquad \textit{(Eq. 2)}$$

The maximum value of VSWR can be calculated as:

Case 1: If $VSWR_{Circulator} / VSWR_{load} \geq 1$

$$VSWR_{max} = VSWR_{Circulator} / VSWR_{load} \qquad \textit{(Eq. 3)}$$

Case 2: If $VSWR_{Circulator} / VSWR_{load} < 1$

$$VSWR_{max} = VSWR_{Load} / VSWR_{Circulator} \qquad \textit{(Eq. 4)}$$

The resulting isolation values due to these minimum and maximum VSWR values can be expressed as:

$$Dmeas\_min = 20\, log_{10} \left[\frac{VSWRmin+1}{VSWRmin-1}\right] \qquad \textit{(Eq. 5)}$$

$$Dmeas\_max = 20\, log_{10} \left[\frac{VSWRmax+1}{VSWRmax-1}\right] \qquad \textit{(Eq. 6)}$$

These correlations between maximum and minimum measured isolation *Dmeas*, the real isolation of the Circulator *D*, and the VSWR of the load $VSWR_{load}$ can be seen as a graph in *Figure 2*. The measured isolation will lie between the upper and lower curve of the relevant $VSWR_{load}$.

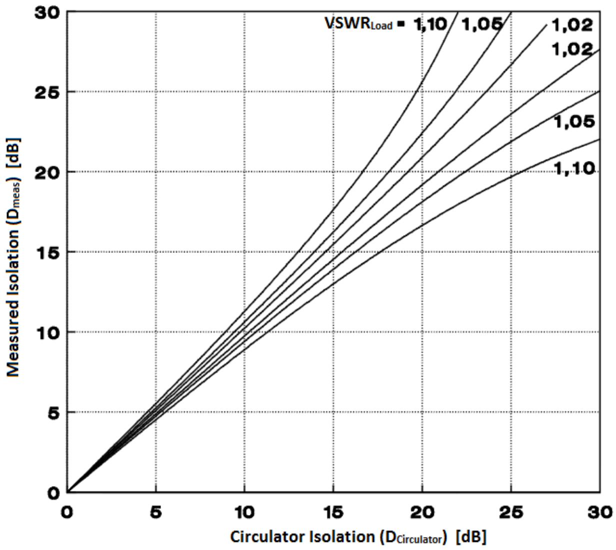


*Figure 2: Measured Isolation v/s Circulator Isolation*

If for example we use a load with a $VSWR_{load}$ =1.02 and the isolation of our circulator ($D$) is 25 dB, our measurement can lie between $D_{meas\_min} = 23.6\ dB$ and $D_{meas\_max} = 27.6\ dB$.

To give a better idea how much the difference between the real isolation of the Circulator and the measured isolation can be, *Figure 3* shows this difference as a function of the isolation of the Circulator $D$ with the VSWR of the load $VSWR_{load}$ as a parameter.

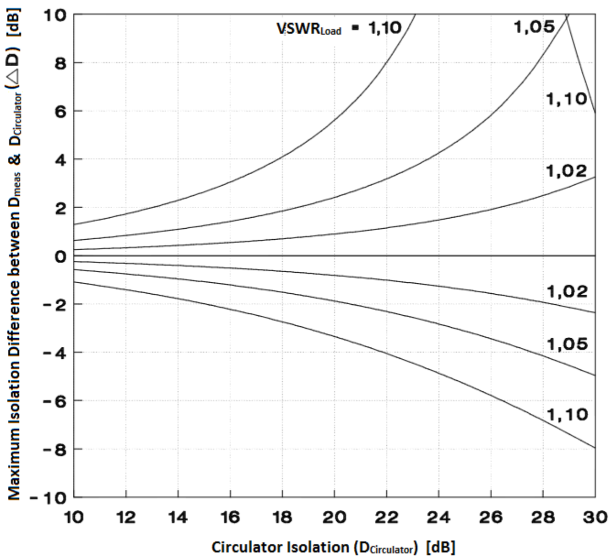


*Figure 3: Difference Isolation v/s Circulator Isolation*

For example for a load with a $VSWR_{load}$ *=1.05* and Circulator with isolation $D = 20\ dB$ the maximum difference of the measured isolation and the real isolation of the circulator is *+2.4 dB* and *-1.9 dB.*

## Load Match Level v/s Isolation:

The most important concept of Circulator is that of port isolation. With poor match levels the comparatively more reflections will be produced which reduces the actual isolation between the ports of the Circulator. Hence, Circulator do not provide specified amount of isolation unless and until they are terminated by sufficiently well matched load level.

# ABOUT VALVO

Valvo Bauelemente GmbH is a Germany based company specializing in design and developments of standard as well as special RF and microwave ferrite components. Valvo Bauelemente GmbH has more than 30 years of experience in providing well-rounded expertise solutions, technologies and design techniques.

The core of the company is a highly experienced team of respected technologists with developments of performance specific, high reliability complex products. The company has delivered excellent performance in several International R&D projects.

All products are controlled to the highest standards for guaranteed delivery and customer satisfaction.

# PRODUCTS

Valvo Bauelemente GmbH is focused on 50 MHz to 18 GHz Circulators, Isolators, Waveguides, and microwave ferrite devices. We offer narrow and broad band devices in coaxial, waveguide, drop-in constructions which are ideally suited for integration into compact systems.

Our highly skilled staff has a strong working knowledge and experience on a variety of ferrite devices with over 2,000 existing designs. This makes us possible to offer custom product solutions in addition to wide range standard product solutions.

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