APPLICATION NOTE ANV005

INSERTION LOSS MEASUREMENT



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Introduction:

Transmission path insertion loss is another important parameter when selecting Circulator / Isolator. The total amount of energy lost while transmitting the RF signal from one port to another port of a Circulator / Isolator is called as Insertion Loss.

Signal traveling through passive RF devices will undergo some attenuation. Insertion loss is the ratio of the output signal to the input signal, and it is measured in decibels (dB).

$$I.L. = 10 \log_{10} \left[\frac{Pout}{Pin} \right] \quad [dB] \tag{Eq. 1}$$

Typical values of Circulator/ Isolator insertion loss are of the order 0.2 to 0.4 dB.

For the same quality of load termination and VSWR values narrowband Circulator / Isolator comparatively have less insertion loss (around 0.35 dB) than that for broadband units (up to 1.5 dB).

Insertion Loss Measurement Principles:

As shown in *Figure 1* the reflection properties of Circulator can be described by S-parameters. An RF vector network analyzer (VNA) can be used to measure the forward transmission coefficients (S_{12}).

The S₁₂ is a transmission loss in forward direction. It can be calculated as: $S_{12} = \frac{P_2}{P_1}$

The S₁₃ represents power a leaking in reverse direction. Its value is given by: $S_{I3} = \frac{P_3}{P_1}$

Where





Figure 1: Insertion Loss Measurement Principle



Power Loss from Specified Insertion Loss:

From the datasheet specified Insertion Loss (*I.L.*) values the actual amount of transmitted power loss can be calculated. This helps to determine the signal transmission path behavior for different incident power levels.

For example, consider Valvo's Isolator <u>VFA 852</u> which has *I.L.* = 0.8 dB (at f = 48 MHz). Now, we will determine the amount of transmitted power that is lost in the Isolator <u>VFA 852</u> with $P_{in}=1$ W.

Insertion loss is given by: $I.L. = 10 \log_{10} \left[\frac{Pout}{Pin} \right] [dB]$

From datasheet specifications *I.L.0.80 dB* (actual value is -0.80 dB, as insertion loss is measure of the attenuation).

$$\therefore -0.8 = 10 \log_{10}\left[\frac{Pout}{Pin}\right]$$
 (Eq. 2)

Rearranging the above equation to get output power,

$$\therefore \left[\frac{Pout}{Pin}\right] = 10^{\frac{-0.8}{10}}$$

$$\therefore Pout = (10^{\frac{-0.8}{10}}) * (Pin)$$

$$\therefore Pout = (10^{\frac{-0.8}{10}}) * (1)$$

$$\therefore Pout = (0.831) * (1)$$

$$\therefore Output Power(Pout) = 0.83 [W] (Eq. 3)$$

Now, power loss due to insertion loss of 0.8 dB is $P_{I,L}$ = Input power (P_{in}) – Output Power (P_{out}) $\therefore P_{I,L} = 1 - 0.83$

Hence, power loss due to insertion loss of 0.8 dB is $P_{I.L} = 0.17$ [W] (Eq. 4)

Now we know, 0.17 Watts of power is lost in the Isolator VFA 852 with 1 Watt input power application.

Similarly, one can calculate the insertion power loss in any Circulator / Isolator depending on input power ratings of the application.

Frequency v/s Insertion Loss:

The insertion loss is frequency dependent, it increases with operating frequency. Hence, insertion loss of Circulator / Isolator becomes more significant at higher frequencies due to more power being dissipated as a heat.

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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