8/3/2023

On Specifications

An Application Note Providing Definitions for Product Specifications

MICRO HARMONCS COOPERATION

Introduction

In this application note the definitions of the specifications for Micro Harmonic's products will be provided. Even specifications that seem straightforward can have multiple interpretations, and other specifications might not be implicitly well-defined or quantitative. The purpose of this document is to resolve these ambiguities for Micro Harmonic's specifications.

The table below provides a summary of which metrics are specified for each Micro Harmonics product.

Specification	**Isolator**	**Cryogenic Isolator***	**Voltage Variable Attenuator***	**Hybrid Circulator***	**Y-junction Circulator***
Flange	✓	✓	✓	✓	✓
Frequency	✓	✓	✓	✓	✓
Power				✓	✓
Forward Power			✓		
Reverse Power	✓	✓			
Average Insertion Loss	✓	✓	✓	✓	✓
Maximum Insertion Loss	✓				
Typical Minimum Isolation	✓	✓		✓	✓
Typical Minimum Return Loss	✓		✓	✓	✓
Typical Max VSWR	✓		✓	✓	✓
Dynamic Range			✓		
Flatness			✓		

*The spec sheets for these components have not yet been updated to the specification standards outlined in this document.

Generic Specifications

Flange

Flange is specified using the MIL-spec (UG-xxxx/U) designation and the EIA (WR-xx) standard rectangular waveguide designation.

Frequency (GHz)

Frequency specifies the frequency range over which all other electrical specifications apply.

Note: Often components perform well outside the frequency band edges (even if the *Frequency* spec covers the entire full band waveguide frequency range). If you are interested in out-of-band performance, please contact Micro Harmonics directly.

Power (W)

Power specifies the maximum CW power that can be applied to any component port without causing damage to the component.

Forward Power (W)
Forward Power specifies the maximum CW power that can be applied to the input port of a two-port directional component without causing damage to the component.

Reverse Power (W)
Reverse Power specifies the maximum CW power that can be applied to the output port of a two-port directional component (i.e., a reflected or reverse traveling wave) without causing damage to the component.

Scattering Parameter Related Specifications

The scattering parameters (S-parameters) for every component sold by Micro Harmonics have been measured on a network analyzer using over 1000 points of sampled data across (and outside) the full waveguide band. For specifications such as insertion loss, isolation, and VSWR, the data collected within *Frequency* are used to determine the electrical specifications and to ensure compliance to the electrical specifications.

Some S-parameter related specifications are determined using historical S-parameter data from a sample set of units. This sample set includes every unit sold over a given period of time (typically the previous calendar year). These electrical specifications are determined for a given product as follows: For each of the M units sold in the sample set, the N points of S-parameter data within *Frequency* are used to generate a statistic characterizing the unit's performance. The statistics generated from each of the M units are then used to generate one final statistic characterizing the product's performance. This process is described graphically in Figure 1. (Note, all computation is performed on the linear data.)

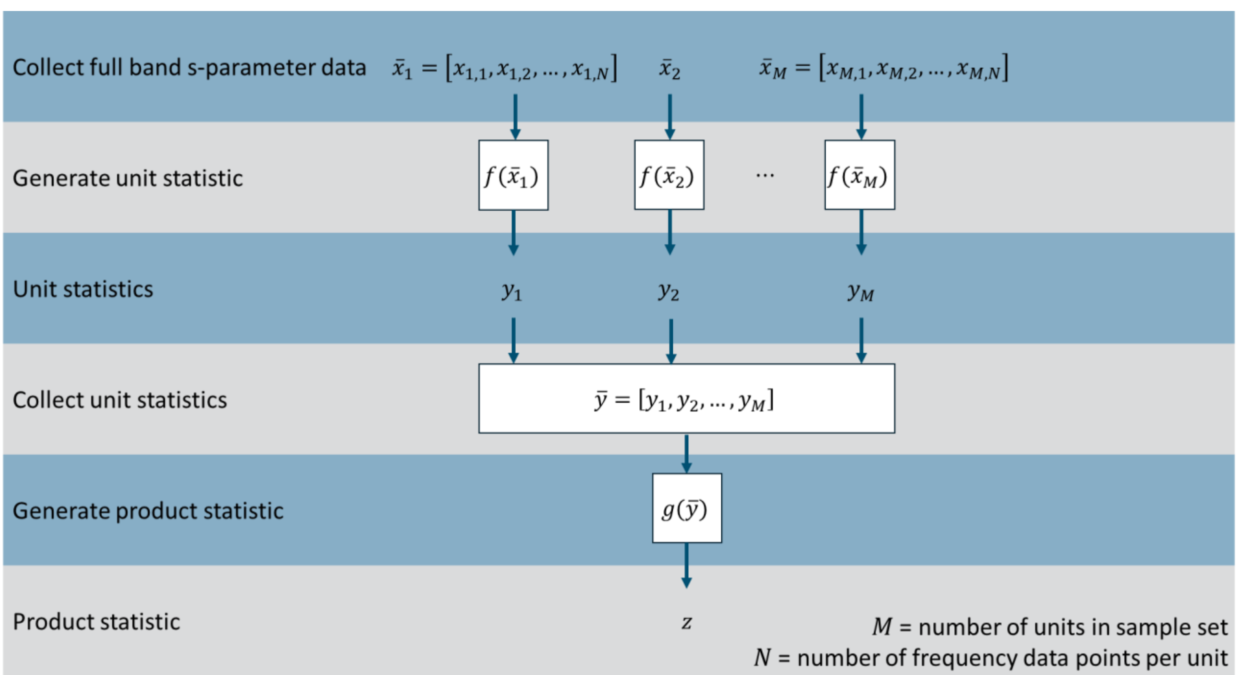

Figure 1: Process for Determining Electrical Specifications

The terms in Figure 1 are define as follows.

- $x_{m,n}$ is a measured parameter from the mth component at the nth frequency point (e.g., insertion loss, return loss, or isolation)
- $\bar{x}_m \triangleq [x_{m,1}, x_{m,2}, \dots, x_{m,N}]$ is the vector of the measured parameter across all N points in *Frequency* for the mth component
- $y_m = f(\bar{x}_m)$ is an intermediate statistic of the mth component
- $\bar{y} \triangleq [y_1, y_2, \dots, y_M]$ is the vector of computed intermediate statistics for all M components
- $z = g(\bar{y})$ is the final statistic used to characterize a given measured parameter for the product

For example, if 10 WR-6.5 isolators were sold in the sample set, the average insertion loss of the WR-6.5 isolators could be computed as follows: The measured s_{21} data are used to compute the average insertion loss for each unit across *Frequency*. Then the average insertion loss specification for this product is computed by taking the average of the average insertion loss for each of the 10 units.

For most S-parameter related specifications (e.g., insertion loss, isolation, and VSWR), the process in Figure 1 is followed. For each of these specifications, the measured parameter $x_{m,n}$ and the functions f and g are defined uniquely, thereby establishing a well-defined, quantitative electrical specification.

Average Insertion Loss (dB)

This specification should help answer the question: What's the average/typical/standard insertion loss for your product?

Average Insertion Loss is computed according to the process described above and shown in Figure 1 with the following definitions for $x_{m,n}$, f, and g

- $x_{m,n}$ is insertion loss
- $f(\bar{u}) = \frac{1}{N}\sum_{i=1}^{N} u_i$ is the arithmetic mean
- $g(\bar{v}) = \frac{1}{M}\sum_{i=1}^{M} v_i$ is the arithmetic mean

Maximum Insertion Loss (dB)

This specification should help answer the question: What insertion loss can you guarantee for every unit across the band for your product? (Naturally this number must be conservative.)

Maximum Insertion Loss is not computed using historical data. Every data point in *Frequency* is guaranteed to be lower than the *Maximum Insertion Loss*. If a unit is tested in which a data point in *Frequency* is higher than *Maximum Insertion Loss*, the unit is disassembled.

Typical Minimum Isolation (dB)

This specification should help answer the question: What's a good estimate for the minimum isolation I should typically get across the band from this product?

Typical Minimum Isolation is computed according to the process described above and shown in Figure 1 with the following definitions for $x_{m,n}$, f, and g

- $x_{m,n}$ is isolation
- $f(\bar{u}) = P_5(\bar{u})$ is 5th percentile (95% of the isolation data across the unit's frequency range exceeds this value)
- $g(\bar{v}) = \frac{1}{M}\sum_{i=1}^{M} v_i$ is the arithmetic mean (average of the 5th percentile values of isolation for the sample set)

Typical Minimum Return Loss (dB)

This specification should help answer the question: What's a good estimate for the minimum return loss I should typically get across the band from this product?

Typical Minimum Return Loss is computed according to the process described above and shown in Figure 1 with the following definitions for $x_{m,n}$, f, and g

- $x_{m,n}$ is input return loss
- $f(\bar{u}) = P_5(\bar{u})$ is 5th percentile (95% of the return loss data across the unit's frequency range exceeds this value)
- $g(\bar{v}) = \frac{1}{M}\sum_{i=1}^{M} v_i$ is the arithmetic mean (average of the 5th percentile values of return loss for the sample set)

Unless otherwise stated, for a two or more port component, the port with the lowest *Typical Minimum Return Loss* is used to specify the *Typical Minimum Return Loss* for the product.

Typical Max VSWR

This specification should help answer the question: What's a good estimate for the maximum VSWR I should typically get across the band from this product?

VSWR is another way of expressing return loss. The *Typical Max VSWR* is computed as a direct transformation of the *Typical Minimum Return Loss*.