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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 Harmonics 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 Harmonics 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	✓	✓		✓	
Minimum Isolation					✓
Typical Minimum Return Loss	✓	✓	✓	✓	✓
Typical Max VSWR	✓	✓	✓	✓	✓
Dynamic Range			✓		
Flatness			✓		

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

Average Insertion Loss and *Typical Minimum Isolation* are measured and specified for the *Cryogenic Isolators* at both room temperature and 25 K.

Generic Specifications

Flange

Flange specifies which flange should be mated with the product to ensure proper performance. *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 these specifications the data collected within *Frequency* are used to determine the electrical specifications and to ensure compliance to the electrical specifications. For each of S-parameter related specification, the purpose and usefulness of the specification is stated first in the form of a rhetorical question. Most of these specifications are determined using historical S-parameter data. For each of these specifications, a detailed technical explanation on the methodology for generating the specification is provided. These specifications are generated from a sample set of units which generally includes every unit manufactured over a given period of time (typically the previous calendar year).

The S-parameter related electrical specifications based on historical data are determined for a given product as follows: For each of the M units manufactured 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 unless otherwise stated.)

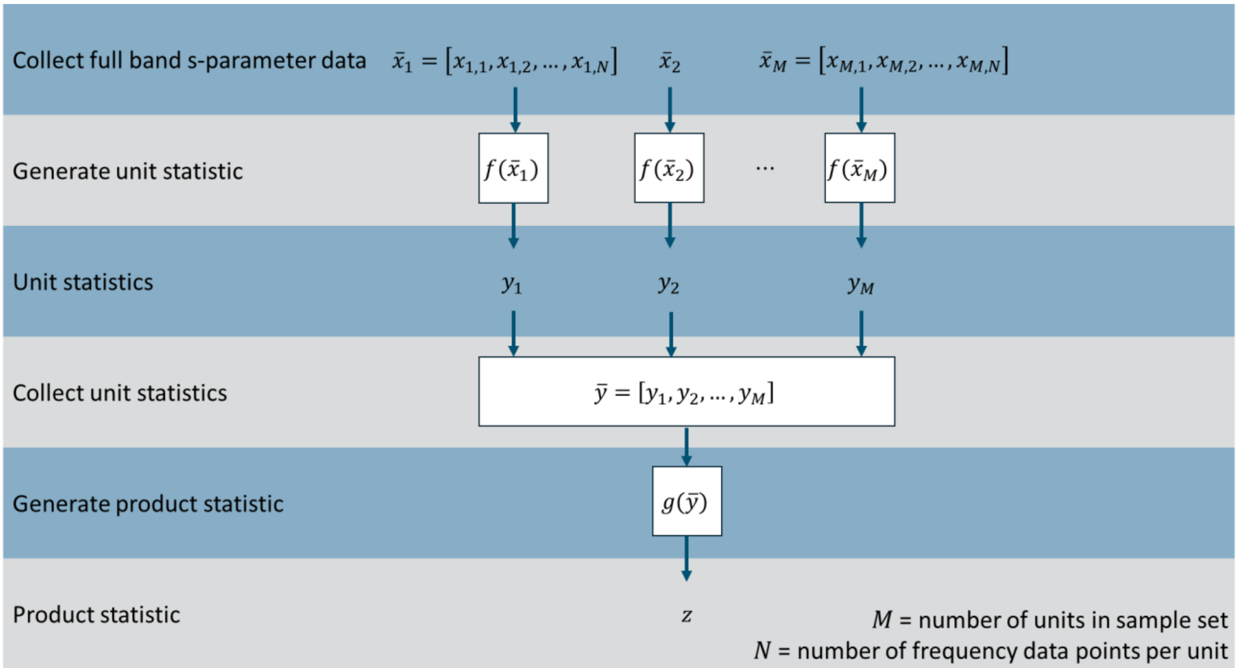

Figure 1: Process for Determining Electrical Specifications

The terms in Figure 1 are define as follows.

- $x_{m,n}$ is a measured parameter from the m^{th} component at the n^{th} 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 m^{th} component
- $y_m = f(\bar{x}_m)$ is an intermediate statistic of the m^{th} 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 at the beginning of this section 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)

Unless otherwise stated, for a component with two or more isolated ports, the port combination with the lowest *Typical Minimum Isolation* is used to specify the *Typical Minimum Isolation* for that unit.

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

Minimum Isolation is not computed using historical data. Every data point in *Frequency* is guaranteed to be lower than the *Minimum Isolation*.

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 at the beginning of this section 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 that unit.

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*. The computed *Typical Max VSWR* is rounded to the nearest 0.05 ratio interval (e.g., 1.3:1, 1.35:1, 1.4:1).

Dynamic Range (dB)
This specification should help answer the question: What is the maximum attenuation guaranteed for a *Voltage Variable Attenuator*?

The *Dynamic Range* indicates the range of continuous attenuation levels guaranteed for each *Voltage Variable Attenuator*.

$$[0 - X]\ \mathrm{dB}$$

The minimum attenuation is always specified at 0 dB, which is a nominal value. The minimum attenuation is the insertion loss in actuality. The maximum attenuation is guaranteed to be at least X dB for every unit sold. The levels of attenuation are continuous and a single level is computed as the average of the measured attenuation ($-S_{21}$) across *Frequency*.

Flatness ($\pm$dB)
This specification should help answer the question: How much variation in the attenuation is there on average across *Frequency* for the *Voltage Variable Attenuator* at different attenuation levels?

Flatness is written as $\pm X\ dB@\ Y$ dB attenuation. Y dB attenuation (the level of attenuation) is defined as the average of the measured attenuation ($-S_{21}$) across *Frequency*. $\pm X$ indicates the magnitude of the greatest peak/valley of the attenuation across *Frequency* on average at Y dB attenuation (strictly speaking, at a very close approximation of Y).

Flatness is computed according to the process described at the beginning of this section and shown in Figure 1 with the following definitions for $x_{m,n}$, f, and g

- $x_{m,n}$ is attenuation in dB ($-S_{21}$) at a given attenuation level
- $f(\bar{u}) = (\max(\bar{u}) - \min(\bar{u}))/2$ is half the difference between the maximum attenuation point and the minimum attenuation point measured within *Frequency*
- $g(\bar{v}) = \frac{1}{M}\sum_{i=1}^{M} v_i$ is the arithmetic mean

The *Flatness* is specified at various attenuation levels to provide the customer with a better understanding of how *Flatness* correlates with attenuation.