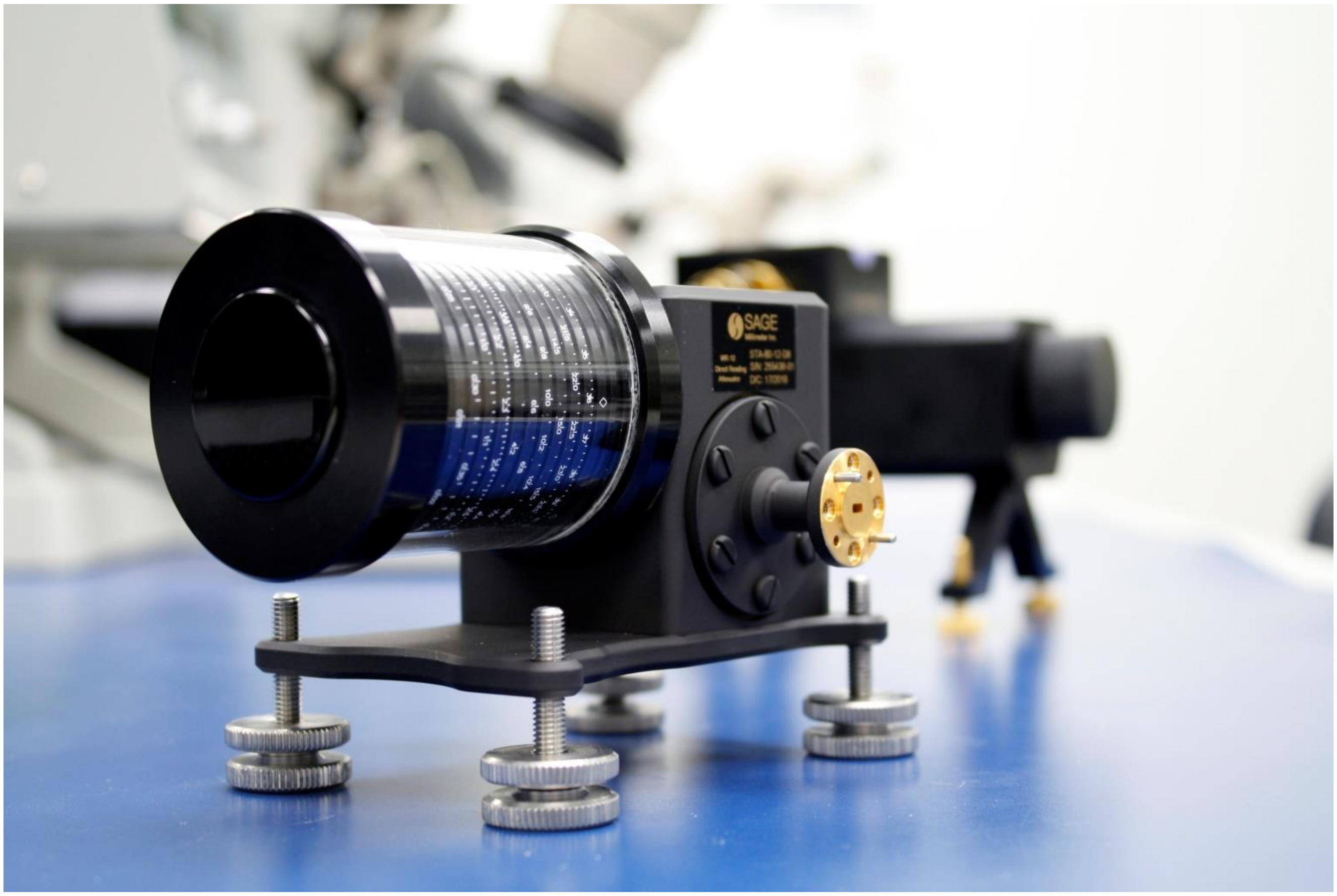
The Challenges of Using Direct Reading Attenuators and Current Solutions

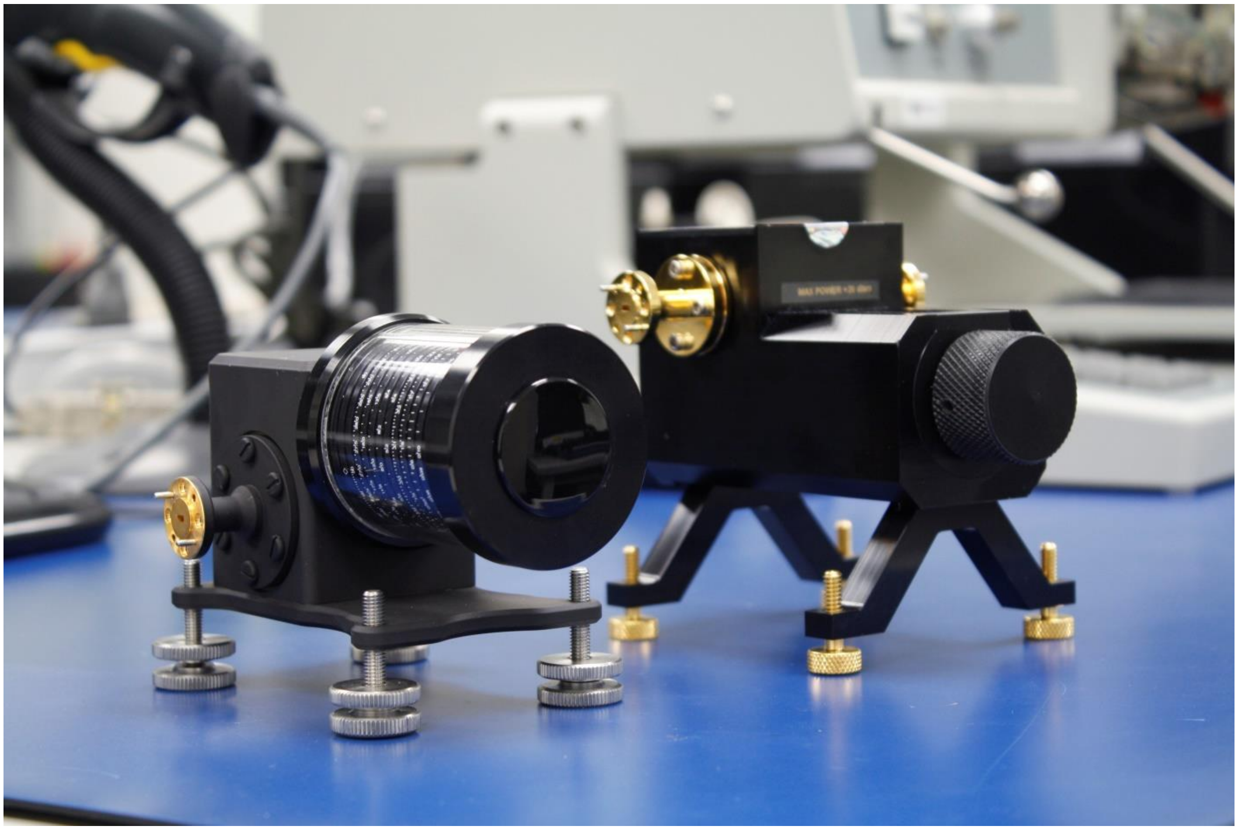
SAGE Millimeter, Inc. USA

May 25, 2018



One of the most challenging things about working with millimeter-wave technology is getting accurate measurements. Uncertainty can be introduced at many points during testing, so selecting the right test equipment is an important decision.

The direct reading attenuator is a key instrument and is widely used in test labs and production lines to give an absolute attenuation setting for many components, sub-assemblies, and system characterizations. It is a very critical and important test equipment in the industry.



While performing the gain or loss measurements, test engineers often worry about the linearity of power sensing devices, such as power sensors and detectors, which could lead to inaccurate values. Therefore, the engineers prefer a constant power exposure level to the power sensing devices. To do so, a known accurate attenuation value is needed during the process. The industry standard approach is to use the direct reading attenuator to set the attenuation level, so that the exact gain or loss can be obtained by reading the attenuation values on the attenuator directly. The drawback of the approach is that the accuracy of the gain or loss value of Device Under Testing (DUT) is strictly determined by the accuracy of the attenuation readings from the attenuator.

In addition to the gain or loss measurement, the bit error measurements of communication systems and Radar systems sensitivity testing often require high accuracy, high attenuation, and direct reading attenuation values in order to guarantee the system measurement's accuracy. The required attenuation value can be 120 dB or higher sometimes.

Furthermore, a flat attenuation level across the full waveguide operating bandwidth is required for broadband components, subsystems, and system measurements.

To meet all of these challenges, SAGE Millimeter offers both general-purpose and high precision instrument grade direct reading attenuators in the millimeterwave bands. These attenuators use a rotary vane configuration which guarantees the attenuation value independent from the frequency. While the model number for general-purpose is "**-D1**", the high precision instrumentation grade is "**-D8**". For example, the model number for the E band general purpose and high precision instrumentation grade attenuators are under the model numbers of STA-60-12-D1 and STA-60-12-D8, respectively.

For convenience, the following table will give an “apples to apples” comparison between two models of E band attenuators to show the main differences.

Descriptions	**General-purpose Grade**	**High Precision Instrument Grade**
Model Number	STA-60-12-**D1**	STA-60-12-**D8**
Cost	Standard	20% Higher
Attenuation Range	Up to 60 dB	60 dB
Attenuation Accuracy	0.1 dB or 3% of reading up to 60 dB	0.1 dB or 1% of reading up to 60 dB
VSWR	1.30:1	1.15:1
Dial Size	1.50” Diameter	2.00” Diameter
Dial Scale Increments	0.01 dB (0 to 0.1 dB); 0.05 dB (0.1 to 1.0 dB); 0.1 dB (1.0 to 10 dB); 0.02 dB (10 to 20 dB); 0.05 dB (20 to 30 dB); 1.0 dB (30 to 50 dB)	0.01 dB (0 to 40 dB); 0.1 dB (4 to 30 dB); 0.2 dB (30 to 50 dB)
Moding	Yes, possible moding after 80 GHz and 50 dB or higher	No
Mechanical Configuration	Standard	Robust

From the above table, one can see that the high precision instrumentation grade direct reading attenuator offers obvious advantages over its general-purpose grade counterpart with only a fraction of increased cost.

1. The larger dial diameter offers a more clear reading ability.
2. Fine dial scale increment guarantees high accuracy and precise attenuation value.
3. Low VSWR improves system measurement accuracy.
4. Larger attenuation dynamic range eliminates possible additional attenuation devices to save overall test set cost, especially when performing the BIT error rate and fade margin testing.
5. Mode free operation provides more confidence on the test data integrity.
6. More robust mechanical configuration elongates the life time of the instrument.

The following plot shows the typical frequency responses of the attenuation values of an E band high precision instrumentation direct reading attenuator. From the plot, the high dynamic attenuation range, flat attenuation values, and accurate attenuation readings across the entire waveguide band can be observed.

Typical Attenuation vs. Frequency