Power Meter Minimum Measurable Power

There seems to be some confusion regarding terms such as 'Resolution', 'Noise Level', 'Minimum Detectable Power' or 'Minimum Measurable Power' of the device. These terms are all used in conjunction with the detection sensitivity of the instrument. However, without the correct understanding of these terms, users can be easily misled when comparing the true measurement capability of Newport power meters and detectors with other power meters in the market.

How to calculate the Minimum Detectable Power for the power meter?

Take the full scale current of the power meter most sensitive range. The full scale current value is usually provided in the user manual. Let's take an example with the Newport 2935-C power meter. The full-scale current is defined as 250 nA for Range 0 of the DC Current measurement mode.

Using the typical SNR (Signal to Noise Ratio) of 108 dB of the power meter, and using the following formula,

$$\mathrm{SNR(dB)} = 20\log_{10}\left(\frac{A_{signal}}{A_{noise}}\right)$$

the ratio between the signal and noise is obtained below. The noise is mostly due to quantization (the process of converting the analog signal to digital signal), and the low level noise is achieved with both the analog and digital filter on.

$$\left(\frac{A_{signal}}{A_{noise}}\right) = 2.51\cdot 10^5.$$

Take the most sensitive full scale current (250 nA) of the power meter as A_{signal}, and calculate A_{noise}.

$$A_{noise} = \frac{A_{signal}}{2.51\cdot 10^5} = \frac{250\,\mathrm{nA}}{2.51\cdot 10^5} = 1\,\mathrm{pA}$$

Here, 1 pA is the quantization noise current which is considered as the Minimum Detectable Current. Divide this value by responsivity to achieve the noise level power. Assuming the responsivity of 1 A/W,

$$1\,\mathrm{pA} \times \frac{1}{\mathrm{Resp(A/W)}} = 1\,\mathrm{pW}$$

The power noise level or Minimum Detectable Power achievable for 2935-C power meter is calculated as 1 pW. Remember that the Minimum Detectable Power is equivalent to the quantization noise level power, and it is NOT the same as the Minimum Measurable Power.

How to calculate the Minimum Measurable Power for the power meter?

A noise error introduced by quantization is unavoidable when making measurements with the power meter. The goal is to minimize the errors for the best achievable precision. If, in our case, the errors are mostly due to the quantization noise, the user can estimate the Minimum Measurable Power using the Maximum Acceptable Error for his/her measurement.

Divide the Minimum Detectable Power by the Maximum Acceptable Error to obtain the Minimum Measurable Power. From our example,

For a 10 % acceptable error level, the minimum measurable power is $\frac{1\,\mathrm{pW}}{10\,\%} = 10\,\mathrm{pW}$.

For a 1 % acceptable error level, the minimum measurable power is $\frac{1\,\mathrm{pW}}{1\,\%} = 100\,\mathrm{pW}$.

Hence, if the user's acceptable error level is 1 %, the Minimum Measurable Power for his/her system is 100 pW. Please be aware that the power meter can measure below the 100 pW level, down to 1 pW, but the measurement error increases proportionally.

The Newport 2931-C power meter, which exhibits the highest sensitivity for low power measurements, has the Minimum Detectable Power of 10 fW (for a detector responsivity of 1 A/W). This will enable the most sensitive measurement with the 1 pW of Minimum Measurable Power in 1 % error range. Again, user can measure down to 10 fW with higher Maximum Acceptable Error level.

When the user calculates the Minimum Measurable Power in the measurement, it is needed to take into consideration not only the noise from the power meter, but also the noise from the detector heads. The detector noise level can be calculated from its amount of NEP (Noise Equivalent Power) or its Minimum Detectable Power specification, but it is not fully discussed in this article.

For further questions or more details, users are invited to contact the Newport Applications Engineers at (800) 222-6440 or tech@newport.com.