APPLICATION NOTE

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Limitations of Using an AM Leveling Loop for Calibrating RF Power Sensors

Characterizing RF power sensors is commonly done using a direct comparison system which employs a resistive RF power splitter with a power standard connected to a power meter. One of the most stable and repeatable type of power standards are thermistor type RF power sensors. The thermistor is part of a DC bridge circuit; RF power is determined by changes in DC voltage on the bridge circuit, caused by incident RF energy. The TEGAM/Weinschel Models 1806/1806A utilize this method. While measuring RF power this way is very reliable and well established for use in cal labs, it can be a cumbersome task.

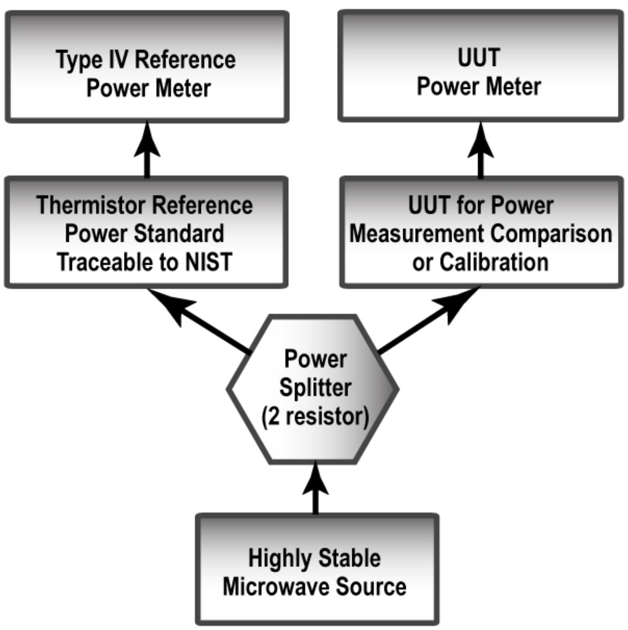

Figure 1 – Block diagram of a Direct Comparison System.

Several years ago, Weinschel Corp. employed a method in their power sensor calibration system to make the task more manageable. Instead of measuring changes in the DC voltage, an analog leveling loop was used to set the DC power. This made the task of calibrating RF power sensors simpler and faster because the operator did not need to take and record readings from a voltmeter and then calculate DC substituted power. With an analog leveling loop the operator simply selected the desired test level.

Figure 2 – TEGAM Model 1805B RF Level Controller.

Weinschel incorporated the analog leveling loop in to the Model 1805 RF Level Controller. The 1805 did make the process easier and for many years has been the main feature of the renowned TEGAM/Weinschel System IIA Power Sensor Calibration System.

While using the 1805 simplifies the power sensor characterization process, the ability to actually control the RF power level is limited. That is due to two things. First, the 1805 sets the RF power level based on the DC substituted power of the bridge circuit. The standard connected to the 1805, like any other RF power sensor, does not detect all of the RF power applied to it. Thus, the DC substituted power detected will be lower than the RF power applied to the standard. Because of this, the 1805 has to level the RF power higher than its DC substituted setting. For example: if an 1805 is connected to a standard with a calibration factor 95%, the 1805B will only see 95% of the power applied to the input of the standard. If the 1805 is set for 1 mW, it would level RF at 1.05 mW because 0.05 mW (5%) will be lost in the standard. Secondly, the range and resolution of the 1805 begins at 0.5 mW and continues in 1 mW steps from 1 mW to 10 mW. For calibrating some types of power sensors these limitations can be detrimental; however, using an 1806/1806A is a better choice.

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High Frequency (26.5 GHz) Sensors
When calibrating sensors above 26.5 GHz, the RF losses from the output of the signal generator to the 1805 can exceed the maximum leveled output the generator can deliver. Sources of loss include any cables and adapters connected between generator output and the power splitter input, the insertion loss of the power splitter, and losses in the thermistor standard (cal factor). For a nominal 1 mW (0 dBm) test, the 1805 will try to level the generator to 0 dBm plus the sum of all the losses described previously.

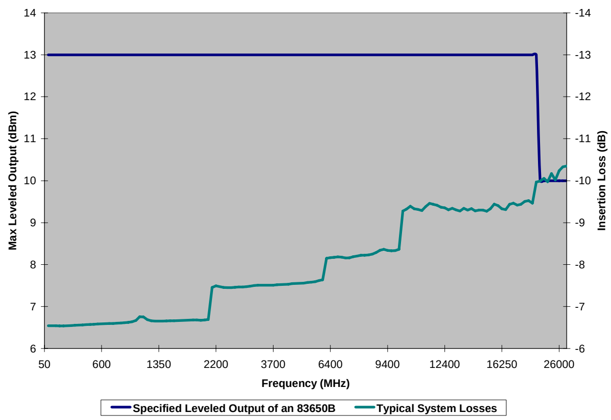

Figure 3 - Graph of signal generator specified output versus typical RF losses for 26.5 GHz System II.

Figure 3 shows the typical losses for a 26.5 GHz standard versus the maximum specified leveled output for an Agilent (HP) Model 83630B signal generator. This graph indicates that after approximately 20 GHz the generator would not be able to produce enough power to level the loop. Since the calibration factor for the DUT is based on the loop being leveled, this would produce erroneous calibration data.

One way to ensure that the loop stays level would be to boost the RF output of the signal generator. Some generators have a "high power" option which may mean a new generator would have to be purchased with additional costs for the option. Another way to boost the power would be to add an external amplifier to the test setup. That too would mean an additional cost.

This problem can be eliminated by simply *measuring*, such as with an 1806A, the power from the standard rather than trying to level the DC substituted power. The losses for cable and the splitter would still have to be considered, but the losses in the thermistor standard would not. For the example in Figure 3 the losses in the standard account for about 1 dB of total loss. That means the specified losses from the cable and splitter alone do not exceed 10 dBm, so the generator would have no trouble producing enough power to keep the RF level at a nominal 1 mW (0 dBm).

High Power (10 W or greater) RF Sensors
"High power" RF sensors (dynamic range starts at 1 mW) can be calibrated at a nominal 10 mW to 25 mW (10 dBm to 13 dBm) level. At that level a normal thermistor standard can be used without additional equipment, such as an attenuator or coupler. However, that is close to the noise floor (0 to 10 dBm) of the sensor so the level of applied RF power is important.

When calibrating high power sensors at lower levels it is important to keep the applied RF power to the sensor as far above its noise floor as possible, within the limits of the calibration equipment being used. The dynamic range of a TEGAM thermistor standard has an upper limit of 25 mW. When using one of these standards, ideally the applied RF power should be maintained at 20 mW to 25 mW. This is outside the range of the 1805, so measuring the RF power with a TEGAM 1806A would be a better method than trying to level it.

Multiple Range RF Power Sensors
Many power sensors that offer a wide dynamic range (>70 dB) often have multiple measurement channels, with a switching point between channels. Often, each measurement channel in these sensors has separate calibration factor tables and has to be characterized individually.

Having precise control of the applied RF power level is critical when calibrating these types of sensors. The switching point should be avoided because if one channel is being calibrated and the other is selected during the process, serious errors will occur in the correction factor data table. Additionally, the next higher channel should be calibrated well above the switch point, because the switch point is often near the noise floor for that channel.

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Conclusion

Using an analog leveling loop such as the one found in the TEGAM/Weinschel 1805 makes calibrating RF power sensors simpler and faster than measuring power from the standard. This was especially true when computers and cal lab automation were slower and not as comprehensive. Modern computers and software applications (such as Northrop Grumman's SureCAL) have made the speed and ease of use differences virtually unnoticeable.

There are limitations to the usefulness of the RF leveling loop. These limitations stem from the fact that that the actual level of *applied RF* power is largely determined by RF losses in the leveling loop. In some cases, more precise control of applied RF power is needed. Measuring the power with an 1806A and making adjustments based on those measurements offer the precise control needed. With modern software applications, the limitations of the AM leveling loop outweigh any minimal advantage.

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