Output Standing Wave Ratio (SWR) Test Using the TEGAM 1830A RF Power Meter

When using a power meter that references to a 50 MHz, 1 mW output power reference it is important to know that the 50 MHz reference is within the specified performance limits. The TEGAM Model 1830A RF Power Meter coupled with a thermistor power sensor (also known as a thermistor mount) can accurately measure the SWR of a 50 MHz reference. By utilizing a unique function that most modern power meters do not offer; the 1830A allows the user to change the value of the thermistor mounts terminating resistance. Utilizing this method for measuring source match works well because it presents the source with two distinctly different values of Γ_{Load} which allows accurate measurement of the power absorbed under two different conditions. This application note will explain how we make this SWR measurement with the 1830A and a thermistor mount.

It is first important to understand how a thermistor mount operates and why by simply changing the resistance that the reference resistor balances at can accurately determine SWR.

Figure 1 shows how a DC bridge circuit maintains series resistance of two thermistors at the nominal bridge resistance, typically 200 Ω. The thermistors(T) are matched so each thermistor is biased at 100 Ω. The thermistors are in parallel for the RF signal path, since each are biased at 100 Ω the pair make a good 50 Ω termination.

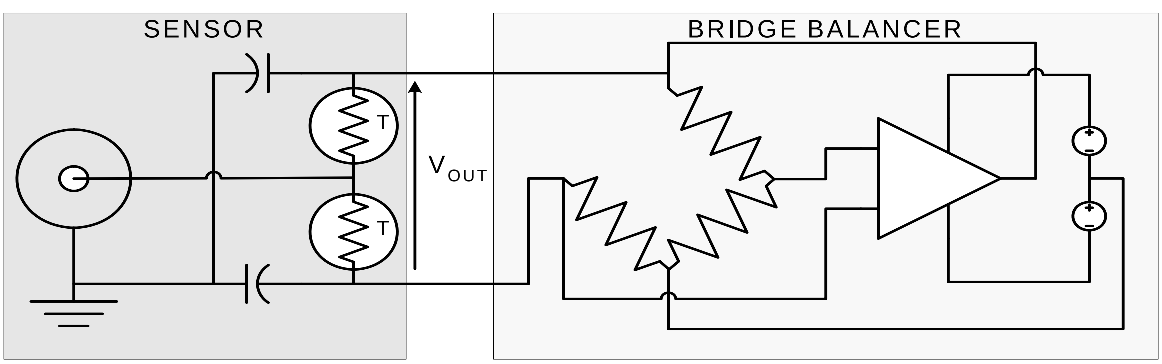

Figure 1 - Thermistor Mount and Bridge Balancing with the 1830A

Thermistor mounts like the TEGAM Model M1130A or the Agilent 478A with option H75 or H76 operate at a DC Resistance of 200 Ω which has an RF impedance of 50 Ω and a negligible Γ_{Load} (zero). [1] With the ability to change the thermistor mount reference resistance to 100 Ω the RF impedance becomes 25 Ω giving a nominal Γ_{Load} of 0.33. The effective efficiency of the thermistor mount remains constant at both 200 Ω and 100 Ω so the power ratio can be measure accurately.

[1] The H75 and H76 are options for the 478A that represent optimized performance for VSWR. Specifically, from 1 MHz to 1 GHz maximum, VSWR is less than 1.3:1, except at 50 MHz, maximum VSWR of 1.05:1.

Calculating Output SWR

Equipment:

- TEGAM 1830A RF Power Meter
- Thermistor Mount
  - TEGAM M1130A
  - Agilent 478A with options H85 or H76
- DUT Power Meter with 50 MHz, 1 mW Reference Port

Procedure:

The following procedure should be used for solving Output SWR:

1. Power ON all equipment and allow proper warm up time for each. If using a temperature compensated thermistor mount allow for proper temperature stabilization.[2]
2. Connect thermistor mount to 1830A
   a. For M1130A use the following cables
      i. TEGAM CA-7-48 (Sensor Cable)
      ii. TEGAM CA-10-48 (Heater Cable)
   b. For 478A use cable TEGAM CA-6-48 (Sensor Cable)
3. Manually configure the 1830A for selected thermistor mount.[3]
4. Make sure the 50 MHz reference is turned off prior to connecting the thermistor mount.[4]
5. Connect thermistor mount to 50 MHz Reference Output Connection.
6. Record RHO_{200} the S22 Magnitude of the thermistor mount at 50 MHz at 200 Ω[5].
   a. For an M1130A this value is available on the calibration report
   b. For a 478A use the value of .0012 as an estimated value
7. Record RHO_{100} the S22 Magnitude of the Thermistor Mount at 50 MHz at 100 Ω.
   a. For an M1130A use the value of .33 as an estimated value
   b. For a 478A us the value of .33 as an estimated value
8. Verify the 1830A reference resistor is configured for 200 Ω.
9. Zero the 1830A.
10. Turn on the 50 MHz 1mW reference on the DUT Power Meter.
11. Record the power level from the front panel of the 1830A.
12. Turn off the 50 MHz 1mW reference on the DUT power meter.
13. Configure the 1830A reference resistor to 100 Ω.
14. Repeat steps 10-12.
15. Calculate M using the following equation.

$$M = \frac{P_{200}\left(1-|RHO_{100}|^2\right)}{P_{100}\left(1-|RHO_{200}|^2\right)}$$

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[2] Verify on 1830A front panel that heating is complete and unit has a stable zero.

[3] Please refer to 1830A User Manual for configuring a Temperature Compensated Thermistor Mount vs. an Agilent 478A Thermistor Mount.

[4] Please refer to the DUT Power Meter Manual for operating instructions.

[5] Gamma of the load is a complex value; however we can give a sufficiently accurate answer providing the phase angles are within a reasonable range. For this reason all calculations in this application note will only use RHO portion of Gamma.

16. Using the Value for M calculate the output voltage coefficient using the following equation.

$$|\Gamma_s| = \frac{(2|RHO_{200}|M - 2|RHO_{100}|) \pm \sqrt{(2|RHO_{100}| - 2|RHO_{200}|M)^2 - 4(|RHO_{200}|^2 M - |RHO_{200}|^2)(M-1)}}{2(|RHO_{200}|^2 M - |RHO_{100}|^2)}$$

17. Calculate the output SWR using the following equation.

$$SWR = \frac{(1 + |\Gamma_s|)}{(1 - |\Gamma_s|)}$$

Worked Example of Output SWR

For this example the DUT was an Agilent E4418B Power Meter. Output SWR is required to be maximum 1.06. A TEGAM 1830A with a M1130A were also used for this example. The output SWR is 1.059.

Recorded Values	Value
Power(mW) (200 ohms Ref Resistor)	0.9936
Power(mW) (100 ohms Ref Resistor)	0.8939
Fixed Values (From Thermistor Mount calibration data)	
RHO (200 ohms Ref Resistor)	0.0014
RHO (100 ohms Ref Resistor)	0.33
Calculations	
Calculate Factor M	0.990485764
Calculate Output voltage reflective coefficient(+)	0.02902246
Calculate Output voltage reflective coefficient(-)	12.04147077
Output SWR(+)	1.05977988
Output SWR(-)	-1.18113529

NOTE: A downloadable spreadsheet with all formulas is located in TEGAM Forums. *http://geneva.tegam.com/forums/*

Having confidence that your 50 MHz reference port SWR is within specifications is important. By adhering to the procedures while using the TEGAM Model 1830A RF Power Meter and a calibrated thermistor mount like the TEGAM Model M1130A, you can be certain that your 50 MHz reference SWR is within the manufactures tolerance.