

Midnight SNA

Scalar Network Analyzer

[Tutorial M1 - Power Level Calibrations](#)

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This tutorial takes you through the process of setting the output level of the PWRCAL circuit to 3 dBm and using that signal to determine the slope and zero intercept values for the RF Power Meter. The calibrated RF Power Meter is then used to set the RF OUT power level to a standard value. Normally these procedures need only be done once but it is advisable to repeat them periodically to assure that the effects of environment changes and component aging have not affected the Midnight SNA settings.

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1 APPLIES TO

All Midnight SNA units running V4.00 firmware or later with the PWRCAL and RF Power Meter circuits installed. It may also be used with NAT-SNA units with the PWRCAL and RF Power Meter circuits installed.

2 PREREQUISITES

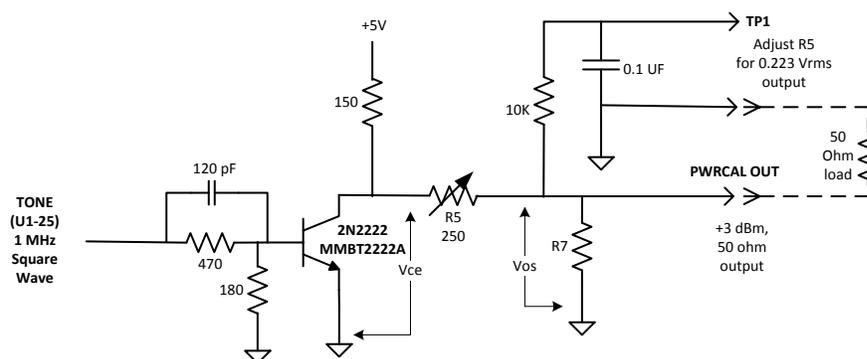
The Midnight SNA must be out of its enclosure to gain access to trim pots in the PWRCAL and DDS-60 circuits and the PWRCAL test point in the PWRCAL.

3 ADDITIONAL REQUIREMENTS

1. Short piece of 50-ohm coax cable to connect PWRCAL OUT connector to the RF IN connector.
2. A 20 dB attenuator with BNC connections.
3. Digital Volt Meter (DVM) capable of reading millivolts.
4. PS/2 keyboard.

4 REFERENCE AND BACKGROUND

The PWRCAL circuit generates a 3 dBm square wave signal at 1 MHz. The PWRCAL is driven by the dsPIC microcontroller firmware which toggles the input every 500 ns giving a square wave with a 50% duty cycle. It has been determined that this signal can be used to calibrate the RF Power Meter*. Once the RF Power Meter is calibrated, it can be used to set the DDS output (RF OUT) level to a known standard level such as one milliwatt (zero dBm).



PWRCAL Schematic

The PWRCAL circuit consists of a bipolar transistor amplifier with an adjustable output. The first objective of this tutorial is to set this adjustment so that the PWRCAL output signal power is +3 dBm. For a square wave, a 3dBm power level is the equivalent of 447 millivolts (mV) peak-to-peak or 223 mV RMS. A DVM at the test point (TP1) in the above schematic will measure the average voltage at the PWRCAL out and, for a square wave with the lower level at ground, the average voltage is the RMS voltage.

There is a complication, however, the output level is offset some (V_{os}) by the collector-emitter voltage of the transistor. This offset must be measured and subtracted from the DVM reading. When the firmware is in terminal mode, the transistor is turned off to reduce power consumption. **Pressing the LEFT ALT key on the keyboard turns on the transistor and the offset voltage can be measured.** Starting a macro with the Power Meter Calibration op mode (P) set will turn on the one MHz square wave. The output level can then be set to 223 mV by adjusting R2 until TP1 reads 223 mV plus V_{os} . Since changing R2 could have some effect on the offset reading, it may be necessary to iterate through the process a couple times.

5 SETTING THE PWRCAL OUTPUT LEVEL STEP-BY STEP

The following procedure will set the PWRCAL output level to +3 dBm:

1. Remove the DDS-60.
2. Connect PWRCAL OUT to RF IN with a short coax cable.
3. Attach a DVM between TP1 and ground.
4. Power on.
5. In terminal mode, **HOLD THE LEFT ALT KEY DOWN** and adjust R5 so that the voltage at TP1 reads about 20 mV. This is the estimated off-set voltage (V_{os}).
6. **Release ALT** and press and release SCROLL LOCK to change to Setup mode (was Command mode).
7. In Command mode select 'U' to edit the upper calibration level and set it to 3.00 dBm and enter ENTER to exit Command mode.
8. Start a macro with op modes Signal generator (S or 5) and PWRCAL (P or 7) specified. The remainder of the macro form will be ignored. This will turn off the DDS-60 and turn on the PWRCAL signal source.
9. Adjust R5 to measure 223 mV plus V_{os} (initially 243 mV) at TP1 to set the output level to +3 dBm.
10. Press Escape to stop the macro and note the voltage level at TP1 (V_{os}). If it is different than 20 mV +/- 1 mV repeat steps 6 and 8 using the new value for V_{os} in step 7.



6 CALIBRATING THE RF POWER METER STEP-BY-STEP

The following procedure will set the RF Power Meter slope and intercept values and save them in EEPROM:

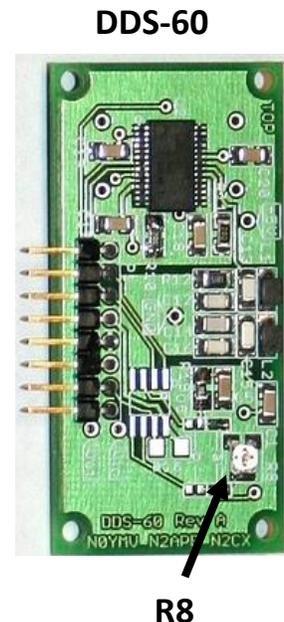
1. Restart the macro and press the Space bar (or tap below the frequency display) a couple times to ensure you are getting a reading. Don't worry about the value, this is the un-calibrated value that will be used to calibrate the RF Power Meter.

2. Press Ctrl-S **ONCE** to capture the current reading.
3. Without pressing any other key, insert a 20 dB attenuator in the PWRCAL OUT to RF IN connection to lower RF IN to -17 dBm.
4. Enter ENTER to capture the -17 dBm reading. The slope and intercept will now be calculated and stored in EEPROM.
5. Press the Space bar to confirm the -17 dBm reading (should be within one dBm).
6. Remove the 20 dB attenuator and connect PWRCAL OUT direct to RF IN.
7. Press the Space bar to confirm the 3 dBm reading (should be within one dBm).
8. Press Escape to stop the macro and turn off the PWRCAL function.

7 SET RF OUT POWER LEVEL STEP-BY-STEP

We recommend setting the RF OUT power level to 0.00 dBm which can be done by following this procedure:

1. Power off and reinstall the DDS-60.
2. Connect RF OUT to RF IN with a short coax cable.
3. Power on.
4. Start a macro with FREQ LO set to 1 MHz and Signal generator (S) op mode specified.
5. Press 'A' to enable auto start mode. The display will be repeatedly updated about four times per second.
6. Adjust R8** on the DDS-60 to set the power reading to 0.00 dBm. If there are variations in the readings they should be less than 0.5 dBm and the level should be set so that the readings vary around 0.00 dBm.
7. Press Escape twice to stop the macro.



* Bob Kopski, K3NHI, "A Simple RF Power Calibrator," QEX, Jan/Feb 2004, pp 51-54 and Bob Kopski, K3NHI, "Tech Notes," QEX, May/June 2010, pp 44-43.

** If you use a metal screw driver to adjust R8 note that any metal in the vicinity of the DDS-60 may affect the DDS-60 output level. In this case, adjust R8 then move the screwdriver away from the DDS-60 before noting the power level reading.

APPENDIX A. -20 dB ATTENUATOR

A simple -20 dB attenuator can be made using standard-value resistors in a PI network configuration. For 50-ohm input impedance, the series resistor should be 247.5 ohms and the two parallel resistors should be 61.11 ohms. Resistors of these values are available but you would have to buy a 2,500 piece reel of each which is not practical. Instead, I used two 120-ohm resistors in parallel (60 ohms) for the 61.11 ohm parallel resistors and a 1 K resistor in parallel with a 330 ohm resistor (248 ohms) for the 247.5 ohm series resistor.

