January 2006 **Number 0601**

How to use two Standard Sensors to calibrate a single UUT with the Power Sensor Package

Customers often ask how they can calibrate a Power Sensor if they don't have a single Standard Sensor that covers the required frequency range. For example, how would a sensor with a 100 KHz to 18 GHz frequency range be calibrated if the only standards available covered 100 KHz to 4.2 GHz and 10 MHz to 18 GHz respectively? The Test Profiles used by the Power Sensor Package only provide for the description of one Standard Sensor per test run, so it would seem impossible to accommodate this situation.

The Power Sensor Package was not designed to allow using two different standard sensors when calibrating a single UUT, but there are ways to "trick" it into doing it. This Technical Note describes two ways this can be done and the pros and cons of each approach.

METHOD #1: CREATE TWO CUSTOM TEST PROFILES AND RUN THEM SEPARATELY

SUMMARY:

This is the "easy" solution. Simply define two separate Custom Test Profiles to cover the required frequency range, dividing the frequencies between the two available Standard Sensors. This approach requires running each profile once, then manually combining the results of the two runs.

PROS:

- **Relative simplicity**
- **No limitation on STD Monitor options in the Test Profile**

CONS:

- **Requires treating the UUT Sensor as if it were two devices, each with separate ID Numbers, separate Test Profiles and separate calibration records**
- **Requires manual data manipulation to generate a composite UUT data file**
- **Requires manual data manipulation to print a composite UUT cal factor label**
- **Requires frequent profile modifications if the UUT Sensor's reference frequency is not supported by both Standard Sensors**
- **"Missing Frequency" messages may be displayed when calibrating EPROM Power Sensors**
- **UUT reference cal factor (if any) must be predefined and fixed**

METHOD #1 - DETAILED INSTRUCTIONS

1) **Give the UUT Sensor two ID Numbers, preferrably with no more than eight characters each so they may also be used as data file names.**

2) **Select the two Standard Sensors required to cover the UUT's frequency range.**

3) **Decide which frequencies will be tested by which standard. Frequency selection should be made based on the following considerations:**

   - **If the UUT Sensor has a reference frequency, this point should ideally be measured by BOTH Standards**
   - **If the UUT Sensor has a reference frequency that is not supported by both standards, then an arbitrary crossover frequency must be selected (in addition to the reference frequency) that is supported by both standards**

   NOTE: If the UUT does not have a reference frequency, the data for the two standards must be calibrated to the same reference frequency or against a common absolute reference.

   - **If the frequency ranges of the two standards overlap significantly, and either standard requires the use of an adapter to connect to the UUT Sensor, select a frequency "switch point" that minimizes the use of the adapter.**
   - **If the frequency ranges of the two standards overlap significantly and no adapters are required, select a frequency switch point that provides the better uncertainty between the two standards in the overlapping region.**

4) **Create two custom test profiles for the UUT Sensor, describing two partial runs: one for each Standard Sensor.**

   - **Specify the frequencies appropriate to each standard**
   - **If the UUT Sensor has a reference frequency and it is supported by both standards, it should be identified as the reference frequency in both profiles**

   NOTE: In this scenario, both profiles should force the reference cal factor to the same value on the Data Format tab.

   - **If the UUT Sensor has a reference frequency that is only supported by one of the two standards, the profile using that standard should specify this reference. The other profile must specify an arbitrary crossover frequency as the reference. The arbitrary crossover frequency must be present in both profiles.**

   NOTE: In this scenario, the profile containing the actual reference frequency of the UUT Sensor must be run first. On completion of that run, the measured cal factor at the arbitrary crossover frequency must be entered as a "forced reference cal factor" for the second profile before it is run.

   - **Disable any "Offset Reference" options on the Data Format tab of the Test Profile**
   - **Both profiles should specify the same cal factor units on the Data Format tab**

5) If comparison to previous data is desired, create two UUT Data Files containing previous cal factor data at frequencies that correspond to the two profiles created in Step #4. For convenience, name these files using the two ID Numbers assigned to the UUT Sensor, with a ".DAT" file extension.

6) Begin a new calibration with Test Manager, using the first of the two ID Numbers for the UUT Sensor.

7) Select one of the custom profiles created in Step #4. (If the UUT Sensor has a reference frequency that is only supported by one of the two standards, this profile must be run first.)

8) Run the CAL FACTORS step, specifying the appropriate UUT SENSOR and STD SENSOR data files to go with the selected profile. If the UUT Sensor contains an EPROM, a message may be displayed with a warning about missing test frequencies. Confirm that any reported "missing" frequencies will be tested by the second profile.

9) If the UUT Sensor has an EPROM, it may be reprogrammed at this point. (Only tested frequencies will be updated.)

10) If an arbitrary crossover frequency is required to link data from the first and second runs, note the measured cal factor value from the first run at that frequency.

11) Print and/or archive the data from the first run so it is not lost.

12) Begin a new calibration with Test Manager, using the second of the two ID Numbers for the UUT Sensor.

13) Select the second custom profile.

14) If an arbitrary crossover frequency is required to link data from the first and second runs, edit the second profile to force the reference cal factor to the value noted in Step #10. Confirm that the reference frequency specified on the Test Points tab is set to the arbitrary crossover frequency and NOT the UUTs nominal reference frequency. (If the UUT's nominal reference frequency is supported by both standards, then this step is not required.)

15) Run the CAL FACTORS step, specifying the appropriate UUT SENSOR and STD SENSOR data files for the second profile. If a missing frequency warning message was displayed on the first run, another one will likely appear now. The list of "missing" frequencies should correspond to points tested by the first profile.

16) If the UUT Sensor has an EPROM, the remaining frequencies may now be updated.

17) Two sets of data now exist for the UUT Sensor. To print a cal factor label that combines the two runs, a composite UUT data file will have to be created. To do this, edit the UUT data file created by the first run using Notepad and COPY the data to the Windows clip board, excluding the header or column labels. Next, edit the UUT data file created by the second run and PASTE the additional data into it. A label can now be generated that includes all frequencies.

18) Print and/or archive the data from the second run so it is not lost.

METHOD #2: TRICK THE PROGRAM INTO SWITCHING STANDARDS DURING A RUN

SUMMARY:

This is the "complicated" solution. A single test profile is created using a composite description of the two standards. This method requires the creation of a composite STD SENSOR data file and may also require a composite ADAPTER data file. The program is tricked into pausing at mid-run to allow the standards to be switched.

PROS:

- **One UUT ID Number, one Test Profile, one calibration record**
- **EPROMs can be updated without "missing frequency" warnings**
- **No editing Test Profiles between runs to update arbitrary crossover references**
- **Cal Factor labels can be generated without manually editing the UUT data file**
- **No restrictions on reference cal factor or offset options**

CONS:

- **Composite STD SENSOR data file is required**
- **Composite ADAPTER data file may be required**
- **Both Standards must use the same monitor hardware**
- **RF Source selection may be limited**
- **Some displayed hookup diagrams may not match the actual hookup**

METHOD #2 - DETAILED INSTRUCTIONS

1) **Select the two Standard Sensors required to cover the UUT's frequency range. These two standards may have different frequency ranges and different connector types, but they must be very similar in other ways:**

    - **Both standards must use identical monitoring hardware. (A composite test profile will be created and only one STD Monitor description will exist. It must apply to both standards equally and cannot be altered in mid-run.)**
    - **Both standards must share a common cal factor reference. Thermistor type mounts are ideal for this because they have absolute calibrations. Standard sensors that have a reference cal factor can only be used if their references are identical, or if their data has been artificially aligned.**
    - **Both standards must operate at the same nominal test level**

2) **Decide which frequencies will be tested by which standard. Frequency selection should be made based on the following considerations:**

    - **If more than one RF Source is required to cover the UUT's frequency range, the LOW FREQ SOURCE must be used with the lower frequency standard and the HIGH FREQ SOURCE must be used with the higher frequency standard. In this case, the ranges of the available sources may be the primary factor in determining what frequencies are applied to each standard.**

NOTE: The test profile will specify that BOTH sources are enabled even if only one is actually used. Doing this provides a way to trick the program into pausing at a particular frequency for the purpose of manually switching the sources. When the program pauses, the standards can be switched instead. If more than one source is actually needed, it must be switched at the same time as the standard.

- **If only one RF Source is needed and either standard requires the use of an adapter to connect to the UUT, select the frequency switch point to minimize the use of the adapter. If two different adapters are required, pick the switch point to minimize the use of the "poorer" adapter.**
- **If only one RF Source is needed and no adapter is needed, pick a frequency switch point that provides the better uncertainty between the two standards in the overlapping region.**

3) Create a composite data file for the two Standard Sensors. If you already have separate data files for each standard, use Notepad to copy and paste the data into a single file. The composite data file should contain all frequencies to be tested and no frequencies should be entered more than once. If the frequency ranges of the two standards overlap, include only the data that will be used based on the decisions made in Step #2 above.

4) If either standard requires the use of an adapter to connect to the UUT Sensor, a special data file must also be created for the adapter. This data file must contain ALL frequencies to be tested, even at points where the adapter will not be used.

NOTE: Composite data files for the STD SENSOR and ADAPTER are necessary to maintain the illusion that only one Standard Sensor exists. (The software is being fooled into treating two standards as one.)

- **If two adapters are required (one for each standard), the composite ADAPTER file should contain data for both adapters. The data should be combined in the same manner as the STD SENSOR file, switching adapter data at the same frequency.**
- **If only one adapter is needed, the file must contain "dummy" entries at all frequencies where no adapter will actually be used.**

NOTE: "Dummy" entries in the ADAPTER data file must exist for all frequencies where an adapter will not be used. Dummy entries should consist of the following:

FREQUENCY(MHZ)	**value in MHz**
S11MAG(RHO)	**0.0001**
S11PHASE(DEG)	**0.00**
S21MAG(DB)	**0.00**
UNCERTAINTY(DB)	**0.001**
S22MAG(RHO)	**0.0001**
S22PHASE(DEG)	**0.00**

5) If comparison to previous data is desired, an ordinary UUT Data File, containing previous cal factors may also be created.

6) The next step is to define a custom Test Profile that creates the illusion that a single Standard Sensor will be used to test the UUT Sensor. This profile will be configured to pause the measurement at a specific frequency, allowing the Standard Sensor to be changed in mid-test. Set up the profile as follows:

- **On the UUT Sensor tab, enter all fields to accurately describe the UUT Sensor (There is no need for trickery on this tab!)**
- **On the STD Sensor tab, the fields will describe a single sensor that has the combined characteristics of the two standards that will actually be used. In the Frequency Range fields, enter the maximum combined range of the two sensors. In the Power Range fields, enter the minimum range that is common to both sensors. The Connector Type entry will depend on the connectors of both standards and whether or not either one needs an adapter to connect to the UUT. If both standards have the same connector, enter that connector type. If either standard requires an adapter, enter the connector type of that standard. If both standards require different adapters, either connector may be entered.**
- **On the UUT Monitor tab, select the Monitor Type and other settings to accurately describe how the UUT Sensor will be monitored during the test**
- **On the STD Monitor tab, select a Monitor Type and other settings that are compatible with BOTH of the Standard Sensors. The same monitoring hardware will be used for both Standards.**
- **On the Source / Amp tab, enable both the LOW FREQ SOURCE and the HIGH FREQ SOURCE. (Even if only one source is needed!) Set the Source Crossover Frequency to the point where you want to pause the program and switch the Standards. The entered frequency should be the first point that will use the second Standard. Disable the option to Automatically Select SOURCE.**
- **On the Test Points tab, enter all fields to accurately describe the Test Level, and frequencies to be tested.**
- **The Data Format, Uncertainty and History tabs may be set as desired.**

7) Begin a new calibration with Test Manager. Set the Flexible Standards assignments as follows:

- **If two RF Sources are used, (one with the lower frequency standard and one with the higher frequency standard) assign them to the LOW FREQ SOURCE and HIGH FREQ SOURCE respectively. If only one RF Source will be used, assign this device to both the LOW FREQ SOURCE and the HIGH FREQ SOURCE, at the same GPIB Address.**
- **Assign POWER MONITOR #1 to the device that will monitor the Feedthrough Type Sensor. Assign POWER MONITOR #2 to the monitor for the Terminating Type Sensor. Unassign the AMPLIFIER / SWITCH.**

8) Highlight the CAL FACTORS step and select the custom profile created in Step #6.

9) Press the SPACE BAR to begin the test. When prompted for the optional UUT SENSOR data file, specify the file created in Step #5, if desired. When prompted for data files for the STD SENSOR and ADAPTER, specify the composite files created in Step #3 and Step #4.

10) When hookup diagrams are shown, they will not explicitly identify which of the two Standard Sensors should be connected. Instead, they will show either the LOW FREQ SOURCE or the HIGH FREQ SOURCE connected. When the LOW FREQ SOURCE is shown, connect the lower frequency Standard Sensor. When the HIGH FREQ SOURCE is shown, connect the higher frequency Standard Sensor.

NOTE: When switching Standard Sensors, be sure to allow sufficient warm-up time for the new hookup before proceeding. If at all possible, keep both standards energized and warm throughout the test.

11) Complete the CAL FACTORS test making hookup changes as described in Step #10.

12) If the UUT Sensor has an EPROM, update the UUT SENSOR data file first, then reprogram the EPROM if desired.

13) Print and/or archive the data so it is not lost. A Cal Factor label may also be generated that lists all frequencies tested.