Performance Measurements, M-Cubed FPM-1 Power Meter (Beta Version)
04 Nov 2005 by Monty Northrup, N5ESE [e-mail: n5ese@io.com]

Objective: Assess the logarithmic compliance and relative accuracy of the power metering functions of the FPM-1, as well as it's raw (uncorrected) frequency response characteristics.

Equipment:

- Logimetric 925 Signal Generator
- M-Cubed FPM-1 Power Meter (beta version)

Notes:

As a signal source, I used my Logimetric 925, which covers from 50 KHz to 80 Mhz, and seems to have a fairly accurate attenuator and output metering. The 925 is spec'd at +/-1 dB accuracy, with the leveling circuit stable to +/- 0.5 dB. It seems to be quite a bit more accurate, but I've never checked it against calibrated laboratory equipment, and it was itself last calibrated in 1999.

In doing these tests, it should be noted up front that it is impossible to segregate the effects of the signal source's attenuation and metering circuit, and the measurement non-compliance of the power meter itself. Nonetheless, the results are enough to provide a high-degree of confidence in both instruments, since the results generally showed measurement accuracies within the range specified by the power meter manufacturer. Where discrepancies were observed, they were generally consistent with variations resulting in the signal generator (rather than the power meter), because they tended to happen at the same attenuator ranges, or because they were inconsistent with measurement circuit variables while they were consistent with possible generator variables.

Calibration:

In the beta version, the FPM-1 was calibrated at 20 MHz, by adjusting the slope (via an onboard potentiometer) to provide a 30 dB spread in raw readings at input levels of -30 dBm (+/-0.1 dBm) and 0 dBm (+/-0.025 dBm). Then, as part of the calibration procedure, and with the push of a button, the firmware stores the gain offset into memory, so that the 0 dBm cal signal gets displayed as 0.0 dBm. That same offset is them applied to all readings.

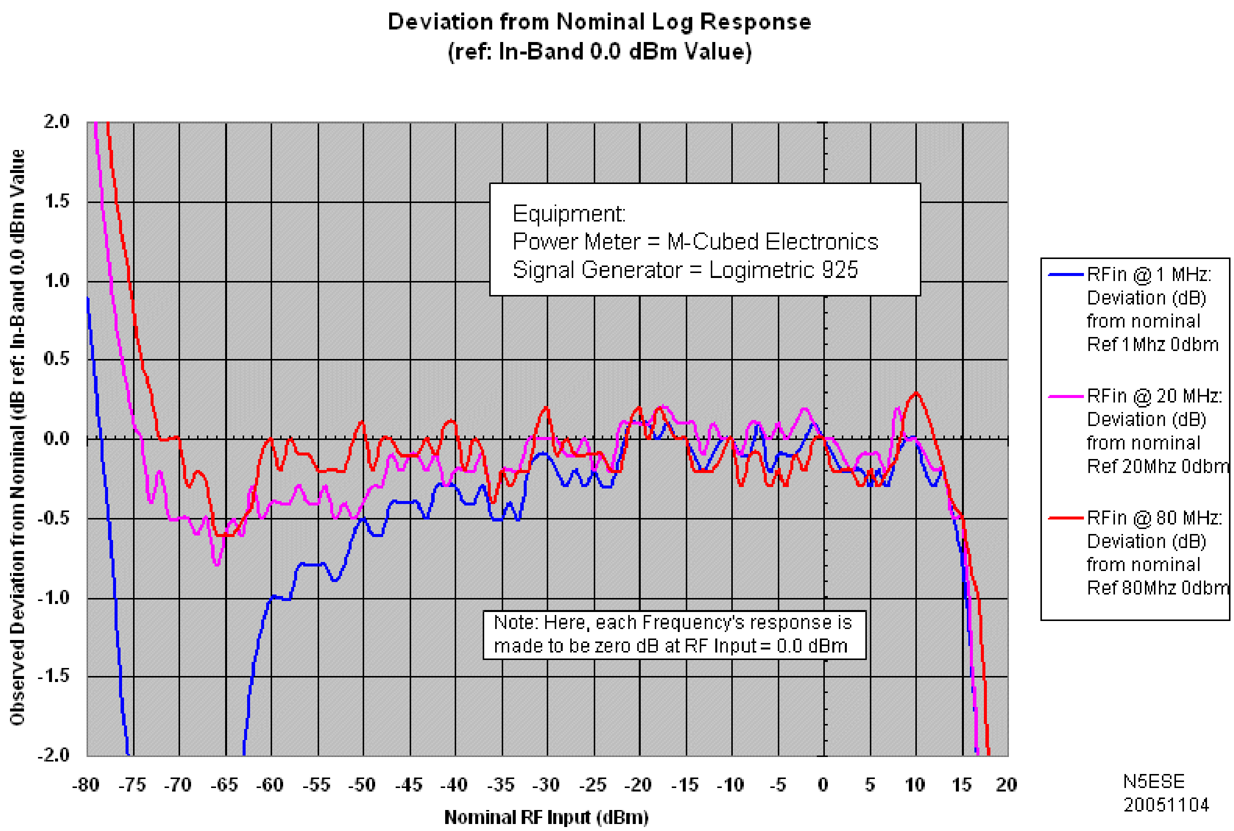
In all cases, the Calibrator used was the M-Cubed Calibrator, which had been pre-calibrated by the manufacturer to the levels stated above. The Calibrator was then double-checked with calibrated laboratory grade equipment, and found to be within the stated levels.

[proceed to the successive pages to see each test result]

<u>Test # 1 – Nominal Logarithmic Conformance</u>

In this test, power meter readings were taken at three different frequencies: 1 MHz (the lowest specified metering frequency), 20 MHz (the beta test calibration frequency), and 80 MHz (the highest frequency available from the 925 Signal Source). Input was applied at 1 dB steps from the low of -80 dBm to a high level of +20 dBm. To remove band-variations in the signal sources leveling circuits, and to remove the effects of frequency correction done by the power meter's firmware, all readings were normalized (zeroed) at the respective frequency's 0 dBm level. For this reason, all three curves cross at 0 dBm.

Note: M-Cubed specifies the log conformance as +/- 1dBm from 1 to 500 MHz over the range -70 to +15 dBm typical.



From the chart at 20 Mhz (where the 0.0 dB calibration was done), the dynamic measurement range is seen to be:

77 dB for +/- 0.5 dB
92 dB for +/- 0.8 dB
93 dB for +/- 1.0 dB

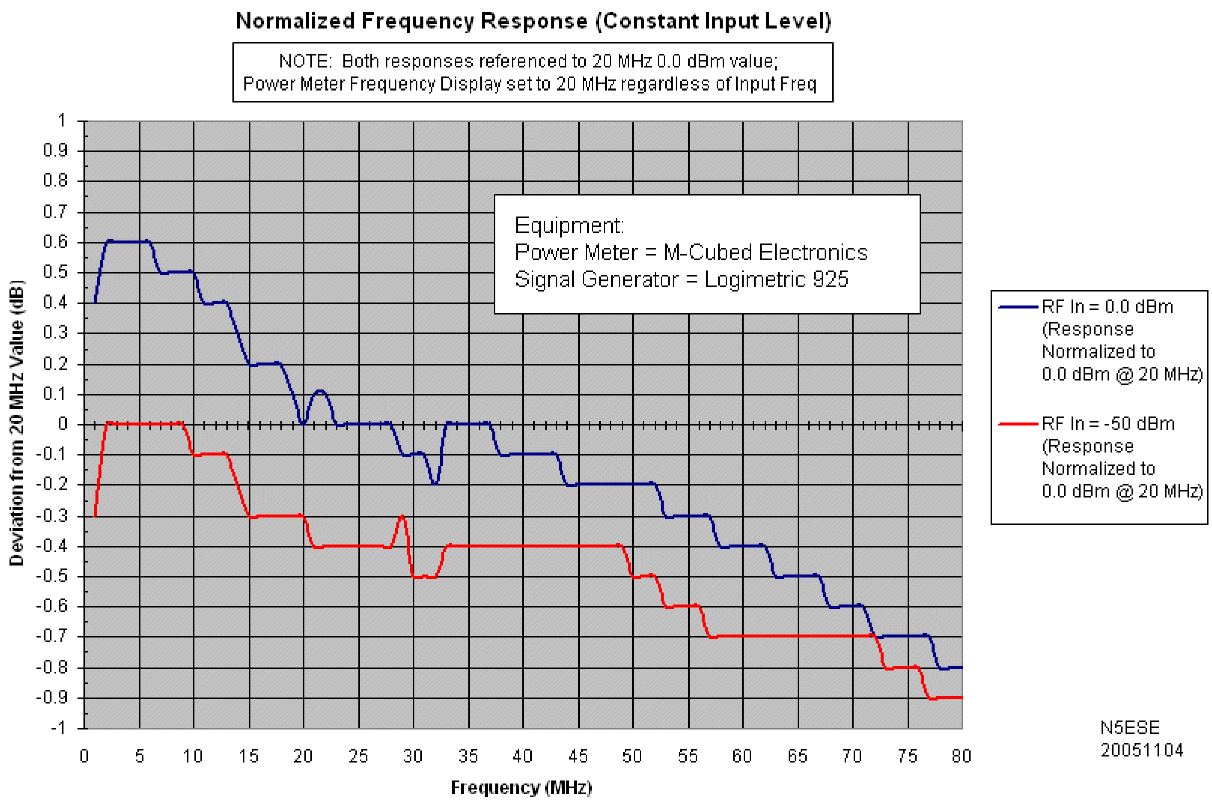
The response seems to be dominated by self-noise at the lower end, and compression at the upper end, which is to be expected. The 80 Mhz dynamic measurement range is seen to be comparable to the 20 MHz response (reduced about 2 dB, mainly by rising self-noise, which is to be expected).

On that same chart, what is puzzling is the significantly reduced range of the 1 MHz response (in blue), down to 75 dB for +/- 1.0 dB. The response cannot be attributed to either self-noise nor externally induced noise, and so its cause is frankly unknown. At first, I thought this was a slew-rate related effect of the AD8307 chip. But since other beta testers and the factory did not observe the same effect, I'm inclined to think this is an effect coupled to the signal source rather than the power meter.

Test # 2 – Normalized Frequency Response

In this test, we attempt to observe the frequency response characteristics of the power meter. The big assumption here is that the leveling circuits in the signal source are working properly, and will hold the selected signal level constant across the frequency range of 1 MHz – 80 MHz Our signal source's upper limit). We did this test at two fixed input levels, -50 dBm and 0 dBm, charting each separately. We took data at 1 MHz steps, starting at 1 MHz (which is the FPM-1 power meter's lower limit).

It should be noted that the response shown is the meter's raw response, normalized to 0 dBm at 20 Mhz. Because the frequency correction algorithms were not finalized at the point this test was accomplished, we let the frequency meter think it was being provided a 20 MHz signal throughout the test. Thus, all frequency correction was circumvented.



Based on the two curves above, it can be seen that in the range from 1 through 80 MHz, all measurements were within 1 dB, with the raw response generally decreasing with rising frequency, which is to be expected. It should be nearly level at 0 dBm in the released version of the FPM-1, if one uses frequency correction by telling the power meter what frequency is being applied.

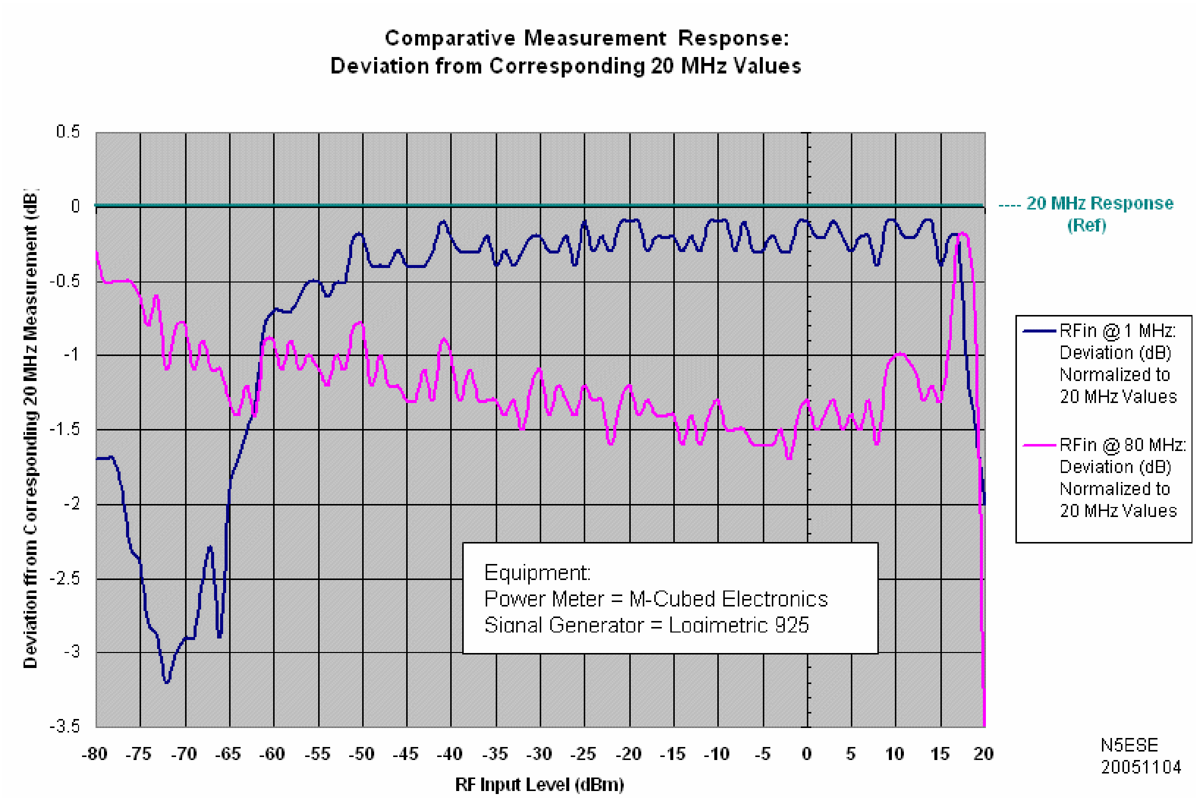
In the 1 MHz to 2 MHz range (above), we see the beginning effects of the high-pass capacitively-coupled input circuit, which amount to about ¼ dB at 1 MHz.

In a linear detector circuit, one would expect to see two roughly-parallel lines here, but as you can see, the slope is slightly different at these two levels. I think this has something to do with the cumulative slew-rates of cascaded log amplifiers, which comprise the AD8307 power detector chip. This is perfectly normal, and as you can see, the effect is easily contained within the specification boundaries of +/-1 dBm.

Test # 3 – Comparative Measurement Response at Three Frequencies

In the Test # 1, we looked at the measurement dynamic range at three frequencies (1 MHz, 20 MHz, and 80 MHz), and normalized those measurements to a single point, 0 dBm. In the Test # 2, we looked at the frequency response, and all the data points were referenced to the 20 MHz Calibration Value at a single point, 0 dB. In this test, we take normalization one step further, so that we can see the comparative effects of frequency over the entire measurement dynamic range. To do this, we adjust our data by adding offsets at each data point, corresponding to input level. That offset is calculated (for each input level) so as to ZERO the 20 MHz reading. In a sense, whatever the 20 MHz reading is, we assume it to be perfectly accurate; as a result, the 10 MHz response (in dark green) shows a flat line, i.e., perfect compliance.

By doing this, we can readily see what the difference is between our lowest power measurement frequency (1 MHz), and out highest (80 MHz, our signal generator's limit), as compared to our calibration frequency, 20 MHz.



Note, when observing these results, that these curves could easily be shifted upward by the FPM-1's frequency correction algorithm, which was not in effect with these data. So, when looking at these curves, focus primarily on the changes from left to right.

What jumps out at us immediately is the blue curve (1 MHz). Its measurement accuracy begins to curve downward at levels below -55 dBm, reaching -3dB deviation with input levels around -70 dBm, where we begin to see the effects of instrument self-noise, which is to be expected. Again, at first, I thought this was a slew-rate related effect of the AD8307 chip. But since other beta testers and the factory did not observe the same effect, I'm inclined to think this is an effect coupled to the signal source rather than the power meter. Still, I do not understand fully what we're observing here. If any engineers recognize the phenomenon, please e-mail me and explain what you think is going on, and the science behind it.