VLA/VLBA Interference Memo No. 31

Memorandum
Date: October 31, 2002
From: Chris Patscheck and Robert Ridgeway
Subject: EVLA Shielded Chamber Power Offset Test Notes

After numerous questions about the accuracy of results obtained in radiated emissions tests conducted in the EVLA Shielded Chamber at the VLA site had been posed, a number of tests were developed and carried out to characterize the error in measurement created by the chamber. Identical tests were conducted inside of the shielded chamber and in an open-air test site (OATS). The results of these tests proved to be quite surprising. This memo presents a brief summary of the tests done and the results found in these tests.

Test Setup/ Procedure

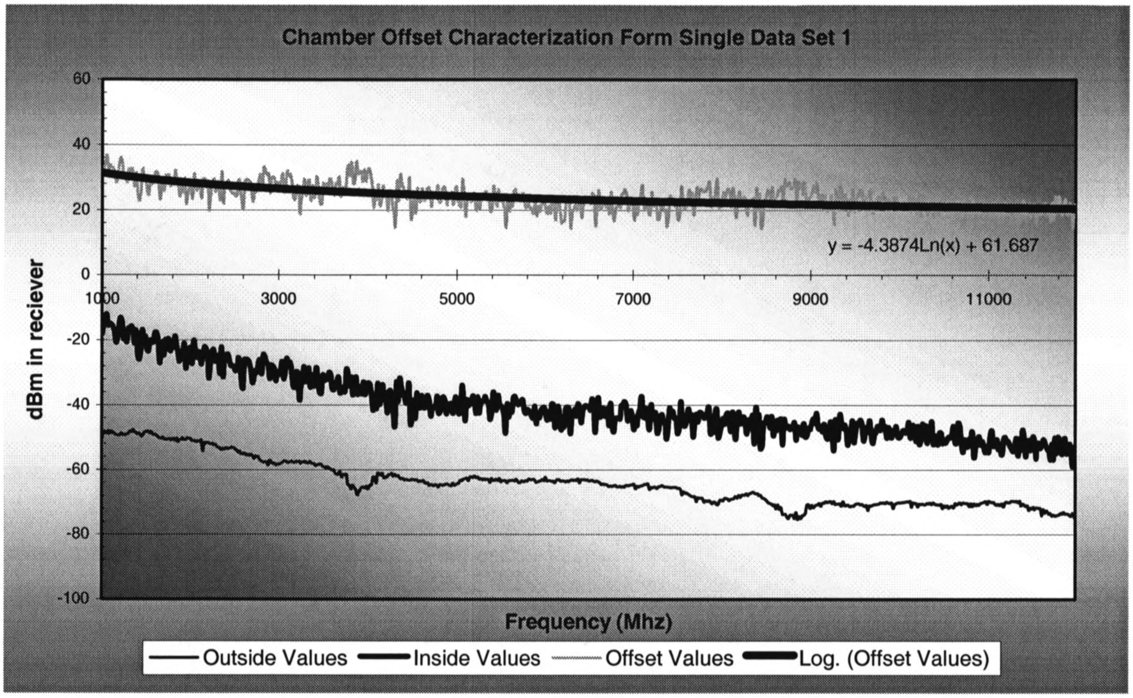
The reasoning here is that OATS testing is a readily accepted form of radiated emissions testing for military and commercial operations. Comparison between an OATS test and an identical test performed in the shielded chamber shows the error caused by the chamber and highlights all of the key differences between OATS measurements and measurements performed in the shielded reflective chamber.

The test setup for both in the chamber and outdoors was as follows. Our omni-directional 0.5-25Ghz conical antenna was driven by a Gigatronics signal generator through about 2m. of ¼" heliax cable. This was used to simulate an RFI source like the equipment under test (such as Ethernet switches, circuit boards, digitizers, etc.). An HP 70000 series spectrum analyzer with a Tensor 1-10GHz double ridged guide horn through ~10m. of ¼" heliax cable was used to receive the transmitted signal.

In both chamber and OATS tests, a common 8m-separation distance was used between the Tx and Rx antennas. This is a standard, recommended separation distance for radiated emissions testing that guarantees true far-field measurements of plane waves above 1GHz. Several spatial positions on a sphere of radius 8m were used for collecting these data. The signal generator was set to 0dBm output power, leveled. The generator was swept in 1MHz steps from 10MHz to 18GHz many times while the spectrum analyzer was left on peak hold mode from 10MHz-18GHz with 1022 linear frequency bins recorded. In some instances these data were averaged to get a more accurate difference between inside and outside the chamber path loss.

Results

The data below is from a single comparison of one spatial position outside to the same position inside (at 8 meter range). The real offset between the two data sets is shown next to a trend line, which fits the offset quite well (σ ~4db). The plot shows only the useful frequency range of our Tensor horn antenna (1-12GHz). This is also most of the frequency range in which emissions from digital equipment are expected to be harmful to the EVLA.



Conclusions

Perhaps the most interesting feature present in the data is the presence of a large positive offset in the power levels measured inside the chamber when compared to OATS results. This offset is consistent throughout the data sets recorded, and can be modeled by means of a statistical regression in the form of a logarithmic function of frequency:

$$\text{offset} = 61.687 - 4.3874\ln(f_{MHz})$$

The standard deviation of the offset data from the trend line is on average 3.813dB. The lowest standard deviation from the trend line is 3.249dB, while the largest is 4.403dB. This standard deviation is almost entirely due to pseudo-random VSWR fluctuations with frequency in the chamber. This hash represents the path loss error as a function of frequency for each measurement performed in the chamber.

What all of this means is that radiated emissions measurements, when carried out in the EVLA shielded chamber, are accurate to within the error represented by the standard deviation of the offset, usually +/-4dB for a single scan of equipment in a single position. Using averaging mode on the spectrum analyzer or averaging multiple position scans done in the chamber, a lower error is achieved. More important than this VSWR error is the offset itself. This offset in power means that measurements done in the "reflection" chamber actually gain sensitivity over measurements done in an anechoic chamber or in an OATS. The plot below illustrates this fact quite well. The blue line 'outside off' is a measurement of the ambient interference of the OATS chosen for these tests (at the VLA site away from reflective surfaces). The yellow line marked 'outside on' is the measurement performed with a Cisco Ethernet switch active 8m away from the Tensor 1-10GHz Rx horn. The only emissions detectable from the Cisco box are about 3dB above the noise floor of the SA at ~2GHz. The black line labeled 'inside on (corrected)' shows the emission levels recorded inside of the chamber with the correction factor for the chamber applied. From this, it may be seen that the measurements match up from indoors to out, and that the chamber test enabled a much better picture of the emissions of the switch to be seen. The chamber is the ideal place to conduct radiated emissions tests where accuracy of +/- 4dB is acceptable. This is due to the lack of any external interference, and to the presence of a large positive offset in path loss as compared to outdoor tests. This adds a great deal of sensitivity to any measurements done in the chamber.