ATTACHMENT C : UNCERTAINTY CALCULATIONS

DETERMINATION OF 95% CONFIDENCE MEASUREMENT UNCERTAINTY OF FREE SPACE CHAMBERS CALCULATED BY TWO INDEPENDENT METHODS

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METHOD # 1 : BASED ON EUT/OATS CORRELATION DATA AND ASSUMED OATS UNCERTAINTY

The overall correlation from the 3 Meter fixed height free space chambers to full scan height, 10 Meter OATS was determined to be as follows based on analysis of data from several systems and several facilities :

Free Space / OATS Correlation
Based on Measurement of EUT's

		% Data Within		
Frequency Range	**# Data Points**	**+/- 2 dB**	**+/- 4 dB**	**+/- 6.8 dB**
30 – 100 MHz	90	43%	79%	98%
100 – 200 MHz	292	52%	82%	97%
200 – 300 MHz	390	54%	81%	95%
300 – 400 MHz	301	35%	70%	91%
400 - 500 MHz	157	52%	89%	99%
500 - 600 MHz	123	57%	89%	98%
600 – 700 MHz	102	49%	84%	94%
700 – 800 MHz	73	36%	73%	99%
800 – 900 MHz	25	60%	96%	100%
900 – 1000 MHz	22	45%	100%	100%
Overall	**1575**	**48%**	**81%**	**96%**

For the purposes of the discussion that follows, an overall correlation of +/- 6.8 dB for 95% Confidence, Gaussian distribution will be used. The above breakdown by frequency range shows that this may not be fully supportive in the frequency range of 300 MHz – 400 MHz and 600 MHz – 700 MHz, and additional statistical analysis in tighter frequency ranges or with different distribution may be more appropriate.

The correlation value is the quotient (subtraction in dB) of the readings from the two types of facilities (FAR and OATS), and therefore the correlation 95% confidence value

represents the Root Sum Square (RSS) combination of the individual uncertainties of the two facilities. To determine the individual uncertainties, one or the other must be first assumed and/or the two uncertainties must be considered to be equal.

For the case where the two uncertainties are considered equal, the individual uncertainty of the OATS or the FAR is obtained from the correlation value as follows :

For 95% Confidence (k=1.96), Assuming Gaussian distribution :

$$U = 1.96 \cdot \sqrt{\left(\frac{Uoats}{1.96}\right)^2 + \left(\frac{Ufar}{1.96}\right)^2} \qquad (1)$$

where U represents the 95% FAR/OATS correlation value and Uoats and Ufar are the total combined, expanded uncertainties of the individual sites. Using the value of U = +/- 6.8 dB determined by analysis of the data population, the individual uncertainties are obtained as follows if Uoats and Ufar are assumed to be equal :

$$U = 1.96 \cdot \sqrt{\left(\frac{Uoats}{1.96}\right)^2 + \left(\frac{Ufar}{1.96}\right)^2} = \pm 6.8 dB$$

$$Uoats = Ufar = \pm 4.81 dB$$

Using a similar calculation, but assuming that Uoats = +/- 6 dB as suggested in the Draft CISPR WG4 uncertainty document for measurement of broadband antennas, the resulting value of Ufar = +/- 3.2 dB.

Assuming a best case value of +/- 4 dB for the OATS, this results in a worst case 95% confidence uncertainty value of +/- 5.5 dB for the FAR. Note that this is unlikely however because it would be difficult to achieve an OATS uncertainty of +/- 4 dB since instrumentation alone is typically +/-2 dB for the receiver and +/- 1.5 dB for the antenna, and site errors by the NSA method may be up to +/- 4 dB.

Summary : Method #1 (EUT Data)

Based on measurement of actual EUT's and assumed values of OATS uncertainty between +/- 4 dB and +/- 6 dB (k=1.96, Gaussian), the typical FAR uncertainty is between +/- 3.2 dB and +/- 5.5 dB.

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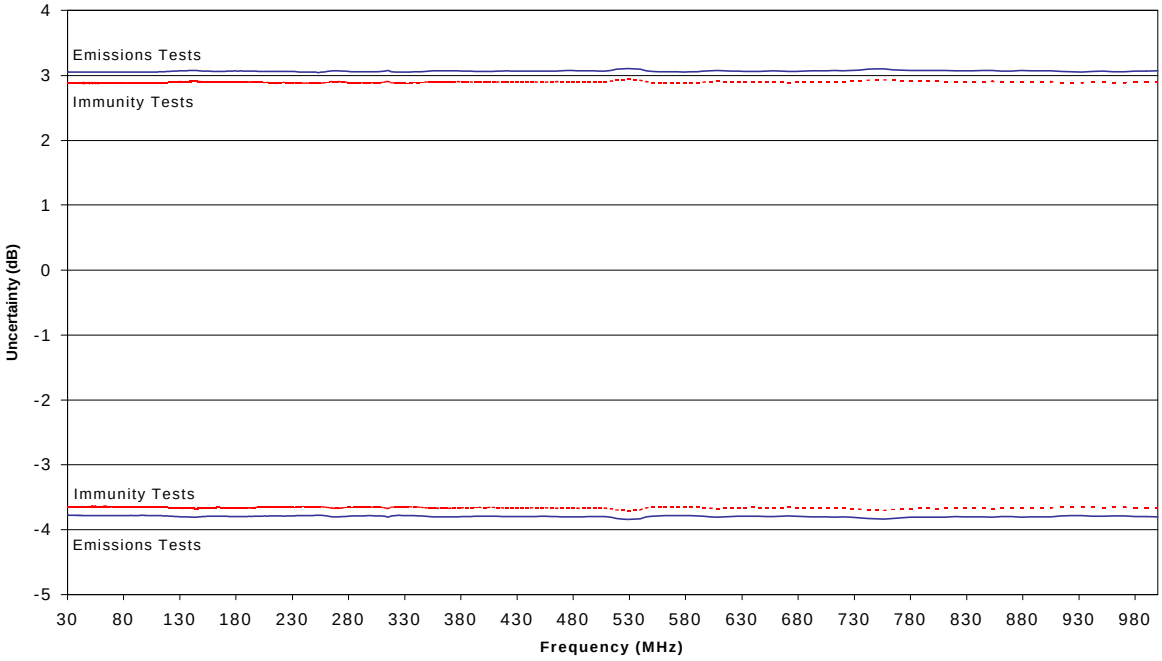
METHOD # 2 : COMPUTATION OF FAR MEASUREMENT UNCERTAINTY BASED ON SAMPLING OF VOLUME TO BE OCCUPIED BY EUT WITH ISOTROPIC FIELD PROBE

CKC Laboratories, Inc. has developed a method of calibration of free space facilities based on sampling of the volume to be occupied by the EUT with and isotropic field probe. By this method, the uncertainty in the field generated or received in the test volume can be determined based on an electric field probe sampling of 16 – 28 locations within the test volume and recording of the system forward power and field strength at each location. The measurement uncertainty computed by the methods detailed in CKC Laboratories, Inc. calibration procedure LP98002 include the facility, antenna, and all measurement instrumentation, and are traceable to NIST through the instrumentation used. The uncertainties calculated by this method can be stated either for subsequent emissions or immunity tests as the uncertainty of the measurement instrumentation, including the facility.

The following charts shows the results of the calibration performed on a typical FAR for both Horizontal and Vertical polarities :

FIGURE 1 : TOTAL COMBINED (RSS METHOD), EXPANDED (k=1.96) MEASUREMENT UNCERTAINTY INCLUDING ALL INSTRUMENTATION: 95% CONFIDENCE VALUES

Vertical Polarity



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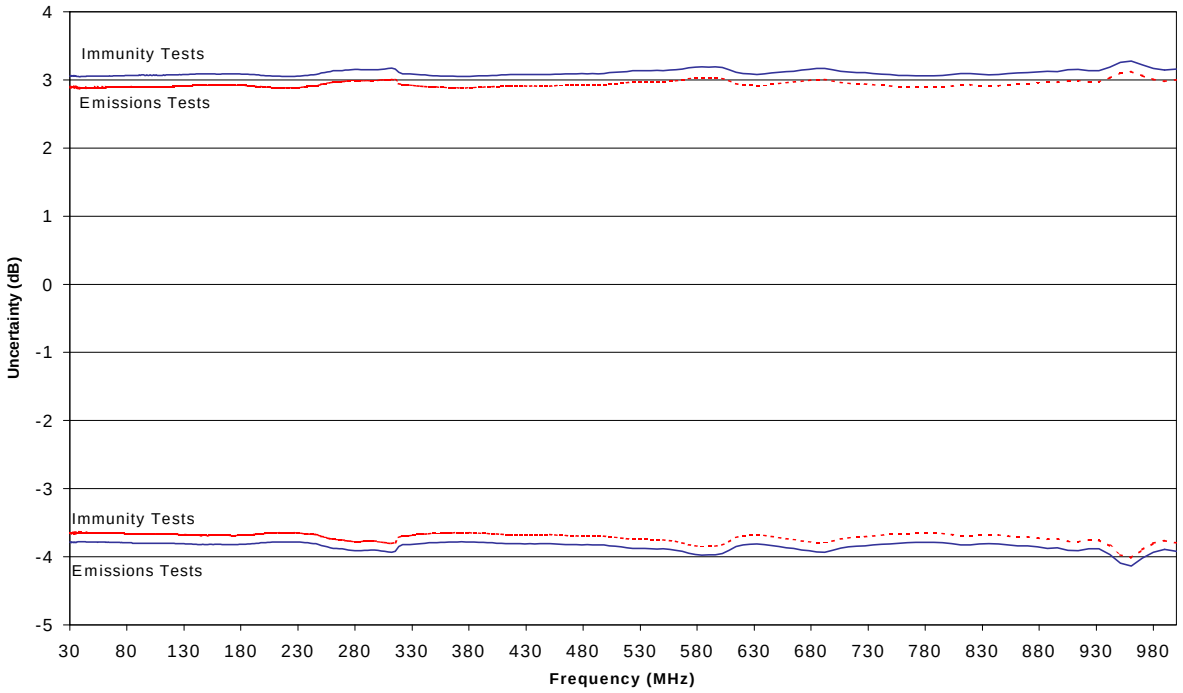
Horizontal Polarity



Note that the measurement uncertainty is slightly greater for emissions tests due to the use of an emissions pre-amplifier during measurements.

Summary : Method #2 (Facility Calibration)

The results of typical FAR measurement uncertainty determined by Volumetric Sampling with and isotropic field probe as summarized as follows for emissions tests :

Combined, Expanded (k=1.96) Measurement Uncertainty including all instrumentation (Emissions Tests, 95% Confidence, Gaussian) :

95% Confidence Levels :

Vertical Polarity	:	+ 3.1 / -3.8 dB
Horizontal Polarity	:	+ 3.4 / - 4.2 dB

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CONCLUSIONS

The above two methods of determining measurement uncertainty for a typical Free Space Chamber both suggest that the 95% Confidence Measurement Uncertainty of the Free Space chamber is between +/- 3 dB and +/- 5.5 dB. The results obtained by Method 1 are based on measurement of actual EUT's on multiple FAR's and the results of Method 2 are based on Isotropic Field Probe Sampling of the test volume to be occupied by the EUT.

It is important to note that Method 1 requires an OATS uncertainty to be assumed between +/- 4 dB and +/- 6 dB in order for the above conclusion to be applied. A worst case uncertainty value of +/- 5.5 dB could result for the FAR if the OATS uncertainty is assumed to be +/- 4 dB, but this is considered unlikely with the broadband antennas used to collect the data. It is more likely that the OATS uncertainty is between +/- 4.8 and +/- 6 dB, which results in a FAR uncertainty between +/- 3.2 dB and +/- 4.8 dB.

These values of measurement uncertainty for the Free Space Room are within the suggested Uncertainty of OATS measurements assumed to be between +/- 4 dB and +/- 6 dB according to the Draft CISPR A Uncertainty Working Group document for OATS. The CISPR A document uses only type A considerations for instrumentation and the test site to arrive at this value, whereas the above methods utilize a combination of Type A and Type B methods.