

FREE-SPACE TRANSMISSION LOSS FOR ANECHOIC CHAMBER PERFORMANCE EVALUATION

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Abstract

A longitudinal probe scan of an anechoic chamber yields a plot of measured transmission loss. Any deviation of this curve from calculated free-space transmission loss can be attributed to chamber reflections or, at small separation distances, to finite-range source antenna gain corrections or to source-probe interactions.

Summary

Antenna pattern comparison and free-space voltage standing-wave-ratio (VSWR) measurements are frequently used for rf anechoic chamber performance evaluation¹. The VSWR measurement, as a preferred technique, consists of measuring the relative signal level received by a probe antenna versus probe position on a linear path. A path transverse to the main beam axis of the source of chamber illumination may be used to evaluate side wall, ceiling, and floor reflections. A longitudinal probe path may be used to evaluate back wall reflections and reflections from near the source antenna². For either probe path in an imperfect chamber, variations in probe signal level with distance are caused by spatial interference patterns resulting from the sum of the direct wave propagated along the measurement axis and waves reflected or scattered from surfaces in the chamber. Examination of the period of the interference pattern amplitude recorded during a probe scan, or VSWR, may lead to the identification of well defined sources of reflection.

A general purpose rectangular anechoic chamber at the NBS Boulder Laboratories contains a cart mounted on precision track extending the full 8.5 m chamber length. Probe antennas placed on this cart are provided with an unusually long longitudinal scan path. Availability of this chamber configuration led to a straightforward comparison of calculated transmission loss (including near-zone source gain corrections) and measured insertion loss to evaluate chamber performance.

Relative insertion loss is the ratio of power received by the probe antenna for an initial test configuration to that received for any other configuration. Free-space transmission loss³ is given by

$$P_{\text{rec}}/P_{\text{tr}} = g_s g_p (\lambda/4\pi r)^2$$

where P_{rec} = power received by probe antenna,
 P_{tr} = power transmitted by source antenna
in same units as P_{rec} ,
 $g_s g_p$ = product of source and probe
antenna gains,
 r = source-to-probe separation distance,
and
 λ = wavelength in same units as r .

The transmitted power, P_{tr} , is held constant during a probe scan; g_s is a known function of r ; g_p is
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assumed constant since the probe is an electrically small dipole. Therefore, P_{rec} is proportional to $g_s r^2$. A plot of relative insertion loss measured dur-

ing probe scan can be compared to a calculated curve of P_{rec} versus r . Any deviation of the measured data from a best fit calculated curve can be attributed to reflections in the chamber or, at small values of r , to finite-range source antenna gain corrections or to source-probe interactions.

Figures 1 through 4 show comparisons of measured and calculated insertion loss. The source antennas used for these data plots were open-end WR3600 waveguide at 175 MHz and 517 MHz and standard gain horns at 517 MHz and 2000 MHz. In all cases the probe antenna was an electrically small dipole. Data in these figures show that chamber reflections may produce errors in standard fields generated in the chamber at 1 m to 3 m separation distances as follows:

Frequency MHz	Range of Error, dB	Uncertainty, dB
175	-0.6, +0.1	±0.10
517	-0.3, +0.2	±0.08
517	-0.3, +0.1	±0.06
2000	±0.1	±0.04

In conclusion, longitudinal probe scans of relative insertion loss in an anechoic chamber provide an excellent visual record of performance on a particular measurement axis. Reflections from all chamber and cart surfaces affect the measured data but those generated by the walls at each end of the longitudinal path are most easily identified.

The data in this report illustrate chamber performance on one particular measurement axis. The error data may be applied only to electrically small antennas or probes positioned on this axis. Complete characterization of chamber performance over a test volume requires measuring the transmission loss throughout the test volume at all frequencies of interest.

References

- [1] IEEE Standard Test Procedures for Antennas, IEEE Std 149-1979 (Revision of IEEE Std 149-1965), The Institute of Electrical and Electronics Engineers, Inc., New York, N. Y., (1979).
- [2] Crawford, M. L., Evaluation of Reflectivity Level of Anechoic Chambers Using Isotropic 3-Dimensional Probing," 1974 International IEEE/AP-S Symposium Program and Digest, Atlanta, Georgia, pp 28-34.
- [3] Scheikunoff, S. A. and H. T. Friis, Antenna Theory and Practice, John Wiley & Sons, Inc., New York, N. Y., pp 183-185, (1952).

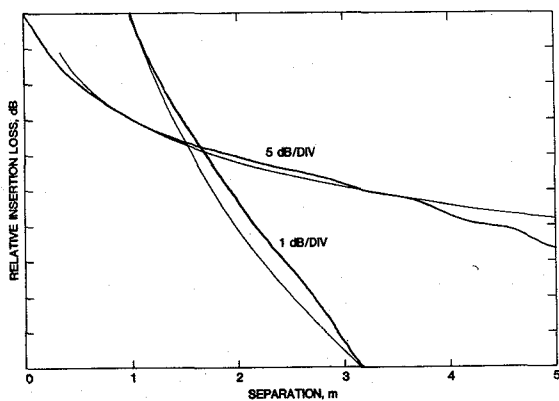


Figure 1. Relative insertion loss versus separation distance with free-space transmission loss fitted at 1 m; frequency = 175 MHz; source is WR3600 OEG.

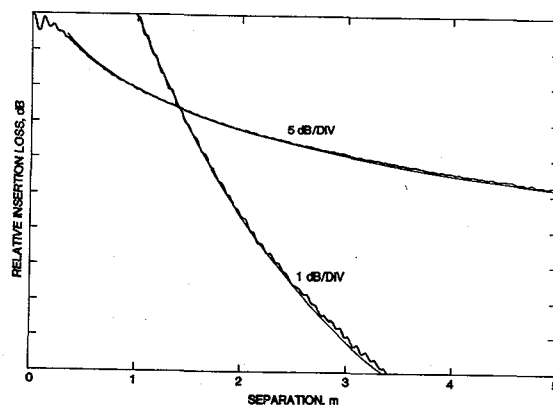


Figure 4. Relative insertion loss versus separation distance with free-space transmission loss fitted at 1 m; frequency = 2000 MHz; source is pyramidal horn.

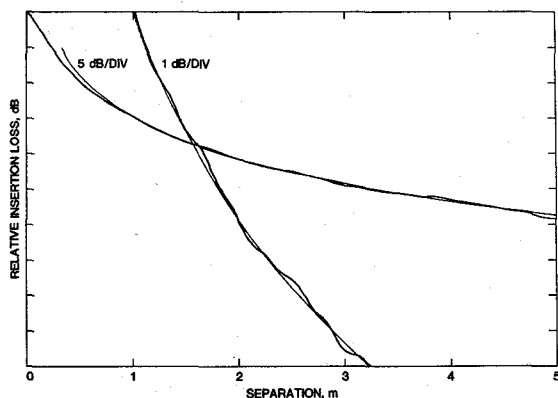


Figure 2. Relative insertion loss versus separation distance with free-space transmission loss fitted at 1 m; frequency = 517 MHz; source is WR2100 OEG.

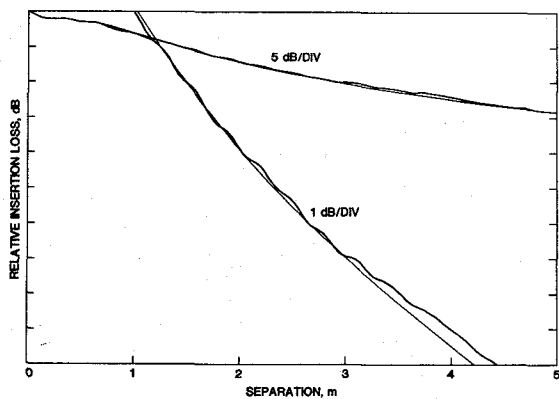


Figure 3. Relative insertion loss versus separation distance with free-space transmission loss fitted at 1.67 m; frequency = 517 MHz; source is pyramidal horn.

Note: The thin, smooth monotonic decreasing curves are the calculated transmission losses. The heavy curves are the measured losses.