Methods of Measuring Shielding Effectiveness

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Agenda

- Overview of Shielding Effectiveness (SE) standards for passive devices and connectors
  - ANSI/EIA-364-66A
  - ANSI/SCTE 48-1
- SCTE 48-1 and EIA 364-66A Measurements < 1 GHz
- SCTE 48-1 and EIA 364-66A Measurements > 1 GHz
- Comparison of SCTE 48-1 and EIA 364-66A
- Shielding Effectiveness of a Complex Cable
  - SE for Panels

Perfect Shielding effectiveness

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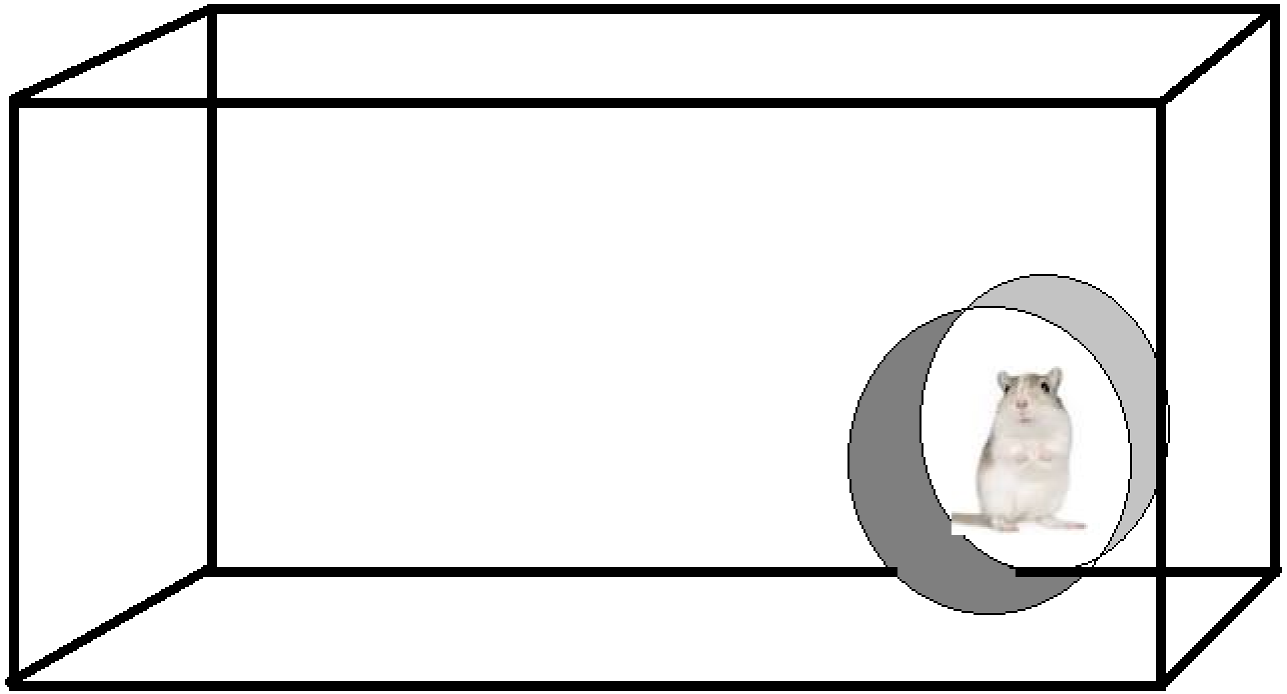
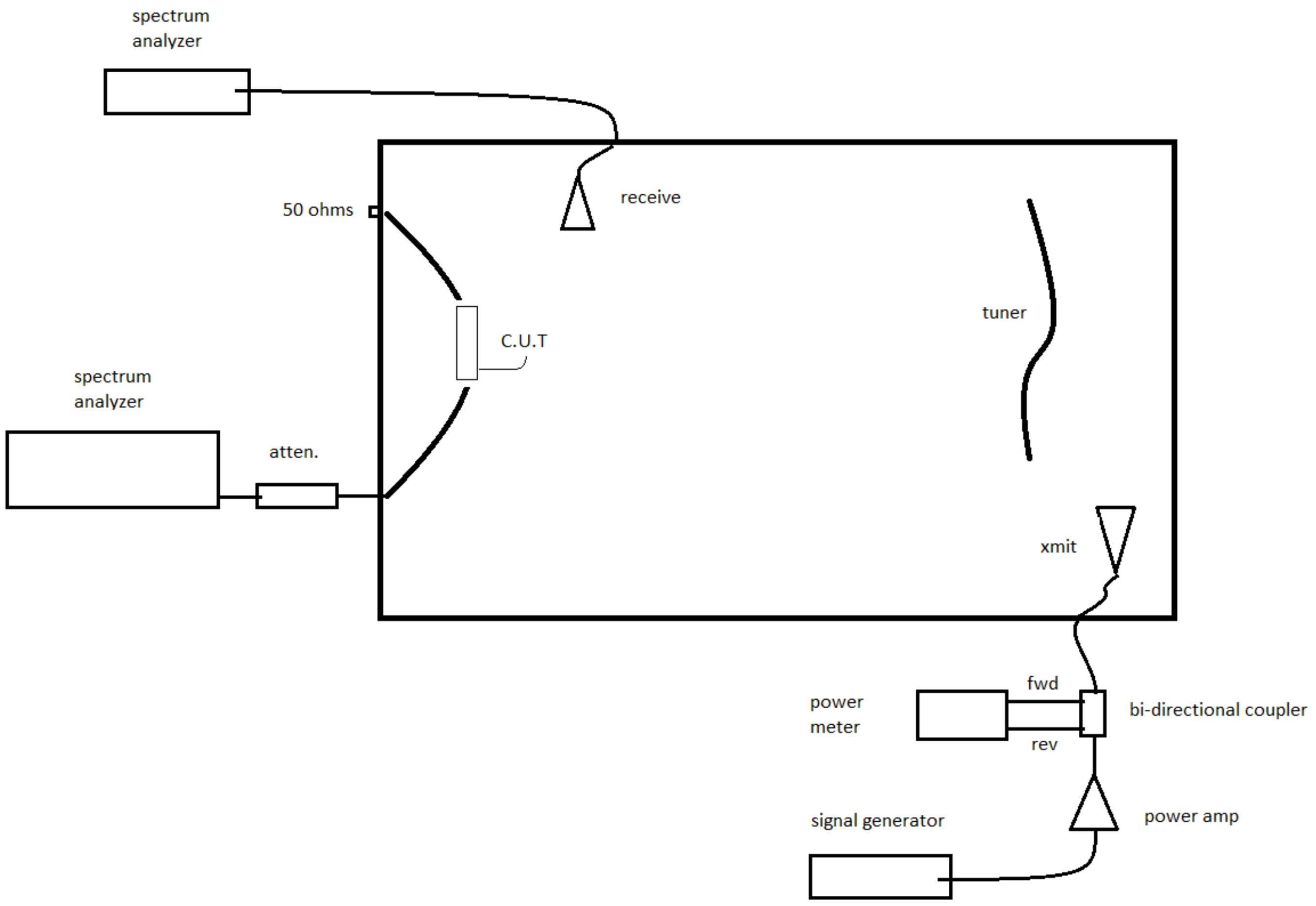


Shielding Effectiveness Standards Overview

- ANSI/EIA-364-66A -2000 Reaffirmed July 2019 Shielding Effectiveness Test Procedure for Electrical Connectors

This standard uses a reverb chamber and the comparison of the reference antenna and the connector under test (CUT) to calculate the shielding effectiveness. This works well for connectors and yields very comparable data to ANSI/SCTE 48.1 2015.

ANSI/EIA-364-66A Setup



Shielding Effectiveness Standards Overview

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- The setup of the CUT into the working volume of the chamber must be considered. ≥λ
- The construction of the test fixture can drastically affect the test.
- The dynamic range needs to exceed the intended attenuation.
- Typically, two semi rigid cable (2 λ) is used for the conduit.
- Typically, I like to use 1 semi rigid coax (4 λ) for dynamic range of the system.

Careful fixturing to create a high dynamic range (no matter how ugly)

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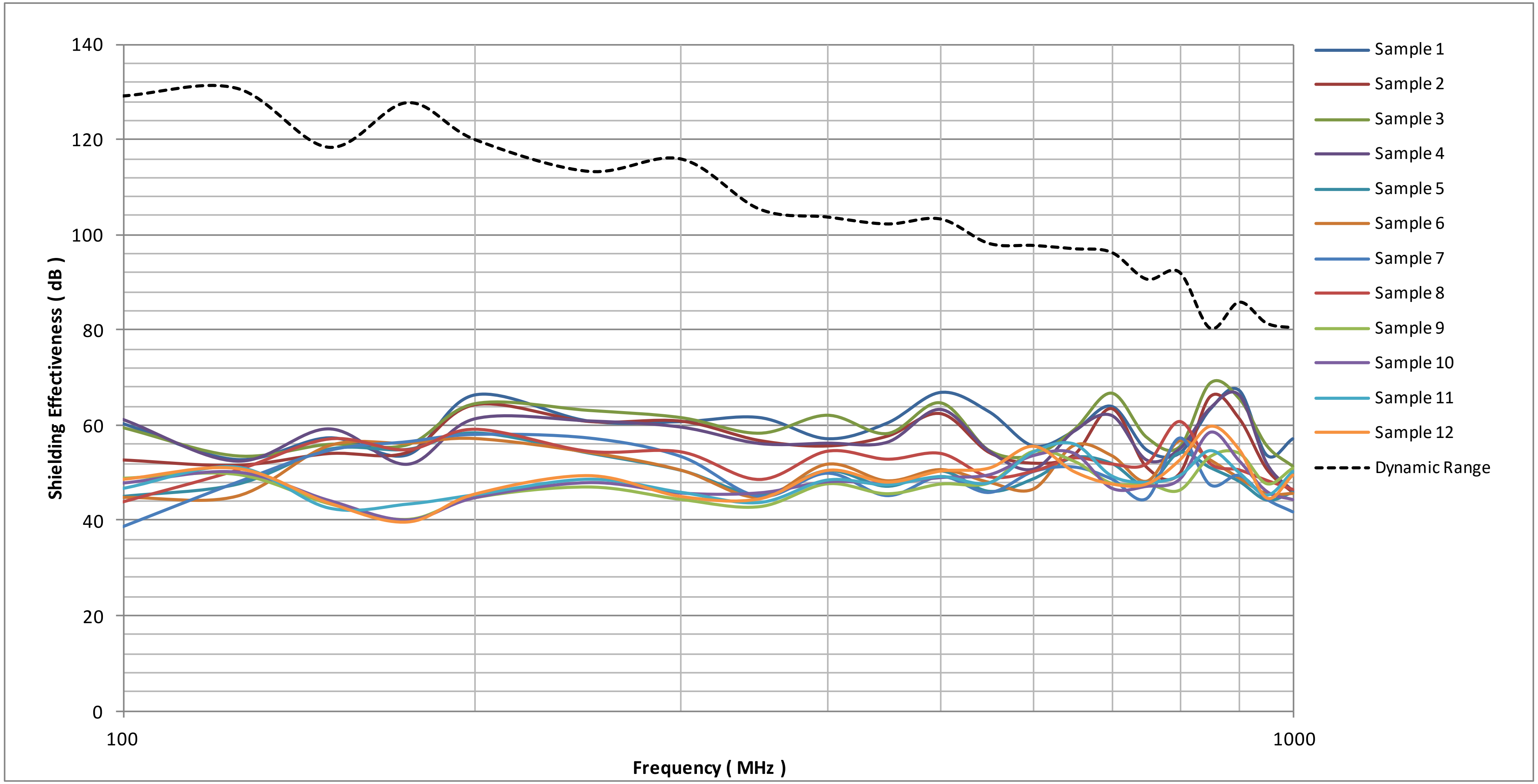
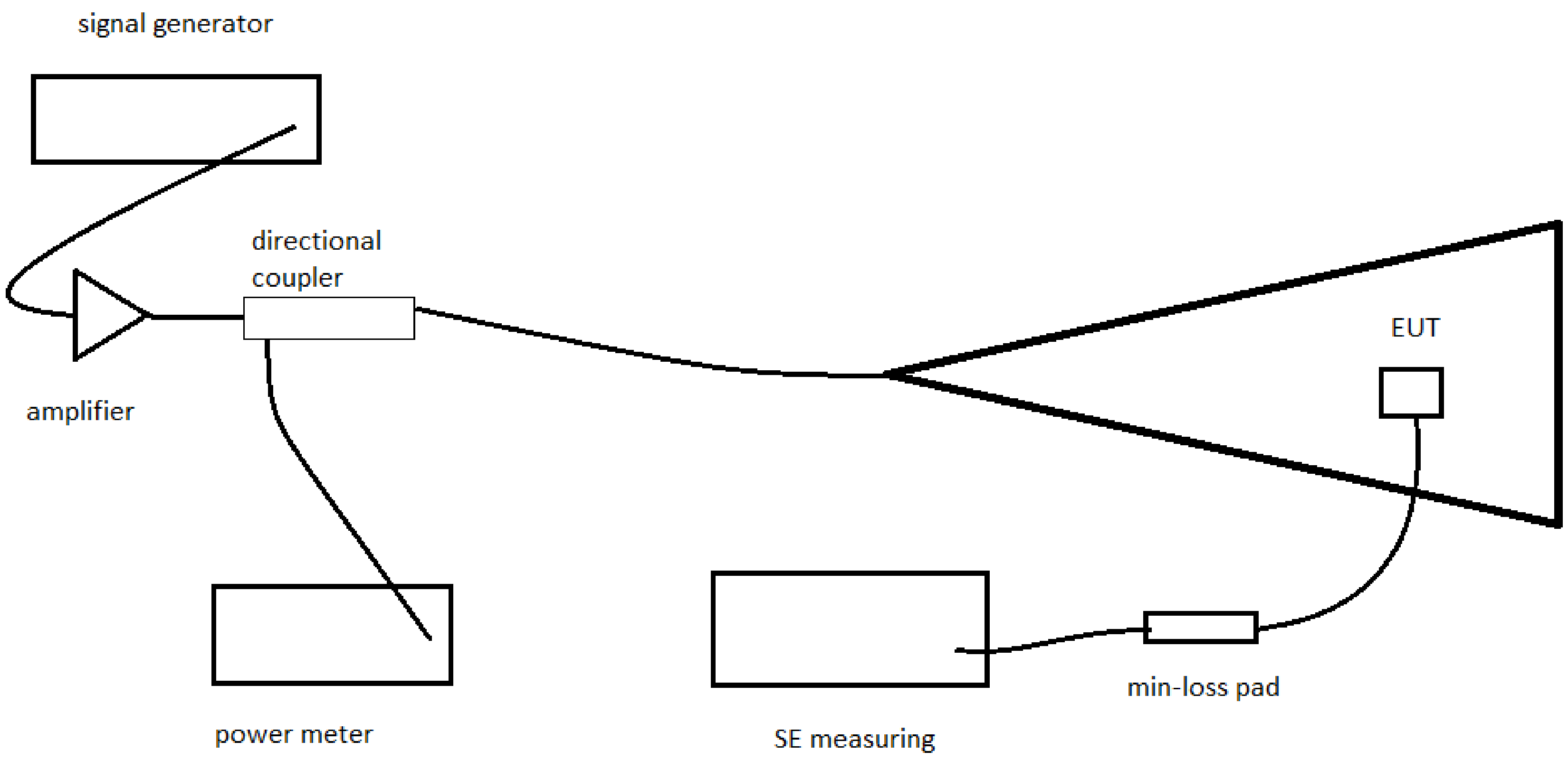
ANSI/EIA-364-66A Example Data



Shielding Effectiveness Standards Overview

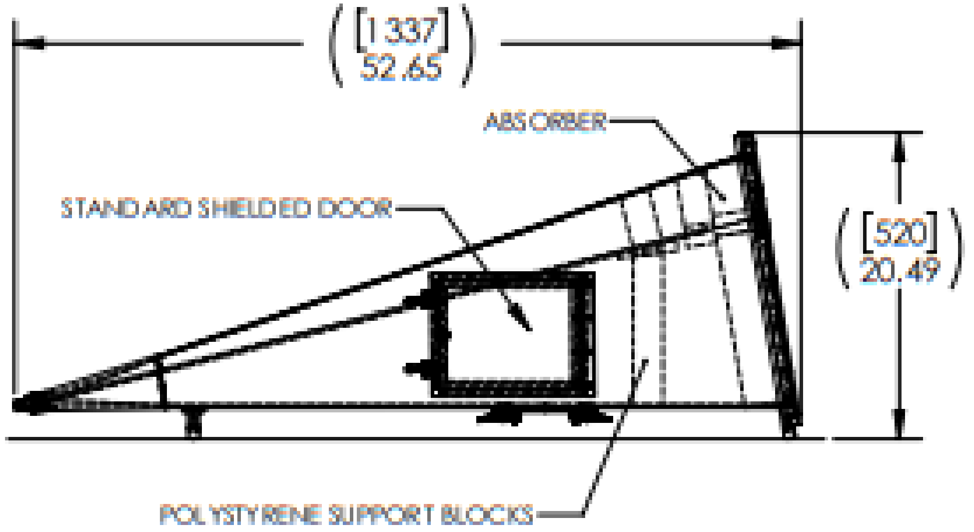
- ANSI/SCTE 48.1 2015 Test Method for Measuring Shielding Effectiveness of Passive and active Devices Using a GTEM Cell.

This standard uses a GTEM Cell and a calibrated RF field (10V/m) and RF energy induced into the devise under test (DUT) to calculate the shielding effectiveness. This works well for connectors and small DUTs. Care must be taken to ensure complete immersion of the DUT into the test volume


signal generator
directional coupler
amplifier
EUT
power meter
SE measuring
min-loss pad

GTEM Dimensions

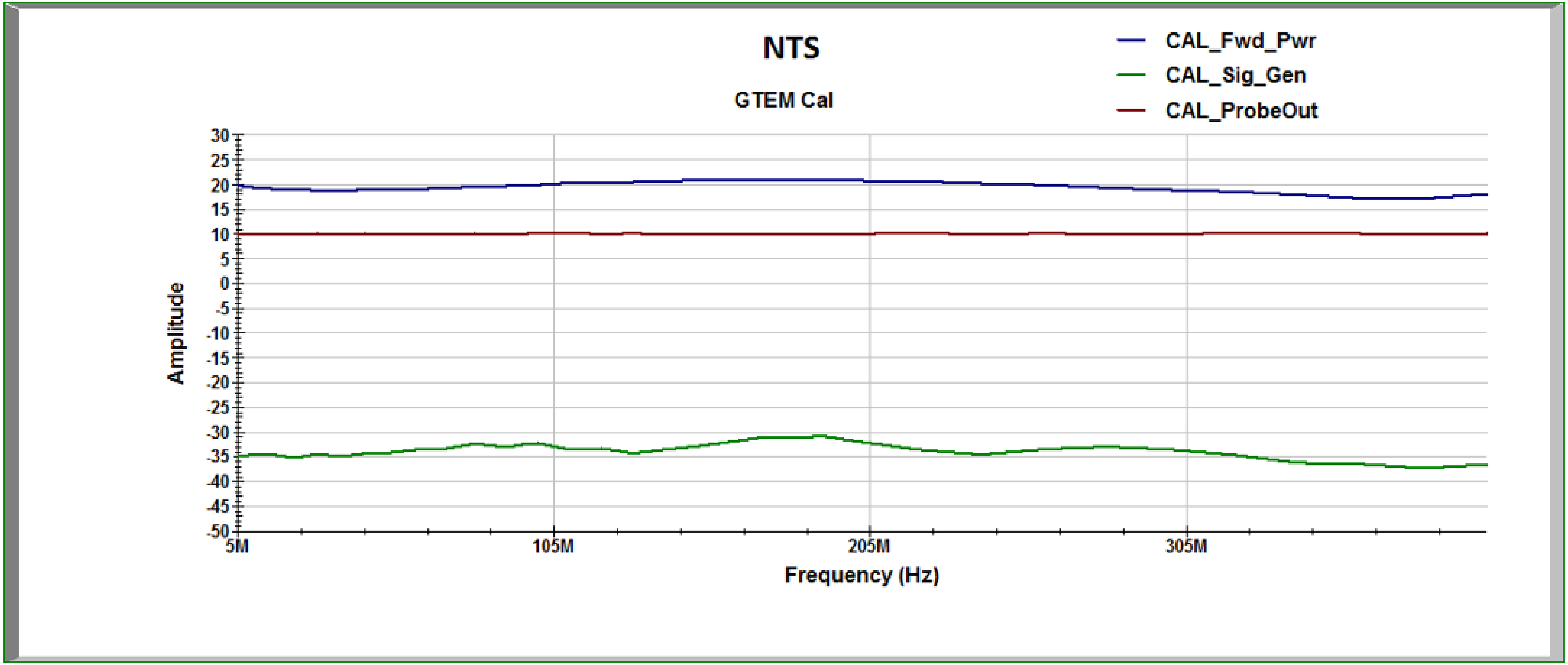
- GTEM – ETS Model 5402
- Outer Cell Dimensions: L 1.4m, W 0.75m, H 0.5m
- Septum Height: 250 mm
- Accurate Transverse Test Surface dimensions: 76.2 mm x 76.2 mm



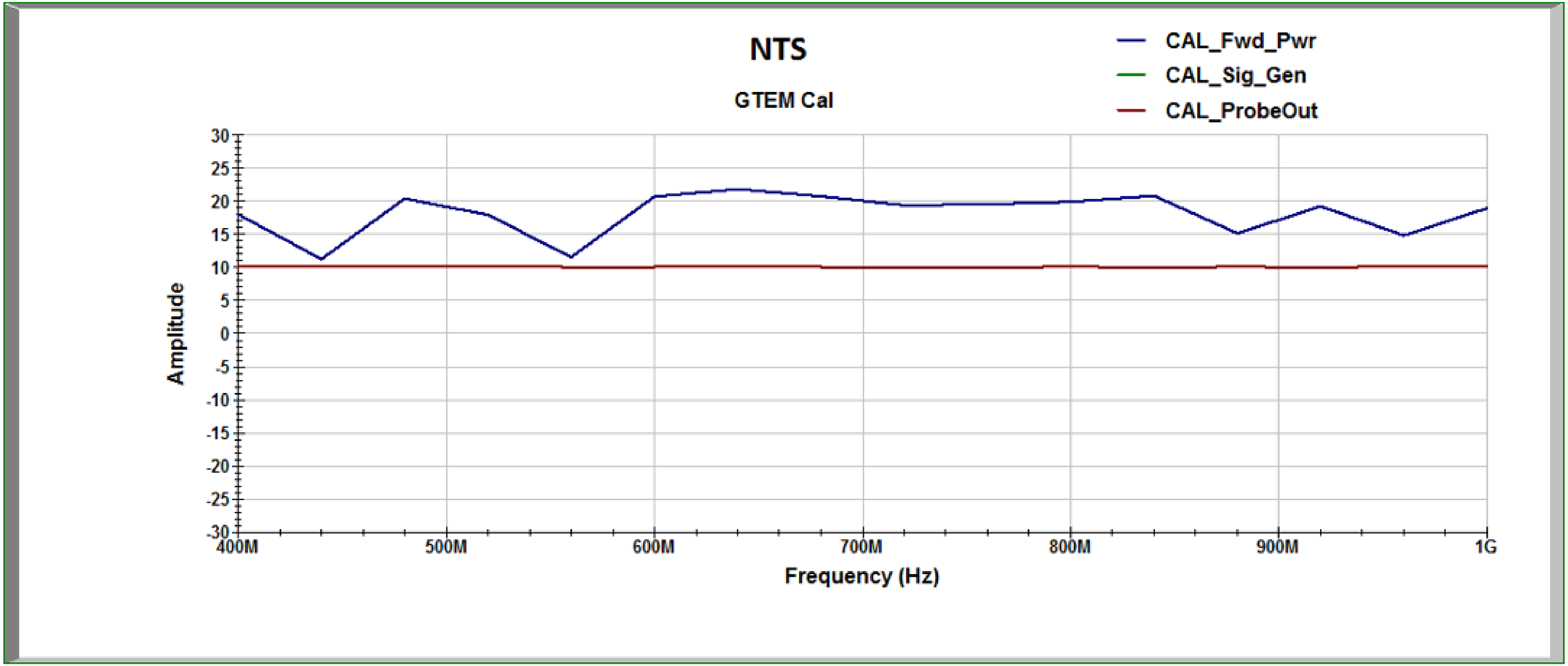
GTEM Electrical Characteristics

- Max power 50W
- 7/16 DIN connection
- SE 80 dB minimum (nesting recommended)
- 10 V/m less than 1 watt

GTEM Calibration low frequency

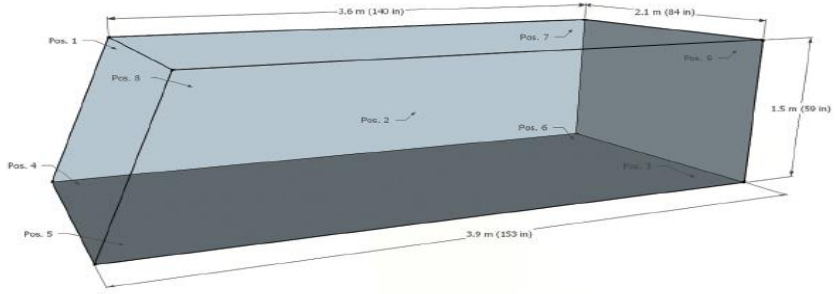


GTEM Calibration high frequency

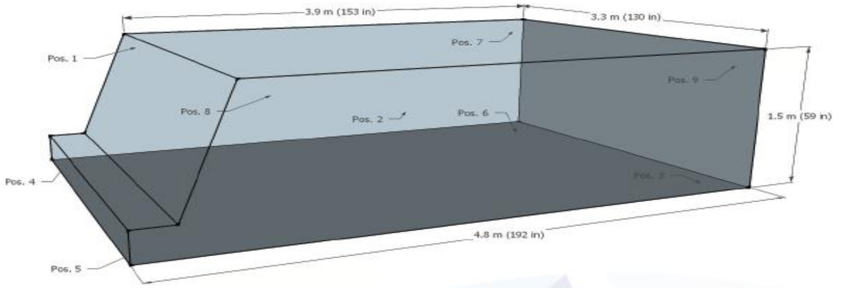


Reverb Chamber Dimensions

- Outer Dimensions: L 6 m, W 3.6 m, H 3 m
- Working volume around 438 cubic feet.



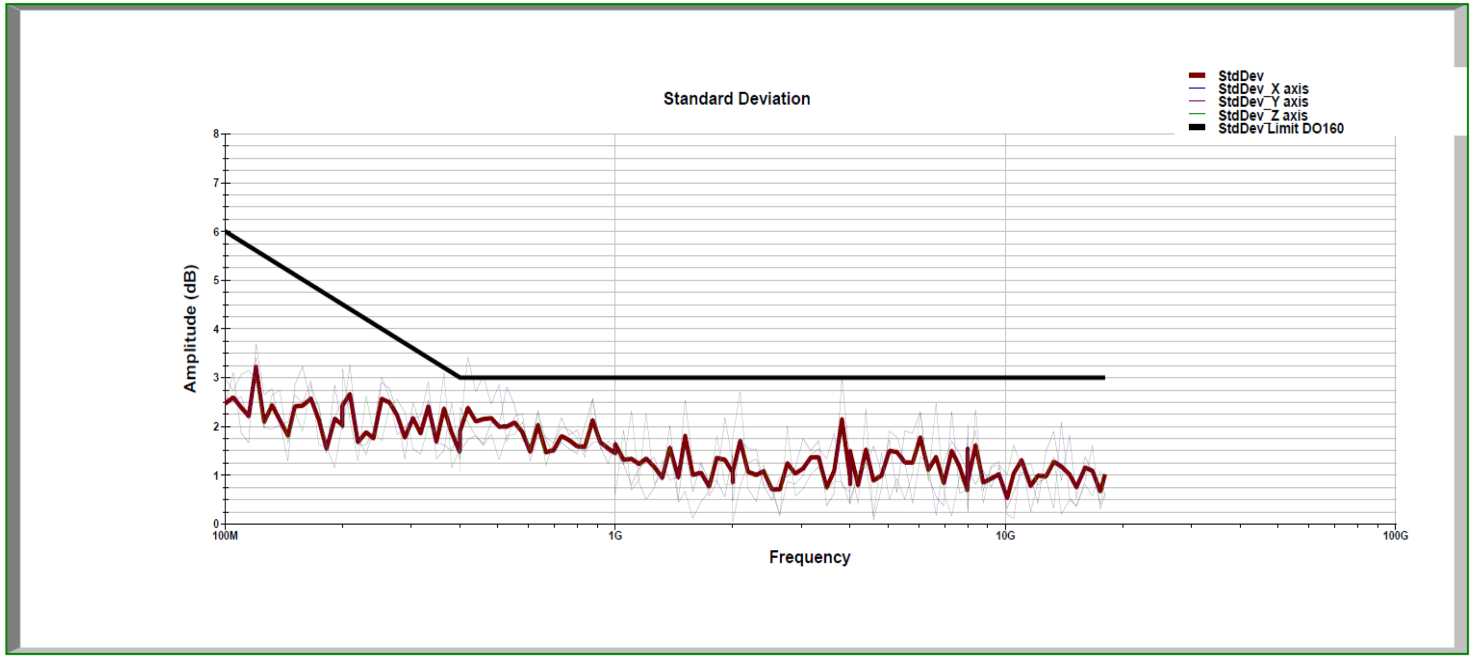
Working Test Volume from 100 MHz to 400 MHz



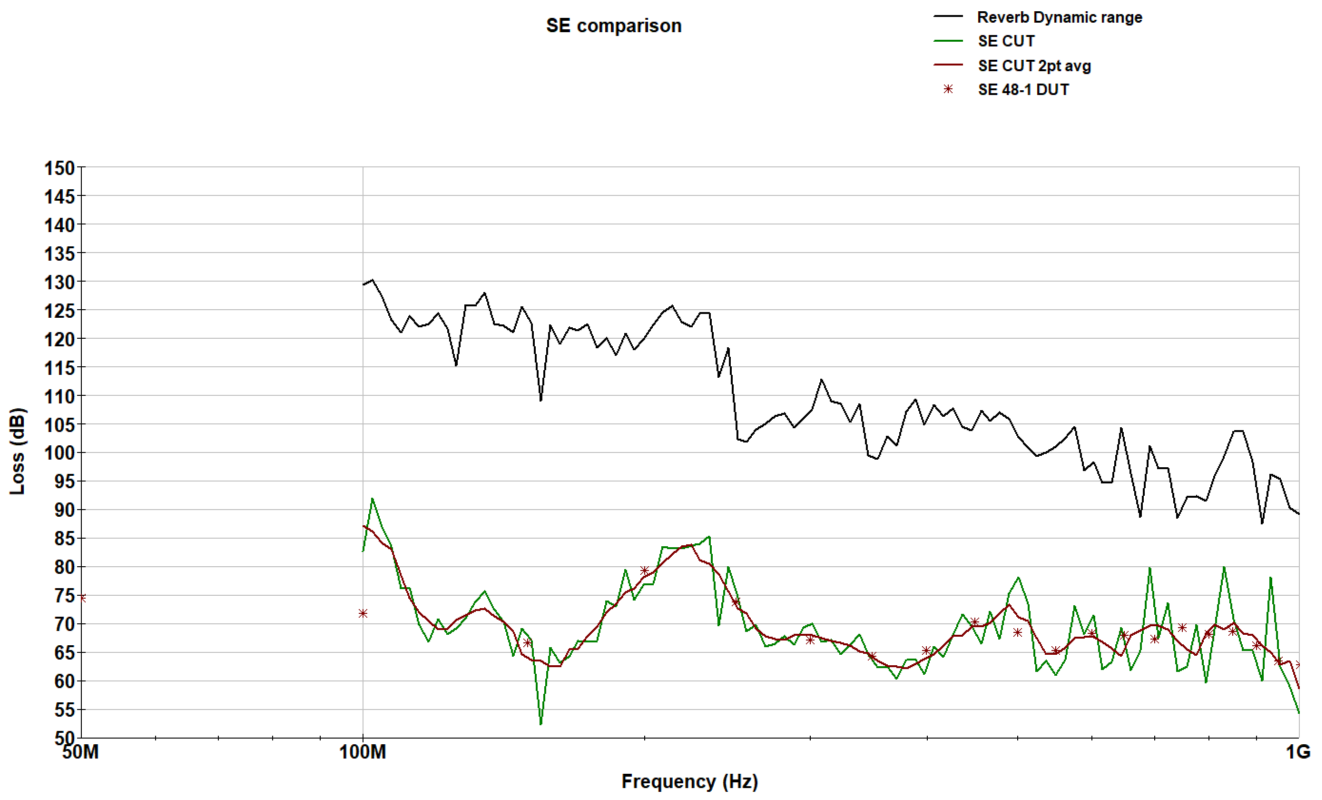
Working Test Volume from 400 MHz to 18 GHz

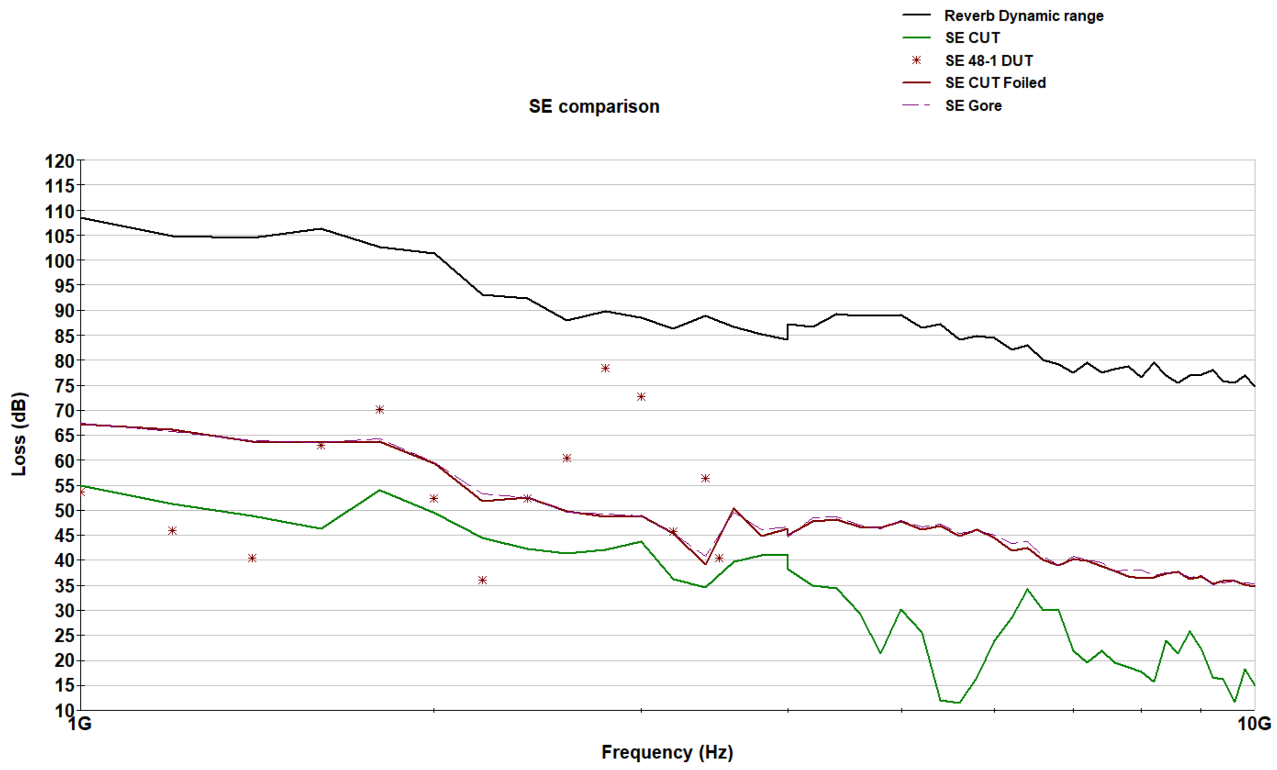
Reverb Chamber Electrical Characteristics

- Standard deviation per RTCA DO160
- 10 V/m achieved less than 0.1 watt



SCTE 48-1 and EIA 364-66A Measurements < 1 GHz





SCTE 48-1 and EIA 364-66A Measurements > 1 GHz

Comparison of SCTE 48-1 and EIA 364-66A

- Frequency range - SCTE 48-1 limited in frequency to below 1 GHz. (Accuracy above 1 GHz suffers likely due to field variation over test volume). Whereas EIA 364-66A measures up to 18/40 GHz accurately. SCTE 48-1 measures down to 5 MHz accurately. Whereas the reverb chamber used for EIA 364-66A will not measure accurately at 5 MHz. The reverb chamber would need to be around 100 ft x 100 ft x 100 ft for 5 MHz. Accurate measurements down to 100 MHz are achievable with some reverb chambers.
- Economy - SCTE 48-1 requires a much smaller initial investment and is typically a faster test than EIA 364-66A.
- Size – Working volume of the reverb chamber as compared to the test volume of the GTEM causes the DUT size to be very limited.

Comparison of SCTE 48-1 and EIA 364-66A cont.

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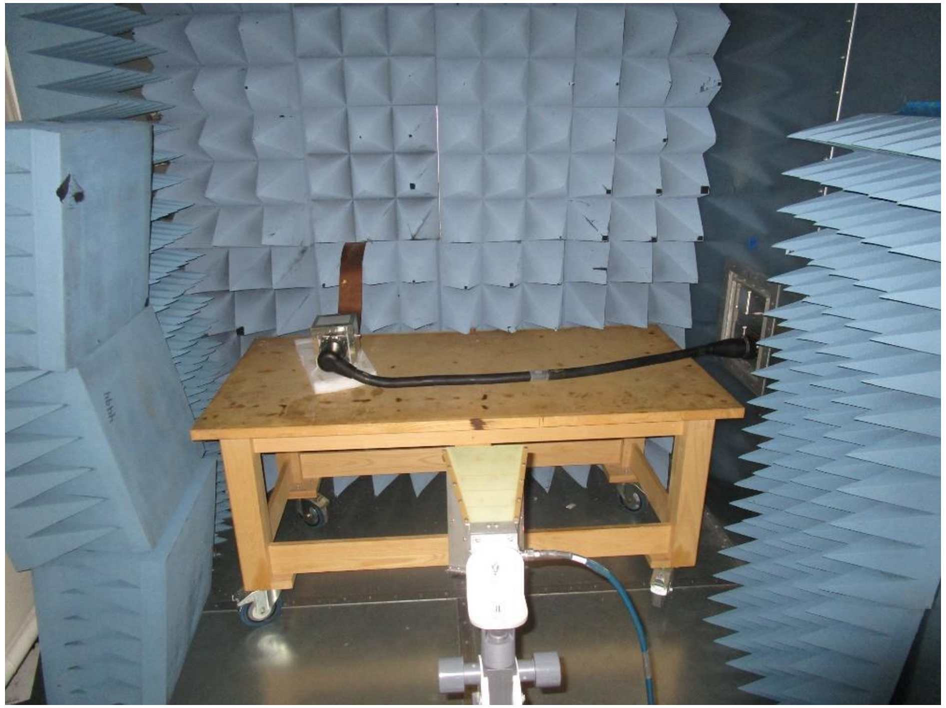
- Accuracy – Both require care in setup (SE of support equipment, layout, etc) and receive path loss / gain documentation.
- Impedance – SCTE 48-1 works for both 50 Ω and 75 Ω systems. Whereas EIA 364-66A is not designed for 75 Ω systems.
- Limitations – Neither EIA 364-66A or SCTE 48-1 works for cables. I have had mixed results on cables using EIA 364-66A. I think due to standing waves or phase issues developed on the cables. (future study / VNA). SCTE 48-3 works well with cable shielding effectiveness for 50 Ω and 75 Ω drop cables.

Reverb Chamber in Operation

Shielding Effectiveness of a Complex Cable

- Custom testing required much of the time.
- In depth study of cable design and application. Affects the setup inside and outside the chamber.
- Choosing what pins to test.

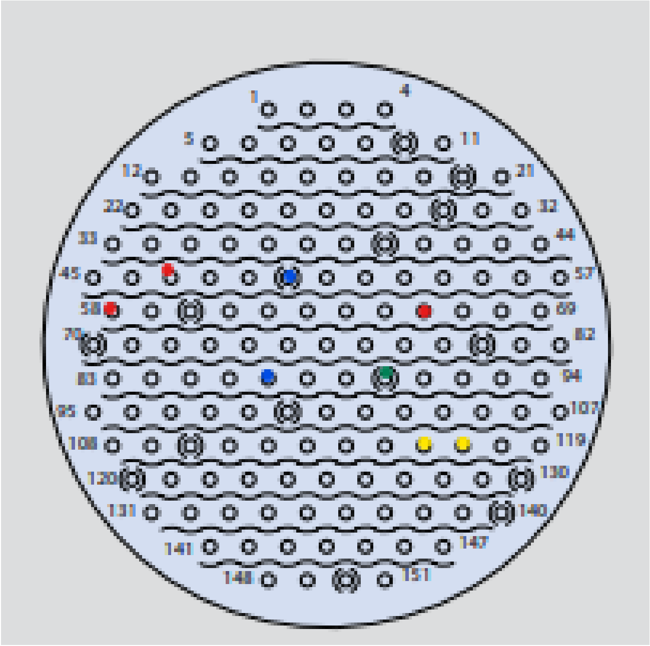


Complex Cable Construction

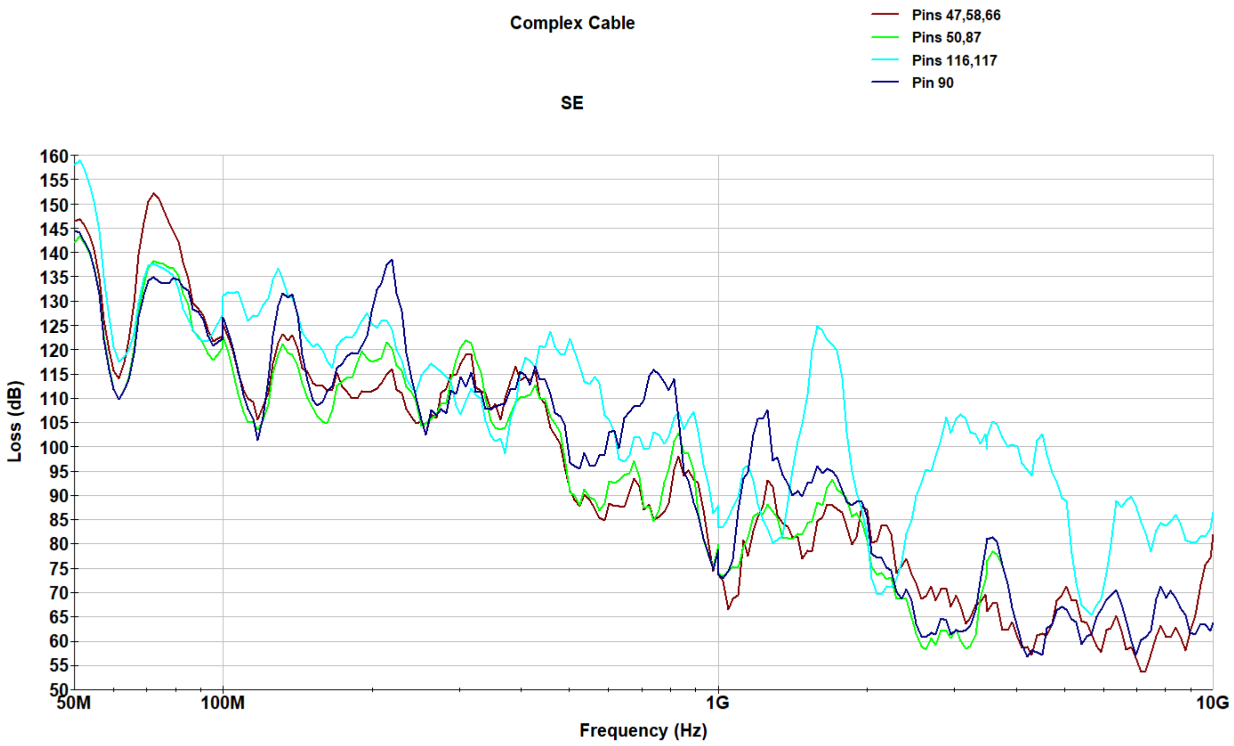
- Cable had >100 pins, composed of shielded twisted pairs, shielded twisted triple, and shielded single conductor all within a braided and foil shield.
- Connector Mil 38999 Circular Deutsch 25 mm
- Choosing what pins to test. This was a process of balancing time, location, and importance of signal.

Pin, pin every where a pin

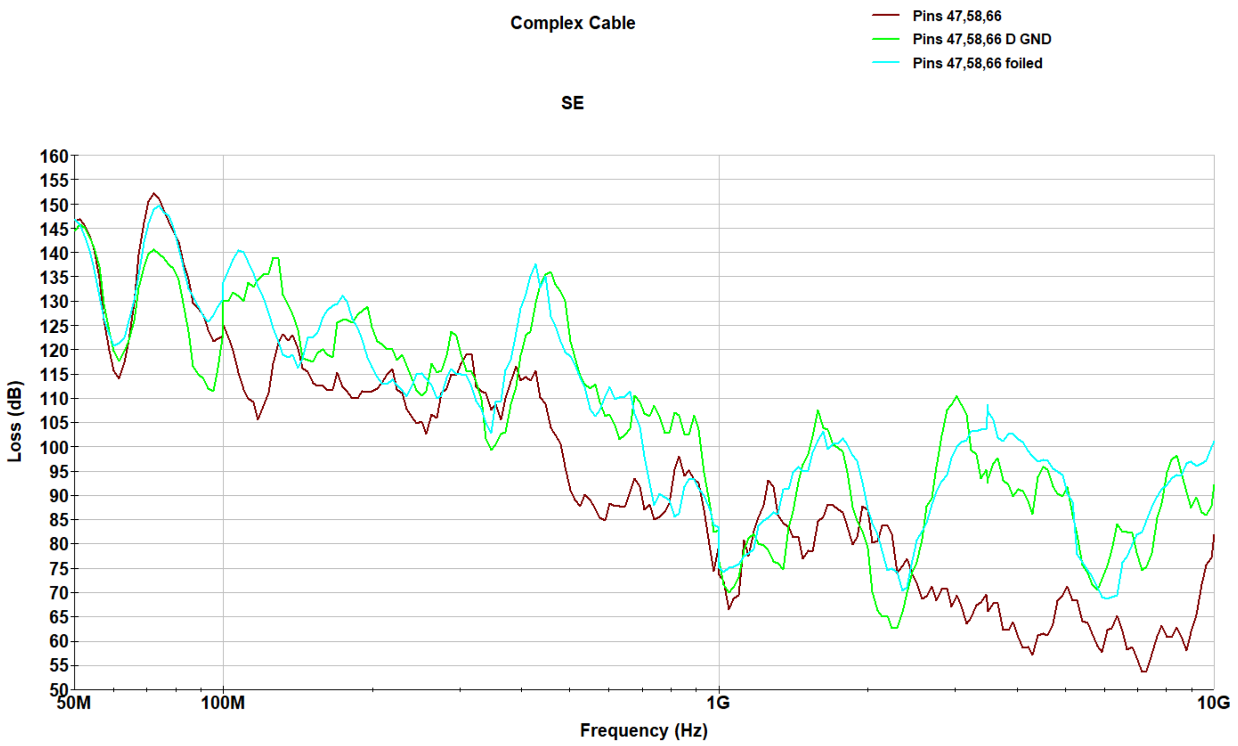
- Pins 47, 58, and 66 were the best triple shielded set both in terms of location in the connector and importance to the design.
- Pins 50 and 87 were critical to the design
- Pin 90 was both critical to the design and location
- Pins 116 and 117 were for comparison to pins 50 and 87



SE Baseline Complex Cable



Mitigation Applied for Triple Shielded



SE for enclosures

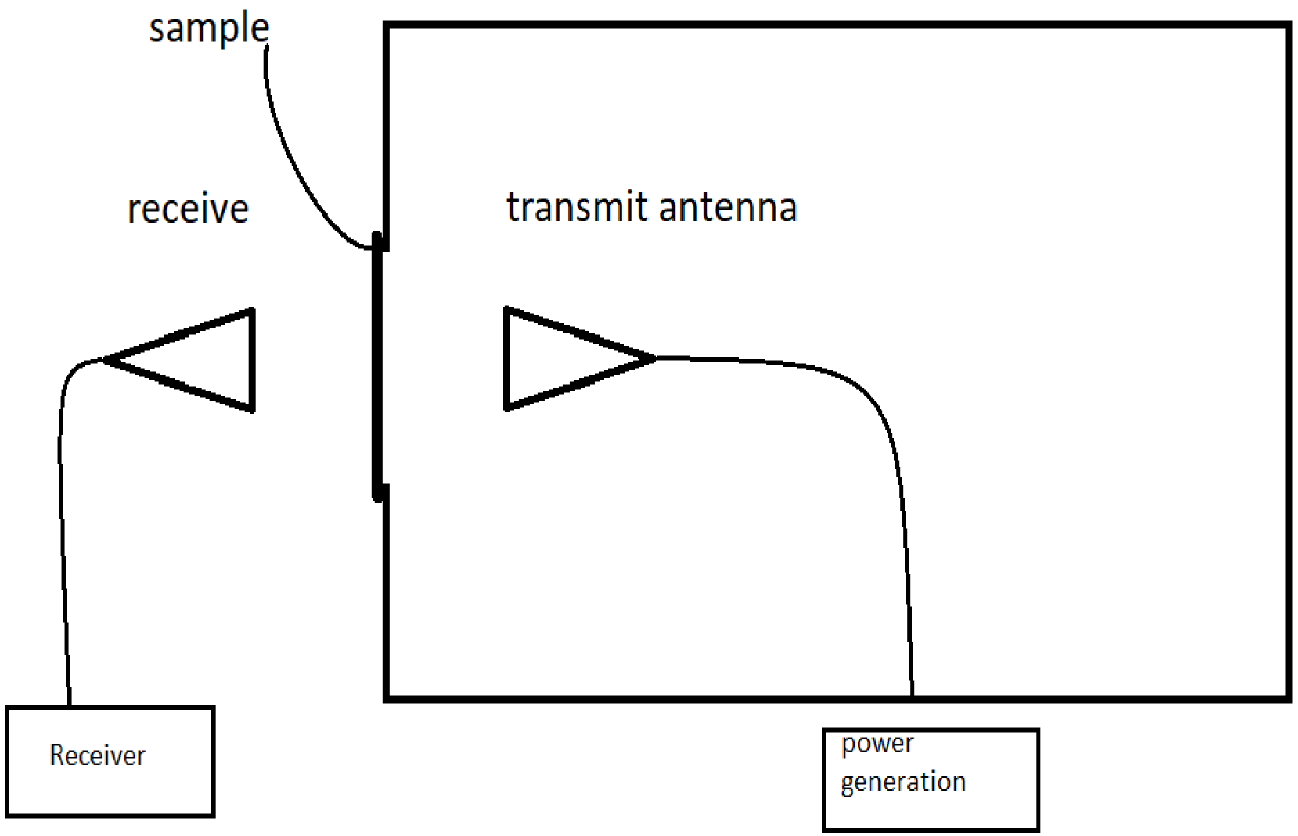
- IEEE 299-2006 IEEE Standard Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures.

This standard uses an anechoic chamber or is used to measure the SE of an anechoic chamber. Enclosure must have all dimensions greater than 2 m.

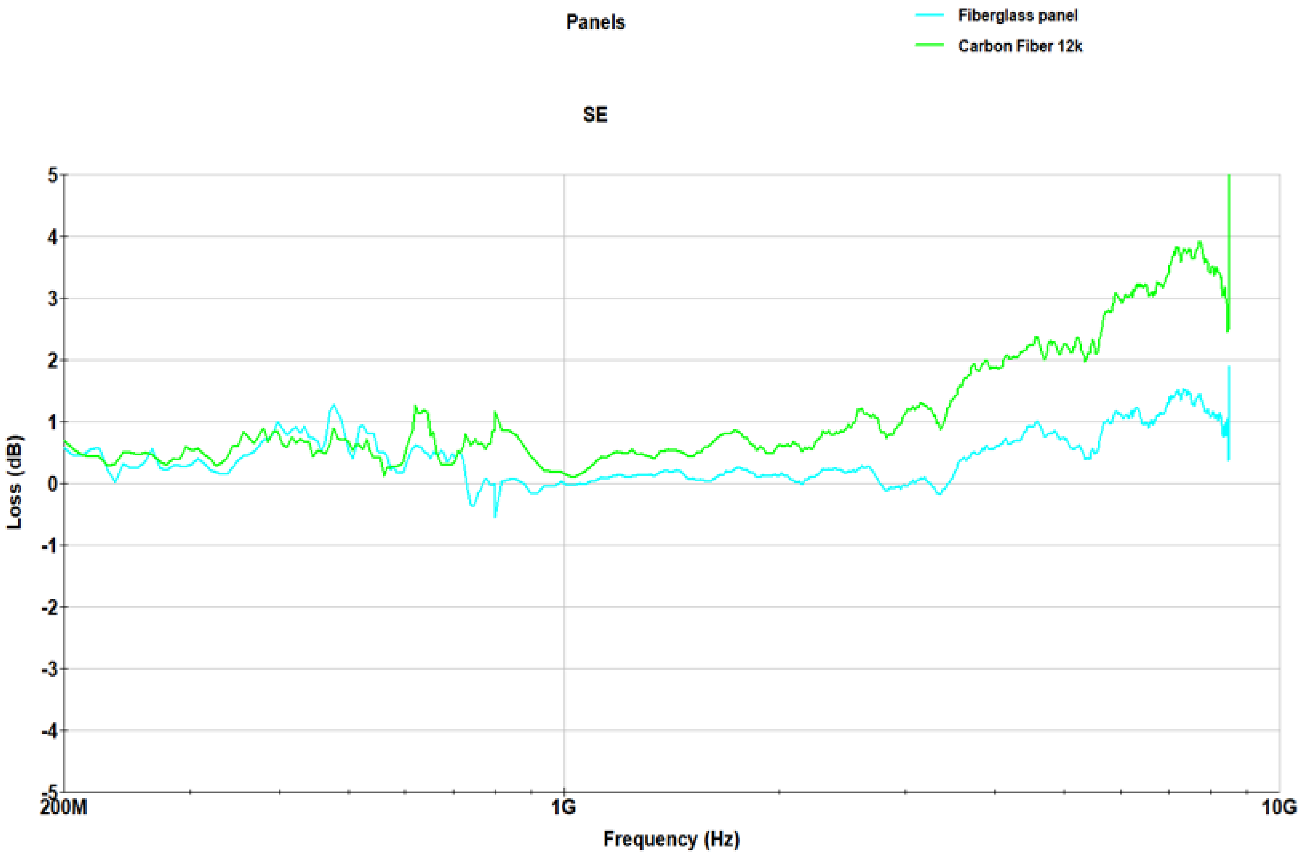
- IEEE 299.1-2013 IEEE Standard Method for Measuring the Shielding Effectiveness of Enclosures and Boxes Having all Dimensions between 0.1 m and 2 m.

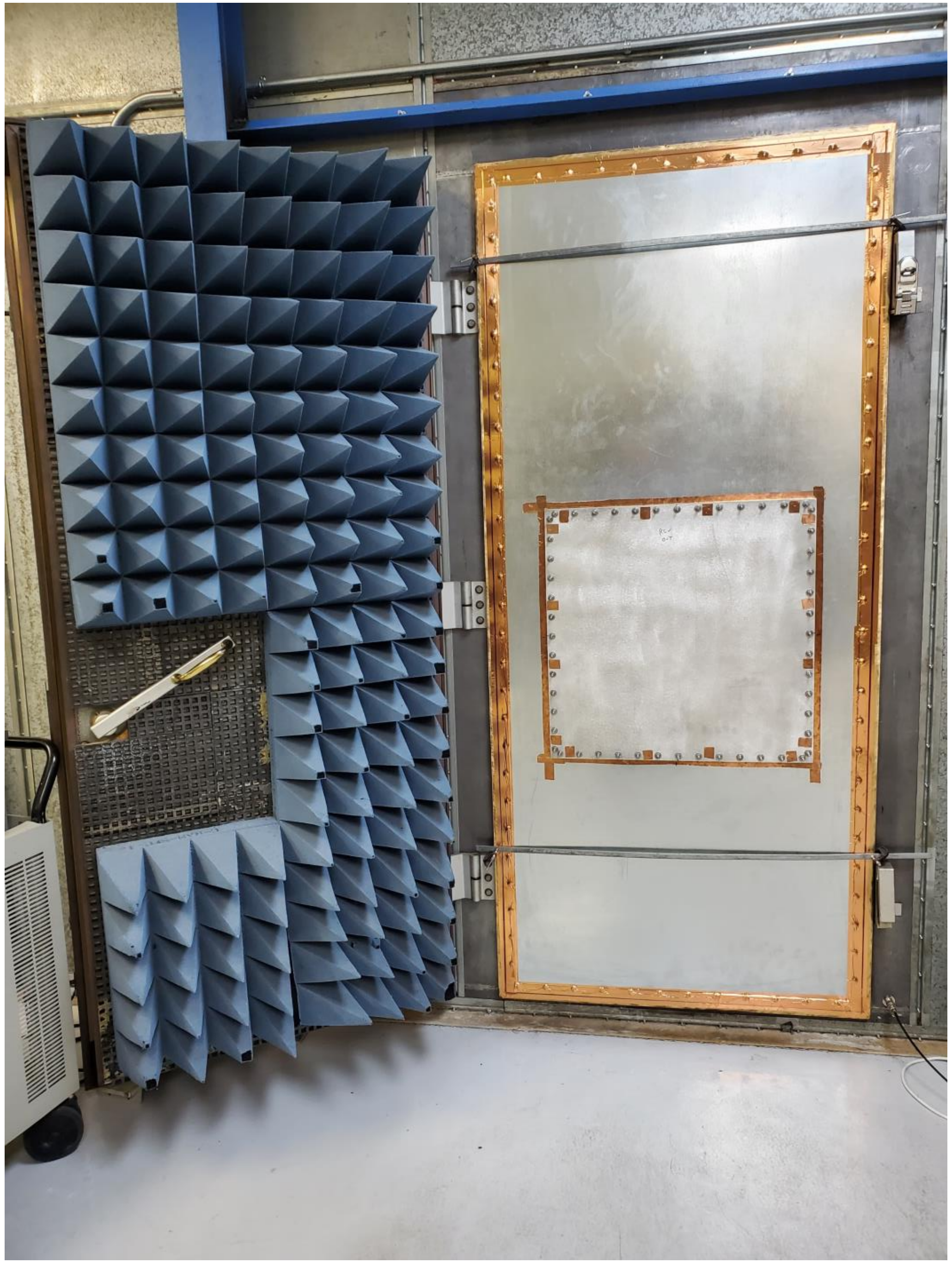
This standard has provisions for measuring SE using a reverb chamber. Annex J

SE for Panels



Fiberglass vs carbon Fiber





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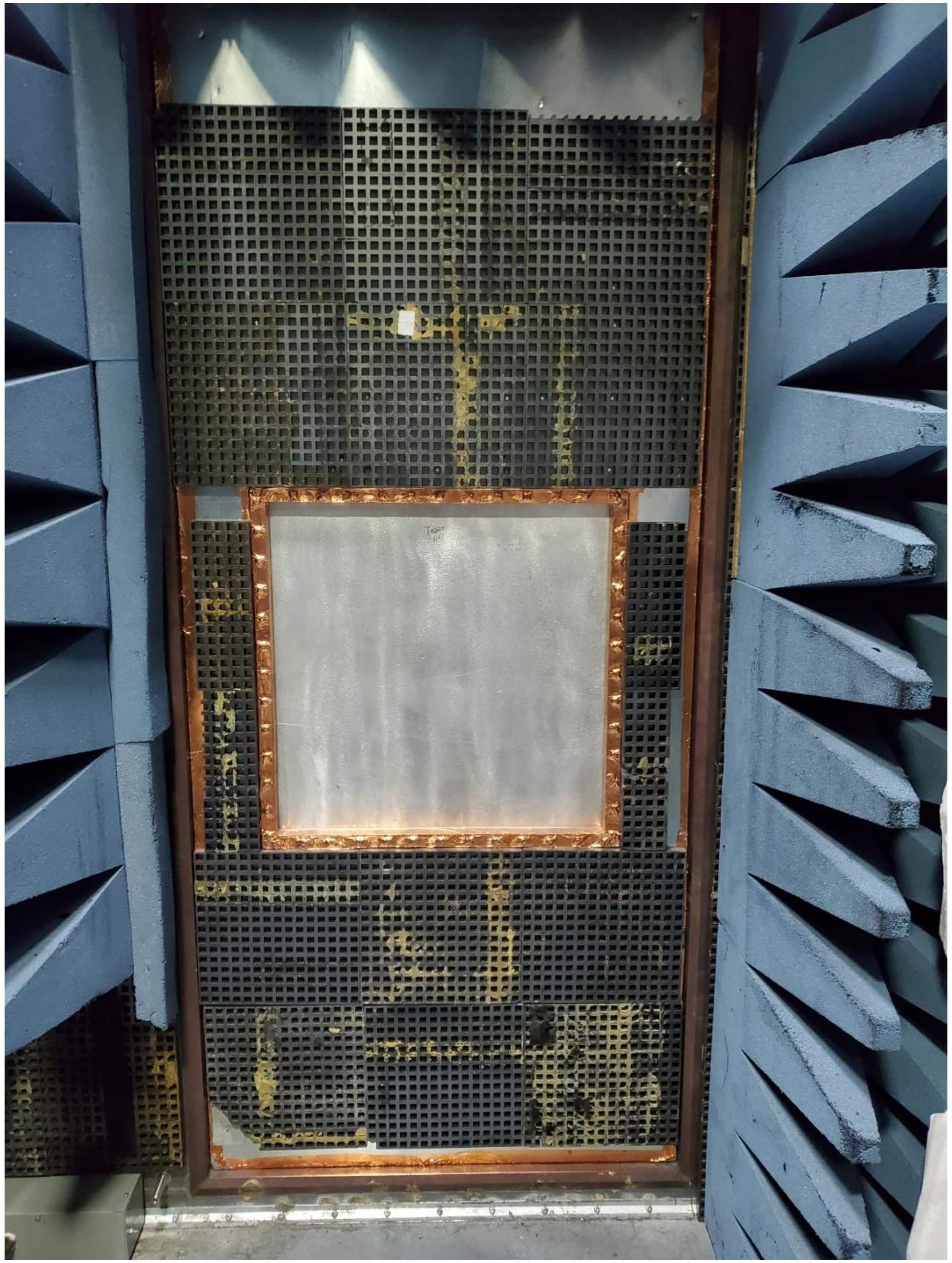
SE for Complex Panels



SE for Complex Panels

THANK YOU