Society of Cable Telecommunications Engineers

ENGINEERING COMMITTEE
Interface Practices Subcommittee

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Test Procedure for Measuring Shielding Effectiveness of Braided Coaxial Drop Cable Using the GTEM Cell

NOTICE

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1.0 SCOPE

This document details the procedure for measuring the Shielding Effectiveness (S.E.) of coaxial cable using the **G**igahertz **T**ransverse **E**lectro**M**agnetic (GTEM) cell. More particularly, this procedure applies to measuring the S.E. of 75 Ohm braided coaxial drop cables presently used within the broadband communications industry. S.E. measurements can be performed with or without the coaxial connectors removed from the measurement.

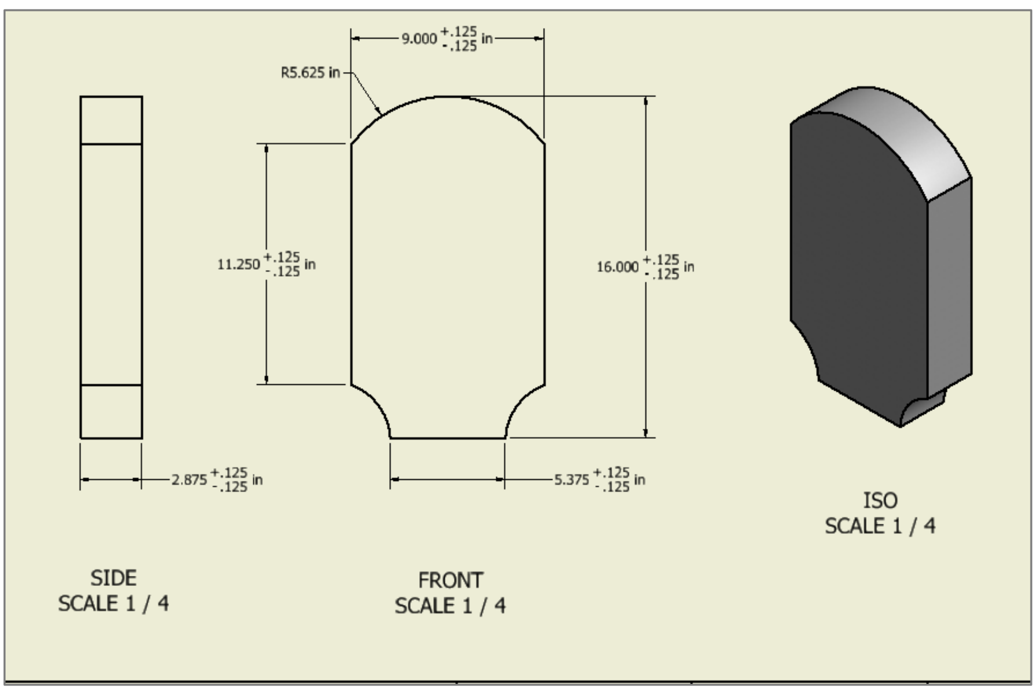
2.0 SHIELDING EFFECTIVENESS DEFINITION

When using the S.E. measurement procedure herein, the S.E. is defined as the level difference in dB between the RF energy coupled with and without the shield in place, therefore, measuring the RF shielding effectiveness of the Device Under Test (DUT). The average value across the entire range of frequencies measured (5 – 1002 MHz) is considered the S.E. of the DUT.

3.0 MEASUREMENT EQUIPMENT LIST

Refer to the Measurement Equipment List in Table A.1 of Appendix A. The measurement equipment list consists of three primary pieces of test equipment, which include a GTEM cell, spectrum analyzer or network analyzer and amplifier. A computer is optional and is strongly recommended in order to automate the measurement process to reduce measurement time and increase measurement accuracy.

Note: A foamed plastic (polyethylene, polystyrene) arch may be necessary to support the cable during testing.



4.0 MEASUREMENT EQUIPMENT

Refer to the Measurement Equipment Setup diagram in Figure B.1 of Appendix B. The arrows show the direction of RF energy flow. An RF voltage is applied to the input of the GTEM cell at point A. The RF energy that is coupled by the DUT is received at point B and is returned to the receiver of the spectrum analyzer or network analyzer for measurement via the test lead.

CAUTION: *It is always important to ensure that maximum rated voltage levels are not exceeded at the input of the amplifier and spectrum analyzer or network analyzer.*

5.0 SHIELDING EFFECTIVENESS MEASUREMENT PROCEDURE

5.1 GENERAL

The S.E. is calculated as the level difference in dB between the coupling loss measurement of the unshielded and shielded DUT. The coupling loss measurement is a measure of the voltage loss in dB between the RF voltage input to the GTEM cell (point A of Figure B.1 Appendix B) and the RF voltage coupled into the DUT and received at point B of Figure B.1 Appendix B. The coupling loss measurement is, therefore, a measure of the transmission coefficient in the frequency domain from 5 to 1002 MHz and is displayed in Log Magnitude format. When measuring the coupling loss, it is important to take into account any insertion loss pads and/or amplifier voltage levels which are used in the measurement. The number of measurement samples taken from 5 – 1002 MHz is at the discretion of the Engineer performing the test, however, as a minimum requirement there will be at least one sample point every 5 MHz (i.e. 5, 10, 15, …1002 MHz). A sweep time of 1 second or greater is recommended.

5.2 SYSTEM VERIFICATION

A system verification shall be performed by removing the GTEM cell from the measurement and connecting the test lead interfaces A and B together as shown in Figure B.1 of Appendix B. Perform an insertion loss measurement of the two test leads and any feed-thru adapters at point B. Refer to Figure D.2 of Appendix D for typical feed-thru adapter configurations. It is recommended that this system verification be performed without the use of the amplifier, since the 50 to 75 Ohm transformer is typically rated at only 0.250 Watts.

If the insertion loss measurement is greater than 10 dB, there may be a faulty component in-line and the dynamic range of the S.E. measurement may be reduced. This insertion loss measurement shall be used to zero out the insertion loss at the A and B reference plane connection, therefore, completing the system verification.

> **NOTE:** As part of the system verification, any amplifiers used in the measurement should be characterized before testing begins. The signal response

and gain of the amplifiers from 5 – 1002 MHz shall be stored until needed to calculate the shielding effectiveness of the coaxial cable.

5.3 COUPLING LOSS MEASUREMENT OF UNSHIELDED CABLE

5.3.1 UNSHIELDED CABLE SAMPLE

Whether or not the coaxial cable connectors are to be included in the S.E. measurement, the verification sample shall consist of a 1 meter (3.28 ft) length of core (inner conductor and dielectric insulation only) with the appropriate coaxial cable connectors fitted to each end as shown in Figure 5.3.1 below. The connectors are typically Type F male.

(*Helpful Note:* A layer of tape may be applied to the end of the core, in order to simulate the foil tape so that the F connector will fit snug. No crimping is necessary, so the connectors are reusable.)

> **NOTE:** The dielectric and center conductor size and type of the unshielded core should be comparable to the size and type of the dielectric and center conductor of the shielded DUT.

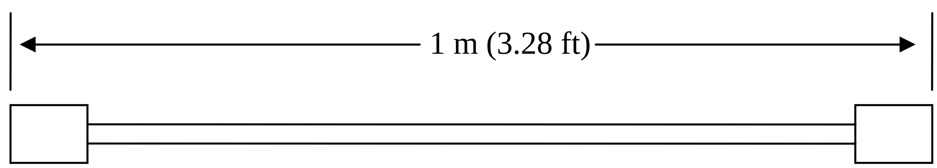


FIGURE 5.3.1 – **Unshielded Cable Sample**

5.3.2 UNSHIELDED CABLE INSTALLED WITHIN GTEM

The unshielded cable sample shall be installed within the GTEM cell as shown in Figure C.1 of Appendix C. The coaxial cable connectors shall be attached to the adapter interfaces on the feed-thru panel located in the center of the GTEM floor (since feed-thru panels are not standard equipment on some models of GTEM cells, holes may be placed on the floor of the GTEM cell centered on the access door and centerline of the cell, and the sample orientation should be in keeping with the diagram in Figure C.1 of Appendix C). One of the feed-thru adapters will be terminated with a 75 Ohm load and the other will be connected to the test lead that returns to the receiver of the spectrum analyzer or network analyzer (the connections to the feed-thru adapters are interchangeable based on the symmetry of the DUT in the GTEM). For typical adapter feed-thru configurations, refer to Appendix D.

5.3.3 UNSHIELDED CABLE COUPLING LOSS MEASUREMENT

Similar to the System Verification of section 5.2, it is recommended that the coupling loss measurement of the unshielded cable be performed without using the amplifier. Perform a coupling loss measurement of the unshielded cable and store the data to be used later for calculating the S.E. of the cable under test.

Figure E.1 of Appendix E illustrates a sample coupling loss plot of the unshielded cable under test. This trace is a measurement of the RF voltage loss between the voltage input to the GTEM cell and the voltage coupled by the unshielded cable under test.

5.4 COUPLING LOSS MEASUREMENT OF SHIELDED CABLE

5.4.1 SHIELDED CABLE SAMPLE

WITH CONNECTORS IN MEASUREMENT

When including the coaxial cable connectors within the S.E. measurement, the shielded cable sample under test shall consist of a 1 meter (3.28 ft) length with the appropriate coaxial cable connectors attached to each end per the manufacturer's instructions as shown in Figure 5.4.1a below. The cable outer conductor shield and jacket shall remain undisturbed.

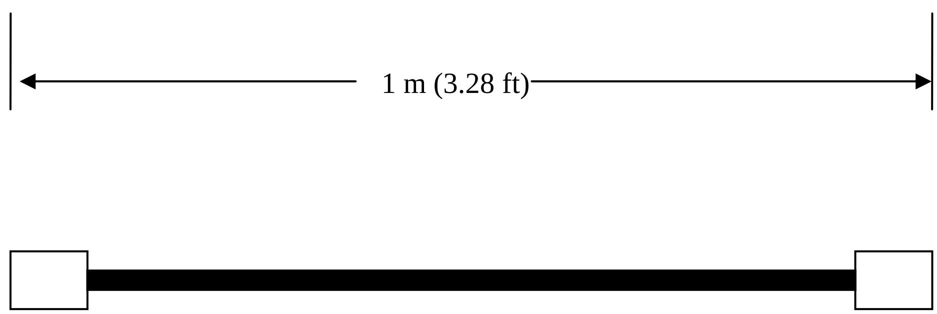
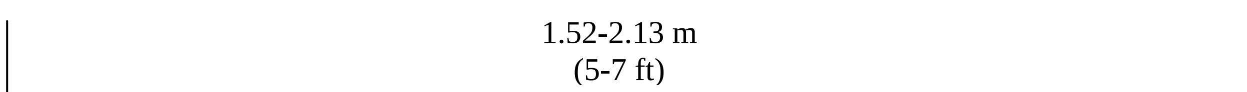


FIGURE 5.4.1a – Shielded Cable Sample
(When Including Coaxial Cable Connectors in Measurement)

WITH CONNECTORS REMOVED FROM MEASUREMENT

The connectors may be removed from the measurement if necessary. When removing the coaxial cable connectors from the S.E. measurement, the shielded cable sample under test shall consist of a 1.52-2.13 m (5-7 ft) length with two sections of jacket removed as shown in Figure 5.4.1b below.



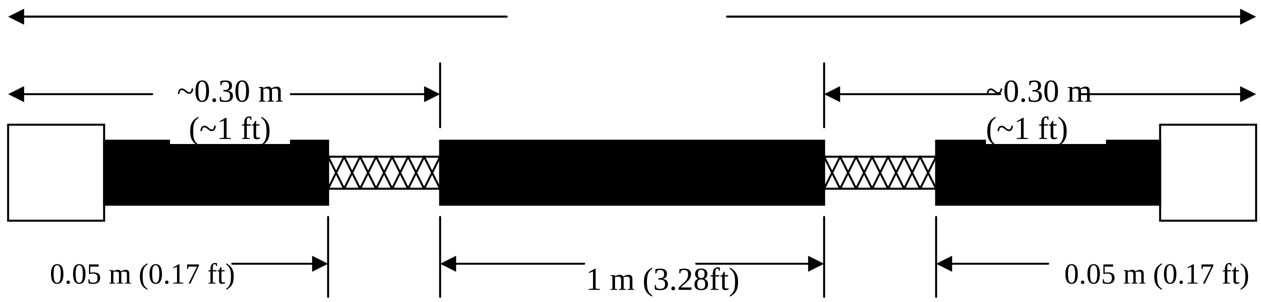


FIGURE 5.4.1b - **Shielded Cable Sample**
(When Removing Coaxial Cable Connectors from Measurement)

The shielded cable sample in Figure 5.4.1b is a total of 1.52-2.13m (5-7 ft) in length. Two inches of jacket are removed at the two locations specified from the drawing, in order to accommodate the cable feed-thrus in the GTEM floor. Therefore, a 1 meter (3.28 ft) section of the shielded cable will remain inside the GTEM cell after being installed.

Due to the coaxial cable connectors being outside of the GTEM cell and isolated from the electromagnetic fields, the coaxial cable connectors do not need to be crimped, therefore, enabling reuse of the connectors.

> **NOTE:** It is important to be careful not to disturb the cable's outer conductor shield, when removing the sections of jacket from the cable.

5.4.2 SHIELDED CABLE INSTALLED WITHIN GTEM

WITH CONNECTORS IN MEASUREMENT

When including the coaxial cable connectors within the S.E. measurement, the shielded cable sample shall be installed within the GTEM cell identically to how the unshielded cable sample was installed in section 5.3.2 and shall use the same feed-thru adapter configurations.

WITH CONNECTORS REMOVED FROM MEASUREMENT

1) When removing the coaxial cable connectors from the S.E. measurement, the adapter feed-thru on the GTEM floor, shown in Appendix D, need to be replaced with the appropriate sized cable feed-thru. It is recommended that interchangeable feed-thru panels be used to switch the size of the cable feed-thru. Refer to Appendix F for a drawing of a typical cable feed-thru.

2.) Once the appropriate sized cable feed-thru are in place, the shielded cable sample shall be installed as shown in Figure C.1 of Appendix C. The cable feed-thru are used to clamp around the outer conductor shield of the cable sample where the two-inch sections of jacket have been removed.

In doing this, a 1 meter (3.28 ft) length middle section of the cable sample will remain inside the GTEM cell and the two ends of the cable that are approximately 0.30 m (12 inches) in length will extend outside the GTEM cell through the floor.

3.) The cable sample ends shall be terminated similarly to how the unshielded cable sample was terminated in section 5.3.2, however, this sample will be terminated outside the GTEM cell.

5.4.3 SHIELDED CABLE COUPLING LOSS MEASUREMENT

The coupling loss measurement of the shielded cable is typically performed with the use of the amplifier in-line as shown in Figure B.1 of Appendix B. Perform a coupling loss measurement of the shielded cable and store the data to be used later for calculating the S.E. of the cable under test.

For highly shielded drop cable it is recommended that a pre-amp be used in the measurement to ensure proper dynamic range of the test equipment. When a pre-amp is used, it shall be inserted at the input of the spectrum/network analyzer.

5.5 SHIELDING EFFECTIVENESS CALCULATION

The S.E. of the cable under test is the level difference in dB between the energy coupled by the unshielded and shielded cable sample and can be calculated from the following equation:

S.E. = (Coupling Loss of Shielded Cable + Amplifier Gain) – (Coupling Loss of Unshielded Cable)

Figure G.1 of Appendix G illustrates a sample S.E. plot and displays the average S.E. values.

> **NOTE:** In the S.E. equation above, all values are considered absolute. Also, the S.E. is defined as the average across the range of frequencies (5 – 1002 MHz).

If a pre-amp is used on the shielded sample measurement, the pre-amp gain will be added to the total amplifier gain in the S.E. equation above.

APPENDIX A – EQUIPMENT LIST

ITEM NO.	QTY	Description	Manufacturer and Model No./P/N
1	1	Gigahertz Transverse Electromagnetic (GTEM) Cell with 50 Ohm Type N interface	EMC Test Systems Model 5305 or equivalent
2	1	Network / Spectrum Analyzer with tracking generator with 50 Ohm Type N interface	Agilent HP8594E with option 010 or equivalent
3	1	RF Amplifier, 10 Watt (+40 dBm), 5 – 1002 MHz with 50 Ohm Type N interface	Amplifier Research Model 10W1000B or equivalent
4	1	50 to 75 Ohm min-loss pad with Type N interfaces and minimum loss (5 – 1002 MHz)	Agilent HP11852B or equivalent
5	1	Pre-amp[1]	Miteq Model AM-3A-000110-N-1179 or equivalent
6	1	Computer (Optional)[2]	

Table A.1 – Measurement Equipment List

[1] A pre-amp is optional for drop cables, but is strongly recommended for highly shielded drop.

[2] A computer is optional, but is strongly recommended in order to automate the measurement process to reduce measurement time and increase measurement accuracy. The spectrum analyzer or network analyzer and amplifier, if fitted with a proper I/O port such as IEEE 488 (HP-IB) or RS 232 can be operated remotely via the computer acting as the system controller. Use of a computer also enables data processing, display and storage.

APPENDIX B – EQUIPMENT SETUP

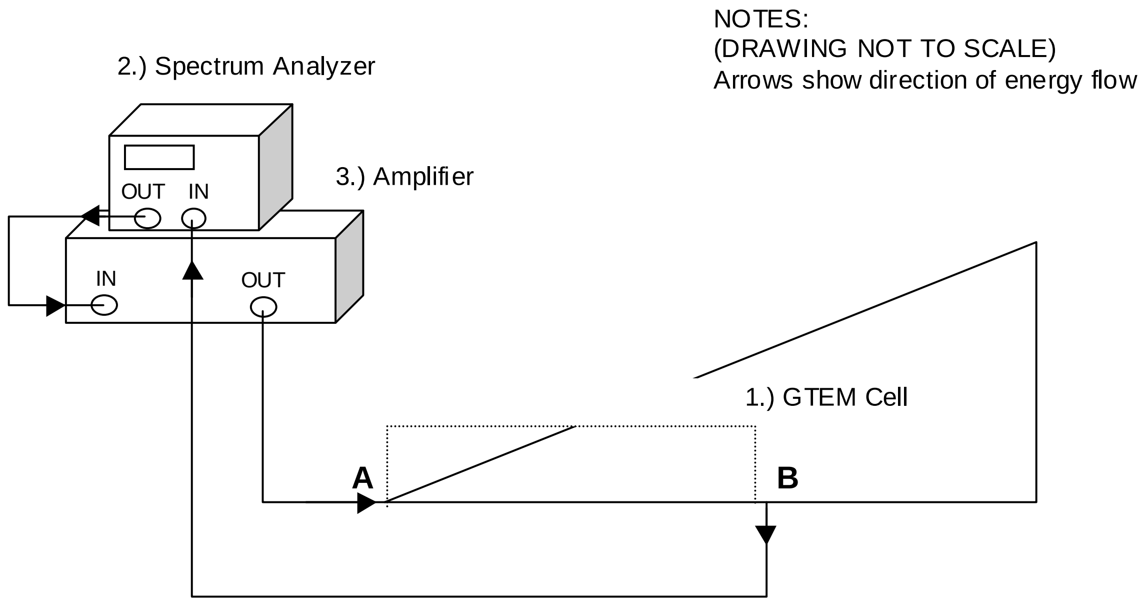


Figure B.1 – Measurement Equipment Setup Diagram

The three test leads shown in Figure B.1 are of the 50 Ohm coaxial cable transmission line type with Type N male coaxial connectors at each end. The coaxial cable design is typically a hard-line construction, but may be of a flexible design as long as the shielding of the cable is of high quality. A poor cable design of the test leads may cause reduced dynamic range in the test measurements.

APPENDIX C – TYPICAL GTEM CONFIGURATIONS

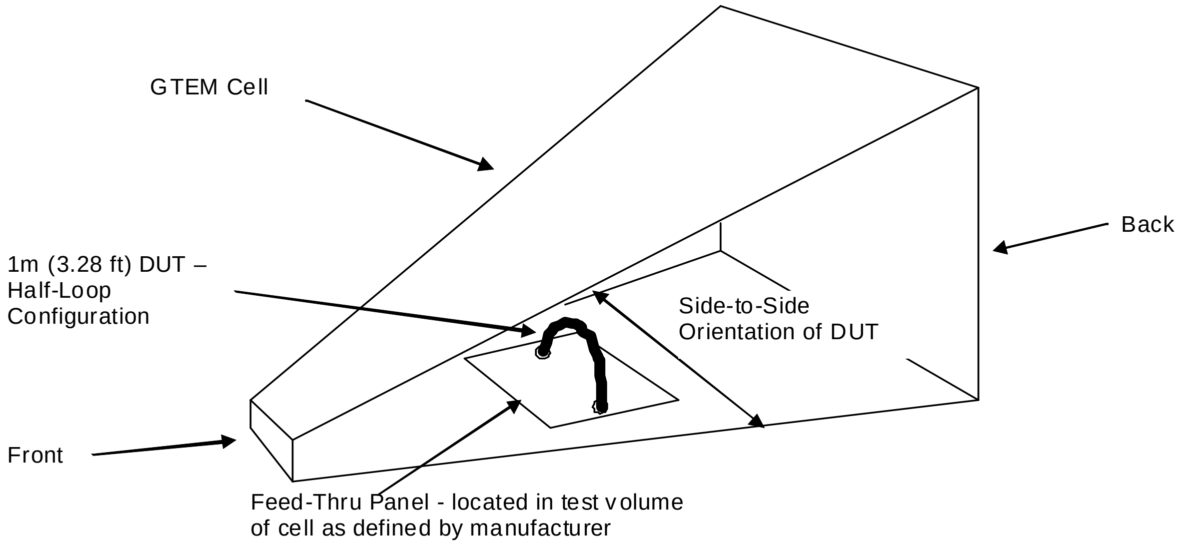


FIGURE C.1 – Cut Away of GTEM Cell Illustrating the Positioning of the DUT in the GTEM

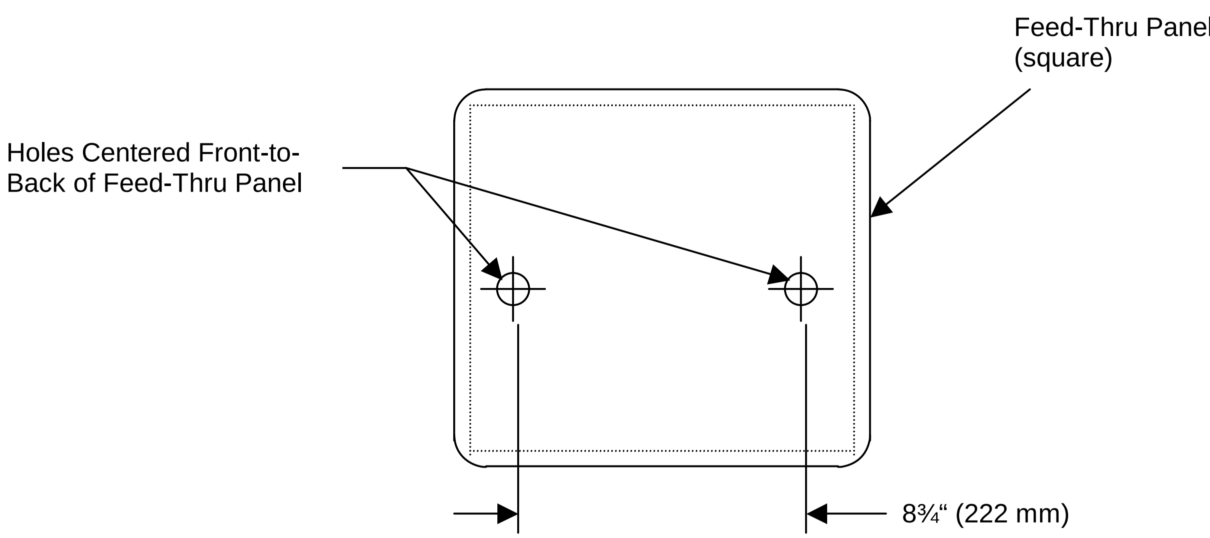


FIGURE C.2 – GTEM Feed Thru Panel With Dimensions

APPENDIX D - TYPICAL ADAPTER FEED-THRU CONFIGURATIONS

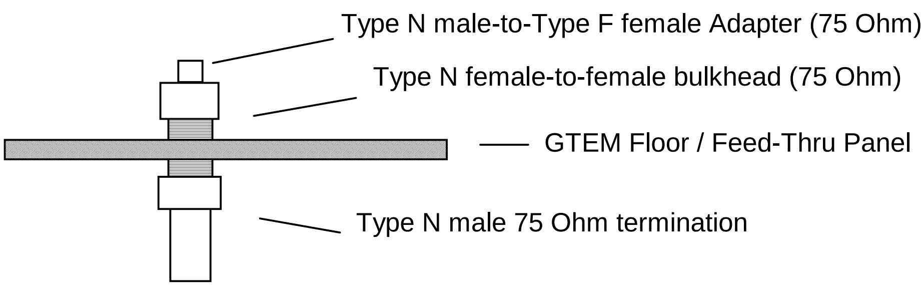


FIGURE D.1

Figure D.1 is a typical feed-thru adapter setup used on the GTEM floor / feed-thru panel in order to terminate a drop cable with its matching impedance.

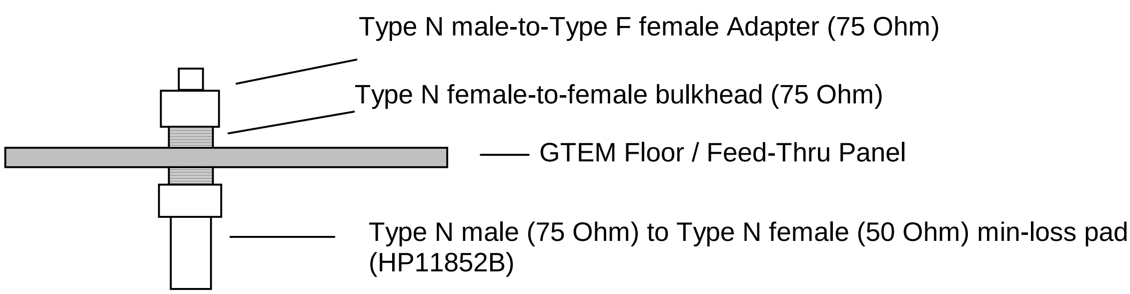


FIGURE D.2

Figure D.2 is a typical feed-thru adapter setup used on the GTEM floor / feed-thru panel in order to match the 75 Ohm impedance of the cable sample under test to the 50 Ohm impedance of the test lead.

APPENDIX E - SAMPLE COUPLING LOSS PLOT OF UNSHIELDED CABLE

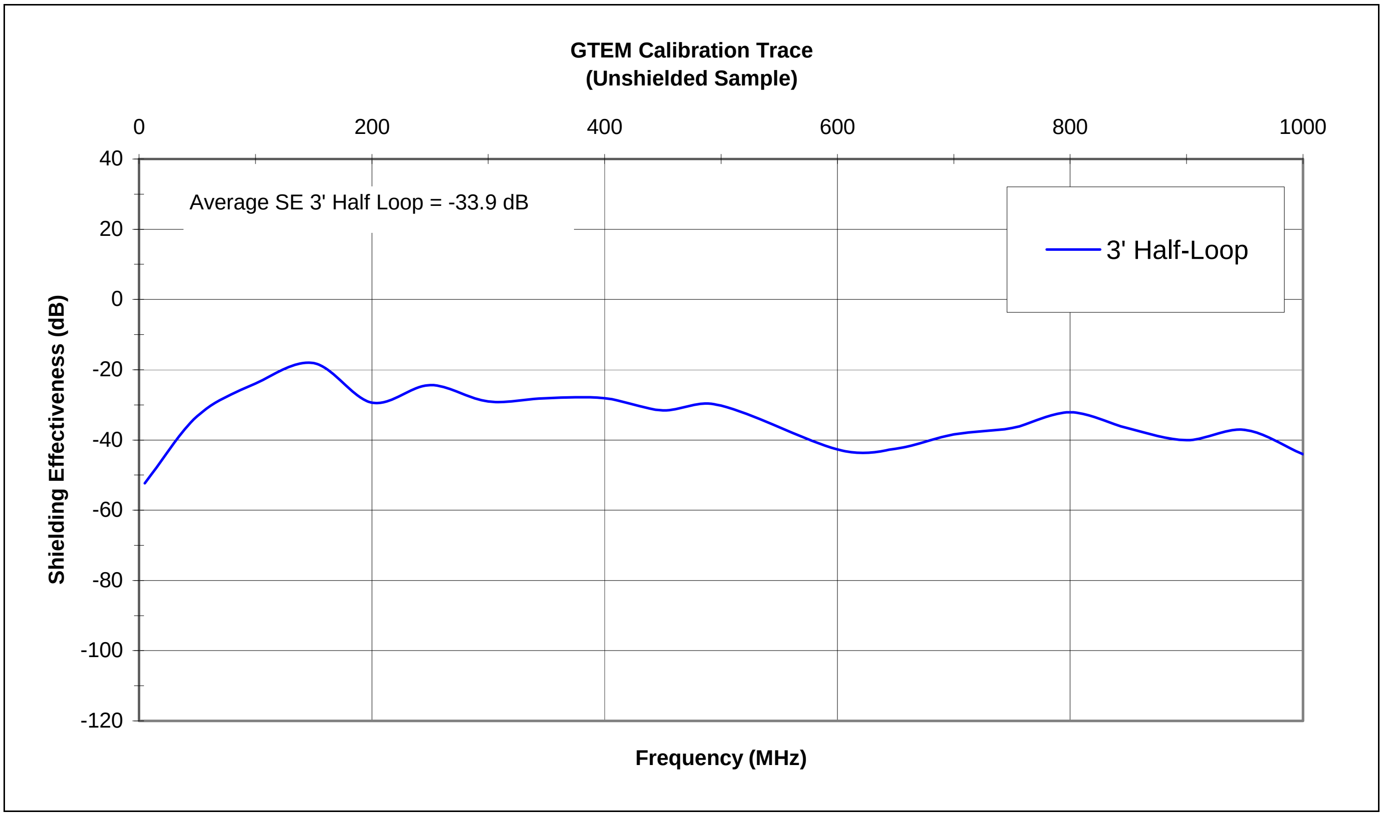
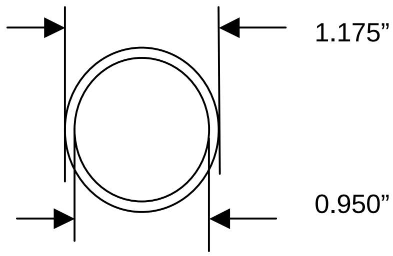
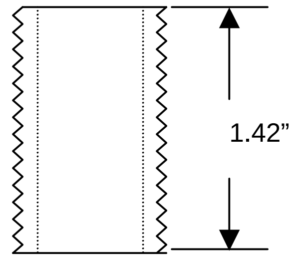


FIGURE E.1 – Sample Coupling Loss Plot of Unshielded Cable

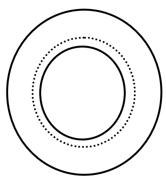
APPENDIX F - TYPICAL CABLE FEED-THRU CONFIGURATION



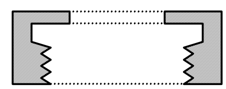
Barrel (Top View)



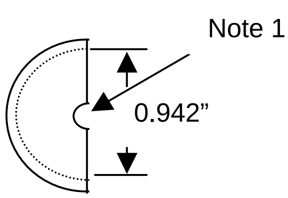
Barrel (Side View)



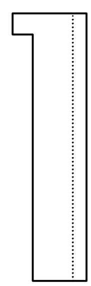
Collar (Top View)



Collar (Side View)



Half Sleeve (Top View)



Half Sleeve (Side View)

NOTE 1: This opening shall be the diameter of the cable under test outer conductor OD.

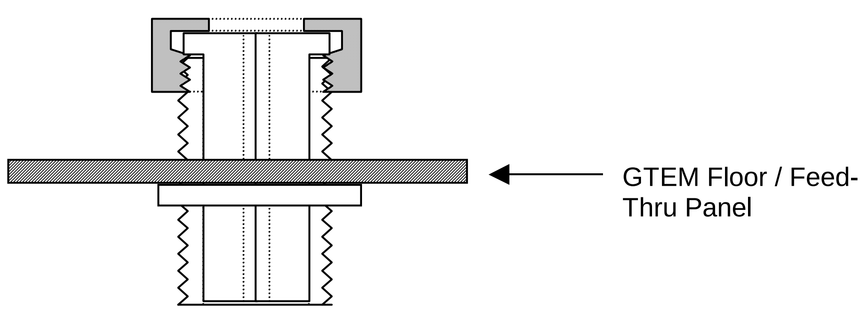


FIGURE F.1 - Assembled Cable Feed-Thru Unit (Side View)

APPENDIX G - SAMPLE S.E. PLOT OF SHIELDED CABLE (CONNECTORS IN THE MEASUREMENT)

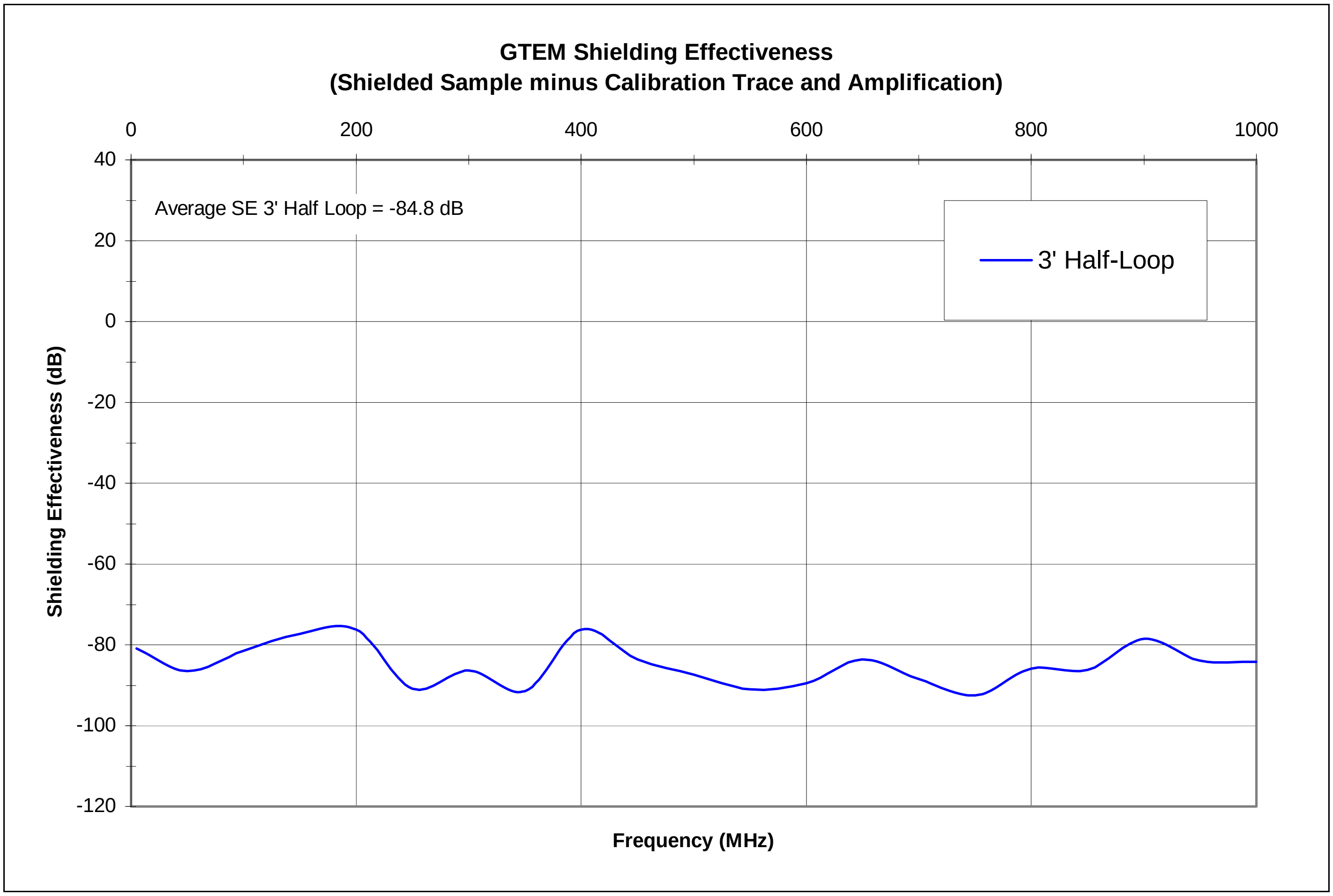


FIGURE G.1 – Sample S.E. Plot of Shielded Cable (Connectors in the Measurement)