Report Of

Shielding Effectiveness Test
For

SafeSleeve Radiation Shielding Technology

Test Date(s): June 02 – June 03, 2021
and June 07 – June 09, 2015

Issue Date: June 8, 2021

UST Project: 21-0183

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I certify that I am authorized to sign for the test facility and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US Tech (Agent Responsible For Test):

By: ______________________________

Name: Alan Ghasiani

Title: Compliance Engineer – President

Date: June 8, 2021

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1 General Information for Above 6 GHz Testing

1.1 Characterization of Test Sample

A roll of the Sample Under Test (SUT) was received on June 1, 2021 in good condition. An approximately 40 cm by 40 cm piece of the material was cut for testing, as shown in Figure 1 below.

1.2 Product Description

The SUT is a proprietary material which is used as a protective shield against RF and magnetic field radiation in consumer and professional applications.

Figure 1. Photograph of SUT used for Above 6 GHz Testing

2 Test Facility for Above 6 GHz Testing

Testing was performed at US Tech's test facility located in Alpharetta, Georgia. US Tech is an FCC Recognized (Designation Number US5117) and NVLAP Accredited (Lab Code 200162-0), third-party independent laboratory specializing in regulatory EMC Testing.

2.1 Test Equipment

A list of test equipment used for these measurements is found in Table 1, following.

Table 1 below lists the equipment used for this test

Table 1. Test Instruments and Accessories used for Above 6 GHz Testing

INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	CALIBRATION DUE DATE
Network Analyzer	N5230A	Agilent Technologies Inc	MY45000829	4/28/2022
Horn Antenna (Rx)	3115	EMCO	9107-3723	2/3/2023 2 yr cal
Horn Antenna (Tx)	SAS-571	AH systems	605	2/28/2022 2 yr cal
RF Enclosure	0100-1030-3-002	MAXSYS	002	NA

3 Theory of Measurement for Above 6 GHz Testing

Shielding effectiveness is obtained by producing a strong CW signal and taking the difference of two measurements: one without any shield and one with the shield, provided that:

1. Nothing changes in the setup when placing the shield.
2. The dynamic range is greater than the anticipated attenuation by the shield.

Then, shielding effectiveness is determined by:

SE (in dB) = 20 log (E1/E2)
Or, in reduction in percentage: 100* (E1-E2)/E1,

where E1 and E2 are the signals measured by the receiving antenna/probe with and without the shield, using the same physical test setup for both measurements.

Since spectrum analyzers read power, shielding effectiveness is determined by the dB difference between the two shielded and unshielded power levels, read in dBm.

4 Test Configuration and Procedure for Above 6 GHz

The Network Analyzer was set to sweep from 5 Ghz to 20 GHz. A metal EMC enclosure with an opening on top was used for this test. Two horn antennas were placed facing each other, one inside the enclosure and the other outside at a distance of 1.5 meters from each other.

Figure 2 below shows the test configuration used to measure the Electromagnetic Radiation Shielding Effectiveness of the SUT at Frequencies of 5 GHz to 20GHz.

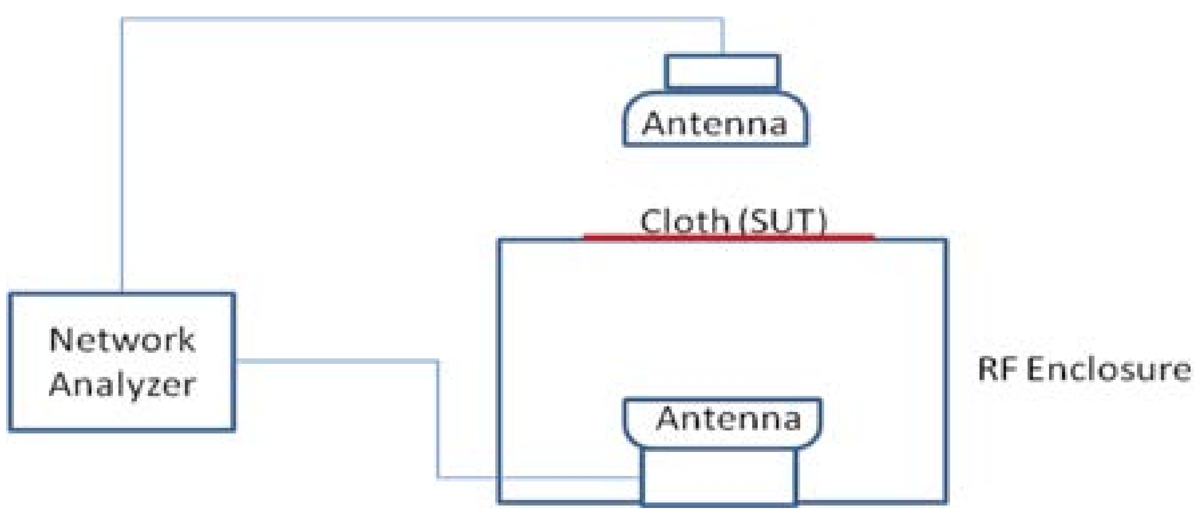


Figure 2. Test Setup Diagram – Above 6 GHz Testing

By disconnecting the inside antenna and placing a 50 Ohm terminator in its place, the dynamic range of the test was measured to confirm the required system dynamic range (40 dB), as shown in Figure 3.

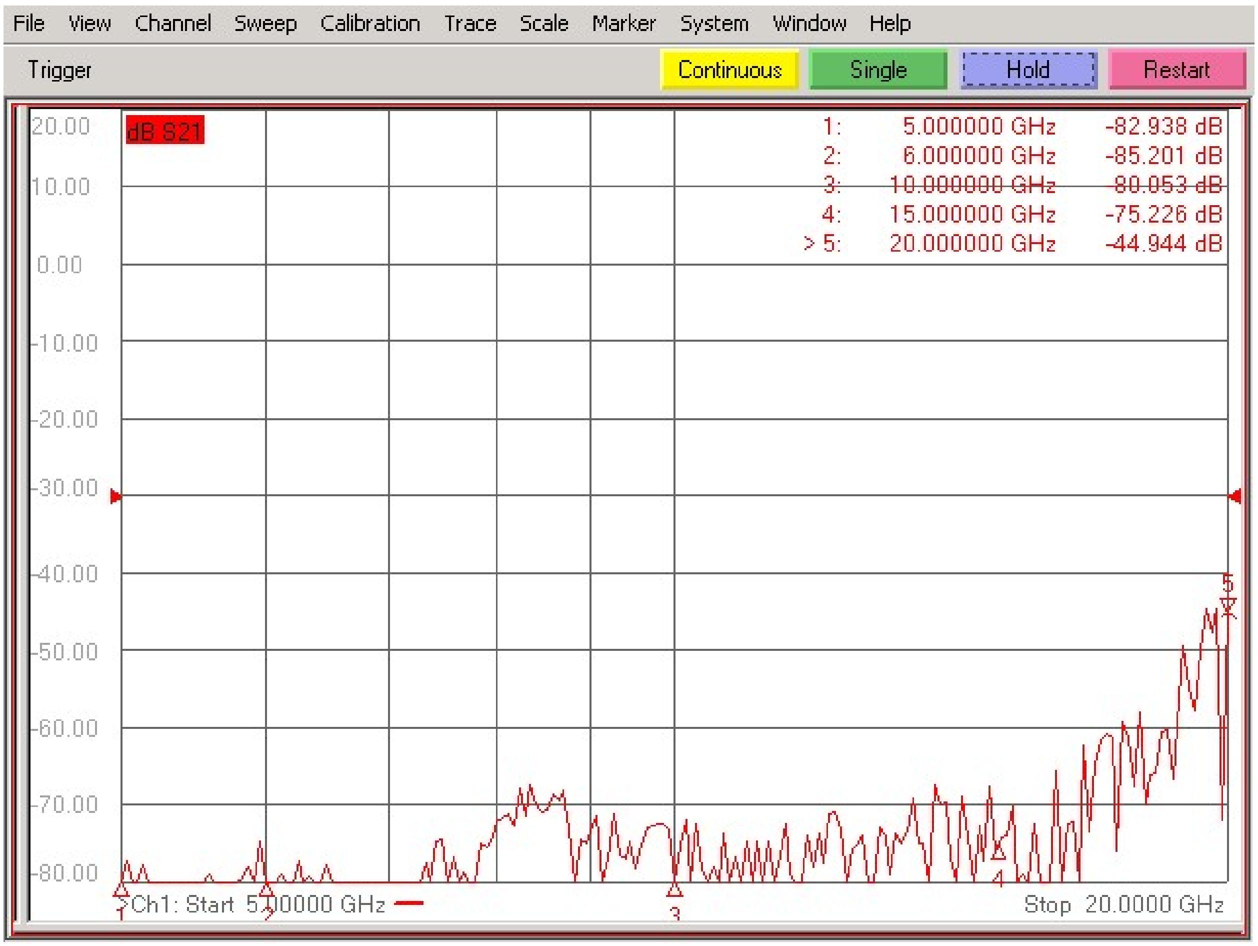


Figure 3. Dynamic Range

The inside antenna was then reconnected. A through response with the enclosure top open was normalized to zero. The sample (SUT) was then placed to fully cover and seal the opening at the top of the RFI enclosure. The Network Analyzer swept the test range of 5 GHz to 20 GHz and the S21 plot was recorded. Figure 4 below shows the plot.

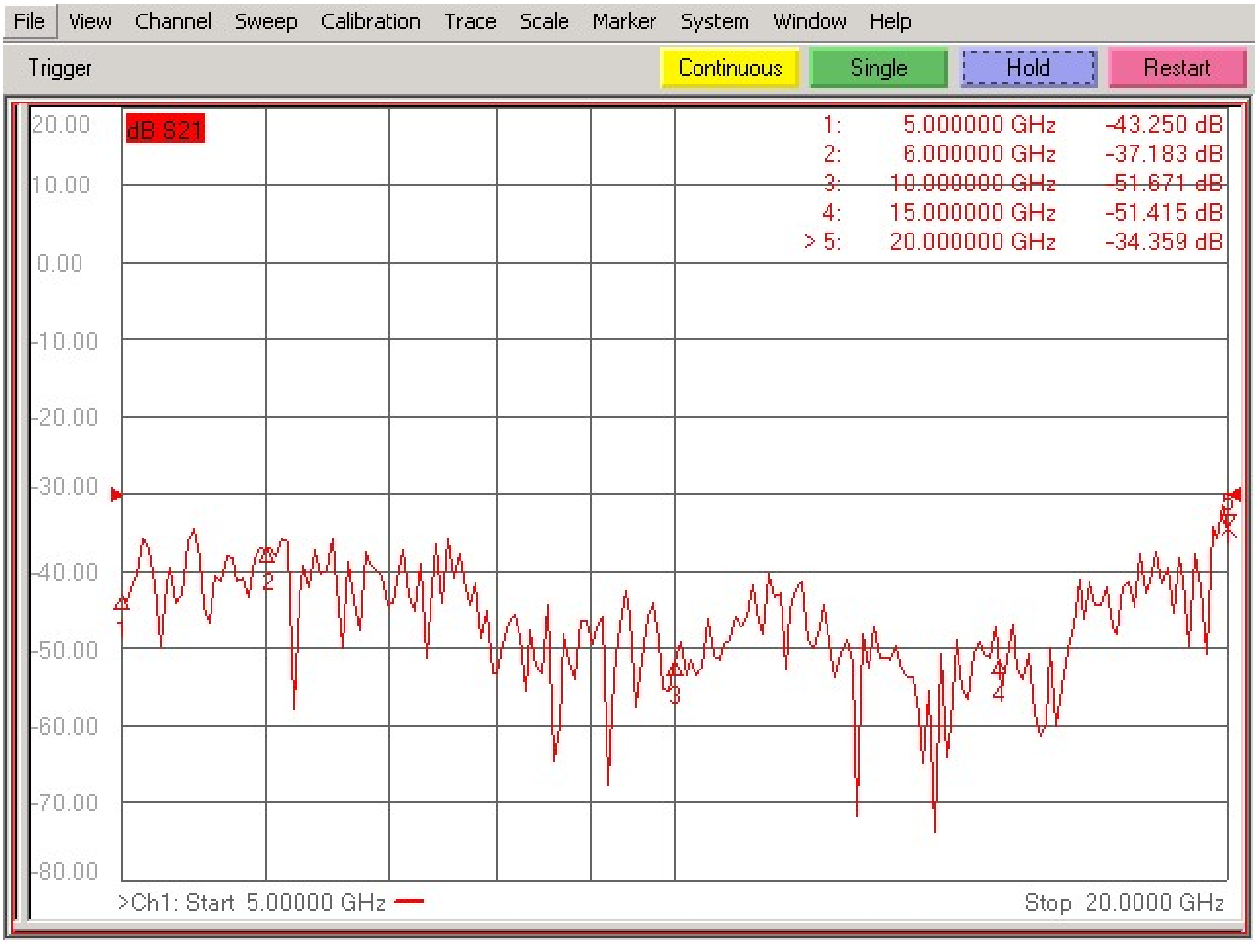


Figure 4. Testing Data, Above 6 GHz Testing

The high frequency test configuration is shown in Figures 5 and 6 following.

Figure 5. High Frequency Test Configuration Photograph – Above 6 GHz Testing

Figure 6. Sample Under Test Sealing Enclosure Opening – Above 6 GHz Testing

5 Summary and Test Results for Above 6 GHz Testing

Shielding effectiveness at requested frequencies was calculated as previously described and results are presented in Table 2 following.

Table 2. Test Results – Above 6 GHz Testing

Frequency	Without Shield (dBm)	With Shield (dBm)	Delta (dB)	Percentage Reduction
6.0 GHz	0 db	-37.18 dB	37.18 dB	**99.98%**
10.0 GHz	0 db	-51.67db	51.67db	**99.999%**
15.0 GHz	0 db	-51.45 db	51.45 db	**99.999%**
20.0 GHz	0 db	-34.35 db	34.35 db	**99.97%**

The measurement uncertainty (with a 95% confidence level) for these tests is ± 3 dB.

6 General Information for Below 5 GHz Testing

6.1 Characterization of Test Sample

Two test samples, referred to as SUT herein, used were received by US Tech on June 1, 2015 in good operating condition.

6.2 Product Description

The original Sample Under Test (SUT) is a 26 cm by 29 cm sample of the shielding material used by SafeSleeve in their Shielding Technology. The SUT is a proprietary material which is used as a protective shield against RF and magnetic field radiation in consumer and professional applications.

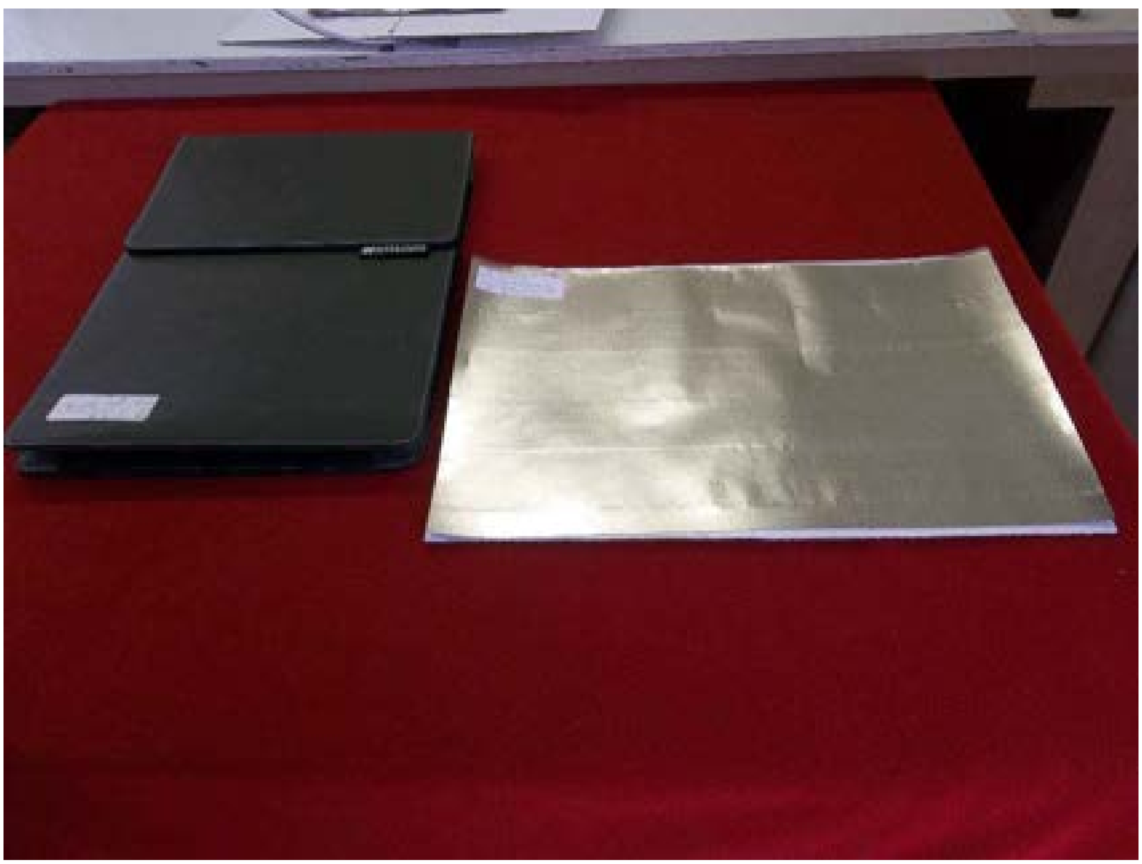


Figure 7. Photograph of Laptop Cover and SUT

7 Test Facility for Below 5 GHz Testing

Testing was performed at US Tech's test facility located in Alpharetta, Georgia. US Tech is an FCC Recognized (Designation Number US5117) and NVLAP Accredited (Lab Code 200162-0), third-party independent laboratory specializing in regulatory EMC Testing.

7.1 Test Equipment

A list of test equipment used for these measurements is found in Table 3, following.

Table 3. Test Instruments and Accessories Used for Below 5 GHz Testing

INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
Audio Signal Generator	1G-5218	Heathkit	1G-5218-01	Adjusted with Calibrated meter
Spectrum Analyzer	E4407B	Agilent	US41442935	1/28/15
Log Periodic Yagi Antenna	LPY2	Ramsey Electronics	WA5VJB-1	N/A
Log Periodic Antenna	LPY26	Ramsey Electronics	WA5VJB-2	N/A
Signal Generator	70340A	Hewlett Packard	3339A00941	During Test
Signal Generator	8648B	Hewlett Packard	3642U01679	During Test
Audio Power Amplifier	EXA2950	GEM Sound	NA	During Test
Graphic Multimeter	Fluke	867B	DM7060268	06/19/14
AC Milligauss Meter	UHS2	Alphalab, Inc.		During Test
Wire Spool	NA	Custom Made US Tech	NA	NA

Note: The calibration interval of the above test instruments is 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

8 Theory of Measurement for Below 5 GHz Testing

Shielding effectiveness is obtained by producing a strong CW signal and taking the difference of two measurements: one without any shield and one with the shield, provided that:

1. Nothing changes in the setup when placing the shield.
2. The dynamic range is greater than the anticipated attenuation by the shield.

Then, shielding effectiveness is determined by:

SE (in dB) = 20 log (E1/E2)
Or, in reduction in percentage: 100* (E1-E2)/E1,

where E1 and E2 are the signals measured by the receiving antenna/probe with and without the shield, using the same physical test setup for both measurements.

Since spectrum analyzers read power, shielding effectiveness is determined by the dB difference between the two shielded and unshielded power levels, read in dBm.

9 Test Configuration and Procedure for Below 5 GHz Testing

The objective is to measure shielding effectiveness of the SUT at different frequencies. Section 4.1 of this report outlines the procedures used to measure low frequency (60 and 300 Hz) magnetic field shielding, and Section 4.2 of this report outlines the procedures used to measure EMC shielding at higher frequencies.

9.1 Extremely Low Frequency (ELF) Electromagnetic Radiation (EMR) Shielding Effectiveness (Magnetic Component at 60 and 300 Hz)

9.1.1 Detailed Test Procedure- Below 5 GHz Testing

Before setting up the test, the dynamic range of the probe was noted to be from a few milligauss to about 1400 milligauss, and, the setup was examined to confirm the required system dynamic range for this test (40 dB).

An audio signal generator was set to generate 60 and 300 Hz signals, which were then amplified for power to drive a wire spool for generating large magnetic fields. An ammeter was used to measure the rms current through the wire spool. The sample was sandwiched between two flat pieces of cardboard, the same size as the sample and placed on the wire spool. Another smaller piece of cardboard, slightly larger than the milligauss meter, and also 1 cm thick was placed on top of the sample assembly. The perimeter of the small piece of cardboard was traced onto the sample to ensure that its position would be fixed for all tests.

With the milligauss meter on top of the small piece of cardboard, the signal was gradually increased for a good and reliable reading above 10 milligauss. This level was recorded as L1. The current was also monitored and recorded. Then the shield was removed without making any changes in the setup and the signal was measured and recorded as L2. The current was also examined to make sure there were no changes. This technique was repeated for all the low frequencies.

The shielding effectiveness was computed as:

% SE = 100* (L2-L1)/L2

Test results are shown in the Summary and Test Results Section of this Report.

Figure 8 shows the test configuration used to measure the Magnetic Field component of Electromagnetic Radiation Shielding Effectiveness of the SUT at Extremely Low Frequencies of 60 and 300 Hz.

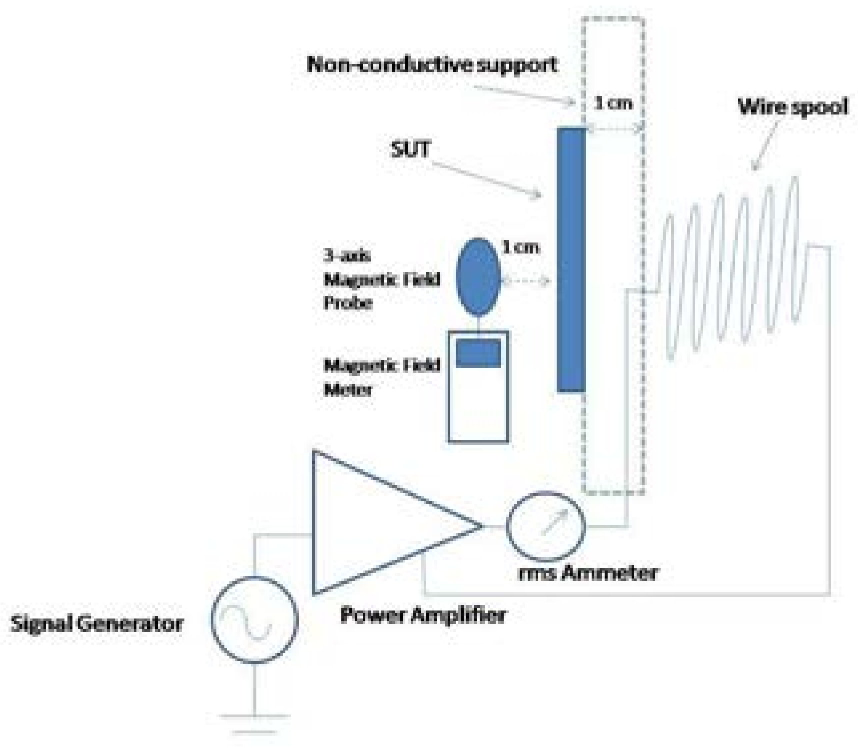


Figure 8. ELF EMR (Magnetic Component at 60 and 300 Hz) Test Configuration Diagram

Figure 9. ELF EMR (Magnetic Component at 60 and 300 Hz) Test Configuration Photograph

9.2 Radio Frequency (RF) Electromagnetic Radiation (EMR) Shielding Effectiveness

9.2.1 Detailed Test Procedure for Below 5 GHZ Testing

As required, the dynamic range of the test setup was confirmed to be greater than anticipated shielding effectiveness by at least 6 dB.

RF signal generators were used to provide the signals at different frequencies. A transmitting antenna was placed on a wooden table and connected to the signal generator. The SUT was sandwiched between two pieces of rectangular cardboard with the same width and length as the sample and a thickness of 1cm each and the assembly was placed on top of the transmitting antenna at a fixed position. The receiving antenna was affixed to the top of a smaller piece of cardboard and this assembly was placed on top the sample assembly and connected to the spectrum analyzer. Two measurements were taken: one with the SUT (P1) and one without it (P2).

The shielding effectiveness is calculated as below:

SE (dB) = P2 – P1 + any adjustment for increasing the signal generator output level
SE in percentage = 100*(v2-v1)/v2 where v2=10^(P2/10) and v1=10^(P1/10)

The spectrum analyzer settings were as follows: Resolution Bandwidth = 1 KHz, Video Bandwidth = 3 KHz, Span =100 KHz, dynamic range near 90 dB.

Note: If ambient signals were present at the test frequencies, the test frequencies were shifted slightly (less than 10 KHz) to avoid overlapping.

Figures 10 and 11 show the test configuration used to measure RF EMR Shielding Effectiveness of the SUT at high frequencies.

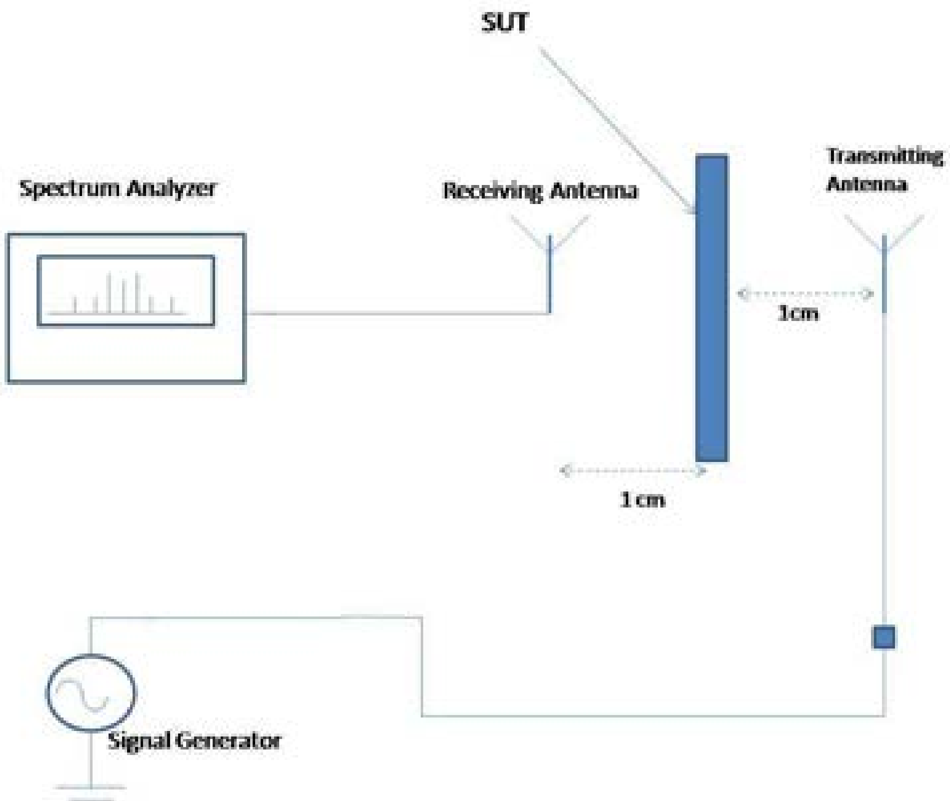


Figure 10. High Frequency up to 5 GHz (RF EMR) Test Configuration Diagram

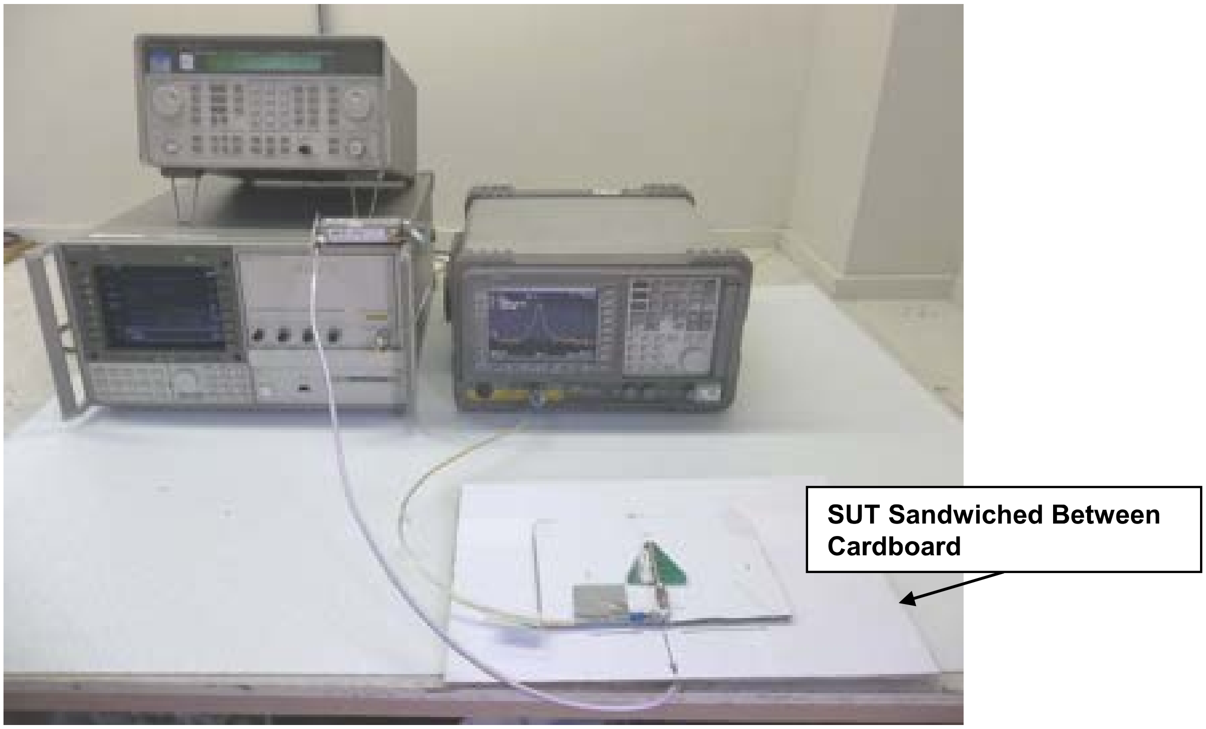


Figure 11. High Frequency up to 5 GHz (RF EMR) Test Configuration Photograph

11 Summary and Test Results for Below 5 GHz Testing

Following is a summary of the SafeSleeve shield Extremely Low Frequency (ELF) Electromagnetic Radiation (EMR) (Magnetic Component) and Radio Frequency (RF) Electromagnetic Radiation (EMR) Shielding Effectiveness results when the SUT is measured as described in this test report:

ELF EMR (Magnetic Component) Shielding Effectiveness @ 60 Hz is 92% and ELF EMR (Magnetic Component) Shielding Effectiveness @ 300 Hz is 92% as shown in Table 4 below.

RF EMR Shielding Effectiveness @ 800 MHz to 5 GHz ranges from 98 to 99% as shown in Table 5 below.

The measurement uncertainty (with a 95% confidence level) for these tests is ± 1 dB.

Table 4. Test Results for Low Frequency Measurements

Frequency	Current Through Solenoid	Without Shield (mgauss)	With Shield (mgauss)	Percentage Reduction
60 Hz	150 mA	1570	126	**92**
300 Hz	150 mA	1640	126	**92**

Table 5. Test Results for Frequencies 800 MHz to 5 GHz Measurements

Frequency	Without Shield (dBm)	With Shield (dBm)	Delta (dB)	Percentage Reduction
800 MHz	-40.5	-63	22.5	**99.4377**
1.7 GHz	-23	-41	18	**98.4151**
1.9 GHz	-29	-49	20	**99.0000**
2.1 GHz	-29.6	-55	25.4	**99.7116**
5 GHz	-30	-62	32	**99.9369**

Data Report on Class 1 Shielding Material
SafeSleeve – CTG PO 700191903.22031

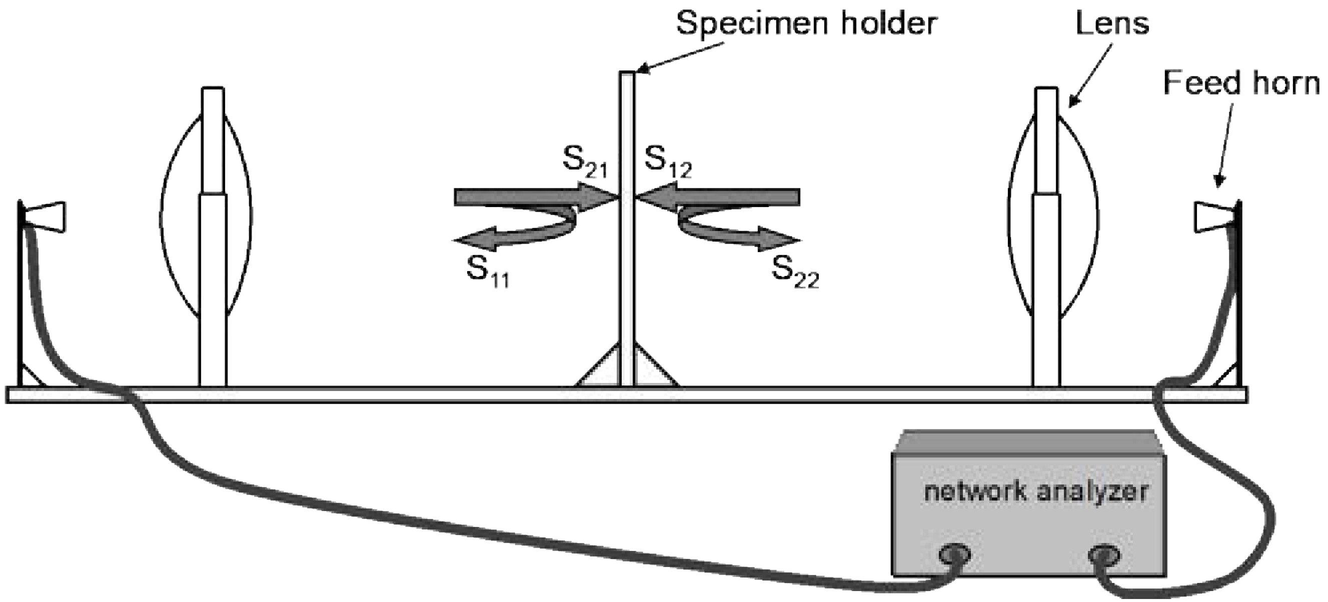
2022-08-30

Compass Technology Group LLC
1005 Alderman Dr, Ste 203
Alpharetta, GA 30005

Overview

Transmission coefficients of 1 EMI shielding textiles were measured on CTG's Focused Beam and Millimeter-Wave Focused Beam (MMWFB) systems. These data were used to compute the shielding effectiveness of the materials.

- Measured by: *Nick Schultz and Brenda Negrete*
- Interpreted by: *John Schultz and Zander Borders*

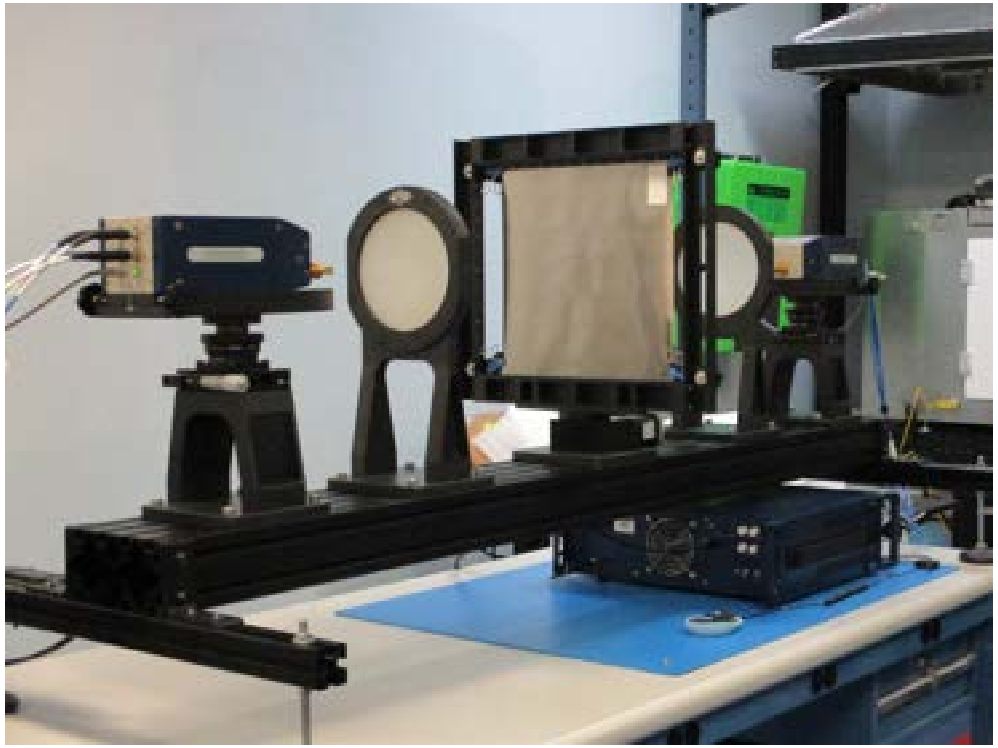


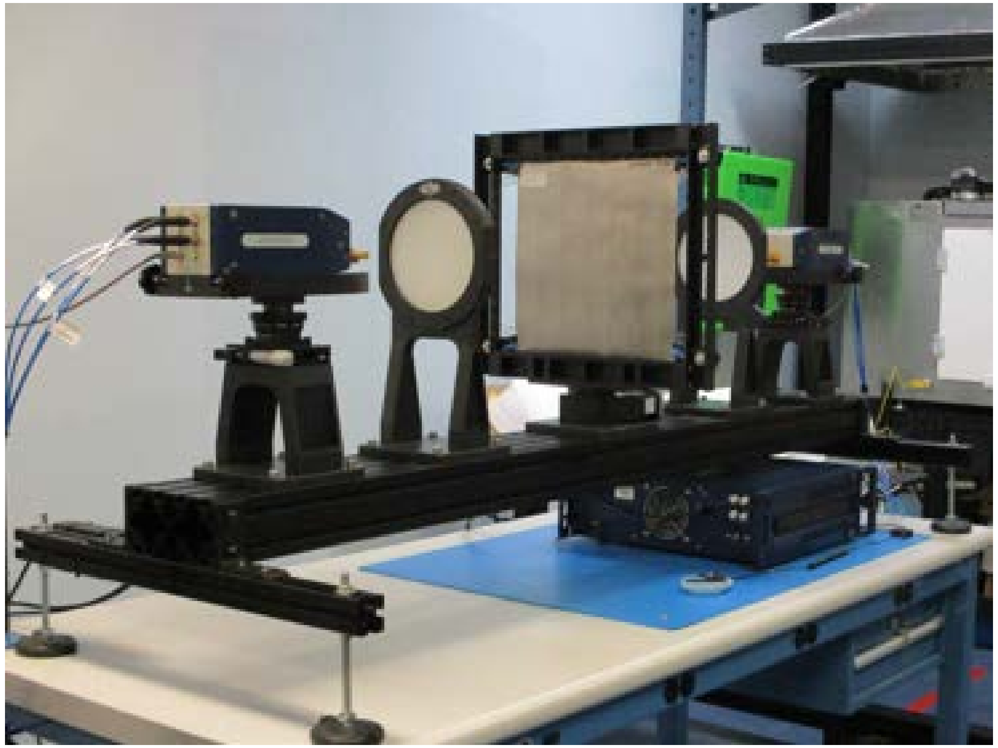
Test Details

- Photos of SafeSleeve specimens and CTG Focused Beam system:

Test Details

- Photos of SafeSleeve specimens and CTG MMWFB system:





Test Details

Table 1: Measurement Equipment	
Measurement System(s)	• CTG Focused Beam • CTG MMWFB
Network Analyzer(s)	• Anritsu ShockLine MS46122B (10-40 GHz) • Copper Mountain C4220 w/ Farran FEV-12 frequency extender modules (60-90 GHz)
Configuration Specifics	• Focused Beam: Inline with shielding wall, normal lens, normal incidence only, VV-pol. • MMWFB: Inline, normal lens, normal incidence only, VV-pol.

Test Details

Table 2: Measurement Procedure	
Method/Calibration	Measured Reflection & Transmission (S_{11}, S_{12}, S_{21}, & S_{22}) and calibrated with a clearsite (no specimen) and metal plate.
Data Processing	Used time-domain gating with a 0.5 ns wide gate. Computed Shielding Effectiveness as SE = $-\|S_{21}\|$ in dB.
Inversion(s)	None.
Procedure	Standard Test Method: CTG-TM-0101-2020 (https://compasstech.com/technical-library/)

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Specimen Description

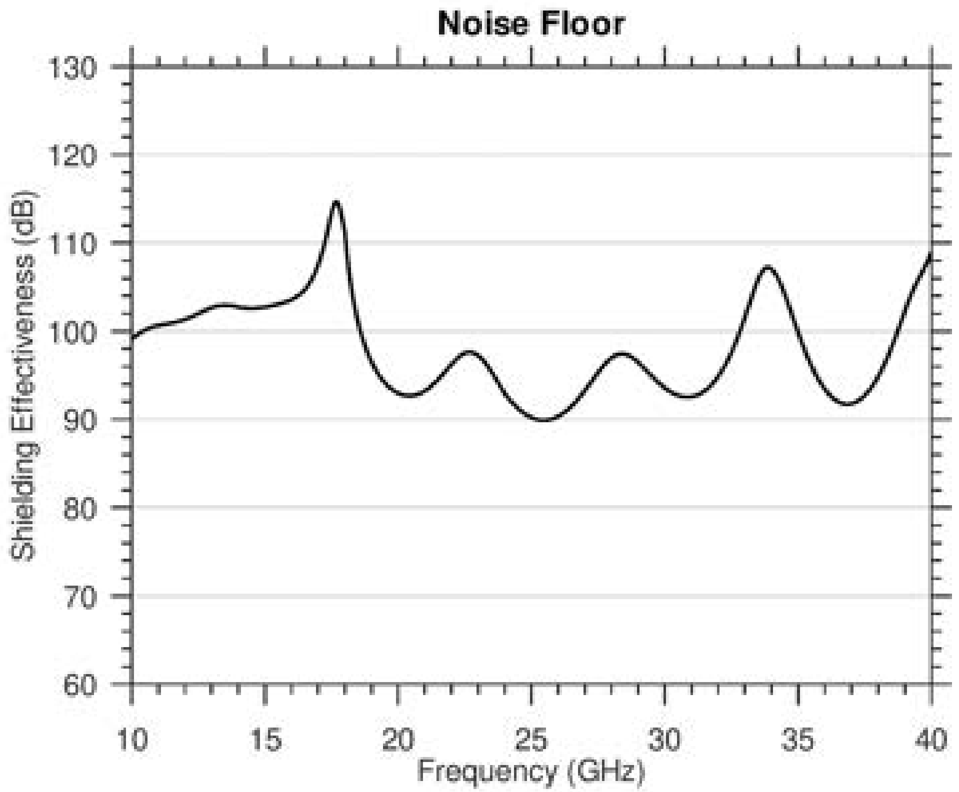
- Specimen descriptions:

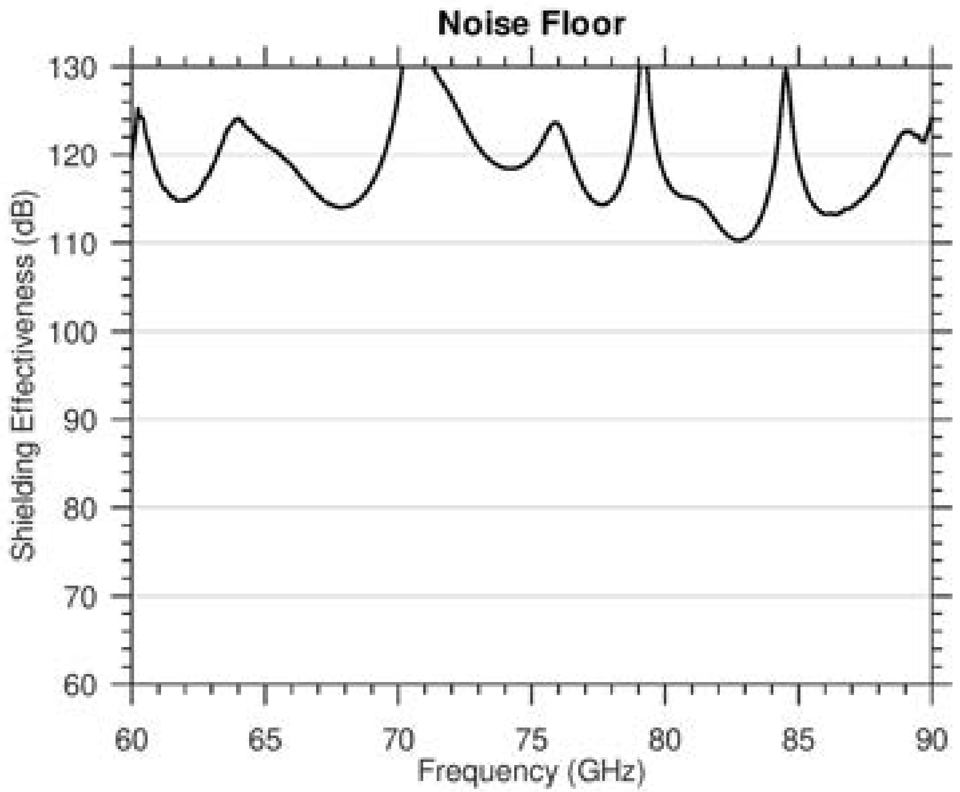
CTG Label	Description	Avg. Thickness (in)
SAFS2201-01A01	Class 1	N/A

Remarks:

- Specimens were first measured in the MMWFB system, then cut to fit within existing 5.5” x 5.5” and 24” x 24” shielding wall specimen holders.

Results:





- Plots show noise floor in terms of shielding effectiveness for the Focused Beam and MMWFB systems.
- 10-40 GHz (Focused Beam) on the right and 60-90 GHz (MMWFB) on the left.

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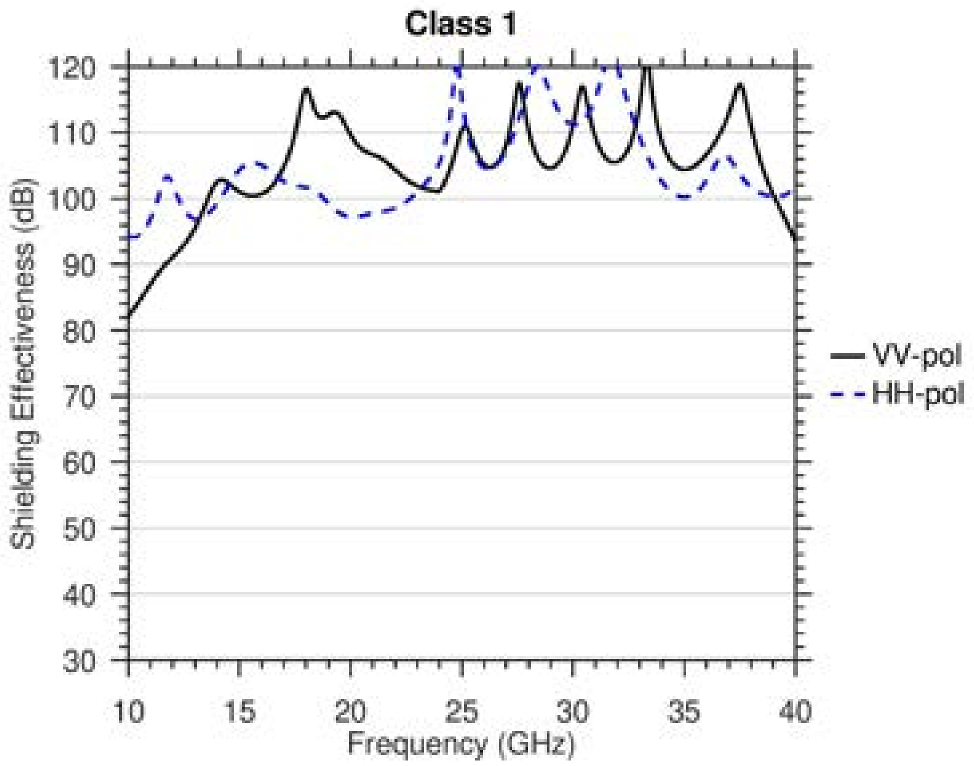
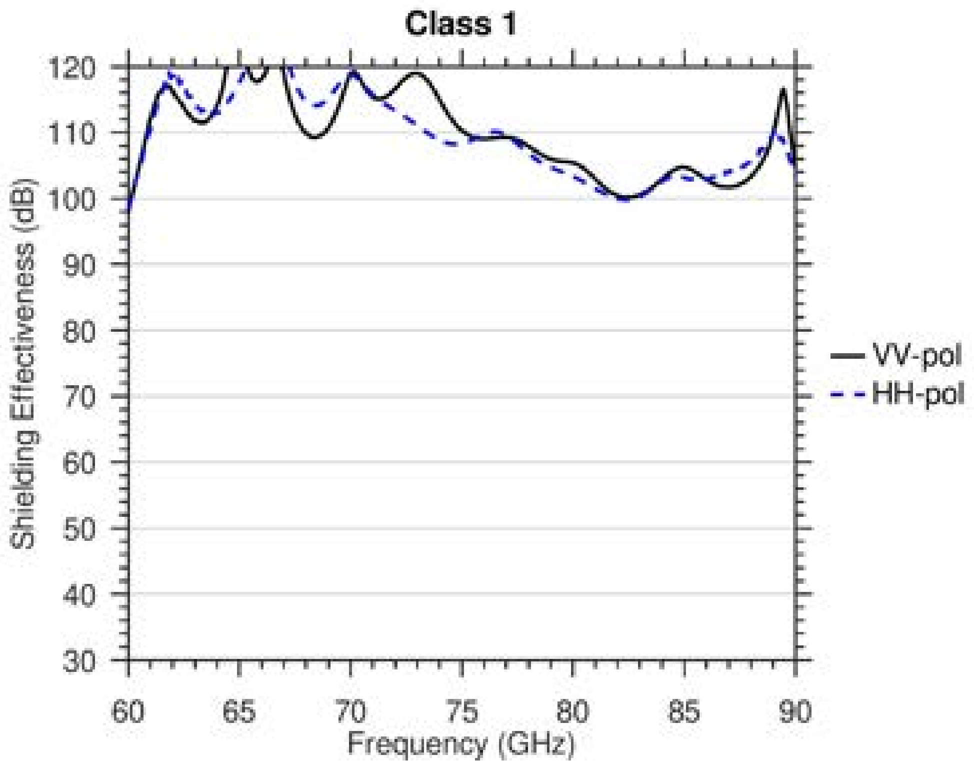
Results:





- Plots show shielding effectiveness of 1 specimen for 2 antenna polarizations.
- 10-40 GHz on the right and 60-90 GHz on the left.
- Sold black traces for VV-pol and dashed blue traces for HH-pol.

Observations

- Shielding effectiveness of Class 1 specimen is in excess of system dynamic range, i.e. >99.99999% power blocked by this material above 10GHz.

- Noise floor roll-off below 10GHz likely caused by leakage around the 8ft x 8ft metal shielding wall.

Company Information

Compass Technology Group (CTG) LLC was founded in 2011 and became an LLC in 2012. We started with a vision to take pioneering research and turn it into useful products that solve customers' real problems in situ, be that a manufacturing facility, field, depot or lab setting. We have grown to be a leading provider of cutting-edge radio frequency (RF) materials measurement equipment. Our systems are used in numerous manufacturing lines to provide high-quality data to electromagnetic materials and component manufacturers. We are also a go-to organization for solving some of the hardest RF materials characterization problems through contract research. And we support many customers with contract materials measurement services.

Cage Code…………….6G0N3
Set-Aside……………...WOSB
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DUNS # …..…………968612858
Organization ………….....….LLC
NAICS...541712, 541330, 334511