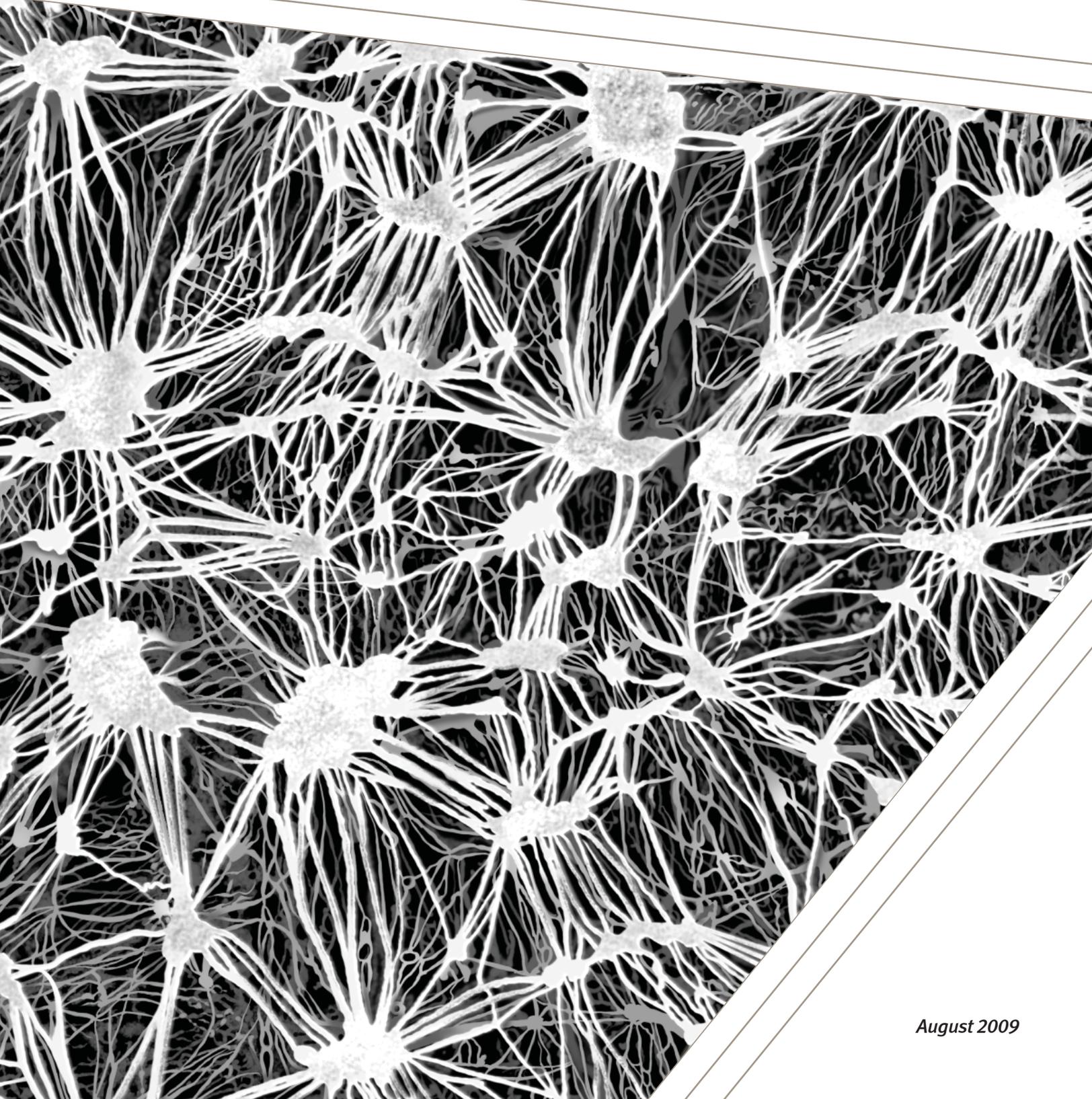




# Phase Stability, Loss Stability, and Shielding Effectiveness

*White Paper*



*August 2009*

# Phase Stability, Loss Stability, and Shielding Effectiveness

Mike Neaves, Signal Integrity Engineer  
Paul Pino, Application Engineer

---

## Contents

---

| Page Number | Topic   |
|-------------|---|
| 4           | Introduction  |
| 4           | Test Subject  |
| 4           | Test Equipment  |
| 5           | Phase and Loss Stability Testing                      |
| 6           | Shielding Effectiveness Testing                       |
| 6           | Test Data: Phase and Loss Stability/<br>Repeatability |
| 8           | Test Data: Shielding Effectiveness                    |
| 9           | Conclusion  |

---

# Phase Stability, Loss Stability, and Shielding Effectiveness of Long Length Gore Microwave Coaxial Assemblies

Mike Neaves, Signal Integrity Engineer  
Paul Pino, Lead Design Engineer

W. L. Gore & Associates, Inc.

## Introduction

This technical note addresses phase stability, loss stability, and shielding effectiveness in cable assemblies exceeding 20 feet. Stability and shielding effectiveness behavior of long length assemblies are not well documented due to the small number of requests for such assembly types and the lack of standardized test procedures. Please be aware that phase and loss repeatability is addressed within this writing as a sub-topic of stability. This document offers basic performance information pertaining to one specific type of GORE® Microwave/RF Assemblies which would typically be used in a test environment where occasional coiling/uncoiling and random movement would occur. Information contained within this document is for reference purposes only and does not constitute a performance specification for any GORE® Microwave/RF Assemblies. For further information regarding these assemblies, please contact Gore directly.

## Test Subject

Testing was performed on a GORE® PHASEFLEX® Microwave/RF Test Assemblies, 50 feet in length, having the following specifications:

**Part Number:** 0UD01D026000

### Cable Type:

Gore 0U series internally ruggedized, enhanced phase stability cable:

- 18 GHz maximum frequency
- Nominal cable outer diameter: 0.305 inches
- Stranded center conductor
- Minimum bend radius: 1.0 inches
- Crush strength: 250 lbs/linear inch

### Connectors:

- Connector A-side: precision 3.5 mm pin
- Connector B-side: precision 3.5 mm socket

**Assembly Length:** 50 feet, measured from connector A-side reference plane to connector B-side reference plane

## Test Equipment

Testing was conducted using the following equipment:

**Vector Network Analyzer:** Agilent Technologies 8510C with 8517B S-parameter test set

**Calibration Kit:** Agilent Technologies 85052B 3.5 mm kit with Agilent Technologies 911E and Agilent Technologies 911D sliding loads, 3 – 26.5 GHz frequency range

**Network Analyzer Cables:** GORE® VNA Microwave/RF Test Assemblies utilized on port 2 of the network analyzer

**Spectrum Analyzer:** Agilent Technologies 70000 series

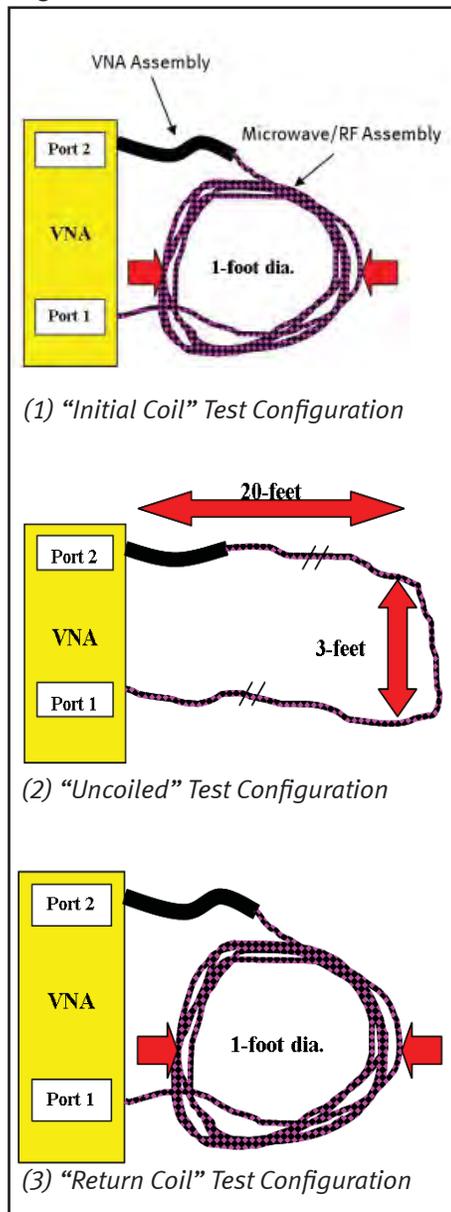
**Mode Stirred Chamber:**

- Custom-built by Global Partners in Shielding, Inc. for W. L. Gore & Associates, Inc.
- Chamber dimensions: 8 feet x 8 feet x 8 feet

Note: All tests were performed at ambient temperature (approximately 20 degrees Celsius) and pressure (sea level).

**Phase and Loss Stability Testing**

Diagram 1



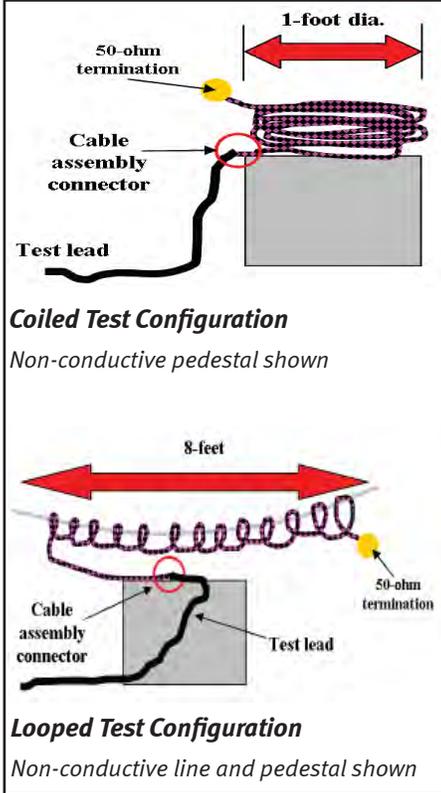
Stability testing was conducted using the following procedure as seen in *Diagram 1*. A full 2-port calibration of the network analyzer was performed using a stepped frequency range of 0.066 GHz to 26.5 GHz, 801 points. The cable assembly was coiled and uncoiled several times before being tested to simulate normal handling. Finally, the cable assembly was coiled with loops approximately 1 foot in diameter. The coiled cable assembly was connected to the network analyzer (3.5 mm socket to port 1, 3.5 mm pin to port 2) and s-parameter data was collected. This data set was labeled: **"Initial Coil Data."**

The cable assembly was disconnected from port 2 only, then uncoiled and laid out in a large "U" shape across the laboratory floor. The connection at port 2 was then restored and s-parameter data was collected. This data set was labeled: **"Uncoiled Data."** The cable assembly was disconnected from port 2 of the network analyzer and again coiled with loops approximately 1 foot in diameter. Re-coiling was performed in the same direction as was done when the cable assembly was initially coiled. The connection at port 2 was once again restored and s-parameter data was collected. This data set was labeled: **"Return Coil Data."**

The *uncoiled* and *return coil* s-parameter data were normalized by the *initial coil* s-parameter data set. Phase and loss information was extracted from the normalized s-parameter data. By choosing the initial coil data set as a baseline, one may observe how the phase and loss characteristics of the cable assembly deviate from a known state. Any deviations are assumed to have resulted from physical manipulation of the cable assembly under test.

## Shielding Effectiveness Testing

Diagram 2



Shielding effectiveness testing was accomplished through the use of Gore’s own mode stirred chamber. Tests were conducted from 1.0 to 18.0 GHz (1 GHz steps) in accordance with MIL-STD-1344A, method 3008.

The noise floor of the test environment was verified before each test, as was instrument dynamic range. Efforts were made to keep the bulk of the test cable and its connectors within the working volume of the mode stirred chamber.

The following test procedure was employed as seen in *Diagram 2*. The cable assembly was coiled with loops approximately 1 foot in diameter. The coiled assembly was placed atop a non-conductive pedestal in the middle of the mode stirred chamber. In this configuration two sets of test data were collected. One data set was collected while the cable assembly connectors were wrapped in a fine-grade steel wool, another set collected while the cable assembly connectors were left unwrapped. Steel wool serves as a supplementary shielding material when wrapped around the cable assembly connectors; this technique is used purely for test purposes. By comparing the shielding effectiveness performance of an assembly with connectors wrapped versus unwrapped, one may more easily determine if the major contributor to RF leakage is connector or cable.

As a final test, the cable assembly was hung in loose loops over a non-conductive line strung within the mode stirred chamber. Test conditions were as stated above. Data was collected for tests with and without connectors wrapped in steel wool.

## Test Data: Phase and Loss Stability

## Test Data: Phase and Loss Stability/Repeatability

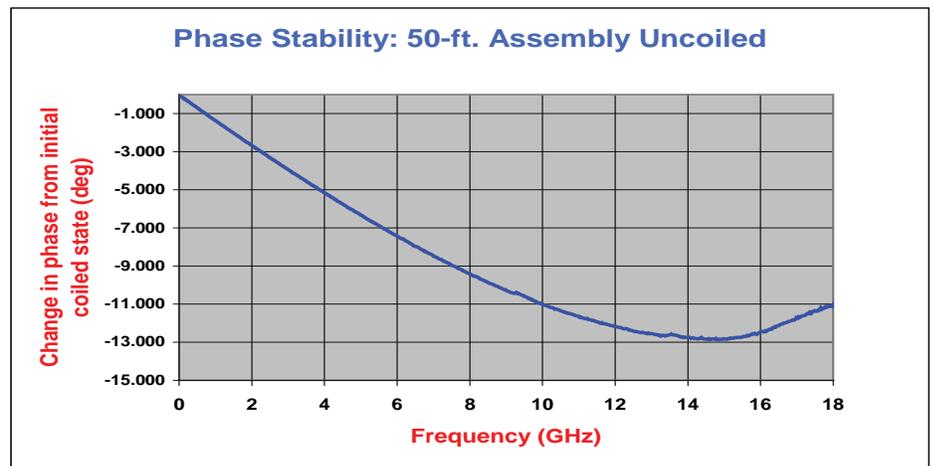


Figure 1: Normalized phase response of uncoiled cable assembly

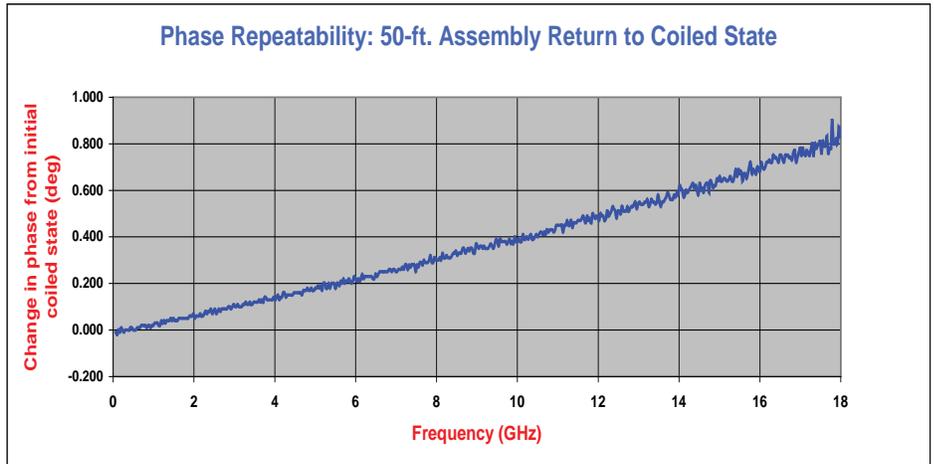


Figure 2: Normalized phase response of cable assembly when returned to coiled state

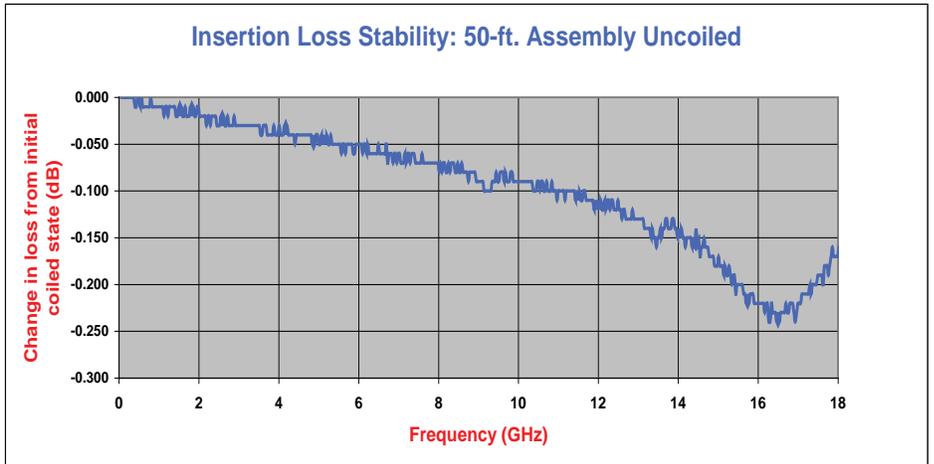


Figure 3: Normalized loss of uncoiled cable assembly

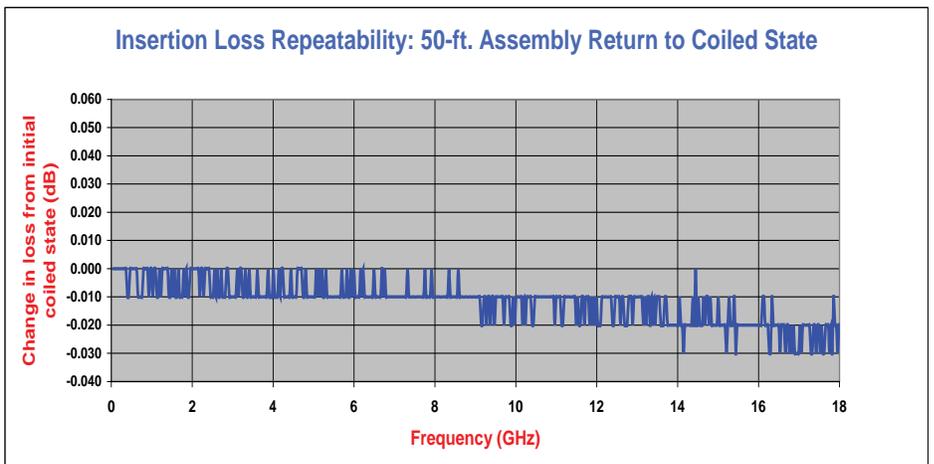


Figure 4: Normalized loss of cable assembly when returned to coiled state

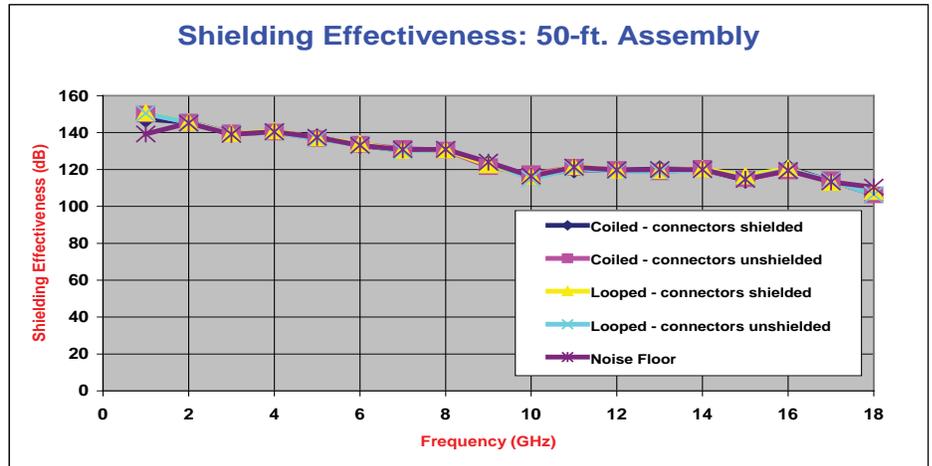


Figure 5: Shielding effectiveness of cable assembly in various configurations

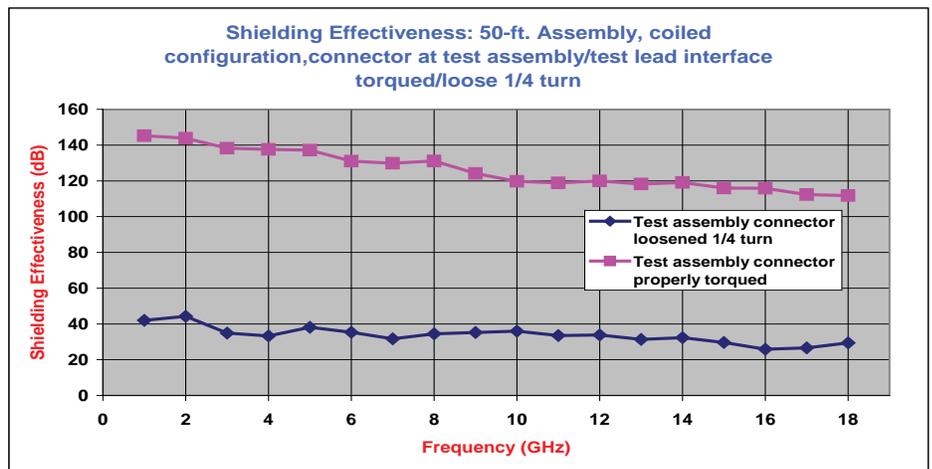


Figure 6: Contrasting shielding effectiveness of cable assembly with connector torqued and loosened 1/4 turn

## Conclusion

### Phase Stability and Repeatability

*Figure 1* illustrates the phase stability of the test assembly when going from a coiled state to an uncoiled state. It may also be noted that the behavior is essentially linear through 8 GHz. Choosing an arbitrary frequency of 10 GHz, the indicated phase change from an initially coiled state is  $-11.0$  degrees. If one considers that a 10 GHz continuous wave signal will cycle through 219,546 degrees over a 50-foot cable, the 11.0 degree figure represents 0.005% of the assembly's phase length.

A high-performance microwave cable assembly must possess excellent phase repeatability. Phase repeatability refers to an assembly's ability to duplicate its original or initial phase behavior when the cable has been flexed (or disturbed) then returned to its original unflexed (or undisturbed) state. *Figure 2* illustrates the phase repeatability of Gore's EJ series cable. Providing a practical example will highlight the importance of repeatability. The 50-foot test assembly is uncoiled and connected to its respective instrumentation. The necessary calibration procedures are followed and phase is noted at 10 GHz, after which the assembly is disconnected, coiled, and stored for future use. A short time later the cable assembly is uncoiled and reconnected to this same instrumentation and phase is noted. Referring to *Figure 2*, the user can expect to observe a change in phase of approximately 0.400 degrees at 10 GHz (20 degrees Celsius ambient temperature).

### Loss Stability and Repeatability

In addition to excellent phase characteristics, Gore's EJ series cable demonstrates exceptional loss stability/repeatability. *Figure 3* depicts the loss stability of the test assembly when going from a coiled to an uncoiled state. At 10 GHz, a  $-0.080$  dB change is indicated, which correlates to 0.54% of the test assembly's insertion loss at this frequency. At 2GHz, a  $-0.015$  dB change is indicated, correlating to 0.24% of the test assembly's insertion loss at this frequency.

*Figure 4* illustrates the test assembly's loss repeatability. Changes in loss from the initial coiled state vary no greater than 0.030 dB from 0.066 GHz through 18 GHz. The practical example provided for phase repeatability can be applied to loss repeatability as well; one may expect a change in loss of approximately  $-0.010$  dB at 10 GHz (20 degrees Celsius ambient temperature).

### Shielding Effectiveness

Shielding Effectiveness (S.E.) was the only area where a standardized test procedure was used (see page 5 for details). Referring to *Figure 5*, the S.E. performance of the test assembly is recorded for several different

configurations. In all configurations, the S.E. values of the test assembly were consistently at or approaching those of the chamber noise floor.

Performance through 18 GHz was notable, producing in excess of 100 dB of shielding effectiveness. *Figure 6* was provided to demonstrate that data supplied in *Figure 5* was merely not a measurement of the chamber ambient noise level. *Figure 6* displays the contrast in S.E. behavior when one connector, at the test assembly/test lead interface, is properly torqued versus loosened by one-quarter of a turn.