TEST REPORT

T&M Research Products, Inc. Model W11K20-3.5s-0.0002433Ω
by M. E. Gruchalla PE, December 6, 2008

1. INTRODUCTION

A T&M Research Products, Inc. Model W11K20-3.5s-0.0002433Ω Current Viewing Resistor ("CVR") is evaluated to document its transfer function under several configurations:

- Basic CVR response
- Compensated CVR response
- Response with 25ft RG223 between the CVR and the compensation
- Response with 25ft RG223 following the compensation

2. TEST CONFIGURATION

All measurements are made using an HP8753B network analyzer. The test configuration is shown in Figure 1.

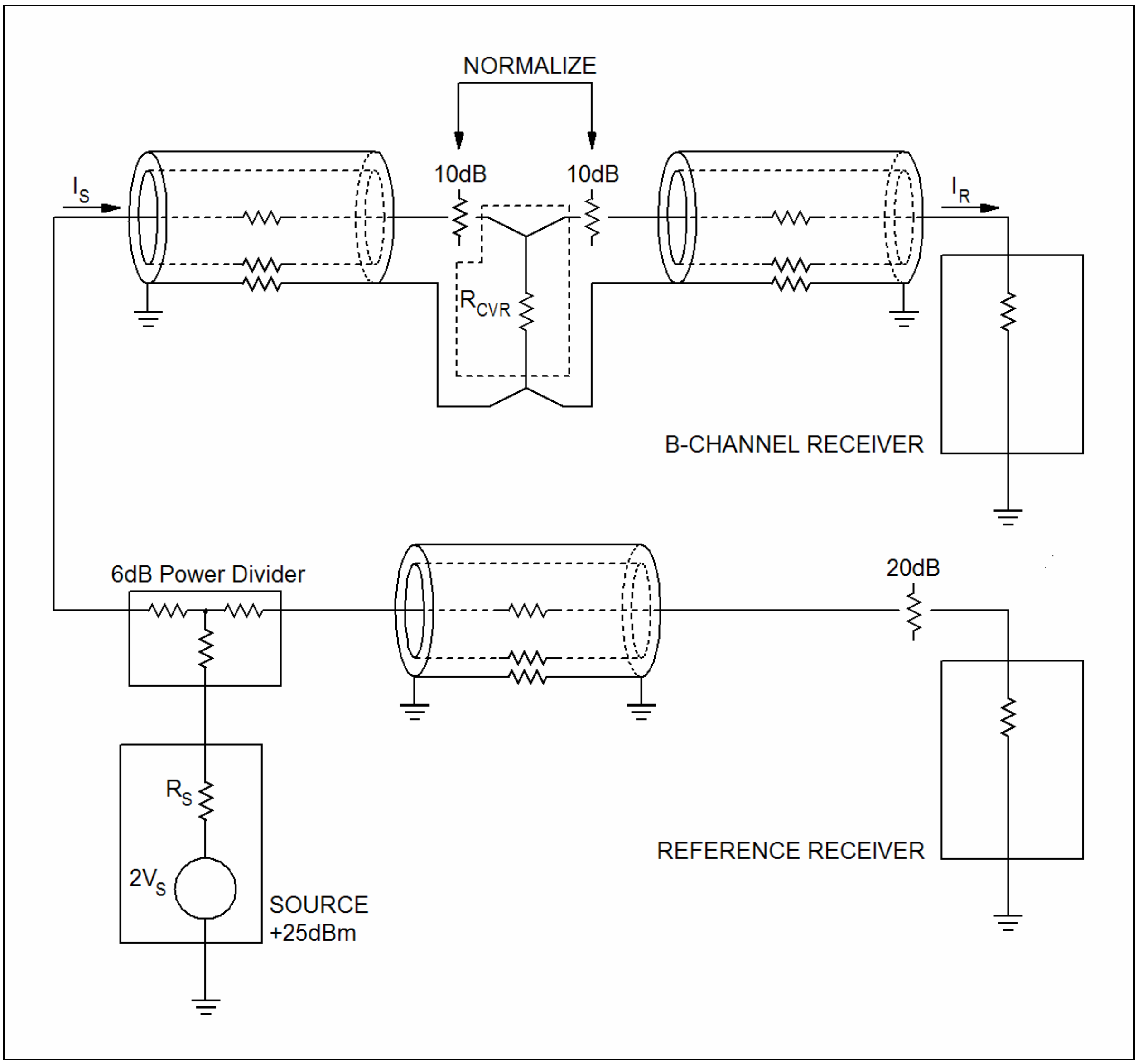

Figure 1. Basic CVR Network-Analyzer Test Configuration

3. TEST-SYSTEM ELEMENTS

All transmission lines are Andrew FSJ1-50 heliax terminated in Andrew F1TSM-HF male SMA connectors. The power divider is a Weinschel 1506A balanced three-port 6dB type-N power divider. The 10dB attenuators are HP33340C APC-3.5 units. The reference 20dB attenuator is an HP8491B type-N unit. The system is configured with all cabling and attenuators, and normalized as shown in Figure 1.

A type-N test fixture is applied at the CVR current terminals, and a type-N to SMA adapter is applied to the type N termination. A BNC to SMA adapter is applied at the CVR BNC potential port. After normalizing, the connection between the two 10dB attenuators is opened and connected to the Test Article as shown.

The linear-phase component is removed from all measurements using the reference-plane extension of the network analyzer.

Validation of the test system against a known resistive reference provided that a nominal +0.5dB error is introduced equally across the full measurement bandwidth in CVR measurements due to the small impedance error that remains with only 10dB padding attenuation.

A 32-record ensemble average is used for all measurements. No data smoothing is applied. The estimated accuracy is ±0.5dB.

4. MEASUREMENTS

Figure 2 is the basic response of the Test Article. The nominal 20dB/Decade rising response and 90 Degree phase indicate a derivative response between nominally 500kHz and 150MHz. The first-order model is that of the 243μOhm resistive element in series with a nominal 160pH inductance.

The anomalous response at 50MHz is estimated to be due to the characteristics of the BNC connector. The response is otherwise a modestly well-behaved derivative response between 500kHz and 200MHz.

Figure 3 is the response of the Test Article with a custom compensation element applied at the Test-Article potential port. The expected gain of the 243μOhm Test Article is -100.2dB. The gain of the compensated Test Article after applying the 0.5dB correction is -99.4dB indicating that the compensation is within nominally 0.8dB of the ideal value. The anomalous response below 1MHz is due to circulating currents in the test system as a result of common source and receiver grounds. This response is not part of the Test-Article response. The gain of the Test Article is expected to remain nominally flat at -100dB to DC.

Figure 4 is the response of the Test Article with a nominal 25ft length of RG223 introduced between the Test Article and the compensation element. The periodic resonances are due to the fact that in this configuration the RG223 section is unmatched at each end. This is the expected response.

Figure 5 is the response of the Test Article with a nominal 25ft length of RG223 introduced between the compensation element and the network-analyzer B-Channel receiver. This is nominally the response expected.

Figure 6 is the simulated response of a CVR comprising a 243μOhm resistive element in series with a 160pH inductance simulated in a 50-Ohm system. As expected, the DC and low-frequency gain in a 50-Ohm system is -100dB. The response exhibits a response zero at nominally 250kHz and follows a first-order derivative response to the limit of the simulation. The simulation nominally follows the actual Test Article response. As a matching point, at nominally 28MHz, the gain of both the simulation and the actual response of Figure 2 are nominally -80dB indicating the simulation is a nominal match to the actual response to a first-order estimate.

5. CONCLUSIONS

The subject CVR Test Article performs nominally as expected. The first-order model of the Test Article is that of a 243μOhm resistance in series with a 160pH inductance. The equivalent series inductance results in a response zero at nominally 250kHz.

The common grounds between the network-analyzer source and receiver result in a peaking response at low frequency due to the circulating currents in the common grounds. This is expected, and this response is not native to the Test Article. The Test Article gain is expected to remain flat at -100dB from DC to the response zero.

The series inductance introduces a network zero in the response resulting in a derivative response above nominally 500KHz.

A custom, device-specific compensation element was designed by the author and applied to the Test Article which corrects the response to eliminate the derivative characteristic to nominally 150MHz.

A comparatively small anomalous response is seen at 50MHz. This appears to be due to the characteristics of the potential-port BNC connector.

Adding a nominally 25ft length of RG223 transmission line between the Test Article and the compensation element results in several resonances due to mismatch to the RG223. In this configuration, useful operation is limited to below 2MHz.

Adding a nominal 25ft length of RG223 transmission line between the compensation element and the network-analyzer receiver results in generally acceptable response to 50MHz, and usable response to 150MHz.

The BNC potential-port connector is problematic due to its physical construction. A screw-type connector (SMA, N or TNC) is recommended if the Test Article is to be applied in a high-level EMI environment (lightning, EMP, HPM, etc.) or in a high-vibration environment.

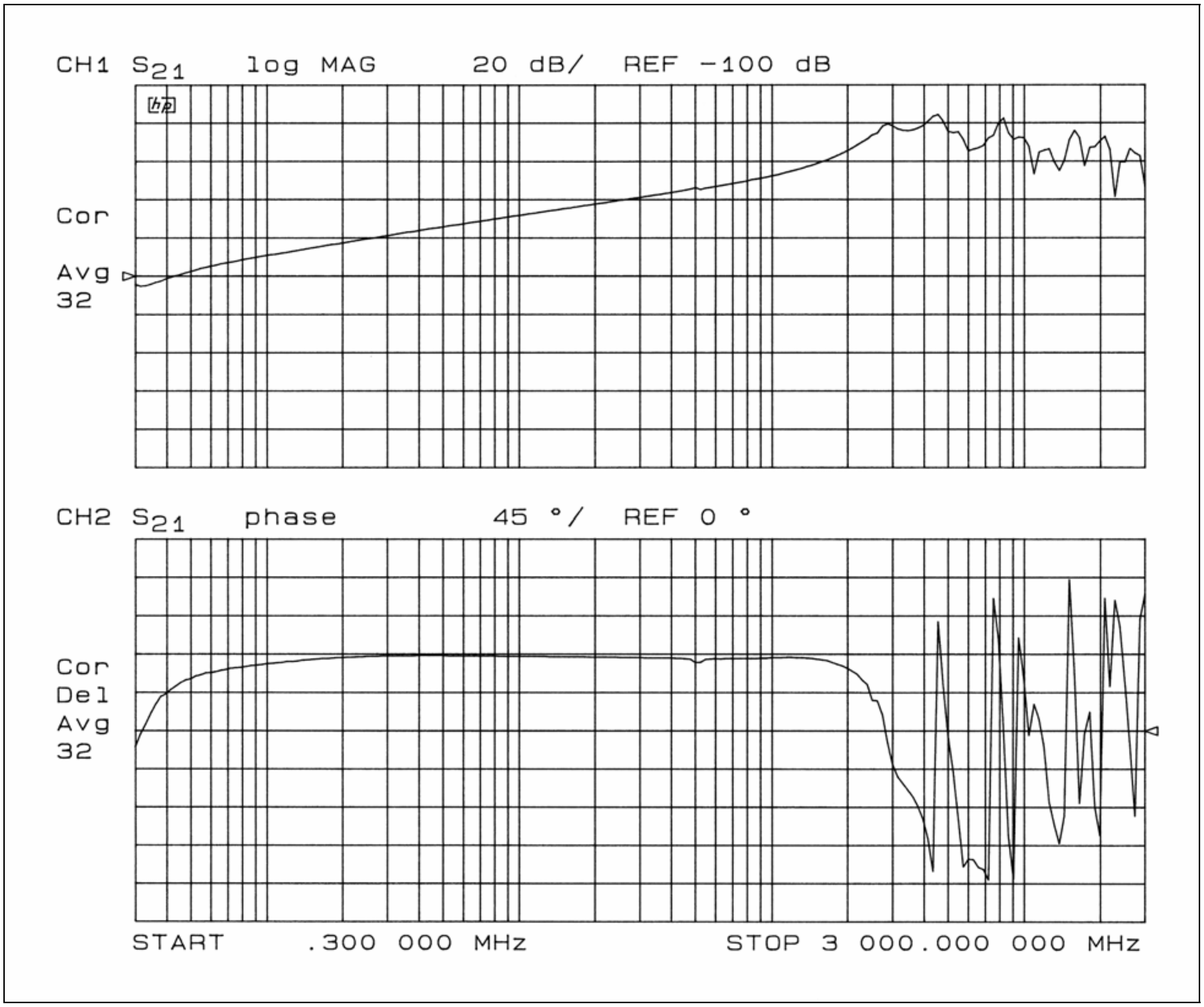

Figure 2. Basic CVR Response

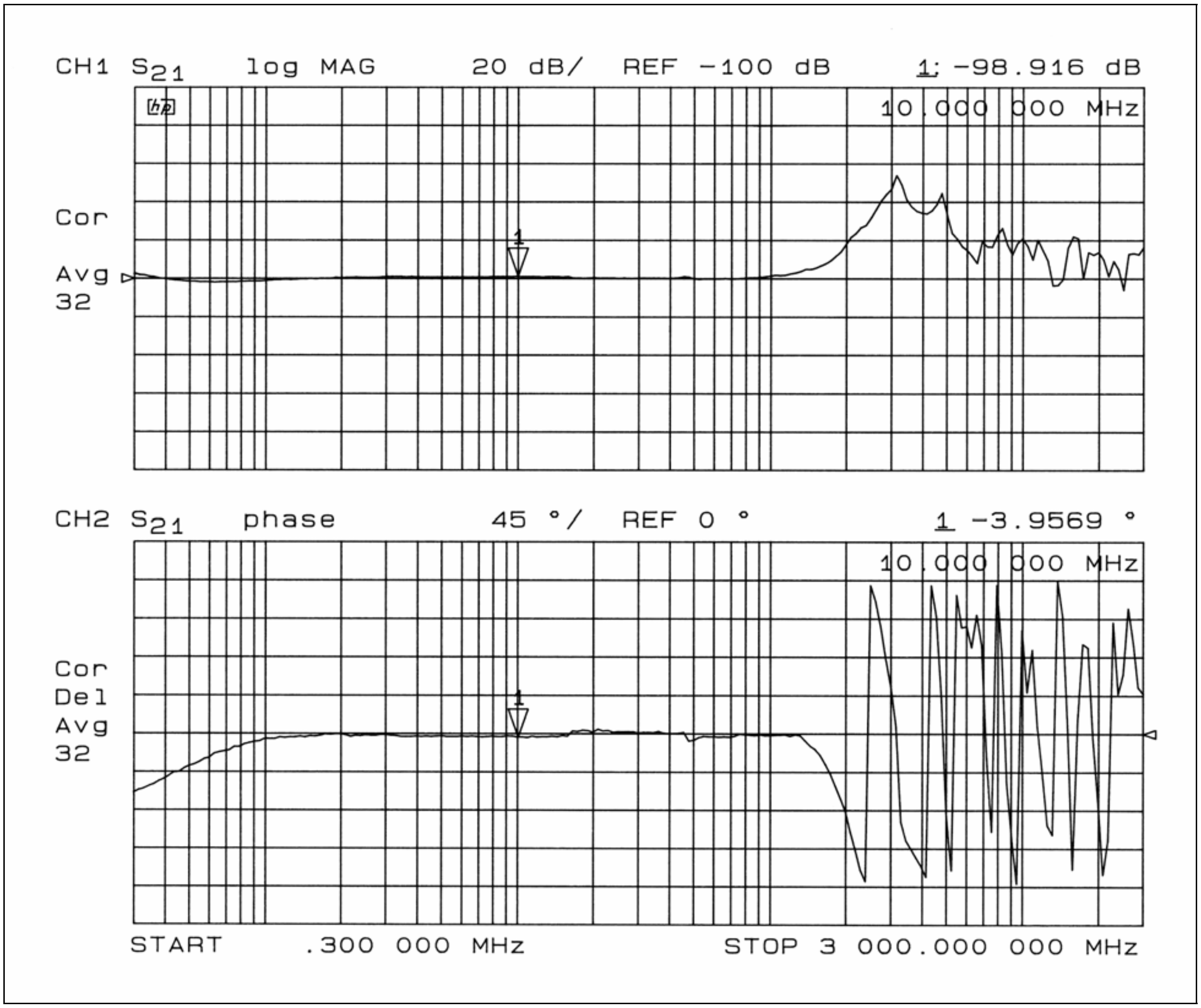

Figure 3. Compensated CVR Response

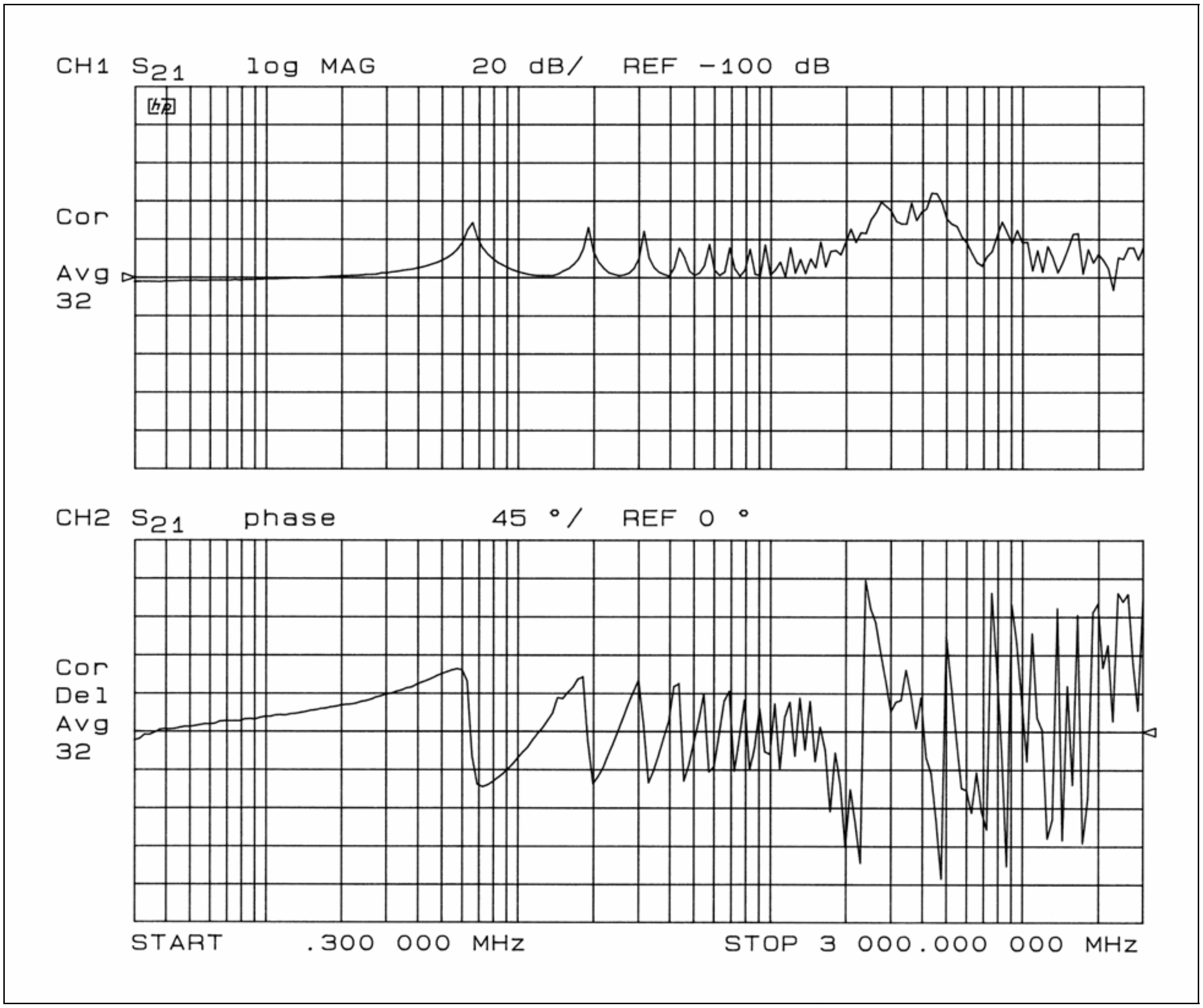

Figure 4. Response with 25ft RG223 Between Test Article and Compensation

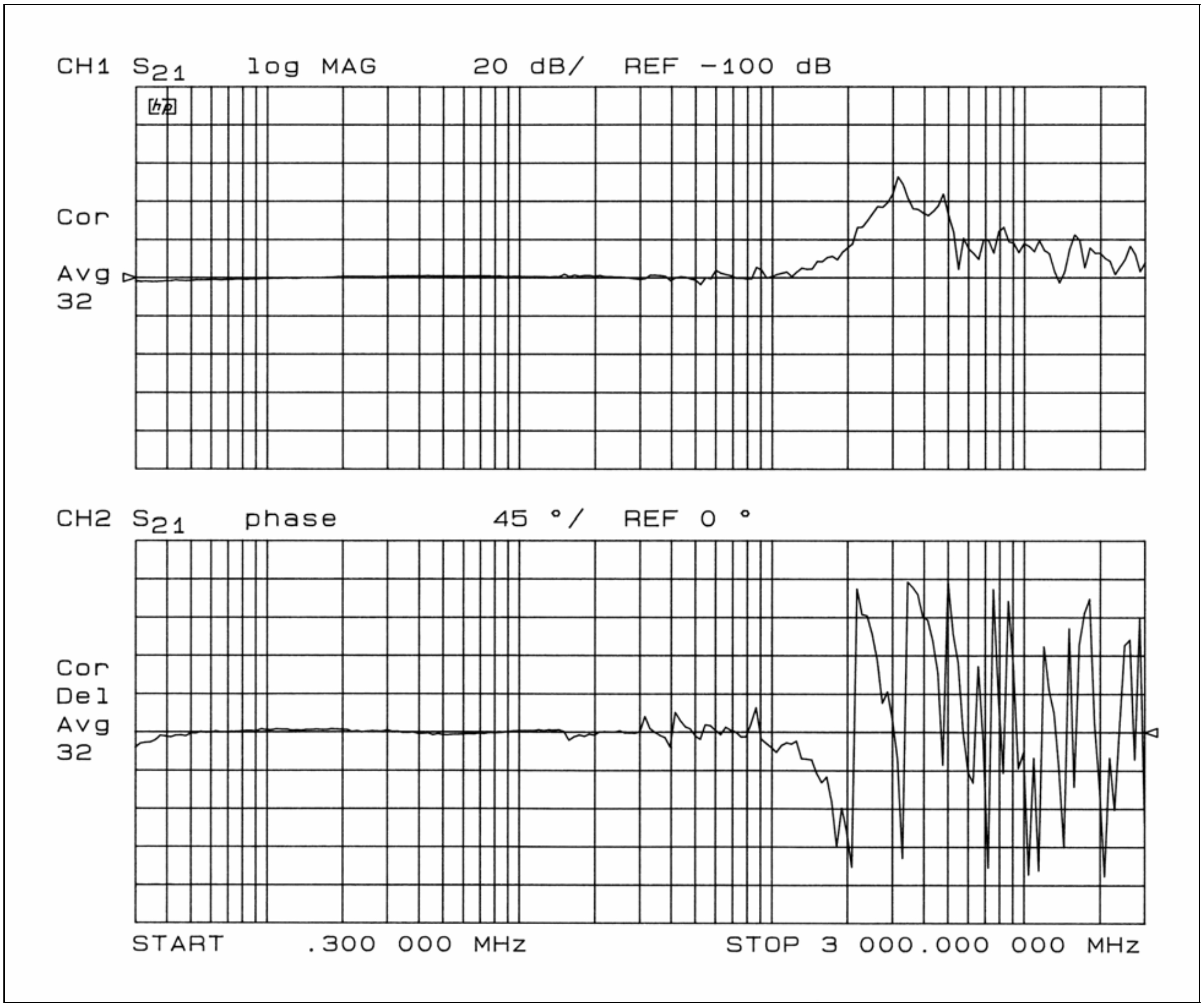

Figure 5. Response with 25ft RG223 Following Compensation

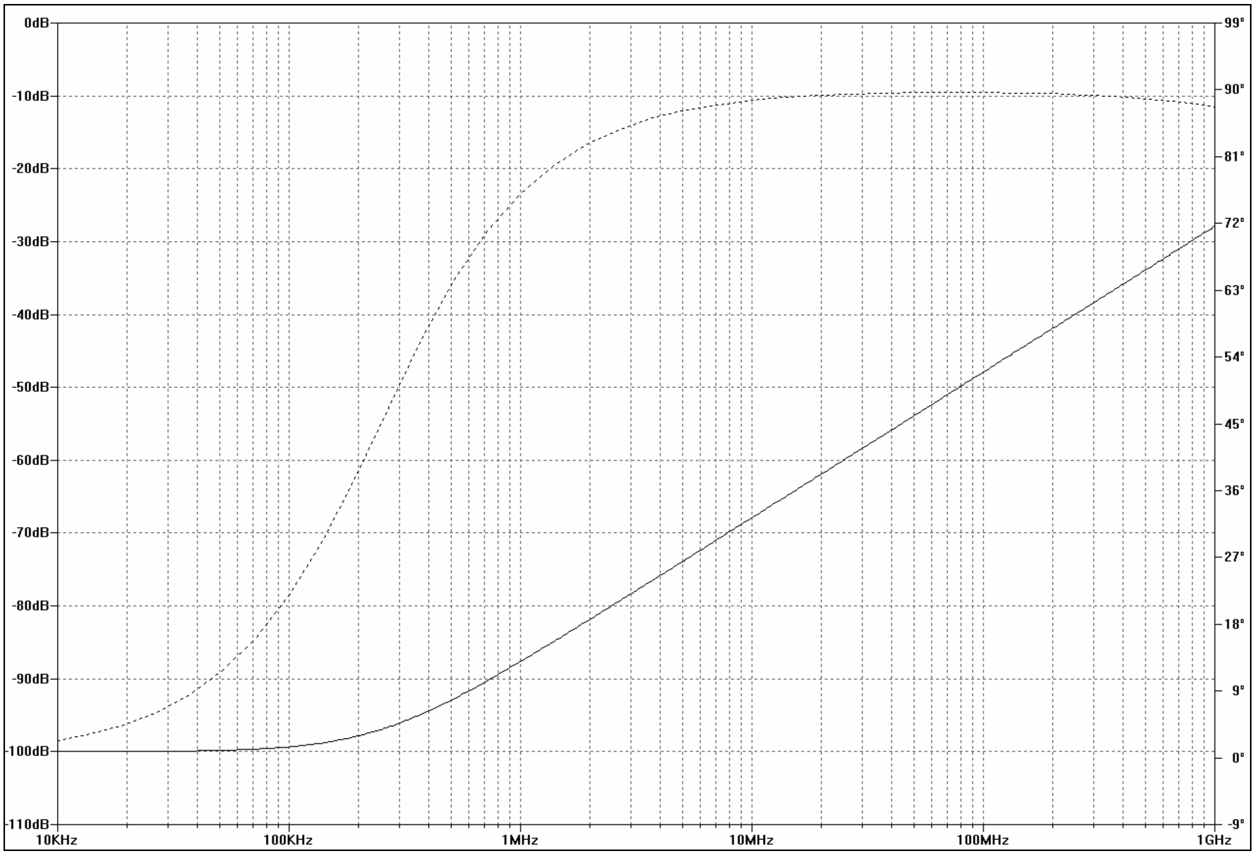

Figure 6. Simulated CVR Response - 243μOhms In Series with 160pH