APPLICATION NOTE

Procedure for Obtaining Accurate GDT Capacitance Values for High Frequency Circuits

Bourns® Next-Generation
GDT25 Series

Bourns® Next-Generation
GDT35 Series

INTRODUCTION

Using Gas Discharge Tubes (GDTs) to protect high frequency circuits in electronic equipment is generally a good approach since these devices typically feature capacitance that is well below 1 pF. However, many circuits can be sensitive to capacitance, which can affect filter or input matching networks, so it is important for designers to have accurate capacitance measurements when creating their applications. Typical industry capacitance measurements at 1 MHz often times are not sufficient to capture the behavior or actual capacitance at 2 GHz or higher.

This application note presents a testing procedure for capacitance and an example of the subsequent results comparing the Bourns® Model GDT25 (2-element) and the Bourns® Model GDT35 (3-element) components. The test procedure uses a Network Analyzer (NWA) that exposes the GDT to actual RF frequencies to determine the capacitance. Bourns' engineers found this technique to be very useful for obtaining accurate capacitance values. Designers should note that this approach can be sensitive to test fixture design where the results can show that the error windows increase with frequency and lower capacitance devices.

In addition to knowing the capacitance of the GDT, it is also important to perform component tolerance analysis on the circuit to help ensure that the design is stable. The application note includes measured data using this technique gathered from a sampling of GDTs with realistic results that may be useful to a designer. During the measurements and tests performed by Bourns, special attention was paid to the capacitance variations during design and the tooling and manufacturing processes used so that the Company could recommend the best approach to help designers achieve world-class performance and stability.

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CAPACITANCE TESTING PROCEDURE

The initial step is to calibrate the Network Analyzer using a matching “thru” for the corresponding Device Under Text (DUT) fixture. A simple insertion loss calibration (thru response) is sufficient as this test is not looking at Voltage Standing Wave Ratio (VSWR) or return loss. The “thru” fixture should be similar in length to the DUT fixture.

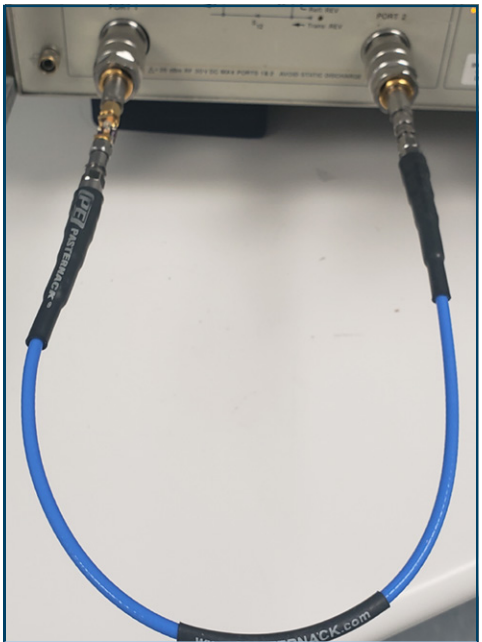

Figure 1. Typical VNA cable test setup

Figure 2 Illustrates the placement of the “thru” fixture in-line for the baseline insertion loss calibration with the DUT test fixture inserted.

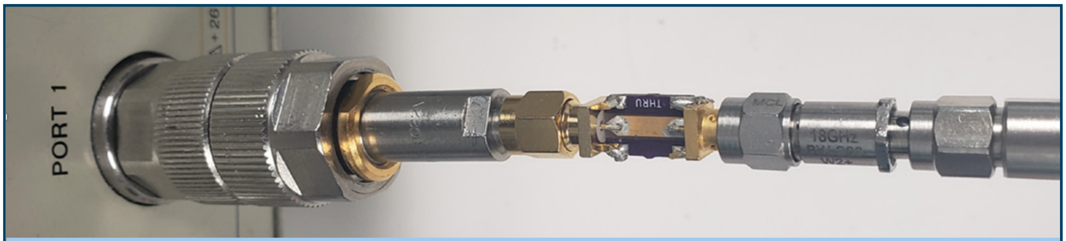

Figure 2. Placement of the “thru” fixture in-line

Figure 3 Shows the DUT fixture with the gap (no copper) set to the appropriate GDT footprint. The third step is to place the GDT on the test fixture.

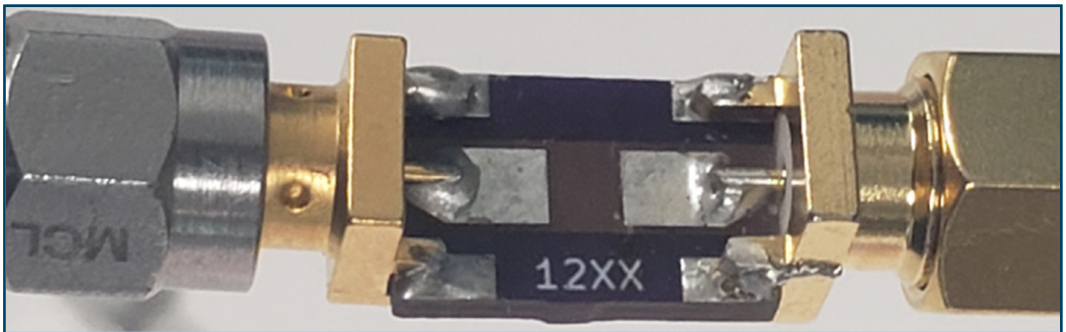

Figure 3. DUT fixture with the gap

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CAPACITANCE TESTING PROCEDURE (Continued)

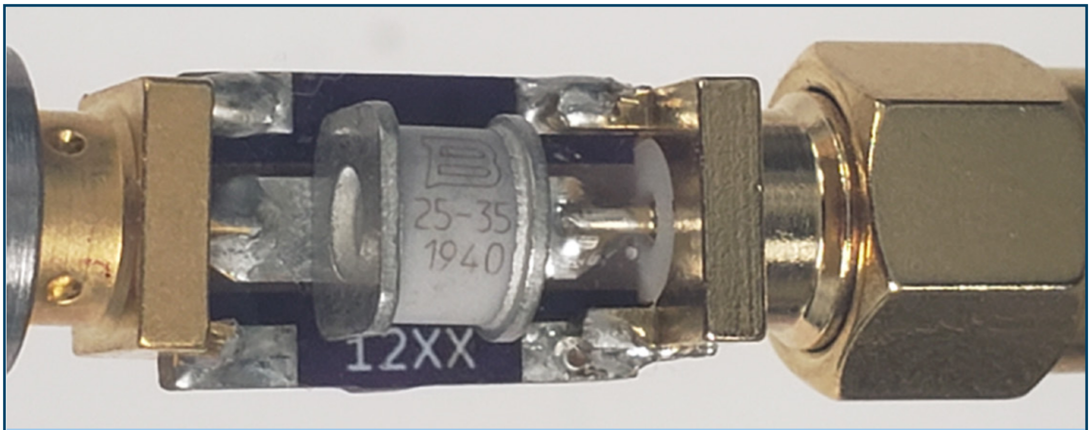

Figure 4. GDT resting on the DUT test fixture

Figure 4 shows the GDT resting on the DUT test fixture.
The fourth step is to measure the insertion loss across the frequency band.
The fifth step is use the marker from the NWA and tune it to the frequency of the -3 dB point.

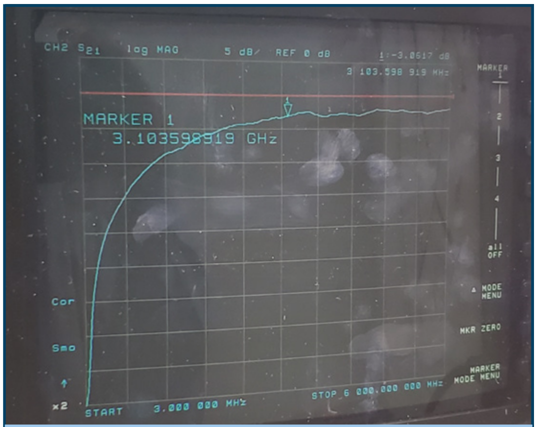

Figure 5. Measured insertion loss for Model GDT25

Figure 6. Measured insertion loss for Model GDT35

Figures 5 and 6 show screenshots of insertion loss measurements with markers at several points.
The sixth and final step is to use simulation software to create a simple series capacitor circuit. The value of the capacitor should be changed to match the -3 dB at the measured frequency.

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CAPACITANCE TESTING PROCEDURE (Continued)

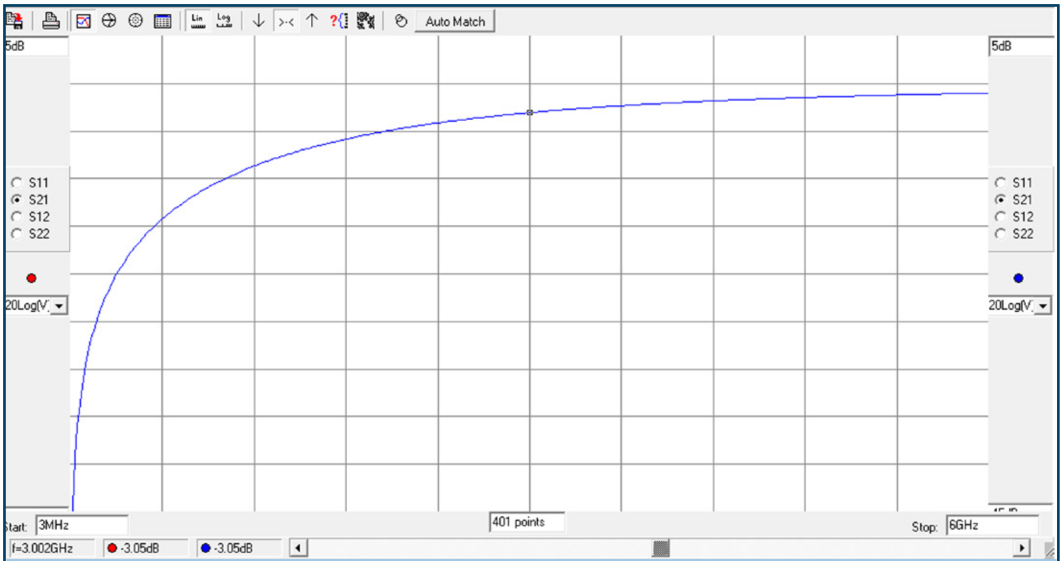

Figure 7. Simulated Insertion Loss for Model GDT25

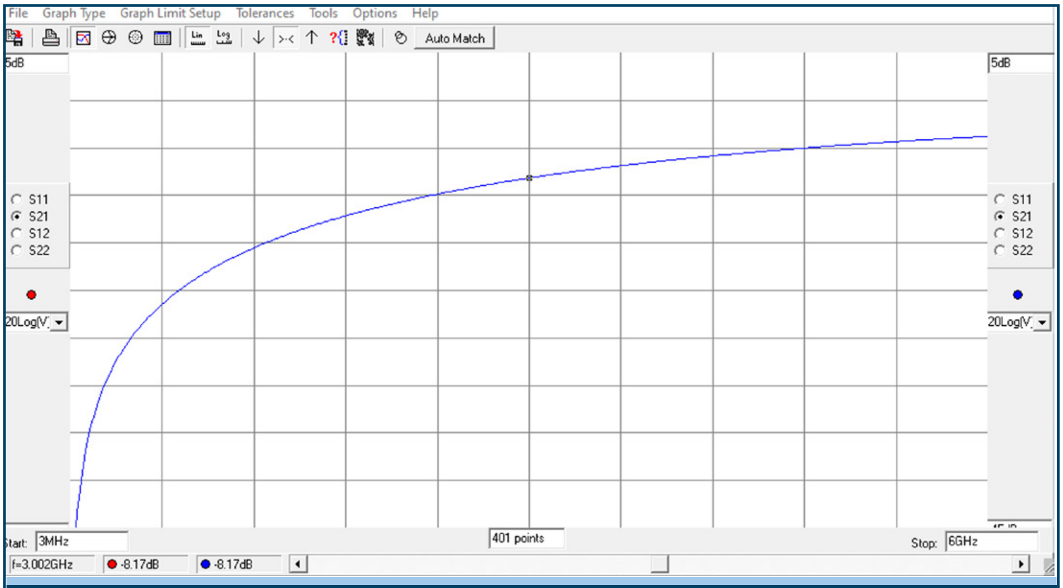

Figure 8. Simulated Insertion Loss for Model GDT25

Figure 7 and 8 show simulation results of insertion loss for a simple series capacitor.

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CAPACITANCE TESTING PROCEDURE (Continued)

In summary, the six steps in the capacitance test procedure are as follows:

1. Calibrate the Network Analyzer (NWA) with a "thru" fixture.
2. Replace the "thru" fixture with the "DUT" fixture.
3. Place the GDT onto the "DUT" fixture.
4. Measure the insertion loss across the frequency band.
5. Use the marker from the NWA and tune it to the -3 dB position.
6. Use simulation software to create a simple series capacitor, and adjust the value until the -3 dB position is matched. This is the equivalent capacitance value.

CALCULATION RESULTS

Based on the measured and simulated insertion loss, the test procedure above enables designers to then calculate the capacitance using the following Bourns® GDT products as an example in Table 1 below:

Table 1. Capacitance results derived from measured insertion loss

Part Number	Typical Capacitance	Minimum Capacitance	Maximum Capacitance
GDT25-07	0.51	0.495	0.53
GDT25-09	0.485	0.475	0.495
GDT25-35	0.475	0.46	0.485
GDT25-60	0.47	0.46	0.48
GDT35-09*	0.225	0.22	0.23
GDT35-11*	0.23	0.225	0.235

*Measured from end to end (using two GDTs in series). Therefore, the capacitance is almost half the value of the models tested in the Bourns® Model GDT25 series. This test method provides more realistic insight into the capacitance of GDTs at high frequencies compared to lower frequency capacitance methods that may not take into account structural and coupling at higher frequencies.

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CONCLUSION

Both the Bourns® Model GDT25 and GDT35 families offer low capacitance and tight capacitance tolerances for applications that require consistent and high-performance GDT protection. These new series are designed for long-term stability and low capacitance between production lots. In addition, Bourns' traditional GDT production lots typically experience yield capacitance variations up to 0.5 pF compared to production lots of the next-generation Bourns® Model GDT25 and GDT35 series which typically yield capacitance variations of approximately 0.2 pF. The combination of low capacitance and tighter tolerances makes these new GDTs from Bourns stable solutions that offer a superior protection solution for high frequency designs.

ADDITIONAL RESOURCES

- Bourns® GDT25 New Product Brief
- Bourns® GDT35 New Product Brief
- Bourns® GDT Product Offering
- Bourns® GDT Technical Library
- Bourns® GDT Brochure
- Bourns® GDT Product Training Modules
- Bourns® GDT Parametric Search Product Selection Tool

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