How to Test Spark Gaps
Application Note

Often, commercial equipment is not available to test spark gaps (GDTs). This application note describes how to design and build instruments for performing several of the more common tests.

DC Breakdown Voltage

This is the voltage level at which the spark discharge occurs when the voltage across the gap is slowly increased. A linear ramp rate is usually specified and typically increases at a rate of 1000 volts per second or less. For most purposes, any adjustable voltage DC power supply (with adequate voltage output) can be used for DC breakdown voltage testing by slowly increasing the output voltage.

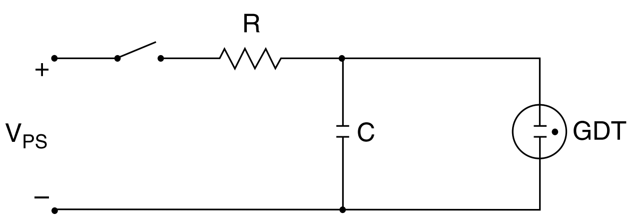

Figure 1 - Simple DC breakdown voltage test circuit using an R-C circuit to set the ramp rate.

For more repeatability of the ramp rate, consider adding an R-C circuit to the output of the power supply as depicted in Figure 1. If the output voltage of the power supply is quickly increased to V_{PS}, then the voltage across the capacitor, $V_C(t)$, is given by:

$$V_C(t) = V_{PS}(1 - e^{-t/RC}) \quad \text{(eqn 1)}$$

The instantaneous ramp rate is given by:

$$\frac{dv_C}{dt} = \frac{V_{PS}}{RC} e^{-t/RC} \quad \text{(eqn 2)}$$

If equation 1 is solved for $e^{-t/RC}$ and substituted into

$$\frac{dv_C}{dt} = \frac{V_{PS}}{RC}\left(1 - \frac{V_C(t)}{V_{PS}}\right) \quad \text{(eqn 3)}$$

If the power supply voltage is set to 150% of the nominal breakdown voltage, then the quantity in parentheses in equation 3 is equal to 1/3 at breakdown. Substituting this into equation 3 yields:

$$\left.\frac{dv_C}{dt}\right|_{@\,BDV} = \frac{V_{PS}}{RC} x \frac{1}{3} = \frac{1.5V_{BDV}}{RC} x \frac{1}{3} = \frac{V_{BDV}}{2RC} \quad \text{(eqn 4)}$$

If the circuit uses a .1µF capacitor and a 25MΩ resistor (with the spark gap to be tested connected across the capacitor) and a 3750V power supply to test a 2500V spark gap, then the ramp rate will be 500V/s according to equation 4. Equation 3 can be used to check the ramp rate for breakdowns different from the nominal value. For a 2125V (.85 x 2500V) breakdown, the ramp rate using the values given above would be 425V/s.

For a more linear ramp, we suggest using a power supply with remotely controlled output voltage (which can function essentially like an operational amplifier) controlled with a low voltage linear ramp generator.

Impulse Breakdown Voltage

Building test equipment for impulse breakdown voltage testing is not as straightforward as for DC testing. One common approach is to use a pulse transformer. In its simplest form, the tester consists of a 0-500 volt DC power supply which charges a capacitor that is discharged through the primary of the pulse transformer. The gap under test is connected directly across the secondary of the pulse transformer. Coarse adjustment of the ramp rate can be accomplished by adding a capacitor (a few picofarad) across the gap under test. Fine adjustment can be accomplished by adjusting the output of the DC power supply.

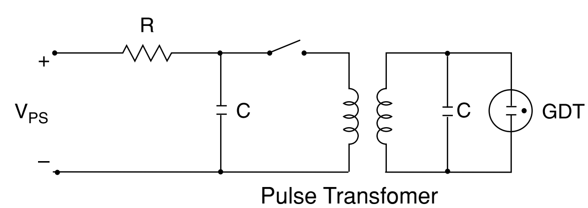

Figure 2 - Simple circuit for generating impulse breakdown voltage waveforms.

Another common approach (especially for faster ramp rates) uses a high-energy spark gap (such as High Energy Devices' SB4.0) as a switch to quickly discharge a capacitor with the test voltage existing across the discharge resistor as depicted in Figure 3. In this circuit, the ramp rate can vary greatly depending on the capacitor inductance and stray impedances.

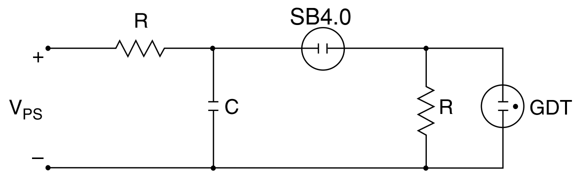

Figure 3 - Simple circuit for generating faster impulse breakdown voltage waveforms.

Insulation Resistance

To make this measurement at the rated voltage (often 100V, but never exceeding the breakdown voltage of the gap) requires specialized equipment. A megohmmeter can be used to directly measure insulation resistance. A power supply and a sensitive ammeter can be used to measure the leakage current at the rated voltage. Dividing the leakage current into the voltage will yield the insulation resistance. For example, if a gap with 100V across it yields a leakage current of 10nA, then its insulation resistance is 10GΩ (100V/10nA).

In situations where the insulation resistance limit is much lower (during life testing), insulation resistance measurements can often be reasonably made using a basic ohmmeter.

Contact Information:

High Energy Devices, LLC
26 Hollenberg Court
Bridgeton, MO 63044
Phone: 314.291.0030
Fax: 314.291.8184
E-mail: info@highenergydevices.com
www.highenergydevices.com

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