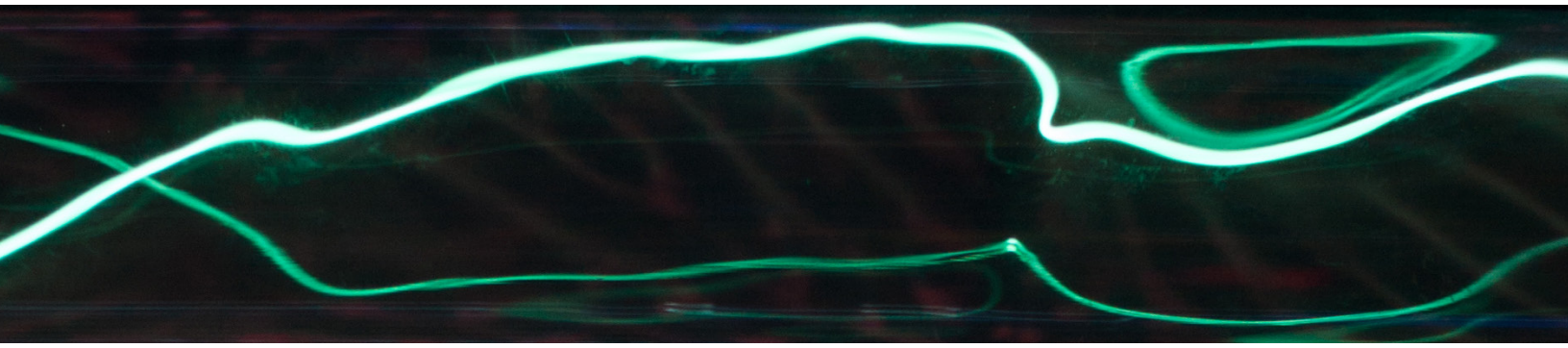

APPLICATION NOTE

Capacitor Reliability Testing: The Importance of Gas Control

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CAPACITOR RELIABITY TESTING: THE IMPORTANCE OF GAS CONTROL

Fast, repeatable spark gap pressure control enables hands-off accelerated lifetime testing of energy storage capacitors intended for pulsed power applications. Accumulating a large number of shots in a short period of time has two components: maximizing test stand shot rate and minimizing downtime. Cost effectively showing that a capacitor is reliable also requires minimizing gas consumption and interventions by test personnel.

Maximizing Rep Rate

Spark gap repetition rates are limited by recovery time, cooling, and triggering. Rapid pressure control eases all three of these limiting factors. Recovery time decreases with gas flow because fresh gas sweeps out ions and free electrons created by previous shots. High gas flow also cools the spark gap electrodes and housing to prevent thermal damage. Gas flow may be either continuous or intermittent, but intermittent pulse-purging has the significant advantage of doubling as a pneumatic trigger so that a separate electronic trigger generator with its own repetition rate limitations is not needed. Regardless of whether continuous flow or pulse-purging is used, it is best to measure pressure at the spark gap rather than at the pressure regulator so that spark gap pressure is independent of the flow rate.

Pressure and Flow

Most mechanical and electronic pressure regulators measure pressure internally using ambient pressure as a reference. Internal pressure sensing complicates capacitor lifetime testing because the pressure in the spark gap and the pressure at the sensor internal to the regulator are not the same. This is because friction in the plumbing between the pressure regulator and the spark gap causes a pressure drop so that the pressure at the regulator is higher than at the spark gap whenever there is flow. Because the pressure drop changes with flow, regulator pressure needs to be adjusted whenever the purge flow rate is changed. Remote sensing solves this problem by measuring the actual pressure in the spark gap independent of flow.

Supply Pressure Effect

Lifetime testing may also be interrupted by regulator “supply pressure effect.” An artifact of mechanical pressure regulator design is that output pressure increases as the supply pressure decreases, which is a typical situation when gas is supplied from compressed gas cylinders. As spark gap pressure increases while the supply cylinder is being emptied, the spark gap may stop firing unless a technician adjusts the mechanical regulator to compensate for the supply pressure effect. Electronic pressure regulators solve this problem because they exhibit negligible supply pressure effect.

Gas Consumption

Emptying gas cylinders pose problems in addition to supply pressure effect. Namely, refilling gas cylinders is costly and a technician has to be on hand to manually swap in full cylinders. Swapping cylinders may even interrupt testing. Minimizing gas consumption alleviates these problems.

Continuous flow purging results in high gas consumption because a high flow rate is needed to blow out spark gap electrode debris that would otherwise interrupt testing. The same results can be achieved with less gas by using pulse-purging where a brief blast of gas blows out electrode debris immediately following a shot and the flow rate is reduced to zero at all other times. For spark gaps operating at high pressure, a solenoid dump valve downstream of the spark gap that opens after a shot does result in effective purging, but gas consumption may be higher than necessary. For spark gaps that operate at low pressure, a simple dump valve may not be effective at removing electrode debris unless it is left open for a long time which reduces the maximum shot rate. A fast electronic pressure regulator capable of high flow rates has the agility to hold pressure where it needs to be during a shot and then quickly change pressure and flow after a shot to purge debris with minimum gas.

Speedy Tests

Qualifying capacitors for pulsed power is faster and cheaper when a fast and repeatable electronic pressure regulator is used to control spark gap pressure. Repeatability and immunity to supply pressure effect and atmospheric pressure variations ensures that testing is not interrupted until the DUT either passes or fails. The ability to rapidly change pressure keeps spark gaps healthy while minimizing gas consumption and total testing time.

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