Introduction

The BX Series of two electrode miniature spark gaps has been designed for applications that have severe environment and high reliability requirements.

The BX Series is made with high alumina (Al_2O_3) ceramic and metal electrodes that are hermetically sealed at high braze temperatures to withstand extreme levels of temperature and rugged environmental conditions.

The small size of the BX gaps allows alternative mounting methods, including circuit board mounting as well as external clamping of the ceramic envelope by using low dielectric materials.

The miniature BX Series is used in military ordnance applications for explosive detonations. Other applications include protection of circuit components from over voltage conditions; transfer of energy in flashlamp applications; crowbarring power supplies and other energy transfer applications.

Delay Time to Fire Two Electrode Gaps

In those applications in which energy transfer is accomplished with two electrode gaps, the delay time in achieving spark gap breakdown is dependent on the time needed to charge the storage capacitor from time zero until the breakdown voltage of the gap is reached. The charging time of the capacitor is normally accomplished in milliseconds. The formative time for the spark to occur after the applied voltage has been raised to the Static Breakdown Voltage level is in the order of ten's of nanoseconds.

At this point, the impedance of the gap drops from several thousand megohms to less than an ohm and the storage capacitor discharges at a rate limited by the circuit impedance.

As an example, the performance characteristics contained in Table 2 were obtained with gaps having DC Breakdown Voltage of 5.0kVdc.

Life Ratings

The end of life of the spark gap is determined by non-conformance to the failure modes as described in the section on Failure Modes during Life Tests. The wear out mechanisms of the spark gap are due to several factors. The first of which is electrode wear, in which vaporization of the electrode occurs due to the high arc temperatures. The vaporization of the electrodes may result in increase in gap spacing and cause higher breakdown voltages. Two other factors affect the life of the gap. Fill-gas cleanup may occur due to chemical activity between the electrodes and the active fill-gas components. The third factor is vapor deposits from the electrodes on to the inner surfaces of the ceramic envelope, which may result in reduction in the insulation resistance of the gap. At high levels of energy transfer, the electrodes may erode with resulting deformation of the electrode surfaces. In this case, the breakdown voltage may be reduced.

When the BX gaps are used for energy transfer applications, the size of the capacitor and the voltage to which it is charged will determine to a great extent the operating life of the gap. For low levels of energy storage (< 1.0 Joule), the arc resistance is in the order of ten's of milliohms. Since erosion of the gap electrodes is primarily related to the energy dissipated in the resistive component of the gap, slight differences in the resistive and inductive components of the discharge circuit will affect the discharge life of the spark gap. The ultimate determination of the life must be obtained by empirical means.

Since each customer circuit is unique, the only way to determine device life is by performing life tests in the actual circuit.

Definitions Applied to Two Electrode Gaps

DC Breakdown Voltage (V_{BD}) i s the voltage level at which a gap sparks over (breakdown occurs) when a slowly rising dc voltage is applied. The typical rate of rise for DC breakdown measurement is 100 volts per second. The rate of voltage rise is slow compared with the avalanche buildup time of the electrode-gas-pressure combination, which is in the order of nanoseconds.

Impulse Breakdown Voltage (V_{bd}) is the voltage level at which a gap sparks over when a fast rising voltage is applied. Due to the time required to ionize the inert gas of the tube, the impulse breakdown of the gap may exceed the DC breakdown voltage by a substantial amount. The impulse breakdown is a function of the rise time of the impulse and increases in value with decreasing rise time.

Insulation Resistance (IR) is the resistance across the terminals of a gap when measured at 100Vdc at ambient conditions.

Maximum Surge Current is that level which the gap can withstand without failing in any of the failure modes listed when a surge current of 8/20 microseconds is applied (8 represents the rise time and 20 represents the time at half amplitude).

Failure Modes During Life Tests

A. Short circuit failure mode - In this mode, the gap shall become permanently short-circuited.
B. Low breakdown voltage failure mode - In this mode, the gap shall have a DC breakdown voltage less than 80% of the minimum breakdown voltage.
C. High breakdown voltage failure mode - In this mode, a gap shall have a DC breakdown voltage of greater than 20% of the maximum breakdown voltage.
D. Low insulation resistance failure mode - In this mode, the gap shall have a resistance of less than 1 megohm.

Applications

The BX Series of spark gaps has been developed for switching applications requiring:
- Long life when subjected to low energy discharges
- Narrow firing limits over the life of the gap
- Rugged construction
- Low cost

Typical applications for the BX Series when used in energy transfer applications include:
- High energy discharge ignitors
- Gas ignitors
- Flashlamp triggers

The BX Series may be used in military ordnance detonation applications. In using the two electrode gap, the time to fire is limited to the charging time of the storage capacitor. In this case, the condenser is charged from a DC source until the breakdown voltage of the gap is reached at which time the capacitor discharges through the gap and the load. The impedance of the gap drops from several thousand megohms to less then one ohm and the storage capacitor discharges at a rate limited by the circuit impedance.

Availability

The BX Series is available with DC Breakdown Voltages of 2.0kVdc up to 20.0kVdc as shown in Table 1.

Table 1
Operating Specifications @25^{0}C

High Energy Devices Part Number	DC Breakdown Voltage @ 100V/s (Nominal kVdc)	DC Breakdown Voltage Limits @ 100V/s (Min - Max kVdc)	Impulse Breakdown Voltage @ 100V/µs (Maximum Vdc)	Surge Current @ 8/20µs (Maximum kA)
BX2.0	2.0	1.8-2.2	4.0	10
BX2.5	2.5	2.25 –2.75	5.0	10
BX5.0	5.0	4.5 –5.5	7.0	10
BX7.5	7.5	6.75 –8.25	10.5	10
BX10.0	10.0	9.0 – 11.0	14.0	10
BX12.5	12.5	11.25 – 13.75	19.5	10
BX15.0	15.0	13.5 –16.5	20.6	10
BX17.5	17.5	15.75-19.25	24.0	10
BX20.0	20.0	18.0-22.0	25.0	10

BX5.0 Characteristics

Operating characteristics, discharge life and environmental ratings of the BX 5.0 are shown in Table 2.

Table 2
Operating Characteristics @25^{0}C

Parameter	Test Conditions	Symbol	Min	Nom	Max	Units
DC Breakdown	100V/s	V_{BD}	4.5	5.0	5.5	kVdc
Impulse Breakdown	100V/µs	V_{bd}	-	-	7.0	kV
Insulation Resistance	100Vdc	IR	-	10^{10}	-	Ohms
Capacitance	1 MHz	C	-	-	1	pF

Life Ratings

Parameter	Test Conditions	Symbol	Min	Nom	Max	Units
Discharge Life	5,000A Pulse Energy (0.7 Joules)	-	10,000	-	-	surges
Maximum Surge Current	10kA (8/20)	-	-	-	1	surge
Cumulative Charge	Coulombs	-	-	3.1	-	Q

Environmental Ratings

Parameter	Test Specifications	Test Conditions
Vibration Mil-Std 202D	Method 107 Condition A	Test at 10g's, 3 axis, 3 hours/axis 10Hz- 500Hz
Shock Mil-Std 202D	Method 204 Condition A	Test at 100g's, 6 milliseconds, 3 axis 3 shocks each direction 18 shocks total
Altitude Test Mil-Std 202D	Method 105 Condition A	No degradation at 30,000 ft. non-operating No degradation at 15,000 ft. operating

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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