ALL ELECTRONIC CIRCUITS are subject to voltage transients. Since circuit components may be destroyed by these transients, some means of protection must be provided. The simplest and most effective means of providing this protection is by using EEV ceramic gas filled spark gaps. These spark gaps will react more quickly to a voltage transient than will an electro-mechanical device or solid state component, thereby giving greater protection.

Features
- Wide range, 500 - 40kV
- Rugged construction
- No stand-by power consumption
- High current capability
- Low inductance
- Universal mounting position
- Wide temperature range
- Low energy triggering

FOR FURTHER DETAILS CONTACT YOUR LOCAL AGENT OR EEV AT THE ADDRESS BELOW:

ENGLISH ELECTRIC VALVE CO LTD
Chelmsford, Essex, CM1 2QU, England
Telephone: 0245 61777
Telex: 99103 Cables: Enelectico Chelmsford
PRECISE HIGH ENERGY SWITCHING is required in many applications, including ignition circuits, short pulse generators, laser pumping, Marx generating switch and EBW circuits. This can be accurately achieved by using EEV ceramic gas filled spark gaps.

**Features**
- Wide range, 500 - 40kV
- Rugged construction
- No stand-by power consumption
- High current capability
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SPARK GAPS
Introduction

What is a spark gap?

The spark gaps manufactured by English Electric Valve Company are sealed gas filled switches and contain two or more electrodes which present a near infinite impedance to a circuit while unfired and a near short when fired.

Principles of operation

A simple two electrode spark gap is shown in figure 1.

At low voltages the gap is a good insulator with a very low leakage current. As the voltage to the spark gap increases an avalanche effect is created until a point
is reached where the gas filling forming the insulation is broken down and an arc discharging is formed between the electrodes which allows the passage of very high currents at a voltage of some 10–20 volts.

The arc persists until the current falls to a value insufficient to maintain arc conditions. The current flow then ceases and the ionization of the gas decays until the gap has returned to its original state.

The addition of the third electrode (see figure 2) makes it possible to establish an arc at gap voltages below the breakdown value. Over a wide range of gap voltage a low-energy pulse applied to the third trigger electrode produces a small arc which transfers rapidly to the main
gap. The device then reacts in the same manner as a two-electrode spark gap.

Applications

Spark gaps are devices used for two basic functions:

1. As a protection device; and
2. As an energy switch.

If we deal with the first function, that of voltage surges and transient protection, the question will be asked - What needs protecting? The following is a list of equipments effected or damaged by external voltage surges:

- Telephone lines
- CATV lines
- Power lines
- Oil and gas pipelines
- Antenna systems, radio, TV and microwave

These transients may be caused by the following:

- Electrostatic fields i.e charged clouds
Lightening

Shorting or interruption of currents in power lines

Auroras

Electromagnetic effects due to near-by nuclear explosions

Protection is also required against voltage surges and spikes. Delicate equipment may be damaged due to intentional or unintentional switching processes.

Examples are listed below:

Amplifiers

Digital volt meters

Control circuits

Radios

Communications equipment

These surges or transients may be caused by the operation or switching of:

Inductors

Meters

Generators

Relays
Arcing of CRT's, power tubes and TWT's
Magnetron missing pulses
Sparkover on switch contacts

Figure 3 shows some typical protection applications.

Moving on to the second function of spark gaps, that of energy transfer switches, these are illustrated on the Applications Chart (figure 4). All these switching duties can be achieved by using EEV spark gaps.

Under the heading Pulse Generators and Relaxation Oscillators, here spark gaps can be used for the ignition of natural gas via a suitable ignitor, for the starting of jet engines and gas turbines. This is where the spark gap is used to discharge a high power capacitor into a ceramic or rare earth ignitor located in the flame chamber. EEV spark gaps are also used for igniting flare stacks on off-shore oil rigs and igniting flammable gases in the petro-chemical industry. Spark gaps are also to be found as simple Relaxation Oscillator switches in such things as electric fences.
Figure 3

**PROTECTION APPLICATIONS**

- **CAPACITORS**
  - **DEFIBRULATORS**
  - **SERIES GRID CAPACITOR DRIVE FOR Power Factor Correction ON TRANS Lines**
  - **TRACTION DC CHOPPERS**
  - **TRANSMITTERS**
  - **RECTIFIER GENERATORS**
  - **MISFIRES IN TWT MAGNETRON KLYSTRONS & TETRODES**
  - **ELECTRON MICROSCOPE**
  - **ELECTRON BEAM WELDING GUNS**
  - **PIPE COUPLINGS**
  - **AIRCRAFT TRANSMIT & RECEIVE ANTENNAS**
  - **METERS**
  - **PULSE TRANSFORMERS**

**CIRCUIT APPLICATIONS**

- **PULSE GENERATORS RELAXATION OSCILLATOR**
- **CAPACITOR SWITCHING**
  - **TIG WELDING**
  - **NATURAL GAS IGNITION BOILERS ETC.**
  - **ELECTRIC FENCE GAP**
  - **JET ENGINE IGNITION**
  - **PULSING LASERS & FLASH TUBES**
  - **SPARK CHAMBERS, KERR CELLS**
  - **EBW CIRCUITS**
  - **IGNITRON TRIGGERING**

English Electric Valve Company Limited Waterhouse Lane, Chelmsford, Essex, England, CM1 2QU Telephone: Chelmsford (0245) 61777
Moving on to capacitor switching, EEV spark gaps are currently being used for:

- Pulsing lasers and flash tubes
- Switching spark chambers and kerr cells
- Switching exploding bridge wire circuits used in the detonation of nuclear explosions, war heads, close proximity shells, etc

Spark gaps are also used for ignitron triggering where they are used in nuclear fusion experiments by Physics Laboratories and Atomic Energy Authorities.

**Competitive devices**

**For protection:**
- Thyrites
- Varistors
- Capacitors
- Selenium Rectifiers
- Metrocils

**For energy switching:**
- Ignitrons
- Thyratrons
- Thyristors
- Krytrons
- Fast mechanical switches

Most of these competitive devices can be replaced by EEV spark gaps due to their high technology features.
listed as follows:

High current capability
Rugged construction
None-moving parts
Reliable hold-off voltage
Low inductance
Low capacitance
Low energy triggering (three electrode)
Very wide temperature range
Fast acting
No stand-by power consumption
Glass and Ceramic Envelope Spark Gaps

English Electric Valve Company Limited,
Waterhouse Lane, Chelmsford, Essex, CM1 2QU.
Telephone: Chelmsford (0245) 61777
Telex: 99103
<table>
<thead>
<tr>
<th>Type</th>
<th>GXM5A</th>
<th>GXMT40</th>
<th>GXE</th>
<th>GXP</th>
<th>GKK</th>
<th>GXL</th>
<th>GXM70</th>
<th>GXA</th>
<th>GXB</th>
<th>GXC</th>
<th>GXN</th>
<th>GXR</th>
<th>GXV</th>
<th>GXH</th>
<th>GXO</th>
<th>GXW</th>
<th>GXF</th>
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<tbody>
<tr>
<td>Cumulative charge (coulombs)</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>50</td>
<td>50</td>
<td>50</td>
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<td>100</td>
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<td>400</td>
<td>400</td>
<td>600</td>
<td>1000</td>
<td>1000</td>
<td>20000</td>
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</tr>
<tr>
<td>Max. discharge energy (joules)</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>100</td>
<td>2000</td>
<td>2000</td>
<td>5000</td>
<td></td>
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<tr>
<td>Max. current (A)</td>
<td>2500</td>
<td>2500</td>
<td>1500</td>
<td>2500</td>
<td>2500</td>
<td>2500</td>
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<td>4000</td>
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<td>10000</td>
<td>75000</td>
<td>75000</td>
<td>80000</td>
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<tr>
<td>Breakdown voltage (kV)</td>
<td>0.5 - 1.5</td>
<td>2 - 5</td>
<td>0.5 - 3.0</td>
<td>0.4 - 12</td>
<td>0.4 - 12</td>
<td>3 - 7</td>
<td>5 - 16 pulsed</td>
<td>5 - 16 pulsed</td>
<td>0.4 - 12</td>
<td>0.4 - 12</td>
<td>0.4 - 12</td>
<td>0.5 - 6</td>
<td>10 - 40</td>
<td>0.4 - 20</td>
<td>0.25 - 15</td>
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<td>Capacitance (pF)</td>
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<td>0.6</td>
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<td>0.5</td>
<td>0.6</td>
<td>0.6</td>
<td>0.4</td>
<td>0.4</td>
<td>1.3</td>
<td>0.5</td>
<td>2</td>
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<td>Impulse ratio †</td>
<td>6 - 2.7</td>
<td>6 - 1.7</td>
<td>7.5 - 1.7</td>
<td>7.5 - 1.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7.5 - 1.7</td>
<td>7.5 - 1.7</td>
<td>7.5 - 1.7</td>
<td>6 - 1.8</td>
<td>-</td>
<td>7.5 - 1.5</td>
<td>12 - 1.6</td>
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<tr>
<td>Minimum trigger voltage (open circuit) (kV)</td>
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<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
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<td></td>
</tr>
<tr>
<td>Number of electrodes</td>
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<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
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<td>2</td>
<td>2</td>
<td>2</td>
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<td>2</td>
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<tr>
<td>Construction</td>
<td>G = glass</td>
<td>C = ceramic</td>
<td>C = ceramic</td>
<td>C = ceramic</td>
<td>C = ceramic</td>
<td>C = ceramic</td>
<td>C = ceramic</td>
<td>C = ceramic</td>
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<td>C = ceramic</td>
<td>C = ceramic</td>
<td>C = ceramic</td>
<td>C = ceramic</td>
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<td>Terminations</td>
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<td>2 leads</td>
<td>1 wire</td>
<td>2 flex</td>
<td>1 cap</td>
<td>1 stud</td>
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<td>2 leads</td>
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<td>2 caps</td>
<td>2 leads</td>
<td>2 caps</td>
<td>1 cap</td>
<td>1 stud</td>
<td>3</td>
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<td>19</td>
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<tr>
<td>Weight (grammes)</td>
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<td>7.5</td>
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<td>12</td>
<td>12.5</td>
<td>40</td>
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<td>27.5</td>
<td>138</td>
<td>18</td>
<td>20</td>
<td>29</td>
<td>37</td>
<td>465</td>
<td>450</td>
<td>900</td>
</tr>
</tbody>
</table>

† The impulse ratio of a spark gap is defined as the breakdown voltage of the device measured under an impulse condition, divided by the d.c. breakdown voltage. The values given are obtained using a 15 kV/µs voltage impulse.

The value of impulse ratio depends on the d.c. breakdown voltage to which the gap is made; the impulse ratio is highest for low voltage gaps. Two values of impulse ratio are given for each type, the first being typical of the minimum breakdown voltage while the second value refers to a gap made to the maximum breakdown voltage.