Glass dielectric capacitors exhibit several key performance parameters critical to high performance circuitry. This technical paper is a summary of specialized tests performed on AVX glass capacitors to demonstrate their in-circuit characteristics.

**ABSTRACT:**

Glass dielectric capacitors exhibit several key performance parameters critical to high performance circuitry. This technical paper is a summary of specialized tests performed on AVX glass capacitors to demonstrate their in-circuit characteristics.
Introduction

Glass Dielectric Capacitor Construction

AVX Glass dielectric capacitors offer the end user the highest performance and reliability features available in the capacitor industry.

The construction of Glass capacitors is straightforward. There are only three elements: glass dielectric and case, aluminum electrodes, wire terminals. (Radial capacitors have a molded case.) The capacitors are made in a multilayer fashion (as shown below).

AVX performs a 100% inspection on each capacitor checking: capacitance value and tolerance, rated voltage, and hermetic seal (axials). The capacitors are made in a multilayer fashion (as shown below).

Simplicity of construction, combined with the excellent dielectric characteristics of glass, make AVX Glass Capacitors outstanding performers.

Glass Capacitor Applications

Glass capacitors have traditionally seen widespread usage in military applications with a large number of new designs occurring in the aerospace and high performance commercial sectors. Glass capacitors have applications across the entire spectrum of electronic circuits and their past success on a variety of manned and unmanned space missions continues to fuel interest of the defense and aerospace industries.

The following is a list of general applications where Glass capacitors are currently utilized:

- Radiation Hardened Circuitry
- Burn in Oven Circuitry +200°C
- High Temperature Circuitry
- Galvanometers
- Radar Systems
- Modulators
- Gyro Systems
- R.F. Amplifiers Output Filters
- Low Noise Receiver Front Ends
- Variable Frequency Oscillators
- Voltage Controlled Oscillators
- Amplifier Coupling
- Impedance Transformation
- Networks
- PLL Circuitry
- Sample and Hold Capacitor
- Ramp Integrators
- Voltage Snubbers
- Transistor Biasing
- Low Temperature Circuitry
- (-150°C)
- Bridge Reference Capacitors
- Temperature Sensing Circuitry
- Jet Engine Monitors
- Dosimeters
- Space Defense/Satellites
- Geophysical Sensors
- Porcelain Capacitor Replacements
- Medical Monitoring Circuitry
- Missile Systems and Avionic Circuitry
- Application assistance on any specific circuitry is available from the Raleigh, NC applications hotline: (919) 878-6224.

Glass Capacitor Electrical Characteristics

Capacitance Stability

Glass capacitors exhibit excellent stability characteristics as a result of their unique material system.

The temperature coefficient for Glass capacitors (stated in linear approximation form) is $140 \pm 25 \text{ppm/°C}$. However,
the actual temperature coefficient is shown below (see Figure 1). Furthermore, the temperature coefficient of all Glass capacitors will retrace to within ±5ppm/°C of the TC curve without exhibiting hysteresis. The capacitance change vs. temperature of Glass capacitors is shown in Figure 2.

**Long Term Stability**

Numerous five year “drift tests” were conducted on standard CY Glass capacitors which indicate Glass capacitors have zero aging rate. The components under test were read for capacitance immediately after production. They were then stored under normal room conditions and reread for capacitance value five years later. The maximum positive drift was 0.07% of initial capacitance value and the maximum negative drift was 0.06%.

Long term stability investigations were also performed under load life test conditions. The results of one such test are as follows:

<table>
<thead>
<tr>
<th>Table I</th>
<th>Long Term Load Life Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Style</strong></td>
<td>No. Hours on Test</td>
</tr>
<tr>
<td>CY10</td>
<td>39,558</td>
</tr>
<tr>
<td>CY15</td>
<td>47,597</td>
</tr>
</tbody>
</table>

All Glass capacitors exhibit zero piezoelectric noise and have zero voltage coefficient regardless of age or style.

**Loss Characteristics**

AVX Glass capacitors exhibit low loss over a wide operating temperature and frequency range. The following graphs describe loss characteristics as a function of temperature, capacitance value/form factor, and frequency.
**Dielectric Absorption**

Glass dielectric capacitors have been tested for Dielectric Absorption (DA) characteristics per Military Specification MIL-C-19978 and have shown a consistently low Dielectric Absorption from lot to lot (0.012% is typical). In addition to DA figures which are comparable to polystyrene, glass capacitors exhibit zero aging rate, zero piezoelectric noise, and a ±5ppm TC retraceability regardless of component age. Furthermore, glass capacitors exhibit zero voltage coefficient and low thermal and charge noise figures.

Glass capacitors continue to experience widespread usage in sample and hold current integrators, and in high gain amplifiers as a result of these performance features.

**AVX Glass Capacitors – RF Current Applications**

AVX Glass dielectric capacitors can handle large Radio Frequency (RF) currents over a wide frequency range. (See following graphs.)

Glass dielectric capacitors have a high Q factor and a low dissipation factor that changes little with frequency and temperature excursions. This coupled with a low, retraceable, extended range temperature coefficient ensures repeatable, reliable performance – regardless of the capacitor's environment.

The large RF currents that glass dielectric capacitors can handle make them ideal for use in modulators, filters, and linear amplifiers.

### Nuclear Radiation Hardness

AVX axial Glass capacitors are made of inorganic materials and are highly resistant to nuclear radiation, voltage breakdown, and high operating temperatures.

When exposed to a neutron radiation field of $10^{15}$ fast N/cm² SEC, AVX Glass capacitors were shown to have a transient capacitance increase of between 0.7 to 2.5 percent, while exhibiting a permanent capacitance increase of less than 0.5 percent. AVX Glass capacitors can operate in neutron flux environments 10 to 100 times more intense than other capacitor technologies and experience only minor damage. Furthermore Glass capacitors will not become a toxic hazard when exposed to radiation.

A summary of various capacitor technologies' performance under a neutron radiation field is shown below:

- **Glass**
- **Ceramic**
- **Mica**
- **Plastic**
- **Paper**
- **Electrolytic**

When exposed to gamma irradiation, Glass capacitors exhibit an extremely small transient and permanent capacitance change and a consistently low dissipation factor with frequency.

The capacitors under test were uniformly exposed to a total dose of 9.6 x $10^7$ rads (H₂O) and measured for capacitance value and dissipation factor across a frequency range of 100Hz to 100kHz before irradiation, immediately after irradiation, 2 hours after irradiation, and 96 hours after irradiation. Results of such testing are as follows:
Elevated Temperature (+200°C) Performance

Temperature extremes are the enemy of reliable and long term circuit performance. Elevated Temperature (ET) series of Glass capacitors are designed to meet these requirements.

After years of research, this wide range capability was achieved by matching and optimizing thermal expansion rates of the materials in Glass capacitor manufacture.

AVX ET series capacitors also provide the same highly reliable characteristics as other AVX Glass capacitors such as nuclear radiation stability, outstanding capacitance retraceability, and rugged, yet simple, construction that eliminates mechanical problems.

ET Features

- Available in both Axial and Radial Configurations
- Radiation Hardened (Axials)
- Values from 0.5pF to 2400pF
- Rugged design and construction
- "Burned in" versions available - 50 hours, 1500 vdc, 25°C
- Voltage coefficient = 0
- Working temperature range 75°C to +200°C
- Short term (≤1 hour) exposure to 250°C no performance degradation
- High Voltage Pulse withstanding capability
- Low Noise – excellent choice with GaAs circuitry

Typical Applications

- Semiconductor Burn-in Ovens
- Oil Well Logging and Down Hole Instrumentation
- Geophysical Pressure Probes
- Remote Antenna
- Low Noise Amplifiers (LNAs)
- Radio Frequency (RF) Output Circuits
- Missile and Aerospace Transducers
- Super Cooled High Speed Logic
- Cold Low Noise Radar Circuits
- Aerospace Solar Array Systems
- Cryogenic Sensors

Standard Operating Characteristics of AVX ET Capacitors

- Working Temperature Range...-75°C to +200°C, Short Term (≤1 hour) exposure to 250°C with no degradation in performance
- Voltage Rating...50 vdc
- Capacitance Range...0.5pF to 2400pF
- Insulation Resistance...at 25°C >100,000 megohms
  at 200°C >1 x 108 ohms
- Dissipation Factor...at 25°C <1% at 1kHz
  at 200°C <1% at 1kHz
- Life...200°C, 1000 hour life at rated voltage
- Post Life Test...Delta C at 25°C <2%
  DF at 25°C <2.5%
  IR> x 108 ohms (Axials)
  IR> x 107 ohms (Radials)

Standard Operating Characteristics of AVX ET Capacitors (cont.)

- "Burned in" versions available - 50 hours, 1500 vdc, 25°C
- Voltage coefficient = 0
- Working temperature range 75°C to +200°C
- Short term (≤1 hour) exposure to 250°C no performance degradation
- High Voltage Pulse withstanding capability
- Low Noise – excellent choice with GaAs circuitry

Dissipation Factor vs. Temperature

% Capacitance Change vs. Temperature
**Product Options/Series**

**Glass Axial: CY, CYR, CYFR, ET & ETR Series**

**CY Series:** Qualified to MIL-C-11272. Available in 2 case sizes; 0.5pF to 1200pF; 500 VDC, 300 VDC rated, hermetically sealed.

**CYR Series:** Qualified to MIL-PRF-23269. Failure Rate Levels M and S; available in 2 case sizes; 0.5pF to 1200pF; 500 VDC, 300 VDC rated; 100 VDC (S level only); hermetically sealed.

**CYFR Series:** Meets or exceeds all requirements of AVX specifications J-950, J-951 (modeled after Minuteman high reliability specification); available in 2 case sizes; 0.5pF to 1200pF; 500 VDC, 300 VDC rated. Insulation resistance greater than 500,000 megohms at 25°C, greater than 10,000 megohms at 125°C; hermetically sealed.

**ET, ETR Series:** Elevated Temperature (ETR High Reliability) series. Capable of operation over -75°C to +200°C with short overexposure to +250°C (≤1 hour). Available in 2 case sizes; 0.5pF to 1200pF; 50 VDC rated across operating temperature range; hermetically sealed; ETR series burned-in at 1500 VDC, 50 hours, 25°C.

**Glass Radial: CY, CYR, ET & ETR Series**

**CY Series:** Qualified to MIL-C-11272; available in 3 case sizes, 1pF to 2400pF; 300 VDC rated.

**CYR Series:** Qualified to MIL-PRF-23269; Failure Rate Level M; available in 3 case sizes; 1pF to 2400pF.

**ET, ETR Series:** Elevated Temperature (ETR High Reliability) series capable of operation over -75°C to +200°C. Available in 3 case sizes; 1pF to 2400pF; 50 VDC rated across operating temperature range. ETR series burned-in at 1500 VDC, 50 hours, 25°C.

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**Table II: Capacitance Range/Case Sizes**

<table>
<thead>
<tr>
<th>Case Size</th>
<th>Capacitance Range</th>
<th>L (±.005 ±.13)</th>
<th>W (±.010 ±.25)</th>
<th>T (±.005 ±.13)</th>
<th>Lead Diameter S (±.002 ±.051)</th>
<th>Weight (Grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.5pF to 300pF</td>
<td>0.344 ± 0.047</td>
<td>0.172 ± 0.001</td>
<td>0.078 ± 0.001</td>
<td>0.020 (+0.51) 0.25 - 0.50</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>220pF to 1200pF</td>
<td>0.460 ± 0.047</td>
<td>0.266 ± 0.001</td>
<td>0.100 ± 0.001</td>
<td>0.020 (+0.51) 0.75 - 1.25</td>
<td></td>
</tr>
</tbody>
</table>

**Table IV: Capacitance Range/Case Sizes**

<table>
<thead>
<tr>
<th>Case Size</th>
<th>Capacitance Range</th>
<th>L (±0.055 ±1.13)</th>
<th>W (±0.010 ±0.25)</th>
<th>T (±0.005 ±0.13)</th>
<th>Lead Diameter S (±0.002 ±0.051)</th>
<th>Weight (Grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/51</td>
<td>1pF to 560pF</td>
<td>0.300 ± 0.055</td>
<td>0.200 ± 0.010</td>
<td>0.115 ± 0.005</td>
<td>0.020 ± 0.020</td>
<td>0.3 - 0.4</td>
</tr>
<tr>
<td>07/52</td>
<td>620pF to 1000pF</td>
<td>0.300 ± 0.055</td>
<td>0.300 ± 0.010</td>
<td>0.115 ± 0.005</td>
<td>0.020 ± 0.020</td>
<td>0.4 - 0.5</td>
</tr>
<tr>
<td>08/53</td>
<td>1100pF to 2400pF</td>
<td>0.300 ± 0.105</td>
<td>0.300 ± 0.010</td>
<td>0.115 ± 0.005</td>
<td>0.020 ± 0.020</td>
<td>0.7 - 0.8</td>
</tr>
</tbody>
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