

# TECHNICAL PAPER

## Assessing the Benefits of Tantalum Capacitors in Electronic Detonator Applications

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### **Abstract**

Electronic detonators have revolutionized explosive applications by allowing precise control over detonation timing, increased safety, and improved efficiency. Since capacitors are indispensable in electronic detonators, choosing the right capacitor is crucial for ensuring system robustness. The emergence of Tantalum (MnO<sub>2</sub>) Capacitors has been a game-changer. Tantalum capacitors offer excellent electrical characteristics and robust reliability, making them suitable for electronic detonator applications. This whitepaper delves into essential parameters for choosing capacitors, focusing on the benefits of integrating Tantalum capacitors.



## ASSESSING THE BENEFITS OF TANTALUM CAPACITORS IN ELECTRONIC DETONATOR APPLICATIONS

### OVERVIEW OF ELECTRONIC DETONATORS

Electronic detonators are devices utilized for initiating explosive charges. Unlike conventional fuse-based detonators, electronic detonators offer precise timing, increased safety, and improved performance in various mining, construction, and defense applications. They are designed using intricate electronic circuits that require consistent power delivery to operate effectively.

Electronic detonators provide microsecond precision, unlike mechanically or chemically

initiated detonators (blasting caps). This enhanced precision leads to better fragmentation, lower ground vibration, and improved safety. The delay time can be programmed into the detonator, offering flexibility for different blasting scenarios. The consistent energy provided by the power source minimizes the chance of misfires. Eliminating external lead wires and offering remote detonation capabilities reduce the risk to personnel.

### COMPONENTS AND BASIC OPERATION

**Power Source:** A small battery providing a continuous source of power, or a capacitor temporarily stores energy in the form of an electric field. This stored energy is released upon command to initiate the detonation.

**Switching Mechanism:** Often an electronic switch or relay, the switching mechanism allows or interrupts the flow of current to the bridge wire, ensuring that the detonator be activated at a precise moment.

**Bridge Wire:** A thin wire, often made of nichrome or tungsten, that heats up rapidly upon passing an electrical current, initiating the primary explosive.

**Primary Explosive:** Sensitive to heat, shock, or electrical current. When initiated by the heated bridge wire, it undergoes rapid decomposition, releasing significant energy in a short time.

**Secondary (Base) Explosive:** Less sensitive than primary explosives but producing a stronger explosion. The primary explosive serves as a trigger for the secondary explosive, amplifying the explosion.

The basic operation of an electronic detonator is as follows:

A control device sends a signal to the detonator wirelessly or through a wired connection. The electronic switch is activated upon receiving this signal, allowing stored energy in the capacitor to discharge into the bridge wire rapidly. This sudden discharge heats the element to a temperature high enough to ignite the primary explosive charge.

### THE ROLE OF CAPACITORS IN ELECTRONIC DETONATORS

Capacitors play a critical role in electronic detonators. They store the energy required to ignite the primary explosive and ensure the instantaneous release of this energy, guaranteeing rapid and precise detonation. They also ensure a stable power supply to the circuit and smooth voltage fluctuations. Their performance, reliability, and stability are paramount in ensuring the safety and effectiveness of the detonation process.

Tantalum capacitors are a class of electrolytic capacitors that use tantalum metal as the anode. The dielectric is a thin insulating oxide layer of tantalum pentoxide (formed on the anode), and the cathode is made of manganese dioxide, conductive polymer, or other materials rather than the liquid electrolyte found in many other types of electrolytic capacitors.

### BENEFITS OF TANTALUM CAPACITORS IN ELECTRONIC DETONATORS

#### Reliability and Durability

Tantalum capacitors are recognized for their long lifespan and ability to operate reliably in harsh conditions. Their robustness is largely due to tantalum oxide, the dielectric in the capacitor, which forms a stable, protective layer. This feature is especially beneficial in environments like mining sites, where electronic components are exposed to extreme conditions.

#### Excellent Temperature Performance

Electronic detonators must function reliably in a wide range of temperatures. Tantalum capacitors operate efficiently over a broad temperature spectrum, making them ideal for such applications. Their stability and minimal leakage current at elevated temperatures gives them an edge over other capacitor types.

#### Compact Size and High Capacitance

Tantalum capacitors offer high capacitances relative to their size. Their high capacitance density means they can be designed more compactly without compromising performance.

#### Tolerance to Voltage Spikes

In the volatile environment of detonations, voltage spikes can be a significant concern. Tantalum capacitors tolerate such spikes, ensuring the

electronic detonator performs predictably without unwanted discharges.

#### Minimal Parasitic Effects

Tantalum capacitors exhibit low equivalent series resistance (ESR) as well as equivalent series inductance (ESL). These minimized parasitic effects lead to faster charge and discharge times, essential for the precise timing required in electronic detonators.

#### Environmental and Safety Aspects

As industries move towards greener and more sustainable practices, using components that reduce environmental impact is crucial. One advantage of tantalum capacitors is their lead-free and RoHS-compliant nature. In addition, tantalum capacitors don't contain liquid electrolytes, minimizing the risk of leakage or spills that can compromise the detonator's integrity.

#### Economic Considerations

While tantalum capacitors come at a higher initial cost compared to their aluminum counterparts, their durability and long lifespan offset this cost in the long run. Low maintenance, replacements, and enhanced reliability can save costs for industries that rely heavily on electronic detonators.

### KEY PARAMETERS FOR SELECTING CAPACITORS FOR ELECTRONIC DETONATOR APPLICATIONS

#### Capacitance Value

The capacitance value determines the amount of energy a capacitor can store. For detonator applications, a balance must be struck between the capacitor's size and the energy requirements of the detonation.

#### Voltage Rating

The voltage rating indicates the maximum voltage the capacitor can withstand without breaking down. For detonator circuits, the voltage rating should be at least 1.5 times the circuit's maximum operating voltage to ensure a margin of safety.

#### Equivalent Series Resistance (ESR)

ESR impacts the discharge rate of the capacitor. Lower ESR values are preferable in detonator

applications as they enable faster discharge rates and efficient energy transfer to the hot bridge.

#### Leakage Current

A low leakage current is essential to maintain the stored energy until the detonation is triggered. High leakage current can result in insufficient energy for reliable detonation. Notably, capacitors with reduced ESR values often exhibit lower leakage currents.

In electronic detonators, excessive leakage can exhaust the stored energy, impacting detonation reliability. Precise detonations in sectors like mining could also be adversely affected, leading to reduced efficacy or even mishaps. Unchecked leakage currents can likewise result in unintended

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### KEY PARAMETERS FOR SELECTING CAPACITORS FOR ELECTRONIC DETONATOR APPLICATIONS

discharges or detonations. For these reasons, lower leakage currents are a prime consideration when choosing capacitors for detonator applications.

Selecting the right capacitor:

- Prioritize capacitors with low leakage currents, often indicated in datasheets.
- Capacitors with low ESR usually have reduced leakage currents.
- Temperature fluctuations affect leakage current. Ensure the chosen capacitors perform reliably across the detonator's operational temperature range.
- Assess leakage current measurements at specific voltage levels and temperatures provided by manufacturers.
- Consider actual leakage current testing for a capacitor sample under application-specific conditions.
- Design adjustments, like switches to disconnect capacitors until detonation, can minimize leakage-induced energy losses

#### Voltage Derating

Voltage derating refers to operating capacitors below their rated voltage, especially in explosive settings. Operating at a derated voltage lowers the risk of capacitor failure from potential voltage spikes, environmental conditions, or material aging. This added reliability can be the difference between successful and potentially hazardous outcomes for detonators.

#### Energy Density

Energy density provides a measure of the energy storage per unit volume of the capacitor. Given the compact size required for electronic detonators, high-energy capacitors are preferred as they pack more energy in smaller spaces, ensuring the detonator can achieve its desired output.

#### Equivalent Series Resistance (ESR)

ESR represents the intrinsic resistance within the capacitor. A low ESR is critical in detonator applications, as it ensures minimal power loss during energy discharge. High ESR capacitors can introduce inefficiencies, reduce the detonation power, and even lead to failures if the resistance becomes too significant.

#### Operating Temperature

Electronic detonators are often used in various environmental conditions, ranging from extreme cold to intense heat. As such, selecting capacitors that can operate effectively within the blasting area's temperature range is essential, ensuring that temperature fluctuations do not compromise performance or safety.

#### Lifetime and Reliability

Given their application's critical nature, detonators' capacitors should boast prolonged lifetimes and high dependability. The right selection should favor capacitors that demonstrate long-lasting performance and minimal degradation over time.

#### Circuit Voltage Profile

Detonators have specific requirements for the rate and manner of energy discharge. Matching the capacitor's discharge characteristics with the detonator's requirements is crucial to achieve the desired explosion characteristics and ensure safety.

#### Shock and Vibration Resistance

Given their environment's explosive nature, detonators' capacitors must be exceptionally resilient to shock and vibration. This resilience ensures that the capacitor remains intact and functional, even in the moments leading up to and during detonation.

#### Safety Standards and Certifications

Given the potential risks associated with detonator applications, selecting capacitors that comply with established safety standards for explosive settings is imperative. Certifications guarantee that the capacitor has been tested and deemed safe for its intended application.

#### Form Factor and Mounting

The design and space constraints within the detonator assembly are stringent. Capacitors should fit within these confines and allow for secure mounting to prevent movement or dislodgement during operation.

#### Cost Considerations

While performance and safety are paramount, cost remains essential. Capacitors that provide

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the best value without compromising essential specifications support the balance between cost and performance.

#### Vendor Reputation

Not all capacitor manufacturers are created equal. The quality, reliability, and customer support track record varies across vendors. Opting for well-regarded manufacturers with a solid history in the industry gives the final assurance needed for a safe and successful detonation.

#### Efficient Electronic Detonation with KYOCERA AVX Tantalum Capacitors

KYOCERA AVX Corp. is a leading Tantalum capacitor manufacturer, offering high reliability, compactness, and performance. Integrating KYOCERA AVX's Tantalum capacitors offers a range

of benefits for electronic applications, including electronic detonator applications. They feature high capacitance values in compact sizes and varied constructions, enabling engineers and designers to create efficient circuits. Their ultra-low ESR means reduced energy loss, leading to efficient power delivery and minimized heat generation.

Thanks to advanced manufacturing and quality assurance processes, KYOCERA AVX's Tantalum capacitors excel in extreme environments, withstanding high mechanical stress and various environmental challenges. KYOCERA AVX Tantalum capacitors are reliable for applications that require consistent performance in diverse conditions.

Please visit the [official website](#) for more information about KYOCERA AVX's Tantalum capacitor offerings.

### CONCLUSION

Electronic detonator applications demand precision, consistency, and safety. Capacitor choice is pivotal in fulfilling these demands. With their unique features, Tantalum capacitors have emerged as a crucial component. Their high capacitance density, temperature stability, and resilience to mechanical stresses make them ideally suited for electronic detonator applications. Furthermore, their long lifespan and minimal leakage currents ensure that the detonators remain effective and reliable for extended periods. KYOCERA AVX's Tantalum capacitors offer an edge in ensuring safety and performance. Collaborating with experts in explosive engineering and electronics ensures optimal capacitor selection and adherence to safety and regulatory standards.



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