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Beyond Pulse Survival: Redefining Reliability with Foil Resistors

In modern electronics, pulse performance is no longer a niche requirement. From industrial automation and aerospace systems to medical instrumentation, EV platforms, defense electronics, and precision sensing applications, engineers increasingly rely on components that can withstand rapid, repetitive electrical pulses without compromising accuracy or stability.

One question continues to surface among design engineers and system architects:

“Do you have graphs showing Pulse Duration versus Pulse Load?”

A recent precision measurement discussion led by Yuval at VPG, may appear to be a straightforward technical request. Engineers naturally want to understand how much pulse energy a resistor can withstand under varying pulse durations. But beneath this question lies a much deeper engineering challenge—one that goes far beyond single-event survivability.

The real issue is not simply whether a resistor survives one pulse.

The real question is:

Can the resistor maintain stable, repeatable, and predictable performance after thousands—or even millions—of pulses over time?

This distinction is where foil resistor technology has emerged as a critical differentiator in high speed pulse applications.

The Growing Importance of Pulse Reliability

As electronic systems become faster and more compact, pulse events are becoming increasingly demanding. High-current switching, transient energy spikes, rapid load cycling, and fast signal processing place immense stress on resistor technologies.

Applications such as:

- Bridge completion circuits
- High-speed instrumentation
- Power conversion systems
- Precision measurement equipment
- Automotive control systems
- Industrial weighing and sensor electronics
- Defense-grade pulse systems

all require resistors capable of handling not just instantaneous energy, but long-term operational stability under repetitive pulsed conditions.

Historically, many designers evaluated resistors primarily on peak pulse survivability. If the component survived a test pulse without catastrophic failure, it was considered acceptable.

However, real-world operating conditions revealed a different reality.

Many resistor technologies may survive the pulse itself, while repeated pulse stress introduces cumulative damage mechanisms such as:

- Resistance drift
- Thermal instability
- Mechanical stress fatigue
- Parameter shifts
- Reduced precision
- Long-term reliability degradation

This is particularly problematic in precision systems where even minor deviations can compromise measurement integrity or system calibration.

Why Traditional Pulse Ratings Are Not Enough

Pulse load graphs are useful engineering tools, but they often provide only part of the story.

A resistor surviving a single pulse in laboratory conditions **does not predict long-term parametric stability** under repetitive pulse conditions.

This concern was echoed by industry professionals discussing pulse applications:

“Single-pulse survival tests don’t reveal long-term drift risks.”

That statement reflects a major shift across the electronics industry. Engineers are moving beyond “survival testing” and focusing instead on **performance consistency over operational lifetime**.

In precision applications, long-term drift can become significantly more problematic than immediate failure because the system may continue operating while producing inaccurate results.

As another engineer highlighted:

“Accuracy today doesn’t matter if it drifts tomorrow.”

This is especially critical in bridge completion networks, sensing systems, and instrumentation environments where resistor stability directly influences system accuracy.

The Technology Difference: Why Foil Resistors Stand Out

Foil resistor technology offers several inherent advantages that make it exceptionally well suited for short-pulse and repetitive pulse applications.

Unlike thick-film or thin-film technologies, foil resistors are designed with characteristics that directly address the thermal and electrical stresses generated during rapid pulsing events.

1. Exceptional Thermal Stability

One of the biggest challenges during pulse events is localized heat generation.

When pulse durations shrink into microsecond or millisecond ranges, energy is introduced extremely rapidly. If the resistor cannot dissipate heat efficiently, hot spots develop.

Localized temperature rise creates hot spots, leading to thermomechanical stress, resistance drift, and long term material degradation.

Foil resistors provide:

- Rapid heat distribution
- Uniform current distribution and reduced thermal gradients across the resistive element and substrate
- Reduced thermal gradients
- Stable resistance characteristics during transient events

This enables the resistor to maintain accuracy even under repeated stress conditions.

2. Extremely Low Inductance

High-speed pulses are heavily affected by parasitic inductance.

Traditional wirewound resistor technologies often introduce inductive behavior that can distort pulse response, affect signal integrity, and create unwanted transient effects.

Foil resistors use a non inductive current path geometry that minimizes parasitic inductance, making them ideal for:

- Fast-switching circuits
- Precision timing systems
- Pulse shaping applications
- High-frequency transient environments

Low inductance becomes increasingly important as systems continue moving toward faster switching speeds and higher operating frequencies.

3. Predictable and Repeatable Performance

Consistency is one of the defining strengths of foil resistor technology.

In pulsed systems, engineers need confidence that component behavior today will match performance months or years later.

Foil resistors are specifically valued for:

- Minimal resistance drift
- Repeatable pulse handling within rated conditions
- Stable long-term characteristics
- High precision retention after repetitive stress
- Low Power Coefficient of Resistance (PCR)

This predictability reduces engineering uncertainty and improves overall system reliability.

4. Superior Long-Term Reliability

Repeated pulsing creates cumulative stress.

Even if catastrophic failure never occurs, repeated thermal cycling can slowly alter resistor characteristics over time.

Foil resistors demonstrate superior resistance to:

- Thermal fatigue
- Mechanical stress
- Long-term parameter drift
- Repetitive pulse degradation

The result is greater operational confidence in mission-critical and precision-dependent systems.

Real-World Applications: Bridge Completion and Precision Systems

One particularly important application discussed by engineers is **bridge completion circuitry**.

Bridge completion networks are widely used in:

- Strain gage load cells
- Strain gage systems
- Precision weighing systems
- Industrial sensors
- Measurement instrumentation

In these environments, resistor drift directly impacts measurement accuracy, where bridge imbalance sensitivity causes even small resistance changes to translate directly into measurement error.

Even minor deviations can introduce calibration errors, unstable readings, or long-term system inaccuracies.

Engineers working in these systems frequently prioritize:

- Tight tolerance stability
- Low TCR performance
- Long-term repeatability
- Reliable pulse endurance

Foil resistor technology aligns exceptionally well with these requirements, which explains its widespread use in precision sensing and measurement industries.

Beyond Component Survival: Designing for System Confidence

Modern engineering increasingly emphasizes system-level reliability rather than isolated component specifications.

This changes how designers evaluate resistor technologies.

Instead of asking:

“Can this resistor survive the pulse?”

Engineers are now asking:

- Will it remain accurate after continuous pulsing?
- Will performance drift over time?
- Can it maintain calibration stability?
- Will the system behave predictably years later?
- Can it reduce field failures and maintenance costs?

These questions are especially important in industries where downtime, recalibration, or inaccurate readings can create operational or financial consequences.

Foil resistors help provide the design margin engineers need to build more reliable systems with fewer long-term surprises.

Distribution and Industry Accessibility

Another interesting insight from industry discussions is the growing accessibility of precision foil resistor technology through major electronic distribution channels.

This availability simplifies integration into both prototyping and large-scale production environments.

For many organizations, easy access to reliable precision components accelerates development cycles while supporting faster validation and deployment.

Conclusion

Pulse applications continue to evolve rapidly across modern electronics.

As pulse durations become shorter and systems become more demanding, resistor selection is no longer just about surviving electrical stress. It is about ensuring long-term precision, stability, and repeatable performance under continuous operational load.

Foil resistor technology has positioned itself as a preferred solution because it addresses the deeper challenges associated with repetitive pulse environments:

- Thermal stability
- Low inductance
- Long-term accuracy
- Minimal drift
- Power coefficient of resistance (PCR)
- Predictable performance
- Operational reliability

The industry conversation is clearly shifting.

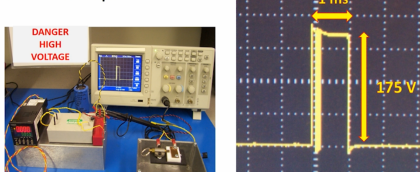
Single-pulse survival is no longer the benchmark.

Repeatable precision over millions of pulses is.

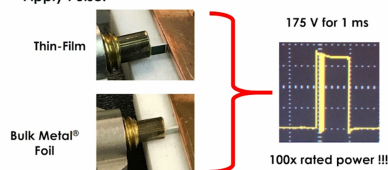
And in high-performance electronic systems, that difference can define whether a design merely works—or continues working reliably for years to come.

short pulse applications

Pulse Test Set-Up:

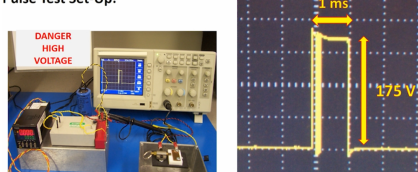


Apply Pulse:



Can It Survive the Pulse?

Pulse Test Set-Up:

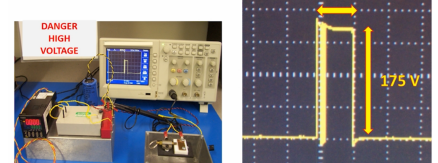


Pre-Pulse Measurement:



From Pulse Survival to Post-Pulse Stability

Pulse Test Set-Up:



Summary Data

	Pre-Pulse	Post-Pulse	ΔR
Thin-Film	0.9994825 kΩ	1.0213123 kΩ	218298 ppm
Bulk Metal® Foil	1.0000291 kΩ	1.0000162 kΩ	-13 ppm

Bulk Metal® Foil = Essentially No Change and No Damage !!!