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The Hidden Risk of Counterfeit Resistors in High Accuracy Electronics

Introduction

In precision electronics, reliability is rarely determined by a single dramatic failure. More often, performance degradation begins subtly, for example: a small thermal drift (e.g., 5–50 ppm/°C shift), an unstable reading, or calibration values that gradually move outside acceptable tolerances.



In mission-critical systems, these seemingly minor deviations can eventually lead to inaccurate measurements, reduced operational efficiency, product recalls, or complete system failure.

In the last decade, the obsolescence of electronic components, including passive components such as resistors, capacitors, inductors, as well as integrated circuits (ICs), has become a significant challenge for many OEMs and design houses in the avionics, military, and space (AMS) market.

Many of the precision resistors and ICs that were designed into systems several decades ago are now becoming obsolete or difficult to obtain, often with lead times exceeding 26 to 52 weeks in constrained markets.

The reasons vary:

- Regulatory restrictions on tin-lead finishes
- Cost pressure to reduce BOM by 10–30%
- Sourcing substitutions from lower cost supply chains

A recent case study discussed by Yuval at VPG highlighted an increasingly serious issue: **counterfeit and re-marked precision resistors entering critical analog designs through unauthorized supply channels.**

The concern is particularly relevant for industries where precision and stability are non negotiable, including:

- Aerospace electronics
- Commercial satellites
- Humanoid Robotics
- Data Centers
- Automotive
- Medical instrumentation
- Industrial automation
- Defense systems
- Calibration equipment
- Weighing and measurement technologies
- High-accuracy sensor systems

The discussion emphasized an important engineering reality:

In precision electronics, where components are sourced from matters just as much as the circuit design itself.

This case study explores how counterfeit resistors impact high-precision systems, why traditional inspection methods often fail to detect them, and how advanced stress testing, particularly pulse testing can expose hidden weaknesses before deployment.

Industry Background: Why Precision Resistors Matter

Precision resistors are foundational elements in analog electronics. Their role extends far beyond basic current limiting. In high-accuracy systems, resistors directly influence:

- Signal integrity
- Gain accuracy
- Thermal stability
- Calibration consistency
- Noise performance
- Long-term reliability

Among the most trusted technologies is Bulk Metal® Foil resistor technology, known for: low TCR (typically $< \pm 0.2$ to ± 2 ppm/°C depending on model), low excess noise (< -40 dB), long term stability ($< \pm 0.005\%$ over 1,000 hours), and strong pulse handling capability compared to thick and thin film technologies.

However, the growing global electronics supply chain has created vulnerabilities. As components become obsolete or difficult to procure, unauthorized brokers and grey-market distributors increasingly introduce counterfeit or re-marked parts into the ecosystem.

These components may visually resemble authentic precision resistors. They may even pass initial low-stress electrical tests. However, under real operating conditions (thermal cycling, load transients, ESD, and long term bias), their weaknesses emerge.

The Core Problem: Counterfeit Precision Components

Counterfeit resistors generally fall into several categories:

1. Re-marked lower-grade resistors sold as premium precision components in emerging markets.
2. Salvaged or recycled components repackaged as new, with a revised date code.
3. Clone products mimicking genuine technologies that look the same from the outside.
4. Components lacking proper traceability or certification without proper documentation.

The most dangerous aspect of counterfeit precision components is not immediate failure, but delayed instability. As noted:

- Counterfeit parts often survive visual inspection
- They may initially meet nominal resistance values
- Failures usually appear under thermal or power stress
- Drift and instability become visible only after deployment

Drift of even 0.05% to 0.5% after stress can be enough to disrupt calibration loops in precision systems.

This creates a major risk for OEMs and design engineers because systems may pass factory acceptance testing while carrying hidden long-term reliability problems.

The Engineering Challenge

A major manufacturer of precision analog instrumentation began experiencing intermittent field failures in a high-accuracy sensing platform designed for industrial process control applications.

The system required:

- tight tolerance (e.g., $\pm 0.01\%$ or better)
- TCR below 2 ppm/ $^{\circ}\text{C}$
- pulse capability in the range of several joules depending on package size
- long operational life (> 10 years in field conditions)
- Minimal calibration or maintenance

During production scaling, procurement teams sourced a batch of “equivalent” precision resistors through non-authorized channels to reduce lead times and costs.

Initial inspection revealed no visible abnormalities.

Standard checks confirmed:

- Correct resistance value (within $\pm 0.01\%$ at room temp)
- Acceptable packaging appearance
- Functional operation at room temperature

However, after deployment, several issues began appearing in the field:

- Sensor calibration instability
- Measurement drift during thermal cycling
- Inconsistent readings after power surges
- Increased maintenance requirements
- Unexpected analog signal offsets

The failures were inconsistent and difficult to reproduce under standard laboratory conditions.

Root Cause Investigation

The engineering team initiated a deeper reliability analysis using accelerated stress testing methods.

Conventional DC resistance measurements failed to expose any major deviations.

Measured values differed by less than $\pm 0.005\%$ at 25°C , masking the issue.

The breakthrough came during high-energy pulse testing.

Pulse Testing: Revealing the Hidden Gap

Pulse testing subjects resistors to short duration high power energy pulses:

- Power surges
- Switching spikes
- Inrush current events
- Thermal shock conditions

Typical test conditions included pulses of 10 to 100 ms with energy levels ranging from 1 J to 10 J depending on resistor type.

Authentic precision foil resistors are engineered with construction techniques capable of withstanding these stress conditions while maintaining stability.

Counterfeit or re-marked components often fail because their internal construction lacks the same robustness.

During testing, the suspected counterfeit resistors exhibited:

- Resistance drift exceeding 0.1% after fewer than 100 pulses
- Localized hot spots leading to microstructural damage
- Early failure compared to foil resistors, which remained within $\pm 0.01\%$ under identical conditions

In contrast, authenticated components from authorized manufacturers maintained stable performance throughout testing.

This aligned closely with observations shared in the industry discussion:

“Robust design shows up under pulse testing.”

The test results confirmed that the issue was not visible through appearance or basic measurements alone. The failure mechanism was embedded within the material quality and internal construction of the counterfeit parts.

Operational Impact

The consequences extended beyond component replacement costs.

The manufacturer faced:

1. Increased Field Service Costs

Unstable systems required repeated recalibration and maintenance visits.

2. Reputation Risk

Customers questioned the reliability of the instrumentation platform.

3. Production Delays

Additional quality verification procedures slowed manufacturing cycles.

4. Engineering Resource Diversion

Teams spent significant time troubleshooting issues that originated from supply chain weaknesses rather than design flaws.

5. Potential Safety Concerns

In precision industrial environments, inaccurate measurements can create operational hazards.

The incident demonstrated a critical reality for modern electronics manufacturing:

The supply chain is part of the engineering design process.

Why Counterfeit Detection Is Difficult

Counterfeit precision components are becoming increasingly sophisticated.

Traditional inspection methods are often insufficient because:

- Surface markings can be replicated
- Packaging may appear authentic
- Basic resistance measurements may fall within tolerance
- Low-stress testing does not reveal long-term reliability weaknesses

As highlighted in the discussion, failures typically emerge after:

- Power cycling
- Environmental stress
- Thermal loading
- Extended operational use

This delayed failure profile makes counterfeit detection especially difficult for manufacturers relying only on incoming visual inspection.

Many counterfeit parts pass initial inspection because standard incoming QA does not include dynamic stress conditions such as pulse loading or thermal gradients.

Best Practices Adopted After Investigation

Following the investigation, the manufacturer implemented a comprehensive mitigation strategy.

1. Authorized Procurement Policy

All precision resistors and critical analog components were restricted to:

- Authorized manufacturers
- Certified distribution partners
- Approved online distributors

This ensured:

- Full traceability
- Verified specifications
- Certificates of Compliance
- Authentic component sourcing

2. Enhanced Incoming Quality Control

The organization introduced advanced stress screening procedures for critical components, including:

- Pulse testing
- Thermal cycling
- Accelerated aging analysis
- Stability characterization

3. Investment in Reliability Engineering

Specialized quality and test engineers were added to evaluate component reliability under accelerated stress conditions.

This reflected another important point raised during the discussion:

Companies that invest in specialist component reliability testing are far more capable of identifying inferior or counterfeit parts before production deployment.

4. Supplier Traceability Audits

Supply chain partners were audited for:

- Procurement transparency
- Storage conditions
- Documentation integrity
- Chain-of-custody verification

Key Industry Lessons

This case highlights several important lessons for the electronics industry.

Precision Cannot Be Assumed

Two resistors may look identical externally while behaving completely differently under real operating conditions.

Cost Reduction Can Introduce Hidden Risk

Short-term sourcing savings can create long-term operational and reputational damage.

Stress Testing Matters

Pulse testing and accelerated reliability testing expose weaknesses invisible to basic inspection methods.

Traceability Is Essential

Without full traceability, verifying component authenticity becomes extremely difficult.

Supply Chain Integrity Is a Design Requirement

For high-precision systems, procurement strategy directly influences product performance.

Conclusion

In modern precision electronics, performance reliability no longer depends solely on circuit architecture or component specifications on paper.

It depends equally on sourcing integrity, traceability, and component authenticity.

Counterfeit and re-marked precision resistors represent a growing risk because their failures are often silent, gradual, and only visible under stress or over time.

This case demonstrates how high-energy pulse testing can expose the hidden weaknesses of counterfeit components and why authorized sourcing remains the strongest defense against supply chain risk.

For engineers, manufacturers, and procurement teams, the message is increasingly clear:

- Precision starts at the source
- Drift is the hidden enemy
- Traceability protects reliability
- And in analog design, “close enough” is failure in disguise

In critical electronics systems, buying authorized is not just a procurement preference — it is an engineering necessity.