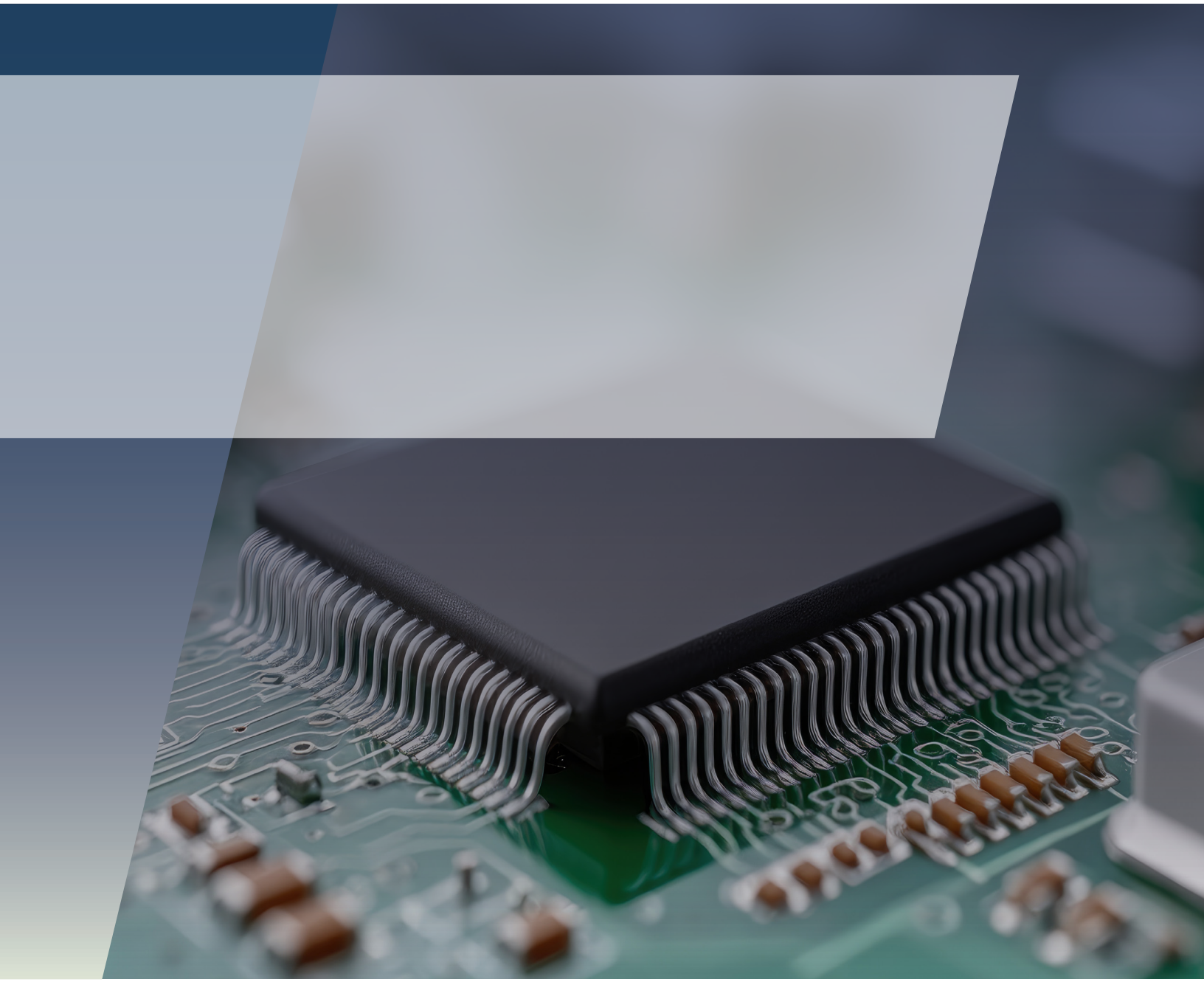
Standex DETECT Electronics

DESIGNING HIGH-VOLTAGE TEST SYSTEMS WITH PRECISION SWITCHING

From Cable Harness Testing to Semiconductor ATE



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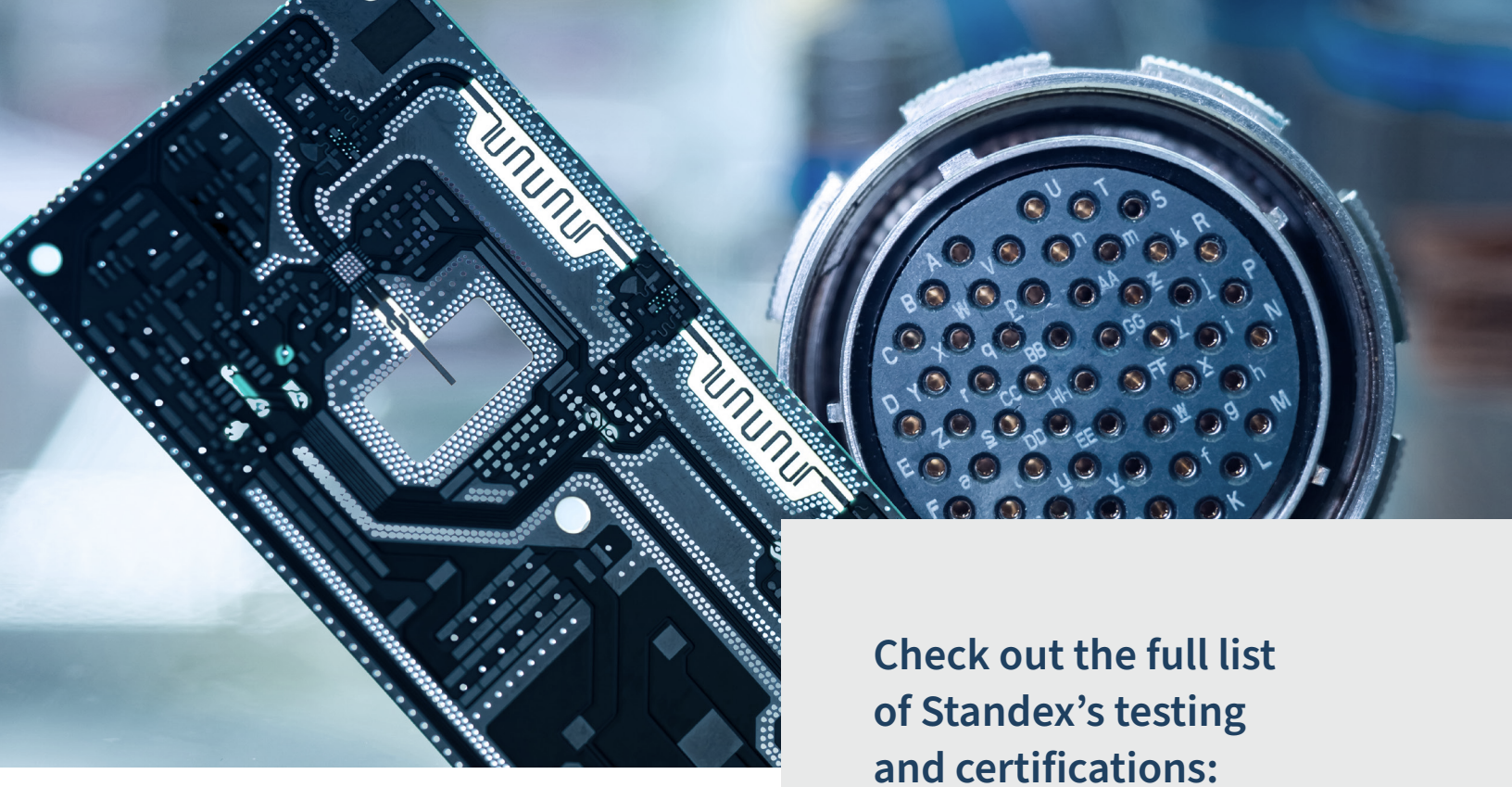


Critical Considerations in High-Voltage Test System Design

Accurate switching of high voltages is a fundamental requirement in modern test systems, directly influencing measurement accuracy, stability, and throughput. In applications such as semiconductor ATE or cable harness testing, the switching element becomes part of the measurement path and must meet the same performance expectations as the instrumentation itself.

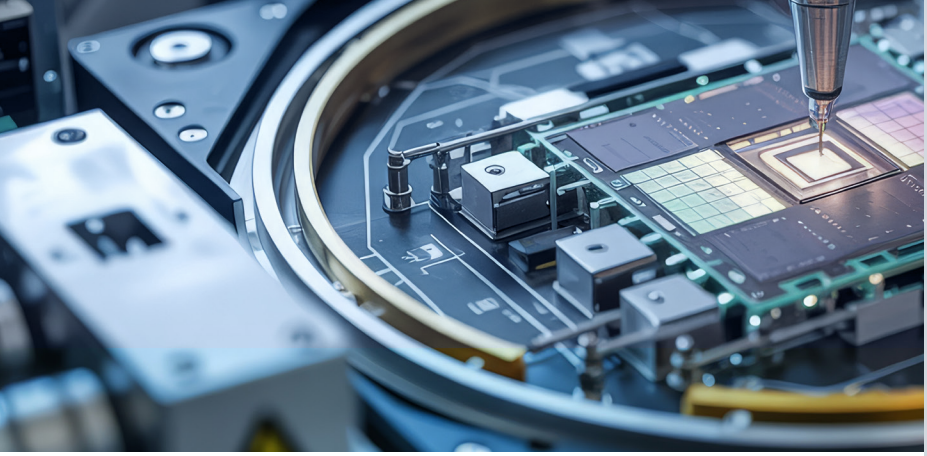
As voltage levels increase and tolerances tighten, effects such as leakage current and parasitic capacitance define system limits and can no longer be treated as secondary considerations.

Selecting the right switching technology is therefore a key design decision.

Reed relays are widely used in these environments because they combine high isolation with very low parasitic effects, enabling precise and repeatable measurements across a broad range of high-voltage applications.

Check out the full list of Standex's testing and certifications:

- AEC-Q200 Qualified
- IEC 61810-4 Qualified
- IEC 60601-1 Qualified
- IEC 62109-1/2 Qualified
- IEC 60664-1 Qualified
- ISO 6469-3 Certified
- IEC 60255-27 Qualified
- UL Recognized
- RoHS, REACH Compliant



Increasing density and shrinking footprints force designers to balance compact layouts with the need for high isolation and low parasitics.

Challenges in High-Voltage Switching

In precision test systems, leakage current is often the dominant source of measurement error. This is particularly critical in insulation testing and high-impedance measurements, where even very small leakage paths can distort results or reduce repeatability over time.

Parasitic capacitance introduces another constraint. It increases settling time and enables channel-to-channel coupling in multiplexed architectures, limiting achievable throughput. As channel count increases, the cumulative effect of capacitance becomes more pronounced.

At the same time, system designers are under pressure to increase density and reduce footprint. This creates a trade-off between compact design and electrical performance, where switching components must maintain high isolation and low parasitics within limited space.

Key Design Considerations

- **Minimizing leakage current to preserve measurement**
- **Reducing parasitic capacitance for faster settling times**
- **Maintaining high isolation in compact, high-density layouts**

Reed Relay Technology in High-Voltage Systems

Reed relays address these challenges through their inherent physical construction. Hermetically sealed contacts ensure leakage in the picoampere range, while the contact geometry results in sub-picofarad capacitance. This combination allows accurate switching of high voltages without introducing significant measurement error.

Compared to other switching technologies, reed relays offer a balanced performance profile that prioritizes signal integrity. Alternatives may offer advantages in specific areas such as switching speed or lifetime, but often at the expense of leakage or capacitance, which limits their suitability for precision measurement systems.

For high-voltage test applications where accuracy and repeatability are critical, reed relays remain a preferred solution.

SWITCHING TECHNOLOGY COMPARISON

Attribute	Reed Relay	Solid State Relay	Mechanical Relay
Leakage current	✓ Very low	✗ High	= Moderate
Parasitic capacitance	✓ Very low	✗ High	= Medium
Isolation performance	✓ High	= Limited	= Good
Switching speed	= Fast	✓ Very fast	✗ Slow

The Standex SHV Relay Family

The Standex SHV series is developed for high-voltage test and measurement applications, combining compact design with stable electrical performance. The family now includes both single-channel and dual-channel configurations, enabling flexible system design.

The SHV-1A with one channel Normally Open contact (Form A) is a proven solution widely used in automated test systems, cable harness testing, instrumentation or Battery Management of Energy Storage Systems . It provides reliable high-voltage switching with stable insulation characteristics and has established a strong track record in the field.

The SHV-2A expands this platform by introducing a dual-channel configuration (2x Form A) within a similar footprint. This enables higher channel density and more efficient system architectures without compromising electrical performance.

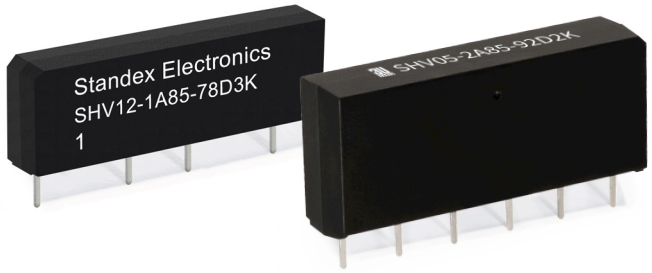
Key characteristics of the SHV family include:

- High insulation resistance supporting accurate measurements
- Very low capacitance enabling fast signal settling
- Compact form factor for high-density switching matrices
- Consistent performance over long operational lifetimes

The SHV-2A supports switching voltages up to 1 kV with breakdown capability up to 2 kV, or 1.5 kV switching and 3 kV Breakdown voltage depending on configuration combined with insulation resistance in the teraohm range and capacitance as low as 0.5 pF.

These parameters translate directly into improved system accuracy and efficiency.

By combining proven single-channel performance with a dual-channel option, the SHV family allows designers to scale systems more effectively while maintaining measurement integrity.



SHV Series - At a Glance

SHV-1A Series

- **Form A (NO)**
- **Proven in automated test, harness testing, instrumentation**
- **Stable insulation characteristics in a compact footprint**

SHV-2A Series

- **2× Form A in similar footprint (higher density)**
- **Switching: 1.0–1.5 kV; breakdown up to 3 kV**
- **Insulation resistance in TΩ range; capacitance ≈ 0.5 pF**

High-Voltage Test Application Examples

High-voltage cable and harness testing requires switching across large matrices while preserving insulation measurement accuracy. In **EV and aerospace systems**, leakage paths directly distort insulation readings, so the switching element must maintain high isolation under high voltage. Reed relays enable reliable routing across multiple channels while supporting compact matrix architectures.

Used in high-voltage harness testers for **MIL-Aero** or in production test systems for analog and mixed-signal semiconductors.

In **semiconductor ATE**, switching elements are part of parametric measurement paths and signal routing networks. Parasitic capacitance limits settling time, while leakage current impacts low-level measurement accuracy. Reed relays minimize both effects, supporting fast and repeatable measurements at high test volumes.

Functional PCB testing involves switching between multiple nodes in mixed-signal environments. High-voltage rails coexist with sensitive measurement points, requiring switching components that maintain isolation and low parasitics within limited space. Reed relays support compact layouts while maintaining signal integrity.

Battery and energy storage testing requires stable switching under elevated voltages for diagnostic and safety functions. Leakage and drift can affect insulation monitoring and measurement consistency. Reed relays provide predictable electrical behavior over time, supporting reliable system evaluation.

Typical applications include:

- High-voltage cable and harness testers
- Semiconductor automated test equipment
- Functional and in-circuit PCB testing systems
- Battery and energy storage diagnostics

Design Considerations in High-Voltage Testing

Achieving optimal performance in high-voltage switching systems requires careful integration of the relay into the overall design. PCB layout plays a critical role, particularly in maintaining adequate creepage and clearance distances and minimizing unintended leakage paths.

Proper switching conditions, including avoiding switching under load where possible, help extend relay lifetime and maintain consistent performance.

System architecture should also consider relay placement and signal routing to minimize parasitic effects and ensure clear separation between high-voltage and sensitive measurement areas.

Important design aspects include:

- PCB layout with controlled creepage and clearance
- Minimization of leakage paths through proper material and design choices
- Controlled switching conditions to avoid electrical stress
- Optimized relay placement for signal integrity

DESIGN CONSIDERATIONS FOR HIGH-VOLTAGE

Do

- Maximize PCB creepage and clearance
- Keep relays away from sensitive nodes
- Switch without load where possible
- Use clean, low-leakage materials and processes

Don't

- Route HV near analog sense lines
- Ignore contamination and residue effects
- Overlook cumulative capacitance in matrices
- Underspec worst-case isolation

Best Practices

- Maintain separation between HV and measurement paths
- Minimize parasitic coupling through layout
- Ensure manufacturing cleanliness for stable insulation

For When it Matters - The Right Design, at the Right Time, at the Optimal Cost.

For over 50 years, Standex has delivered engineered solutions that perform when it matters most. As an extension of our customers' engineering teams, we collaborate closely to turn complex challenges into elegant, manufacturable designs. Our approach combines precision performance with craftsmanship where engineering meets aesthetics and every component reflects quality and reliability.

Standex's high-voltage reed relays are key enablers in advanced test and measurement platforms, where precision, durability, and safety are critical. As testing demands grow more complex, the reliability of high-voltage switching and protection systems becomes increasingly vital.

To learn more about how Standex Detect can support your high-voltage test and measurement projects with custom relay solutions, visit **standexdetect.com** or contact our engineering team to discuss your specific application needs.

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