LITTELFUSE **SOLID-STATE INDUSTRIAL RELAYS** QUALITY TEST REPORT

TECHNICAL PAPER

Littelfuse®

Expertise Applied | Answers Delivered

Introduction

Solid-State Relays (SSRs) are a critical component in modern electrical & electronic systems, providing reliable switching capabilities for various applications from industrial automation to consumer electronics. When it comes to choosing the right solid-state relay for your application, it's important to know the quality of the product you are purchasing.

There are many low-cost products on the market and choosing based on cost instead of quality can be a costly mistake.

Low-cost SSRs are often made by low-quality manufacturers who do not follow the strict standards and requirements and are not subjected to the rigorous testing and certification process. There are even many counterfeit SSRs on the market that claim to have the same specifications and performance as the quality brands.

In this report, we will explain the risks of choosing a low-quality SSR and share the test results of the Littelfuse products compared to two other suppliers.

Risks to Using Poor Quality SSRs

Low-cost SSRs may have disguised lower ratings, inferior components, poor design, and inadequate testing and certification. As a result, they can cause serious risks and issues for you and your equipment, such as:

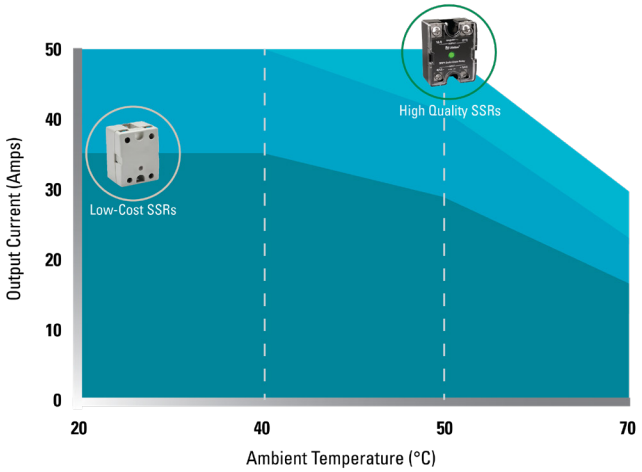
- **Overheating and fire hazard:** Low-quality SSRs often use lower-rated power components on the inside to switch the load current, which can cause excessive heat dissipation and voltage drop. This can lead to overheating, melting, and even fire of the SSR and the connected load.
- **Electric shock and injury:** Low-quality SSRs may not only endanger your own safety and equipment, but also jeopardize the safety and satisfaction of your customers and end-users. It is possible they don't have proper insulation and isolation between the input and output terminals, which can expose the systems and people to high voltages and currents. This can cause electric shock, injuries, or fatalities if the SSRs malfunction or cause fire or electric shock. Moreover, low-quality SSRs may not have adequate protection against overvoltage, overcurrent, short circuit, and surge, which can damage the SSR and the load, and create sparks and arcs that can ignite flammable materials.
- **Poor reliability and performance:** Low-quality SSRs may not have accurate and consistent switching characteristics, such as zero-crossing or random turn-on, which can affect the load operation and efficiency. For example, some low-quality SSRs may not switch on or off at the zero-cross point of the ac waveform, which can cause transient voltages and currents, harmonic distortion, and electromagnetic interference. Furthermore, low-quality SSRs may not have a long lifespan and may fail prematurely, which can cause downtime, maintenance, and replacement costs.
- **Reputation damage:** Low-quality SSRs may also tarnish your reputation and credibility as an OEM or panel builder who provides quality products and services to your customers and end-users. If you use low-quality SSRs inside your machine, panel, or system, you may face the risk of customer returns, complaints, lawsuits, or loss of trust if the SSRs fail or cause problems. This can affect your business and profitability in the long run.

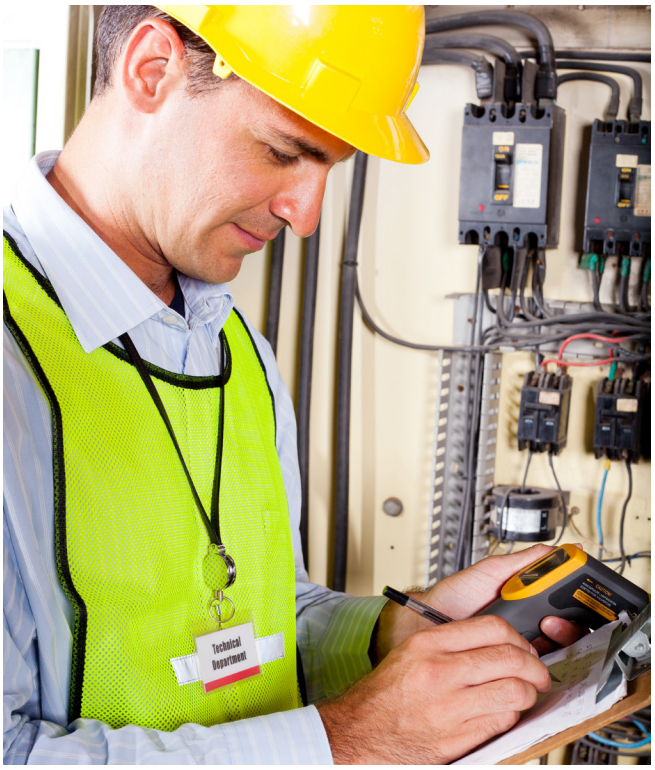
How to Choose a Quality SSR

You might think the solution is to use a widely known brand, but this is not always a guarantee of high-quality, as solid-state is a very precise technology, that not everyone can produce, and many of these brands just private label from low-cost manufacturers in order to provide full panel solutions to customers without caring to offer high-quality components. There are 4 general recommendations when looking for high-quality SSRs.

1. **Pricing and Source:** The quickest and easiest way to detect low-quality SSRs and choose quality ones is to compare the price and the source of the SSRs. Low-quality SSRs may have significantly lower prices than the quality ones, which may seem too good to be true. However, you should be aware that the low price comes at the expense of the quality and safety of the SSRs. And always remember that you should only buy from authorized and reputable sellers, distributors, or websites that can provide you with the original and genuine SSRs that have the warranty, support, and after-sales service.

2. **Derating Curves:** The first thing to do is to always analyze the datasheet thoroughly, not only the general values that need to match your application, but especially the "derating curves" that will tell you the continuous current and the ambient temperature at which the product can be used. There exists a not-written standard of specifying the values at 40 °C with resistive loads, but not every company follows this standard, and you may be surprised. And always remember to take a value margin, as even some reputable brands are known to use the limit values of the product in their curves instead of those recommended by the international safety organizations.





3. **Standards Conformity & Certifications:** Another way to avoid low-quality SSRs and choose quality ones is to look for the safety marks and certifications that indicate the SSRs have been tested and certified under the guidelines of independent and reputable organizations like IEC (International Electrotechnical Commission). These marks and certifications show that the SSRs comply with the relevant safety, quality, and performance standards and requirements. Some of the common safety marks and certifications for SSRs are:

   A. Official certificates issued by official Third-Party Certified Bodies:
      i. UL or ЯU Mark: This is a North American safety mark issued by UL, which shows that the SSRs have been tested and certified to meet the applicable UL standards, such as UL 508 and CSA C22.2. The UL Mark is accepted by authorities having jurisdiction (AHJs) and inspectors across the US and Canada.
      ii. TÜV or VDE Mark: These are German safety marks issued by TÜV or VDE, which show that the SSRs have been tested and certified to meet the European harmonized standards, such as EN 62314, EN 60947-1 and EN 60947-4-3. These marks are voluntary, but they are widely recognized and trusted in Germany and other European countries.

B. Self-declaration certificates issued by each SSR manufacturer:
   i. CE Mark: This is a European conformity mark that indicates that the SSRs meet the essential requirements of the relevant EU directives, such as the Low Voltage Directive (LVD) and the Electromagnetic Compatibility Directive (EMC). The CE Mark is mandatory for SSRs sold in the EU, but it is self-declared by the manufacturer or importer and does not require independent testing or certification.
   ii. UKCA Mark: This is a UK conformity mark that indicates the SSRs meet the essential requirements of the relevant UK regulations, such as the Electrical Equipment (Safety) Regulations 2016 and the Electromagnetic Compatibility Regulations 2016. The UKCA Mark is mandatory for SSRs sold in the UK, but it is self-declared by the manufacturer or importer and does not require independent testing or certification.

4. **Proof of Product Testing:** Another way to avoid low-quality SSRs and choose quality ones is to look for the proof of endurance testing and other quality assurance tests from the manufacturer. These tests show that the SSRs have been subjected to various stress and environmental conditions, such as high and low temperatures, humidity, vibration, shock, and load cycles, to verify their performance and durability. These tests also show that the SSRs have been designed and manufactured with high-quality materials and components, such as SCRs, triacs, MOSFETs, optocouplers, resistors, capacitors, and diodes, that can withstand the electrical and thermal stresses.

Solid-State Relay Endurance Testing and Performance Evaluation

Competitor Selection

To establish a robust benchmark for Littelfuse SSRs, three leading competitors were selected based on the following criteria:

- DC Input Control (4-32 V dc)
- Zero-Cross Controlled (opto-Isolator)
- 50 A rms Output Load Current Rated
- 24-240 V rms Output Rated
- Single Pole Switching
- Panel Mount (Hockey Puck Style)
- UL Recognized
- Available at main distributors

Samples of each SSR brand were procured from authorized distributors, enabling a fair and accurate comparison. The selected SSRs are listed in Figure 1.

Littelfuse - SRP1	Competitor 1	Competitor 2	Competitor 3

FIGURE 1. SSR Competitor Selection

Testing Setup and Methodology

A rigorous stress test was conducted under controlled conditions at our Rapid City, SD location to ensure the robustness and longevity of Littelfuse SSRs. Littelfuse, a world leader in semiconductor-based power modules from IGBTs to MOSFETS to SCRs, leverages extensive design and testing expertise to deliver high-performance products. The endurance tester's high-level capabilities used for the test include:

- 2x rated SSR (100 A rms Resistive System)
- Duty Cycle: 1 second On, 7 second Off
- Fault Detect: Overcurrent (SSR short), Open-Circuit (SSR Open)
- Chiller plate: Maintain SSR Baseplate temp at 22 °C
- Test 2 sets of 10 SSRs at a time (Branch 1 and Branch 2)

Given the general-purpose nature of SSRs, which involves infinite load combinations and making it challenging to quantify life expectancy, this test was designed to quantify life expectancy under controlled and identical conditions from the first to the last cycle. Figures 2 and 3 illustrate the SSR endurance tester and the chiller plate with mounted SSRs, respectively. Each SSR was mounted with 20 in-lbs (2.2 Nm) of torque using Wakefield-Vette 120 series thermal joint compound. In addition to what is not shown, there is an outdoor load to control the desired setpoint of 100 A rms (resistive) load current.

FIGURE 2. SD SSR Endurance Tester

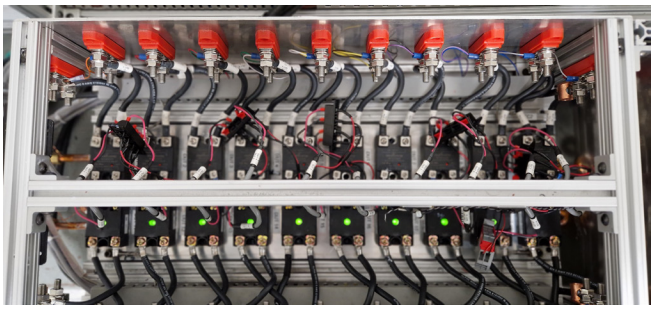


FIGURE 3. Chiller Plate with Mounted SSRs

Test Criteria

The endurance tester operated continuously, completing approximately 10,800 cycles daily per branch. Key data points included:

- Voltage Across Each SSR
- Temperature at Each SSR's TSn (2 mm below baseplate)
- Currents Through Each Branch

In the event of a failure, a jumper wire was placed across the failed SSR's output, and the test was restarted. The total run time for all testing was 18.5 weeks, excluding time for replacing failed SSRs and restarting the test.

Endurance Test Results

Ten SSRs each were tested, except for Competitor 3, whose units experienced catastrophic failures that posed a danger to personnel and equipment. The results, as seen in Table 1, demonstrate that Littelfuse SRP1 series SSRs significantly outperformed the competitors, with an average cycle count of 750k cycles compared to 200k cycles (Competitor 1), 130k cycles (Competitor 2) and less than 70k cycles (Competitor 3).

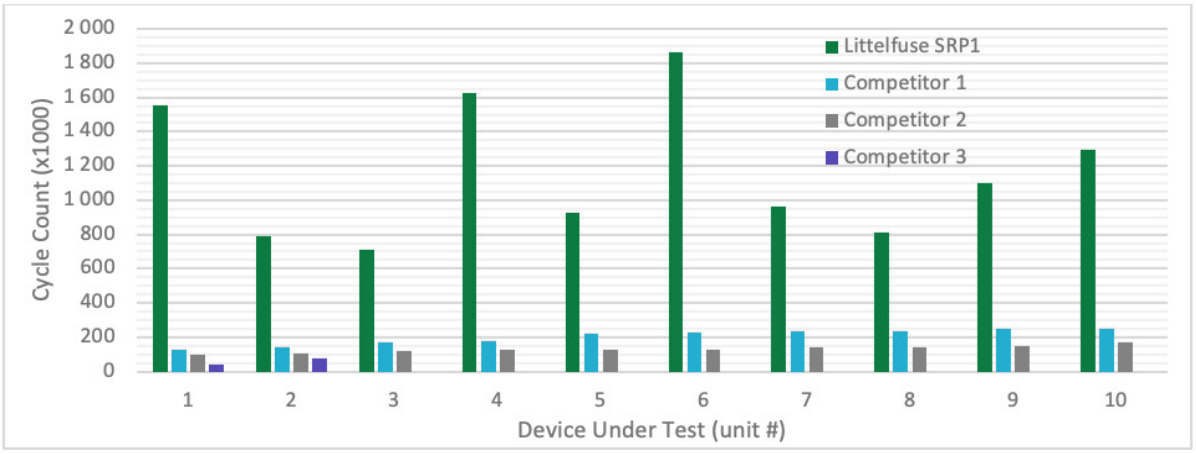


TABLE 1. Endurance Results. Note: two products from Competitor 3 were included but the testing was stopped due to catastrophic failure and resulting off-gassing. See Table 2 for details on the failure.

During the endurance test, each SSR was closely monitored for failures. Upon failure, the top cover was removed for a detailed examination. Table 2 showcases one failed SSR from each batch, illustrating typical failures where the chip overheats, causing the clip to fuse and break the anode-to-cathode connection of the SCR (Silicon Controlled Rectifier) in one direction. The endurance tester detects faults and halts testing to prevent further damage.

In an application, SSRs will face stressors (ambient temperature changes, unexpected overloads, aging, faulty connections, etc) that will significantly reduce their lifespan. Littelfuse SSRs stand out in number of cycles due to advanced Direct Bonding Technology and high-end power semiconductors of our proprietary IXYS Technology. These innovations enable our SSRs to manage thermal fatigue effectively, ensuring superior quality and reliability, providing longevity even under extreme conditions.

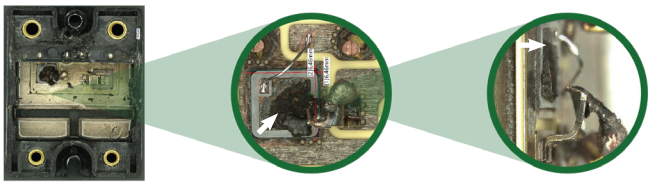
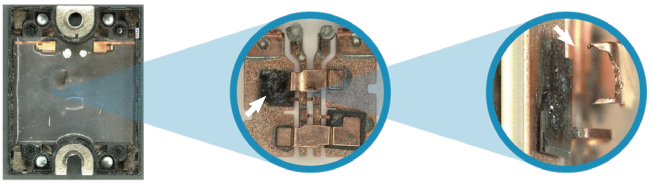
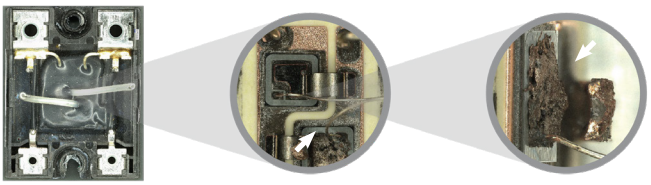
Littelfuse - SRP1 SSRs with the top cover removed. The SSRs exhibited failures after an average of **750K cycles.** The damage was primarily due to thermal fatigue, which caused a break in the anode-to-cathode connection within the SCR.	
Competitor 1 SSRs with the top cover removed. The SSRs exhibited failures after an average of 200K cycles. The damage was primarily due to thermal fatigue, which caused a break in the anode-to-cathode connection within the SCR.	
Competitor 2 SSRs with the top cover removed. The SSRs exhibited failures after an average of 130K cycles. The damage was primarily due to thermal fatigue, which caused a break in the anode-to-cathode connection within the SCR.	
Competitor 3 SSRs with the top cover removed. The SSRs experienced catastrophic failures after an average of just 60K cycles. The primary issue was a semiconductor explosion, posing significant safety risks.	

TABLE 2. Endurance Results

Conclusion

This study underscores the critical importance of quality in SSR assembly to mitigate risk and enhance reliability. While all 50A rated units may have similar catalog specifications, the assembly and design quality vary significantly. The Littelfuse SRP1 series outperformed competitors by two to three times in cycle count, showcasing our excellence in SSR design and manufacturing.

Littelfuse vertical integration—encompassing in-house chip design and wafer fabrication—ensures unparalleled control over the supply chain and product quality. Our solid-state technology expertise, rigorous testing, and certification processes guarantee that Littelfuse SSRs deliver superior performance and safety under various conditions.

For OEMs seeking reliability, efficiency, and superior performance in their SSRs, Littelfuse stands out as the clear choice. Using Littelfuse SSRs can lead to substantial cost savings over time due to reduced downtime and maintenance. Partnering with Littelfuse means leveraging decades of innovation and excellence to power your applications with confidence and precision.

For more information, visit
Littelfuse.com/IndustrialSSR

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