HYBRID POWER SWITCHING

A Highly Efficient Alternative to Solid State Relays
Application Note #102 — rev B

INTRODUCTION
Advanced arc suppression capabilities offered by NOsparc™ technology provides product designers, technicians and engineers the opportunity to design an application specific, hybrid-power electrical switching solution. One example is to replace a Solid State Relay (SSR) with an electromechanical relay combined with a NOsparc™ arc suppressor connected across its contacts.

A Solid State Relay (SSR) is considered an excellent but costly alternative for an electromechanical relay by most product designers, technicians and engineers. When safety considerations of an application require switching without any electrical contact arc (i.e., in the presence of explosive gasses, etc.) an SSR is the best solution. Beyond this, however, the advantages of an SSR are significantly diminished by the heat generated from the flow of load current through the load carrying solid state device. The excess heat is wasted energy that leads to inefficiency and performance issues in hot operating environments. This requires a very large heat sink (either with or without a fan) to effectively dissipate the heat generated by it's operation, making an SSR a costly and only modestly effective alternative to an electromechanical relay combined with an arc suppressor.

DEFINING PROBLEMS
There is a common perception among technicians, product designers and engineers that an SSR performs better than an electromechanical relay. SSRs generally have a longer life span when operating at low ambient temperatures and/or in low power (less than 5A) applications, this advantage disappears when an SSR operates in high power applications and/or in hot environments.

In contrast, high power applications and/or hot operating environments require the utmost design experience to avoid serious reliability issues when operating and SSR. Key considerations include:

- SSR mounting screws must be properly torqued down
- Cables must be properly selected, prepared, cut, and crimped
- If cooling fans are used, they must be closely monitored and maintained

Proper operation therefore requires that the SSR's heat-radiating mounting plate is in good thermal contact with a properly designed (and aligned) heat sink (see Figure 1). SSR operation in a hot environment typically requires a heat sink of significant size with sufficient unobstructed air space surrounding it to create and maintain a “chimney effect.” Ultimately the heat sink requires additional space and adds both weight and cost to any design. (A detailed example is provided on the back page of this application note.) Unfortunately, technicians, product designers and engineers typically give insufficient consideration to the necessity of removing heat from an SSR, often designing the SSR into a system with an inadequate heat sink or no heat sink at all. For example, mounting an SSR against a stainless steel wall of a product or appliance is a poor substitute for a heat sink since the wall to which the SSR is mounted becomes a regional hot-spot, which is a poor radiator of excess heat!

SOLUTION
An ideal way to address the shortcomings of an SSR is to employ a “hybrid power” solution. A hybrid power switching system combines the advantages of a mechanical contact with the advantages of a solid state switch. (Akin to a hybrid electric vehicle’s design to combine the advantages of an internal combustion engine with the advantages of an electric motor.) A hybrid power relay may be effectively created by attaching a NOsparc™ arc suppressor (figure 2) across the contacts of an electromechanical relay (figures 1a, 1b and 3).
In addition, the NOsparc™ arc suppressor acts as an EMI source suppressor, i.e., the arc suppression acts directly on the source that causes the EMI. This removes the need to address the EMI effects of arcing through the use of snubbers or other ancillary components (i.e., EMI filters, EMI enclosures, EMI gaskets, and/or other EMI counter-measures).

Arc suppression also increases the electromechanical relay’s operating life by a factor of 100 times or more (depending on application and operating conditions) by the significant reduction of contact destruction caused by electrical current contact arcing.

**Example Application and Thermal Calculations**

Let's consider a 25 Ampere load current SSR application:

**Assumptions:**
- Operating frequency: \( f_{op} = 60 \text{ Hz} \)
- Load current: \( I_{L} = 25 \text{ A (rms)} \)
- SSR forward voltage drop: \( V_{f} = 1.2 \text{ Volts} \)
- SSR power dissipation: \( P_{pd} = 30 \text{ Watts} \)
- Duty cycle: \( DC = 100\% \)
- Temperature, maximum SSR plate: \( T_{p} = 80^\circ \text{C} \)
- Temperature, operating ambient: \( T_{a} = 70^\circ \text{C} \)

The temperature difference between the SSR heat-radiating mounting plate and the operating ambient (see Figure 5) is:

\[
(T_{p} - T_{a})/P_{pd} = (80^\circ \text{C} - 70^\circ \text{C}) / 30 \text{W} = 0.666^\circ \text{C/W}
\]

(Note: 10^\circ \text{C} is a relatively small cooling differential)

Assume that using an appropriately selected and applied heat sink compound results in about 0.1^\circ \text{C/W} thermal resistance between the SSR mounting plate and the heat sink mounting area. The total thermal resistance between the SSR mounting plate temperature and the operating ambient temperature is:

\[
(T_{p} - T_{a})/P_{pd} = (80^\circ \text{C} - 70^\circ \text{C}) / 30 \text{W} = 0.333^\circ \text{C/W}
\]

The actual thermal heat sink resistance is the difference between the total thermal resistance minus the SSR mounting plate/heat sink thermal resistance:

\[
R_{th(ps)} = 0.333^\circ \text{C/W} - 0.1^\circ \text{C/W} = 0.233^\circ \text{C/W}
\]

The appropriately selected heat sink in this example will have to be able to dissipate 30 Watts of thermal power via a thermal resistance of 0.2^\circ \text{C/W} (this is not a small heat sink!).

**Relay Contact State Table**

<table>
<thead>
<tr>
<th>CONTACT STATE</th>
<th>RELAY CONTACT STATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>Make/Bounce OPEN</td>
</tr>
<tr>
<td>On</td>
<td>Closed</td>
</tr>
</tbody>
</table>

**Supporting Documents**

Arc Suppression Technologies Lab Notes
(www.ArcSuppressionTechnologies.com/LabNotes.aspx)

NOsparc MMXac™ User Manual and Data Sheet
(www.ArcSuppressionTechnologies.com/NOsparcMMXac.aspx)

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