# *Hybrid* Power Switching
A *Green* Alternative to Solid State Relays

Application Note #101 — rev C

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 it's 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.
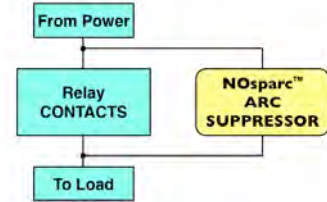
DEFINING PROBLEMS

There is a common perception among technicians, product designers and engineers that an SSR performs better than an electro-mechanical 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:
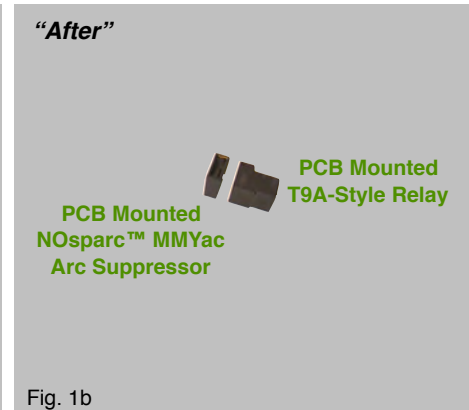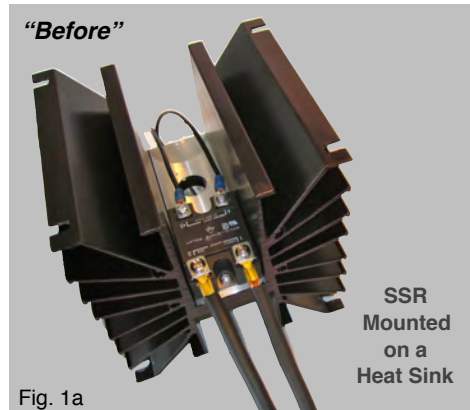
Hot operating Environments require special care
- The choice between natural convection or forced air
- Heat sink compound or heat transfer pad must be selected and applied properly

- 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). ➡
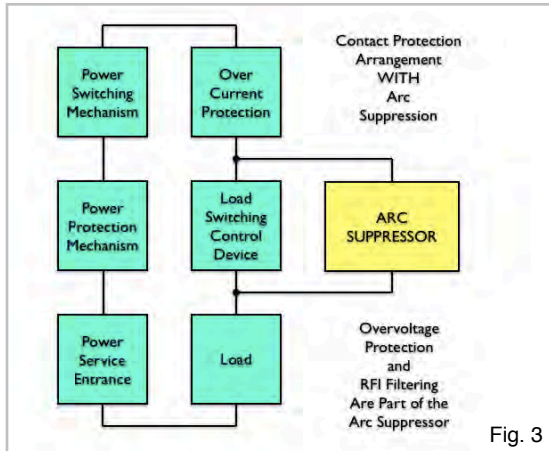

"Before"

SSR Mounted on a Heat Sink

Fig. 1a

"After"

PCB Mounted T9A-Style Relay

PCB Mounted NOsparc™ MMYac Arc Suppressor

Fig. 1b

NOsparc™ SOLUTION

Fig. 2

Panel mount MMXac (top) and PCB mount MMYac (lower left)

Fig. 3

SOLUTION *(continued)*

The advantages of the electromechanical relay's contacts come into play during the On and Off states due to it's very low contact resistance when CLOSED and its high air gap and insulating material resistance when OPEN (figure 4.).

The solid state advantages of the NOsparc™ arc suppressor come into play during the BREAK, *BOUNCE and MAKE* states to *suppress the electrical contact arcing that occurs during these states.*
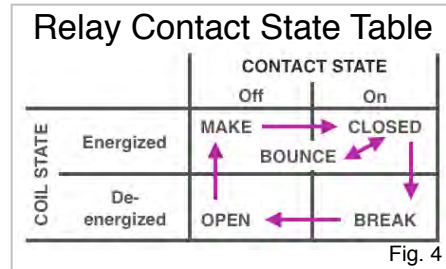

Fig. 4

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 ....fop = 60 Hz
Load current..IL = 25A (rms)
SSR forward voltage drop...Vf = 1.2 Volts
SSR power dissipation ....Ppd = 30 Watts
Duty cycle..DC = 100%
Temperature, maximum SSR plate..................................Tp = 80°C
Temperature, operating ambient......................................Ta = 70°C

The temperature difference between the SSR heat-radiating mounting plate and the operating ambient (see Figure 5) is:
Tp – Ta = 80°C – 70°C = 10°C
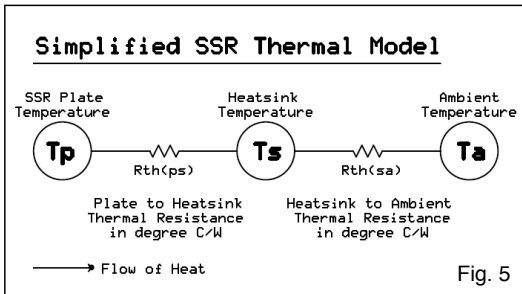(Note: 10°C is a relatively small cooling differential)

Fig. 5

Assume that using an appropriately selected and applied heat sink compound results in about 0.1°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:
(Tp – Ta)/Ppd = (80°C – 70°C) / 30W = 0.333°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:
Rth(pa) – Rth(ps) = 0.333°C/W – 0.1°C/W = 0.233°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°C/W (this is not a small heat sink!).

It is most important that the heat sink is oriented in a way that its fins are located in an unobstructed vertical laminar airflow (natural convection) path to take maximum advantage of using the hot 70°C ambient air as a cooling medium.

Please note that heat sinks have two different thermal resistance values, one is for natural convection, the other is for forced air flow. The advantage of forced air cooling is that it allows for a smaller heat sink. The disadvantages of forced air cooling is the possible cooling fan failure due to the poor reliability of cooling fans in hot environments and the thus required regular costly maintenance accompanied by the necessary but planned equipment outage to prevent premature cooling fan failures.

If the max SSR plate temperature would be allowed to be 90°C the heat sink and issues involved will not be lessened. This is not recommended due to reliability issues.

(Tp – Ta)/Ppd = (90°C – 70°C) / 30W = 0.666°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:
Rth(pa) – Rth(ps) = 0.666°C/W – 0.1°C/W = 0.533°C/W

The appropriately selected heat sink will have to be able to dissipate 30 Watts of thermal power via a thermal resistance of 0.5°C/W.

Heat sinks in the thermal resistance rating (natural convection or forced air) range of 0.5 to 0.2°C/W are relatively large, expensive and painful to work with.

Finally, SSRs with higher current ratings would only see an increase in the above heat dissipation issues!

Supporting Documents

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

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

NOsparc MMYac™ User Manual and Data Sheet
(www.ArcSuppressionTechnologies.com/NOsparcMMYac.aspx)