crydom® Solid Statements

May 2012

Protecting SSRs against short circuit and overcurrent

Absolute protection or a solid state relay from a shorted load or line condition requires more thought than simply providing a common circuit breaker of fuse in the circuit.

Compared to electromechanical switching devices, the solid state thyristor switching elements used in the output section of a Solid State relay have very short thermal time constants. Consequently, extreme current levels and surges caused by load or line faults, even if only applied over extremely short time periods, may cause the thyristor devices to permanently fail.

Semiconductor or “Ultra fast acting” *fuses*

Standard fuses simply cannot react quickly enough to prevent the fault current from exceeding the maximum levels that the thyristors can withstand.

Fortunately for the system designer, solid state relay manufacturers provide within their datasheets a specification value that designates the maximum current vs. time that the thyristors can handle.
This value is commonly listed as ”maximum I^2t for fusing”, (amperes squared seconds).

Description	25A
Maximum I^2t for Fusing 50/60Hz (1/2 cycle) [A^2 sec]	1620/1500

Equally fortunate is that fuse manufacturers have certain types of fuses that also carry an “I^2t” value.
These fuses are generally called “Semiconductor” or “Ultra Fast Acting” fuses, and are specifically designed to completely open within their published “total clearing I^2t” value.

Rated Current [A]	Part No. without Striker	Total I^2t-value @ 690 V [A^2s]
10	50 124 34.10	60
12	50 124 34.12	90
16	50 124 34.16	190
20	50 124 34.20	340
25	50 124 34.25	740
30	50 124 34.30	1 400
32	50 124 34.32	1 900
35	50 124 34.35	2 800
40	50 124 34.40	3 100

Basically the “total clearing I^2t” rating of the fuse selected must be below the I^2t rating of the selected solid state relay, and yet carry the expected “normal” running current and surges of the load.

Crydom Inc.
2320 Paseo de las Americas, Suite 201 San Diego, CA 92154
Tel.: +1 (877) 502 5500 - Fax: +1 (619) 210 1590 - E-mail: sales@crydom.com
www.crydom.com

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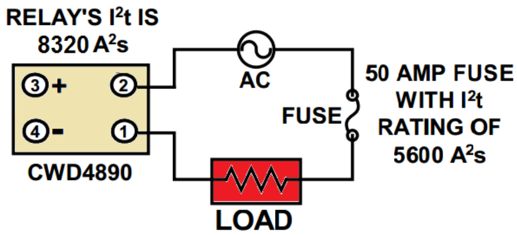
This is an example:



It may happen on some occasions that the “normal” current and voltage ratings required of the fuse push its I^2t rating close to or beyond the I^2t rating of the solid state relay. If this is the case, a higher I^2t rated solid state relay can be selected.

As stated previously, this is a very simplistic and general method of determining adequate fusing for solid state relays. There are several other items that should be considered if one needs to “dial-in” a perfectly ideal fusing solution. These factors include among other things, the available fault current from the overall system, the amount of load surge cycling that will affect the cumulative heating of the fuse itself, and the peak “let-through” current of the fuse prior to clearing. Fuse manufacturers such as Ferraz – Shawmut, Bussmann, Littlefuse, etc., publish extensive notes detailing the calculations and methods of using those factors.

Cost / Benefit Considerations

All of the above being said, the cost of a semiconductor type fuse may exceed the cost of a replacement SSR. In some applications, basic fusing could provide adequate system / wiring protection more cost effectively at a calculated chance that the SSR might be damaged. Before considering this type of protection though, the factors mentioned earlier, (available short circuit current, etc.), should be taken into account. In addition, considering the probability of a fault, and the degree of protection desired is advisable.

What the IEC standard says

IEC publication 60947-4-1 make a distinction between two different types of protection, (called “coordination”), which are designated types “1” and "2".

Any short-circuit that occurs is cleared safely by either type of coordination. The only difference between the 2 categories concerns the extent of the SSR damage caused by the short-circuit.

- **Type "1" coordination** requires that in the event of a short-circuit, the Solid State Relay (or Solid State Contactor) does not endanger personnel or installations, but permanent damage to the SSR is permissible. In this case the SSR may need to be replaced.

For this type of co-ordination, the use of fusing or circuit breakers adequate to protect the system and wiring from short circuits, (but not specifically considering SSR protection), can be used.

Applications that use lower current rated SSR's, (including PCB mount types), may be particularly suitable. The cost of protecting a low current rated, relatively inexpensive SSR with a low I^2T rating, can be disproportionately large.

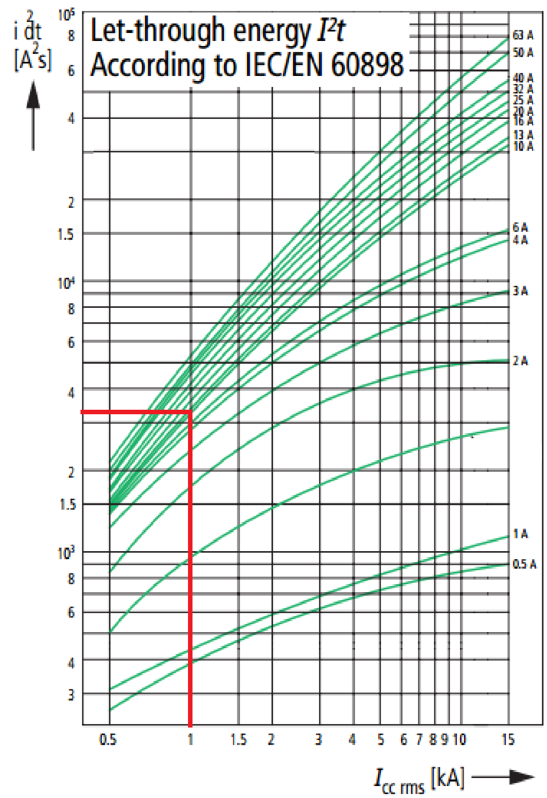
- **Type "2" coordination** requires that under a short-circuit condition, the circuit is interrupted, the SSR does not endanger persons or installations, and in addition the SSR will be able to operate after the fault condition is repaired. In this case, the protection is chosen in conjunction with the load and SSR I^2T rating as described earlier in this article.

Circuit breakers

The question often arises… "Can a circuit breaker be used in place of a semiconductor type fuse to protect both the circuit and the SSR?" (Type "2" coordination.)

The short answer is a qualified "yes" .

The long answer is that one needs to consider the I^2T parameters of t he SSR, the available total short circuit current in the system, and of course to select a circuit breaker that carries an I^2T rating sufficiently below that of the SSR yet still can handle the normal load surge current without nuisance tripping.
So, the first item needed to select the appropriate circuit breaker is to identify the maximum prospective short circuit current of the circuit according to IEC/EN 60898. There are detailed and articulated formulas to calculate that; here we can simply state that generally the short circuit prospective current rarely exceeds 1,5KA.



This is a typical curve diagram from a circuit breaker manufacturer which on the vertical scale shows the let-through energy I^2T with one curve for each different rated breaker. Once the prospective short circuit current (Icc rms) is determined we can identify the maximum I^2T value that the selected circuit breaker may let-through before it opens the circuit. In the above example we use a prospective short circuit current of 1KA, and that we are using a 10A rated circuit breaker. The let-

Crydom Inc.
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www.crydom.com

through energy will be around 3200 I^2T. To be certain that the SSR will be protected with this circuit breaker, the SSR has to have an I^2T value higher of 3200 I2T.

The above example highlights the importance of having an SSR with a sufficiently high enough I^2T value in order to protect it in the best way against the short circuit current.

As part of an ongoing process to improve existing design specifications, engineers at Crydom have increased the 30A CKR series one-cycle surge current and I2T ratings which are now well in excess of the previously published specifications.

Utilizing oversized SCR die and with a superior mechanical and thermal design, the CKRxx30 relays now boast a 1,140Apk / 1,200Apk (50Hz / 60Hz) one-cycle surge current rating, and a 6,500A2S / 6,000A2S (50Hz / 60Hz) I^2t rating. These enhanced ratings make the CKR 30 amp series ideal for use in heavy industrial applications where surge currents may be of significant concern, and allow greater choice in fusing and circuit breaker selection.

Technical Contact Information:

Americas & Rest of the World
support@crydom.com

Europe, Middle East, Africa
support-europe@crydom.com

China
support-cn@crydom.com

Crydom Inc.
2320 Paseo de las Americas, Suite 201 San Diego, CA 92154
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