Switching safety

Spurred by an increasingly long list of fire issues from PV products, IMO Precision Controls recently wrote to an international electrical body expressing their concern regarding a safety critical component being used in many installations of PV equipment. **Graham Viney, Quality Manager at IMO** discusses the safety issues with AC to DC switching and highlights a lack of industry awareness of the challenges or the solutions

As any electrician is aware the nature of DC switching has to be considered with care because on disconnection an arc can occur that is more arduous than that produced with an AC load because there is no zero point on DC. The nature of this arc means that design considerations have to be made within the switch in order to quench this phenomenon that not only includes significant contact gaps with high speed of operation, but also thermal transmissive materials.

What you have to consider is that any AC isolator is predominantly designed with materials chosen such that the load will be AC. This means that the load supply will be a 50/60Hz sine wave, whether it be 230Vac or 400Vac, etc. When switching AC it should be remembered that the nature of the load supply will always pass through 0Vac and therefore although loads can be arduous in type the supply is self extinguishing. By that I mean that even if the isolator switches at peak load and an arc between contacts is formed the action of the supply reducing to 0V means that the load will tend to zero and the arc be extinguished.

DC load, on the other hand, is always there and unless the load becomes zero the power being pulled through the contacts will always be the same, so if the load is 500Vdc 25A it will be 500V 25A now, in 1s , in 1min, in 1hour – that is constant. If this is the case unlike the AC above if you switch “OFF” on load you will also be switching “ON” on load; DC does not go through a 0V level unless there is system supply failure (or some other fault). Slow switching action or paused action could potentially allow the dangerous arcing of the DC across the contacts. Dependent upon the failure mode of the switch the DC arcs could cause fire damage or worse still failure of the isolation of the product and possible DC electric shock. At the very least, if installers are going to use AC type switches modified for DC use, we feel that they should label the isolator as indicated by the manufacturer. This may still not be clear to the consumer but will at least reduce the level of safety risk from the current high level.

Problem solving

In principle these modified AC isolators will allow the user to switch DC, however, the market design for this product is such that the disconnecting action is normally linked to the speed of operation by the user. It is also important that the action be a continuous movement rather than with any kind of pause in the switch operation which might create a sustained arc.

Whilst IMO will not modify and de-rate its AC isolator switches for use in DC applications, we respect the rights of both our competitors and installation companies to use these switches if they have evaluated them as safe. However, many of the manufacturers of these AC switches endeavour to protect their position by inserting the phrase “with rapid handle operation” or “continuous rapid handle operation” in their technical literature and this essential piece of safety information is not being passed on to the consumer representing a substantial safety risk.

This is something IMO feels passionate about and makes every effort to educate potential users about safety in AC or DC installations.

Fast switching

In view of the safety issues abounding IMO recently introduced a True DC Isolator specifically designed for use in PV installations. The IMO switch design incorporates a user action independent switching mechanism that will cause the disconnection of the load circuits in a maximum of 5ms and also incorporates specific suppression chambers in order to alleviate the arc that will occur when switching these levels of electricity. In launching our product to the installation market, we have noted that the current overriding trend is the use of AC type isolators that have been de-rated for DC use.

IMO PV isolator products are true DC switching isolators, not an AC type de-rated or re-wired for DC operation. IMO products have a switching speed that is independent of the operator, that is the IMO mechanism is such that there is no direct linkage between the operator handle and the switch contacts. As the IMO handle is moved it interacts with a spring mechanism which upon reaching a set point causes all the contacts to “SNAP” over thereby causing a very fast break/make action which means that the arcs produced by the constant DC load are normally extinguished within 5ms.

In a DC rated AC Isolator, there is usually a direct link between the operator turning the handle and the contacts switching, therefore if the operator turns the handle slowly then the contacts will break slowly leading to arcing times of up to 100ms or more. As these kinds of AC isolators have direct action the operator can stop the making/breaking of the contacts thereby oscillating them about a point that could make/break the arcing causing significant contact wear and excessive product heating. With the IMO range it is impossible to stop the make/break once it has started movement and therefore the operation must go to completion before any secondary movement can occur.

Check the fine print

In many instances where AC isolators are modified for DC use, the DC ratings are often covered with a caveat such as “quick switching only” in small print and raises the question, “What is quick switching?”

IMO products operate with a “knife switch” mechanism meaning that when the unit is operated the operation gives a double break but the arcing effect occurs on the corners of the switch only and so the main contact is made on an area where no arcing has occurred. The contact mechanism has a rotary nature which also means that when the isolator is operated a self-cleaning action occurs on the arcing points thereby producing good contact integrity over the life of the product. An advantage of this is that in the event of the supply to earth failure the high short circuit current pulls the contacts together thereby giving an high short circuit withstand up to 1700A (product dependant).

If you consider the AC Isolator based type of DC product, this as a norm uses a double break but on a contact bridge, similar to that in a contactor; therefore, although this also offers a double break like the IMO the mechanism, the arcing occurs at the switching/contact point and any subsequent operation leads to continuity being made (or trying to be made) at the same point. Should contact welding occur where these contacts touch then of course the isolation of the unit drops and therefore its effectiveness for switching the higher powers.

If we then consider, as above, a short circuit situation then the capability of an AC based isolator is of the order of up to 400A only (product dependant). As stated initially, the AC supply goes through a 0V point so there has been very limited commercial consideration to designing arc suppression mechanisms into AC isolators.

Losses & Failures

The knife type mechanism gives a set of contacts per pole however, as indicated previously the typical AC based isolator uses a contact bridge mechanism therefore, as each pole face will incur losses due to contact resistance (oxidation, etc) this means that self heating will occur within the photovoltaic device.

If you consider a DC installation where, to obtain the isolation, a four pole AC Isolator is wired with each pole set in series, this will actually give the customer 8 contact sets, leading to 8 losses per pole, and 8 heating effects per pole; which at high current levels could produce significant product heating as well as system losses.

Summary

The PV industry is moving towards grid parity and eventually a sustainable industry that is not reliant on government subsidies, but the future success of the industry is dependant on public and customer perception. A lack of concern for specific safety issues has led to fire hazard issues for PV installation overseas and every mistake is bad publicity reducing public confidence.

Although the industry is moving at an incredibly fast pace, it requires only a basic understanding of electrical engineering issues and a small amount of corporate foresight to prevent most safety issues the solar industry faces. Educating the value chain to the dangers is the first step. Now the industry needs to respond with a clear message of safety to potential PV users.