Fuse with integrated varistor or varistor with integrated fuse

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Keywords: MOV, varistor, fuse, protection, integration

Introduction

MOV's are very well known solution for protection against transient over-voltage impulses, caused by the lightning and other unexpected events in electrical network and installations. But on the other hand it is also known that the problems with overheating of the MOV body may occur. There are at least two reasons for this overheating. First reason could be a damaged varistor, which could represent conductive path with certain resistance already at rated voltage. The consequence is a current through the MOV varistor, which is over-heated and could lead to heavier damages. Second reason is an occurrence of frequency overvoltage of longer duration which causes the MOV to react and thus the MOV opens the path for short-circuit current. In both cases, the actual current through the MOV can be from the value less than 1A up to the value of several kA. In such cases fatal consequences can appear, namely, the MOV can explode. Therefore, these cases have to be prevented in order to prevent the damage on installation where MOV is installed.

Protection principles already available

In this article only two or three existing typical solutions are taken into account. The first is very simple with soldered wire under spring force. In case of over-heating of the MOV, the solder is melted and spring opens the contact of the wire and thus the MOV is not any more in connection. The problem of this solution is, that the contact has no breaking capacity and is not capable to open correctly the short-circuit currents. An example of this solution is given on the market by the source (1) and it is presented on next Fig.1.

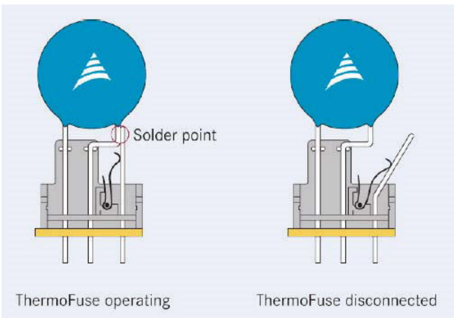

Fig.1

Next solution is proposed by the source (2) and presented on Fig.2. termal fuse element is added together with monitoring of situation when the MOV causes the disconnection of thermal fuse element.

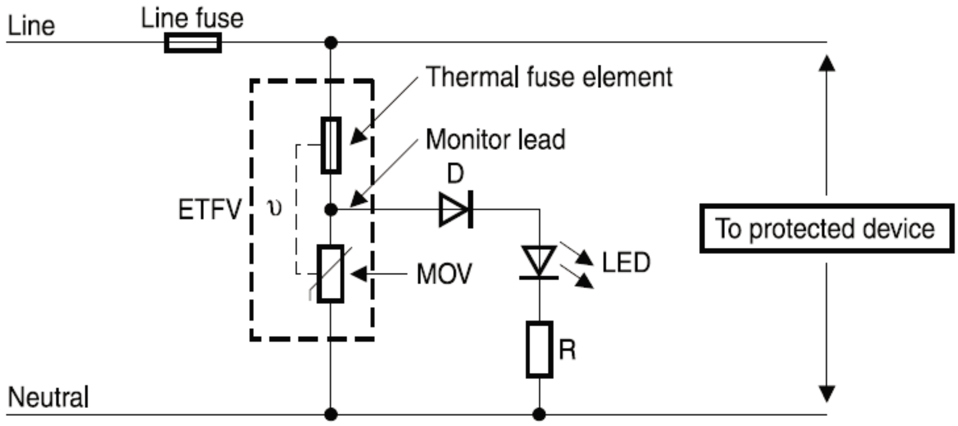

Fig.2

Next solution is a special fuse, connected in series with MOV. Such fuse, called SRF Surge Rated Fuse are reported by the source (3) has to pass the transient over-voltage impulse of certain value, e.g. 10kA 8/20, but should open the circuit in case of over-current before the MOV would explode. A disadvantage of this solution is how to make SRF fuse for lower over-currents. Next disadvantage is also in the fact that additional wiring is needed to connect the MOV unit and SRF unit. Similar fuse, called surge suppression fuses are reported by source (4). Basic schematic diagram is presented on Fig.3 below.

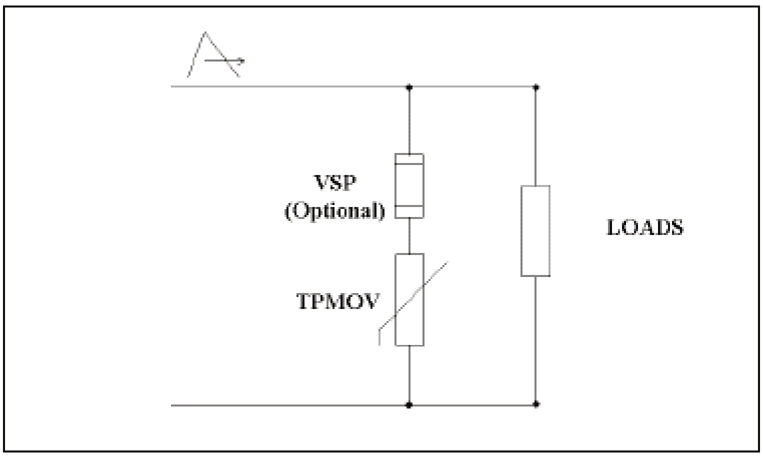

Fig.3

Surge rated fuses are only the first step into next generation of integrated SPD + fuses in one integrated device. Next solution, reported by the source (5) already shows an attempt of such integration. This solution was based on cylindrical shaped varistors which was suited in a cylindrical type of fuse size 22X58 and the melting element was the same as in SRF fuse. The Fig.4 shows some constructional pictures. Protection against thermal effect of bad varistors was mentioned to be carried out by M-efect on the very end of melting element at the point where was it soldered to the inner layer of the cylindrical varistors. Later tests, carried out after ICEFA2011 showed that this M-effect is too slow and thermal protection for cylindrical varistors has to be improved.

Fig.4

Further, another source (6) is explaining that the thermal protection of varistors is provided by melted material, which makes the short circuit between both varistors electrodes. Finally, the source (7) provides information about the varistors SPD integrated with the fuse in serial connection and with additional thermal protection, see Fig.5.

Fig.5

Proposed solution with cylindrical varistors

First of all there is a question, why to take a cylindrical shape of varistors? Source (8) is showing some types of bare MOV's. They are usually round or rectangular shaped, out of technical data it is possible to detect that the rated voltage depends on thickness of the MOV and the energy absorption capability depends on the physical volume of the MOV. Below on the Fig.6 we can see some specimen. We can clearly see the difference in thickness and in physical volume, as well.

Fig.6

How to create a varistors with higher value of energy absorption? In order to increase the volume and to remain the thickness for the same rated voltage there is the only way how to do it, namely to extend the shape.

But there is another way of doing it. The solution is already mentioned in the cylindrical shape of varistors. Partly, this is shown already on the Fig.4. Next Fig.7 shows next generation of such cylindrical shaped varistors which are presented by the source (9)

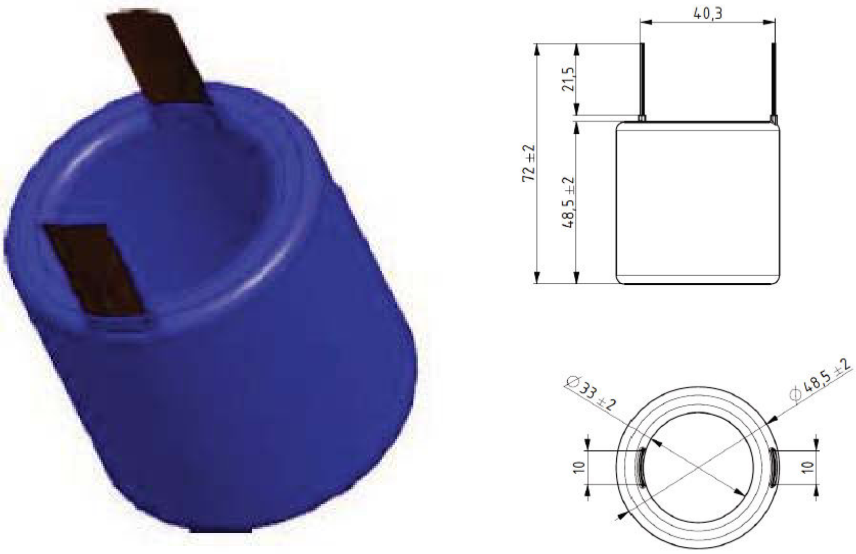

Fig.7

Basic technical data for such varistors:

- Rated Voltage: 275V a.c.
- High.Max.Discharge Current Capability Imax (8/20µs) 100kA
- Highe Peak Impulse Current Capability Iimp (10/350µs) 30kA

According to these data, such varistors can be used for high capacity SPD devices which, of course, have to contain also appropriate disconnection device, so that the SPD corresponds to the latest SPD technical standards.

How to involve this varistors into modern SPD?

We need to choose the right melting element such as the one in SRF fuses and appropriate thermal disconnector and everything put into the housing of the fuse. Next Fig.8 shows more about possible schematic diagram how to connect all three components, namely: the varistor, the thermal protector and the melting element.

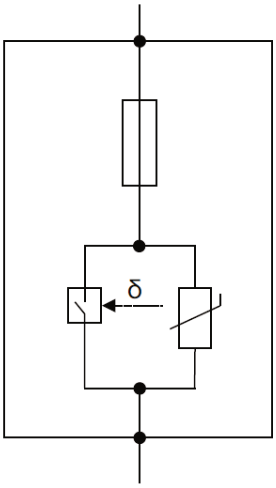

Fig8.a.

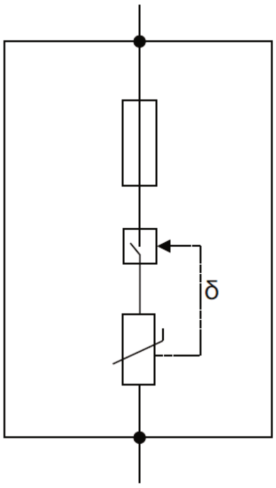

Fig8.b.

Fig.8

Fig.8a shows the schematic diagram where the thermal disconnector is coupled in parallel with the varistors. That means that in case of the bad varistors and too much heat energy exposed, the thermal disconnector will make a short-circuit an directly connect the melting element to the short-circuit conditions. If there is enough short-circuit current available, then the melting element will operate and finally disconnect whole SPD from the network. On the other hand, we have to be aware that SRF melting element has high melting integral, because it has withstand high impulse currents of 8/20 or 10/350 without being melted. Therefore the schematic diagram shown on Fig.8b. is more appropriate. It is also very important that any kind of thermal disconnector has to fulfill any current and voltage conditions at the moment of varistors overheating. Below on the Fig.9 we can see the basic construction elements of Varistor-Fuse.

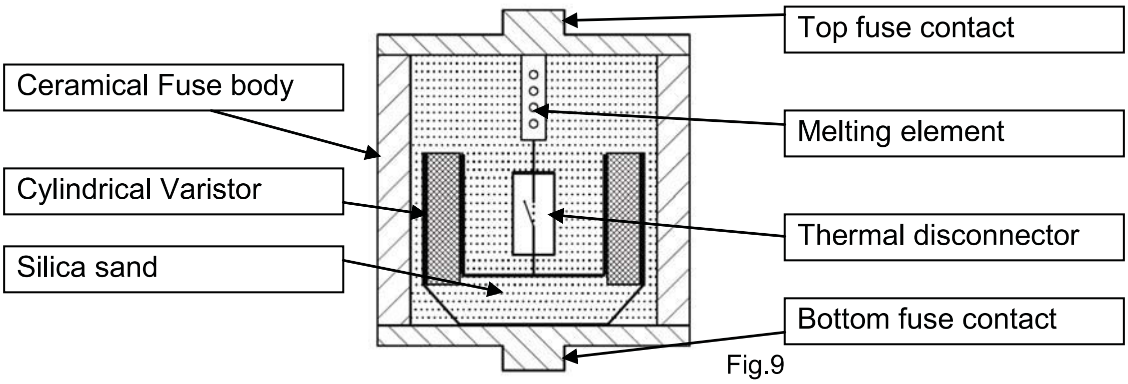

Fig.9

In reality, some of these constructional elements are presented on the Fig.10 below, where we can see ceramic fuse body and cylindrical varistors placed in inner volume. Thermal disconnector and melting element are also mounted inside and at the end of assembly process complete volume and inside components are filled with silica sand.


Fig.10

Conclusions

Presented article showed the possibility how to use a cylindrical shaped varistors to develop an integrated SPD together with melting element, acting a role of SRF back-up fuse. It is also much easier to increase the surge rating capability by changing the length and/or diameter of the varistors. Another advantage is also in the fact that all components are placed in and surrounded by silica sand which could prevent possible incorrect action of thermal disconnector. Further investigations and tests are planned to be carried out in order to finalize a proof of concept of so-called Varifuse.

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Conference: 10th International Conference on Electric Fuses and their Applications

Organized by: Dresden University of Technology
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Frankfurt am Main, Germany
September, 2015