A New Solution for a Domestic Low Voltage Surge-Arrester

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Abstract

This article presents a new product, developed by the authors, which made the object of a research contract and a technological transfer, from university to industry and mass production. It is a low voltage class D surge-arrester, based only on metal-oxide varistors, a state of the art electronic device used to protect domestic and similar consumers against any type of overvoltage (pulse or long time). On the first stage, it was developed after some research studies carried out by the authors at the Paul Sabatier University/Laplace Laboratory in Toulouse, France in partnership with the Politehnica University in Timisoara, Romania. The applicative research was transferred, in order to be produced at PROTENERGO S.A., a local electronic products manufacturer in Timisoara. It has some original ideas which make this product cheaper, easy to use and adapted to any low voltage installation existing even in ancient buildings. It could be the description of a simple technological transfer between the academic environment and the industrial one.

1. Introduction

Nowadays, there are on the market a lot of low voltage (domestic) electric consumers, most of them being extremely sensitive to any electric perturbation like flickering and overvoltages (especially electronic ones). Power quality is now an issue for each power/electricity provider, and there is a real need on the market for finding state of the art technical solutions in order to protect this sensible piece of equipment against any electromagnetic disturbances which can appear inside the power supply grid.

Those protecting devices are known as surge-arresters because they are making an efficient cut of the overvoltage shock wave, absorbing its energy.

Today, the general protection of low voltage consumers against any type of overcurrents is practically solved, by means of simple, cheap and versatile devices (protection switchers, fuses, relays), all researches are now conducted towards getting protective systems against overvoltages. Modern electric low voltage consumers such as: IT/communication electronics, electronic equipment for measurements and control, medical electronics, home appliances, audio-video apparatus, power electronics (and practically any other piece of electric/electronic equipment supplied directly from a socket, for domestic, office, medical and industrial use) are expensive and very sensitive.

By consequent, we notice an increase users' interest that these electronic pieces of equipment must work properly.

From the point of view of the power suppliers, efficient overvoltage protections are an additional cost and a supplementary investment not always accepted. By consequent, not many surge arresters are present on the power supply network.

From the point of view of the producer/manufacturer of electronic goods or home appliances, overvoltages are really a source of benefits. Destroyed items have to be replaced, service and maintenance must be carried out, or, in a worst scenario when no replacement or fixing is possible, consumer has to buy another new electronic product, which is clearly the normal intent of the manufacturer. By consequent, not many overvoltage protective devices are placed inside an electronic product.

As a principle, the overvoltage protecting systems are needed only by the electronic goods consumers, people or organizations who want to protect their investments in electronic goods, as well as to increase safety in service. By consequent, a new generation of surge arresters, working at low voltages in power supply installations, located in buildings, having the role of completing the already existing ones, is going to entry on the market. By using these complementary equipment (located mostly in the socket area), the co-ordination and selectivity of protections could be achieved.

Although all over the world, (EU included) there is a clear strategy concerning protection against overvoltages of low voltage consumers, there is a lack of clear, simple and effective standards to normalize the presence and the construction of such protecting systems. We can say that, except 2 or 3 standards, which are not mandatory, this policy is practically absent worldwide. There is also a lack of consumers' technical culture in the field of overvoltage protection. This article wants to present some useful information for both companies and common people, about modern overvoltage protecting systems.

2. Overvoltage Protection Systems

An overvoltage protection device must comply the following requirements: to not allow the dielectric breakdown of the existing insulation of the protected electric circuit or electronic equipment, to avoid any type of accidental discontinuities in power supply, to limit the risk of human operator electrocution due to voltage potential increase of some parts of the equipment and to prevent fires or emergency situations caused by electric arc or overheating.

Nowadays, the protection of power systems against overvoltage is made by lightning rods, protective passive conductors, LC circuits, automatic speed circuit breakers and spark gap based parallel protections, diodes and varistors.

All types of such parallel protections are building a temporary connection by having a very low impedance between the high voltage protected equipment and earth, which is effective only for a relatively short period of time, but long enough in order to conduct the transitory overvoltage produced by the direct or indirect atmospheric discharges, or by the accidental connections inside the power networks. Those connection times have to be limited to a certain value which is inferior to the maximum level of protection required by the protected installation.

This type of parallel protection used in power systems includes spark gaps, simple dischargers, gas dischargers and variable resistance dischargers (surge arresters). Modern surge arresters are based on SiC, semi-conductor Si or Se Zenner diodes, semi-conductor ceramics made of ZnO and other metal oxides (MOV surge arresters).

MOV surge arresters have some clear advantages, when compared with other similar devices, like short response time, high energy absorption capacity, excellent voltage calibration. Due to those advantages, today, state of the art surge arresters are made with MOV varistors, sometimes called ZnO varistors, due to their main ingredient. First used for high and medium voltage surge arresters, they have recently been used in the area of low voltage devices, too, mostly for protecting sensitive electronic equipment against any type of overvoltage.

3. A New Low Voltage Protection Module based only on ZnO Varistors

In order to protect the low voltage electric installations and equipment against overvoltage, ZnO varistors, in many situations, are not integrated alone, but together with other specific electronic devices, forming an overvoltage protection module.

Generally, a MOV protection module includes:

- Some (one or two) varistors used for absorbing quickly the electromagnetic power of the voltage pulse, as internal heat, that dissipates completely into the environment;
- A spark-gap gas discharger capsule, which disconnects (one or all) varistors when the protected installation is working in normal permanent regime and for fixing the value of the opening voltage when long time overvoltages appear;
- A simple thermo-bimetal element used to disconnect the varistor if its temperature increases after a voltage shock pulse, in order to avoid its temperature increase;
- A fuse element which is the last line of defense when limiting the leakage currents, avoiding the complete thermal destruction of the varistor.
- Some LED or bulb lamps indicating the working state of that protecting module.

According to IEC 61643, protecting modules of this type are produced worldwide in five different protection classes, in order to co-ordinate the level of overvoltage protection in buildings. We will present a standard Class D (or 4) – protecting module placed in the plug/socket area, before the entrance in the electronic sensible consumers.

Figure 1 shows us the electric schema of a classic module used on the plugs of domestic and similar consumers produced by DEHN & SOHNE Gmbh from Germany, only as a case study for the actual look of such a device [4].

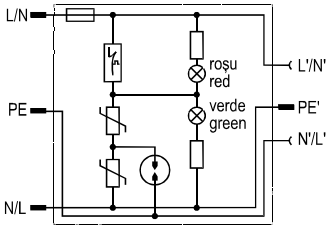

Fig. 1. Class D Protection Module

We observe that it involves a very complicate structure of the module, with reduce liability. In many situations, the use of such overvoltage protecting modules in low voltage distribution networks is convenient only for class A, B, and C, where a lot of equipment will be protected. By consequent, we will take into account the costs, because these apparatus are not affordable for every appliance. When speaking about this class D protecting module, we notice this electric schema which could be applied only to perfectly symmetrical and balanced low voltage networks. By consequent, their application in certain low voltage networks which are unbalanced and non-symmetrical, in most cases showing a strong neutral voltage deviation, is not always efficient.

This market and technical case study imposed the idea of designing and producing an original overvoltage protecting module, which should answer the requirements of a low voltage distribution network and, at the same time, has to be affordable to a number of consumers as large as possible, with at least 3-5 years of complete liability. This original module was designed by the authors at the POLITEHNICA University in Timisoara and then produced on a large scale by S.C. PROTENERGO S.A. Timisoara, Romania. Product code is MPS-01 and it has a very simple electric schema with three ZnO varistors which realize phase-neutral, phase-earth and neutral-earth protection, as shown in Figure 2.

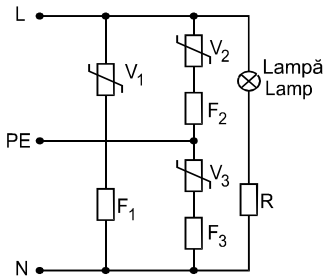

Fig. 2. The electric schema of the overvoltage protecting module MPS-01

The circuit was made on a printed-plate on a classic glass silk texture. It includes 3 V250K20 type varistors produced by VARSI Varistor d.o.o. Ljubljana, called V1, V2, V3, 3 fuses called F1, F2, F3 designed to work at a peak current of maximum 8 kA in order prevent varistors from excessive over-heating and avoid any phase-neutral or phase-earth short circuits, a neon bulb lamp which signals the presence of voltage on the terminals of the module and a resistor R which limits voltage on the neon lamp, for a proper function.

The simple conception and design of this electric schema practically eliminates the possibility of varistor overheating, because no matter the origin and the terminals where an overvoltage occurs, all varistors are working in parallel.

It offers the possibility of eliminating both the thermo-bimetal block and the gas discharger, reducing the cost price of the module, and making it more liable, strong and calibrated.

This MPS-01 overvoltage protection module can work as an E class module imbedded at the supply entrance of the protected electronic consumer or as a D class one being a component part imbedded in an electric plug type unit (placed inside or outside the wall) or of a multi-plug standard lengthener.

A product unit called 'Multi-plug Block Protected from Overvoltage – BMS-01' was equipped with this MPS-01 protecting module, after being mass produced and marketed by PROTENERGO S.A. company in Timisoara. It is presented in Figure 3.

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Fig. 3. 'Multi-plug Block Protected from Overvoltage – BMS-01

The conception and the design of this original product were made by the authors, and PROTENERGO S.A. Timisoara is one of the spin-off companies belonging to the industrial innovation park of the University. BMS-01 can be used up to a power of 2,500 W (even larger when changing the plug conductors).

4. Experimental Part and Quality Check

The Multi-plug Block Protected from Overvoltage – BMS-01 product has been homologated according to SF 16/2011 internal production standard and first, it has been tested at the High Voltage Laboratory of the Electrical Engineering and Power System Faculty of U.P. Timisoara and at LAPLACE Laboratory of the University 'Paul Sabatier' of Toulouse - France, where it has got the Certificate of Conformity in Electromagnetic Compatibility for electric domestic equipment.

All laboratory tests were performed on the whole apparatus and they endorsed both tests of mechanic resistance for the carcass and the electric bonds as well as dedicated overvoltage tests concerning the response at the voltage step and current signal with 8/20 µs standard waves having a peak voltage of 4 kV, according to the IEC 61000 norms. Figure 4 shows an example of the response wave form of the product. It is known that, in most industrial buildings, there are many domestic consumers, which, in normal work regime, through inductive disconnections, they can produce overvoltage 'wandering waves' which travel through the distribution network. One of the main issues of the authors' was to determine the behavior of this BMS-01 block when exposed to such 'wandering waves'. A test stand, presented in fig. 5, has been conceived, made of a sparking-coil supplied, in primary, at the 230V AC network, which produces, in secondary, a combined train of overvoltage waves having about 1.35 kV, which are discharged on plugs B1 and B2 as intermittent electric discharges of 50 Hz.

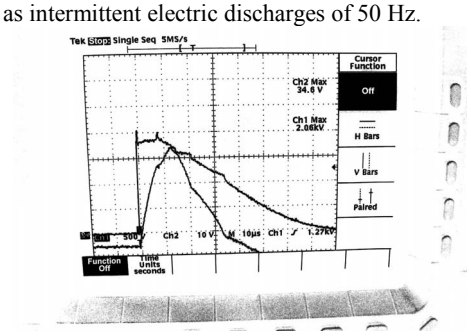

Fig. 4. Response of BMS-01 to an 8/20 µs standard pulse

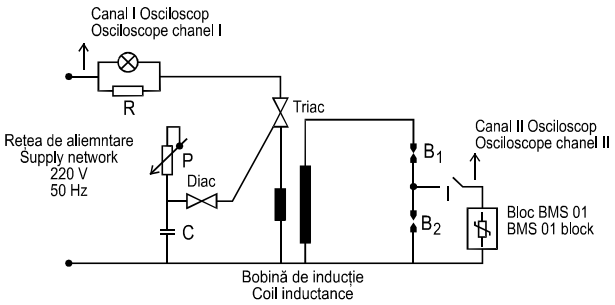

Fig. 5. Test stand for studying the behavior of the BMS-01 block for a train of overvoltage wandering waves

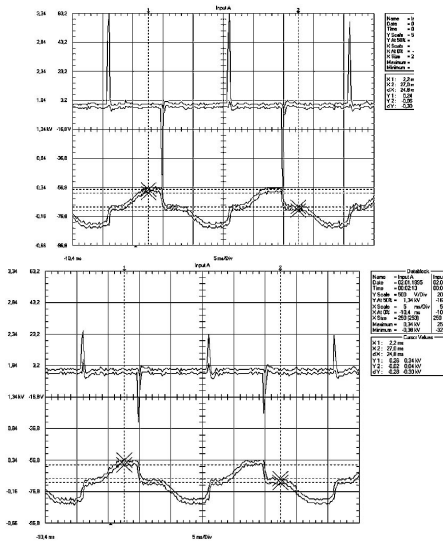

Fig. 6. Diagrams for a train of overvoltage wandering waves applied to a domestic consumer: a) without any overvoltage protection; b) with overvoltage protection

When switch no. I is off, by applying the 230 V AC voltage of the supplying network to the equipment, we can easily see electric discharges on both sparking plugs. If switch no. I is on, by connecting the BMS-01 (or MPS-01) to the sparking plug B2, we can notice that the electric discharge appears on sparking plug B1 only. The measurements of the phenomena, provided by using a simple digital oscilloscope, are presented in fig. 6.

It shows that the train of wandering waves is practically cut by the presence of BMS-01 at a third of its initial peak value, so, by consequent, its effect is not felt any longer by the sensitive protected domestic consumer.

Another benefit is that, using this multi-plug block BMS-01 for supplying the electric home consumers which generate voltage inductive disturbances, the whole electric network of the building is protected against any bad effect of the overvoltage wandering waves like the premature fatigue of condensers inside the electronic domestic apparatus, the degradation of the 'economic' electric bulbs, the precocious aging of some isolations, etc.

5. Conclusions

Quality of power delivered to consumers requires some protecting measures to be adopted at consumers' low voltage, too. All these requirements are fairly common described in Europe, but not very applied on the market. There are not many companies producing overvoltage protecting systems using MOV (ZnO) varistors. The first Romanian product of this kind, engineered and built in Timisoara, has demonstrated through the tests that it meets the European standards and regulations existing in this field. Designed for the specificity of the low voltage distribution network, this product has a good price/quality ratio, being affordable to a large number of domestic users and consumers.

The original technical solution described above use only 3 varistors, with no gas-discharge or thermo-bimetal elements, which increase time response and calibrated even better that element. There is an increased liability, proved during the last 4 years, where a few ten thousands BMS-01 were produced, with no warranty or post-warranty complains.

All these performed experiments shown the benefits of the use of BMS-01 and the correct choice of the technical solution applied.

6. References

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