Intelligent fuse for M.V. distribution systems: a current need.

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Abstract:
The widespread application of fuses is based upon its low cost, high reliability that roots in their simplicity, and on the application of well-known physical principles. From its invention (roughly by 1880), the main improvements have been aimed to use of better materials, to extend the application range, and towards the development of faster and cheaper construction techniques. Many parallel and series combinations of similar or different fuse links were also described in the literature. The phrase "New fuse design or type for specific applications …" has been groundlessly expressed many times. No critical changes towards adding intelligence to the traditional fuse have been lately produced. During more than 120 years of fuse application several improvements have been published at conferences and magazines, but just a few of them have been really available and of stable market position. A literature survey of the main fuse intelligence adding and innovations from their beginnings is here described and discussed. Current needs, especially for medium voltage fuses applied to distribution systems having embedded generation are also presented. Directionality and discrimination between phase-to-earth and phase-to-phase faults are today fuse capability needs, describing some ideas about the ways to reach them. Medium voltage fuse technology urgently need of new breed and fresh blood, otherwise their future application would be very uncertain, which unfortunately have been broadly revealed in the past. Distribution system is still a field where fuses are strongly suited thus any effort towards increasing its presence would be worthwhile.

Keywords: electric fuse, distributed generation, discrimination, intelligence

I. INTRODUCTION

Unfortunately, we, fuse researchers are seeing as day by day fuses are relegated to smaller and smaller niches, such as semiconductor protection, and medium voltage motor applications. Such exclusion is perhaps caused by the lack of new fuse designs able to adapt to the quickly changing electrical system needs.

Lately, big movement has been done towards the improvement of motor protection fuses, but the distribution system fuse has been practically left aside except for the breaking capacity widened towards the low current area [1].

In many application fields, especially on low and medium voltage distribution applications, fuse competitor devices have incorporated a big deal of improvements and enhancements, specially giving flexibility and adaptability. Two characteristics of which the traditional fuse lacks.

The very high cost of fuse developments, primarily due to the high short-circuit testing charges, trends to slow down the introduction of new fuse designs.

Today due to this fuse flexibility lack, fuses are in risk to be banned of any distribution circuit having distributed generation (DG).

The cited flexibility can be also called as intelligence, understanding for intelligent fuse the protection device that is able to make decisions, for instance doing opening and reclosing operations, discriminating direction and detecting phase currents from earth currents.

II. BACKGROUND AND HISTORY OF FUSE IMPROVEMENTS

The today widespread application of distribution fuses is based upon its low cost, high reliability that roots mainly on their simplicity, and on the application of well-known physical principles.

From fuse beginnings, first scientific reference by Sir. Edward Nairne during 1773 and first official US fuse patent granted to Thomas Edison by 1880, the main improvements have been aimed to use of better materials, to extend the current and voltage application ranges, and towards the development of faster and cheaper construction techniques [2, 3].

Between the transcendental fuse improvements the M-effect incorporation by Metcalf during 1939 need to be mentioned [4].

After that early improvements many changes into the original fuse design have been presented, all of them in order to extend the low current interruption capability having different acceptation or success degrees.

Among them can be mentioned:

- Utilization of non-traditional fuse element metals, as for instance Aluminum or Cadmium [5, 6].
- Use of bounded silica sand [6].
- Use of two dissimilar bounded or unbounded metals [7, 8].
- Current limiting and expulsion elements put together inside a single fuse body [9, 10].
- Paralleled combination of high-voltage expulsion fuse and Z_nO varistors [11].
- Hybrid fuse using SF_6 or vacuum fuse in series with traditional high current part [1, 12].
- Repetition fuse and self-healing or permanent fuse using high-pressure sodium and mercury as fuse elements, idea lately extended to the application of polymeric compounds [13, 14].

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The phrase "New fuse design or type for specific applications …" has been groundlessly expressed many times. No critical changes towards adding intelligence to the traditional fuse have been lately produced.

A literature survey of the main fuse intelligence adding and innovations from fuse design beginnings intending to analyze the presented DG problem was done. From this survey, just two suitable original ideas had come out, the application of chemical charges and the use of saturable transformers.

The two ideas can be summarized as follows.

a) Application of chemical charges:

The idea was originally presented for Muth & Zimmermann by 1938 [15], based upon the fuse blowing due to the ignition of a chemical charge caused by a externally controlled heater, being the device described as the combination of the accuracy of a relay with the cheapness of the fuse. Afterwards the same idea was pursued and developed, especially on the ignition control system, introducing in the market by 1963 the device called "limiter", which have been since in the market [16]. The same concept was further developed and applied to the Automatic Seccionalizer, coming out by the eighties [17]. By the same decade many other designs using this principle were presented, especially developed for medium voltage distribution systems, having dissimilar market success [18, 19]. One of them, called Electronic Power Fuse loaded with up-to-date or last generation electronics has got a relatively good foot in the market, in spite of its still high cost [20]. By 1990 a technical paper was produced, presenting a new design applying this concept to low voltage dc systems, called Smart Fuse [21]. No more than five years ago, the limitations of the application of this chemically charged device for the expansion of distribution systems were emphasized giving recommendations about how to avoid frequent misapplications [22].

b) Use of saturable transformers

During the seventies an interesting idea was proposed, related to the availability in a single fuse cutout of a double fuse time-current-characteristic. This double TCC was obtained by using a current transformer which working zone included the saturated and non-saturated areas, changing the two paths current sharing depending on the overcurrent level. The mentioned design was proposed for the solution of coordination problems between the main feeder and branch protections. Initially the current transformer was located by the detachable fuse link, being lately attached to the fix cutout part [23].

III. PROPOSED FUSE

One of the today most important needs is the availability of medium voltage fuses especially designed for being applied to distribution systems having embedded generation, where particular requirements shall be considered. Figure 1 shows a typical system having embedded distributed generation. In Fig. 1 the Sensitive Equipment and faulted branch locations are shown in Distributed Generation and main supply sides respectively.

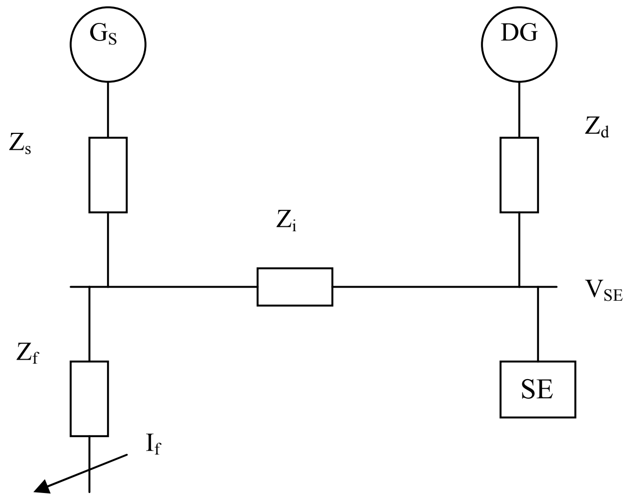

Fig. 1, Typical distribution system having DG

Currently there is a big movement in the field of distribution generation having DG mainly due to the present Power Quality strict requirement, being voltage sag presence one of the biggest issue [24].
From the voltage sag point of view, is really very important to keep the DG connected and feeding the system during fault events, due to its capability to backup the system voltage, increasing the possibility that the sensitive equipment would remain operative. In the other hand there is a serious risk of keeping part of the system working under “islanding” conditions. Besides there are serious difficulties on getting selective coordination for all the possible operating conditions, having the fault energy coming from either the main supply or from the DG, being the DG presence in the system decision of the DG owner and not of the main utility.

The solution for the listed drawbacks can be done by using complex and expensive protection schemes, due to many of the needed task are out of the traditional fuse reach. Among the intelligence that the fuse today needs to have, the most important ones are directionality and discrimination if ground is included in the fault path.

Besides the solution must have a cost enough low as to keep the complex fuse as an attractive possibility if compared with the competitors.

Both ideas have been combined in a design that analytical studies shown to be very auspicious. As the design is in its way to start the patenting process, no further details can be provided here.

IV. CONCLUSIONS

Medium voltage distribution fuse technology urgently need of new breed and fresh blood, otherwise their future application would be very uncertain, which unfortunately have been broadly revealed in the past. Distribution system is still a field where fuses are strongly suited thus any effort towards sustaining and increasing its presence would be worthwhile. The joint application of the well-known chemical charges and saturated transformer technologies allows the production of a fuse able to operate following two dissimilar TCC depending on the direction of the current passing through the fuse construction.

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