# How should we rebuild relaying?

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**Massive power grid failures (blackouts), lead to huge losses and often to death. Malfunction of protective relays is one of the main causes of the heavy failures that periodically occur in power systems all over the world.**

According to the North American Electric Reliability Council, in 74% of cases the reason for heavy failures in power systems was the incorrect actions of relay protection. Thus the reliability of a power system depends on the reliability of relay protection in many respects.

In previous publications the author has already analysed the transition from electromechanical to a microprocessor-based protective relays, and considered the prospects and problems of microprocessor relays applications [1, 2]. The rather sharp reaction of the readers, show that among the specialists in this area there is no common opinion about the prospects of microprocessor protection. There is no unequivocal understanding that, as with any other complex device, microprocessor protection not only possesses obvious advantages, but also has weaknesses.

One of the widely widespread fables [3, 4] justifying the inevitability of transition to Digital Protective Relays (DPR) is the myth that electromechanical protective relays do not provide for the performance of the technical requirements for relay protection and the continuing existence of electric power industry of today is not possible without DPR.

Actually, no new functions in relaying DPR have been introduced. The parameters and facilities of the high-quality electromechanical and semi-conductor, that is, the static analog devices constructed on the basis of discrete solid-state elements and integrated microcircuits, completely provide all relay protection requirements. In relaying there are no actual problems that could not be solved by means of electromechanical or static relays (note: recording emergency modes is not relay protection function). Confirmation of this is the fact that branched and complex electrical networks and systems exist and successfully function all over the world, and have for more than a hundred years; whereas microprocessor-based relay protection has appeared in use in not very appreciable numbers just 10 – 15 years ago. Thus, with the beginning of the use of DPR the functioning logic of an electric power system has not changed, the number of operations that are carried out by an electric power system has not increased, the quantity of the produced electric power has not changed, principles of transmission and distribution of the electric power have not changed.

*Fig. 1: Today each type of DPD has its own body which significantly differs from that of any other DPD type.*

**Some conclusions from previous author publications [1 – 4]:**

- Reliability for DPR is lower than reliability of electromechanical relays and electronic relays on discrete elements.
- Built-in self-diagnostics for DPR is ineffective and is not a means at all for increasing of MPD reliability.
- Nanotechnologies, used in manufacture of DPR's elements, leads to the occurrence of problems not known earlier for relay protection. Ignoring these problems can lead to catastrophic consequences. The managers making of the decision in the field of relay protection and the personnel of the power companies should be informed about these DPR features.
- The recording function of emergency modes in power network and data transmission function on modern connection channels are not direct functions of relay protection and for their realisation there are separate microprocessor devices which carry out these functions much better than DPRs. As against relay protection, failure of these devices does not lead to heavy failures in power systems. Therefore for relay protection devices the focus should be on other demands on reliability and, accordingly, to use other approaches at the designing, directed on increasing of reliability and decreasing in vulnerability.
- The persons responsible for making the decisions on reconstruction of relay protection and ways of further developments should understand, precisely, the properties and features of the DPR, to take into account not only widely promoted DPR advantages, but also the serious shortcomings, one of which is lowered reliability.

*Fig. 2: The modern method of mounting the DPD in relay cabinets.*

**So, what to do with all these problems?**

To answer that question we should look at the construction of DPD. As is known, the DPD has a modular design. The basic functional units of DPD are: motherboard

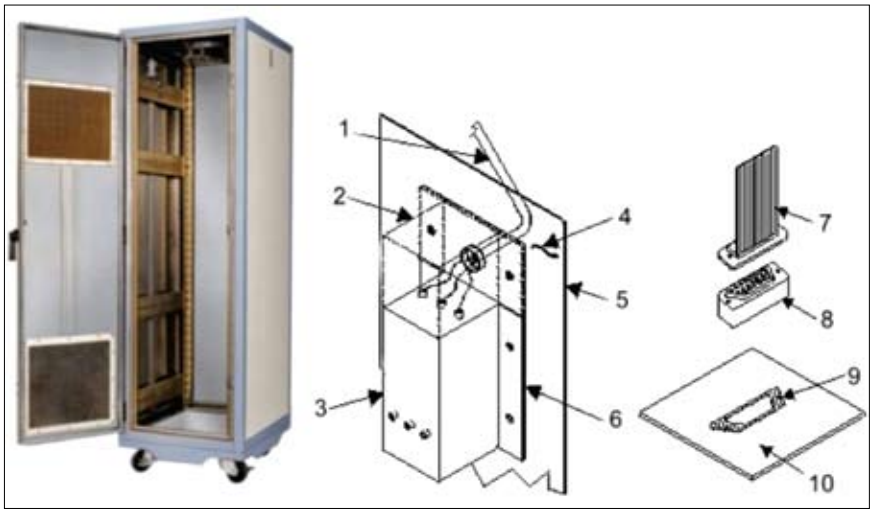


*Fig. 3: Relay cabinets should be designed to protect contents from EMI.*

with an analog-to-digital converter, microprocessor, various types of memory and other accessories; digital (logic) inputs with photocoupler modules; analog inputs based on the current and voltage transformer module; output relays module. Isn't this modular design of DPD similar to that of personal computer (PC)? However, there is one significant and even essential difference between PC and DPD: each PC module is available on the open market and you can assemble your PC with modules produced by different manufacturers from different countries. What does it lead to? It leads to price reduction and ability to assemble a PC with the best suited modules regarding their characteristics and price. The same applies to the software. There is some universal platform (Windows) and a huge market of applications for every taste.

But, are there any significant structural differences between the PC and the DPD? In reality, there are few essential differences it uses the same power source, the same main module (motherboard) connected to auxiliary modules, such as the analog inputs module (a set of CT and VT with the filter and ADC) – instead of the video card, logic inputs module – instead of the TV Tuner, output relays module – instead of the sound card. What is the essential difference between the software designed for multifunctional DPDs and any other software? There is no difference! So what's the problem? Why do we have now a vast number of totally non-interchangeable DPD designs, instead of a set of universal modules in the form of printed circuit boards?

**Why do we have a wide variety of the DPD software versions that are inconsistent even with each other?**

To answer this question, let's trace how this remarkable business works. For example, what happens if some specific module of a specific DPD type at a given substation fails? This is what. Since there is no market for universal modules, the user can replace the failed module only and exclusively by the same one, produced by the same manufacturer. Thus, after you spent a small fortune to purchase the DPD from one of the manufacturers, you actually fall into the bondage of economic dependence on this manufacturer for the next 10 – 15 years, since after you have chosen one manufacturer it no longer matters if there are other manufacturers on the market as you cannot use their products.

And the only way to get out is to pay a small fortune one more time for the DPD from another manufacturer (and, thus, you go from one bondage to another). And what does the manufacturer in such situation of absolute monopoly do? Right: the manufacturer increases the price! The price of one spare DPD module can reach almost one-third or even a half of the price of the entire DPD! As you have nowhere to go, you pay that price. And what happens after 8 – 10 years of the DPD operation? Here's what happens: the manufacturer had already developed several new designs during that time and it has become unprofitable for the manufacturer to maintain the facilities producing spare modules for the old relays, so production has been stopped. What does the consumer do in this situation? Right: throw the old DPD into the garbage, even if there is only one faulty module (printed circuit boards of the modern DPD are developed with irreparable technologies), and shell out for purchasing a new one. Who wins? Right, the same manufacturer! But why is the manufacturer allowed to cash in on the consumer? What should have been done to turn the tide in favor of the consumer? That's right, the DPD should be realized as a set of the modules – circuit boards with universal standard dimensions and connectors, just like those for PC, and with integrated basic program

*Fig. 4: Thick folios containing user information about DPD.*

shell compatible with the software for the given type of the protection or the protection kit, available on the market. Today each type of DPD has its own body which significantly differs from that of any other DPD type, sometimes even from the same manufacturer (Fig.1).

Today as a rule, a single DPD is installed in the relay cabinets: 3 – 5 units in each cabinet, Fig. 2. If a new DPD will be realized as a set of universal modules on printed circuit boards, then such sets (at least, in most cases) will not require the individual cases. Each DPD may be installed as a single horizontal section in the cabinet with printed circuit board guiderails, individual door and the rear wall with connectors and terminals for connecting external cables just as in PCs.

The relay cabinet should be made by special technology intended to protect its contents from electromagnetic influences. There are modern technologies (special cases, electrically conductive pads and greasing, filters, etc.), which could significantly reduce the effect of external electromagnetic emission of wide frequency range on high-sensitive DPD equipment, Fig. 3.

The proposed development could open the DPD market to new players, some of whom could produce analog input modules equipped with current and voltage transformers, others – motherboards, or software. The consumer could build the DPD out of the separate modules from different manufacturers, just as it is today for PC, based on the cost and quality of these modules, as well as use the same software for all its DPDs. It would solve many of the questions set out above, and significantly reduce the cost of relay protection.

This could also enable installing two sets of identical DPDs instead of one in order to improve the reliability, and use the second set as backup, starting automatically upon the "watchdog" signal of the damaged core DPD. In addition it would eliminate the necessity of the individual power source for each DPD, and allow using one double high-capacity power source set of improved reliability for the entire cabinet. And finally this would allow installing many service modules, capable of improving the DPD reliability, in the same cabinet.

Thus the relay protection maintenance would be simpler as the service staff would not need to read thick folios (Fig. 4) about different DPDs installed in the facility and study characteristics of the software of each DPD type. In addition to easier maintenance and reducing the new DPD lead time, it would significantly reduce the percentage of errors caused by the human factor. Such DPD design would solve also the problems of testing complex DPD functions [5].

How can such new way of DPD reconstruction described above be realised in practice? The easiest way is to start in one big country with a large market and several DPD manufacturers able to close with each other. In our opinion, the first step in this direction should be the setting of national standards containing requirements of the new type of DPD, its software, test procedures, etc. These standards must be developed by a wide range of professionals, including scientists, potential DPD producers, their potential customers and representatives of project organisations. It seems that such relay protection development, even in one country, would show an example to be emulated around the world.

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