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Problems of Modernizing Relay Protection and Electric Power Supply Systems Automatics

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There are considered the problem issues of transition of relay protection and automatic equipment from electromechanical base to the microprocessor. The approach analysis to rearmament in technical and economic aspects is made. The positions of this problem of leading Russian and foreign scientists are considered. Works and statements of cand.of eng. V. Gurevich are analyzed about that inevitability of transition of system of power supply to microprocessor protection is the myth based on opinions that allegedly devices of protection of the electric networks, constructed on electromechanical relays, aren't capable to provide performance of the technical demands made to relay protection and automatic equipment. The data on the main shortcomings and advantages of electromechanical and microprocessor systems are provided. The main tendencies of future development of relay protection and automatic equipment are defined. Studies of failure rate of relay protection of different types are conducted.

Recent publications in Russian popular science, industry and manufacturing journals debate on the topic of energy systems modernization. One of the most discussed topics is the problem of switching power supply systems of relay protection and automation (RDA) based on electromechanical relays to microprocessor relay protection (MPD).

The rising cost of electricity, possible ways to reduce it are very relevant for everyone – because *consumers* will have *to pay* the price for the power modernization. Therefore, the forecast path of this trend in the energy sector is undoubtedly of interest.

The practice shows that power engineers tend to new technologies. This is natural. Modernization of the relay protection is moving towards the introduction of microprocessor systems, especially for complex protection. But is this approach justified in the technical and economic aspects?

The present level of development of microelectronics allows total re-technical base of the RPA and its transition to the microprocessor system. This process has both its supporters and opponents. Speaking of enemies, then it is not about countering scientific and technical progress or of opposition to the MPD integration to the power system. Rather, it is the skeptics who are just trying to analyze all aspects of the modernization of relay protection process and give it an objective assessment. It is surprising what they can make.

Wide scientific debates were held among specialists about the practical implementation of a new concept of building electrical network protection. On the one hand, the arguments of Vladimir Gurevich (Ph.D., Israel Electric Corporation Haifa, Israel), based on years of research, on the other hand, argued reviews of his opponents, including scientists of KSPEU Department "Protection and automation of electric Power Systems" from Kazan, the Russian Federation.

V. Gurevich in more than two dozen of his works, including publications in reputable international scientific journals, says that the latest generation of electromechanical protection meets all modern requirements for RDA. They have provided protection of electric power facilities from emergency conditions not worse than microprocessor systems, and that has been confirmed by many years of practice. According to him, all the articles in the field of relay protection and automation give only positive feedback on the microprocessor devices, because the initiators of these publications are the manufacturers of the equipment that are interested in advertising their product. These magazines are extremely reluctant to publish articles with objective criticism of this product. They artificially shape public opinion that the only area of modern relay protection and automation (RDA) power systems development is a full transition to microprocessor protection.

Now the idea of further existence of electricity without power microprocessor systems of protection and automation is simply unthinkable. It is believed that relay protection before microprocessor technology invention was in a backward state. But is it? Of course not!

It is difficult to overestimate the importance of the VNIIR (All-Russian Research, Design and Technological Institute of Relay with Pilot Plant) development that had in the Soviet period (1961-1991.) on the level of the electrical industry. The institute was given the task - to create reliable products that can operate reliably for decades in all conditions. Time has shown that the company has successfully coped with the task. Its electromechanical relays and static protection devices work 20-40 years, with the standard useful life of twelve

and a half years. Virtually all relay protection devices of the Soviet Union enterprises were designed by VNIIR, and largely thanks to the reliability of this technology there haven't been any system failure in the country.

Nowadays in half-advertising articles published by experts of the world's leading manufacturers and distributors of relay protection (MPD) only their positive qualities are indicated. There are literally few publications by individual authors on the analysis of the problems associated with the transition to microprocessor-based systems, although in reality there are a lot of them [1]. For example, Vladimir Gurevich in his work has honestly shown the advantages and disadvantages of the MPD. However, he understands and takes full advantage of the MPD and does not deny the importance of the transition to microprocessor-based systems, moreover he is not going to get in the way of scientific and technical progress. The author only suggests finding the best options for the coexistence of electromechanical relays and microprocessor protection in the modern energy industry. In his view, the maximum reliability of relay protection on power is possible when combined.

Despite the difficulties connected with the implementation and operation of the MPD, in practice, they are widely adopted and fully replace electromechanical relays. The transition is inevitable, first of all, because the production of electromechanical relays is completely stopped by all world leading manufacturers of relays. The reason for this is not insurmountable fundamental shortcomings of electromechanical relays (which are not only worn out and weren't improved for the last 30-40 years), but the super-profits that companies get making MPD [2]. After all, it is no secret that the microprocessor equipment manufacturers often impose additional cost of the equipment to the customer in the form of service tinning, complex interface, system setup and software upgrades, presenting options as a highly intelligent product. Although the cost of these things is often not so high, it is clear that the sale of electromagnetic relays because of its simplicity prevent producers such opportunity to inflate prices and make enormous profits...

Again, V. Gurevich does not advocate a return to the past, but supports the idea of searching options for rational and constructive ways to improve the RDA. Who can give an absolute guarantee that a fully robotic system will not fail and will not serve as a source of dangerous situations in the power system? And such situations have already been!

There is a fact which is very important in the discussion of this problem. Thirty years ago, was artificially stopped the process of improvement of electromechanical relays, all development efforts were focused on the creation of electronic and then the MPD. In our opinion, the issue here is not in some fundamental shortcomings of electromechanical relays and their inability to provide adequate protection of power facilities [3]. Production of MPD from cheap electronic components with high degree of integration offered by a wide range of Asian companies is much more profitable than the production of high precision mechanical components of electromechanical relays. Assembling microprocessor units is performed using a high-performance, fully computer-assisted equipment. Thus the cost of microprocessor systems in hundred times exceeds the cost of their predecessors. Sale of relay protection brings producers excess profits and this is their main advantage.

In fact V. Gurevich is right in asserting that an unreasonably high cost of microprocessor hardware, software, the need for continuous upgrading borne by the cost of energy. It is clear that there is a price to consumers. The reliability of power supply doesn't increase for them.

Electro-mechanical systems have been criticized and presented as unreliable, cumbersome and inefficient. But it fails to show their positives and long-term reliable operation at power facilities. It must be admitted that the parameters and possibilities of high quality electromechanical and solid state relays can fully meet the needs of relay protection. Accumulated for many years of operating experience and electromechanical devices RH A demonstrated their high reliability. They are successfully used in electrical systems throughout the world for over a hundred years, whereas the microprocessor protection appeared in operation less than two decades ago. Will the MPD be able, for example, to operate thirty years reliably in accordance with regulatory requirements [3] and how will the issue of spare parts and software be solved?

The basic provisions of the reliability theory claim that at complication of the device, consisting of a large number of elements, the indicators of its reliability are reduced. The founders of the theory of relay protection of the former USSR (e.g., M.A. Shabad) insisted on the need of simplifying the protection of distribution networks. When developing new models of MPD it would be logical to seek for simplifying and minimizing the functional ... But microprocessor manufacturers in completive fight forget about it and complicate the proposed equipment more and more.

Speaking of safety ... MPD manufacturers declare low reliability of electromechanical relays and absolute reliability of microprocessor-based protection... At the same time they held back the fact that in the structure of any terminal microprocessor protection in output part of the executive body there is a tiny electromechanical relay. The question arises if the presence of MPD electromechanical relays reduces the reliability of the terminal? Biased approach here is evident. Unfortunately, advertising is not always resort to the help of logic... Here more and more emotions work…

I would like to quote a well-known expert in the field of MPD, a former leading specialist Institute of Relay Structure, long time working in the company of Siemens, Doctor of Technical Sciences, prof. E.M. Schneerson, who in his book "The digital relay protection" (Energoatomizdat, 2007) on page 491 writes: "By itself, raising the technical level of PE does not necessarily leads to greater efficiency in responding to the damage occurring. For example, by now obsolete electro-mechanical and electronic partly static protective relays for the correct choice of protective functions and settings, of course, provide more effective protection of the network than the microprocessor protective relays without

sufficiently informed choice of these parameters "[2].

In publications on the need of implementing the MPD many authors cite such reasons as lack of an electromechanical relay record emergency regime, the possibility of exchanging information between relays, etc. But such arguments are like a publicity stunt. In fact on the market today hundreds versions of microprocessor recorders of emergency operation which register emergency operation much better and more stoutly are offered, than it is done by MPD. There is equipment with functions on data transfer over the network, for example, SCADA-systems that can work with electromechanical relays. But at recorder failure, reliability of electricity supply in general is not reduced, and failures in the MPD could cause a serious accident. [2]

Supporters of microprocessor protection systems give the results of comparisons of Russian-made RT-40 or RT-80 electromechanical relays, without mentioning the best samples of the leading Western manufacturers. The absurdity of such comparison is that RT-40 is a modification of the ET-520 relay developed in the USSR for more than 50 years ago, and its design was "borrowed" from a similar current relay of the Siemens firm in the30-ies of the last century. Relay RT-80 is almost an exact copy of the RIK relay of the Swedish company ASEA, produced in the 30 years of the twentieth century. It is incorrect to compare this rather primitive relay with a product of advanced electronic technologies. Here we have the problem of inadequate outlook of electromechanical relays. Apparently, except RT-40 and RT-80 other models of the relay are unknown to V. Gurevich's opponents. Why not compare the best samples of the world's leading companies GeneralElectric, BBC, Siemens? For example, a three-stage electro-mechanical relay distance protection LZ31. From foreign publications it is known that these relays are now being used to protect the line voltage of 160 kV, sometimes in parallel with microprocessor relays, Figure 1. [2]

Figure 1 - Section of distance protection charge of 160 kV lines containing electromechanical relay of LZ31 type (top) included in the parallel operation with microprocessor protection of MiCOM P437 type

One of the examples of a non-equivalent comparison is comparing the model of relay RF-1 and RF-2, developed 40 years ago (which is an analogue of the relay with a rotating disk of Charles Steinmetz, 1921) with a modern microprocessor-based device. Used hitherto frequency relay type RF-1 and RF-2 have an error response not less than ± 0,2 Hz. At the same time, the accuracy of microprocessor relay actuation frequency doesn't exceed ± 0, 01 Hz [3]. It is quite clear why, taking into account modern requirements of increasing the accuracy to maintain power frequency network, the widest circulation was gained by microprocessor relays.

Static relay on discrete semiconductor elements of FCX103s type has burst tolerance ± 0.03 Hz, that is an order of magnitude higher than the RF switch, and it is still successfully used in networks around the world. Its accuracy is comparable with an error rate of microprocessor protection of almost all manufacturers. However, some leading Western manufacturers in their design have achieved accuracy up to 0,005 Hz. But whether such accuracy is necessary? And how can it be used in real-world operating conditions of post-Soviet power systems?

Such advantage looks no more than a marketing ploy of the manufacturer. The advantages imposed by advertising presentations become the norm, and then the requirement for operational services. In such a situation transition to the MPD is the only option which simply has no alternative because of the dictatorship of manufacturers.

In the market there are simply no electromechanical relays, designed by using modern materials and technology, and all the leading manufacturers of relays completely switched to producing only the MPD [2]. This suggests that manufacturers are driven purely by economic expediency rather than by a desire to improve the reliability, speed, sensitivity and selectivity of protection.

To date, in-use electromechanical relays have long finished their useful life, and only through the efforts of relay protection of power facilities services personnel their performance is being maintained. This situation is due to the fact that at the end of the twentieth century because of the economic and political situation in the former Soviet Union there was no proper investment in this sector. However, as well as in all other sectors … If these systems received proper amount of financing on development and operation, now the situation would develop in a different way. Designers and manufacturers of MPD have quite different capital investments because here it is possible to receive excess profit using the marketing.

As mentioned earlier, V. Gurevich doesn't offer to give up the implementation of MPD, and he only calls for a fair and objective position of producers and raises the question of explaining all the positive and negative aspects of the use of their product.

The apologists of the Soviet school of RDA insisted on the need for a common defense without sacrificing selectivity and other important qualities of protection. There is not always a need and expediency of installing expensive terminals in the 6-35 kV distribution networks, requiring not only technical, but also system service. However, progress in the field of new materials and new components permits to build a protective relay on an entirely new basis, for example, hybrid relay.

Today, manufacturers of MPD are engaged in the complication of the products and the expansion of their functions, which are not used in practice. For example, in terminal current protection of SIMENS lines there is 8-fold reclose. This makes it possible, without investing significant funds, to increase the cost of the MPD or for over the years not to reduce it.

It is almost impossible to interest the manufacturer to produce some alternative types of relays that are not able to compete in terms of profitability with MPD. Revenues of a MPD manufacturer are made up of not only significant difference between the cost price and the selling price, but also of the use of technologies based on highly integrated elements of surface mount multilayer trace elements on the circuit board. In case of failure of one of the elements of such equipment, there is a need for a block or complete replacement. Microprocessor-based relay protection devices do not allow the possibility of repairing; the replacement of modules to the new MPD is the only possible solution. Thus, the manufacturer artificially increases the sales market.

This fact is hidden by advertisers and is presented as the convenience and speed of service, not a lack of maintainability...

Sample calculation of the cost of a microprocessor terminal protection is 5-15 thousand dollars. Repair, if necessary, would cost 30 percent of its value. It's too expensive "maintainability" with respect to electromechanical systems, where the RT-40 costs for about $100 on the market.

If you think about the fact that these devices are in operation today is less than 20 percent of the total employed relay protection, the thought occurs: what will happen when the power grid goes for microprocessor protection by 70-80 percent? What then there will be a tariff for the electricity …?

It is also important that the manufacturer constantly improves and updates the manufactured products, leading to difficulties with spare parts for older MPD models. It is impossible to find them, they are already laid off. Updating of producing microprocessor modifications occurs every 2-3 years (competitive fight pushes the manufacturer to do it). In such cases an exit one is to replace the entire terminal. A similar situation can be seen in the computer market.

The MPD manufacturer's income is provided by shifting the operation of technical devices and system problems, forcing them to purchase software that requires constant updating to pay installation, additional units and modules to extend the functionality and reliability of operation. As an example, [2] additional power modules, to ensure efficiency of MPD during auxiliary power breaks for 0.5 seconds. But such a demand is made directly to the most of MPD, not to the additional supply units and modules. In Section 4.5.8 [RB] unequivocally stated: "The MP RDA devices must maintain the specified functions without changing the parameters and characteristics of switching power supply failure in the duration of up to 0.5". Why not enter additional large-capacity capacitor to the MPD internal power supply to maintain its performance for 0.5s during operational power breaks (especially as own energy consumption of modern MPD is very insignificant). It can be concluded that it is cheaper to get the consumer to bear the cost for the acquisition of additional power supply module, as recommended by managers offering an MPD [2].

The argument in favor of the MPD reliability is the possibility of a rapid modular replacement: under operating conditions of almost any MPD block, it is possible to restore its working capacity by replacement of quick-detachable modules [4]. Time cost for microprocessor protection device diagnosis and the faulty module replacement doesn't exceed 2 hours. Most importantly, the repair of microprocessor protection devices by replacing the module does not foresee relay specialist with professional skills and abilities for experts needed to repair.

Maintainability, according to supporters of the MPD concept of is provided by replacing the motherboard with a new one costing one-third of the terminal, and the old should be thrown due to the failure of low value item. Following the logic of manufacturers, organizations in charge of this equipment, need to have a warehouse with spare modules. What will happen if not repairable units start to fail in large quantities? Energy supply companies would have to seek very substantial funds for the purchase of new blocks, by increasing tariffs. .

Manufacturers claim a 25-year operation life period for microprocessor, and for electromechanical relays. But experience has shown that the electromechanical relays are actually operated 30-40 years, while microprocessor technology is aging much faster. And here an important issue arises: not only physical, but also the obsolescence of the MPD, the software aging. Physical wear is caused by electronic components aging, especially such as electrolytic capacitors (which service does not exceed 10-15 years).

Manufacturers are constantly developing new software and producing a new product every 3-4 years (the necessity caused by competition). Following the acquisition of MPD client will have to spend a small amount of a software update, which did not have to do when using electromechanical protections.

We do not set a goal to show the position of Mr. Gurevich as the ultimate truth. He sometimes gives his thoughts and forgets about the scientific reliability of his ideas. Scientific ethics should be present in all utterances, because the dispute must follow the authority of truth. In some cases, answering the questions of his opponents, he distorts scientific and technical terms, provisions and wording. One of the examples repeatedly (over five years) published by him in various compilations is a chart. The question arises if nothing has changed on the market RDA over the years.

Now energy situation is developing in the following way. Despite these problems, in the development trend of relay protection a wide and ever-increasing introduction of microprocessor-based protection terminals is inevitable.

The introduction of the MPD into the grid is connected with many factors, objective and subjective. First of all, it is, of course, high wear of equipment of relay protection, working at the facilities. Its replacement is necessary. In the second place, the customer is limited by the choice of equipment that it offered by the

manufacturer. For a manufacturer, as we have said above, it is much more profitable to produce microprocessor equipment than electromagnetic relay.

Figure 2 – Market of microprocessor devices.

Another factor leading to the introduction of MPD - many manufacturers of modern power equipment require (or rather impose) to use microprocessor-based protection. Promotion of MPD on the market provided by numerous sales representatives, who spend a very active advertising campaign, hiding some negative moments and belittling the dignity of electromechanical relays. The cornerstone and important argument is promised by the manufacturers very high reliability of microprocessor relay protection in comparison with the old and heavily worn electromechanical relays.

MPD is a complex technical system consisting of thousands of components. Like any complex electronic systems, they can't but have flaws and possess absolute reliability, especially under the real operating conditions of the MPD in electrical networks. In literature, there are no materials, considering the technical problems of operation of microprocessor relays, the vast majority of articles in journals is devoted to the MPD, is written by the representatives of the manufacturing companies or suppliers.. Publications are veiled or overt advertising, rather than a serious analysis of the problems of microprocessor protection reliability.

Analyzing all the foregoing information, you can make two important conclusions that may seem paradoxical:

- Annual relative failure rate of microprocessor relay protection is much higher than the electromechanical;

- Annual relative failure rate of relay protection has increased significantly in recent years due to the use of new types of microprocessor-based relays.

The table shows the statistics on the failure rate of various types of relay protection on the data obtained from the company KEGOK Kazakhstan for the period from 2007 to 2008.

The failure rate of various types of protection relays

Parameter	electromechanical		microprocessor	
	2007	2008	2007	2008
Total number of relay used	2312		3787	
Amount of damage	1	4	43	51
Relative amount of lesions,%	0.043	0.173	1.135	1.347
Average annual relative amount of damage, %	0.11		1.24	
AFR (Annualized Failure Rate)	1		11.3	

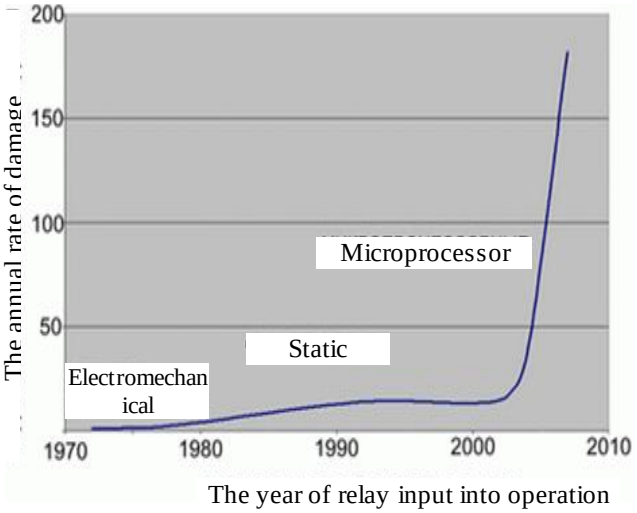

Figure 3 - The growth trend in the lesions intensity of MPD new types

In reality, there is nothing unusual in these conclusions. According to statistics, it is clear that the IEDs are 50 times more likely to fail than electromechanical. Note that this does not take into account such important factors as human error in programming of protection, the so-called "human factor".

In conclusion, we note that today's energy needs modernization of relay protection with the introduction of the MPD, as electromechanical systems are worn and their further exploitation in the next ten years must be completed. Microprocessor-based systems have a number of advantages: higher sensitivity, high rates of return, compactness, lower power consumption, more advanced features and more. In this case, it is necessary to note some inherent disadvantages: the need for a stabilized DC power supply, interface complexity, high cost, software and more. In this situation an objective approach to the advantages and disadvantages of the MPD and scientific and technical research improvement are necessary. There is an obvious need to simplify their exploitation.

We would like to express the hope that the manufacturer will fully inform the RDA operating personnel with all the nuances and features of his product.

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Ю.В. Электрмен қамтамасыз ету жүйелерінің автоматикасы мен релелік қорғанышын жаңғырту проблемаларының сұрақтарына.

Релелік қорғаныш пен автоматиканың электрмеханикалық базадан микропроцессорлық базаға ауысуының проблемалық сұрақтары қаралды. Техникалық және экономикалық аспектілердегі қайта құралдауға талдау жүргізілді. Бұл проблемалар бойынша ресей мен шетелдердің жетекші ғалымдарының ұстанымы қаралды. Энергиямен қамтамасыз ету жүйесінің микропроцессорлық қорғанышқа ауысу шарасыздығы электрмеханикалық релелерге құрылған электр желілерінің қорғаныш құралдары релелік қорғаныш пен автоматикаға қойылатын техникалық талаптардың орындалуын қамтамасыз етуге қабілетсіз деген пікірге негізделген аңыз болып табылатындығы туралы т.ғ.к. В. Гуревичтің тұжырымы мен еңбектері талданды. Электрмеханикалық және микропроцессорлық жүйелердің негізгі кемшіліктері мен артықшылықтары туралы деректер берілген. Релелік қорғаныш пен автоматиканың болашақтағы дамуының негізгі тенденциялары анықталды. Әртүрлі релелік қорғаныштың істен шығу қарқындылығы бойынша зерттеу жүргізілді.

Таткеева Г.Г., Югай В.В., Алдошина О.В., Ким Ю.В. К вопросам проблемы модернизации релейной защиты и автоматики систем электроснабжения.

Рассмотрены проблемные вопросы перехода релейной защиты и автоматики с электромеханической базы на микропроцессорную. Выполнен анализ подхода к перевооружению в техническом и экономическом аспектах. Рассмотрены позиции данной проблемы ведущих российских и зарубежных ученых. Проанализированы труды и утверждения к.т.н. В. Гуревича о том, что неизбежность перехода системы энергоснабжения на микропроцессорные защиты является мифом, основанным на мнениях о том, что якобы устройства защиты электрических сетей, построенные на электромеханических реле, не способны обеспечить выполнение технических требований, предъявляемых к релейной защите и автоматике. Приведены данные об основных недостатках и достоинствах электромеханических и микропроцессорных систем. Определены основные тенденции будущего развития релейной защиты и автоматики. Проведены исследования по интенсивности отказов релейной защиты различных видов.

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