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The Analysis and Principle Setting of High-Voltage Relaying Systems

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Abstract

In this paper, the analysis of the relay devices and systems performance (and another monitoring, controlling systems) to properties of the automatic power system objects is represented. The paradoxes of using a number of relaying are considered. Some events graduated from the current such as: prevention of violation of stability, liquid on of an asynchronous regime, differential guards of transformers and auto transformers are proposed and analyzed. The recommendations for operation increasing, selectivity and sensitivity of systems properties improving are given.

Keywords: *Relay protection, automation, power system, overcurrent relay protection, setting*

1. Introduction

The systems or devices both systems of a relay guard and automations (RGA) in electric power industry are used as means of maintenance of normal operation of power systems in conditions of galloping processes originating with damages and perturbations. The managing operations RGA is carried out automatically to supply required speed. Furthermore, number of other properties RGA renders the influence on normal operation of power systems. There are sensing but selective detection of damages and perturbations, reliable work of elements, connections between them and as a whole of schemes RGA means installed on force objects the power systems. However, called properties should be by logic of things supplemented by a generalized property of the correspondence, adequacy, fitness to properties and performances of an object, on which are installed RGA. Such derivative or generalized response parameter or criterion synthesized from base parameters (a current, voltage) should be found, that its measurement unequivocally testified an emergency or opposite condition of an inspected object. Derivative's parameters or criterions such as power, resistance is formed with a current and voltage with the help of multiplication-division converters. Some generalized parameters (frequent, symmetrical component of three-phase systems of magnitudes) are received with the help of frequent filters or filters symmetrical component. Other generalized parameters are derived by various functional transformations [1-3].

The maintenance of the correspondence, adequacy, fitness of an inspected response parameter to properties and performances of an automatic object is possible also by use of other ways broadly applied in RGA. So, in differential relay guards the connecting circuit bearing a response parameter of measuring loops and connection of a relay measuring

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organ which ensures the best sensitivity and selectivity is used, keeping operation speeds in a natural kind. The graduated guards are suggested to have no circuit possibility of manipulation by a response parameter. Therefore, problems of sensitivity and selectivity for them are solved by use of speed. During detection of short-circuits (SC) and their localization (switch-off) by cascade work of sensing packages of a relay guard, the scheme of electrical junctions of a network is modified. It ensures redistribution of streams of a response parameter and in a number of cases required sensitivity of rougher completes. However total time of liquidation SC is increased. To save a property of speed the packages of graduated guards on different ends of a line is connected with channels of information about an operation of packages of a guard on opposite ends of a defended object. Due to this, it is possible to reach almost the same speed and selectivity as for differential guards. However, sensitivity it remains noticeably below. Almost same properties of adaptation to guarded object take place in specialized two-stage on a response parameter (blocking and switching channels) guards with information interchange between packages on ends of a defended object. The sensitivity of these guards is much higher than sensitivity of usual graduated guards [4-7].

2. Main Part

The represented analysis concerns relay guards of separate simple or ramified objects in the form of circuits connected to an electrical network by switches. The circuits are inspected as a whole (differential principle) or separately in circuits of appropriate ends or switches (graduated principle). The property of selectivity on monitoring of the indicated objects is possible to define through accommodation of response parameter sensors on extremities of defended object, SC place (center of damage) and blocking of an operation relay guard (RG) on SC in external elements. The measures in case of differential guards are carried out a circuit way, in case of graduated guards with information exchange between apparatus sets on extremities of the defended object by use of the indicated exchange, in case of usual graduated RG by the coordination on time and response parameter of stages of guards defended and external objects.

The graduated principle is used also for construction of an automation to prevent of violation of stability (APVS) aid automation of liquidation of an asynchronous regime (ALAR). The electromechanical processes, to which called automations react, are more slow-acting. Therefore, problem of speed for these means not so is actual. The problem of sensitivity stands just for graduated guards. Problem of selectivity cannot be in this case determined in that kind as for channels RG. Really, the concept of internal and external elements of electro transfers, in which crossings are installed an equipment APVS or ALAR, for these systems is not defined. There is no also precise concept of an operating, and no operating fields which differentiation in a large degree determined accommodation of sensors of a response parameter and system of blocking acting like an external disposition of the damage or perturbation center. Therefore, any organization of blocking these systems is impossible. The concept of the center of damage or perturbation appears as short- time and does not represent the direct interest for management. So, the perturbation as SC, liquidated practically instantly by the relay guards, or short-term modification of a power system loads both in first, and in the second cases cannot influence current of the consequent electromechanical process, to which react with APVS and ALAR, more essentially, than it is done with the entry conditions of the given process [1] and [9-10].

Still to a lesser degree on a comparison APVS for automations of increase (AIV) or decrease (ADV) of voltage, frequent (AFP) or fast (speed) on voltage (ASP) of unloading the concept selectivity of an operation in that kind it was made for RG channels can be determined. It is stipulated, probably, still larger than APVS and ALAR by differences of these automations from channels RG. So, the majority of channels RG reacted to so-called data- flow parameters (currents, power, potency and even resistances), while discussed automations react to field parameters (voltage, frequency), which in a static are dispersed on every power system (voltage) or are constant in all places of a power system (frequency). The described discordances of means APVS and ALAR are stipulated by their data-parameters of an automation that are rather insufficiently adapted to properties and performances of electro transfers. Existing APVS it is enough reliably and fast can record exceeding specific set by an actual power in a crossing of electro transfer. However as this exceeding is connected with condition of concrete dynamic elements, which only can determine a condition of a synchronous regime the given system independently to execute cannot. The additional monitoring of a condition of dynamic elements is required, since the performances last can noticeably differ and their ultimate (UM) state in violation of a synchronism will occur individually. That is the state in which one or several dynamic elements is on an edge of transition from a synchronous regime, while other have the certain stocks rather UM mode is quite possible. Control actions APVS, as though it was arranged, should move on dynamic elements: to force systems of excitation of the overloaded elements were on an edge of loss of a synchronism, or to disconnect them, if the resources are reached; to load a little unloaded dynamic elements. The switch-off of the overloaded aggregates should be accompanied by a cut-off of an appropriate load in the nearest them. Due to these measures the balance of manufacture of potencies and power consumption is reached, the working conditions of electro transfer in an inspected cut become acceptable for a synchronous regime, and APVS, automatizing fulfilling of these measures, executes the functions, ordered to it.

However, if it is necessary to make individual monitoring of a state of dynamic elements, and the required solution of a problem, APVS consists of prohibition of an asynchronous regime (AR), which cannot exist outside of dynamic elements, what sense to execute mediated monitoring in a cut of electro transfer, where a state information of data of elements is approximate and inexact. What it gives? It ensures the only fact of proximity of an actual power to its UM value. The latter for systems APVS is carried out a settlement way, and rather approximately. The latter is caused by that the existing settlement procedure's aggravating of a mode cannot unambiguously map a structure of a preceding load mode in consequent aggravation a mode so to ensure a constant trajectory of aggravation and the appropriate to it UM potency [11,12].

Because of stated the first paradox stated in a tide can be formulated. It is, that the processes of aggravation in crossing of electro transfers are secondary and mediated on a companion with processes in dynamic circuits (generating elements). The monitoring UM of parameters in dynamic circuits, as shows experience, can be realized easier and more points, than in crossings. And in case of realization of monitoring in dynamic circuits, it is simple to take into account also influence of current voltage for want of modeling UM potency. Determination of UM potency in a crossing of electro transfer requires repeated tests on aggravating of a mode, in each of which the structure of a mode of preceding test is lost, and consequently; the ambiguity of determination of UM potency is accumulated. Despite the indicated defects of monitoring in a cut of electro transfer the practical application APVS is realized by monitoring an active potency in a crossing of electro transfer.

The second paradox consists, in effect, of ALAR. These systems fix the fact of origin of a possible two-frequent asynchronous regime (AR) in elements of network connections of some cuts of electro transfer and in case of its long, character ensures a rupture of inspected elements of electro transfer. For this purpose any control actions in current time on dynamic elements as a means ALAR cannot make, since there is no synchronous mode anymore and any effects on generating elements can aggravate a situation, to promote an amplification of destabilizing processes in a power system. Other control actions on commutations of connections can be made under the beforehand designed script. However, exactitude of improvement of data of operations, no less than operations APVS in a crossing of electro transfer under the script, will be low. Generally work of means

APVS and ALAR under the script (for want of rigorous criterions of operation) can be considered as a rather unnatural solution. This solution by a casual way can imply as in stabilization of a synchronous mode, and transitions in an AR, if it yet was not or aggravation of the latter, if it already existed. The effect of such operation is usually low, what the annual statistics on correct and incorrect operations of means RGA shows.

It generally quite can do without a system ALAR work of electric installations. The indications an AR are appreciable on all power systems and simply are inspected both visually, and automatically. The destructive damage takes place in the equipment of network components of electro transfers, through which pass exchange streams an AR, and all of them depending on dynamic resistance can be beforehand predetermined to a remote or automatic switch-off when AR taken place. Any uniform demonstrating, apparently, the centralized module ALAR, is expedient for activation of automatic switch-offs of elements of electro transfer. The means of ALAR in crossing of possible division of electro transfers also are useful to liquidation an AR. But the liquidation executes an AR in dynamic branches by a switch-off last together with a switch-off of a corresponding load in the nearest rim function ALAR practically unequivocally. From the point of view of liquidation, an AR the construction ALAR with monitoring of streams in network elements not only does not give of any advantages on a comparison with ALAR on dynamic elements, but introduces to a procedure of liquidation an AR the factor of a contingency of an outcome. The elimination of the given defect is possible by monitoring dynamic elements. The given monitoring has sufficient possibilities independently to execute functions of ALAR.

The paradox of ALAR is that such system is not necessary at all. A system, which tries to find the order in chaos an AR, is doomed on incorrect operations. Even if the order in chaos exists, there are no unambiguous ways of its searching in chaos. If it is not present, there is no need to arrange a system of its search. It is impossible to assert unambiguously, that the operation's ALAR result in liquidation an AR However, ALAR by a switch-off of dynamic generating elements in a starting part of electro transfer together with a switch-off of a load in a receiving part is more securely can imply in liquidation an AR, than ALAR on network elements. What is important in this case is the preservation of a structure of a power system.

The third paradox is stipulated by violation of requests of a differential principle consisting in unnatural application of differential RG for transformer circuits by analogy with electrical. The given paradox is now widespread everywhere. Lots of constructions and schemes of differential guards of transformers and auto transformers are developed and continue to be developed. At all existing schemes and constructions of differential RG of transformer elements, the same defect takes place consisting in natural selection in a differential circuit (a place of inclusion of a relay measuring organ) of a current of magnetization as of an obstacle. It results in need of triggering from jumps of rather large currents of magnetization for want of inclusion of transformers and auto transfers, especially without load. This decreases sensitivity. The current of magnetization for the circuits and constructions existing differential RG of transformers and auto transformers in the certain degree noticeably differ from current's SC: on a symmetry with respect to the axis of time, on a duration of times between positions of a current through zero or impulses by one and other polarity, on presence of higher harmonics, on their parity or oddness, *etc.*, The use of these differences allows the developers to realize the construction of different updating rather sensing differential RG. However, reproduction of distinctive indications for blocking a guard for want of jumps of a current of magnetization requires some time. It results in increasing of time of an operation of a guard and, as a corollary, loss of a patrimonial property of differential guards, their speed. Therefore, modem updating of differential guards is supplied by the rough channel, for which is not stipulated of any measures for an increase of sensitivity and consequently; the natural speed is not reduced. Such combination of sensitive and rough channels allows to decide a required practical problem of a guard. For want of large current's internal SC the guard acts instantly, not allowing to develop large destruction by current's SC, and for small currents also it will be revealed internal SC, but with slowing down.

The liquidation of a discussed paradox of differential guards of transformers and auto transformers is executed simply. It consists in retuning of a natural purpose of the differential principle, *i.e.*, to apply it, separately for galvanic ally disconnected circuits of different windings. In an outcome, the differential guard of transformers and auto transformers should be realized through separate differential packages for each winding. The problem of jumps of currents of magnetization at such differential packages is not present. The current of magnetization of force transformers and auto transformers appears to be open for each package and in a differential circuit of these packages of a current of magnetization is also absent. The modern transformers and auto transformers are equipped with enough number of built-in transformers of a current to realize the construction of a differential guard of each winding. And there are no basic essence obstacles to build additional packages of transformers of a current for want of shaping of the order on new force transformers and auto transformers.

The analysis graduated from current RG shows that a structure and operation of this guard are opposite to a differential guard. So, the structure graduated RG in difference from differential RG is open, not closed 'on gauges of opposite extremities of a defended object. It stipulates alternate requests to set-up of measuring organs (MO) graduated RG on a comparison with set up MO differential RG. So, if in a circuit MO differential relay for want of external SC, the minor current imbalance of huge currents of loops of a guard flows past only, in graduated RG through MO always passes a current as though of one loop differential relay, and with the maximal possible power supply of a place of SC. Proceeding from this, the large sets are selected. For check of sensitivity of the differential RG in MO the sum of currents of all loops flows, and in case of graduated guards only one. Therefore, both sensitivity, and the selectivity graduated RG is much lower on a comparison with differential relays. However, given problem for want of construction graduated RG is not decided purposefully. At the same time, on logic of things, the paths of improving of main properties of these guards can be found. So measurement of all currents, implying from a knot, of associations and searching among them maximum is suggested to be real. The given current, as shows the analysis, in overwhelming majority of cases can be an indication SC on association. The best outcomes take place, if the maximal values not of actual currents, but of their deviations from average value of currents, implying from a knot is inspected.

By the tool allowing to evaluate the quality of main properties: selectivity and sensitivity of means RGA, is a factor of correlations, represented in [1-13].

The monitoring systems of voltage in knots, frequency in power systems, fire dangers are constructed practically on the same principles, as considered systems of RGA. However, in structure of these systems, there is essential difference consisting that if considered differential, and graduated from current RG, APVS, ALAR react to streams (currents, potency and to some extent, resistances), such devices and systems as an automation of increase (AIV), decrease (ADV) of voltage react to a field parameter of voltage, automatic frequent unloading (AFU) on a field parameter of frequency, system of fire danger on a field parameter, for example, temperature.

For want of construction of systems of RGA the developers usually do not pay attention to the indicated distinctions. However, from the point of view of correlation of the devices and systems of RGA, reacting on data-flow and field parameters essentially differed also on a property of selectivity. Outwardly given difference is exhibited that the data-flow means of monitoring react to selected response streams of a power system on processes, which are flowing in the center of damage or perturbation. The field means of RGA make a measurement of a response parameter as though being in different places at the center of damage or perturbation, which has not neither physical nor parametrical boundaries. In this connection, the property of selectivity of field means of monitoring is expedient for defining through information search or movement in a direction of a maxima measured as a response parameter or center of the center of damage (perturbation). The given recommendation stipulates expediency and necessity to place gauges of a response parameter on all fields it of significances. The operations of field monitoring systems at the center of perturbation, as a rule, will be more effective.

In addition to the indicated measure for improving a property of selectivity of field means of monitoring some measures, which could be realized with the help of data-flow systems and systems are expedient also. In case AIV, ADV monitoring current's SC on associations removing from a knot is expedient. It eliminates excessive operations ADV and in the certain, degree improves selectivity of an operation of the given device for voltage reductions. Similarly, monitoring of streams of active potencies is stipulated by a dynamic modification of frequency allows to select regions of a power system with the reduced frequency, in which structure to make priority frequent unloading, and thus to increase efficiency of an operation, to improve a property of selectivity AFU.

3. Conclusion

In this paper, some conclusions are proposed:

1) The analysis of the relay devices and systems performance (and another monitoring, controlling systems) to properties of the automatic power system objects is represented.

2) The paradoxes of using a number of relaying are considered.

3) Some events graduated from the current such as: prevention of violation of stability, liquid on of an asynchronous regime, differential guards of transformers and auto transformers are proposed and analyzed.

4) The recommendations for operation increasing, selectivity and sensitivity of systems properties improving are given.

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