THE IMPACT OF THE NEW BASED-ON-INTELLIGENT-EQUIPMENT MANAGEMENT METHODS ON THE STRUCTURE OF THE DISTRIBUTION POWER NETWORKS NODES

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1. INTRODUCTION

The increase of the controllability level of the switchgear provided by the new leading techniques allows a series of reconsiderations on their structure and function. These ones take especially the form of possibilities to reconsider the primary equipment with elements whose function is of command and protection, that is the circuit-breakers’ function.

In the switchgear, circuit-breakers are the most important and expensive elements, with negligible use times (minutes per year) for the function for which they were mounted in the switchgear. From here comes the idea of multiple use of the circuit-breakers (a circuit-breaker should ensure the command and protection function for several circuits) which presents advantages owing to the fact that it reduces the number of circuit-breakers (the investment expenses) and allows their intensive use. There are already known several principles regarding the multiple use of circuit-breakers; they are based on combinations with disconnectors where the maneuvers consist of a strict succession of switch on and off, which, in the classical leading solution, increases the maneuver's times as well as the operators' request.

In the new leading techniques, the operator prescribes the maneuver at global level, its segmentation in operations (the command’s multiplication) being made by the leading system. This feature of the new leading techniques allows the reconsideration of the specialists’ positions regarding the application multiple use principles of the circuit-breakers in distribution and connection power network.

2. PRINCIPLES OF MULTIPLE-BREAKERS SYSTEMS

The principles governing the use of a circuit-breaker for command and the protection of several circuits are the following:

- the principles of handling no load disconnectors;
- the principle of handling the bypass disconnectors;
- the principle of bypass electric arc.

The principle of handling no load disconnectors which governs the multiple uses of circuit-breakers (with preselection disconnectors) can be applied in several ways:

a) **Cells with several departures,** where several feeders are connected to busbars by a single circuit breaker (switchgear), each feeder with its own line disconnector and for the single circuit-breaker to take on the functions of circuits’ individual protection, each circuit should have a current transformer.

Figure 1 Single busbar with two feeders

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The circuit breaker command function for each feeder supposes one more operation compared to the case where each feeders would have a circuit-breaker that is at the circuit 1 disconnection (see figure 1) for instance: turning on the common circuit-breaker; switching on the disconnector on the circuit; turning off the common circuit-breaker.

In order to turn on the circuit: turning on the common circuit-breaker; switching off the disconnector on the circuit; turning off the common circuit-breaker.

b) The design known as "trousers" for more important customers

This design is actually an application of the previous design one for the case of feeding some more important customers that do not accept the short out times in supply, from to the previous design of a circuit where the other one is turned on or off (see figure 2). We should notice that the two circuit-breakers in the schematic take on the command and protection functions for the other four circuits practically by applying this principle the number of circuit-breakers in an installation is cut down to half with minor drawbacks for feeding and voltage's quality.

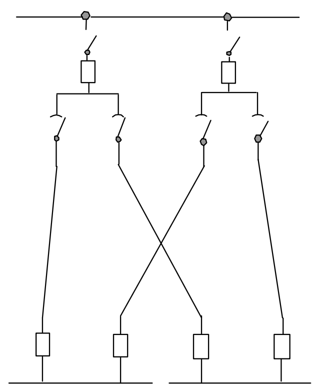

Figure 2. "Trousers" design

c) Combinations with short-circuit devices and isolation disconnectors

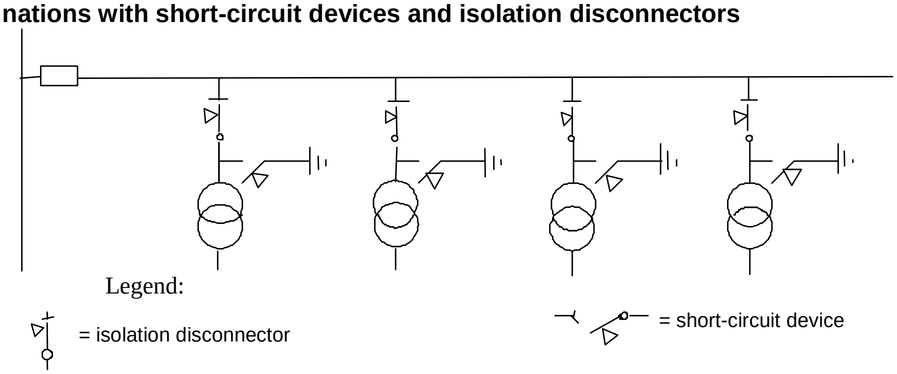

Figure 3 Switchgear with a circuit breaker for many transformers

This principle allows the elimination of the circuit-breakers in the stations "hung" on an electric line by replacing them with a combination of short-circuit device and "isolation disconnector". This principle is practically better known for the particular, simple case with a single transformer where the short-circuit device actually replaces the pilot wire cable but only for achieving the transformer's protection by the line's circuit-breaker placed at some distance from the transformer.

In this situation we consider the way in which the command and protection functions of several circuits, that is transformers, are achieved by a single circuit-breaker (the line's circuit-breaker) being aware of the fact that in order to achieve the command function, we should have the remote control of all the isolation disconnectors, short-circuit devices and certainly the line's circuit-breaker whereas for the protection function, we should consider a sequential command coordinated with the RAR on the line's circuit-breaker (figure 3).

d) The principle of handling bypasses disconnectors.

It is a well known fact that the bus coupler circuit-breaker takes on the command function of the circuits connected to a double busbar. The double busbar witch a bus coupler also known as “switch with operate busbar” is shown in figure 4.

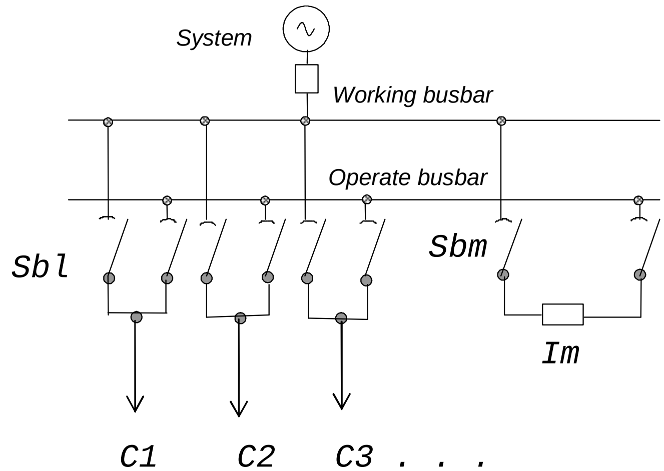

Figure 4. Switch with operate busbar

By using this design, many circuits *(C1…Cn)* can be controlled (commanded and protected) by a single circuit-breaker *(Im)* also known as maneuver circuit-breaker. The design is equivalent with one with simple non-sectioned busbar (working busbar) to which all the circuits are connected (the normal position for the working busbar disconnectors *Sb1* for the running circuits is off), the operate busbar only has the role to facilitate the handling of the working and operate busbar disconnectors by bypassing them at the moment when they switch off or on.
The switching on or off, intended by command given by operator (dispatcher) or automatic started by relays protection of any circuit will be made without stopping it by a series of circuit-breakers, as follows:

a. In order to switch off the circuit C1:
   - a1. Im is switched off (the normal position is off, for shorting the maneuver times);
   - a2. the busbar disconnector of the circuit C1 is switched on, as it is bypassed on the route Sb_1 of the circuit C1 - working busbar - bus coupler – operate busbar;
   - a3. the busbar disconnector of the circuit C1 is switched off, as it is bypassed on the described route upon the switching off of the working bar disconnector of the same circuit;
   - a4. the circuit-breaker Im is switched off, at the same time the circuit C1 is switched off (disconnected from the working bar and thus from the other circuits);
   - a5. the busbar disconnector of the circuit C1 is switched off in order to isolate the circuit C1 from the operate busbar and its isolation on the purpose of using it for other maneuvers;
   - a6. the circuit-breaker Im is switched on again, if it has the normal position on.

b. For the circuit C1 to be switched on (its connection to the working busbar where the other circuits are connected), the following series of maneuvers is carried out:
   - b1. the circuit-breakers is switched off if it has the normal running position on;
   - b2. the Sbm operate busbar disconnector of the circuit C1 is switched on;
   - b3. the circuit-breaker Im is turned on and at that moment the circuit is bond together with the other circuits to the working bar but on the route operate busbar disconnector-operate busbar - bus coupler - working bar;
   - b4. the operate busbar disconnector of the circuit C1 is switched on, operation made possible by the fact that this one is bypassed on the route already presented;
   - b5. the operate bar disconnector of the circuit C1 is switched off, this one is also bypassed on the same route;
   - b6. the circuit-breaker is turned off only if its working position is normally off.

We should notice that this design also allows the performance of RAR upon the breaking out through protection of any circuit, the RAR sequence being interposed after the maneuver a4 previously presented.
Thus it may apply especially to customers’ feeders of the distribution and connection power network whereas the source switchgear may be provided with individual circuit-breakers (cells).

Thus, the number of feeders controlled by a circuit-breaker may be as large as possible; its limitation being dictated by the fact that the circuit-breaker "serves" feeders one after another and that there is no possibility of simultaneous maneuvers. A too large number of feeders controlled by a circuit-breaker may thus lead to inconvenient delay when performing a certain maneuver. It is possible that this may be diminished by entering the priority list principle into the leading system logic which is the case for the commands given by the protection through relays. The maneuver circuit-breaker as the most important one may be protected by providing the installation with two maneuver cups.

It is obvious that each feeders without circuit-breaker has its own current transformer for performing the protection function, a function that may be carried out by a classical protection or more rationally, by the integrate leading system which, besides other roles, also performs protection. As far as the current level of achievements in the field is concerned, it seems that a combination among the previous possibilities seems plausible, the maneuver being clearly performed in a sequential way by the latter one.

e) The principle of bypassed electric arc governing the multiple use of circuit-breakers

This principle is similar to the one in previously paragraph on handling disconnectors; this time it is used for performing the protection function with switches with a power lower than the short-circuit power on the busbars on which these devices are mounted. In order to achieve this, the low performance switch is brought to the bypass position by another device with corresponding performances that will be next called bypass circuit-breaker. The fault from the low performance switch's downstream is practically moved to the collecting busbar where the bypass circuit-breaker is moved. This principle may be used for the case of mono-phase faults but only in the networks with the neuter directly connected to ground but it may be also used for the networks with neuter connected by resistance as it will be further seen but in the latter case for eliminating the temporary faults. The principle schematic is given in figure 5.

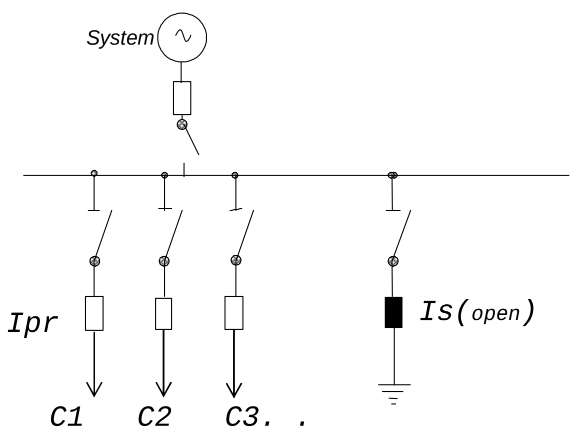

Figure 5 The principle of bypassed arc governing the multiple use of circuit-breakers

The command function of the circuits Ci is classically performed by the low-performance individual circuit-breakers (Is). However these circuit-breakers can not perform the protection function of the circuits on which they are mounted as they have a lower cutting power than the short-circuit one on busbars.

In case of some faults occurred in their downstream, they can be switched on by turning on the bypass circuit-breaker Is first, turning on the circuit-breaker Ipr of the damaged circuit which is no longer crossed by the short-circuit current, as it is bypassed by Is and then Is is switched off.

If for performing the protection function, the bypassed electric arc principle has the disadvantage of moving the damage of downstream, from a departure on the busbar, the use of this principle for turning off the damage electric arc in the networks of average voltage more efficient than the classical RAR.

3. THE INFLUENCE ON THE QUALITY OF FEEDING SERVICE WITH ELECTRICAL POWER

With a view to establish the influence that the multiple use of circuit-breakers has upon the quality of supplying service with electrical power energy we will analyze a bloc diagram as the one in figure 6.

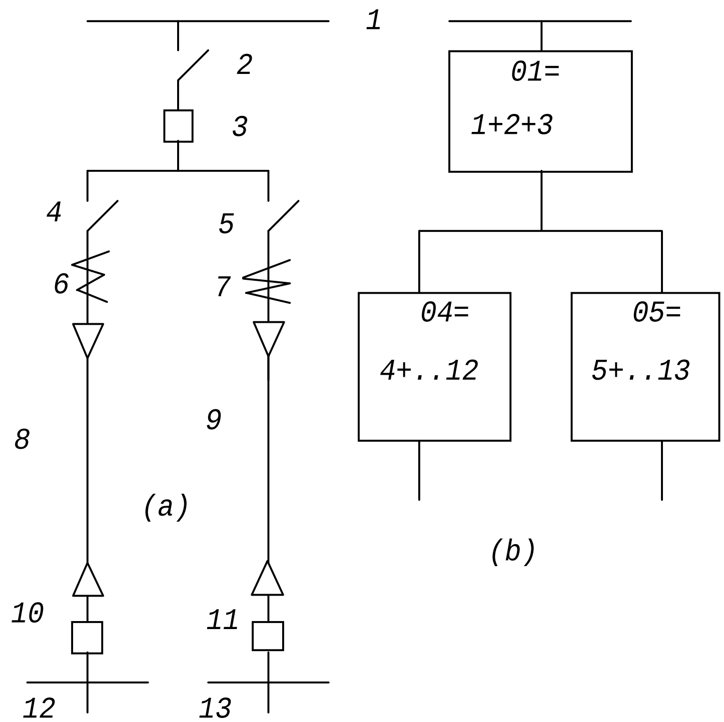

Figure 6 The influence of the multiple-breakers systems to the quality of supplying service

In order to study the influence that the multiple use of circuit-breakers has upon the quality of customers' supplying we will replace the design elements from figure 6a with three blocs as in figure 6b from which we will calculate the reliability indicators for the design taken globally and for the point of consumer 12.

The results are given in the next table where by normal design we understand design with circuit-breakers on each circuit and by simple design with two feeders on a circuit-breaker. This happens in the following hypotheses:

- there are no disconnectors 4 and 5 and at faults on branch 5…13 the consumer connected in point 12 is out during the repairing period, the results being given in Trep' s line;
- there are disconnectors 4 and 5 and they are switched off in a time Tk of 1h, 0.1 h and 0.001h, the results being presented in the table's corresponding lines;

The calculated indicators are presented in the table's columns and have the following meanings:

λ – failure rate (h^{-1})
μ – reparability rate (h^{-1})
n – mean number of interruptions
Tr – mean time to repair
Td – maximum mean time to repair, for various risk factors.

Table 1

		$\lambda\ h^{-1}$	$\mu\ h^{-1}$	n	Trm	Td max		
		$x\ 10^{-4}$	$x\ 10^{-4}$	$x\ 10^{-4}$	h	r=0.1	0.05	0.02
Simple design	Trep	1,305	377,33	1,1392	26,5	63,18	82,26	106,95
	Tk=1 h	1.305	441	1,139	22,65	54,1	70,31	91,42
	Tk=0,1 h	1,305	443,09	1,139	22,57	53,81	70,05	91,08
	Tk=0.001h	1,305	443,27	1,139	22,56	53,79	70,03	91,08
Normal design		1,063	437,52	0,9289	22,87	49,81	66,26	87,55

4. CONCLUSIONS

By analyzing the table, we can draw the following conclusions:

- the installation of the isolation disconnectors has an important influence upon the switching times and less on the number of circuit-breakers as it is natural;
- the switching times have low influences, especially at low values;
- compared to the normal design, the deterioration of continuity indicators in feeding is obviously acceptable only for some categories of customers.
- It is obvious that in the trousers version, the indicators become similar to the ones in normal design.

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