STUDY ON THE PROTECTION AGAINST DEFECTS OF THE HIGH VOLTAGE OVERHEAD POWER LINE RESITA - IAZ

Mihaela Molnar, *Babes -Bolyai University, Cluj Napoca, ROMANIA*
Eugen Răduca*, *Babes -Bolyai University, Cluj Napoca, ROMANIA*
Cristinel Popescu, *"Constantin Brâncuşi" University, Târgu Jiu, ROMANIA*
Nicolae Șușară, *Reşiţa, ROMANIA*

Abstract: After a short presentation of the high voltage overhead power line Resita - Iaz, the paper studies the defects on this overhead power line, their causes, and how the line is protected from defects and how the defects were resolved. Finally, a solution is proposed to improve the protection against defects of the high voltage overhead power line Resita - Iaz, justifying the proposed solution.

KEY WORDS: overhead power line, defects, protections, digital protections.

1. INTRODUCTION

In the operation of energy systems, protection against defects is an indispensable element, which conditions the correct and efficient operation of these systems.
In the case of high voltage lines, designed to transport ever-increasing amounts of electricity over long distances, with increasing quality requirements of consumers, the simple protection based on the measurement of a single electrical quantity that occurs at the installation site can no longer it works and there is a need to compile protection systems, which contain complex apparatus and equipment capable of quickly identifying the defect site and proceeding to its liquidation.
Overhead power lines are outdoor installations, tens and hundreds of kilometers long, composed of conductors, insulators, clamps, fittings, poles, foundations and earthing installations that serve to transport or distribute electricity, from producer to consumer.
The overhead power lines is designed in such a way that the energy losses are as small as possible and the detection and elimination of defects is relatively easy compared to underground power lines.

The overhead power line Resita-Iaz is a 110kV line and is part of the transmission and distribution network of the national energy system and uses two protection systems [6]:
- a basic one, distance protection;
- a reserve one, homopolar protection.

The operation of the line takes into account the policies promoted within the companies of production, transmission and distribution of electricity which consist in limiting the number of failures in electrical installations, acting so that defects are eliminated quickly and with the interruption of a minimum number of consumers connected to this network.

2. HIGH VOLTAGE OVERHEAD POWER LINE RESITA - IAZ

2.1. Overview

The high voltage overhead power line Resita - Iaz has a length of about 50 km, operates in a loop, being arranged between the 220V/110kV Power Station Resita and the 220V/110kV Iaz Station [8]. The management of the appeared defects and of the existing protections on the line is done from these stations.
The line makes the galvanic connection between a 110 kV bar B1 of the 220V/110 kV

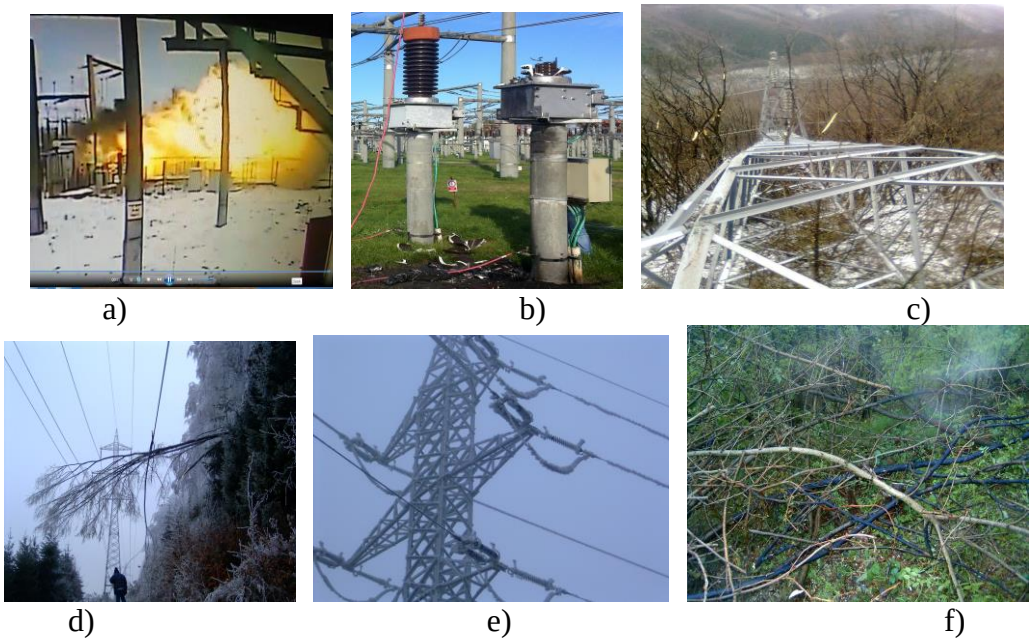
Iaz station and a B2 bar of the 220V/110 kV Resita station. In this way, it is possible to safely supply industrial and domestic consumers in Resita and surrounding areas, but also some consumers in Caras-Severin County.

2.2. The components of the line

The connections with the two busbar of 110kV systems (B2 Resita and B1 Iaz) are made through the two cells of 110 kV which are formed [8], essentially, from:
- Orthojector type switches with oil arc quenching actuated by an oleopneumatic mechanism which raises the operating oil pressure to a pressure of 300-360 barr;
- 4 STEP separators of 110 kV;
- Two bar separators that make it possible to pass in exceptional cases (breakdowns, maneuvers, change of configuration of the normal scheme) of the 110 kV overhead power line Resita-Iaz from one 110 kV bar system to the other, as well as bringing through the opening in a visibly separate state of the cell, a mandatory measure in order to carry out repair work [5];
- A line separator that makes it possible to bring the 110kV cell into a separate visible state, in case of execution of works on overhead power line;
- A transfer bar separator which makes it possible to supply the line from another busbar of the station bypassing its own cell using the transfer coupling cell;
- Two grounding knives forming part of line separator and bar separators which ensures in case of repair works repairs, grounding of the installation as a measure of protection against electric shock to the executing staff;
- Three-capacitive voltage transformers of 110 kV each, type TECU (one for each phase), which have the role of lowering the mains voltage (110kV) to a voltage of 100 V, a voltage that does not endanger the personnel serving the installation as well as a voltage that is used by measuring and protection devices;
- 3 The current transformers are of CESO 145 type, one on each phase, they have the role of lowering the current circulating on the overhead power line at a current that can be used by its measuring and protection devices;
- The overhead power line of hexagon-type double-circuit metal pillars, namely: support type S.S-110 256, tension type I.C-110 263, terminals type I.T 110 264 to which are added a number of 4 pillars to the assembly;
- Conductors between high voltage lines;
- Insulators for 11kV lines, VKLF type.

3. DEFECTS ON OVERHEAD POWER LINE 110 KV RESITA-IAZ.

The overhead power line 110kV Reșița-Iaz has a route with many types of relief (hills, mountains, meadows), so that in a period of five years, the study was done, all types of defects took place: single-phase, two-phase, two-phase with earth, three-phase, almost half of them being single-phase.
Most of the reported short circuits were those between a phase and earth, these coming from falling trees over the line conductors or just by touching them (fig.1.c, d).
Other causes of damage were the breaking of insulators or their circumvention, frost, breaking of poles, electrical discharges and less often those caused by birds (fig.1.e, f).
There were also disruptions to the equipment of the overhead power line cell made by:
- rupture of insulators, explosions (fig.1, a, b);
- faults in the mechanism of actuation of the orthojector type switch;
Damage due to staff faults such as:
- opening separators in charge;
- closing the grounding knives without checking the lack of voltage;
- non-compliance with the distance from the neighborhood;
- removal of fences.
which usually lead to the destruction of equipment and especially to the serious injury (often fatal) of the personnel that produces them [7], were not reported during the monitored period.



a) b) c)

d) e) f)

Figure 1. Incidents occurred on the overhead power line 110 kV Resita- Iaz

4. THE OVERHEAD POWER LINE 110 KV RESITA - IAZ PROTECTIONS

The overhead power line 110kV Resita - Iaz is protected against short-circuit currents that may occur in case of damage due to defects by two protections:

- targeted distance protection as basic protection;
- two-stage homopolar protection as reserve protection.

4.1. Distance protection

The distance protection being one directed on the overhead power line 110 kV Resita- Iaz is a protection type RD-110 and the element of minimum impedance Q3.

The RD-110 relay detects the appearance of pendulums on the overhead power line and blocks the trigger.

The low impedance starting relay Q3 is intended for high voltage networks with neutral connected directly to earth and consists of three low impedance starting members and a homopolar relay for the selection of earth faults [2].

4.2. Backup protection

The backup protection 110kV Resita-Iaz is a homopolar one, directed in two stages.

The protection protects the network, the electrical connection line with the energy system against the damage to the ground insulation of a phase.

Maximum homopolar current protection is associated with directional relays.

4.3. Automations of overhead power line 110 kV Resita-Iaz

4.3.1. Fast automatic reconnection device

For the automatic reconnection device after the triggering of overhead power lines through protections, considering that about 80% of the defects are transient and the line can resume its service after their elimination, the fast automatic reconnection devices are provided on the overhead power line [2].

The fast automatic reconnection devices at both ends of the lines and the adjustment of the protection devices by the respective relays must ensure the reconnection only once, corresponding to the type of fault, in a predetermined order of the switches triggered by protections, to isolate the fault on that line and resume the overhead power lines service, in case of transient defects [8].

Cases where the fast automatic reconnection device is blocked or not started when [1]: line

voltage test, actuation of technological protections of oleopneumatic mechanism devices, actuation of differential bar protection, actuation of backup trigger on switch refusal and actuation of automatic load tripping when decreasing frequency or voltage

The fast automatic reconnection device operates in 110 kV networks with synchronous control or low voltage control, the fast automatic reconnection device breaks being chosen appropriately to ensure successive switching and with the appropriate controls at both ends, regimes will always be the same at both ends of the overhead power lines and provides a single three-phase cycle and has an adjustable break between 0.15 and 0.7s.

4.3.2. Switch-off backup trigger

Defects in the energy system are eliminated by triggering adjacent switches (switches that delimit the element on which the defect occurred).

4.3.3. Protection devices for automatic disconnection of the load when the frequency or voltage decreases

The role of protection device for automatic disconnection of the load when the frequency decreases is to avoid the total fall (service interruption) of the national energy system or parts of it to disturbances that exceed the sizing criteria (major disturbances).

The protection device for automatic disconnection of the load when the frequency decreases must stop the decrease in frequency in the event of a disturbance, disconnecting consumers in stages to restore the balance between the power generated and that consumed.

The protection device for automatic disconnection of the load when the voltage decreases has the same purpose as protection device for automatic disconnection of the load when the frequency decreases only that it prevents the voltage drop due to major disturbances.

It is made with low voltage relays that are set to give the trigger pulse when the voltage drops below 185 kV in the 220 kV voltage level from where the voltage relays are supplied, the set time is 6s.

5. DIGITAL PROTECTION WITHIN THE OVERHEAD POWER LINE 110 KV REȘIȚA – IAZ

5.1. The current stage

The development and increasing complexity of power plants require the implementation of increasingly high-performance protections, which have a short response time and a high degree of selectivity of defects.

Considerable advances in the field of digital technology have led to the separation of such protection systems that include more and more digital electronic circuits [5]. These systems, in addition to the classic protection functions, achieve in a short time the acquisition of information from the system and their processing so that the defects can be managed more efficiently.

The process of equipping with digital protection systems is an incipient one within the overhead power line 110 Kv Reșița - Iaz. Thus, in the 220/110kV Iaz Transformer Station, out of a total of 10 cells for 110 kV overhead power line, only one cell is equipped with a 7SA522 Siemens type TNP relay, the remaining 9 cells being electromechanical relays of the RD110 + Q3 type. The 220/110kV substation transformer Resita, out of a total of 10 cells for 110 kV overhead power line, does not even have a numerical protection, most of the protections being from the beginning of the construction of the station with low reliability and sensitivity.

5.2 Proposal of a digital protection system

5.2.1. Propose equipments

It is proposed to implement a protection system for overhead power line 110 kV Resita-Iaz which at the basic protection should contain the numerical protection

terminal SIPROTEC 7SA612, such a system being presented in Fig. 2.

For the digital protection terminal reserve protection of the maximum homopolar protection should contain of the SIPROTEC 7SJ 622 type [7] being presented in Fig. 3.

It is proposed that the two equipments be present in protection board, model C2-SR1 presented in figure 4.

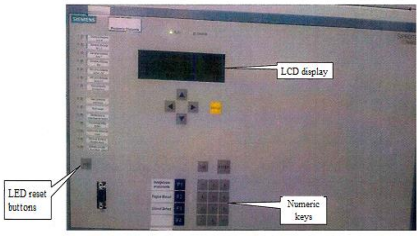


Figure 2. Distance protection

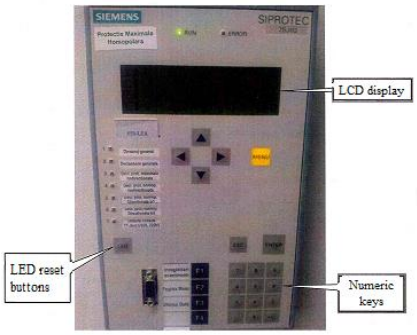


Figure 3. Maximum homopolar protection

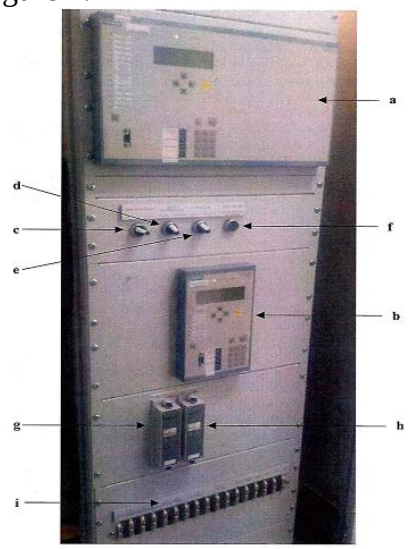


Figure 4. Protection board

The protection board contains:

a. distance protection type SIPROTEC 7SA612 (basic protection);

b. maximum homopolar protection type SIPROTEC 7SJ622 (backup protection);

c., d., e. - keys for choosing the synchronization mode when connecting the switch, for choosing the mode of operation of teleprotection and for choosing the fast automatic reconnection device regime;

f. LED reset button and cancel locked lock;

g. test block of 7SA612 distance protection;

h. test block of 7SA622 maximum homopolar protection;

i. disconnect clamps [7].

These solutions resulted from defect simulations performed through the "Maneuvering Simulator" program on the prow equipments and comparison with the results held as a result of actual defects previously occurring on the overhead power line 110 kV Resita-Iaz and solved with existing equipment. "Maneuver Simulator" is a program specially designed to artificially create situations that may occur in reality in electricity transmission and distribution networks [9].

Through these simulations you can see how the control and protection equipment works in normal operation and in emergency mode.

The working mode of the basic protection RD 110 was studied and compared, as well as the advantages of replacing it with a much better digital protection terminal.

5.2.2. Comparison between existing protection and proposed solution

The results obtained at reaction and selectivity times were compared between the existing protection, distance protection type RD-110 and the proposed one with SIPROTEC 7SA612. The times for operating the existing protection are those recorded as a result of the occurrence and resolution of defects in the high voltage overhead power line Resita - Iaz and those for the proposed equipment were obtained by simulation with the program "Maneuver Simulator" [3]. In this way, conclusions could be drawn regarding the two protection systems regarding sensitivity, selectivity and safety in operation.

In the graphs below, we have shown the working time of the distance relays and the

internal time errors depending on their nature calculated in milliseconds. (Fig. 5 and fig.6).
The operating time of the relays differs a lot depending on their type, so that the electromechanical relays have a running time about 3 times longer than the numerical relays and double the static ones.
The reliability of the system and the relays depends on the time errors, the reliability increasing with the decrease of these errors.

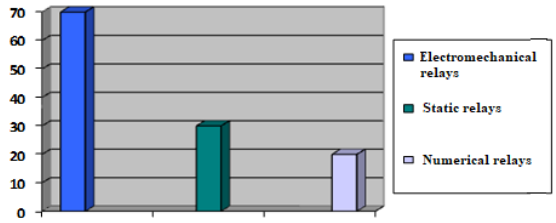


Figure 5. Distance relay operation time [ms]

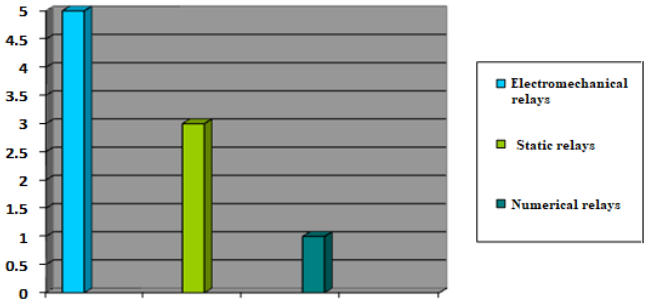


Figure 6. Internal time relay time errors

It can be seen from the graph that the numerical distance relays are much more reliable than the electromechanical ones due to the small time error, of approx. 1% of the set time, compared to approx. 5% of electromechanical relays. The time values for the electromechanical relays were obtained following the readings made by the centralized monitoring system within the Territorial Dispatch Office.

6. CONCLUSIONS

The study showed that:
- the basis of a good operation of an overhead power line is conditioned by the fact that the entire overhead power line assembly, the switching equipment related to the overhead power line cells, the protections and the automations to operate each and in general in the indicated parameters.
- at the level of the TRANSELECTRICA company, it is necessary to modernize the transformation and transport stations, these being physically and morally outdated.
Thus, regarding the overhead power line 110kV Reșița - Iaz, the following are urgently required:
- changing the insulation on the overhead power line, replacing the glass insulation with composite;
- the primary equipment from Reșița and Iaz stations must be replaced with modern equipment with composite type insulation and modern switches with electric arc extinguishing in Sf6 or vacuum;
- protections and automations must be replaced by modern and high-performance ones;
- the implementation of modern data acquisition and transmission systems (SCADA) is required.
After the propose modernizations it is estimated that:
- will increase the degree of safety in operation and the operation times of the protection will decrease;
- the detection and liquidation of defects will be simpler and internal time errors decrease;
- the total costs during operation will be reduced
- will increase operating speed and operational safety;
- parameter settings and adjustments will be made easier.

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* corresponding author