Research on optimizing the control of SCADA system upgraded stations

Teză de doctorat – Rezumat

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autor ing. Dumitru CIULICĂ
conducător științific Prof.univ.dr.ing. Manuela PĂNOIU

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Summary

In this paper is taken into consideration the actuality domain of controlled switching of high voltage circuit breakers during their operation with SCADA control systems.

This paper with a basic text of 247 pages is structured on 8 chapters, is based on a bibliographic list of 110 topical titles, edifying for the research in the thesis.

Some of the contributions related to the thesis were validated by the author through publication of scientific papers, as follows: 2 papers published in volumes ISI indexed conferences; 3 papers published in the volumes of BDI indexed conferences.

The topic addressed in the thesis is very topical as the thesis addresses the issue of power supply, specifically studied some problems that occur in the case of switching with high power SF6 switches.

In the European Union, the quality of the electricity supply service is quantified using three categories of indicators: commercial quality, continuity of supply and energy quality. The research carried out in the doctoral thesis is mainly focused on the continuity of power supply, but also addresses to a certain extent the quality of energy, by studying the transient regime that occurs when switching electrical switches.

The doctoral thesis is a laborious study on the optimization of command and control of power stations, where the switching elements are switches with SF6 and the control command system is performed using the SCADA system. The research carried out resulted in the realization of a program that can be installed in the control command system in order to make a real-time analysis of the voltage and current to optimize the switching point at the circuit breaker SF6.

The thesis also presents a proposal to optimize the supply of some stations for internal services, a study that involves maintaining stable electricity.

The paper presented a series of results of their own research, in a logical way, by identifying the problems that may arise and proposing solutions.

Chapter 1 presents the motivation and objectives of the thesis, the advantages and the disadvantages of controlled switching, problems that may occur during normal switching, as well as the content of the thesis.

Chapter 2 presents the information necessary to know the control system, the current state and trends of the control system of the refurbished power stations. [1][2]

It also presents a classification of the high voltage circuit breakers used, their role as well as the conditions they must meet. [3][4]

For a more accurate knowledge of the SF6 circuit breakers are presented the constructive elements, operating modes, [7][8] components and their operating characteristics, and for a more accurate knowledge of the switching process are presented the operations and

phases of the closing or opening process. [11][12][13]

Also presented is the spring mechanism of the SF6 circuit breaker actuator as well as the main phenomena of the switching process. [5][6][9][10]

Chapter 3 presents the information necessary to know the process of switching off the alternating current electric arc and the mathematical models approached in the literature that simulate the behavior of the electric arc, respectively modeling the voltage restoration between the contacts of switching equipment. [14][15]

The mathematical formulas that define the phenomenon of dynamic disconnection in AC installations as well as the controlled connection model presented in the literature are also presented.

In order to implement the different simulation scenarios, graphical user interfaces have been developed in Matlab that allow the adjustment of the values of the model parameters in a certain established field.

In Chapter 4, a controlled switching model was made by exemplifying the times required for the switching process. Thus, two simulations were performed for the operation of connecting an inductive load with a graphical representation of the main quantities involved in the process, the logic diagram underlying the calculation of the switching time and the measured values. [16][17]

Also in this chapter, two simulations were performed for the disconnection operation controlled with the algorithm used, the graphical representation of the operation as well as the comparison with the model from the specialized literature.

Based on the results obtained in this chapter, the following conclusions were identified:

- The simulation of the closing time in the case of circuit-breakers with SF6 largely depends on the type of circuit-breaker.
- For each type of circuit-breaker, their characteristics must be raised according to the temperature, the DC supply voltage of the actuating coils and the pressure of the hydraulic agent.
- Given that the switch operates under normal conditions, ie the temperature within the limits of 0˚C ÷ +40 ˚C, we can approximate this coefficient as equal to 72 milliseconds for the connection operation and 22 milliseconds for the disconnection operation.
- To check these times it is necessary to use auxiliary contacts, which copy the position of the switch contacts, very fast and accurate.
- The calculation algorithm for the connection time is simple, it all comes down to calculating the seven time moments and applying the control to the circuit breaker as quickly as possible.
- High precision measurement with the help of existing transducers in the installation of the DC temperature and voltage.
- The simulation was performed for a single phase, in case the switch control is monopolar. Then on each phase the phase-out switching command must be transmitted compared to the studied phase with a certain calculated delay.

Chapter 5 presents a simulation program for the controlled switching of the main types of tasks. [18]

Several types of switches considered representative for the considered process were synthesized and analyzed: controlled disconnection of a capacitive load; controlled connection of a capacitive load; controlled disconnection of an inductive load; controlled connection of an inductive load; controlled disconnection of a power transformer; controlled connection of a power transformer.

Controlled switches were analyzed and compared with uncontrolled switches to highlight which of them performed better.

Chapter 6 deals with the problem of controlled switching of high voltage circuit breakers in transient mode. The first part presents the equivalent schemes by types of defects.

Several types of switching were synthesized and analyzed, considered representative for the transitional regime, depending on:

- type of source: capacitive character, resistive character, inductive character.
- type of load: capacitive character, resistive character, inductive character.
- place of defect: near or far.

Also in this chapter, simulations were performed for the transient controlled disconnection operation with different types of defects.

Following the simulations, the following conclusions can be drawn regarding the controlled disconnection of the transitional regime:

- allows obtaining a current and voltage characteristic whose shape is equivalent to that found in the literature;
- allows obtaining different breaking currents, necessary for the disconnection process;
- allows changing the character of the source by changing the phase shift of current and voltage;
- allows the modification of the load character by modifying the current and voltage phase shift;
- allows highlighting the parameters that are supervised in the case of real electrical installation;
- allows working with different fault distances;
- follows the waveforms of current and voltage, obtained from the real installation;
- the maximum breaking current of the arc is obtained for an opening at the moment when the fault current is at the maximum amplitude of the fault current;
- can be used in the synthesis of management structures.

Chapter 7 summarizes the study of the process of controlled switching of high voltage circuit breakers using the control command system. In this chapter, the studies from the previous chapters were applied by simulating the controlled switching in: the controlled opening and closing of a line switch with the control command system; controlled opening and closing of an autotransformer switch with the control command system.

Chapter 8 examines the automatic switching on of the backup power supply with the control command system for internal AC services with 3 basic sources and a generator set of a power station.

This chapter simulates all possible defects that may occur in the supply of internal services, as well as solving these problems using algorithms installed in the control command system.

Chapter 9 concludes the scientific approach undertaken through the research in the thesis, focusing on the conclusions and contributions. Future research trends are also presented. Based on the stated objectives of this work, the following contributions can be listed:

- Elaboration of a study on the basic issues of the process of switching high voltage equipment in order to control their switching.
- Identifying the current state of the switching process in high voltage installations.
- Analysis of the main operations and factors that influence the switching process of high voltage circuit breakers through the prism of interests related to controlled switching and validation of proposed mathematical models and development of controlled switching strategies.
- Development and implementation (in Excel and Geogebra) of mathematical models of current, voltages as a function of time for the controlled connection and disconnection of the 400kV compensation coil
- Development and implementation (in Matlab) of mathematical models of current, three-phase voltage as a function of time for the connection and disconnection in unfavorable conditions of a capacitive load, inductive loads and transformer.
- Development and implementation (in Matlab) of mathematical models of current, three-

phase voltage as a function of time for the controlled connection and disconnection of a capacitive load, inductive loads and transformer.

- Comparative analysis of mathematical models of current, three-phase voltage as a function of time for controlled switching to uncontrolled switching of a capacitive load, inductive loads and transformer.
- Development and implementation (in Matlab) of mathematical models of current, three-phase voltage as a function of time for the controlled and uncontrolled connection and disconnection of high voltage circuit breakers in transient mode of a capacitive, inductive, resistive load.
- Development and implementation (in Visual Basic) of time determination programs for the controlled connection and disconnection of a line switch with capacitive or resistive load with the control command system.
- Development and implementation (in Visual Basic) of time determination programs for the controlled connection and disconnection of a line switch with capacitive or resistive load with the control command system.
- Development and implementation (in Visual Basic) of time-determining programs for the controlled connection and disconnection of an autotransformer switch with the control command system.
- Development and implementation (in Visual Basic) of programs for graphical representation of current, voltage as a function of time and time for the controlled connection and disconnection of a line switch with the control command system.
- Development of a program (in Visual Basic) for the study and simulation of AAR automation for the control command system of internal services of a.c. of a station, as well as the simulation of all variants of operation.
- Development and implementation of an AAR operation program in all variants of possible power supply defects for services a.c. of a station.

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