UPGRADING OF MEDIUM VOLTAGE SUBSTATION, CRITICAL INFRASTRUCTURE COMPONENTS. CASE STUDY: "CONSTANTIN DINCULESCU" LABORATORY OF POWER ENGINEERING FACULTY

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The EH building within the Power Engineering Faculty of the University POLITEHNICA of Bucharest hosts a dynamic model of an electrical power system, unique both in our country and in Europe, designed, built and implemented in 1971 under the guidance of emeritus professor Constantin Dinculescu.

40 years after establishing the „Constantin Dinculescu" Laboratory, it was upgraded. Today it represents an elite pilot unit and an experimental facility used in education, specialisation and research in the fields of designing, constructing, operating and maintaining the electrical machinery in power stations, substations and the quality assurance of the power supply service.

Keywords: electrical power system, manoeuvres, electrical substations, electrical equipment, vacuum breaker, SCADA, control room, synoptic desk

1. Introduction

It is almost impossible to make a hierarchy of Romanian achievements in electrical power engineering in a given time frame, according to their importance, without mentioning the contribution of the professors belonging to the Bucharest Polytechnic academic environment, who have made constant and sustainable efforts in the field of electric machinery and electrical substations. Crucial input was provided by professors such as *Ioan Stefănescu Radu, Dimitrie Leonida, Constantin Dinculescu, Martin Bercovici, Pavel Buhuş, Alexandru Selischi and Mihaela Iordache*, whose contribution was essential in consolidating the prestige of the Romanian school of power engineering, both at national and international level.

An industrial scale laboratory was established in the *EH* building within the Faculty of Power Engineering from the Polytechnic University of Bucharest and it was fitted with all the facilities required by a didactic lab. The equipment was specific to the 1970s, mostly manufactured by the Romanian industry at the time (Figure 1).

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Fig.1. Overview of secondary circuits from the laboratory commissioning.

2. Practical value of "Constantin Dinculescu" Laboratory

Throughout time, the laboratory has been developed and modernised. Its practical value consists in:

- Providing future power engineers with the opportunity of getting acquainted with actual installations, specific for various types of medium voltage substations in operation in our country. When the lab was inaugurated, it included three building types of medium voltage substation cells;
- Providing the opportunity of performing actions in electrical substations, under circumstances identical to the operation ones, but with a high degree of safety, both for the students and the equipment involved (for work safety reasons the voltage used is 0.4 kV);
- Achieving substations with diverse connection schemes; the laboratory was designed with three categories of connection schemes, of which, one is exclusively specific to high voltage installations (the scheme with a single busbar and bypass busbar); it is worth mentioning that students can perform operations under circumstances similar to the actual ones, including manoeuvres of parallel coupling the generators in a power station with the electro-energetic system;
- Studying both the construction and the actual operation of common automatics such as *AAR* and *RAR*;
- Implementing certain abnormal functioning regimes and testing the modalities for solving them: short circuits, single phase earthing in networks with isolated neutral, transitional regimes of generators connected in parallel the system etc.;
- Fitting the lab installations with the entire command, measurement, protection and automation systems required by an actual installation; placing this system in

the main room, next to the electrical substations, enables easy access to its various components.

3. Directions to modernise

Two trends have been followed in modernising the laboratory:

1. ***Purchasing modern equipment in substation "B"***. Cells have been replaced with modern cells fitted with vacuum breakers and digital relays (Figure 2).

Fig. 2. Overview five cells in substation "B"

2. ***Modernising substation "C" by fitting the existing cells with digital relays and connecting the substation, together with substation "B", to a SCADA system***, which allows operations in the two substations to be performed through a computer. Thus, at present, the lab enables performing operations and implementing functioning regimes both under the circumstances of older substations (many still in operation in the national electrical power system) and under the circumstances of modern substations fitted with digital protection and running by a *SCADA* system (Figure 3).

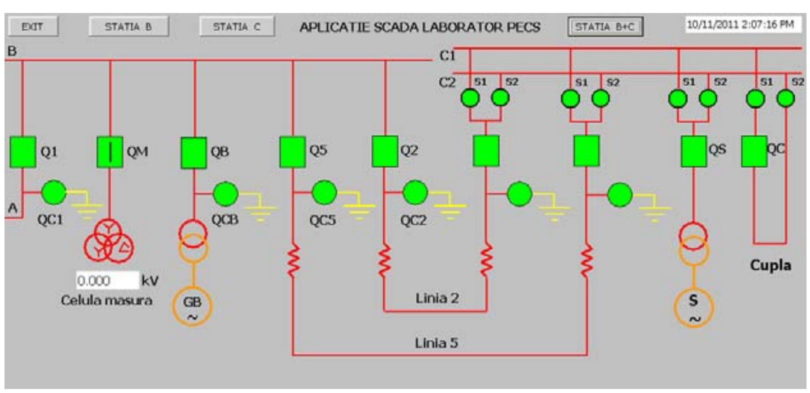

Fig.3. *SCADA* global scheme

Nowadays, applications for subjects such as *Electrical components of power stations and substation, Electrical substations, The quality assurance of the power supply service, Electrical substations maintenance, Electrical power installations maintenance* take place in a real working environment, consisting of:

- ***5 electrical energy sources*** (4 synchronous generators of 15-20 kVA) and a connection to the national electrical power system (SEN).
- ***28 medium voltage electrical cells*** of various types, grouped in 4 electrical substations fitted with 10 - 20 kV switch equipment:
  - ***substation "A"*** is a 10 kV electrical substation with double busbar system with one busbar sectioned. It is fitted with 11 walled electrical cells (Figure 4).

Fig.4. View of substation "A" and dispatching point of Lab.

  - ***substation "B"***, fully modernised, is a 20 kV electrical substation with only one busbar system. The 5 cells, fitted with vacuum breakers include complex secondary equipment based on numerical technology (they implement all commands at the breaker, ensure necessary protections, monitor the functioning of the breaker and allow its operation through a computer, Fig. 5).

Fig.5. Substation "B" local command

- ***substation "C"*** is a 20 kV electrical substation with double busbar system. It is fitted with 6 type ICMP 7 prefabricate electrical cells (Figure .6).

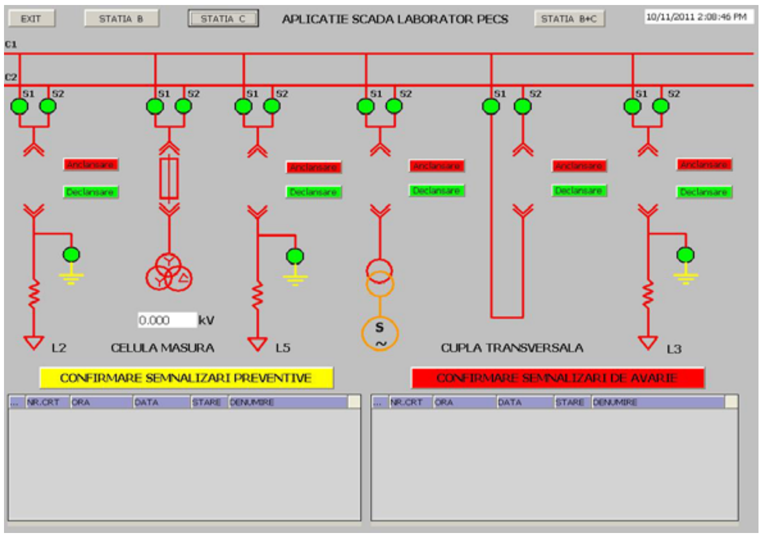

Fig.6. Substation "C" remote control and signalling screen.

- ***substation "D"*** is a 20 kV electrical substation with single busbar and bypass busbar. This scheme is not used for medium voltage substations; it is a special order for the lab with the purpose of students getting acquainted with the manoeuvres in the substations with bypass busbar. The substation is fitted with 5 type ICMP 7 prefabricate electrical cells (Figure 7).

Fig.7. View of substations "C" and "D" and dispatching point

• ***A model of a system fitted with secondary circuit installations*** which ensure command and distance signalling of the commutation apparatus position, the command of generators, the measurement of electrical parameters, technological blockage preventing wrong manoeuvres, primary circuits protection in case of emerging defects, common automation used in electrical substations (*AAR, RAR*).

• ***Users systems*** (asynchronous machines, power resistors, inductance, etc.).

• ***An energy dispatch point*** consists of:

- *a synoptic desk* (in the centre of the room) which illustrates the real single line diagram of the electrical power mini-system, as well as the measurement apparatus indicating the values of the electrical parameters in the relevant points;
- *a command panel* (in front of the synoptic desk) fitted with measurement apparatus, command keys, position indicators etc. The desk allows operating and overseeing the primary equipment constituting the electrical power mini-system (Figure 8).

Fig.8. View of dispatch point in room EH008. In the background, substations “C” and “D”

• ***5 models of electrical lines*** “***L1 - L5”*** with adjustable length, whose building characteristics are simulated through concentrated circuit elements (adjustable inductance and capacitors).

• ***Installation of intentional production of defects,*** by means of which any type of defect (short circuits, single phase earthing etc.) can be produced in pre-established points of the system model.

• ***Development, modelling, and simulation software***.

• ***Equipment used for ensuring electrical energy parameters***.

• ***Thermal vision camera*** for predictive maintenance.

A *SCADA* informatics system was achieved intended for student instruction, under real technological circumstances in *SEN*. The informatics and educational informatics applications use a complex of software applications with the purpose of simulating the installations within the electrical substations fitted with classical and/or numerical command, control and protection equipment for testing defect situations and their impact upon the equipment in the electrical substations.

4. Conclusions

The great professors' outlook on this matter was ahead of their time and, without exception, they strived to improve Romanian science and technology, keeping it in step with world science development and actively contributing to the process of modernising our country.

After 40th years, Lab *EH 008* has an exceptional value and constituted the foundation for establishing an important school of economic thinking in designing and operating electrical power installations.

Table 1

Exemple of practical approach to"*Electrical components of power stations and substations*"

Topic 1	Safety regulations for working with electrical installations in power stations and substations, as well as rules for performing the activities in Lab EH008.
Topic 2	Getting to know the type of electrical power system and the main installations from the power stations and electrical substations lab.
Topic 3	Getting to know the high voltage equipment and the ways in which the commutation apparatus in the lab can be operated.
Topic 4	Drafting the manoeuvre sheets in substations containing simple connection schemes.
Topic 5	Synchronising, connecting to the system and regulating the load of the synchronous machines from power substations.
Topic 6	Performing operations in substations with various connection schemes. Blocking systems for disconnectors.
Topic 7	Complex operations including an ensemble of power stations and electrical substations, using real installations and a manoeuvre simulator.
Topic 8	Detecting grounding in networks with isolated neutral.
Topic 9	Choosing the principle schemes for power substations.

Relevant research has been completed here, dealing with: increasing energy efficiency; perfecting the construction and operation of electrical substations; reliability of technical systems; critical infrastructure; original optimization methods in electrical power distribution; energy prescriptions and instructions for designing and operating electrical installations; education, specialization and research in the field of electrical substations maintenance and the quality of electrical power service.

Outstanding results of the research performed in this laboratory have been presented in scientific symposia and have been published in journals, scientific bulletins or in proceedings of conferences in the country or abroad.

R E F E R E N C E S

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