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INTEGRATED SYSTEM OF PROTECTION AND CONTROL IN S/S CATICI 35/10(20) kV,2x2.5 MVA

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1. INTRODUCTION

S/S CATICI 35/10(20) kV, 2x2.5 MVA in operation since 1954. In 1997, the reconstruction and rehabilitation comprise all electrical equipment, with the exception of power transformers 2x2.5 MVA, and the existing building . Achieved technical solutions of electrical equipment reconstruction are made so that they don’t change the basic purpose of S/S CATICI, and achieve a good flexibility in operation and reliability in exploitation, enabling the incorporation into the 20 kV network.
By the selection of relay protection , control and instrumentation equipment of modern microprocessor technology , the incorporation of S/S CATICI into the remote and supervision system is enabled.

2. TECHNICAL DESCRIPTION OF S/S CATICI 35/10(20) kV, 2x2.5 MVA

2.1 Object general data

S/S CATICI 35/10(20) kV, 2x2.5 MVA is switching distribution station. All electrical equipment, with the exception of power transformers and surge arresters , is placed indoor.S/S CATICI is located in the Catici, in the surrounding of Kakanj town,near to TE “Kakanj” .
Regular power supply of pit services of “Kakanj” and of part general consumers in the region of municipality of Kakanj, and alternative power supply of industrial plants and of general consumers in the regions of municipalities of Visoko, Breza and Vares is realised from S/S CATICI **,** by 35 kV and 10 kV overhead lines.
S/S CATICI is supplied from 110/35/6 kV switchgear of TE “Kakanj” , by 35 kV overhead line (600 m) .

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2.2 35 kV Switchgear

35 kV switchgear is assembled of nine (9) metal enclosed,air insulated cubicles, with single busbar system of 1250 A current rating,with withdrawable vacuum circuit breakers equipped with motor charged spring operating mechanism and cable connections to power transformers and 35 kV overhead lines.
Technical characteristics of circuit breakers as well as of all other major equipment (primary equipment) within cubicles,are selected so that can satisfy network parameters for the lifetime and for the prospective development of Bosnia and Herzegovina Power System as well.
Secondary equipment (relay protection,signaling,indicating instruments and local control devices) are located into belonging relay compartments of cubicles. All the cubicles are arranged in one row.
The neutral of 35 kV network is isolated.

2.3 10 (20) kV Switchgear

10 (20) kV switchgear is assembled of nine (9) metal-enclosed,air insulated cubicles with single busbar system,without bus sectionalizing ,of 1250 A current rating and of 20 kV rated voltage,with withdrawable vacuum circuit breakers equipped with motor charged spring operating mechanism and with cable connections to power transformers and 10 (20) kV overhead lines.
The secondary equipment (relay protection,signaling,indicatihg instruments and local devices) are located into belonging compartments of cubicles. All cubicles are arranged into a single row and are located in the same room with the 35 kV switchgear.
The neutral point of 10(20) kV network is isolated.

2.4 S/S Auxiliary Services Power Supply System

This system enables the power of station services consumers at 3x380/220 V AC(50 Hz),and at 220 V DC. System consists of (2x10)/0.4 kV, 50 kVA dry type auxiliary power transformer accommodated in separate compartment which is located along with 10 (20) kV switchgear, of the main 0.4 kV distribution cabinet,and of UPS with 220 V DC distribution
The main 0.4 kV distribution cabinet together with UPS system is located in the same room with the 35 kV and 10(20) kV switchgear.

2.5 Secondary Equipment

Electrical protection of 35/10 (20) kV CATICI equipment is realized by relay protective devices of contemporary digital technology .
The measurements of current ,voltage and power is enabled locally, provided by indicating instruments suitable for measuring transformers connection, and remotely via appropriate measuring transducers..
Electric energy metering is foreseen in each 35 kV and 10 (20) kV feeder for two direction.Meters are two-tariff,of 0.5 accuracy class,with pulse output. The energy summation,accurate time counting,data storage,maximum demand calculating are realized by microprocessor based tariff device.
35/10(20)kV S/S CATICI is unattended . Control is provided from dispatching center DC ZENICA remotely , as well as from switchgear devices (cubicles), locally. Remote control is realized over corresponding remote control equipment. The cabinet for remote control,measuring and signaling is made according to corresponding contemporary technical abilities of this kind of equipment.
Signaling of equipment failures as well as faults within 35 kV and 10(20)kV networks is realized over local signaling devices which are built into belonging cubicles of 35 kV and 10(20) Kv switchgear. Light and audible alarm signaling is foreseen in 35/10(20)kV S/S.CATICI. A part of signals are remotely transmitted to the dispatching center DC ZENICA.
Fire alarm annunciation inside the switchgear building is realized by appropriate fire detectors and belonging electronic central unit,and the alarm is transmitted by remote control system to DC ZENICA.
The telephone is installed in the 35/10(20) kV S/S bulding,and the telephone line is used for remote control and measurement system.

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3. INTEGRATED SYSTEM OF PROTECTION AND CONTROL IN THE S/S CATICI

In the fig.1 shows the system configuration.This system contains of three-function part:

- Control-protection units of feeders
- Comunication equipment
- Program MicroSCADA with hardware

3.1 Control units of feeders

The basic control-protection unit is control-protection unit of feeder . It is here the microproccesor relay. We will be described the microprocessor based relay type SPAC 535 (fig. 2).

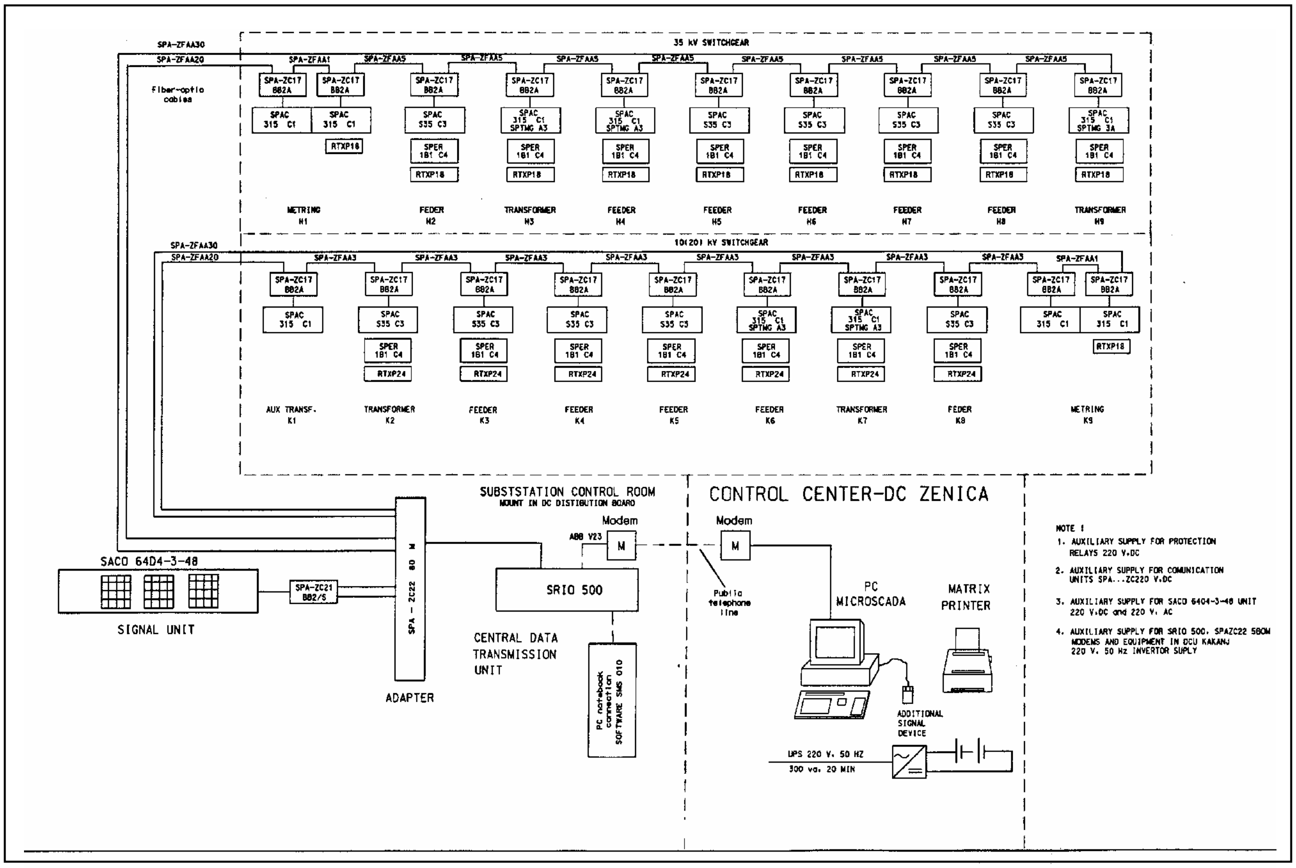

Figure 1: System Configuration in S/S CATICI 35/10(20) kV

Microprocessor based relay type SPAC 535 contains :

- Control module type SPTO 6D3
- Combined overcurrent and earth – fault relay module SPCJ 4D29
- Directional neutral overcurrent relay module SPCS 3C4

The control module type SPTO 6D3 can be executed open and close commands for controllable switching devices of the switchgear . Input channels are used for reading status information of the switching devices. Each of these channels includ two physical inputs, one for the “ object open” and one for the “object closed” information.

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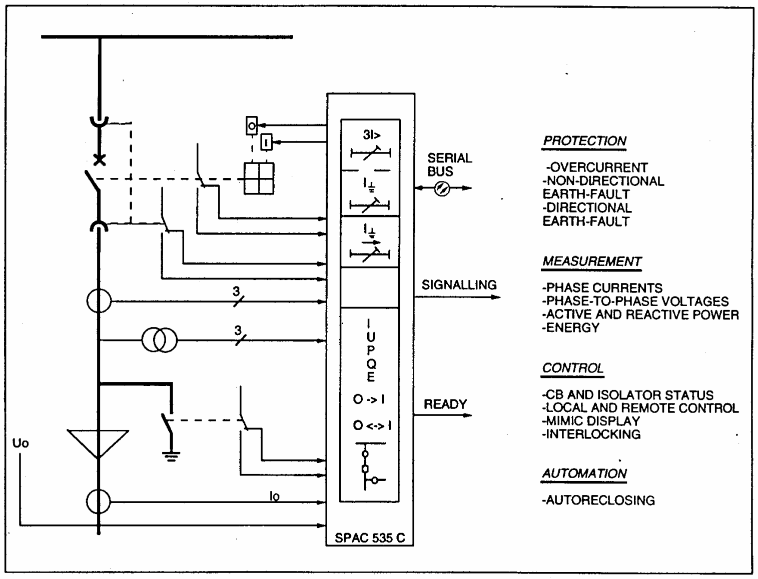

Figure 2: Basic functions of the integrated feeder terminal SPAC 535

The control module indicates the status information locally on the front panel and transfers the status information to the substation level comunication equipment using the SPA serial bus.
The control module measures and indicates the three phase currents and the three phase-to-phase voltages.
For additional measuring functions an optional measuring module is required. The optional module rectifies and processes the analog signals and forwards them to the control module.Three types of optional measuring modules are available : SPTM 8 A1,SPTM 6A2 and SPTM 6A3. Each the optional module measures three phase currents, three phase-to-phase voltages,active and reactive power and energy.The measured signals can be scaled for display locally and for remote transfer over the SPA bus.
The control module SPTO 6D3 is capable of performing five auto-reclosings.Each autoreclose cycle(reclaim time and dead time selectable 0,2.......300 s) can be started by three different initiation signals delivered by the protection relay modules of the feeder terminal.

The combined overcurrent and non-directional earth-fault relay module SPCJ 4D29 is designed for single –phase , two-phase or three –phase overcurrent protection and non-directional earth-fault protection. The phase overcurrent unit of the relay module SPCJ 4D29 includes two overcurrent stages: low-set stage i > and high –set stage I>>.
The operation of the low-set I > can be based on definite time or inverse time characteristic phase overcurent stage. The operation characteristic is selected with SFG1 switches. At definite time operation characteristic the operate t > is directly set in second within the range , 0.05......300 s.The high –set stage I >> can operate with definite time charactenistic only (the setting range 0.04......300s) The operation of the low-set phose overcurrent stoge I > based on inverse time chatacteristic will be blocked by starting of the high-set stage I>> and them the operate time of the overcurrent unit is determined by the set operate time of the high-set stage at heavy fault currents.
The setting range of the start current of the low set overcurrent stage I > is 0.5.....5 x I_n at definite time characteristic and 0.5.....2.5 x I_n at inverse time characteristic.
The setting range of the start current of the high – set phase overcurrent stage I>> is 0.5....40x I_n.
The set start current value I>> of the high-set phase overcurrent stage can be doubled automatically on connection of the protected object to the network, i.e.at starting.The automatic doubling function is selected with switch SGF 1/5.The high – set phase overcurrent stage can be set aut of operation with switch SGF 2/5.
The non-directional earth-fault unit of the relay module SPCJ 4D29 measures the neutral current I_o , It contains two earth-fault stages: a low-set earth – fault stage I_o > and a high –set earth-fault stage I_o >>.

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The operation of the low-set earth-fault stage $I_o >$ (the setting range 0.01....0,8x I_n) can be based on definite time (the setting range 0,05.....300s) or inverse time characteristic.
The high-set stage $I_o >>$ (the setting range 0,1.....10x I_n) can operate with definite time characteristic only (the setting range 0.05......300 s).
The operation of the low-set earth-fault stage $I_o >$ or the high-set earth-fault stage $I_o >>$ can be blocked by routing blocking signal to the earth-fault unit (the blocking configuration is set with switchgroup SGB).The high – set fault stage can be set out of operation with switch SGF 2/6.

The directional neutral overcurrent relay module SPCS 3C4 measures the residual voltage U_o and the active component $I_o \sin\varphi$ or the reactive component $I_o \cos\varphi$ of the neutral current I_o . The phase angle φ is the phase displacement between the measured voltage and current ($I_o \sin\varphi$ or $I_o \cos\varphi$) If the system to be protected is resonant earthed or nearly solidly earthed, the operation characteristic to be selected is $I_o \cos\varphi$, whereas $I_o \sin\varphi$ is selected for the protection of isolated neutral systems.
The directional neutral overcurrent relay module contains two neutral overcurrent stage : a low set $I_\varphi >$ (the setting range 1......10% x I_n) and a high-set stage $I_\varphi >>$ (the setting range 5.......40% x I_n or 1.......8% x I_n).The low-set stage and high-set stage can operate with definite time characteristic only (the seting range for $I_\varphi >$ 0.1........1 s or 1 ....10s and $I_\varphi >>$ 0.1.......1s).The high-set stage can be given the same or the oposite direction of operation as compared with the low –set stage.
$I_o \sin\varphi$ or $I_o \cos\varphi$ operation characteristic selected by locally by switches or by control over the exsternal control input.

The parameters can be set via the front panel (the key switch in the LOCAL position) or via PC notebook software SMS 010 (the key switch in the REMOTE position).

3.2. Communication equipment

All the microprocessor relays are interconnected by means of two optical cable loops through the adapter SPA-ZC 17 BB 2A (converting the electric into optical signals) with the central adapter SPA-ZC22 A5 BOM (converting the optical into electrical signals) to which the central signal device SACO is connected via separate loop and the adapter SPA-ZC21 BB/SS (converting optical into electrical signals) as well as the central transmission unit SRIO 500M .
Apart from the accessory direct-current voltage and alternating-current voltage signal in the transformer station the signal unit SACO also has the possibility to signal the arc appearing in the cells 10(20) and 35 kV. Compared to the copper cables the advantages of the fiber-optic cables are:

-Fiber optics has a wider frequency area and fewer losses than copper those enables transmission of more information at longer distances.
-Fiber-optic cables are much smaller-sized and easier to handle than the copper cables, which makes installation easier.
-Fiber-optic cables are practically insensitive to electro-magnetic interference's causing static or other linear noise in the copper systems so that the transmission quality is much higher.

For the purpose of light transmission each fiber needs a transmitter (a laser diode) on one of its ends and an optical receiver for light reception on its other end (a photo diode with the avalanche effect).
The fiber-optic cables are SPA-ZF AA20, SPA-ZF AA30, SPA-ZF AA3 and SPA-ZF AA5, mono diode cables with the graded index of refraction, section 9/125 μm wavelength 1300 nm and 1550 nm.
The information is transmitted from the transformer station to the control center and in reverse through the central data transmission unit, type SRIO 500M, that is connected with Zenica control center PC via appropriate modems and telephone line.

3.3. MicroSCADA

MicroSCADA, the program support for monitoring and control, is an integral system for electric energy

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network management in real time whose functions can be presented as SCADA and EMS/DMS functions. SCADA (Supervisory Control and Data Acquisition) functions are**:** control functions, operational functions, event presentation, calculations and overview of values in a period of time.
EMS (Energy Management System) / DMS (Distribution Management System) functions are: monitoring and analysis, network defining, energy calculations and openness.
The following have been selected from ample MicroSCADA functions:

- Display of single pole S/S scheme on PC screen,
- Registration of user and authority,
- List of alarms,
- List of events,
- Sound alarms,
- Reports,
- List of chronological registration of events,
- List prints out,
- Device handling (on/off),
- Numeric security relay remote setting,
- Blockage of incorrect operation,
- Trends.

The following hardware has been used for installing MicroSCADA program package in Zenica control center: Personal Computer and Matrix printer .
The operating system is SCO UnixWare 2.1 and the following MicroSCADA programs have been installed: MicroSYS 8.20, MicroTOOL 8.2 D and MicroLIBRARY 3.1 B.

We operate the system with a mouse and keyboard and the information are monitored on the computer screen, printer or additional signal device connected to the computer.
The system servicing homepage enables monitoring system status and tasking. It contains the single pole S/S scheme and various menus in the heading and footing for transfer to other pages.
The single pole S/S scheme showing the current status of the switch devices, peak load and voltage on busbars is the operator’s main tool. The single elements are manipulated by means of dynamic elements on the screen. The basic manipulation is the switch operated manipulation on two levels: operation selection and verification or canceling the on/off task. Besides that the offered menu provides information on the switches status and all other events in the processes of manipulation, blockage of tasking as well as blockage of forced tasking . In general, all the important manipulations are conducted on two levels in order to provide the possibility to cancel the task prior to its confirmation.
For the purpose of protecting the system from the unauthorized manipulation several below mentioned operation levels have been installed.
The alarms are a special kind of information about the system warning us about harmful events that have not been caused by some task. The system operator is to confirm personally all the events, which it the way to ensure that all the events are under control There are several alarm forms and stages. The basic ones are: alarm active, alarm over and alarm confirmed. For the operation mode and signal generation several combinations can exist in the system:

-Active alarm that has not been confirmed yet,
-Active alarm that has been confirmed and restored to the dormant state,
-Inactive alarm that has not been confirmed,
-Inactive alarm that has been active but not confirmed.

On each page there is visual red-marker-shaped information blinking when the new alarm appears. The entire chronology of alarm appearing is noted and can be printed out.
Besides the alarm signals that instantly inform the operator about the state of the system the chronological list of other events occurring in the system are also noted on a separate page (f.e. manipulation by switch, entering/exiting the program). Any change in the operation is signaled on the screen and on an additional signal device and on the printout on the screen and printer.

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The subsidiary pages also offer the survey of measurements in the system like current measurement, voltage, electric power and electric energy measurements. The power and electric energy measurements are recorded in certain periods (day, week, month, year) and presented in tabular reports.
The trends enable us to monitor changes of measurands in a period of time. They can be presented in linear diagrams, histograms and tabular reports. The maximal period length on one trend is 240 hours and the minimal one is 1 minute.

4.BASIC CHARACTERISTICS AND ADVANTAGES OF INTEGRATED SYSTEMS OF PROTECTION AND CONTROL

The classical approach treats designing the protection devices and systems and the devices and systems for transformer station control as two separate systems. The integrated system of protection and control is a contemporary concept whose implementation is related to the newest technology generation – micro processing technology generation. All the functional domains of protection and control are included in one system.
The basis characteristic of this approach is that protection and control functions are integrated in an integral system based on distributed microcomputer structures. The architecture of the integral computer system enables distributed processing and distributed data base.
The system also offers a possibility for hardware optimization as well as for unique approach to software designing. The goal of the coordinated modular approach is to implement all the requested functions using the minimal number of different hardware components.
This situation is new in comparison with the conventional relay protection equipment in which every single hardware component is designed to perform its own particular function. Functionality of a new modular hardware concept is defined through software modules so that the identical software units perform various functions depending on implemented software modules.
The special modules for communication software enable a serial communication through fiber optic lines. The communication software controls the local data base and provides data consistency in the entire system.
The special function, which can be fulfilled only in the systems based on microprocessor technology, is a continuous self-supervised protection and control system function.
Work of the system is monitored through program performance checking up proper operation of some parts of the system. In this way the errors are immediately detected and signaled. For example, in the parts of the systems performing the relay protection functions these procedures to a large extent eliminate the problems of errors that would occur in case the conventional technique is applied in the period of time between two functional tests and these errors would be detected only in case of non-action or wrong action of the protection relay.
Interface with the operator is centralized which enables centralized displaying of the data and managing the system from the local or remote control desk.
The basic advantages of the integrated protection and control system can be learnt from the aforementioned characteristics.

a) Optimization of wiring towards plant

Adoption of the integrated concept enables the measurands to be directed only to one subsystem, but distribution of these measurands to other subsystems is done within the integrated system, unlike the conventional wiring for each device in a conventional concept.

b) Providing the entire system interface for the operator

The integrated concept enables the integral operator interface on one place for the entire system unlike the conventional solutions in which the operator interface is provided through the standard elements like signaling LED diodes and various manipulative elements. The integrated concept is very flexible since the computer system peripheral devices are used for this interface. These interfaces and the computer system itself enable new functions in the domain of system maintenance and testing as well as regular exploitation.

c) Possibility to integrate the integrated protection and control system into the remote control system

An important advantage of the integrated concept is related to the possibility of relatively simple integration of this system into the entire system of remote control of the electric-power system. In this way the relay protection functions can be fulfilled as an additional part of the overall strategy of electric-power system control, which creates new possibilities in terms of control in cases of engine trouble and normal regime operation of the electric-power system. This primarily means having the possibility of adaptive relay protection version whose settings can be altered during the entire system operation (It can be expected that that the adaptive protection is going to be discussed in the future more and more as the micro processor based devices get increasingly present in the plant since the technical support that is reflected in the computer controlled station is necessary in order this activity is successfully performed and it is also necessary that the computer controlled system is on a high hierarchy level.), so that optimization of setting the relay protection in relation to the system exploitation parameters can be made at that point.

d) Improvement of correlation price / performance

One of the main motifs for installation of these systems is reducing the costs in relation to the conventional equivalent systems. Establishing the basis for comparison is pretty complex since the integrated system is capable of introducing the new system functions and performances (chronological registering of all the events, the diagrams of the measured changes, immediate detection of the protection relay disturbances, etc.), which the conventional system is not.

5.CONCLUSIONS

The following conclusions can be drawn from the aforesaid:

- The concept of the integrated protection and control system introduces a number of novelties in comparison with the previous solutions;
- The main advantage of the integrated protection and control systems is enabling improvement of the correlation price / performance for the entire secondary equipment in S/S;
- The system that has been fully applied has proven the aforementioned conclusions;
- The next direction in development of the integrated concept will be its integration in the remote control of the electric-power system.

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