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AUTOMATION IN HIGH VOLTAGE POWER GRIDS

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INTRODUCTION

A lot of publications have been released on the topic of automation in hundred-plus kilovolt power grids, and most power distributors have adopted their solutions to the challenge. This paper's ambition is to focus on the aspects of high voltage power grid automation and give the CIRED conference participants an idea of the level of automation in power grids in the Czech Republic as well as the benefits of automation in 6 to 35kV systems to electric power distribution quality. This lecture is mainly going to be about remotely controlled disconnectors and reclosers, for both outdoor and indoor applications.

.......IN CZECH REPUBLIC

A great interest in automation of the distribution points arose in the Czech Republic about eight to ten years ago when privatization of the distribution companies was in its preparatory stage. The power distribution companies were privatized and separated from the central company producing and distributing electricity, ČEZ, and they were transformed to joint stock companies, each of them operating in one administrative region of the Czech Republic. The power distribution companies are all private now in the Czech Republic. The new owners started bringing pressure to bear on the power distribution companies to improve their business performances and achieve savings in all their activities. There was a sharp decrease in the distribution companies' number of staff, regional and districts centres were dissolved. Concurrently, however, extensive automation in power distribution grids had to take place and the power distributors' communications systems underwent thorough changes too. The threat of penalization for failing to supply demanded quantity and quality of electric power due to the Czech Republic's accession to the European Union has been another significant incentive to implement automation in power distribution grids.

MAIN REASONS TO AUTOMATIZE POWER GRIDS

- reduction in numbers of service and emergency staff resulting in labour cost savings
- reduction of high voltage power grid operation equipment
- reduction in consumption of fuels for vehicles
- fast localization of approximate spot of failure
- reduction of power downtimes (only power supplied can be invoiced)
- reduction of time to locate the spot of failure,
- reduction of high voltage power grid scheduled maintenance preparation times
- reduction of the chance of being penalized
- improvement of power distribution quality

HIGH VOLTAGE GRID REMOTELY CONTROLLED SWITCHING COMPONENTS

The remotely controlled switching components in high voltage grids are disconnectors and reclosers for both outdoor and indoor use – the latter use is in transformer stations, for example.

DISCONNECTORS

Outdoor disconnectors are the principal components in high voltage grid automation systems. They are switches with arc extinguishing chambers to disconnect grid's nominal current. There are large quantities of such manual operation switches in high voltage grids. Seven to ten percent of their total quantity need selecting, choosing those that are suitable to equip with remote controls, from the point of view of their locations within high voltage grids. There are some software tools available to select convenient switching points as well as set priorities in remote control installations. When entering the input information, however, you need to know so many conditions for each control point that it is infeasible to provide them. The practice shows that consultancy on locating each point with local engineers and control room operators is a considerably simpler and cheaper way since these people face common operation problems on a day-to-day basis. You have to, naturally, bear in mind there are entities, among electricity consumers, with operations that must not be broken as high losses or casualties may be incurred with power interruption.

The remotely controlled points can feature different kinds of accessories to increase operator comfort or provide other services besides remote control. You need to realize that a remote control point is not only a point of measurement, but it should help control room operators in remedying failures. You may even encounter control room operators' opinions that a lot of information is undesirable and it confuses the operator. Especially when the operator tackles emergencies or breakdowns, too much information takes their time away from action.

Remote control **must provide** some basic services:

- switching point remote powerup and shutdown
- remote point status detection plus basic diagnostics
- proper operation at temperatures from minues twenty to plus forty degrees centigrade
- no power supply operation at high voltage side (standby accumulators)
- indication of open cubicle door
- indication of local or remote operation mode
- local electric operation
- drive disconnection on engaging manual operation handle

It is further **convenient to equip** a remote control system with other functions:

- indication of short circuit current
- indication of ground current
- indication of manual operation handle engagement

The following can be considered **optional features**:

- measurement of U,I,P,Q values
- archiving and transmission of U,I,P,Q values to control centre

Indoor disconnectors in transformer or switching stations are controlled in a fashion similar to that of outdoor devices. There are only differences in drive and cubicle designs. A remote control system at such a station also usually allows measurement of voltage, current, power, and reactive power values, including storage of load history records at each point.

RECLOSERS

Installation of reclosers in high voltage grids has recently become very popular. They are circuit breakers capable of cutting off short circuit currents hence featuring conventional

vacuum arc extinguishing chambers and appropriate electronic protection. Reclosers can be fitted right on high voltage line posts. With respect to their higher costs it is convenient to choose their locations carefully. Reclosers are usually installed at long lines out of distribution plant. Correctly set protection selectivity ensures that only the faulty line section is disconnected. An outdoor recloser provides practically the same operation as a standard indoor circuit breaker in a distribution plant.

INDICATION OF SHORT CIRCUITS ARD GROUND CONNECTIONS

Short circuit and ground connection currents can be indicated in two ways. One, the more complex, method is direct measurement of high voltage parameters of voltage and current in all the phases to determine faulty conditions. This is an exact, unambiguous method of indication, but it is rather costly.

The other, simpler and much cheaper, method is measurement of the electromagnetic field in the high voltage line proximity. This is inexpensive contactless measurement with easy installation and easy operation. The latest generation of Czech-made indicators offers adoptive algorithms and can operate without prior parameter setup.

DRIVE

A remote control system's drive is its very important component. Especially if reliability of this part of the system is considered. You can generally say that drives available on the market meet the requirements.

COMMUNICATIONS

Another important part of the system is a communication link between the control room and the remotely controlled device. The connection is usually achieved using a radio channel with the possibility of utilizing even phonic channels of existing radio networks. An alternative approach is data transmission via a trunked radio network's control channel. A different technology is remote control using GPRS services of wireless telecommunications network operators. Generally speaking, remote control using radio equipment represents higher capital costs with minimum operating costs while it is just vice versa using the GPRS technology. Sufficient protection against misuse of information transmitted in any systems must be provided using encoded messages.

REMOTE CONTROL ELECTRICAL BOX AND CIRCUITRY

The remote control electrical box is located right on a high voltage line post and it should be protected against theft and farming or wild animals, besides the effects of weather. You can very hardly protect the equipment against deliberate damage by third parties. To protect it against a random assault, use at least a double-door box. Another design solution is access to screw heads holding the post attachment brackets from inside the box.

The cubicle material may vary with each manufacturer. The box may be of stainless steel, welded or riveted, or of zinc-dipped steel sheet.

The remote control circuitry means a remotely controlled point's control system, rechargable power supply, and communications device (radio station or GPRS modem). A remotely controlled point's electronic circuitry must meet very stringent operating reliability and performance requirements. It is important to realize that the circuitry has to reliably work within a wide range of ambient temperatures (from minus twenty to plus forty degrees centigrade), the equipment must withstand extreme ambient effects, such as from ice, snow, rain or, on the contrary, high summer time temperatures or high air humidity causing water condensation on cabinet's walls.

The remote control circuitry must comply with the following requirements:

- wide range of operating temperatures

- sufficient number of inputs and outputs to connect sensors and actuators, respectively
- high reliability rate
- protection of communications against misuse by intruder

A usual drawback with many manufacturers is that their remote control systems have circuitry only operating in a temperature range above zero degrees Celsius while the box is heated. The problem occurs at the moment the device has had no input power at the high voltage side for an extended period of time, hence no heating.

REMOTE CONTROL SYSTEM POWER SUPPLY

Remote control systems are usually powered via instrument voltage transformers. Such transformers are available from a lot of manufacturers in different qualities. A general rule is a requirement of installing overvoltage protection for the transformers as voltage surges propagate incidentally in high voltage lines. They are surges from switching as well as of atmospheric origin. Our statistics show that four to five percent damaged transformers a year must be considered if no overvoltage protection devices have been installed. With overvoltage protection in place the annual percentage of damaged transformers is nought point five to one, mostly after directly hit by lightning. In such a case the overvoltage protection devices are always damaged too.

It is convenient to transform the hundred volts from the instrument transformer at the cubicle entry point once again thus isolating it from the external transformer.

The remote control equipment is powered from accumulators and these are charged by a charger. The charger's design must provide protection against accumulator overcharging as that would reduce the accumulators' service life.

The charger must provide good charging of the accumulators and sufficient resistance against overvoltage, which is very common in high voltage grids.

It is suitable to use maintenance-free accumulators, such as gel cells. Their featured service life is five years, which can practically be exceeded many times.

CONCLUSIONS

All this information is based on many years of experience with implementation of remotely controlled points. Up to date we have installed more than **960 remotely controlled disconnectors and reclosers**. We also put one disconnector and one recloser in test operation at Elektrokrajina Banja Luka, BiH, in the year 2003.

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