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Intelligent and redundant high voltage substation

By

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Abstract:

Over the last decade, the "digitization" of the electron enterprise has grown at exponential rates, utility, industrial, commercial, and even residential consumers are transforming all aspects of their lives into the digital domain. Automation systems in the area of power systems are widely accepted today.
This paper describes the design of modern intelligent and redundant high voltage substation. The automation system design makes use of bay controllers, which integrate the control, and protection of individual bays into a single Intelligent Electronic Device (IED). These IED_S provide not only control and protection functions, but also fault recording, event recording, equipment monitoring as well as self diagnostic capabilities.
Redundant and smart gate ways, replacing the traditional remote terminal unit (RTU) in connecting the switching station to the system control centre. A new communication model developed and standardized as IEC 61850-communiction networks and systems in this modern substations. With the maturing of the IEC 61850, utilities are beginning to implement substation automation systems (SAS) that are based on this new international standard.
New IT technologies are new solutions for the protection of EHV/UHV substations.

Keywords:
Substation automation systems, intelligent electronics device, IEC standard, redundancy.

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1. Introduction:

The advent of microprocessors and networking technology into the real substation control and protection systems has and will continue to have a considerable impact on the way in which control and protection system are design. Multifunction intelligent electronic devices (IEDS), capable of performing a number of complex tasks simultaneously combined with high – speed data networking, enable engineers to dramatically increase the functionality of the traditional substation control, protection and monitoring systems while improving reliability and decreasing costs.

Central to the design of the substation automation system (SAS) was the use of a type of multifunction IED known as a bay controller, which in a single device perform control, protection and monitoring functions. The combination of these historically separate systems into one tightly integrated SAS proved to be an attractive approach to provide a system that delivered high reliability and functionality at a cost effective price.

This paper provides insight into the design of redundant and intelligent SAS including a description of the system architecture, IEDs used, substation networking as well as the station gate ways.

Key system design features are presented and the benefits derived from these features are discussed. This new substations are unmanned since operation is done from remote control centers and maintenance is outsourced.

2. System Design

The substation automation system is designed to provide a number of primary high level functions relative to the overall design of the station, these include:

i. protection functions
ii. station interlocking to provide for safe operation of equipment to protect not only the equipment but operating personal as well .
iii. local control of the switching equipment from within the switching station control building .
iv. remote control of the switching equipment from the system control center (SCC).
v. local and remote monitoring of measured values, equipment status and other quantities to facilitate network operation.

How these functions, as well as others are provided by the SAS is described in the following sections.

2.1. Design concept

The design of this type of substation is largely based on decentralized control and protection. This concept reduces the need for a centralized station control and placed the responsibility for station operation with the IEDs performing the control functions of the bays themselves. In this type of substation, multifunction bay controllers were provided in each bay to accomplish this.

The use of decentralized control has a number of advantages including greater reliability because the impact of a single point of failure is localized. As well, because the bay controller used in this application is capable of also providing protection functions for the bays, the decentralized design results in significant cost savings when compared to a centralized control scheme.

2.2. System architecture

The architecture of the system consists of a number of devices interconnected as shown in figure 1.

The fully redundant local and remote control solution meets even the highest availability requirements. The continuous controllability of substation will be assured.

It is of prime important and it is solution for usually unmanned substations.

Feature of this control system are [1]:

- redundant, highly reliable embedded industrial smart gate way for tele control.
- independent redundant industrial station computer with HMI .
- separate station LAN and inter bay bus .
- redundant station level LAN .
- basic monitoring and control .
- advance monitoring and advance control if it is needed .

Substation secondary equipment is successively connected to a WAN network for easy and fast access to substation data, e.g. disturbance report and every metering, from assent owner central office.

With the powerful real – time data distribution system, applications can be allocated among several computers, thus boosting performance, connectivity and availability [2-4].

The device master function for communication with IEDs supports a large number of well established protocols.

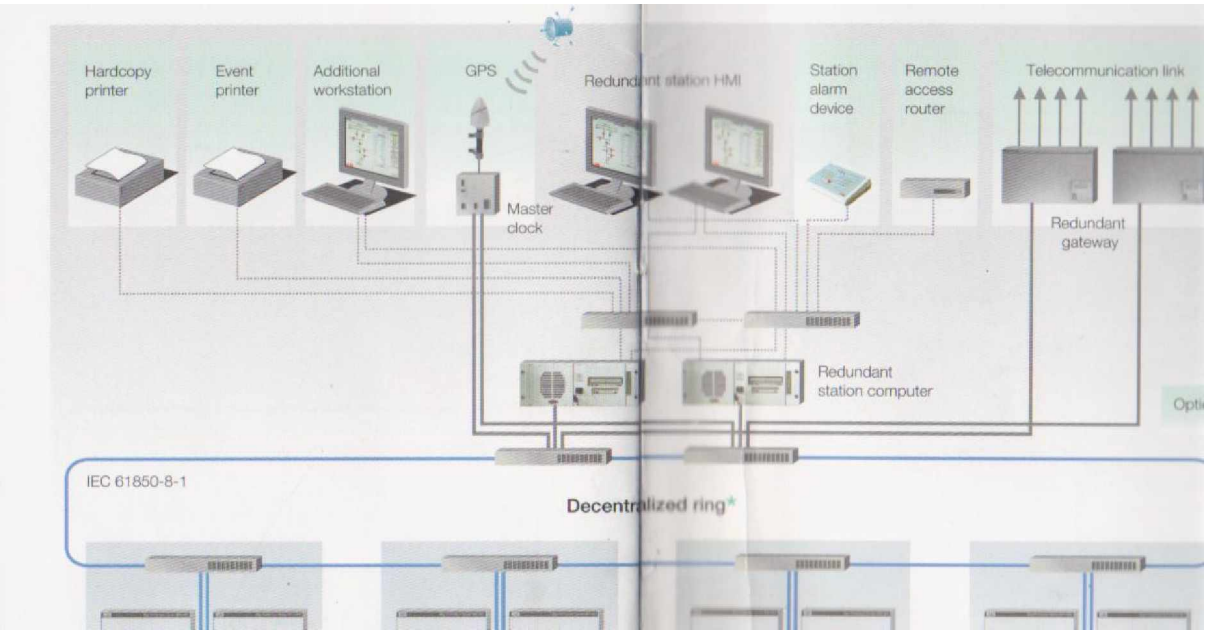

Fig. 1 Redundant and Intelligent remote control of HV substation

To facilitate incident analysis, the fault recording from protection units are retrieved and archived automatically during operation.
This is supported by the IEC 61850 and PROFI BUS FMS protocols or the IEC 60870-5-103 protection units protocol [5-7].
In this type of substation the various types of protection units, IEDs, bay units, measured value recorders and telecontrol units from wide range of manufactures can be use. The control system offers a large number of commercially available communication protocols for recording data from various devices and through differing communication channels.
Subsequent expansion is easy.
Ethernet features

- switches in bay and station cubicles
- choice of large or small switches
- 100 mbit/s backbone application

Many IED_S per cubicle/ kiosk long bay – to – station distance IEDs with dual Ethernet ports for high redundancy and cost are achievable using managed Ethernet switches [8]. Ethernet topology use in some of HV substation to increase reliability is shown in fig.2.

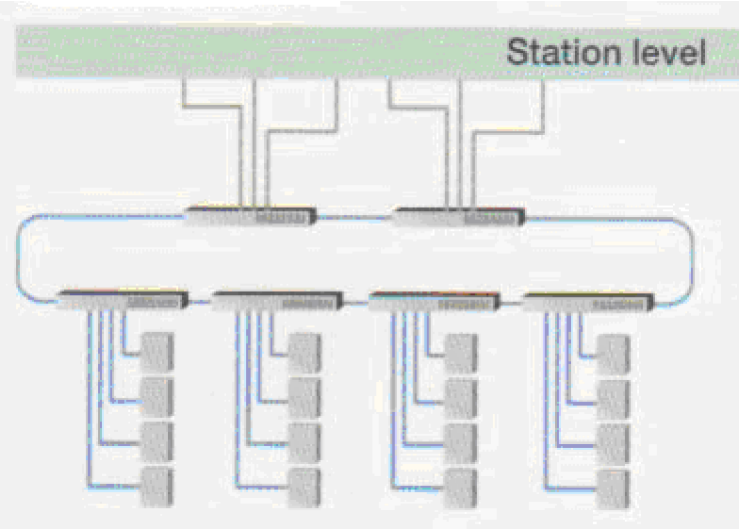

Fig. 2 Reliable Ethernet Topology

3. Communication standard

3.1 IEC 61850 STANDARD

IEC 61850 is the communication standard for interconnecting the devices at the bay and station control levels on the basis of Ethernet.

IEC 61850 support the direct exchange of data between IEDs, thus enabling switching interlocks across bays independently of the station control unit for example.

Users and vendors benefit from the standard in a similar manner because IEC 61850:

i) is a global standard .
ii) uses mainstream technologies like Ethernet , TCP/IP , object modeling and XML .
iii) is highly flexible .
iv) reduces engineering and maintenance costs .
v) is a seamless solution for cross – application requirements .
vi) reduce the diversity of solutions to supported .

Besides introducing commercial communication technology in the substation automation system, IEC 61850 incorporates the following features in substation automation.

- A complete standardized object model of the substation. The control of and the information coming from the process equipment like switchgear, power transformers, instrument transformers and other sensors but also the automation functions like e.g. protection junctions are mapped in a standardized object model.
- The substation configuration language (SCL).

SCL is used to exchange configuration information of the substation between the different configuration tools used to specify the substation, to configure the substation

automation system and to configure the individual IEDs.

- The integration of communication interfaces in the process equipment. The copper wires connecting the binary I/Os of the switchgear are replaced by a communication link. The analog output of instrument transformers is as well replaced by a communication link transporting a stream of sampled values. The analog to digital conversion is moved from bay level to process level.
- accepting new designs e.g. moving away from master slave to client – server communication .
- clear definitions for the interface between systems of different parties are important . The interface comprise functions and the corresponding data.

there were two main requirements for this new development i.e. new SAS based on IEC 61850.

i) interoperability: protection and control devices from different manufacturers should be able to work together within the same substation. It should be easy to substitute a new model or manufacturer for any device. It is should be an open system.

ii) powerful engineering and maintenance tools. These tools should allow reutilization of engineering at different substations and easy modification of the system (for example, a change in the data base should be as simple as adding extra wiring for a conventional substation).

3.2 Smart Gateways

Gateways are used both in complete IEC 61850 systems (for connection to the network control center (WCC)) and in hybrid systems for the connection of different protocols. Consequently, gateways are a functional part of IEC 61850 systems, hence they must also be considered in the assessment of the benefits and the capacity of the system as a whole.

The smart gateways should fulfill the following functions:

- protocol conversion
- Buffereing
- data monitoring
- enhanced functionality
- SCL support
- flexible implementation

3.3 Wireless data communication in power system operation

The wireless data communication technologies include old technologies such as spectrum and MAS, as well as newer technologies such as Wi Fi, Blue tooth, Zigbee, Wi Max , and phone systems .

Wireless data communications are becoming widespread in many industries, since they offer significant benefits over wired communications, including low cost intercalations, rapid deployment, and easy user access mobility. At the same time the use of wire less technologies in power substation presents all of security and reliability concerns. These concern include the impact of noisy electrical environments wireless media, the reliability of the currently available commercial wireless equipment, the over loading available bandwidth (particularly during emergency conditions), and the security of communications. Wireless could provide viable and attractive alternatives to wired solutions.

3.4 Wide area network (WAN)

By introducing protection and control equipment which is equipped with Ethernet communication facilities, it is of course natural to also build a local area network (LAN) within the substation. By connecting the LAN to a router all equipment connected to the LAN can be accessed via the WAN by connecting the computers in new substations to a WAN, it increase the possibility for the operators, protection engineers etc. to get more detailed information from the substation compared to using the ordinary remote control facilities . For example, local event list and disturbance recordings can easily be transferred to a central fault analysis functions. Even equipment that only communicates via serial communication live Rs 232 can be connected to the WAN via an asynchronous device server.

4. WEB – CAMERAS In Substation

Substations today's are unmanned and every operation of high voltage apparatuses done from remote control centers. In this type of substation all the apparatus will be operated from remote, also the earthing switches.

Before operating an ear thing switch from remote, the operator must, from personal security point of view, be absolutely sure that no people are close to the apparatuses, which can be verified by the camera view. It is also a grate at advantage for the operator to be able to get a close up verifying the closed position of the earthing switches before issuing work permits on e.g. power lines.

In order to fulfill these requirements, web cameras has been installed in substations.

In a large substation, one or two cameras will be enough to cover the whole switch yard.

Camera(s) with fixed setting of zoom and pan can be used to get an over view of the substation. At least one of the cameras can be maneuvered from remote by changing its zoom level and the panning. This camera can be used to get close up views of e.g . . . . close ear thing switches . The maneuverable camera is set to a number of pre set positions in order to facilitate for verify the position for a specific apparatus.

Since the web cameras are connected to the WAN the operator can follow the activities in the switchyard an in real time. Together with the possibility to switch on the switch

yard lighting, the cameras can be a useful complement when the intruder alarm has been activated. It is also possible to identify persons or vehicles outside the gate or close to the control building entrance. The operator can then unlock the door of the control building from remote if it is necessary.

5. Conclusions:

New IT technologies offer new solutions for the protection and control system development. By using IEC 61850 standard:

i) further reductions in hard – wiring and cabling during installation is expected .
ii) software is hardware independent and different kindly of hardware can be used for protection and control
iii) separate markets cab be established for hardware and software components , which will speed up development .
iv) Interoperability for IEDs from different manufactures. It is should be an open system.
v) Wireless technologies could apply to power substations.
vi) Engineering and maintenance of communication will be simplified and cost savings are also foreseen.
vii) The benefits of open systems include longer expected system life, investment protection, upgradeability and expandability and readily available third party components.
viii) Application of the IEC 61850 standard has been found feasible to develop a complete protection and control system in real substation.
ix) to achieve interoperability , the user must have a detailed specification of the data models and communication services .
x) the implementation process is neither simple nor impending although very necessary .

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