# NEW STANDARD SOLUTIONS FOR DATA ACQUISITION IN INTELLIGENT PROTECTION SYSTEMS

George MATEI[1]

*Dezvoltarea sistemelor de comunicaţie şi achiziţie a datelor reprezintă un pas important ce permite dezvoltarea unor echipamente de protecţie adaptive şi a unor sisteme de comandă inteligente care sunt dependente de viteze de comunicaţie mari şi o acurateţe deosebită în transmiterea datelor. În opinia autorului reprezintă contribuţie personală prezentarea modului în care echipamentele de comunicaţie şi achiziţie de date au evoluat precum şi evidenţierea interdependenţei între aceste echipamente şi sistemele de protecţie comandă control în staţiile electrice. În lucrare au fost prezentate noile protocoale de achiziţie şi comunicaţie în staţiile electrice precum şi tendinţele de dezvoltare în domeniul comunicaţiei pentru echipmanetle energetice*

*Development of the communication systems and data acquisition represent an important step which allow the development of the adaptive protection equipment and of the intelligent control systems that are depended by the high communication speed and special accuracy in data sending. In the author opinion, represent a personal contribution the presenting the way, which the data communication and acquisition systems had evolutes and the prominence of interdependence between these equipment ant the substations protection and control systems. In the paper was presented the new protocols for data acquisition and communication, which are used in the electrical substations and the communication development tenors for electrical power field.*

**Keywords:** protections and control systems, communication protocols, data acquisition

## 1. Introduction

The protection and control systems had a deeply full changes way due to the microcontrollers and digital communication appearance. Intelligent and multifunctional terminals (IEDs – Intelligent Electronic Devices) had replaced the classically equipments which had a lot of electro-mecanique equipment. Combining protections, monitoring and control devices and the integrated automation systems – LAN (Local Area Network) type systems, these equipment are in the top of technology for present day energy systems. The modern communications, which contain Internet facilities, are used for monitoring, settings, and recorded events on numerical terminals taking-over. High

[1] Project Manager, Siemens SRL Romania, george.matei@siemens.com

performance and low costs were decisive factors in implementing of these technologies. Implementing integrated systems tenor will continue due to the important factors like low costs pressure, competition, and technology progress.

## 2. Standards and new communication protocols

Simple systems for electrical distribution or for industrial networks use protection terminals, which combine the protection functions and control functions since a PC central unit is available. Alternatively, there is an increase in a using of RTUs (Remote Terminals Unit) with open input/output units. Ethernet communication is accepted generally in LAN networks type. Profibus and LON communication protocols are used in Europe, while DNP3.0 and Modbus are preferred in USA. Recently was introduced also the Ethernet protocol with TCP/IP. Big energy networks use a central unit (server) and separately units for control. The protection relays are independently and connected with these control units. The remote control functions are included in the central unit IEC60870-5-101 communication standard was adopted for communication between big substations and central dispatch center. Time synchronizing (internal clock) for equipment which are in direct communication are made using the GPS (Global Positioning System) technology which use four interconnected satellites for a permanently synchronization of connected equipment. Direct communication (peer-to-peer) between digital terminals, which are included in different cubicles, is used for interlocking and automation functions like ABT (Automatic bus bar transfer) or autoreclosure function. This communication type is not used for protection function due to the low reaction time (in some cases the total time can be 100ms).[1]

The new IEC 61850 standards for open communication in substations was finalized and was already implemented in networks applications. This standard is the only one, which cover the communication at all three levels of substations equipment: station level, bay level and process level. The other standards like DNP3, 60870-5-103, UCA 2.0, LON cover the communication only for one or two levels because most of them was developed for specific tasks. IEC 61850 is based on a common application model of substation automation functions. It defines a set of standard interfaces through which data flow. These interfaces are called nodes, and a logical node is like a window or function to outside world. The use of Ethernet technology fulfils user requirements to access al intelligent components of the automation substation system. The information exchanged between devices includes operational information and configuration information. Operational information, such as status and control, is standardized and of medium priority. Configuration information, such as file transfer and changing settings, is of low priority.

The major advantage of IEC 61850 is the interoperability of IEDs of different manufactures and the elimination of gateways. The absence of gateways means less equipment, no delays and no additional errors caused by protocol conversions. The use of Ethernet communications for all the substation automation functions means standard and simpler cabling in comparison with the use of parallel communications. Ethernet communication is highly backward and forward compatible. For example, a 10Mbit/s network can be included easy into a 100Mbit/s, and a 100Mbit/s can be included into a 1Gbit/s network in the same manner.

The use of the Ethernet TCP/IP based protocols for substation communication will open the world of the Intranet and Internet of the substation.

## 3. Trends in data acquisition systems

The latest trends in the data acquisition systems field are the Internet technology. The important manufacturers already have in their offer, integrated control, monitoring and protection systems for electrical substations, which include hardware equipment for communication via Internet. Using Internet, data acquisition and information exchange can be with low cost and involving a large number of users. New and complex functions there are possible to be set from national dispatch control center. This technology use high-level security levels up to 128 bits since exchanged data are very important. In Japan, some integrated control and protection systems were energized by remote control after mini-servers were implemented in the cubicles at control and protection terminals. These equipment are based by JavaVM (Java Virtual Machine) communication. [2]

The implementations in the substations of the technology for server level application were tested also at England National Dispatch Center (NGC). Relays, control and monitoring devices were connected to a central server using an Ethernet gateway. The obtained data were stored in a SQL database in order to be accessed by standard browsers using ASP (Active Server Page) standard procedures.

An American manufacturer had been made a real progress offering a monitoring system which was managed from manufacturer using the own high capacity servers. The user had to install in his substations the equipment and supplied hardware and to connect them to Internet using a local provider. Security against unauthorized access is guaranteed due to security passwords, complex access procedures and high tech firewalls were used. [3]

### 3.1 Sensors in acquisition systems

In the electrical substations, electronically sensors are used for data acquisition instead classical current and voltage transformers. The sensors are used in combination with digital protections and control equipment, which allow the design of compact and more reliable substations than classical type.
In the distribution field these equipment already come up and are used. Therefore, the measurement transformers were replaced with sensors based on Rogowski coil or low signal core transformers. Capacitive or resistive voltage dividers are used like voltage sensors. Low level of the voltage need shielded cables in order to connect the integrated control and protection equipment (IED). [4]

The idea of the current transformers replacing is sustained by low energy consumption of the acquisition systems at automation and protection modern devices. Also the following specifically problems of the current and voltage transformers sustain this change:

- High costs of current and voltage;
- Accuracy is affected by secondary circuits loading, power consumption of all devices which are connected in the secondary wirings;
- In the dynamic regime there are problems which are linked by short-circuit issues like: magnetic circuit saturation, deformation of wave shape;
- Voltage transformers are week points in electrical networks due to the isolation problems;

a) Rogowski coil sensors

This type of transformer use for working also the electro-magnetic induction low but the magnetic circuit, which usually is made from ferromagnetic materials, was replaced with magnetically core (sill). From this reason, the output power is very low and transfer characteristic is linear type. An analog-digital converter can be integrated in this transformer and data can be transmitted using fiber optical transmission system. In this way, problems like electro-magnetic compatibility are avoided.

b) Capacitive voltage sensor (transformer)

A capacitive voltage sensor is made based of capacitive voltage transformer principle. Modern achievements include metallically reinforcements, which are immersed in the bushings. For SF6 equipment, due to the decrease of isolation distances between live parts and earthed parts, the voltage sensors can be used very easy and the development possibilities are very high.

There are produced also the combined sensors for current (with Rogowski coil) and for voltage (capacitive type). Execution principle takes in consideration the mixing of current sensors manufacturing technology with voltage sensors manufacturing technology. Since the combined sensors save a lot of space, this can be used in the equipment compact solution in the medium voltage substations.

c) Current sensor based on the Faraday Effect

Faraday Effect consists in changing of light polarization angle due to the presence of the external magnetically field. External field is produced by the current, which must be measured. The measured process must be a near one. [8]

On the high voltage side, were appeared the opto-electronically current transformers and voltage transformers for measuring which are working on the Faraday and Pockels principles. Current and voltage sensors which include digital outputs and data transfer bus are connected on the data collector bus at switchgears level in order to send data at distance (transfer rate is 100Mbit/s or even 1 Gbit/s). [5, 6, 7]

A high number of pilot projects take in consideration the current and voltage sensors implementing for distribution substations and even for transport substations. These projects have two objectives: reducing of the equipment costs and the increasing of the equipment performances.
Using of new sensors at high voltage switchgears (air or gas insulated) is the result of many advantages. In the air insulated substations, the optical sensors are very often used since cover long distances between phase potential and earth potential. For gas-insulated substations, optimized inductive current converters are preferred like on medium voltage substations. The voltage measuring is made with resistive and capacitive dividers in both solutions.

The measuring current equipment isolation can be simplified using dielectrically materials like fiber optic. This equipment is called optical sensor and use conventional or semi-conventional low voltage elements in order to transform a current into a low voltage signal, which can be sent to an analogical and digital converter. This converter is installed on the high voltage side of equipment. Using a optically communication unit and fiber optic all information are sent until to the earth potential. Hybrid systems had the following disadvantage: electronically circuits are on the high potential side. This disadvantage can be solved by using on the passive measuring devices, which are working based on the Faraday principle. Light polarization plan (linear polarization) rotating when the light is conducted on the magnetically field. If a coil, which is made from fiber, optic or glass ring will be used for light guidance on the conductor way, the current from

the conductor can be measured. One sensor with a fiber optic coil is much sophisticated from manufacturing technology point of view, but has the advantage of compact shape, flexibility and vibration insensitivity.

The advantages of this new technology for current measuring are:

- Own electrically isolation;
- Compact design and low weight;
- The possibility of circuit breaker installation;
- Low cost for installation and maintenance;
- Environment safety since do not use oil or SF6;
- High efficiency for protection systems;
- Personal safety improved (all the connectors are isolated on the high voltage side);
- No saturation, no remanence, no resonance;
- High bandwidth, linear response;
- No additional error due to an A/D conversion in the secondary equipment
- High reliability due to completely passive sensor head and self-monitoring.

### 3.2 Semi-conventional transducers

Compared to air insulated switchgear the service conditions in gas-insulated switchgear are quite different. The reduced spatial distance between high and ground potential allows a compact design with a current sensor located on ground potential. Generally, the service conditions are more similar to those in medium voltage equipment. Therefore, in high voltage GIS current transducer of the same type as in the lower voltage range is applied. The current transducer is also based on conventional current transformer technology. The sensor is connected to a merging unit, which performs the analogical/digital conversion and transmits the data onto process bus.

Major advantage of these semi-conventional transducers is their compatibility to conventional instrument transformers. Having the same dimensions and using the same support both conventional instrument transformers and sensors for digital bus systems can be combined within one GIS (Gas Insulated Switchgears) offering the possibility to apply a new control and bay protection together with an existing bus. Semi-conventional transducers together with their burden can be designed in such way that they work precisely in a wide over-current range covering the requirements for metering, measurement and protection. [9]

For voltage measurements optical sensors using the Pockels-effect, which is similar to the Faraday Effect but for the electric field, are used. On the other

hand semi-conventional technologies with low output power like RC-dividers offer similar advantages at a lower cost.

The technology of these RC-dividers is used since more than 20 years. The main application was in DC voltage. Amplifiers have been used in the past between the low voltage terminal of divider and the secondary equipment. The new developed divider can be used with a direct connection of the secondary voltage to protection relay and measurement equipment or with a digital link using the merging unit. Dividers for system voltage up to 170kV have been tested, higher voltages are under development. The dividers can be build in housings for single phase and three phase encapsulations and for AIS (Air Insulated Switchgears).

With the using of new current and voltage sensors, use of the old analogue interfaces with high output power and currents up to 100A does not make sense anymore. Modern digital protection and control devices do not need high power anymore and for the new sensors, it is impossible to supply it without loosing much of their advantages.

Novel electrical instrument transducers have been developed in the last years. Performed field tests have already shown the maturity of this new technology. The design of these sensors must be optimized for the voltage level and the environmental conditions of the switchyard. Specialized designs allow to the user to gain maximum advantages from this new technology. For the success and the broad use, the standardization of the analogue small signal and the digital interface has to be finalized.

## 4. New standards and protocols in data acquisition systems

The future progress in data acquisition systems, in the data integration and storage will allow a development on the protection functions, monitoring, data recording and fault locating functions. A large range of LAN networks and using of Internet technology (integrated relay servers and browsers for main dialog) will determine a high availability of information. Selecting of necessarily information from a multitude of recorded and stored data in database will remain. Expert systems should take over this task.

With introducing of new technologies and media implementations such: color graphical, video images, voice recognition will increase the functionality, performance and high control of the substations. “Wireless hand” devices will be used for local control. These devices will be interconnected in WAN systems (Wireless Area Network) which will be connected with control center system at national dispatch center. The access for operations control will be possible in every place due to the mobile communication via Internet. The control of the substations from a distance (remote control) will be extended also to the

distribution systems level. The automation of the distribution substations will bring high reduction of personnel, which sometimes are not so well accepted. Some customers are also complaining about the complexity of the present integrated control systems and they requested easy setting procedures, setting and parameterization facilities, which do not need supplier's assistance. The technical specialists will noticed if the promised standards and communication protocols will be available in the near future and if the „plug and play" compatibility will enter in the electrical power field.

## 5. Conclusions

The particularities of the energy generating, transmission and distribution processes involve a high automation and protection level for all installations, which are included in this process.

The classical automation, with analogical apparatus (conventional type) is often outdated by the quality, accuracy, rapidity and reliability requirements, which are mandatory for these types of equipment and processes. Now the protection market requires new protections with multiple functions easy to parameterize and with very flexible software, which allow to the operator to implementing a wide range of the settings.

Appearance of the interface systems with processes had opened wide perspective of the microcontrollers and PLCs (Programmable Logic Controllers) and process PCs in real time with special control, optimized, diagnose prognoses functions that have a high efficiency and adequately reliability. The recent or the future researches take in consideration the interface systems for (numerical and analogical) data processing and the manufacturing and implementing of industrial applications prototypes.

In this context, the control equipment development and electrical processes automation are the priorities of the informational technologies development and models library development for technological equipment and processes and for the elaboration of the software control advanced strategy.

Analyzing the actual stage of development for interface systems needed for main data acquisition and processing and the facilities at the hardware level, with accent on the microcontrollers and PLCs use for rapid processes, the elaboration of the coherent conception succeeded for present and future developments of this application. Development of the communication systems and data acquisition represent an important step which allow the development of the adaptive protection equipment and of the intelligent control systems that are depended by the high communication speed and special accuracy in data sending.

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