# Modernization of Electrical Substation Automation Systems Using IEC61850

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**Abstract -** *There is a need for a high-performance, flexible substation automation system (SAS) that is easy to incorporate. The increasing use of Intelligent Electronic Devices (IEDs) in substation protection, coordination, control, monitoring, metering, and testing offers interoperability and enhanced communications capabilities. The IEC Technical Committee 57 worked to create IEC 61850, an open standard for substation modelling and communications. The international adoption of the standard has grown in popularity. This article explores the use of IEC 61850 in conventional substation automation. It introduces the experience of a real SAS modernization scenario. This instance emphasizes how useful the IEC 61850 is for operating and monitoring substations.*

***Key Words***: **IEC 61850, Substation Automation System, IEDs, GOOSE message, intelligent control, protective relay**

## 1. INTRODUCTION

To better meet the demands of expanding Intelligent Electronic Devices (IEDs) installation, effective communication, comprehensive protection, and future growth, power system substations are undergoing renovation. In order to operate and control power system components, modern substation automation (SA) makes use of data from IEDs, control and automation capabilities within the substation, and control orders from remote users. Ethernet technology brings a standard physical connection that makes universal communication protocols possible and lays a solid foundation for substation automation systems (SAS). The integration of IEDs, Ethernet LAN, communications protocols, and communications methods, make the whole substation a functional system with the combination of correct physical/virtual connections, common communication protocols, shared storage, and sequential/combinational logic for coordinated monitoring, protection, and control. The data models defined in IEC 61850 can be mapped to several protocols. The most important international standard for substation automation systems is IEC 61850 and its related standards. The installation of IEDs in substations, when combined with IEC 61850, enables interoperability, flexibility, and increased efficiency and creates a wide range of potential solutions for substation operation, protection, monitoring, control, and automation.

### 1.1 Goals of SAS Project

**An Open System:**

- Ability to configure an IEC61850 system using manufacturer tools already in existence without requiring on-site manufacturer support.
- To carry out automated activities, communication, protection, control, monitoring, and measurement data from IEDs can be combined.

**Higher Efficiency:**

- Ethernet-based, quick communications systems.
- A successful data management system.

**Lower cost:**

- Using less copper cables, commissioning becoming simpler, and the likelihood of failures decreasing.
- Auxiliary relays and other apparatus in the control and protection panels are reduced.

**Flexibility:**

- The ability to test any LED individually without worrying about interfering with the substation's routine operations.
- Modernized substations enable free function allocation, allowing any vendor to carry out a particular task using its own design.

## 2. NETWORK ARCHITECTURE

IEC 61850 standard often adopts the DNP3 LANIW AN protocol for supervision system communications. In order to use this protocol, a gateway is required to gather and process IEC 61850 data from the IEDs, convert it to LANIW AN, and deliver it to the local HMI and the distant control centre. The process bus is defined and essential to data collection and exchange in the IEC 61850-based architecture. The substation system architecture is separated into station level, bay level, and process level, as seen in Fig. 1. In Fig. 2, the plant's network connection diagram is displayed. Signals can be transferred between the bay level lED and station control (station bus), the bay level lED and system equipment, and devices and transducers via the station bus and process bus (process bus). The twin redundant stations and process bus are displayed in the communications architecture. Compared to a single bus, this offers crucial substations a higher level of reliability. Ethernet switches set up in a ring configuration are frequently used to implement the station and process bus systems. Only station buses are used in conventional system architecture. Hierarchical rings are preferred for the station bus and process bus in substations based on IEC 61850. The ability to deliver current and voltage samples from a merging unit to numerous devices that use them for various applications is the foundation for the applications of the IEC 61850 process bus. IEC 61850's Part 9-2 explains how sampled values can be exchanged in place of a traditional analogue interface. Control and monitoring of IEDs can be done using GOOSE, and their data can be transmitted using TCP/IP. The timestamp resolution to the microsecond is required by the IEC 61850 standard. Accurate timestamps can be produced by IEDs whose clocks are synchronized to the same time standard.

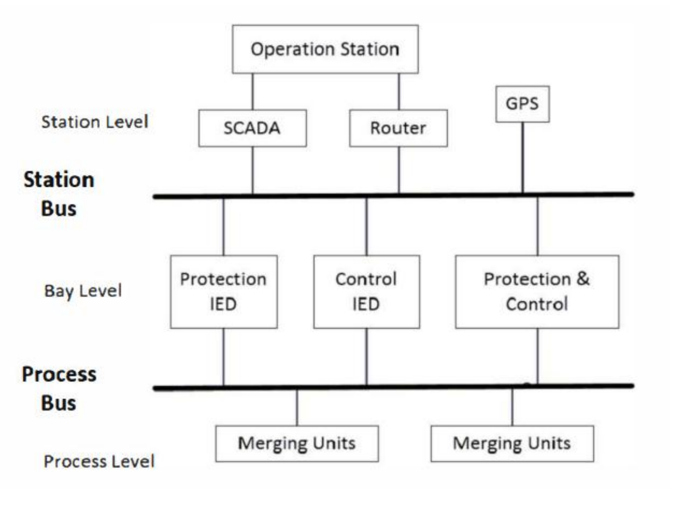


**Fig -1**: Simplified Communications Architecture Based on IEC 61850

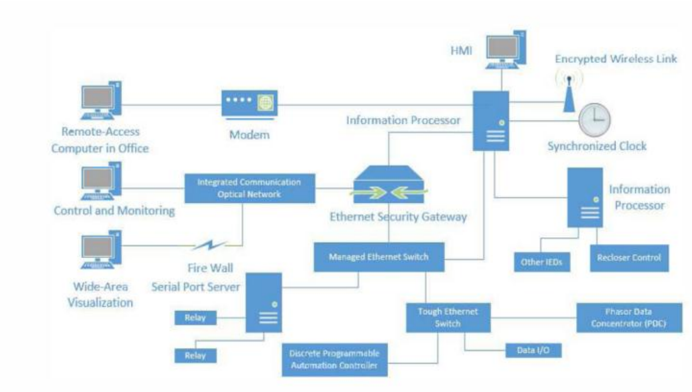


**Fig -2**: Example Network Communications Diagram

IEDs attached to Ethernet switches can all be controlled. Optical cable is used to link to the bay controllers, protection relays, circuit breakers, and gateways. For redundancy, multiple IEDs are required to control some IEDs, such as circuit breakers and switches at the IED level. The sampled values produced by a merging unit from conventional or non-conventional converters in the case of GOOSE are a continuous data stream in a stationary case (no change in status). With regard to sampling values, the process bus must be isolated from the station bus.

## 3. GOOSE MESSAGE APPLICATION

A framework for achieving interoperability between IEDs provided by various vendors is provided by IEC 61850. The distribution of tasks among gadgets and control levels is flexible. The standard therefore supports any function allocation. Interoperability should be offered between tasks that will be carried out in a substation but reside in equipment (physical devices) from various vendors in order to enable a free allocation of functions to IEDs. Functions may be divided into pieces and executed by various IEDs, yet they still communicate with one another (distributed function).The station level, the bay level, and the process level are the three levels where functions can be assigned. A new structure was created to carry out these functions, comprising the extra logical interfaces (IF). The IEC 61850 series is built on the diagram in Fig. 3.

The meanings of the interfaces are as follows:

**IF1:** Protection-data transmission between the station and bay levels.

**IF2:** Interchange of security-related data between local and distant protection (beyond the scope of this standard).

**IF3:** sharing of data at bay level

**IF4:** Instantaneous data interchange between the process and bay levels via CT and VT, particularly for samples.

**IF5:** Interchange of control and data between the process and bay levels.

**IF6:** Control-data transmission between the station level and the bay.

**IF7:** Data transfer from a substation (level) to a distant engineer's office.

**IF8:** Direct data transfer across the bays, particularly for quick operations like interlocking.

**IF9:** Data exchange within station level

**IF10:** Exchange of control information between a substation (devices) and a distant control centre.

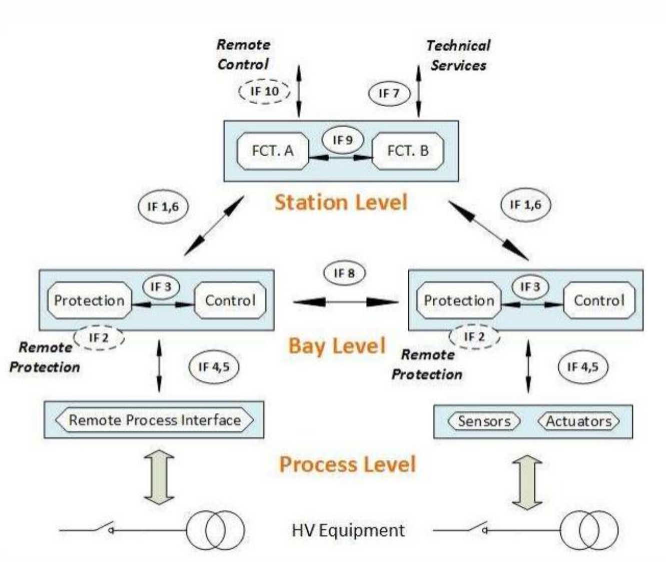


**Fig -3**: Interface Model of a Substation Automation System

According to IEC61850-1, logical interface 8 is utilised for peer-to-peer direct data exchange between bays, and as illustrated in Fig. 5, GOOSE messages may also be transferred between the bay and station bus (level). For the purpose of sending messages between various IEDs and utilising the message data in automation and interlock logic schemes, the IEC 61850 standard employs the peer-to-peer IEC 61850 GOOSE protocol. A real-world use of GOOSE in a substation protection plan is shown in Fig. 4. Relay/copper wire hard wiring is replaced with GOOSE messages using the IEC 61850 standard to provide comparable performance and outperform copper connections in timing. In the event of a feeder circuit breaker failure, the SAS may use GOOSE messages to transmit a trip command to the power transformer secondary circuit breaker. Traditional copper wire connections can fail without warning, but the IEC 61850 method is more secure because if a connection fails, the system quickly sends alerts due to the loss of GOOSE system health messages.

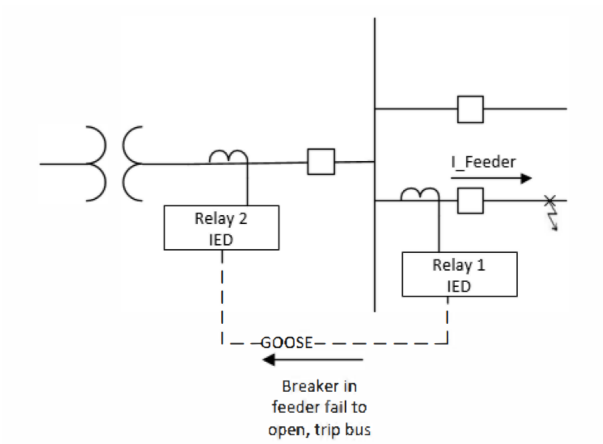


**Fig -4**: Circuit Breaker Trip Failure

The flowchart for the protection strategy utilizing GOOSE messages is shown in Fig. 5. The feeder current will be detected by Relay 1's lED as being higher than typical in such a malfunction. The feeder circuit breaker receives a trip order from the LED. Relay 1 lED will transmit a trip instruction to Relay 2 lED, and Relay 2 will trip the bus by opening the circuit breaker in the transformer branch, if it determines that the feeder current is still high after a predetermined amount of time, indicating that the fault has not been cleared. The protective system terminates if the feeder current reaches normal levels after a predetermined amount of time. The backup protection system will take over if the fault current is still present in the feeder (perhaps as a result of both circuit breakers being out of commission). Circuit breakers in the transformer branch react more slowly to electromagnetic current relay protection techniques than more modern protection methods. The circuit breaker will trip the bus more quickly if GOOSE messages are used. In order to offer redundancy, the relay IEDs are connected to two Ethernet channels. If one of the communication lines fails, this will greatly boost the scheme's reliability. In order to offer redundancy, the relay IEDs are connected to two Ethernet channels. If one of the communication lines fails, this will greatly boost the scheme's reliability.

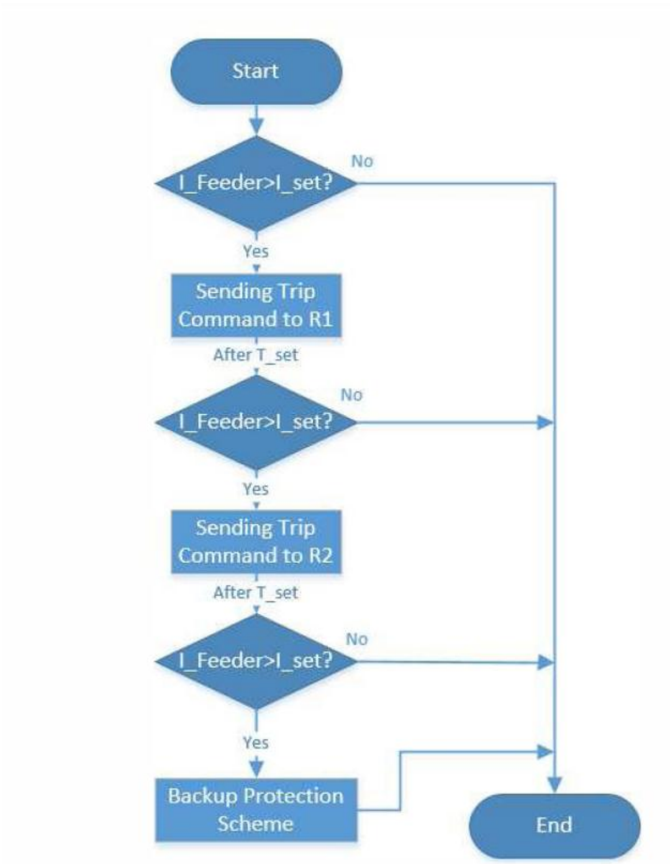


**Fig -5**: Flowchart of Protection Scheme Using GOOSE

## 3. CONCLUSIONS

To better meet the needs of upcoming power systems, power system substations are being updated with an increase in the installation of intelligent electronic devices (lED), effective communication, and comprehensive protection. In SAS, IEC 61850 is now a widely recognized standard. In this study, the SAS modernization experience of a power plant integrated with the IEC 61850 family of protocols is presented. IEDs are easily integrated into this SAS modernization project to send control data between relays, automation controllers, HMIs, and other equipment.

The architecture of networks and communications is introduced in detail. In this system, the protection and control schemes are communicated between the feeder, bay control, and transformer relays using peer-to-peer IEC 61850 GOOSE messages. A circuit breaker failure prevention scheme application case is provided. With the help of equipment from different manufacturers and the adoption of IEC 61850, the plant owner was able to improve system operation efficiency and implement comprehensive protection, control, and monitoring.

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