

gement of power systems and primary equipment in substations and readers, who are more familiar with information technology (IT) and involved in the development, design, production, and application of modern IEDs intended to be used for SA.

The authors share their vast experiences in the field of SA gained for more than 20 years and were personally involved with the development and implementation of a comprehensive platform for multipurpose control and protection IEDs as well as in the process to standardize the communication within substations, which has resulted in the new Standard IEC 61850.

### 555 55444 Serial connection to protection devices

From technical considerations, the best solution is a direct digital fiber optic process bus connection rather than low-level and non-active signals that might have to be amplified to conventional values like 1 A or 100 V thus requiring expensive amplifiers and having information loss due to the acceptance and holding of the signal. The main obstacle for the application of a serial connection is the lack of international standards that assure the interoperability between IEDs from various vendors. This problem has been addressed by the new IEC 61850 standard.

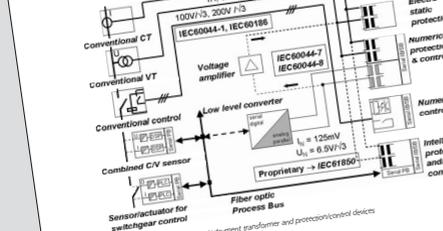


Figure 5-9 Interfaces between instrument transformers and protection/control devices

## Chapter 5 · Primary Equipment in Substations

Apart from substation related issues, the SA Handbook highlights that the implementation of SA enables a new strategy related to wide area protection that counteracts multi-contingency disturbances in order to avoid power system collapse.

### 555.1.1 Process electronics (sensor technology, PISA)

Decentralized distributed microprocessor based modules (PISA—Process Interface for Sensors and Actuators) can be used for direct control of the protection and control of switchgear installations. At the same time, these modules enable a wide range of protection and control functions to be implemented locally without the need for a central control unit.

Another possibility for reducing the space required for outdoor installations is the use of hybrid gas-insulated switchgear (GIS) and gas-insulated circuit breakers (GIS-CB) installations and circuit breakers (GIS-CB) installed in a common gas insulated housing (GIS-H). The main advantage of this technology is that the GIS-CB and GIS-H are installed out of doors.

All new switchgear components are distributed by consistent integration of non-conventional sensors in this case primarily current and voltage sensors, protection and control functions, and connection to the bus control with fiber optics. The key is the following:

- increased availability
- smaller project runtimes and
- extended maintenance intervals with a significant increase in case of maintenance.

Figure 5-10 Split switching module with CT Circuit breaker (CB) and interlocked DC, earthing transformer (ET) and surge arrester (SA) for 145 kV

### 555.2 Innovative switchgear

A significant step toward reducing the space requirements of switchgear installations has been made by compact multifunctional switchgear units. This concept is not new and has already been implemented many times in applications such as outdoor switchgear installations with draw-out circuit breakers. The implementation of non-conventional current and voltage transformers now makes it possible to combine a large number of functions in one device. As a

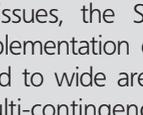


Figure 5-10 Split switching module with CT Circuit breaker (CB) and interlocked DC, earthing transformer (ET) and surge arrester (SA) for 145 kV

### 555.2.1 Compact outdoor switchgear installations

For the transmission of sensor data fiber optic cables are used and for the communication the transmission protocol according to the standard IEC 61850.

Electromechanical relays and push buttons only like the main characteristic from the system structure point of view is that each function point is realized within its own dedicated hardware.

- needs its own inputs and outputs to the process and to its own HMI (Figure 8-1).

The local control cabinet serves additionally as a marshalling point for sensor data from the switchgear to all devices which need it, using contact relays, separation amplifiers etc.

### 8.2 From conventional control to intelligent automation

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### 8.2.1 The Impact of Computer Technology

The advent of the microprocessor in the substation allows to process data in digital form. Therefore, the data must be converted to digital form before it can be processed for all binary data like alarms and switch positions this is not a big problem, because this data is already available in digital form. For analog data, however, it is necessary to convert it to digital form. The advantages of providing data in digital form are:

- Digital data cannot be distorted by aging of the hardware. Data gets and stays much more accurate than before. No calibration or testing is necessary after commissioning but the upper limit of the ADC may be recommended at least for protection.
- Data in digital form can easily be exchanged by serial communication. This reduces the former bundles of cables to a thin serial bus, usually in form of optical fibers.

### 8.1 Introduction

In the previous chapter we looked at substation automation system structures from the point of view of geography and from the operator's point of view. Here we will have another look from the electrical possibilities of existing conventional systems to the electrical communication structures, and from the safety and availability point of view of these structures.

- An EMU barrier against disturbances and over-voltage consisting of opto-electric coupled relays or opto-electric coupled relays with separating relays and interposing transformers shields the I/O from the outside world.
- A local fault either built in or via a serially connected PC allows to configure the IED.

This leads to the following typical structure for IEDs (Intelligent Electronic Devices) used at bay or process level in the process (Figure 8-2):

- An internal bus connects the central processing unit (CPU), the needed RAM, ROM, EPROM or flash memory, and the serial interfaces for communication to one side, and digital as well as analog I/O modules to the other side.

In order to enable long-term oriented maintenance, the approach that has been taken for the IEDs (Figure 13-3) is that the device should be able to be replaced in the field without the need for a complete replacement of the whole device. This is achieved by the use of a modular architecture. The device is divided into modules which can be replaced individually. The modules are connected to the main bus via a serially connected PC. This allows to configure the IED.

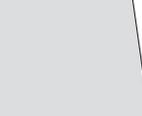


Figure 8-1 Conventional substation control and protection

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Figure 8-2 Typical structure for IEDs (Intelligent Electronic Devices) used at bay or process level in the process (Figure 8-2)

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### 6.3 Operative Functions

Operative functions are all those functions which directly enable an operator to control the substation. These are the typical SCADA functions: Supervision, Control, and Data Acquisition. The data acquisition part of SA systems contains some substation specific functions and performs attributes, which are not functions and performed in standard industrial SCADA systems. The same applies for the specific and safety related switch control functions.

If a network control center remotely controls a substation, then with the exception of the communication link to the network control center only the monitoring and data acquisition functions of SCADA might be implemented at the substation. This monitoring could be completely implemented locally with the possibility of remote operator access to the substation data. Another possibility is to have only the data acquisition function implemented at the substation.



Figure 6-6 Process state single line diagram for local substation operation and supervision

and the HMI and archiving related functions are located in the remote control center, which might cover a number of substations. For special purposes applications like asset management even a separate remote monitoring center can be used. The following sections describe the operative functions in detail.

### 6.3.1 Monitoring and supervision functions

The main purpose of monitoring and supervision functions is

- to show the state of the process, i.e. the switchgear and the control system itself,
- to inform about the development of possible dangerous situations and,
- to archive data for later evaluation either of the process performance, or for later failure analysis if some failures or dangerous incidents have occurred.

All those functions except disturbance recording are standard SCADA functions, i.e. they are not specific for substation automation, although some of their parameters like time stamp accuracy of 1 ms are specific for power system applications.

The typical monitoring functions are

- Event management
- Alarm management
- Data storage and archiving
- Disturbance recorder/fault data retrieval
- Log management

### 6.3.1.1 Process state display

There are different methods to browse through the process state of a system:

- **Zoom and pan:** one can move a window across a virtual picture of the whole system (panning) and get an overview of an area to see more details, or to get an overview out of an area respectively to big systems (sub-area). This is typically used for big systems (sub-area). This is typically used for big systems (sub-area). This is typically used for big systems (sub-area).

The following examples illustrate the hierarchic window approach.

The actual state of the whole switchyard is shown in a graphical overview, and in more detailed pictures by zooming in.



Figure 6-7 Process overview example of a small system with busbar coloring

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