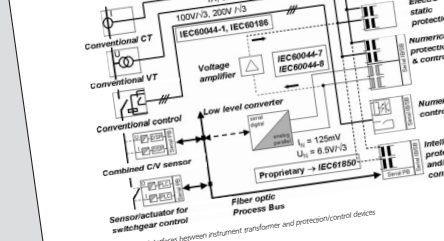


gement of power systems and primary equipment in substations and readers, who are more familiar with information technology (IT) and involved in the development, design, production, and application of modern IEDs intended to be used for SA.

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.

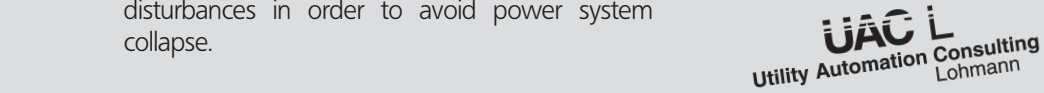
555 55444 Serial connection to protection devices

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 boring information loss through the amplifier and boring information loss through the amplifier and boring information loss through the amplifier...



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.



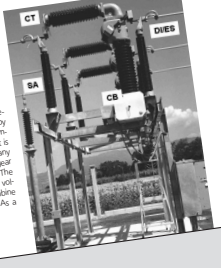
555.1.1 Process electronics (sensor technology, PISA)

Decentralized distributed microprocessor based modules PISA—Process Interface for Sensors and Actuators can be used for direct control of the protection devices in substations. The main advantage is that the modules are installed close to the sensors and actuators, which reduces the length of the signal lines and improves the reliability of the system.

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). These devices combine the advantages of GIS and conventional switchgear, resulting in a more compact and reliable design.

555.2 Innovative switchgear installations

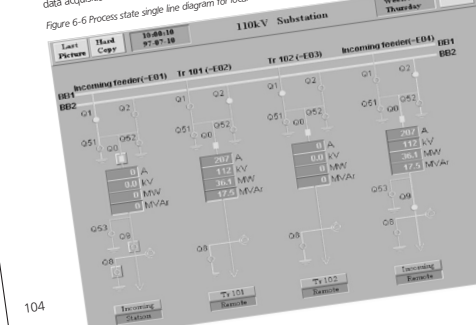
A significant step toward reducing the space requirements of switchgear installations has been made by compact outdoor switchgear units. These units are designed to be installed in a more compact and reliable manner, reducing the overall footprint of the substation.



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.



Chapter 6 · The Functions of Substation Automation

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. It also provides information about the development of possible dangerous situations and allows for later evaluation of the process performance or for later failure analysis if some failures or dangerous incidents have occurred.

8 Substation Automation Architectures

8.1 Introduction
In the previous chapter we looked at substation automation system structures from the point of view of the operator and from the point of view of the system. Here we will have another look from the system architecture point of view, and from the electrical communication structure, and from the electrical communication structure, and from the electrical communication structure...

8.2 From conventional control to intelligent automation
Conventional control means that the substation control functionality is implemented by means of devices like electromechanical relays and push buttons only. The main characteristic from the system structure point of view is that each function point is realized within its own dedicated hardware.

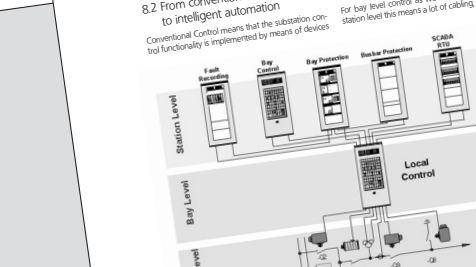


Figure 8-1: Conventional substation control and protection

Chapter 8 · Substation Automation Architectures

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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 zoom in on a specific (sub-)area. This is typically used for big systems (GIS) and mostly if one wishes to navigate into a neighboring 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 on a specific area.

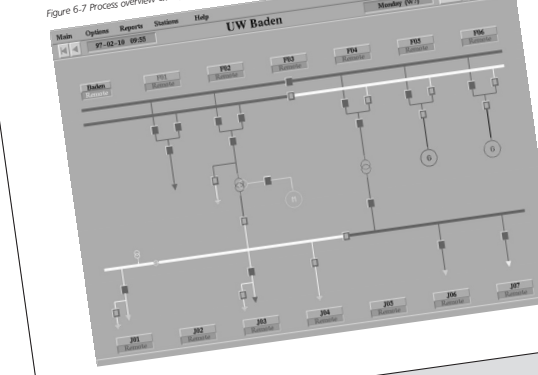


Figure 6-7: Process overview example of a small system with busbar coloring

6.3.1.2 System protection center
The incoming data from the PMUs must be pre-processed and arranged in a database structure. The system model for the actual situation is generated via calculation considering the actual grid topology. On this basis, the stability status is determined in terms of the power margin (PM) of the critical area. Optimized stabilizing actions are initiated accordingly.

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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. Before, a 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. This conversion is done by means of analog-to-digital converters (ADC) and is used to convert measured values to digital samples. 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.

8.2.2 Model approach
In order to enable the system operator to monitor the system, it is necessary to have a model of the system. This model is used to simulate the system and to provide the system operator with the necessary information. The model is used to simulate the system and to provide the system operator with the necessary information. The model is used to simulate the system and to provide the system operator with the necessary information.

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Chapter 11 · Wide Area Protection

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Chapter 13 · The System Standard IEC 61850 for Substation Automation

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13.5.3 The engineering approach
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Figure 11-10: Set-up of a wide area protection scheme with PMUs



Figure 11-11: Principle of stability monitoring



Figure 11-12: Voltage instability prediction

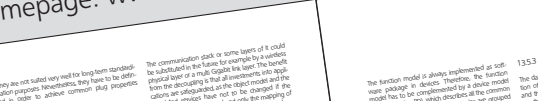


Figure 13-2: The approach of IEC 61850

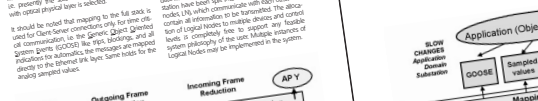


Figure 13-3: Mapping of IEC 61850 to existing communication technologies

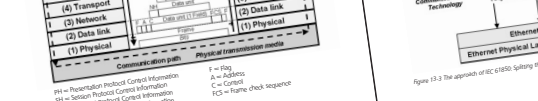


Figure 13-4: The approach of IEC 61850

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