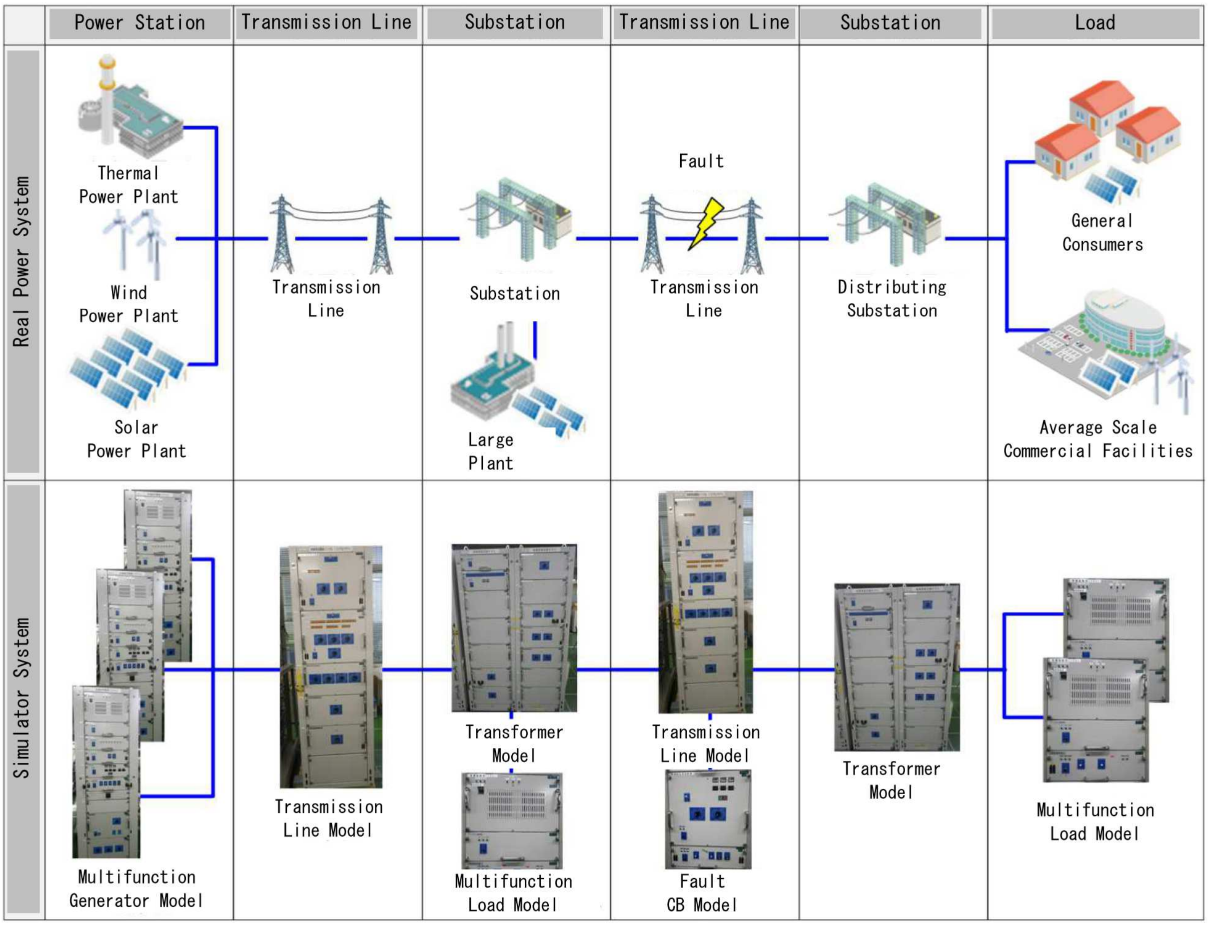
NAME : Yoshifumi FUKUYA
COUNTRY : JAPAN
REGISTRATION NUMBER : 2256

GROUP REF. : SC B5
PREF. SUBJECT : PS2
QUESTION N° : Q2.05

Experience in Studying Implementation of IEC 61850-based PAC Systems using Analog Power System Analysis Simulator

In Japan, as a preliminary step to install PAC equipment compliant with the IEC 61850 standard in a Digital Substation, a system consisting of such equipment was connected to an Analog System Analysis Simulator to evaluate the validity of the system. The Simulator consists of a 50V-62.5mA rated analog main circuit (Power System Simulation circuit) and the following model groups connected to it: Multifunction Generator Model group (hybrid type of arithmetic unit + analog amplifier circuit), Multifunction Load Model group (same configuration), Transmission Line Model group (RLC passive circuit) Transformer Model group (miniature transformers) and CB Model group. The primary voltage and current ratings are different from the Real Power System. The Simulator can simulate Real Power System conditions by properly interconnecting each model (Generator, Load, Transmission Line, and Transformer). In addition, PAC equipment (MUs and IEDs) for Real Power Systems can be implemented in this Simulator by modifying the voltage/current converter.



1. Implementation of IEC 61850 equipment

The number and function of MUs and IEDs in this Simulator are as follows

(1) Functions of IEDs for Measurement, Control and Protection (191 units)

・Analog main circuit measurement (PQVIF, etc.).

・Internal data measurement of the Generator Model (dq axis data, internal data of the control unit, etc.).

・Open/Close control of CBs (System Switching, Reclosing, when Protective Relays are Tripped, etc.).

・Transformer Tap control.

(2) Function of Protective MUs (34 units).

・Converts primary-side AC values to digital data with 3,75 degree electrical angle sampling.

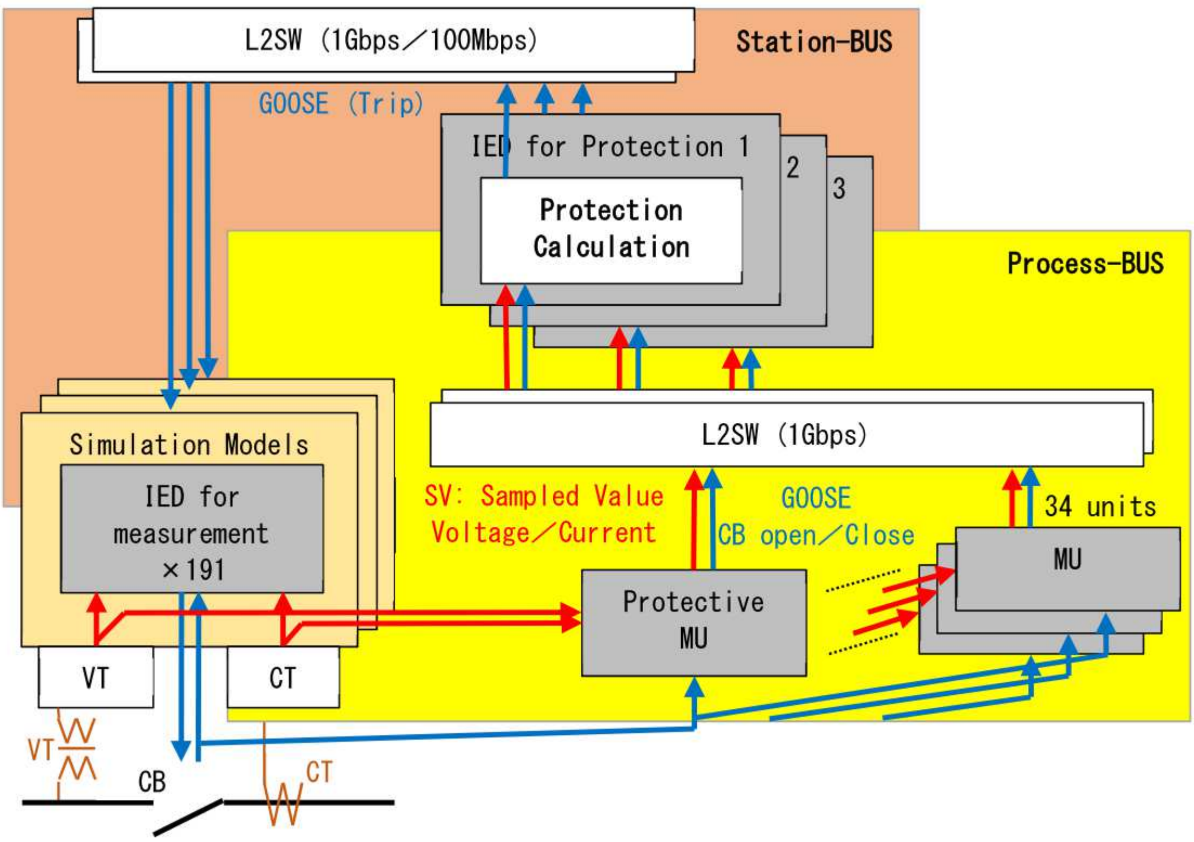
・Transferred to IED as SV data.

(3) Functions of Protective IEDs (3 units)

・Execution of various protective function operations using SV data from the Protective MU.

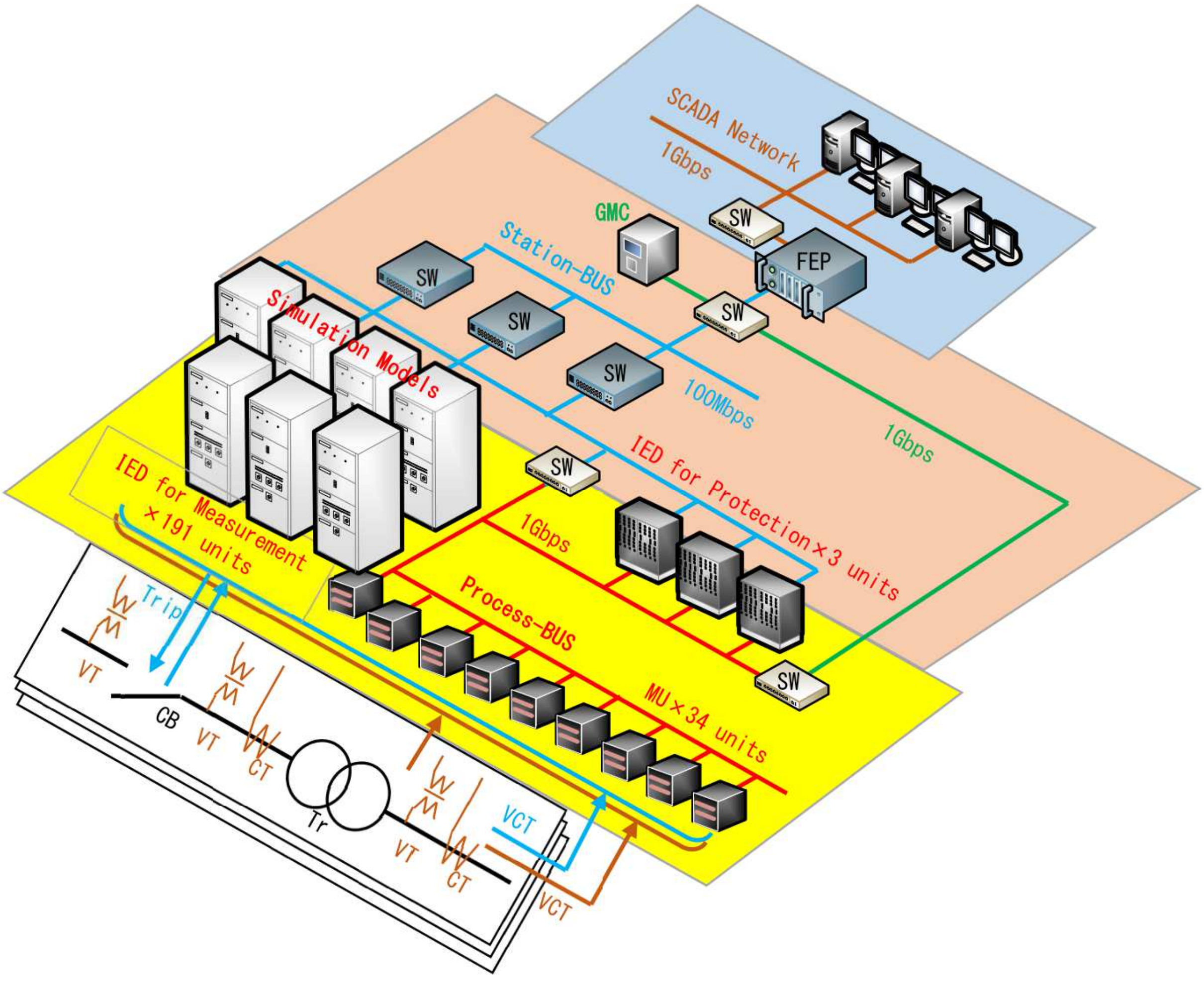
・Transmission of Trip commands from the Protective IED to the CB Model IED via GOOSE communication.

Various protective functions: Relay elements used in Real Power Systems (e.g. Current Differential Relays for Transmission Lines and Transformers, Distance Relays, Overcurrent Relays, Over- and Under- voltage Relays, Earth Fault Direction Relays, etc.).



2. Time synchronization system

There are a total of 228 IEDs for Measurement, Control and Protection, MUs for Protection and IEDs for Protection. Because of the all 228 units use Time Synchronization Master (GMC: grandmaster clock) and time synchronization (using IEC 61588-PTP standard), the time synchronization accuracy is within 1 microsecond. The IED for Measurement and the MU for Protection are sampling synchronized starting from the time synchronization timing of every second. Therefore, all digital data in the Simulator are all sampling-synchronized data (simultaneous data analysis is possible). However, due to the characteristics of the communication SW adopted for SV communication between the Protective MU and IED, phenomena such as sampling synchronization discrepancies, missing data, and retention occurred. From this phenomenon, we found that there is a problem in the communication network configuration or in the distribution of the amount of communication data through each SW. This experience has shown that the characteristics of the SW for SV data must be determined with the highest priority.



In Japan, based on experience in evaluating the application of IEC 61850-based Measurement, Protection, and Control equipment using Simulators, it is now possible to develop these equipment and study system configurations for application to Real Power Systems.

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