Basic Technology Subjects

System Engineering Research Laboratory

Brief Overview

The System Engineering Research Laboratory (SERL) conducts research on planning, operation, control, and analysis methods for electric power transmission, distribution systems, and information and communication systems, in order to facilitate the secure supply of electricity generated by large-scale and distributed power sources. The laboratory also pursues research on the development, testing, and assessment of customer service technologies to achieve the efficient use of electricity.

Achievements by Research Theme

Electric Power Systems

We clarify the effect of the large penetration of distributed generations on power system stability in terms of voltage deviation and power oscillation at the system fault condition. The development of distributed generation models is also an important task to conduct such power system stability analyses. In addition, we develop a support tool to coordinate protection relays under circumstances of increased complexity with a large penetration of distributed generations.

- Through a power system simulator experiment, we discovered unstable phenomena due to large amount of PV (photovoltaic) installations, such that system voltage did not recover after a system fault and that power oscillation increased with multiple oscillatory modes. PV models for stability analysis incorporating principal control and protection functions to analyze PV dynamics were verified through a comparison with experimental results.
- We improved the assessment method taking care not to overlook the malfunction of protection relay coordination in the condition of distributed generation installation and power flow change. This enabled almost every distribution system relay for short circuit protection and grounding fault protection to evaluate the relay coordination (R10007).

Customer Systems

We develop element technology for supporting the acceleration of energy-saving. We also clarify the effect of harmonic current flowing from customers connecting to high-voltage (6.6 kV) distribution lines on the suppression of the increase in voltage distortion of the distribution line.

- We developed a heat source characteristic model through which the heating performance of home-use air conditioners with defrost operation can be calculated simply by using an open technical document. We also verified the accuracy of the developed model by experimentation. The results led to the possibility of the high-accuracy estimation of air conditioner consumption power under various operating conditions, including defrost operation (R11017).
- We clarified that the harmonic voltage of a distribution line was due to harmonic current flowing from single-phase loads, while harmonic current flowing from three-phase loads restrained harmonic voltage (Fig. 1). We also clarified that the addition of series-inductive reactance to a capacitor installed at a high-voltage-using customer for reactive power compensation was an effective measure toward suppressing harmonic voltage (R11003) (R11009).

Communications Systems

As fundamental technologies of future communications networks for power utilities, we develop disaster countermeasure technologies, communication media technologies for facility maintenance work, security technologies for SCADA systems, and others.

- In order for the disaster tolerance of access optical fiber networks (PON) to be improved, we have proposed a highly dependable PON transmission system. An optical switch is installed at the shared transmission line of the PON system to connect with a neighboring shared line as a bypass route during communication failures (R11034).
- To improve the fault tolerance of IP networks, we proposed a faster route reconstruction method. While the existing routing protocol requires a long time to detect network failure by sending the hello packets periodically, our proposed method achieves a faster detection time by monitoring user IP packet flows on the network at any time (R11022).

Mathematical Informatics

To realize accurate diagnosis in electric power equipment maintenance and inspection, we develop diagnosis methods for electric power equipment based on high-performance machine learning and image processing techniques. We also develop optimization methods for complex large-scale systems.

- To support the restoration operation of power systems, we developed an efficient method to numerate all the restoration operations with the lowest unrestored loads and the minimum number of switching operations, and to classify them into various groups based on a restoration policy using the clustering technique (Fig. 2) (R11020).

- To observe the movements of overhead power lines during severe weather, we developed a new stable video tracking method to detect the targets attached to wires even in low visibility with heavy snow, by narrowing the existing areas of the targets based on the physical constraints and on image processing (R11007).

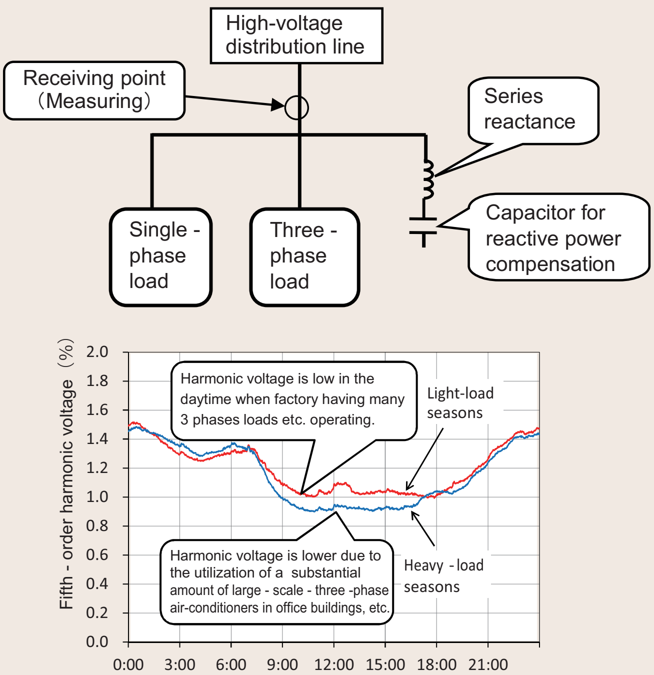
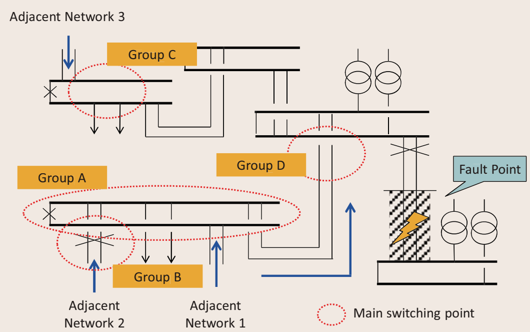


Fig. 1: Daily change of harmonic voltage

Daily change of fifth-order harmonic voltage, which is the largest value of all the orders (average of 66 measuring sites): Harmonic voltage tends to decrease in the daytime when loads increase, due to the suppression effect of three-phase load.



Group	# of target Systems	Unrestored loads (MW)	Energy not supplied (MW-min.)	Restoration policy (how to ensure supply margin etc.)
A	3	75.0 75.0 75.0	624.0 624.0 780.0	The de-energized loads are supplied by the adjacent network 1.
B	1	75.0	936.0	The loads are supplied by the adjacent network 2.
C	2	75.0 75.0	624.0 624.0	The main switching point is different (adjacent network 3).
D	1	75.0	780.0	More loads are supplied by the adjacent network 1.

Fig. 2: An example of enumerating all the optimal restoration operations

Similar restoration operations are classified into the same groups based on a restoration policy (restoration route, etc.).