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 development, testing, and assessment of customer service technologies to achieve more efficient use of electricity.

Achievements by Research Theme

Electric Power Systems

Fundamental techniques of transmission system analysis and evaluations, control and protection for economic and stable operation of the system are developed. Also, using these fundamental techniques, solutions for recent technical issues surrounding the increase in renewable energy introduction, wide-area interconnection and so on are developed.

- The aging of transmission equipment is becoming a crucial issue, and adequate maintenance/replacement schemes (asset management) are required. Maintenance/replacement planning is an important part of this scheme. Currently, maintenance/replacement plans are developed separately from system upgrade plans. Therefore, we developed a program which modifies initial maintenance/replacement plans to harmonize them with system upgrade plans. This program contributes to developing more efficient maintenance/replacement plans. (R12009)
- There is a possibility of harmonic instability occurring in the case of parallel operation of an existing line commutated converter and newly-built voltage source converter when additional frequency converter is constructed. We analyzed the harmonic instability, and revealed the cause and occurrence condition of harmonic instability through transient simulation by XTAP (eXpandable Transient Analysis Program) (R12010).
- A fault clearing method using DC circuit breakers has been proposed for multi-terminal high voltage DC transmission systems which will be applied to the power transmission of long-distance wind power resources (R12007).

Customer Systems

Elemental techniques and tools to support promotion of customer energy saving are developed. Elemental techniques to support effective operation and maintenance for photovoltaic power generation of mega solar system are also developed.

- By comparing the seasonal energy consumptions of marketed air conditioners with the estimate value obtained from the same model, we verified that the developed heat source characteristic model, used to estimate power consumption of household air conditioners, which is an elemental technique to support promotion of energy saving, could be applied to various commercially sold air conditioner models. (R12002)
- Problems of conventional standard, such as the number of *tatami* mats which is a basis for choosing household air conditioners, were extracted. To promote energy saving by avoiding such problems, we devised a new tool to assist selection of appropriate air conditioners taking account of various lifestyles (Fig. 1) (R12008).
- For the development of a convenient on-site failure detection technology of photovoltaic (PV) modules using power conditioning systems (PCS), a method to detect PV modules failure by measuring change of current-voltage characteristics (I-V characteristics) which can be executed by PCS, was invented. It was confirmed by the results of a simulation and experiments that the proposed method could possibly be applied to detect connection failure and disconnection fault including mega solar systems. (R12017)

Communications Systems

In order to secure highly reliable communications networks for power utilities required for the operation and control of power systems, we develop disaster tolerance improvement technologies of communication systems, communication system construction technologies for restoration assistance at damaged power systems and security technologies for SCADA systems.

- In order to enhance the lightning protection ability of microwave wireless communication equipment used as important communication network for power utilities, a configuration which reduces the effects of lightning surges by applying an optical fiber transmission technique to a waveguide of wireless communication equipment was proposed. We have estimated the effect of added noise in optical transmission and expect to achieve the required communication quality (Fig. 2). (R12006)

In order to improve disaster tolerance of optical networks connecting distribution substations and wireless access points for smart meters, we have proposed a novel network system using optical switches for transmission lines altering at trunk lines of the passive optical network and experimentally demonstrated communication recovery behavior after disconnecting failures. In addition, we estimated the effects of optical transmission loss increased by the optical switches and circumventing transmission paths and believe that the proposed system could be applied in standard residential areas. (R12019)

Mathematical Informatics

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

To efficiently support the maintenance and inspection of power equipment, we propose a new classification procedure which can detect abnormal signs and classify them into groups using similarity between the values of engaged sensors and the values of abnormal signs' sensors. When this procedure was applied for one year to the running data of a hydroelectric power plant, the proposed classification procedure detected 29 abnormal signs, appropriately classifying 25 of these into mechanical abnormal signs and 4 into composite abnormal signs.

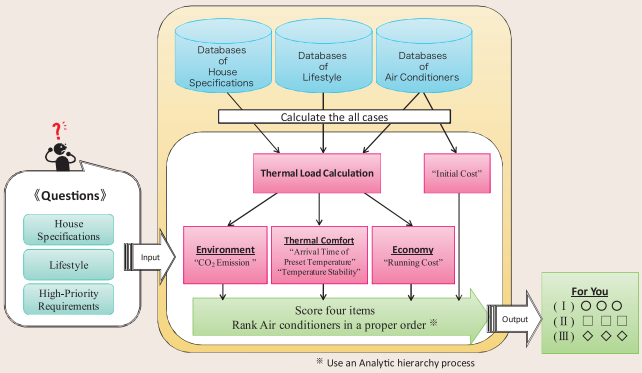

Fig. 1: A tool assisting the selection of appropriate air conditioners

After consumers enter information about their way of life, that is, the specifications of their house, their lifestyle (how frequently and for how long they use their air conditioner), and the values they allocate to consumer preferences (the environment, the thermal comfort, and the economy)—the air conditioners available for purchase on the market are automatically ranked on the basis of a database of information previously recorded on a tablet or other device. This quickly shows consumers the model that is the best fit for them. Through this method, consumers are able to rationally and easily make their choice from the various models.

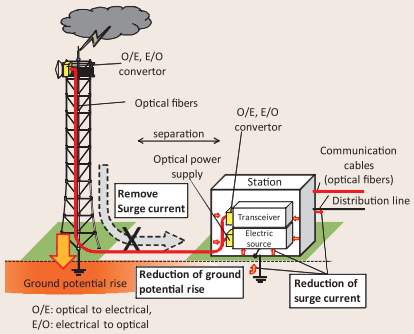

Fig. 2: A configuration of microwave wireless communication equipment using optical fiber for lightning protection

Electrical insulation between an antenna placed on a tower and wireless communication equipment in a room is provided by replacing the waveguide with optical fibers. An O/E (optical to electrical) convertor installed on the tower side is driven by optical power supply and electrical circuits are minimized by using a radio-on-fiber technique in order to enhance lightning protection ability by potential equalization.