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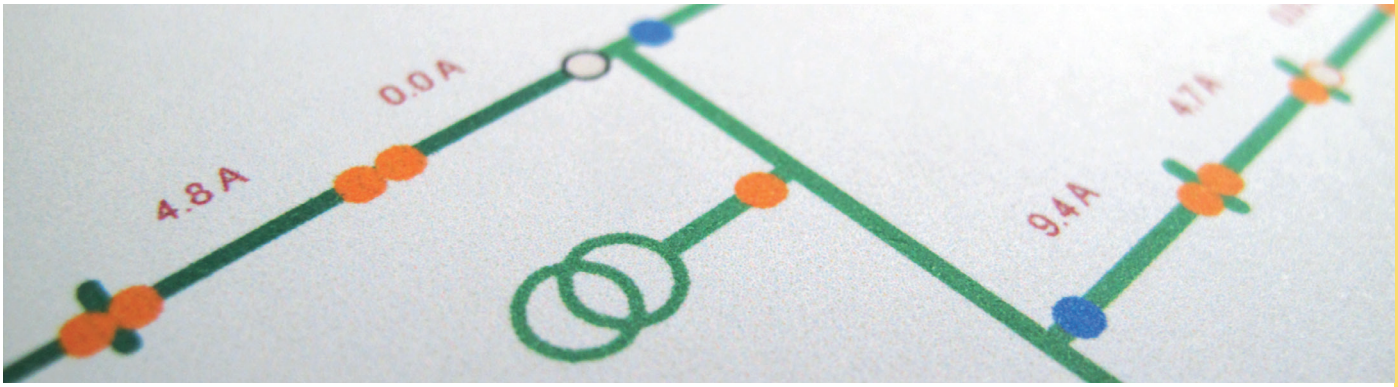


HIGH-LEIT grid trainer

Dynamic training simulation for electric networks

Structure

Power supply networks have become more reliable thanks to latest system engineering, integrated reserves and computer-based control systems. Consequently, the task of troubleshooting in the grid control centre – which used to be a routine task in the past – is nowadays the exception rather than the rule. Therefore, new members of staff have little opportunity to gain experience in handling faults, but this may change as a deregulated energy market leads to higher utilization of equipment and a new definition of required reliability. Faults will thus occur more frequently again.

Owners of power supply networks are obliged to train their staff with regard to handling and elimination of potential faults. Given, however, that many faults and errors only occur very rarely, a suitable offline training tool is required. **HIGH-LEIT** therefore includes a training tool that simulates real-life situations.

Our **HIGH-LEIT** grid trainer differs from common training tools as it offers:

- familiar environment – the control system is operated in training and simulation mode at the usual workstation;
- realistic simulation – the complete simulation of all components including protective equipment with real-time response, enables training and simulation under realistic conditions;
- broad range of application – the **HIGH-LEIT** grid trainer is able to simulate all voltage levels from industrial stand-alone network to municipal distribution systems up to nationwide transport networks.

The training system consists of

- training system server
- training simulator
- trainee workstation
- trainer workstation

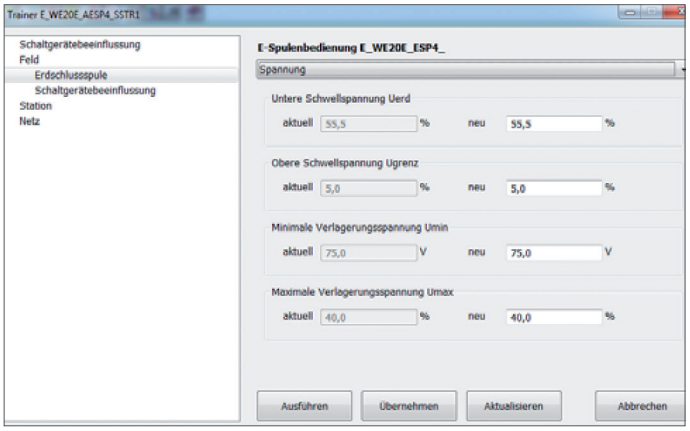
The control system used for real operation and control runs on the training host computer as well. The grid trainer simulates the dynamic behaviour of electric networks at any voltage level, according to their modelling. The electric network may correspond to the actual configuration and switching state or even to a planned state.

Whereas the real managing host computer communicates with the electric network via telecontrol connections, the training host computer actually uses the same process interface but only interacts with the simulator when in training mode.

The grid trainer is a self-contained software suite that only requires a few interface functions on the training host computer. Depending on the implementation, the grid trainer is able to run on the training host computer or any other computer. The **HIGH-LEIT** grid trainer can be used together with the control system **HIGH-LEIT**.

Grid simulation

Outside training times, training host computer and trainee workstation may be used as test system, eg for changes to the data model. The trainee workstation may alternatively serve as system maintenance workstation, for example, as it is designed like an ordinary maintenance and service workstation. The trainee workstation provides all functions to visualize network conditions including all information delivered by the simulation computer. Furthermore, it permits the execution of switching commands and other interventions. However, all these actions only have impact on the training host computer and not on the real process.



Example for asset control: operating menu of an arc-suppression coil

In training mode, a trainee carries out exactly the same operations as in normal operation mode, but switching commands are actually sent to the simulator. The simulator reacts dynamically to these commands in the same way as the electric network and changes switching states, displays tripping or protection messages or alters measured values.

Information provided by the training control system during the training session corresponds to

- details given in maintenance operation (including visualizations);
- displayed network and switching states;
- measured values given in figures ad graphs;
- event states, fault conditions and processing status;
- limitations of operation and lists (eg operational logbook);
- archived measured value trends given in curves and tables.

By means of information put into the trainer workstation, the trainer may spontaneously induce changes in the network state to which a trainee has to react properly at the trainee workstation.

Based on the previously defined initial state and depending on the actions taken at both trainee and trainer workstations, the simulator completely mimics a real network and delivers the same information to the trainee workstation as the real network would have delivered to a maintenance workstation.

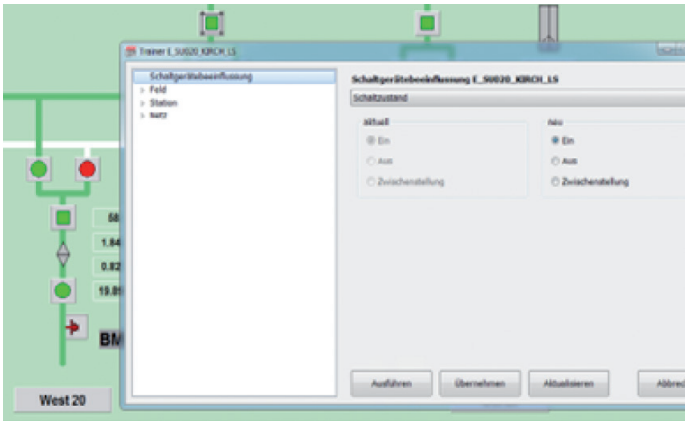
Trainer options
A trainer may spontaneously intervene and

- change switch positions;
- change transformer stages or cause tap switch faults;
- change set points;
- lock/unlock assets and automated processes;
- set three-pole circuits anywhere in the system;
- set up to two earth faults of a specific phase anywhere in the system;
- cause protection equipment failures.

Time behaviour
To enable realistic training, a simulation must mimic the behaviour of the actual system with regard to reaction times and the like.

However, to create a real-time effect it is not required to simulate actions humans cannot perceive as they happen below their temporal threshold.

The time behaviour of the grid trainer thus considers the following:
telecontrol cycles for the acquisition of measured values are within a range of several seconds. Therefore, events within the grid are recognized and tracked by the maintenance personnel at exactly the same time resolution.



The operating menu of the trainer workstation depends on the selected object

Network modelling

Network disruptions caused by the trainer or resulting from changes to loads as well as training activities are represented by a staggered series of messages demanding for protective measures and indicating switch tripping. Disruption calculations of the grid trainer run parallel to other activities and created messages are entered into an internal event list for transmission to the control system.

In accordance with the defined protection times, messages show a 'real' event timestamp and are transferred from the event list at scheduled times. This simulates a realistic sequence of events in the case of disturbances for trainees.

The grid trainer is able to reproduce the following components when calculating the condition of the grid.

Topology
- Galvanically isolated network components and stand-alone grids
- Busbar section disconnectors
- Multi busbar systems with coupling and transfer busbar

Feed-ins and loads
- Time-dependent load curves, also in the form of standardized schedules
- Dependency of load power on voltage and frequency
- Control of voltage and reactive power
- Primary/secondary control
- Reservoir level of pumped storage power stations
- Battery storage power stations
- Wind turbines/Solar farms
- Biogas plants
- Loads with virtual power station and load management
- Feed-in control of plants in accordance with German law (EEG)
- Specification of reactive power output mode for plants in accordance with German law (EEG)
- Hydroelectric power station (run-of-river, reservoir or conventional)
- Feed-in of frequency-dependent active power (50.2Hz control of plants in accordance with German EEG)

Neutral point treatment
- Solid earthing
- Low-impedance earthing
- Arc-suppression-coil earthing

Transformers
- Regulating transformers with on-load tap-changer or control of voltage and reactive power
- In-phase controller, phase-angle controller, quadrature controller

Protective equipment
- Instantaneous overcurrent protection
- Definite time overcurrent protection
- Distance protection
- Over/under voltage protection
- Over/under frequency protection
- Line/transformer differential protection
- Short-circuit indicator
- Earth fault relay
- Momentary single-phase-to-earth fault
- Reactive power undervoltage protection
- Underimpedance protection

Supporting functions
Besides cyclical load as well as grid condition calculations after earth faults and short circuits in compliance with VDE 0102, the grid trainer offers the following functions:
- specification of switching status for grid simulator;
- upload of process images, eg latest real grid image;
- storage of process images as examples;
- upload of feed-in scenarios;
- manipulation of voltage and frequency;
- manipulation of simulation time (leap in time);
- simulation of selected process values;
- simulation and monitoring of protective measures;
- simulation of earth faults and short circuits.

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