

Training simulator for modern load dispatching centers

The recent completion of the second stage of a modernization programme being carried out at the load dispatching center of BKW Energie AG, a Swiss utility with headquarters in Berne, included the start-up of a dispatcher training simulator (DTS). Besides being used to train dispatchers and staff engineers, the simulator also offers many advantages for routine power system operation. The DTS is integrated in the Energy Management System, the standby computer acting as server. If required, the simulator can also be run on the on-line computer. Two full graphics workstations are provided to enable trainees to work in an environment that approximates real-world conditions.

The load dispatching center at Mühleberg, approximately 20 km from BKW headquarters in Berne, is responsible for the day to day energy interchange as well as control of the HV power system. It began operation in the 1970s and was progressively modernized, in collaboration with ABB, from 1990 until 1995 [1]. The modernization programme included the installation of an advanced Energy Management System (EMS) which, besides featuring traditional control system functions, has a modern dispatcher training simulator (DTS) incorporated in it [2] **1**.

Operations management concept of BKW

BKW's load dispatching center in Mühleberg employs a unique facility for training its staff in power system control. The tasks of the load dispatching center are restricted to short-term scheduling of power system operation and energy interchange on the HV and EHV grids, daily monitoring and control, plus recording

and documentation. The network management, including the remote control, covers substations and lines at the voltage levels of 132 kV, 220 kV and 380 kV.

All the medium-term and long-term preparatory work for power system operation is carried out by staff engineers at headquarters in Berne. As a rule, the dispatchers in the load dispatching center are not qualified engineers, and some of the staff have had no formal training in electrical engineering at all. This deficit is more than compensated for by the valuable experience that has been accumulated over the many years they have spent operating power plants and me-

dium-voltage networks. In addition, the staff receive internal, task-oriented training to prepare them for their specific duties as load dispatchers.

Dispatchers carry out their power management tasks within a restricted, clearly defined duty area. The internal training the dispatchers receive therefore focuses primarily on reliable and safe systems operation and on proper use of the available information and documentation rather than on electrical engineering principles. The documentation consists essentially of instructions and regulations that specify, among other things, procedures to be taken in the event of disturbances. These procedures are tailored to particular substations or lines. The framework of responsibility defined by the instructions allows the dispatcher to control the network independently. A staff engineer is available round the clock to help with decision-making in cases where the dispatcher does not have the authority to act alone.

To provide the kind of support such an operational structure needs, it is necessary to have, besides the workstations in Mühleberg, additional workstations at BKW's headquarters in Berne. The described configuration therefore features 'remote' workstations in the load dispatching center and regional centers with exactly the same functions, appearance and operating modes as the workstations in the central control room. The only difference lies in the area of authorizations allocated as and when they become necessary.

Necessity and benefits of the DTS for power system operation

There are three main reasons for using the DTS during normal power system operation. Besides being designed for training dispatchers in system operation, it is also useful for teaching them how to handle uncommon events and for preparing them for the higher power system loads that can be expected in the near

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New simulator for training staff in the load dispatching center of BKW. A trainee's workstation is shown.



future. Both of these aspects are gaining in importance. Since normal training in system operation does not require any further explanation, it will not be dealt with here in detail. However, the second aspect – the training of dispatchers to deal with uncommon events – is linked closely to the way power supply reliability has developed to its present level, and still continues to develop.

Electric power supplies are of a very high quality today. Factors which have played a dominant role in this development are the improved availability of the operating equipment installed, systematic service and maintenance programmes, highly dependable discriminative protection, plus central monitoring and remote control of the power systems. On the other hand, the im-

provement in power supply quality has meant that load dispatchers are less experienced at dealing with disturbances. Also, the few disturbances that call for a fast and decisive response by the dispatchers are becoming increasingly complex and usually involve whole regions within large numbers of customers. Major disturbances can even have supraregional consequences.

If dispatchers cannot be trained to deal with such disturbances on a permanent basis, the reliability of the power supply will eventually be downgraded to an 'apparent' reliability based exclusively on the quality and availability of the installed components. Due to the small number of actual events, it will no longer be possible to evaluate the reliability dependably when a disturbance does

occur. Such a situation is of course unsatisfactory, particularly where systems as complex as interconnected grids are concerned and in view of how important reliable electrical power supplies are to the economy at large. To achieve the required level of training for the operating staff, the simulator must not only be designed so that the modelling approximates real-world conditions but also in a way that satisfies a range of non-technical requirements. These involve, for example, workplace ergonomics and the operator interface.

The third reason for simulators being necessary for training dispatchers is the increasing number of HV power system situations in which individual equipment is loaded to the limits of its design capability. Several developments have contributed to this. In principle, technical aids such as a modern energy management system make it possible today to operate HV networks at levels which are much closer to their maximum capacity than was possible some decades ago. An additional factor is the tendency to delay urgently needed power system expansion programmes, which might have been planned and approved for some time. What is more, the increasing number of regulations involved in power system construction are making planning schedules uncertain. Finally, the trend towards saving vital resources is bringing about a change in how power systems are being expanded. The common practice of raising the voltage level of existing lines frequently causes supply bottlenecks for as long as the work is being carried out, putting extra demands on those plants and installations that are still providing power. Together, these developments make it essential for BKW and other utilities to evaluate in detail the status of their power systems both before carrying out essential unscheduled switching operations and before routine switching.

In order to evaluate the benefits of a dispatcher training simulator, it is necessary to look not only at how it meets the

technical requirements but also at how it interfaces with the users' workplace environment. In spite of all the aids and tools that are available, the decisions that have to be made in the dispatching center to ensure safe and reliable power system operation are inevitably the responsibility of designated members of staff, and not the energy management system.

Thanks to the installed DTS, the majority of the decisions are no longer based on experience but can be evaluated on the basis of simulation results. The same is true when checking the consequences of planned switching operations. Training on a continual basis also helps to ensure that the dispatchers will deal expertly with network situations with which they are not familiar in practice but which are similar to the simulated cases. As a result, the dispatcher will take into consideration alternative methodologies besides the routine ones, or develop analogies with cases that are already known.

In the past, the operations engineer at BKW headquarters in Berne had to rely on his theoretical know-how, his experience with disturbance analyses, and the comprehensive documentation to which he had access. The DTS integrated in the new energy management system now enables the engineers in Berne to accumulate their own experience and knowledge about how the network will behave in critical situations.

Integration of the training simulator in the EMS

Structure and components

The structure of the DTS and the way in which it is embedded in the energy management system is shown in 2. Its database, which is also part of the EMS database, makes use of the same statistical data as the real-time EMS software components. Only data which differ from the real-time data in the training mode are saved in separate storage areas.

The main task of the simulated SCADA is to intercept at a convenient location the commands which would otherwise be sent to the substations and to redirect them to the simulated world. On the other hand, information – especially measured values and status signals from the standard user interface – have to be led back to the simulated world. This bridge between the real world and the simulated world is the critical component of the entire simulator, and allows all of the relevant SCADA functions to also be used in the training simulator.

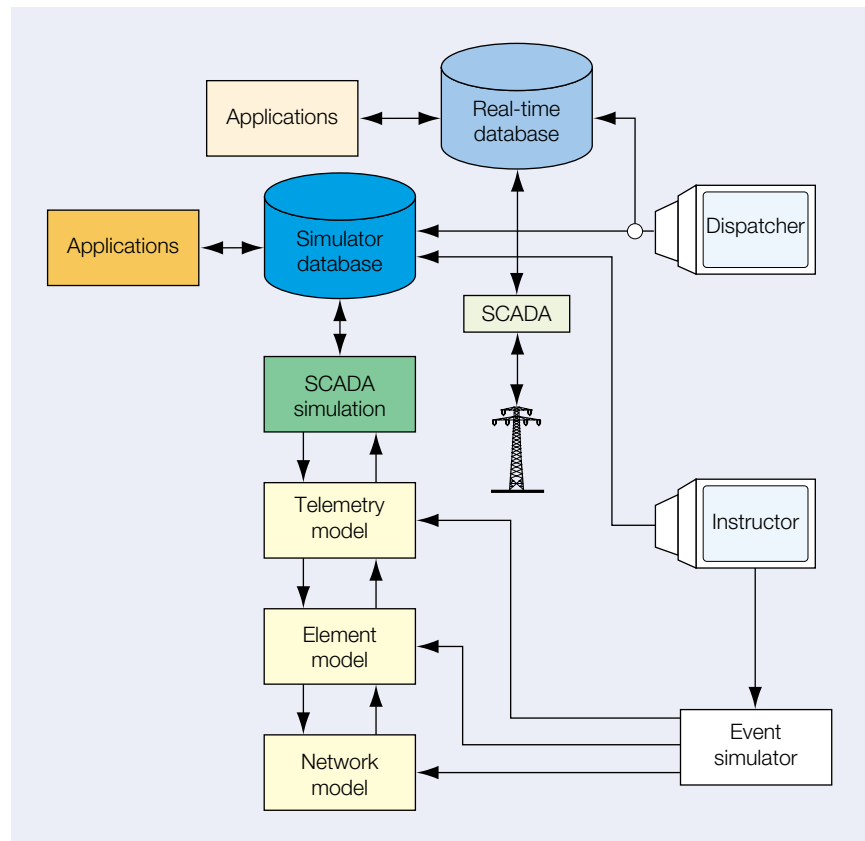
The telemetry model simulates all the main functions of real-world telemetry. It consists typically of front-end computers, communication media and remote terminal units (RTUs). Only those functions which are useful for dispatcher training are modelled. For the most part, these concern failures of the links to individual elements or remote terminal units, block-

ing/deblocking of an RTU, and the normally undisturbed (but also disturbed) transmission of commands and measured values.

The element model simulates the standard characteristics of the power system components providing they are of interest to the dispatcher (ie, they are visible or controllable). Components concerned include switches (circuit-breakers as well as isolators), generators, loads, transformers (with their controls), measured values and protection units. Here, too, emphasis is on realistic modelling. A typical situation could involve a circuit-breaker which does not open or close properly during operation and should therefore trigger an appropriate alarm after a certain time delay. Further commands to open or close must be dealt with accordingly by the simulated SCADA.

The network model is the core feature of the DTS. The network itself is repro-

Configuration of the dispatcher training simulator integrated in the new energy management system



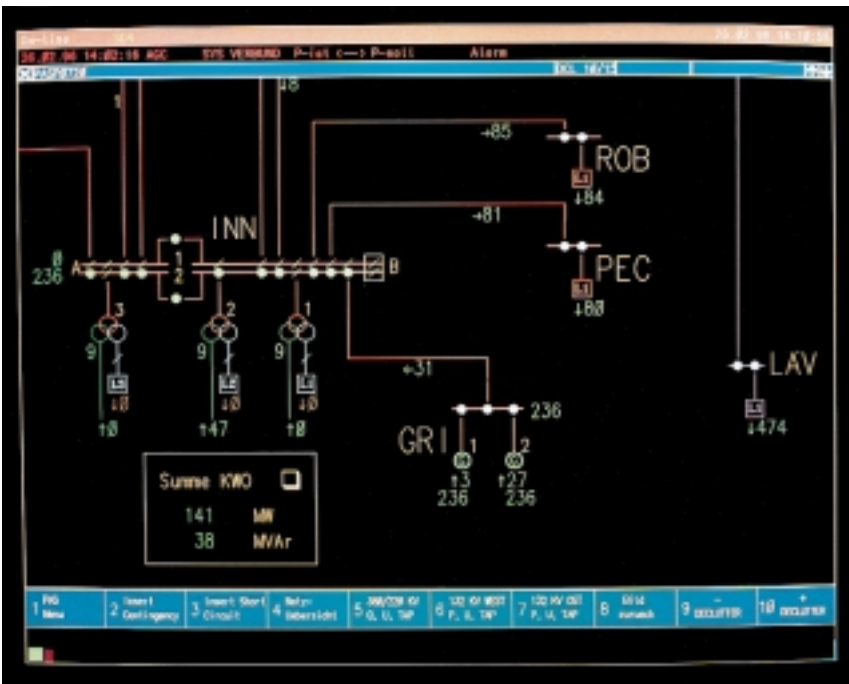


An abrupt change in the power system load (top curve) in isolated operation causes a corresponding reduction in the power system frequency (bottom curve). Without load-frequency control there would be no correction and the frequency would not return to 50 Hz.

3

With the new DTS it is possible to simulate the transmission of values of manipulated variables to the control center as well as their distribution among the controlled power plants.

4



duced in the same way as for load-flow calculations and the failure analyses used in non-dynamic (ie, steady-state) network evaluations. Calculation of the load-flow calculation, including the topology, is cyclic and event-driven. In addition to this quasi-static approach, the dynamic response of the network is also simulated. This has the special purpose of training the dispatcher in load-frequency control. Static and (slower) dynamic modelling makes different demands on time. Since considerably longer cycle times are required for dynamic modelling (typically 1 second), the steady-state and dynamic modelling are carried out separately.

The dynamic network model, which is used mainly to reproduce the power plants, simulates how the frequency behaves. Factors which are taken into account include the energy interchange over tie lines connecting the controlled areas and the active power produced by the individual generators. Although the model covers several controlled areas, it only simulates the primary control. To simplify matters, a controlled area is reduced to a single node to which all the generators, loads and tie lines in this area are connected direct.

The primary control takes place via the network (ie, the generators) and therefore has to be simulated by the network model 3. Secondary control is integrated in the load-frequency controller, but is also integrated in the DTS by means of a software copy of this controller.

The factors considered in the case of the generators are the active power limits, the limited rate of change of power generation, and the spinning reserves. The total produced active power is calculated on the basis of individual power plant modules. Depending on the type of power plant concerned, the models are either of hydraulic or thermal machines and involve different degrees of resolution. The values of the manipulated variables of the generators located in the external network (non-BKW supply re-

gions) are calculated with the help of a simplified load-frequency model. A special feature of the BKW set-up is that the result of the BKW load-frequency control (ie, secondary control) is transmitted to a neighbouring control center and distributed there among several jointly operated power plants **4**. This distribution is also modelled by the simulator.

The protection equipment is part of the network model and is reproduced in two categories with different individual characteristics and properties. In the first category, an actual fault current is detected and the respective circuit-breakers open instantly. The user observes the detection of the fault, activation of the protection and, under certain circumstances, clearance of the fault, in the form of indications, alarms and event information. Such events can be simulated by activating scenarios with the appropriate indications, alarms and event trips. A simulation at the functional level is not necessary under such circumstances.

The second category of protection modelling allows the simulation of relatively slow processes that the dispatcher can also follow and influence. Activation of the protection can be caused by a wrong manipulation by the dispatcher or thermal overloading of power system components. Since this response lies within the time horizon of the dynamic or steady-state network simulation, such protection equipment is modelled direct. The protection response is defined precisely with respect to time and function by specifying the protection parameters, the power system components to be monitored and the circuit-breakers concerned.

The event simulator provides general support by generating load fluctuations, local switching operations in substations, fault situations and so on. These events can be activated either interactively or in batch mode. The instructor can simulate in interactive mode certain situations that constitute unforeseen events for the trainees. If required, events can also be

stored as scenarios with a defined time structure. Such scenarios are run in batch mode.

Instructor/trainee user interface

Here, the main interface is the standard dispatcher workstation. All the station displays and overviews, as well as menus, reports and lists required by the users to perform their daily duties, are made available to the instructor and trainees **5**.

The trainee's two main jobs when working on the simulator is to start the training session and execute the initialization using either data from the on-line system or a stored historical system status **6**.

The main task of the instructor is to define and activate the scenarios. It is this facility for generating scenarios that enables DTS (ie, the network model) to have 'life' injected into it, allowing realistic behaviour of the network to be simulated.

A training session which is under way can be interrupted at any time and,

if necessary, restarted at the point of interruption. In such cases, the simulation clock is stopped to allow the retiming of all the activities (eg, prescheduled events, etc) when training begins again.

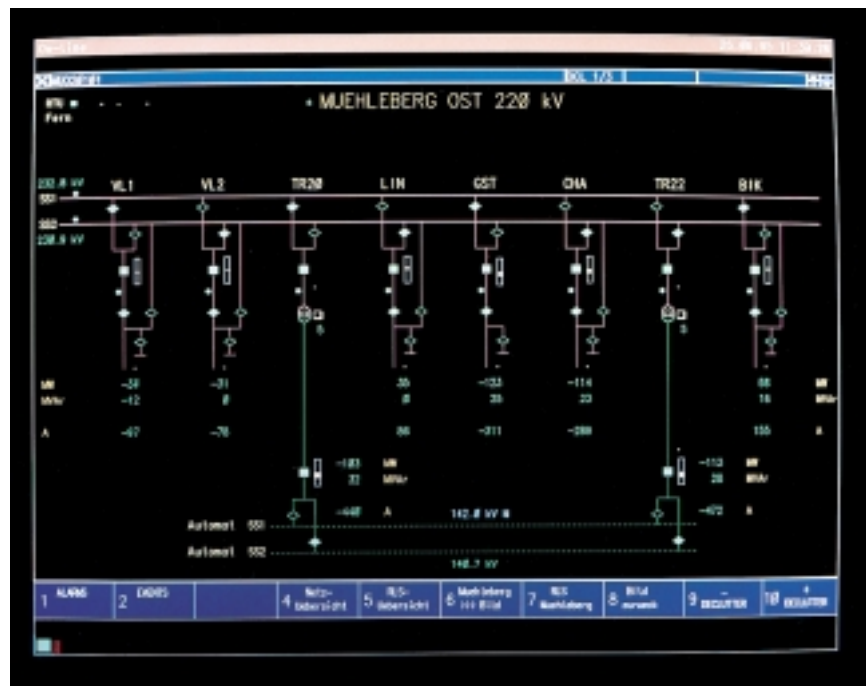
All the scenario events and the instructor/trainee activities are recorded. This is the basis for an objective evaluation of the trainees' performance during a session as well as for later discussions between the trainees and instructor. In addition, it allows the level of training of each individual trainee to be documented.

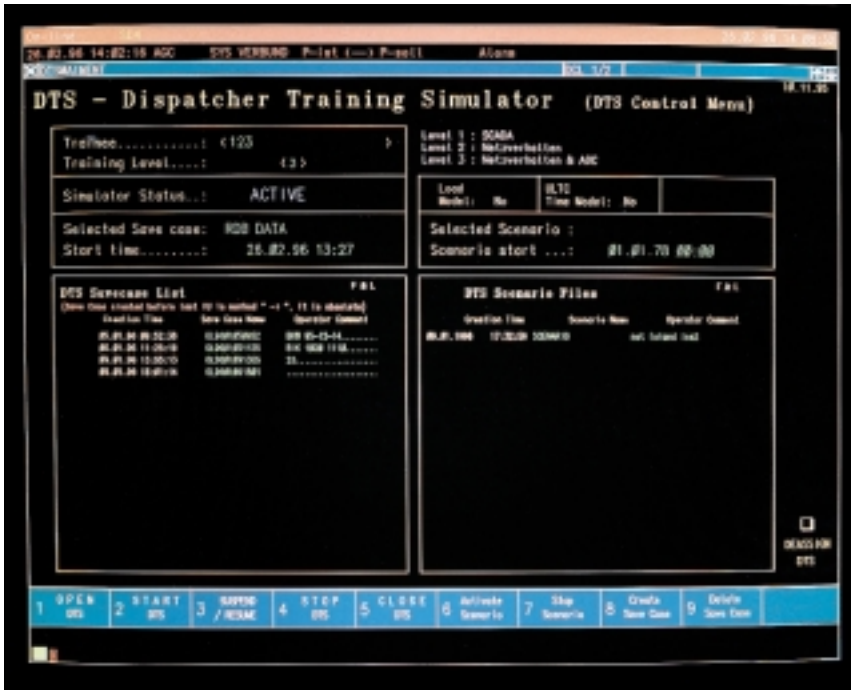
Field experience

The Dispatcher Training Simulator was installed and placed in operation at BKW in 1994. A whole series of acceptance tests was carried out before the simulator was taken into service. Although the simulator has been in operation for only a relatively short time, the know-how and experience already gained has been very valuable:

- Initial training experience based on steady-state network modelling can

The station displays and overviews that the dispatchers can access on the simulator are the same ones that they require for their daily duties. **5**





The dispatcher training simulator's control menu can be used to start, interrupt or stop the training session, as well as to select the starting status or activate scenarios. 6

be considered positive in every respect. The dispatchers can practise their response to uncommon switching operations in a safe environment. One example of this is the planning and testing of automatic switching cycles.

- Cross-the-board checking of the functionality of the applications in on-line operation is hardly possible in real life. Here, the training simulator has proved to offer an efficient test environment. For example, faults in the topology are easily detected, whereas data provided by the on-line system would impair the results of the estimation considerably. Even testing of the bad data functionality of the estimator in the DTS is made much simpler.
- Frequency modelling is at present still at the test stage. Scenarios in which the BKW network is separated from the rest of the UCPTe grid are being studied. The critical components here are the parameters of the hydro-electric power plants, which dominate

in the BKW network. Experience has shown that it is extremely time-consuming to calculate the parameters on which the frequency depends. Often, only tests carried out on the actual network, with subsequent identification of the parameters, help here.

Outlook

The medium-term goal of BKW in installing the DTS is to provide a facility for basic and advanced training of both the dispatchers and staff engineers. The staff engineer acts as instructor, working from his desk at headquarters in Berne, while the trainees are the dispatchers, who sit at their workstations in the load dispatching center in Mühleberg. Through this configuration, the staff engineer also profits in his function as instructor, being responsible for appraising and evaluating not only the activities of the dispatchers but also the response by the network. The same applies to the trainees in their function as dispatchers.

Another benefit of the simulator is the role it plays in the training of new recruits. Whereas in the past this training focused on the transfer of experience and, ultimately, the accumulation of know-how gained on the job, the new DTS gives valuable support in preparing new staff for their duties. In intensive training courses, the dispatch center personnel become more familiar with the behaviour of the controlled network and soon learn the routine responses to unforeseen disturbances in the power system.

The new dispatcher training simulator helps BKW to achieve and maintain a defined, controllable and documented level of training. An appreciated by-product of the simulator is that the level of staff training can also be documented externally.

References

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