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PSS®CAPE System Simulator Module

Step through your protection system's response

At a glance

As a relay engineer what should you do when encountering the following situations?

- A misoperation has occurred on your system that needs to be understood and explained to management in a timely manner.
- You have been working on settings in a relatively dense part of your system and there are a few hypothetical fault conditions that should be thoroughly evaluated.
- Your company employs single-pole-opening schemes and you need to evaluate response to an evolving or simultaneous fault.

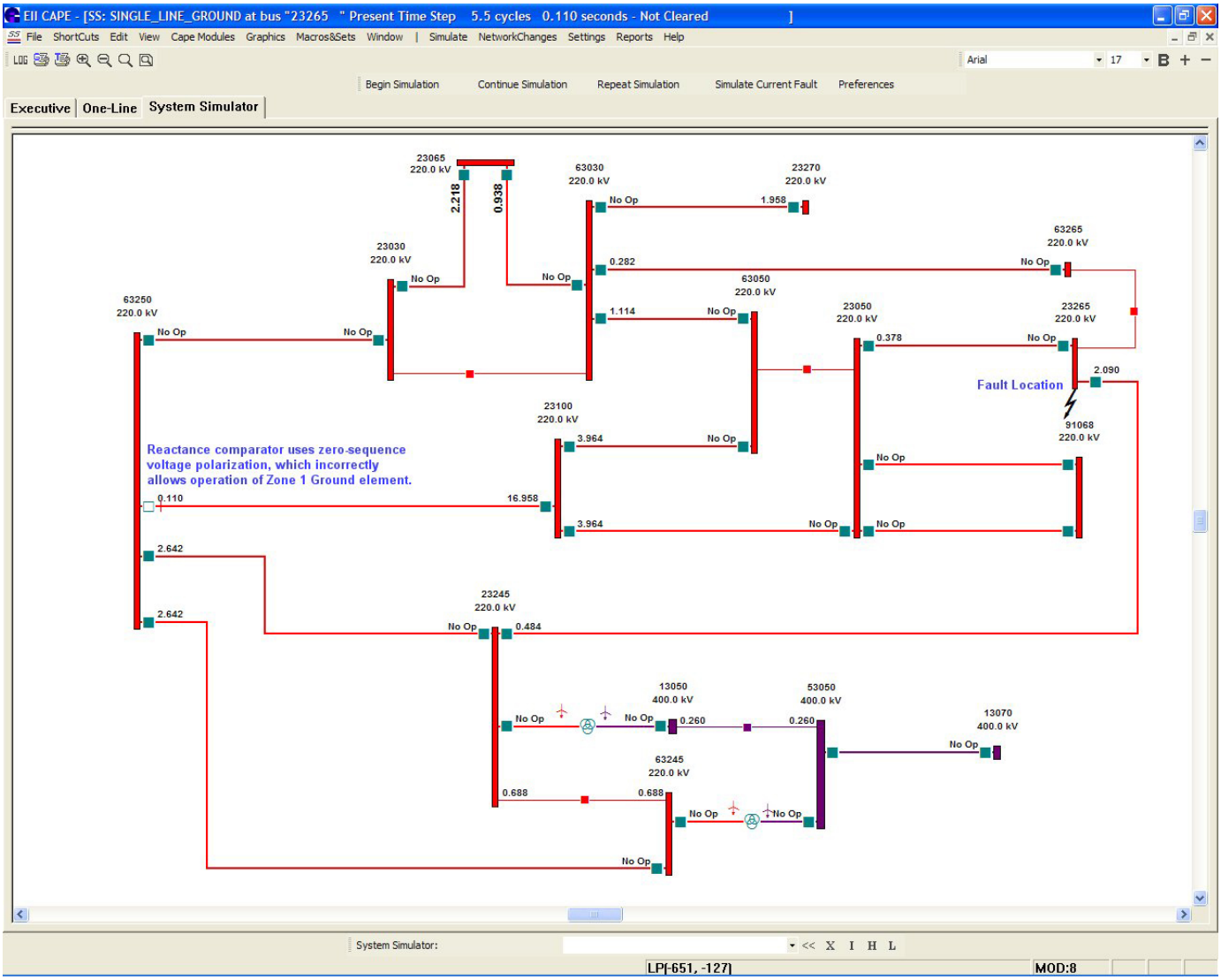
The challenge

A relay engineer might face any of these situations. If you had an easy-to-use, interactively-controlled, stepped-event analysis program at your disposal, you could conduct studies like these routinely, gain valuable insights into the performance of your protection system, and make the most of the time you have at work.

Our solution

PSS®CAPE's interactive System Simulator, together with its batch companion Relay Checking, is one of the most powerful tools in the industry today for evaluating protection system response from the time a fault occurs until it is cleared. With System Simulator you can initiate a fault with your mouse and simulate the reaction of up to 3000 relay elements around it; that is, a real protection system with real relays, complex arrangements of instrument transformers, actual contact logic, and varying breaker operating times. Ground and phase fault protection can be simulated together. Distance, overcurrent, and voltage relays can be simulated together. Just like your real protection system. The simulation pauses at each switching operation (or "event") so that you can examine the condition of any relay or relay panel with one of PSS®CAPE's convenient "point-and-click" reports. You can even change the existing fault or add a simultaneous fault. When you are ready, click "Continue Simulation" to see the next predicted operation. You may resume the simulation as many times as it may take to isolate and clear the fault.

Stepped-event simulation
The crucial component of System Simulator, the one that enables it to simulate your protection system so effectively, is its unique stepped-event simulation of the response of every relay element from the time you apply a fault until the last breaker opens to clear it. As in the companion Relay Checking module, System Simulator automatically determines which Local Zones of Protection (LZOPs) provide primary protection. After you initiate the fault simulation, System Simulator evaluates every relay element in the simulation area, determines what trip logic is satisfied and when the trip signals would be given, opens the first breaker (more if simultaneous), pauses the simulation, and displays the "snapshot" condition on your one-line diagram. Typically, your One-Line Diagram will automatically display trip paths and actual or predicted breaker opening times. At this point you are encouraged to click on the diagram to pop up any of System Simulator's many types of reports (described below). When you are ready to proceed, you click "Continue Simulation." Partial time-outs or reset of induction disks are computed, the fault is reapplied (or modified), fault currents and voltages are recomputed, element supervision is re-evaluated, and the simulation proceeds until the next breaker opens. Again, System Simulator pauses to let you examine the situation. You can continue the stepped-event simulation until finally the fault has been cleared or no further breaker operation occurs.



System Simulator's unique stepped-event simulation details every relay's response from the time you apply a fault until the last breaker opens to clear it. You do not have to tell it which devices provide primary protection.

Simple interactive setup

Starting a simulation is just like applying a fault: Point to a bus or line end and click. A pop-up appears and you choose, for example, "Fault Simulation | Midline." In that case you will also be prompted to choose the type and location of the fault. You may also decide whether to take various lines and generators out of service. That's all! The simulation will then proceed on its own. In addition to the sliding fault, you may choose a bus fault, a close-in fault, or a line-end fault. Need to conduct a "post mortem" study? You can also apply simultaneous or arbitrarily complex faults. If you wish, you can set up, apply, and study the fault first in Short Circuit and then move to System Simulator and start the stepped-event simulation. By the way, you don't need a one-line diagram. PSS®CAPE provides an alternative form that lets you run any study without one.

Automatic simulation window

The interactive simulation process conducted by System Simulator is normally focused on the region "around" the fault and this region may contain hundreds of relay elements of importance. System Simulator begins at the fault location and assembles a temporary set of relay elements (up to 3000) whose response it will simulate until the fault is cleared. This set is called the "simulation area" and may be pictured as a kind of window around the fault. System Simulator follows guidelines controlled by you when it assembles the simulation area.
For example, you might tell System Simulator to include all protection within three buses from the fault and to jump over several mutual couplings to select other protection that might be affected inadvertently. Likewise, you may restrict your study in almost any way imaginable. You might want to consider only certain protection schemes or particular types of relay elements (e.g. overcurrent only). The nice thing is you don't have to think about selecting primary or backup devices yourself. System Simulator does that for you.

Realistic models

The sophisticated stepped-event simulation performed by PSS®CAPE System Simulator (described above) requires a correspondingly sophisticated set of device models. Partial travel and

reset of induction disks in electro-mechanical overcurrent relays are modeled. Directional element models accept both voltage and current polarization from realistic arrangements of VTs and CTs. Separate taps and individual minimum-multiple requirements on the operating and polarizing quantities are modeled in addition to the minimum-product pickup taps of these elements. When relevant, the effect of source impedance and load compensation on distance element operation is modeled. PSS®CAPE models the actual comparator equations or other methods used by the relay. At a higher level, internal or external supervision ("torque control") of one element by another is modeled. Above that, the contact logic of the relay panel controlling a breaker is properly represented. Special forms in the Database Editor make it easy to describe this logic and use it over and over.

Quick, pop-up reports
A key feature of System Simulator is its great reporting. Everything you could ask about a protection system simulation is either already displayed or just a click away. The most important report, of course, is the graphical display of operations given by the One-Line Diagram. Breaker operations are shown prominently as the simulation proceeds. In addition, you can choose any combination of LZOP trip signal time, breaker opening time, relay identifiers, and element trip paths for display in the branch-end text fields. Five types of textual reports are offered as pop-ups. Point to any branch end for the Element Summary Report; it lists each relay element in the LZOP, the instrument transformer ratios, operating quantities (e.g. apparent impedance), operating times, and contact logic. Much larger versions of this report can be requested by clicking away from any graphical object. An equally valuable report called the LZOP Summary lists all LZOPs in the Simulation Area, their trip times, breaker opening times, and total times, in order of increasing response time. The Contact Logic Report gives the predicted operating status and time of elements that may influence breaker tripping. The Event Summary Report gives you the same step-by-step evaluation as Relay Checking; that is, the fastest primary LZOP, the fastest backup LZOP, suitable comparisons, and notification of a miscoordination or CTI violation. Lastly, the Device Setting report shows the settings for a specific element, the whole device, the entire protection panel (LZOP), or the entire Simulation Area. The name of the game is information, and System Simulation provides what you want when you want it.

Complex faults
We have long maintained that PSS®CAPE Short Circuit (SC) is the best fault analysis program available anywhere. Here is an example why. SC is the engine of System Simulator. With this engine, System Simulator can simulate initially just about any fault you can define: faults connecting different voltage levels, faults with complex impedances, combinations of standard faults and open phases, fallen conductors, and so on. Of course you can inhibit breakers from operating so that they will fail to open after receiving a trip signal. With System Simulator's Add Fault, Start and Pause, and Continue with Pause commands, you can change the fault scenario during the simulation. You might assume we are referring to modeling evolving fault conditions. "Interesting," you might say, "but this isn't something I need to study very often." We would agree, although so-called "post-mortem studies" can be urgent, high-pressure demands from management when they do occur. In any case, the Add Fault feature goes beyond simulating evolving and simultaneous faults. If any of your relays is capable of issuing a single-pole-trip command and if you have set it to do so, System Simulator will use this feature internally to automatically model single-pole breaker operation. For some engineers, this can be a very important capability today. For others, well, we are all aware of how slowly new transmission lines are being built and the increasing dependence this places on some existing circuits. If it isn't now, single-pole switching may well be in your future.

Teleprotection (pilot) schemes
PSS®CAPE offers a general auxiliary type of element which we call the AUX element. This element supports the simulation of most forms of teleprotection communication. We have developed receiver and transmitter blocks that can accept any combination of remote or local element contact status, circuit breaker positions, and contact logic. The AUX element may have both pickup and drop-out times associated with it. PSS®CAPE's teleprotection wizard lets you model teleprotection schemes such as permissive overreach transfer trip (POTT) and directional comparison blocking (DCB) in minutes. The reports mentioned above have been supplemented with contact logic status and logic timeline displays to give you further insight into your protection system response.

Features

- Unique, automated, stepped-event simulation of protection system.
- Simple, interactive setup.
- Automatically-generated simulation window combining distance, overcurrent, and voltage protection together.
- Realistic models of relay elements, instrument transformer connections, protection scheme contact logic, and breaker operation.
- Quick pop-up reports with the information you want.
- Ability to simulate complex faults, single-pole operation, and failed breakers.
- Ability to simulate teleprotection (pilot) schemes.

System Simulator's stepped-event analysis is unique

It depends on a comprehensive and tightly integrated database of the network and its protection, unusually detailed protective device models, a short circuit computational engine that can analyze nearly any combination of complex faults, and PSS®CAPE's advanced interface for easy setup and reporting.

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Published by
Siemens AG

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Digital Grid
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Article No. SIDG-T10022-00-7600--pss-cape-system-simulator-module