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PSS®CAPE Coordination Graphics Module

Easily examine and adjust protective devices more easily

At a glance

Coordination Graphics is an interactive facility for evaluating graphically the coordination among selected sets of protective devices, modifying tap settings or device size, evaluating the effects of the modifications, and optionally storing the new settings back into the database.

The challenge

Protection engineers need to display the operating characteristics of overcurrent elements, distance elements, or sometimes both together. In addition, there is often a need to display interactive contingency and fault application, graphical relay resetting, and direct resetting of relay and distribution recloser taps and test points.

Our solution

You choose the protective device elements to be displayed by dragging them from the Data Tree, by clicking their location on a one-line diagram, or by choosing them from a pop-up. Wherever you start, the search is always presented in a natural, top-down order beginning with the substation. Whether you use the Data Tree or a pop-up, your search path remains in full view, making it easy to search back and forth. If you wish, you may also save your selections in a set for quick recall at a later date.

PSS®CAPE remembers the last display you were working with at the end of the day and automatically restores the display the next time you restart it.

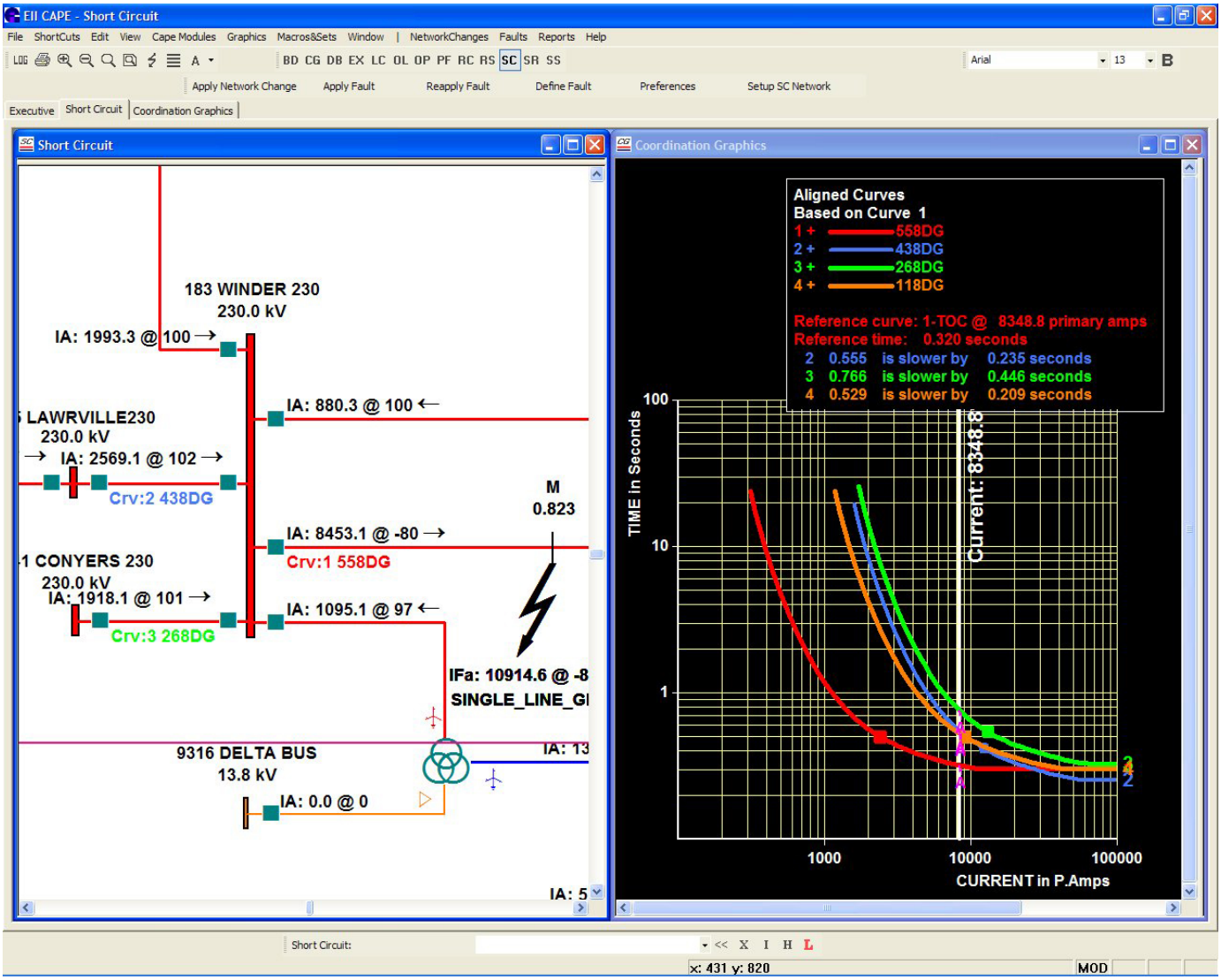
Overcurrent and distance device curves
Coordination Graphics supports the display of up to thirty (instantaneous or time delay) overcurrent or distance curves at one time, each with a different color and line style. Overcurrent curves are displayed on log-log time-current axes with user-controlled units and scales. Test points and IOC/TOC curve truncation are display options. Coordination Graphics gives you similar control over distance element curves. Your RX display can have as much contiguous network as you want and you can display distance elements located on any part of it. They can be primary-backup, facing, a combination of these, or even several transmission lines apart. Multiterminal lines are treated naturally in PSS®CAPE. Not only can the displayed elements be located almost anywhere, their characteristics can have virtually any shape: circular, rectangular, polygonal, lens, tomato, load blinder, "ice cream cone," and any other shape the relay manufacturers may dream up. If a distance element has two units, you may display either or both. Attached transformers may be displayed as well.

Any or all curves can be annotated with PSS®CAPE's flexible "Info Boxes" or you can view the annotations together in the Legend Area.

Responses to any type of fault
Once you have displayed a set of protective device curves, you will want to specify network contingencies and faults so that you can check the operation of those devices. If you apply any fault on the Short Circuit one-line diagram, the fault can be immediately displayed with the characteristics. Easier still, if you are working with an RX diagram, apply your faults directly on it. It really couldn't be simpler. The results are displayed graphically with the curves and in tabular form in the Coordination Graphics Legend. The Legend can be scrolled, edited, and printed separately from plots of the curves. Its width, text font, and text size are all selected with the mouse.

PSS®CAPE SC allows you to define and study any arbitrary fault or unbalance, not merely the traditional types of faults. Faults can involve many buses at once, many voltage levels at once, and with connections of any impedance value. Coordination Graphics can therefore evaluate protective device responses to real-life situations whenever a postmortem analysis is necessary. If you wish, it can display graphically the response of each phase loop.

Automated curve alignment
When a fault has been applied during the display of a combination of primary and backup devices, it may be easier to evaluate the coordination among overcurrent relays if the curves are



You choose the protective device elements to display; Coordination Graphics shows you the operating characteristics of overcurrent elements, distance elements, or both.

aligned as your boss may once have done with a light box. Alignment is a graphical offset of backup overcurrent curves relative to the primary curve so that the coordination time interval and possible miscoordinations are clearly depicted. The PSS®CAPE implementation of alignment will make you smile; you may drag the fault around with the mouse and watch the curves and displayed time intervals adjust themselves dynamically! The graphical "dragging" of curves described below is supported during alignment, too.

PSS®CAPE's dynamic TCC display makes it easy to see how coordination time intervals change as you drag the fault around the network.

Dynamic distance characteristics and other special displays

No other program offers the special displays that PSS®CAPE does to support your needs. Since PSS®CAPE always works with its detailed relay models and can model any fault impedance, displaying the true dynamic distance characteristic is simple for you. Right click on the curve of interest and select "Display dynamic distance characteristic" from the menu. PSS®CAPE computes and displays the characteristic while you watch. Or, you can tell PSS®CAPE to display the maximum resistance the distance element can see plotted as a function of fault location. Or, you can request a plot of the maximum fault impedance the element can see for a particular fault location (as a function of impedance angle). Do your system operators want to see P-Q line loading limits imposed by the distance relays that protect it? Coordination Graphics has a display for that too.

Fault-based time distance diagram

When you want to evaluate the performance of your phase or ground distance, overcurrent, directional, or product (V*I) protection, or any combination of them, Coordination Graphics offers another powerful feature unique to PSS®CAPE: a fault-based time distance diagram. Using only a mouse, you first select any path through your network; the path may loop back on itself if you wish. As you move from one bus to the next, you may pick one or more distance,

overcurrent, product, and directional relays and elements that you want PSS®CAPE to "watch." Separate choices are made in both the forward- and reverse-looking directions. When you have completed your path, Coordination Graphics then applies sliding faults to find the precise reach of each element on the remote lines. Distance relay operation is based on PSS®CAPE's detailed internal comparator models, not on apparent impedances drawn on RX diagrams. (You would probably never attempt an analysis like this manually!) Finally, Coordination Graphics plots the Time-Distance display in both directions. Since the reaches are based on accurate fault calculations, not on line impedances and reach settings, you have the most accurate analysis of distance, overcurrent, and directional relay coordination short of PSS®CAPE's unequaled System Simulator and Relay Checking modules.

Graphical manipulations of curves
A convenient feature of Coordination Graphics is the ability to drag an overcurrent or distance curve with the mouse. The tap settings and test points needed to conform with the new location are recomputed automatically. Dragging may change the pickup tap, the time dial, or several distance taps, depending on the type of curve dragged and the direction it was moved. In all cases, the move is permitted only if the required taps are physically possible. Often a tap can have only certain discrete values; in that case, PSS®CAPE chooses the closest permissible tap setting.

Three other graphical manipulations are supported. You may add a constant time to a time-overcurrent curve and thereby account explicitly for a breaker operating time; multiply a time-overcurrent curve by a constant factor; multiplying the current can account for a transformer between a fuse and a relay, while multiplying the time can derate a fuse curve; add two time-overcurrent curves, a technique you might use to display the cumulative operating time of a set of fast and slow recloser curves.

Relay settings may be changed temporarily by dragging the characteristic with the mouse or directly in a pop-up edit window.

Pop-up edit windows
The other method for editing relay settings is through Coordination Graphics's pop-up edit forms. Each form contains much detail on the relay, its location, and its instrument transformer connections. The actual setting of each tap is shown on a button or field that, when clicked, produces a pop-up with all its alternative values. For distance elements you may edit each zone and unit by pointing to the curve and clicking it with the mouse. Coordination Graphics enforces relationships among related quantities such as actual/desired reach, tap settings, and test points so that a change to one causes the automatic recomputation of the others. Typically, you might enter a new desired reach; Coordination Graphics will recompute the necessary taps (using algorithms recommended in the manufacturer's catalogs when available) and, depending on the options in effect, alter the test point voltages or currents. As in the Database Editor, the original (database) values can be viewed by clicking the Original/Modified toggle button.

The edit form for an element can be accessed in various ways. You may invoke the edit window after you click a displayed curve or you may find the relay in the Data Tree and click it. Or, you may click the "Change Device Settings" button and then select the elment from a pop-up form. You may search for any relay in the entire database regardless of whether or not it is currently displayed.

Optional storage of modified settings
Setting changes made in Coordination Graphics are always assumed to be hypothetical and are not transferred to the database unless and until you issue an explicit command to save them. Even then, you may restrict this operation to individual relay elements. Alternatively, you may clear the tentative settings for some or all relays and start over.

Distribution devices and equipment damage curves
Coordination Graphics is continually expanding to include a wide range of protective devices for distribution and damage curves for associated power system equipment. More than 2000 fuses are available in the PSS®CAPE library; they may be placed, evaluated, and modified just like relays. Minimum melting and total clearing times may be plotted independently or together. Detailed models of reclosers have been implemented that support the latest manufacturer designs where controller and switchgear may be purchased from different vendors. Low voltage Circuit Breaker models are now being prepared. Coordination Graphics models the partial reset (ratcheting) of an upstream overcurrent relay as it is subjected to a sequence of multiple open/reclose operations of downstream reclosers. Mechanical and thermal transformer damage curves are drawn interactively following the ANSI Standard 57.109-1985. Conductor damage curves are drawn with Coordination Graphics' "raw data" feature; you can use the same feature to draw any damage curve your company may prefer.

A special CG function evaluates the ratcheting of an overcurrent relay during successive operations of downstream reclosers and suggests improvements to reclose delay times that will prevent inadvertent operation.

PSS®CAPE's standard set of advanced features:
Visual C++ graphical interface, macro facility, set facility, PSS®CAPE User's Programming Language, pop-up HTML help documentation, command line and history pop-up for " power" users, and a single click to save your preferences for all options.

Features

- Quick selection of protective devices from Data Tree or one-line diagram.
- Color-keyed displays of up to thirty overcurrent or distance curves at a time.
- Graphical and tabular displays of protective device responses to any type of fault.
- Dynamic overcurrent curve alignment to clarify coordination margins as you drag the fault location.
- Dynamic distance characteristics and special fault impedance displays.
- Unique “two-way” Time-Distance Diagram based on automated sliding faults to verify overcurrent, distance, product, or directional relay coordination, or a mixture of all.
- Graphical curve “dragging” that automatically recomputes settings.
- Pop-up edit windows for the direct editing of settings.
- Optional storage of modified settings back to database.
- Display of relay ratcheting during distribution recloser operations.
- Operating/reset sequence simulation of series relays, distribution reclosers, and fuses.

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