GRIDSCALE X ADVANCED PROTECTION ASSESSMENT

Short Circuit Reduction Module

Reduce your network model down to size

SIEMENS

At a glance

The Advanced Protection Assessment Short Circuit Reduction module is a fully interactive program designed to reduce the size of a network model by replacing sets of buses and the lines and transformers that connect them with a smaller but exact, numerically equivalent network.

The challenge

The majority of utilities around the world have one or more connecting tie lines to another utility serving as a means of moving power across the grid from one system to another. In order to ensure that the protection requirements are met between the two separately operated and managed grids, a system equivalent of the neighbor system needs to be provided. Generally, the equivalent is prepared to include either one or two buses away from the connection point.

Our solution

For a properly chosen set of buses, this equivalent network will have fewer buses and branches than the original, yet still provide the correct response to faults or other electrical conditions in the unreduced portion. Advanced Protection Assessment and its Short Circuit program do not use or benefit from the smaller network produced by Short Circuit Reduction. (The Advanced Protection Assessment Short Circuit module has no inherent size limits and solves faults in any size network almost instantaneously.) There are other reasons, however, for making network reductions; see "Why reduce?" below.

Quick and easy bus selection

Much of the work in preparing a reduced model often involves selecting the part of the network to reduce. In Advanced Protection Assessment, this task is made very easy. If the number of retained buses will be small, click on them in your one-line diagram. If you are going to retain a large portion of your system, use your mouse and Short Circuit Reduction's special menu to build a set of buses. You may add or remove groups of buses selected by attributes such as base kV and area, buses selected individually, and previously defined sets. At every step you can ask for a pop-up list of your current selections. When you are ready to proceed with the reduction, you may instruct Short Circuit Reduction to either keep or eliminate the buses in your set. Your set definition can then be saved in a file for future recall.

Two network reduction methods

Two separate reduction techniques are offered in Advanced Protection Assessment Short Circuit Reduction. The first technique, referred to as "normal" or "conventional" reduction, completely reduces the specified set of buses, leading to an equivalent network with a minimum number of buses but possibly many branches. The second technique, called "sparsity enhanced" reduction, determines mathematically which extra buses to retain to minimize the number of equivalent branches created. It is easy to simply try both methods and then select the equivalent with the more desirable characteristics.

To learn more about the sparsity enhanced method, see the following reference (included with the Short Circuit Reduction documentation): Mark K. Enns and John J. Quada, "Sparsity-enhanced network reduction for fault studies", IEEE Transactions on Power Systems, Vol. 6, No. 2, pp. 613-21, May 1991.

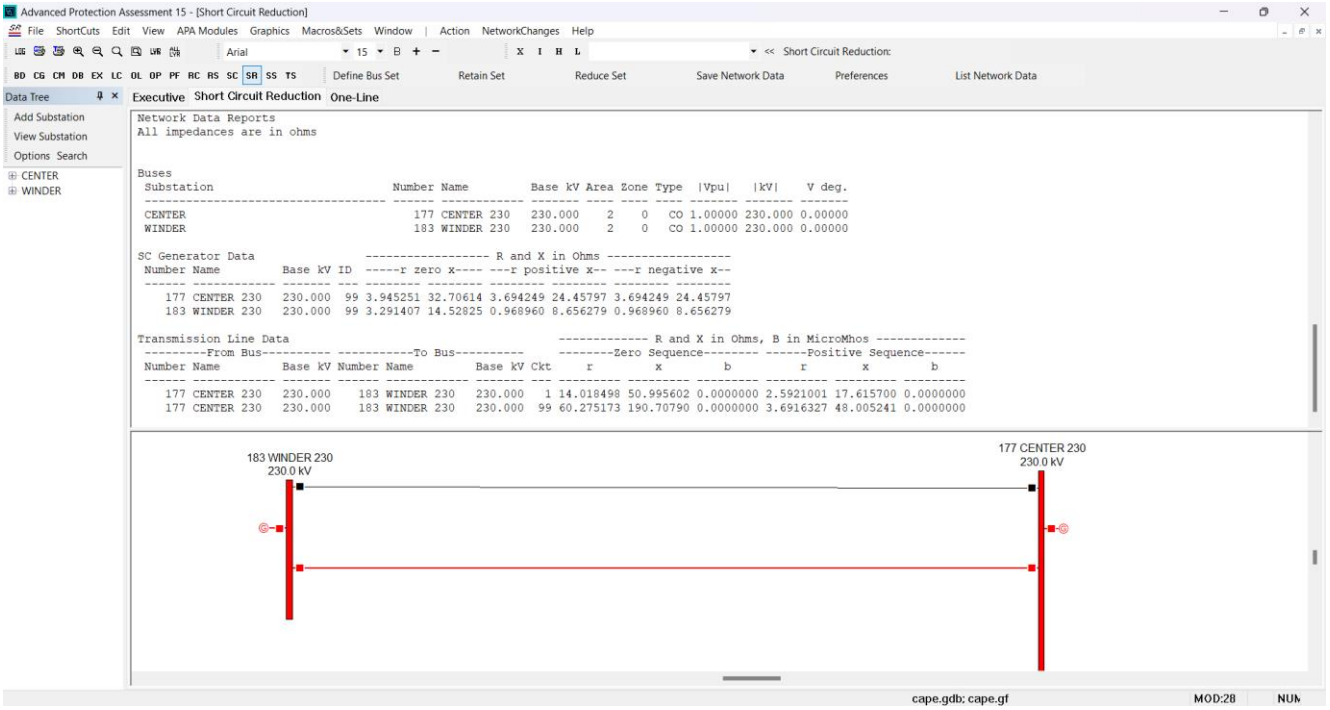

Figure 1: Start a reduction by selecting the retained buses from your one-line diagram.

Detailed reporting

To help you understand the reduction that was done and the equivalent that was generated, Advanced Protection Assessment Short Circuit Reduction summarizes various statistics of the reduction process. The summary reports the number of buses retained and eliminated, the number of boundary buses in each sequence, the number of shunts and branches (lines and transformers) that were discarded for efficiency (see discussion below), and a table itemizing the effect of the reduction on the number of buses, shunts, branches, mutual couplings, and bus ties.

Physical network equivalent

It is common in utility engineering work that one needs to develop a much simplified, i.e. reduced, model of a network. Electromagnetic transients analyses, HV system models for distribution studies, and various hand calculations are typical examples. The simple equivalent model must have the same form as those of the lines, generators, and other physical network elements on which the study focuses. A distinct advantage of Advanced Protection Assessment Short Circuit Reduction is that it produces precisely this type of equivalent: impedances that interconnect retained buses and admittances that connect buses to ground. The equivalent generated by Short Circuit Reduction therefore may be easily combined with the detailed model, whether on paper or in the data for some other program.

A convenient text report is produced by clicking the "List Network Data" button following a reduction; equivalent network elements are clearly identified.

Or you can export the reduced network in various text formats, such as PSS®E, or in a new Advanced Protection Assessment database.

Options for discarding extraneous equivalents

The Preferences menu of Advanced Protection Assessment Short Circuit Reduction gives you control over fields such as Shunt_Code and Shunt_Name that are used later to distinguish between components of the original network and those of the equivalent.

Three other quantities are more interesting, however: Shunt_Minimum, Maximum_Series_Z, and Minimum_Series_Z.

One of the characteristics of network reduction is that the boundary buses between the retained and reduced bus groups will always be interconnected by an equivalent branch if a path existed between them beforehand through the now-reduced network. Likewise, equivalent shunts will appear at boundary buses if formerly there was a path from the

boundary buses to shunts in the reduced network. Often these equivalent branches and shunts will have impedance values that have almost no impact on the calculations for which the equivalent is sought. You have direct control over automatically discarding such impedances in the interest of a more efficient reduced model. The goal of this feature is similar to that of the sparsity-enhanced reduction option but is entirely independent. In other cases, a branch impedance may be so small as to warrant modeling as a zero-impedance bus tie rather than introduce numerical ill-conditioning into a solution matrix.

Special tool for replacement of external system

Every utility with connected neighbors is faced with the job of keeping its model for those neighbors up to date. Otherwise, currents for faults near the boundaries will not be realistic and settings derived from them will lead to misoperations. We call this the "doughnut and hole" problem. You maintain your own network (the "hole") and its protection. The external system model (the "doughnut") is obtained from your neighbors or reliability council. Somehow you have to cut off the old external model from your data, cut out the simplified model of your system from the data having the new external system model, and merge the two. You would probably like to reduce the part of that large external system model that lies "far enough" beyond your boundary. Advanced Protection Assessment Short Circuit Reduction has a great tool to perform all these steps. Just ask us about it.

Why reduce?

Short Circuit Reduction can help with:

- Producing a small model for use in other types of studies and with other programs such as the Electromagnetic Transients Program (EMTP)
- Sending data to other electric utilities or (in the USA) to your reliability council. Your neighbor or reliability council probably does not want a large, detailed model of your network and your company may not wish to distribute its detailed model.
- Reducing data received from neighboring utilities or a reliability council. Normally, your only interest in the "outside world" is to model its effects on your own system. You may not want to bear the overhead of retaining a large external system model. Likewise, you may not want to pay the sender to reduce the data for you.

Generating transmission system equivalents for distribution studies. If your company is using a program other than Advanced Protection Assessment for distribution studies, you may want to supply the Thévenin equivalent impedances of the high-voltage system needed for each feeder model.

Features

- The easiest-to-use interface we've seen for choosing the buses to retain or remove
- Two reduction techniques: "conventional" and "sparsity enhanced"
- Detailed reporting of the reduction process
- A physical equivalent. All output is in terms of series impedances and shunt admittances in a text report, a Short Circuit data file, or a database
- Options for automatic removal of both high-impedance branches and low-admittance shunts
- Powerful "doughnut and hole" tool for replacing the external system model
- Advanced Protection Assessment's standard set of advanced features: macro facility, set facility, Advanced Protection Assessment User's Programming Language, popup help displays, online documentation and popup windows for options and printer control

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