GRIDSCALE X ADVANCED PROTECTION ASSESSMENT

Power Flow Module

Your path to more accurate fault currents

SIEMENS

At a glance

The purpose of a power flow analysis program is to compute precise steady-state voltages of all buses in the network, and from them the real and reactive power flows into every line and transformer, under the assumption of known generation and load.

The challenge

The modeling of controls such as tap-changing transformers, generator reactive power output, and area interchange are (admittedly important) details are the basic functions of Power Flow.

Our solution

Power Flow programs have been in use by engineers for more than 50 years. You might wonder what could possibly be special about a power flow function within the software. The answer lies in the integration of Advanced Protection Assessment's power flow function with its database and short circuit function.

The objective of Advanced Protection Assessment is to promote a more secure and reliable protection system with less effort and cost. Advanced Protection Assessment Power Flow provides initial conditions that allow Advanced Protection Assessment Short Circuit to include load currents in its calculations. More accurate fault currents lead to more accurate settings.

Newton and decoupled solution methods

The power flow problem requires the solution of a large set of equations that are nonlinear in the variable of interest, voltage. Large nonlinear problems are usually best solved through a process of linearization and iteration. Advanced Protection Assessment PF provides you with the two most effective algorithms for power flow solutions available today: Newton and Fast Decoupled. Experience has shown that, on rare occasions, one or the other of these techniques will fail to solve a physically realizable network. That is why Advanced Protection Assessment PF gives you complete interactive control over the iterative solution procedure.
You may, for example, begin a solution with the Decoupled method, interrupt it at any point, and then resume with the Newton method. Controls such as transformer tap changing may be selectively activated. In the vast majority of cases, of course, such "tricks" are unnecessary, and the exact solution will be obtained most efficiently by the Fast Decoupled algorithm.

On the question of accuracy, there has been a common misunderstanding regarding the solution computed by the Fast Decoupled method. So long as the mismatches are computed correctly, both the Newton and Fast Decoupled methods give the same, exact answers. This is true for Advanced Protection Assessment PF and for other commercial power flow programs. Each Newton iteration takes enough longer to compute than a Fast Decoupled iteration that the latter method is usually faster despite requiring more iterations. Limit on network size is another paper tiger. There is no inherent limit on the size system that Advanced Protection Assessment PF or the database can handle, be it 5 or 50,000 buses. Whatever your system size, Advanced Protection Assessment dimensions itself automatically as it reads your network data.

Device and control models

Advanced Protection Assessment PF models a variety of network elements and controls. Among these are:

- local or remote voltage control by switched capacitor/inductor banks
- local or remote voltage control by reactive (Q) generation
- local or remote voltage control by tap-changing transformers
- reactive power flow control by tap-changing transformers
- active power flow control by phase-shifting transformers
- area interchange control

Any of these can be activated or deactivated selectively. Solutions without controls can be initiated from the "Solve" menu.

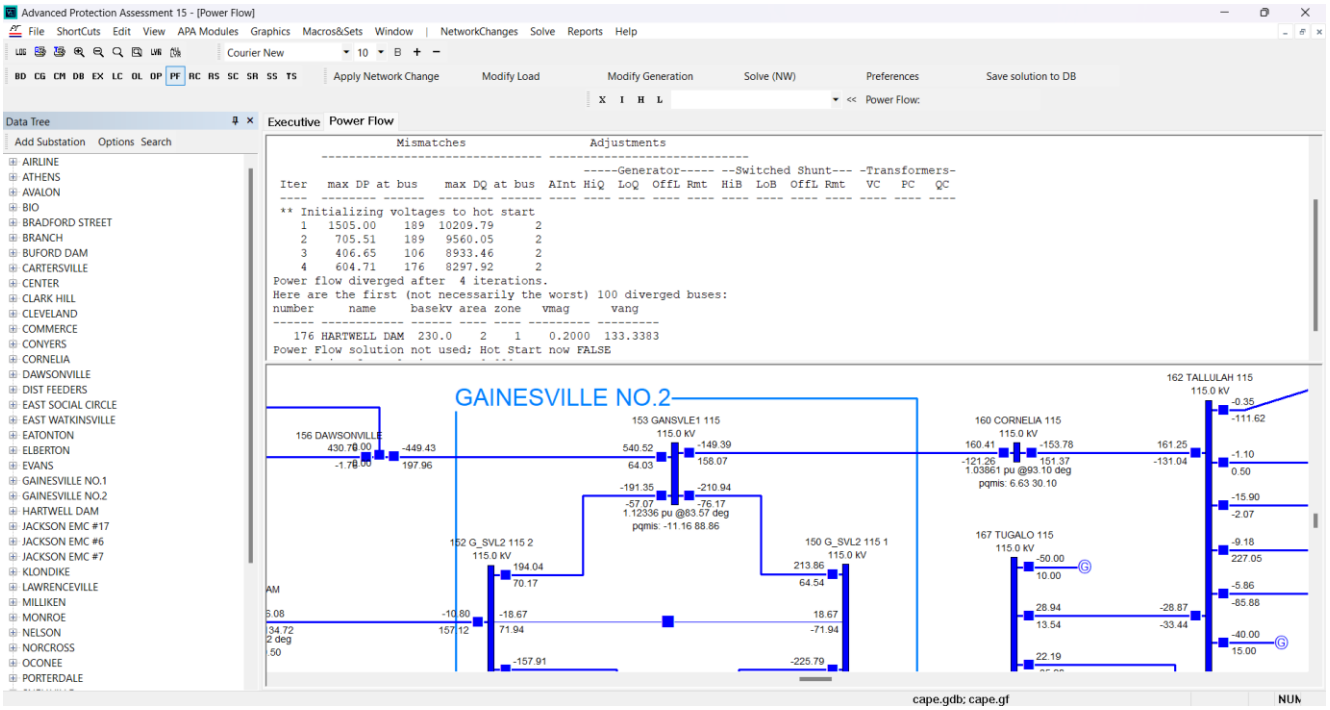

Figure 1: Power Flow gives you the two most effective algorithms available: Newton and Fast Decoupled. It gives you complete interactive control over the iterative solution procedure.

One-Line Diagram interface

The One-Line Diagram performs the same important, although optional, functions for Power Flow as it does for Short Circuit. During setup of the study, you may click on lines to take them out of service or on bus ties to open or close them. You may click on buses to change local generation or load. In the “Network Changes” menu, you may access powerful forms for adjusting load and generation in arbitrary bus groups or in predefined bus sets. You may click on most graphical objects to examine and edit the associated database data. Immediately following a solution, real and reactive flows and bus voltages are displayed on the diagram. You may choose to have the OL diagram emphasize overloaded lines or over/ under voltage buses by automatically redrawing them with a particular color. Plots of the diagram can be printed with standard print commands.

Modular text reports

Advanced Protection Assessment Power Flow shows the benefits of its heritage as a planning program with its extensive list of carefully designed, modular reports. When relevant, reports can be generated for all buses, any one bus, or any set of buses (again using Advanced Protection Assessment’s versatile bus set feature). Some are exception reports, such as those for overloaded lines/transformers or for voltage violations. Others are summary reports. All together there are 16 reports. By mixing and matching, you can customize your company’s report and can easily standardize it by generating your complete report from a simple script.

Advanced Protection Assessment PF’s reporting facility has many touches to make reports more readable. For example, the bus data and bus results reports have a special feature designed to keep related data together. Bus reports always include information for the branches attached to them. The user is free to specify the number of printed lines that may appear on a page. Thereafter, Advanced Protection Assessment will count ahead and always restrict the number of buses reported on a page to that for which all associated branches can also be reported. You can specify wide or compact reports as your needs dictate. If you like more detailed control, consider this: you can specify the number of significant digits after the decimal for ten different report quantities. All of these are just “bells and whistles” of course; the important thing is the content and its responsiveness to your needs. Considerable thought went

into arranging our reports
for clarity, depth, and conciseness. We invite you to judge for yourself.

Customize your company's report by selecting from the 16 summary, violation, equipment, and standard bus/ branch reports offered by Power Flow.

Short Circuit initialization

The main purpose of Power Flow in Advanced Protection Assessment is to boost the accuracy of the computed short circuit currents fed to relays through instrument transformers. If load current is a significant fraction of available fault currents in your system, this is a feature you should consider seriously. With a click of a mouse button, you can send a full power flow solution – voltages, load and generation, transformer taps, and shunt device values – back to the database. When Short Circuit next builds its network model, the power flow solution can be included. SC can then utilize a self-consistent initial voltage profile, rather than the traditional flat or "adjusted voltage" profiles, when it computes fault currents. Through the SC Preferences menu, you can then choose to exclude or include the load current component in fault reports and relay simulations.

Integrated data

In some respects, a power flow calculation requires more data than a short circuit calculation, the one exception being short circuit's need for zero sequence impedances. Real and reactive generation and limits, branch flow limits, bus loading, and details of transformer and switched shunt controls are good examples. Much of
the data is the same, or nearly so, and it is clearly a disadvantage if your company has to duplicate it for analysis programs that require separate models. Whatever way you look at it, Advanced Protection Assessment's comprehensive database not only helps to unify your network model, it presents that model more clearly than ever before. When different data must be used to model the same device, as in the case of generator impedances and injections, the Database Editor forms show it organized together. When the data overlaps heavily,
as for line impedances, the DBE forms again show the data clearly. Transformers with flow controls for power flow and with zero-sequence and neutral network models for short circuit are a special challenge. The DBE forms help to bring it all together. Take a good look at our database design. We think you'll decide an integrated database makes your data management responsibility
a whole lot easier.

Features

- Fast, exact Newton and Decoupled solution methods
- Variety of device and control models
- One-line diagram interface for quick setup and reporting
- Extensive set of modular textual reports to support planning functions
- Short Circuit initialization with load currents for more accurate relay studies
- Integrated power flow and short circuit data easily maintained with Advanced Protection Assessment Database Editor

Published by
Siemens AG
Smart Infrastructure
Grid Software

Siemens Technopark
Humboldtstr. 64
90459 Nuremberg, Germany

For the U.S. published by
Siemens Industry Inc.

3617 Parkway Lane
Peachtree Corners, GA 30092
United States

For more information, please contact: Gridscale-X-APA-Contact.si@siemens.com

Article No. SIDG-T10012-00-7600 – Advanced Protection Assessment – Power Flow Module