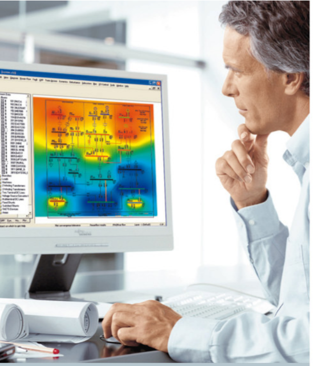

PSS®E

Power Flow

At a glance

The PSS®E Power Flow module is widely recognized as one of the most fully featured, time-tested and best performing commercial programs available for power systems analysis. Over 30 years of commercial use and user-suggested enhancements have made the PSS®E Power Flow base package comprehensively superior in analytical depth, modeling, and user convenience and flexibility. Rich graphical tools allow the user to easily edit models and present results.

Analysis

- User-switchable choice of five solution methods including Newton-Raphson (full, decoupled, fast decoupled), Gauss-Seidel, and modified Gauss-Seidel
- Inertial and governor power flow redistributes generation after major load or supply changes
- Standard and complex contingency analysis and transfer limit calculations
- Automatic corrective actions for improving system responses
- System reliability calculations
- Simulated generator economic dispatch or participation factors
- Generator reactive capability curves
- Extensive load modeling capabilities

Modeling

The PSS®E power flow base package includes a full range of standard models as well as flexible models that allow users to include groundbreaking technologies in their analysis. Models include:

- Local or remote control switched shunts and transformers (continuous range or discrete step control available)
- Extensive transformer models include tap impedance correction
- Two and multi-terminal HVDC transmission lines
- Extensive and flexible modeling of FACTS devices
- Extensive vendor-provided and generic wind models
- Multi-section lines
- True zero impedance branches
- Network equivalent construction (optional)
- Transmission line constants calculation

The challenge

The challenges in power systems planning and analysis are directed toward the same objectives as other business environments – do more with less.

To meet these needs, a power systems engineer needs an analytical tool that is accurate, efficient and flexible. To gain maximum benefit, the user must have access to techniques, technologies and processes developed by a large cross-section of power systems engineers and experts in their fields, and must be able to adapt the software to localized processes and procedures.

Our solution

The PSS®E Power Flow incorporates the experience of a world-wide user base to allow today's and tomorrow's power systems engineers to perform thorough steady state analyses of network plans or events. PSS®E has been used and tested against most, if not all, major power systems disturbances since the 1970s. This use has demonstrated the accuracies of PSS®E, justifying it as a world leader in power systems analysis. PSS®E has also been used to study all new network equipment and control technologies introduced in power systems over this same time period. The result is a software package that is accurate and versatile in modeling power systems.

But, of equal importance to the PSS®E accuracy and modeling flexibility is the improvement of the engineer’s efficiency through using PSS®E. The user interface in PSS®E is based on a full-graphical representation of the network and rich Microsoft Excel®-like data spreadsheets used to manipulate the data and present the results. In combination, these two presentations, and others, allow the engineer to clearly understand the data and analyses.

Additionally, what differentiates PSS®E is its open data structure and user controllability. World-wide experience has shown that any analytical tool must be prepared to perform major studies “out of the box” as well as allow for user differences in standards and practices worldwide. PSS®E exceeds these needs through its fully open data structure and integration with the Python scripting language. These characteristics provide user control of the PSS®E execution and preparation of customized results presentation.

The PSS®E Power Flow offers outstanding accuracy, user efficiency, and flexibility.

Application example

PSS®E offers tools for both deterministic and probabilistic reliability assessment.

The PSS®E Automatic AC Contingency Computation and Multi-Level AC Contingency Computation (ACCC/MACCC) features can be used to perform deterministic reliability assessment, while the PSS®E probabilistic methods provide another dimension to system planning.

The automatic contingency analysis processes user-specified and automatically-selected single and multiple contingencies within one run. User specified and automatically generated contingencies can be tested individually or combined with each other as overlapping outages of up to three levels (N-3). The contingency enumeration process is based on the use of several built-in contingency ranking schemes which provide tremendous savings in computation effort by avoiding the explicit evaluation of contingencies that are not likely to affect system reliability.

Automatic contingency analysis also features generation dispatch, a non-divergent power flow solution algorithm, tripping simulation and corrective action. Figure 1 outlines the computational procedures in performing a deterministic reliability assessment.

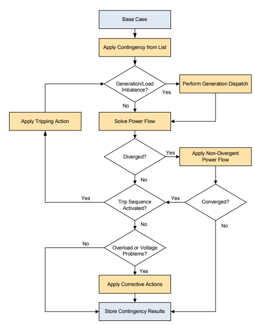

Figure 1 - Computational procedures in a contingency analysis

Within the automatic contingency analysis process, a new load flow solution is developed whenever trip sequences are triggered. The tripping option can be applied to model special protection schemes (SPS), to simulate cascading outages in severely overloaded conditions, and many other complex events.

Corrective action functions can be applied to simulate operator responses, such as the re-dispatch of generation, curtailment of load and adjustment of phase-shifting transformers. This translates system-based reliability measures, such as the location and magnitude of branch overloads and bus voltage violations, to customer-impact indices in terms of the potential amount of service interruptions.

PSS®E provides several functions to post process results for reporting. The Single ACCC report function provides seven types of reports and Multiple ACCC runs compare up to nine contingency runs. Python programs allow users to extract data stored in contingency result files for use when creating their own reports.

Probabilistic transmission reliability incorporates the impact of frequency and average duration of equipment outages on system reliability assessment. Bulk reliability measures are obtained relative to various system problems, including branch overloads, load interruptions, voltage limit violations, and voltage collapse conditions. These indices provide a better indication of power system reliability by taking into consideration the relative likelihood of different contingencies that may occur (see Figure 2).

The basic contingency analysis process can be extended to assess the steady state power transfer capabilities in a power system. The capability of transmission system to support power transfers is a measure of interconnected transmission system reliability. The PSS®E functions for transfer capability study include the transmission interchange limits calculation (TLTG) and interchange limits with two opposing systems (POLY).

The PSS®E reliability functions allow for deterministic reliability to evaluate certainty of service, and for probabilistic analysis to evaluate consequences that can be expressed in terms of cost.

RELIABILITY INDICES FOR SYSTEM LOSS OF LOAD

LOAD CURTAILMENTS (MW)	FREQ. (OC/Y)	DURATION (HOUR)	PROB.	POWER INT. (MW/Y)	ENG CURT (MWH/Y)	NO.OF CONT.	WORST CONT.
ENTIRE SYSTEM	0.8652	12.6	0.0012	90.6	632.5	822	
0.0 --100.0	0.4331	12.4	0.0006	98.1	456.1	481	12_789
100.0 --200.0	0.5050	31.8	0.0018	180.1	1132.3	778	BREAKER_FAIL
200.0 --300.0	0.0549	10.2	0.0001	135.1	2.6	63	EAST_WEST

```
CONTINGENCY LEGEND:
LABEL         EVENTS
12_789      : OPEN LINE FROM BUS 4105 [MAINSUB   138.00] TO BUS 2110 [EAST-TIE  138.00] CKT 1
              OPEN LINE FROM BUS 2106 [NRIVER    138.00] TO BUS 2110 [EAST-TIE  138.00] CKT 1
BREAKER_FAIL: trip branch from BUS 1341 to BUS 1701 CIRCUIT 1
              trip branch from BUS 1461 to BUS 14619 CIRCUIT 1
              trip branch from BUS 3201 to BUS 14619 CIRCUIT 1
EAST_WEST   : trip branch from BUS 1061 to BUS 10619 CIRCUIT 1
              trip branch from BUS 1861 to BUS 10619 CIRCUIT 1
              trip branch from BUS 1631 to BUS 10619 CIRCUIT 1
```

Figure 2 - Probabilistic reliability assessment results

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