Application

Security Analysis is a package of advanced and flexible software, designed to evaluate the steady-state security of a power system for various postulated contingencies. System security is assessed in terms of the equipment overloads and voltage limit/drop violations that occur as a result of the postulated outages.

Benefits

- Improving the network security. Since the power network is monitored in real-time the power system operator gets a clear view of the potential weaknesses in the power system and enables him to take preventive actions to minimize the potential dangers.
- Adds confidence to the power system operator. Even if no preventive actions are taken to avoid potential dangers, the power system operator will have a clear picture of the effects of a contingency. Thus, if the contingency occurs, the effects are already known and the operator can use this knowledge as a base for his further actions.
- Aid in system planning. The SA function will help the engineer in planning of the maintenance strategies.
- Severity screening. The SA function will always select the most harmful contingencies for a complete analysis.

Functions

The SA, Security Analysis, function is executed upon request and can also be configured to execute cyclically and after certain power system events. During each execution, the SA function evaluates the user-specified contingencies and reports any resulting violations of the monitored equipment limits. If the current execution results in a violation not present in the previous execution, the operator will be notified via an alarm.

The SA function is capable of handling the following types of outages:

- single branch (transformer, power line)
- multiple branch
- local bus-section
- generating unit
- synchronous condenser
- shunt element
- load
- multiple combinations of the ones above.

It can also handle islanded networks and split buses. The SA function uses the State Estimator output or the output from the Dispatcher Power Flow as a starting point for the calculations. In study mode, input can be taken from either the State Estimator or the Dispatcher Power Flow function.
Functions, continued

Methods
SA consists of the following sub functions:
• On-line contingency definition
• Contingency topology pre-processing
• AC contingency screening
• Full AC contingency analysis

Contingency Definition
The contingency definition function is used to specify all the contingencies to be analyzed as well as the components of the system to be checked for violations. This is accomplished on-line, in dedicated displays in the man-machine subsystem. After data validation, the new lists are ready to be used immediately by the SA function at the next execution.

Topology Pre-Processor
The contingency topology pre-processor function verifies the lists with contingency definitions and the list with equipment who’s limits are to be monitored at the start of each execution of SA. The function adjusts these two lists to the base case network conditions. Contingencies are redefined to reflect the actual connectivity of the system. For instance, contingencies involving already disconnected equipment’s are adjusted to reflect that.

AC Contingency Screening
The AC contingency screening is based upon a modification of the single power flow iteration approach. The method, the complete bounding method, automatically determines the set of nodes for which the Q-mismatches must be calculated. It uses the efficient bounding method for the initial selection of buses for which the angular increment has to be calculated as well as for the selection of branches whose flow limit may be violated as a result of the contingency. Sparse vector techniques are extensively used in the implementation of the compensation methods for the solution of the line power flow. Five severity indices are calculated:
- Branch Flow Violation Severity
- Voltage Violation Severity (either limit or drop)
- Reactive Power Violation Severity
- System Shift Index for Bus Voltages
- System Shift Index for Reactive Power Generation Requirements.

The system shift index is defined as a measure of the total change from the pre-outage state. No branch flow shift indices are calculated due to the use of the efficient bounding method.

Full AC Contingency Analysis
The AC contingency analysis is designed to accurately process a set of contingencies identified as potentially harmful. The selection is based upon the severity indices calculated by the AC Contingency Screening.

The function uses the fast decoupled AC algorithm in combination with the partial matrix factorization and sparse vector methods. The regulation effects are modelled using highly efficient methods designed to eliminate the interaction between the different controls by scheduling them in an appropriate sequence and performing a fast “auxiliary” solution to ensure that each regulation has been sufficiently resolved. The algorithm used is capable of processing islanded networks and split buses.

The contingencies are ranked according to:
- Branch Flow Violation Severity
- Reactive Power Violation Severity
- Voltage Limit Violation Severity
- Voltage Drop Violation Severity

An overall severity index is also calculated for each contingency. This is the weighted sum of the above four severity indices. The user has the capability to specify the weighting factors for the different types.