POWERFACTORY

Contingency Analysis
Analysing N-1 . . . N-k Fault Outages

Introduction

Any network owner or operator has to consider the possibility of unplanned outages in the network, and the effect that these can have on the system as a whole. For utility companies, it is essential to analyse all credible events in order to ensure that system security will not be compromised in the event of a fault, and that grid code requirements will still be met.

Such analysis is often referred to as N-1 analysis or contingency analysis. However, the coincidental failure of more than one primary network element, i.e. N-2...N-k, must also be considered. There is a need to evaluate the effect of such faults in terms of thermal loadings and voltage stability, together with effectiveness analysis and the assessment of potential pre- and post-fault remedial actions.

With *PowerFactory* Contingency Analysis calculations generating results across a whole network, for large numbers of different cases, and potentially including effectiveness information, efficient reporting is important. The user needs to be able to assess the network visually, to see at a glance where there are potential issues. More importantly, it is essential that the results of the calculation can be examined in detail, which means having access to ease-to-use reporting tools. Customised post-processing of the raw results should also be an option.

1 Contingency Analysis Features

Contingency Analyis in *PowerFactory* is a load flow based assessment of a network, and by default uses a standard balanced or unbalanced AC Load Flow, with alternatives being the faster DC or AC Linearised calculations. Contingencies are defined using Fault Cases, which specify the faulted equipment and optionally extra events such as additional switch operations. Parallel computing can be selected and configured by the user, to utilise multiple cores of the computer. In the following sections, the most important features of the Contingency Analysis module are described.

Fault Case definition

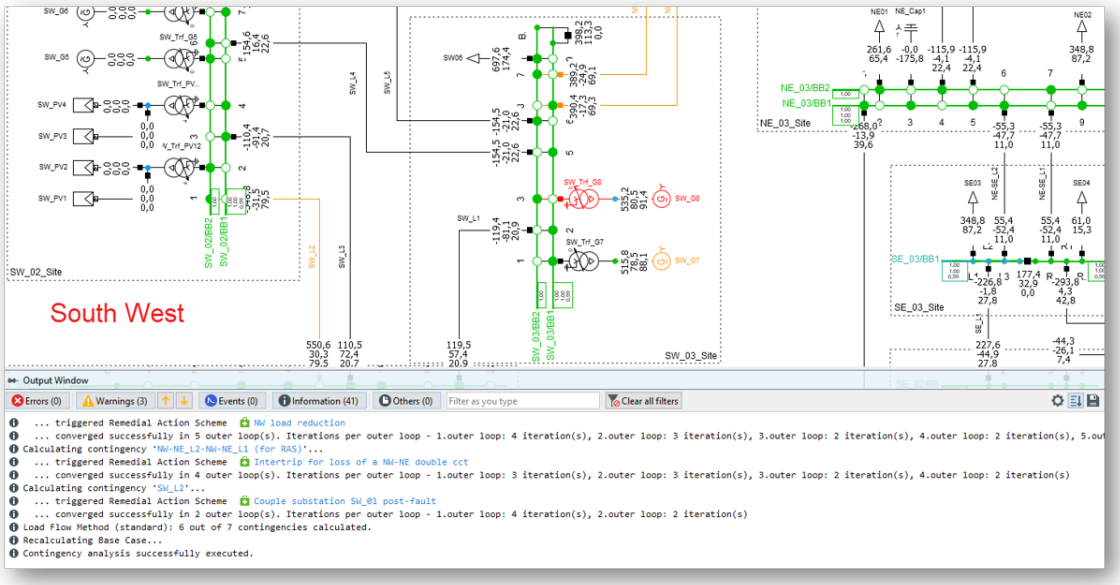
Fault cases can be defined automatically, based on user specification such as all lines or all busbars, and stored in the project library. A Fault Case typically consists of one or more short-circuit events. When the Fault Case is executed in the Contingency Analysis, topology tracing is used to find and open the correct circuit breakers. Users can customise Fault Cases to add, for example, additional switch actions or generation dispatch events.

Time Phase analysis

As well as single time-phase analysis, where all events are assumed to occur at the same point in time, a multiple time-phase analysis option allows the user to take into account the relative times of individual events during a fault scenario. For example, transformer tapping, automatic switch operations or generation dispatch. A multiple-time phase case can be played out graphically using a trace function.

Remedial Action Schemes

Remedial Action Schemes (RAS) are sets of actions that are triggered by certain system states. In the context of Contingency Analysis, a typical example might be the dispatch of generation to reduce the post-fault overload on a circuit. In *PowerFactory*, the highly flexible RAS functionality allows for the modelling of a wide range of events, including user-defined variable changes, in response to trigger criteria, which can be nested in order to model complex situations. RAS can be used in conjunction with either single time-phase or multiple time-phase analysis.



Remedial Action Schemes

Dynamic Contingencies

Executing a large number of pre-defined contingencies may not be the preferred approach when what is needed is a rapid assessment to identify the main problem areas. In *PowerFactory*, it is possible to have the contingency cases defined "on the fly", based on the initial load flow flow results. A typical use case would be to request contingencies to be executed for any circuit loaded about a certain percentage level in the base load flow case. This enables rapid assessment, which can also be supplemented by static fault cases in the same analysis run.

Effectiveness Calculations

Contingency Analysis can also incorporate effectiveness calculations. The user specifies a set of generators and/or phase-shifters, and the effectiveness of these against any circuit overloads are returned, taking into account user-defined thresholds. This information can then be used to determine the best pre- or post-fault remedial actions.

Time Sweep

The Time Sweep feature is designed to allow the calculation to be executed multiple times, for example for every hour of a day. Making use of *PowerFactory*'s Study Case time definition, the Time Sweep Contingency Analysis will automatically pick up time-varying data and time-related topology changes such as network developments and planned outages.

Presentation of results

Detailed results of Contingency Analysis calculations are presented via inbuilt tabular reports. This can include circuit loadings and potential voltage violations, together with reporting of information such as loss of demand or generation, or islanding. In addition, summary values can be viewed in a graphic or *PowerFactory*'s Network Model Manager. All the results are stored in a file that can be accessed from within *PowerFactory* or externally. This makes it possible for users to write their own customised reporting scripts as an alternative to the inbuilt reports.

2 Executive Summary

PowerFactory offers a comprehensive Contingency Analysis module, covering the whole process from fault definition, through network analysis, to reporting of results. The package enables users to carry out straightforward calculations very easily, whilst offering a wide range of more sophisticated options such as dynamic contingency definition, multiple time-phase analysis and remedial action schemes.

3 Licence Configuration

Required
✓ Contingency Analysis

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