PSS®E 34 is full of many important enhancements, such as more thermal ratings, the addition of branch names and new dynamics models, but the most powerful addition is integrated node-breaker support. The PSS®E team has painstakingly worked towards a node-breaker implementation that meets the requirements of the industry while also being intuitive and straightforward to use. This article will outline what node breaker has to offer, as well as mention several other key improvements coming with the release of PSS®E 34.

Node-breaker Overview

Node-breaker support in PSS®E 34 allows the detailed modeling of substation topology, down to the breaker and switch level. PSS®E 34 uses a carefully designed integrated approach to node-breaker modeling which allows you to continue interacting with your network through the traditional bus-branch view, while having the ability to drill down into the details of breakers and switches when you need to. Solution efficiency and robustness is not a problem. By using state-of-the-art topology processing techniques, PSS®E 34 can support tens of thousands of additional nodes without the loss of any speed or accuracy in the powerflow solution.

The PSS®E node-breaker data model is implemented as an extension to the standard bus-branch data model, so you can add or remove the node-breaker data without any loss of functionality to the bus-branch model. The internal details of the data mapping and topology processing are completely hidden, allowing you to focus on engineering. Also, because node-breaker data is tedious to generate, PSS®E 34 provides tools for automatically building up the substation topology and substation single-line diagrams.
There are some situations where users are required to use older versions of PSS®E. You can leverage the power of node-breaker support for older PSS®E versions, by generating bus-branch models from version 34 that are compatible with PSS®E versions 32 and 33. These models include the effects of node-breaker switching operations.

**Node-breaker Model Creation and Navigation**

Having node-breaker detail in your network models is very powerful, but creating Node-breaker substation models can be very tedious. Because of this, we have developed tools in PSS®E 34 to automatically generate node-breaker topology for you, based on several common layouts (ring bus, breaker and a half, etc). A graphical representation of the substation is automatically created for you in the form of a substation single-line diagram (Substation SLD). The layout of the substation SLD can be manually changed for proper placement of terminals, and to approximate the general arrangement of your substation.

![Figure 2 - Automatic Substation Node-breaker Topology Generator Dialog](image)

The bus-branch and node-breaker models are seamlessly linked, and complex node-breaker detail can remain hidden from view until you need to drill down and perform switching at the breaker and switch level. To navigate to a substation node-breaker SLD from a traditional bus-branch SLD, simply double-click a bus that has underlying substation topology, and PSS®E will either find your custom SLD for that substation, or it will create one on-the-fly.

![Figure 3 - Bus-branch View](image)
Buses that have associated node-breaker data will appear surrounded by a box, indicating that there is underlying node-breaker topology. If there has been switching operations within the substation, the box will be dashed, indicating an abnormal switching condition. This is important, because the traditional concept of a bus as a zero-impedance point of electrical connectively is no longer valid in the node-breaker world. The underlying solution model may have to dynamically add or combine internal buses. This internal activity is mostly hidden from view, except for the important case of a bus-split. If the node-breaker switching condition causes the splitting of a bus into two or more sections, these sections will be viewable in the spreadsheets and reports, with their own voltage magnitude and angle data.

**Node-Breaker Contingency Analysis**

One of the most important consequences of having node-breaker detail in your network models is powerful new ways of defining and simulating contingencies. Because of our integrated approach, you can define contingencies based on the bus-branch topology that automatically implement the more complex node-breaker contingencies. For example, a branch contingency can still be defined as:

```
open line from bus 101 to bus 102 circuit 1
```

But, in the presence of node-breaker data, the contingency engine will actually implement this contingency by isolating this branch using the appropriate breakers. New contingency commands will be available for simulating complex protection behavior that used to be difficult or impossible to properly simulate using bus-branch data only. For example, the definition of a stuck-breaker contingency is simply:

```
stuck breaker from bus 101 to bus 102 circuit 1
```

This command will outage the specified branch and it automatically determines which breakers need to open to isolate the stuck breaker at the bus 101 side.
Figure 5 - Ring-bus Example with Breaker Outage

The ultimate goal is to allow as many contingency types as possible to be automatically generated by PSS®E, eventually removing the need to manually maintain contingency lists for all but the most complex contingencies.

This table shows the additional NERC TPL contingencies that can be properly simulated and automatically generated with PSS®E 34 node-breaker data. Although there are many different grid codes used throughout the world, we use the North American NERC standards here as an example.

<table>
<thead>
<tr>
<th>NERC Contingency Category</th>
<th>Short Description</th>
<th>Can be Properly Simulated in PSS®E 33</th>
<th>Can be Automatically Generated in PSS®E 33</th>
<th>Can be Properly Simulated in PSS®E 34 with Node-breaker</th>
<th>Can be Automatically Generated in PSS®E 34 with Node-breaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>Basecase</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>P1</td>
<td>N-1</td>
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<td>All</td>
</tr>
<tr>
<td>P2</td>
<td>Bus or Breaker Fault</td>
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<td>All</td>
</tr>
<tr>
<td>P3</td>
<td>N-1-1</td>
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<td>All</td>
<td>All</td>
</tr>
<tr>
<td>P4</td>
<td>Stuck Breaker</td>
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<td>All</td>
</tr>
<tr>
<td>P5</td>
<td>Delayed Clearing</td>
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<td>All</td>
</tr>
<tr>
<td>P6</td>
<td>N-2</td>
<td>All</td>
<td>Som</td>
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<td>All</td>
</tr>
<tr>
<td>P7</td>
<td>Common Structure</td>
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<td>Some</td>
<td>All</td>
<td>Some</td>
</tr>
</tbody>
</table>

**Other PSS®E 34 Enhancements**

**Branch and Equipment Names**

In addition to indentifying and referencing branches and equipment with key fields (such as bus numbers and circuit ids), PSS®E 34 will allow you to attach names (or “labels”) to these elements. This is useful for two reasons: human readability and external system compatibility. Adding branch and equipment names can make your network data, contingency files, and reports more readable and less cluttered. For example, a three-winding transformer can be very difficult to readily identify with an auto-generated string of bus names and kV values, but by adding a name like “NUC X2”, you can quickly recognize it in a report. Also, many EMS and regional data exchange systems (such as SDX) use names as key fields to reference network elements. Node-breaker elements also support names.
More Rating Sets

Due to very popular demand; we have added the capability to manage up to 12 thermal rating sets. These rating sets have useful meta-data (names and descriptions) and can be used to model any type of ratings desired (seasonal, contingency level, transient, etc).

Other Additions Coming in PSS®E 34

- Python™ 3 Support and Python Version Independence
- Solution Options Saved in RAW File
- New IEEE 421.5 Models
- Improved Transformer Impedance Correction tables
- Results Spreadsheets (Replacing Text-based Reports)
- Improvements in Slider Layout, Functionality and Settings
- Improved File Handling and Directory Management