# Transient Stability Analysis with PowerWorld Simulator

T2: Transient Stability
Data Management

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## Transient Stability Data Management

- The Transient Stability tool makes it possible to deal with a large amount of input data (and result data, discussed later)
- Reading/writing to various file formats
  - Input data can be used to define the dynamic models of the system as well as the steady-state model of the system
  - Simulator also makes it easy to save out transient stability information to files
- Navigating available models
  - Model explorer
  - Stability tab of dialog for individual models
- Additional resources are available, including
  - Block diagrams
  - Simulator Help documentation

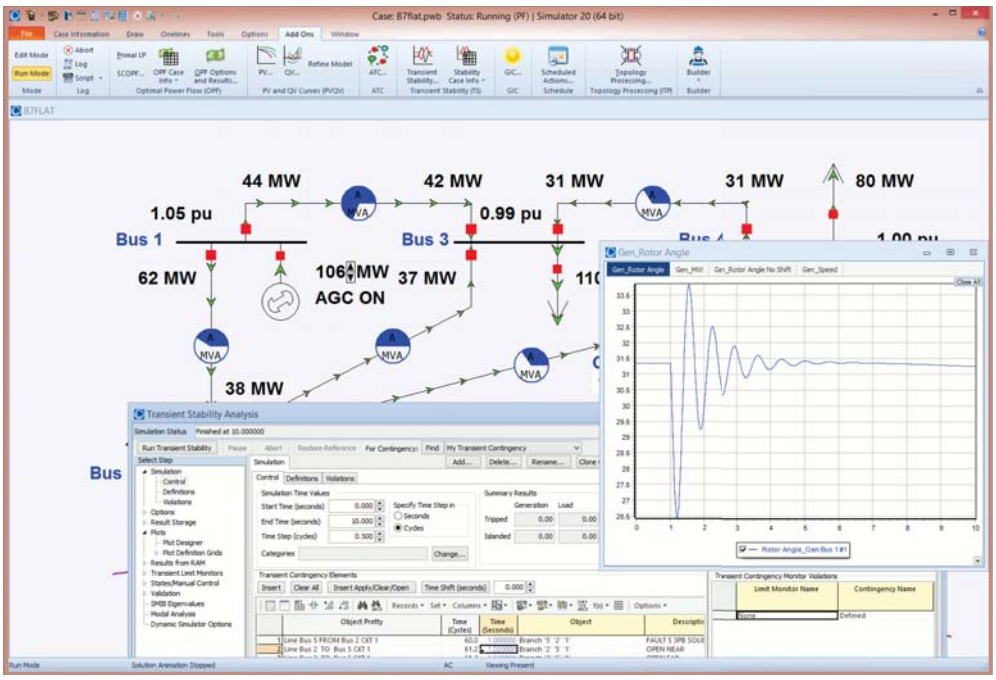
# Design Philosophy

- PowerWorld's design philosophy is to make power system analysis as easy as possible
  - This holds true in the transient stability domain. Our goal is to reduce the entry barrier to allow more power system professions access to transient stability.
- As much as possible we have leveraged our existing methods for data interaction
- Transient stability data augments the power flow model data





# Example: Running Transient Stability on the B7Flat Case




Our Philosophy: While doing transient stability solutions on large cases can certainly require large amounts of engineering expertise, the barriers of entry in learning to do such studies should not arise because of the software.

# External Data Files

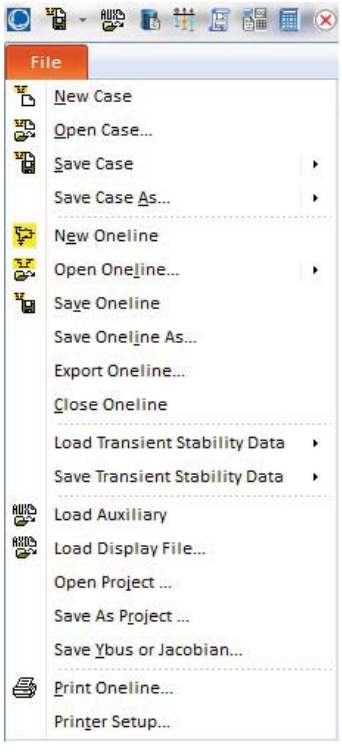
- A particular pwb case may or may not already have dynamic models saved in it, and there must be at least one model to do a transient stability simulation
- Models may be read in from an input file or manually entered
- Several external file types including
  - PowerWorld Auxiliary File (AUX)
  - PTI File (DYR)
  - GE File (DYD)
  - BPA File (SWI)
- PowerWorld Simulator can read and write Transient Stability data to these formats
- Only models that are available in the specific format can be saved back into that format





# External Data Files

- Access for loading and saving these files can be found in several places within Simulator
- Application File Menu by clicking the PowerWorld icon in the top left corner of Simulator
- At the bottom of the specific model pane in the Transient Stability portion of the Model Explorer
- Stability Case Info Menu buttons
- Transient Stability Dialog buttons



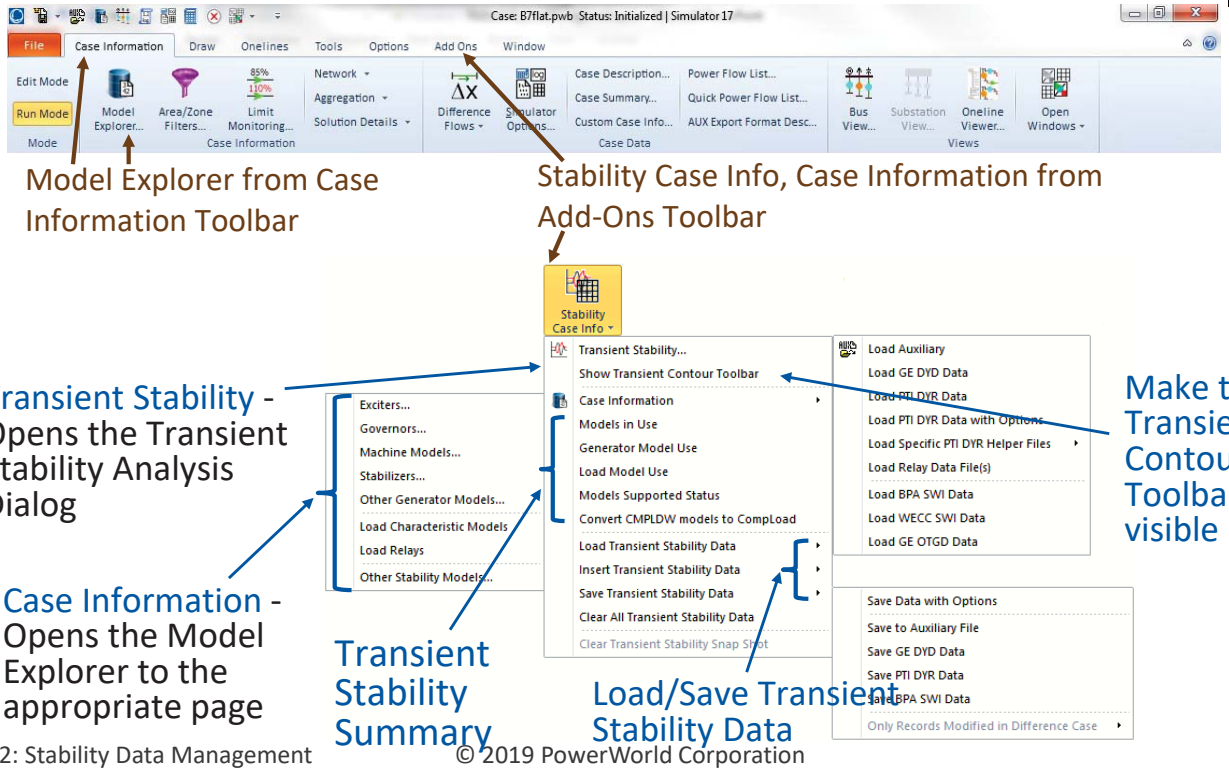
# Auxiliary Files (AUX)

- The ability to use AUX files exists throughout Simulator, and it is something that is supported by Transient Stability as well
- Another training course covers AUX files in more detail
- Save to Auxiliary
  - Store any results and settings that need to be retained for future use
  - Easily loaded into different power flow cases
- Load Auxiliary
  - Load relevant option settings to be used during the transient stability analysis
  - Can load the same AUX file into many cases
- Transient-stability specific results and options can also be saved with the pwb case



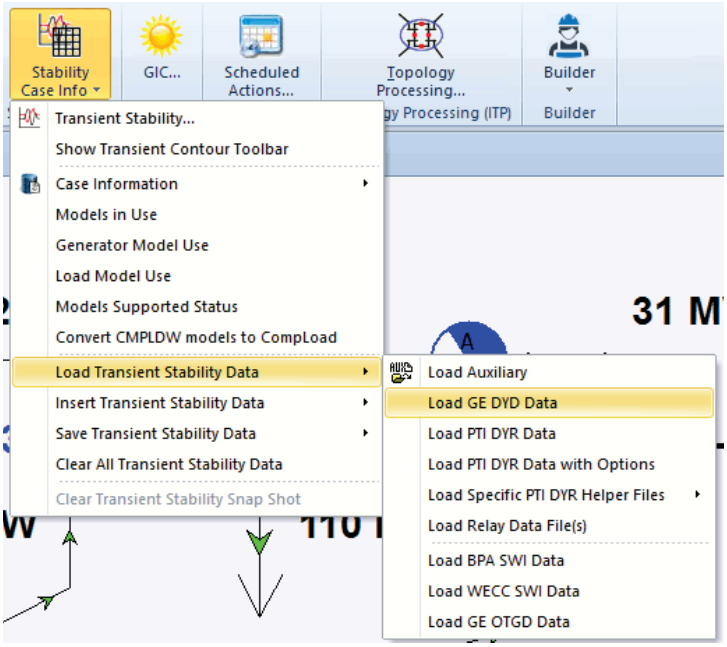


# Transient Stability Case Information and Model Explorer



# Example: Loading Data from External File Formats

- Open WestExample.epc
- This contains power flow model data
- Go to “Load Transient Stability Data” and “Load GE Data” from the Stability Case Info drop down menu on the main ribbon
- Load in WestExample.dyd
- This contains dynamic model data



# GE DYD Special Handling: Cross-Compound Units

- Cross-compound units are two generators that both operate off the same steam plant
- Often represented in a DYD file
  - 2 machine models
  - 2 exciters
  - 2 stabilizers
  - 1 governor which is either IEEEG1 or CRCMGV
- Ideally, the power flow model represented by the EPC file will model these two generators separately and will easily link to the DYD models

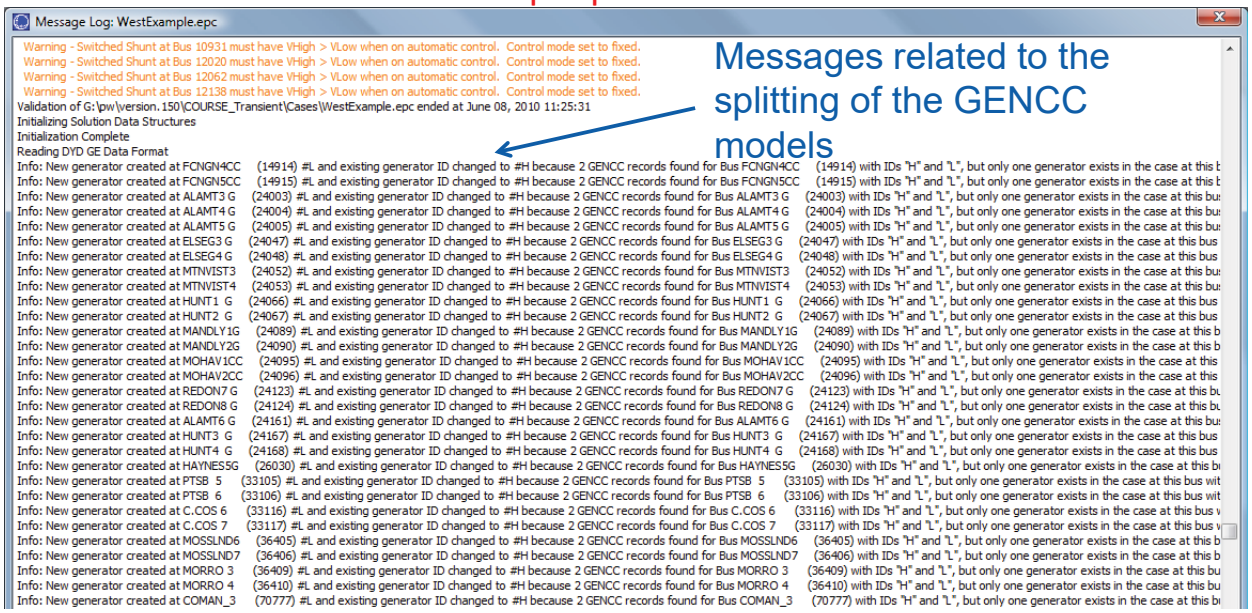
# GE DYD Special Handling: GENCC model

- The GENCC model is often modeled as one generator but signals that two generators in the DYD file may be represented by one in the EPC file
- When this situation is found, Simulator will automatically split the existing generator into two
  - An appropriate log message will be written
- Parameters *Pfac* and *Qfac* determine the percentage of MW and MVAr assigned to each of the two generators



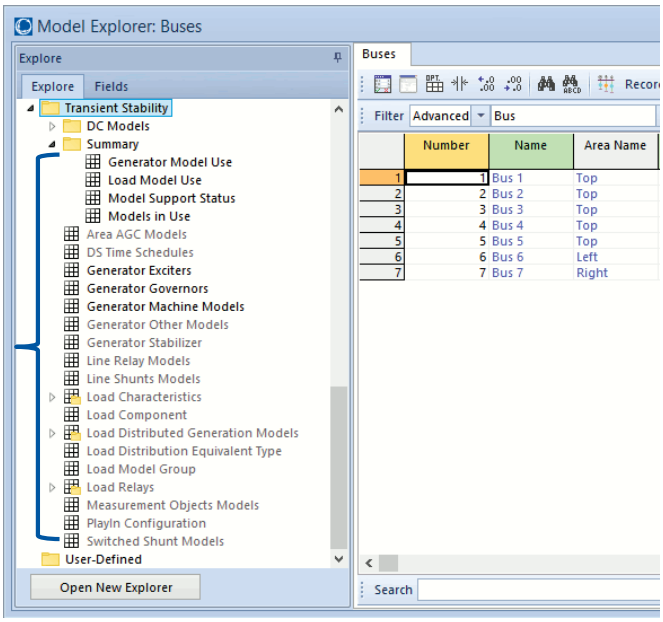
# Example: Loading Data from External File Formats

- Informational messages, warnings, and errors created by reading in the data will appear in the log
- Save the case as WestExample.pwb for future use



# Transient Stability Case Information and Model Explorer

- Model Explorer contains a Transient Stability Folder
- The first item is the Summary sub-folder
- Also, pages are listed for each class of available model
- The same options and Model Explorer pages can also be accessed from the Stability Case Info menu

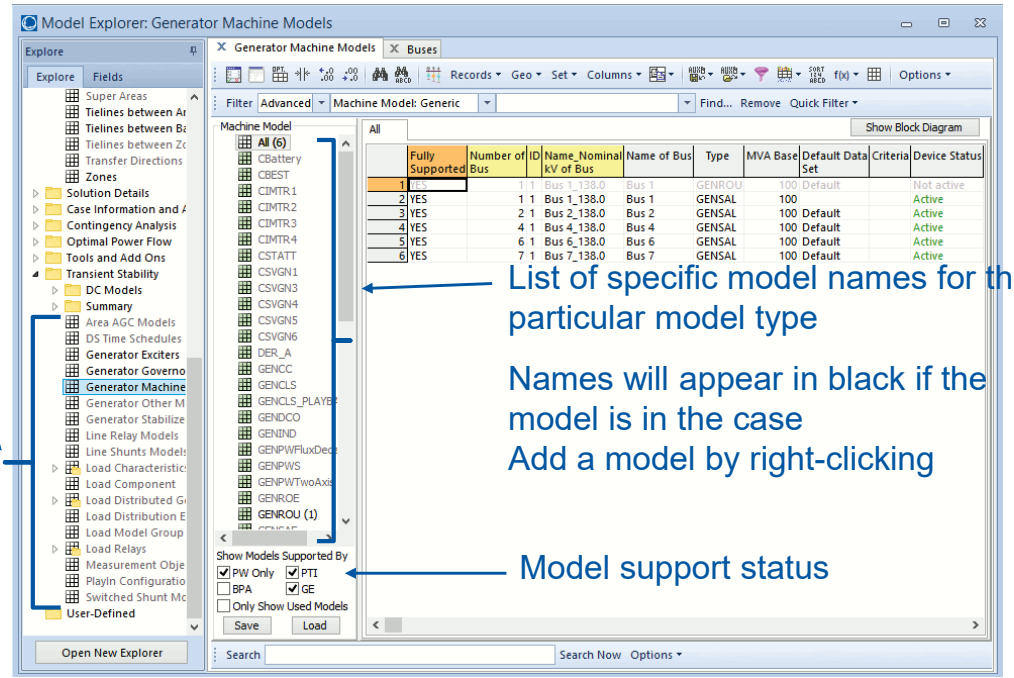






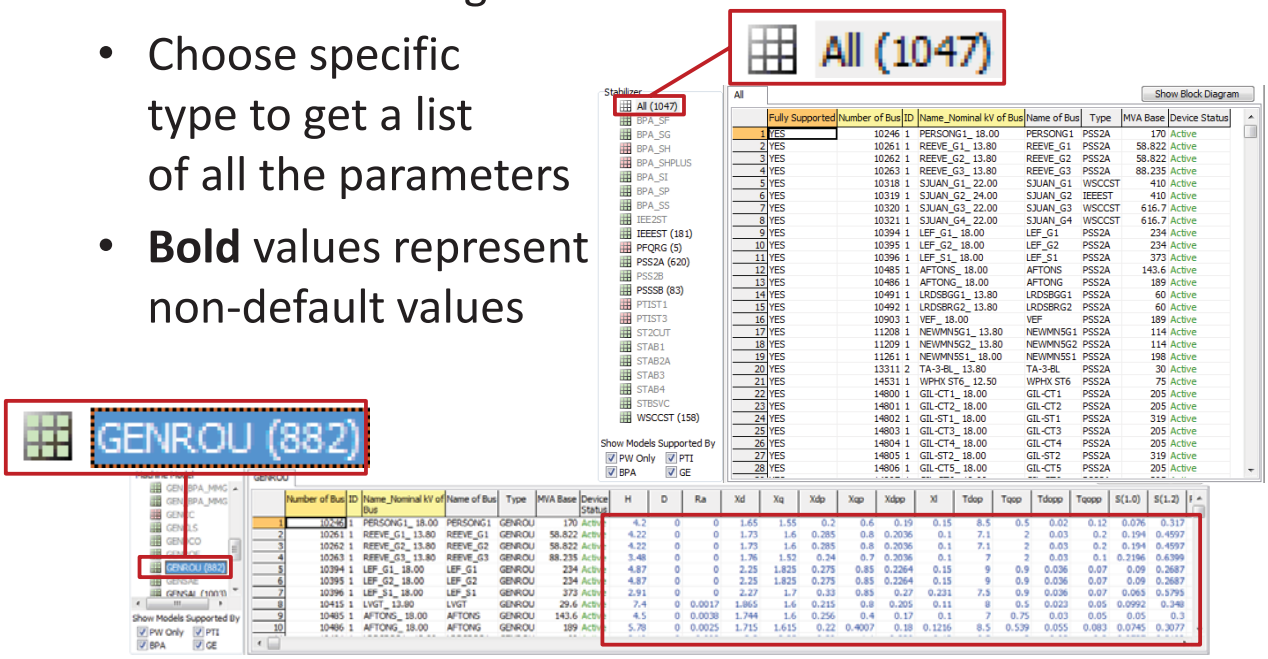

# Navigating Available Models

Model Explorer lists the supported models



# Navigating a List of Models

- Choose “All” to get a list of all Stabilizers
- Choose specific type to get a list of all the parameters
- **Bold** values represent non-default values



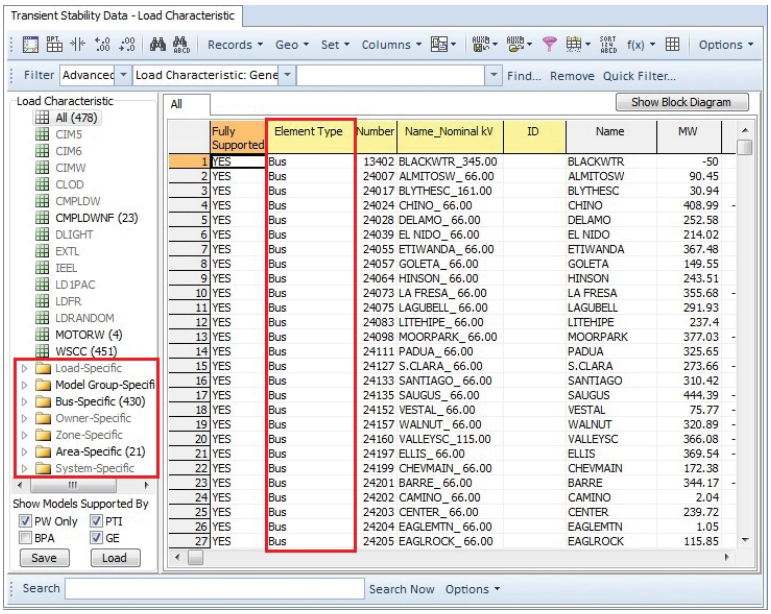





# Load Characteristic Models

- Load models apply to either a load, bus, owner, area, or the entire case

Precedence:
1.Load-specific
2.Load Model Group-specific
3.Bus-specific
4.Owner-specific
5.Zone-specific
6.Area-specific
7.System-specific
8.Load Component-specific
9.Default load modeling option with transient stability options

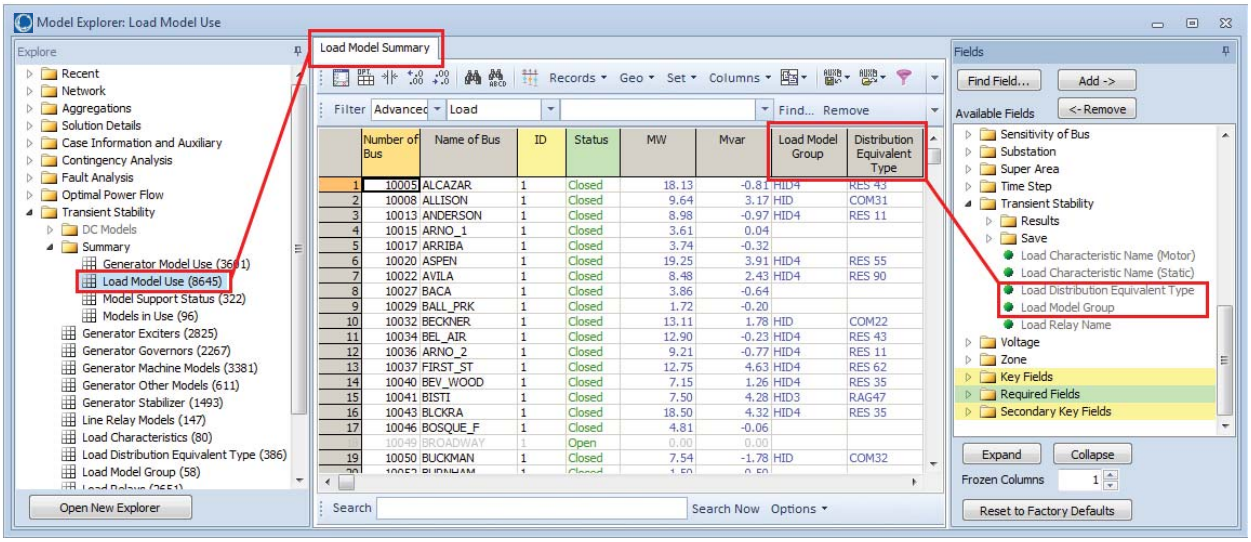


# Load Characteristic Models

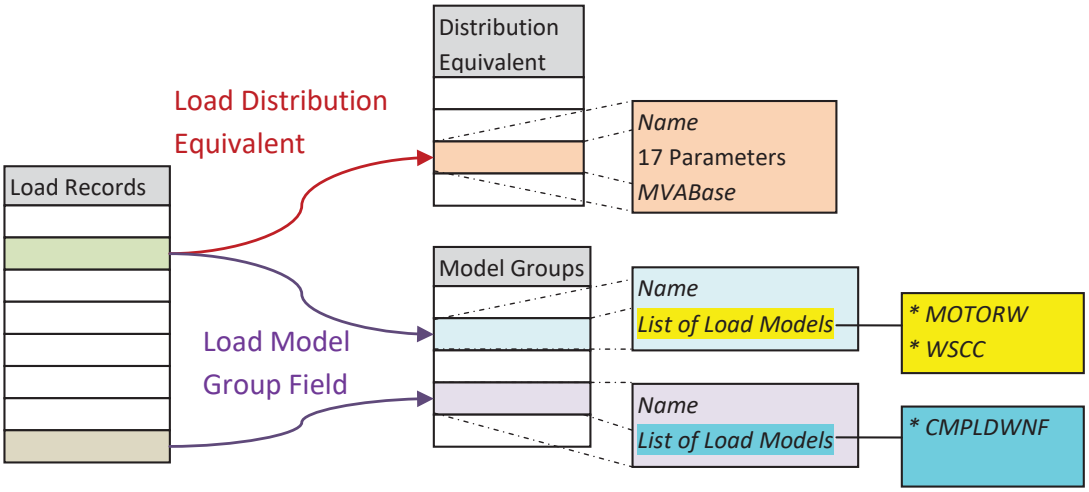
- Models like CMPLDW have up to 130 parameters
- Hundreds or thousands of loads with the same CMPLDW parameters
- Group together models with the same parameters
- Create new objects in Simulator
  - Load Model Groups
  - Load Distribution Equivalent Types



# Load Characteristic Models



# Load Characteristic Models








# Load Model Group

- Load Model Group:
  - Identified by unique name
  - List of Load Characteristic Models assigned to it
    - MOTORW, WSCC, CMPLDWNF, etc.
  - Allows flexibility in grouping load characteristic models with the same parameters that area, zone, etc. aggregations do not
  - May represent the behavior of a climate group
    - "High Desert"

# Load Characteristic Models

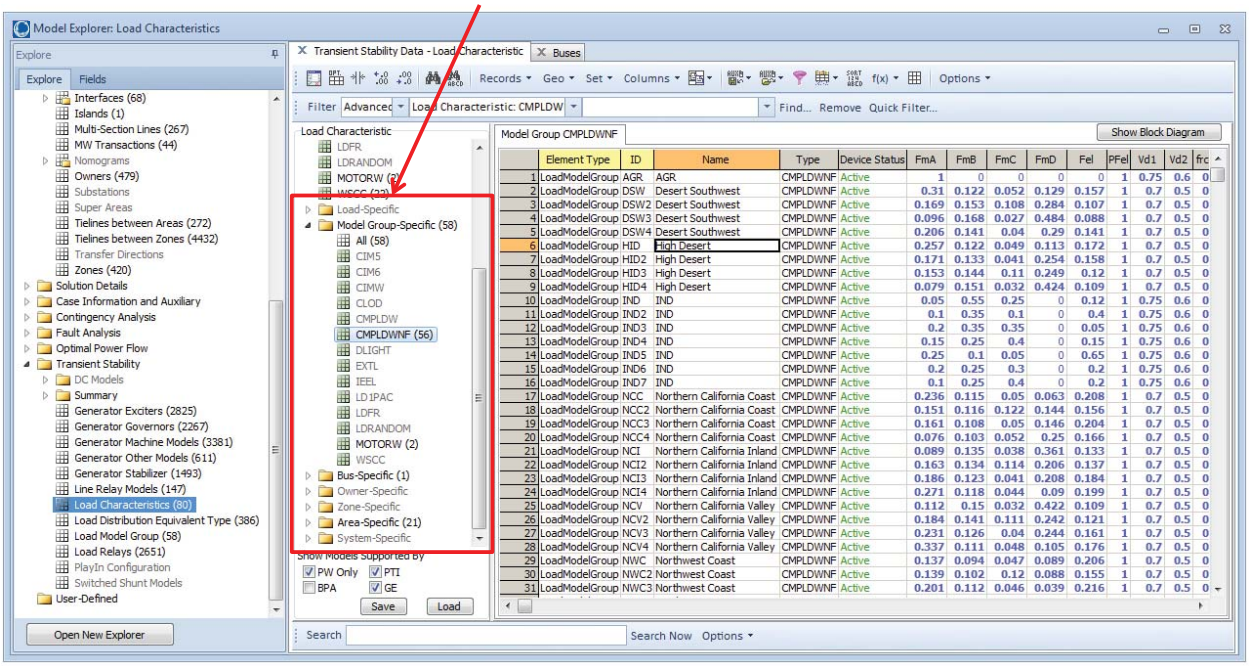
- Load Model Hierarchy:
  1. Load-specific
  2. Load Model Group-specific
  3. Bus-specific
  4. Owner-specific
  5. Zone-specific
  6. Area-specific
  7. System-specific
  8. Load Component-specific
  9. Default load modeling option with transient stability options





# Load Characteristic Models

Load Model Hierarchy



# Load Distribution Equivalent

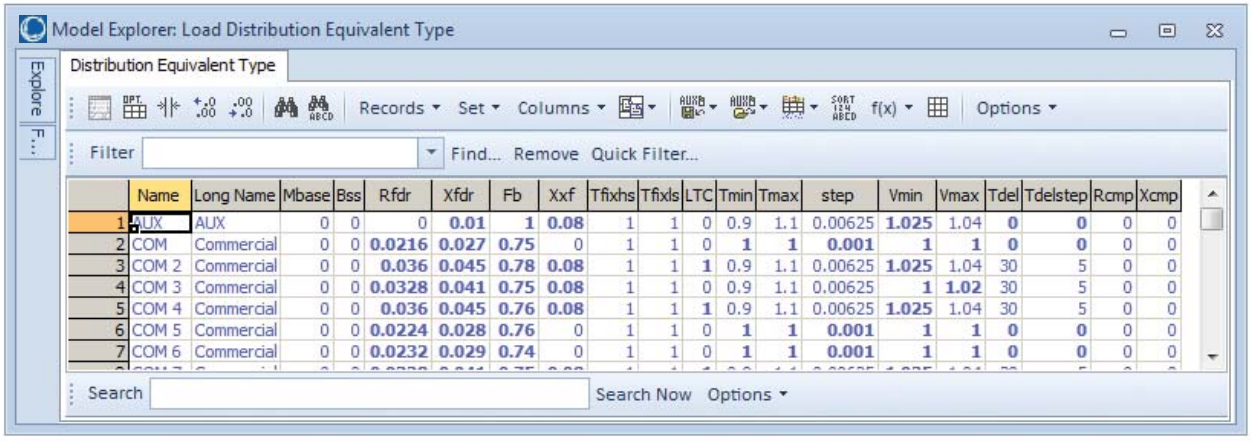
- Supplementary model that defines an equivalent of the distribution system's transformer, capacitors, and feeder
- Created independently of the load characteristic models
- Can be used with any load characteristic model
- Design assumes small number of Load Distribution Equivalent Types with many different loads assigned to each





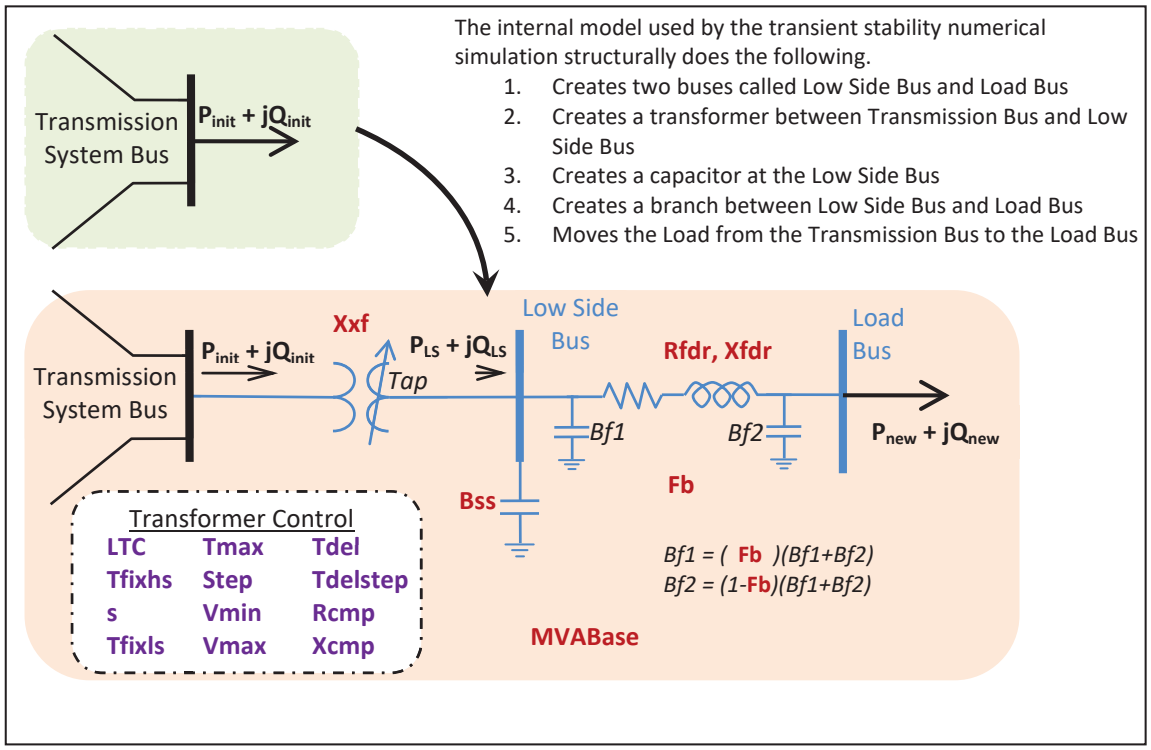
# Load Distribution Equivalent

- First 17 parameters of the CMPLDW load characteristic model along with MVA base




| | Name | Long Name | Mbase | Bss | Rfdr | Xfdr | Fb | Xxf | Tfixhs | Tfixls | LTC | Tmin | Tmax | step | Vmin | Vmax | Tdel | Tdelstep | Rcmp | Xcmp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AUX | AUX | 0 | 0 | 0 | 0.01 | 1 | 0.08 | 1 | 1 | 0 | 0.9 | 1.1 | 0.00625 | 1.025 | 1.04 | 0 | 0 | 0 | 0 |
| 2 | COM | Commercial | 0 | 0 | 0.0216 | 0.027 | 0.75 | 0 | 1 | 1 | 0 | 1 | 1 | 0.001 | 1 | 1 | 0 | 0 | 0 | 0 |
| 3 | COM 2 | Commercial | 0 | 0 | 0.036 | 0.045 | 0.78 | 0.08 | 1 | 1 | 1 | 0.9 | 1.1 | 0.00625 | 1.025 | 1.04 | 30 | 5 | 0 | 0 |
| 4 | COM 3 | Commercial | 0 | 0 | 0.0328 | 0.041 | 0.75 | 0.08 | 1 | 1 | 0 | 0.9 | 1.1 | 0.00625 | 1 | 1.02 | 30 | 5 | 0 | 0 |
| 5 | COM 4 | Commercial | 0 | 0 | 0.036 | 0.045 | 0.76 | 0.08 | 1 | 1 | 1 | 0.9 | 1.1 | 0.00625 | 1.025 | 1.04 | 30 | 5 | 0 | 0 |
| 6 | COM 5 | Commercial | 0 | 0 | 0.0224 | 0.028 | 0.76 | 0 | 1 | 1 | 0 | 1 | 1 | 0.001 | 1 | 1 | 0 | 0 | 0 | 0 |
| 7 | COM 6 | Commercial | 0 | 0 | 0.0232 | 0.029 | 0.74 | 0 | 1 | 1 | 0 | 1 | 1 | 0.001 | 1 | 1 | 0 | 0 | 0 | 0 |

# Load Distribution Equivalent








# Load Distribution Equivalent

- MVABase determines the *DistEquivMVABase*
  - (MVABase > 0) then *DistEquivMVABase* = MVABase
  - (MVABase < 0) then *DistEquivMVABase* = Pinit/MVABase
  - (MVABase = 0) then *DistEquivMVABase* = Pinit/0.8
- Impedance parameters are on the *DistEquivMVABase* and are converted to system base
- Transformer taps and impedances are converted to the system MVA base on the fixed taps
- Transformer tap ratio set so that Low Side Bus voltage is equal to the average of Vmin and Vmax
- After converting the impedances and taps, Low Side Bus voltage and flow on the Low Side Bus ($P_{LS} + jQ_{LS}$) are calculated exactly
- Iterative process to determine $P_{new} + jQ_{new}$ , Bf1, and Bf2 depending on the transient load model

# Load Distribution Equivalent

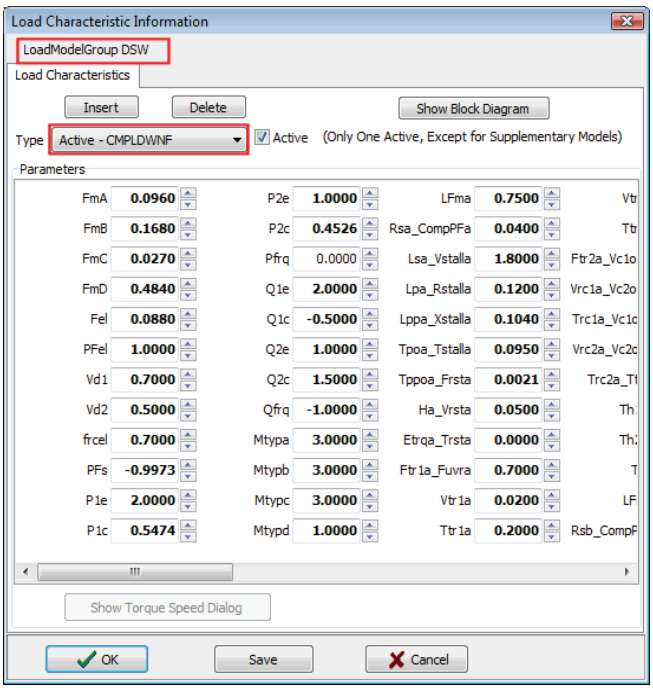
- If Load Bus voltage falls below 0.95 per unit, feeder impedances Rfdr and Xfdr are reduced so that the Load Bus voltage is 0.95 per unit
  - There is no need to modify the input data to prevent the Load Bus voltage from being too small





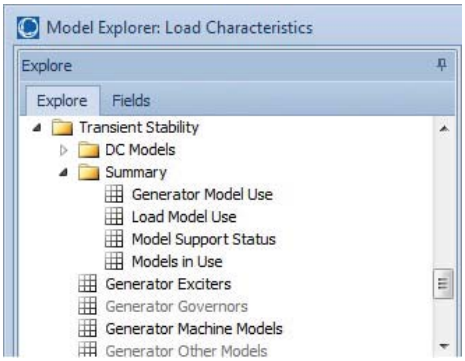
# New Model CMPLDWNF

- Identical to CMPLDW except that parameters for Load Distribution Equivalent have been removed (first 17 parameters and MVABase)



# Model Explorer: Transient Stability\Summary\

- On the Model Explorer, under Transient Stability\Summary, there are the following entries:
  - Generator Model Use
    - Lists each generator along with the dynamic models it is using
  - Load Model Use
    - Lists each load along with the dynamic models it is using
  - Model Support Status
    - A list of all the models that Simulator can read/write
    - Listing of models that can be read from or written to the appropriate text based file format for other software packages
  - Models in Use
    - A list of all the models used in this case, along with a count of each

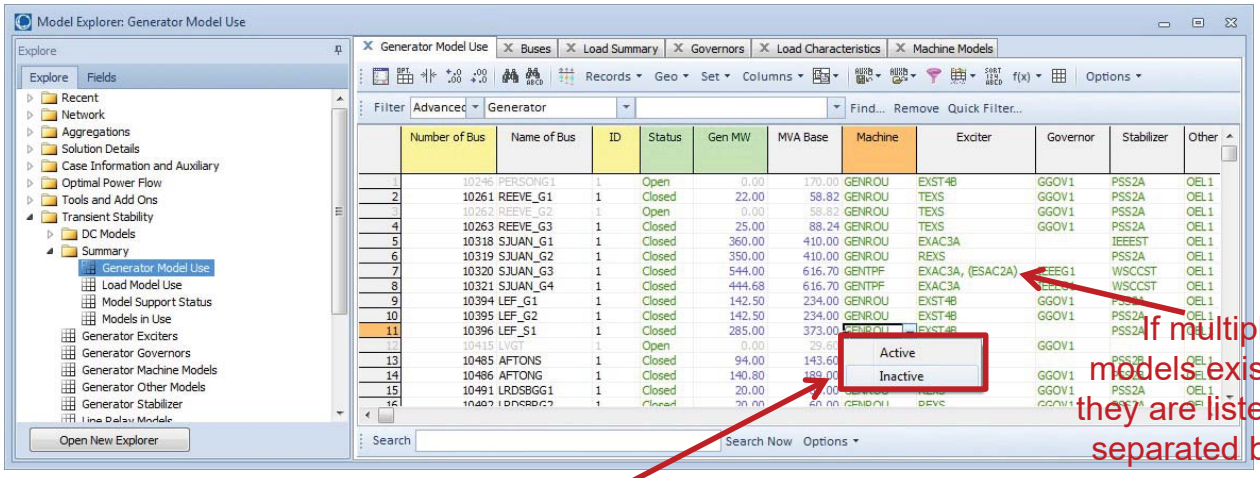







# Generator Model Use Example

- For the example case, open the Summary folder
- On the Model Explorer, open the Transient Stability\Summary page
- Open the Generator Model Use page



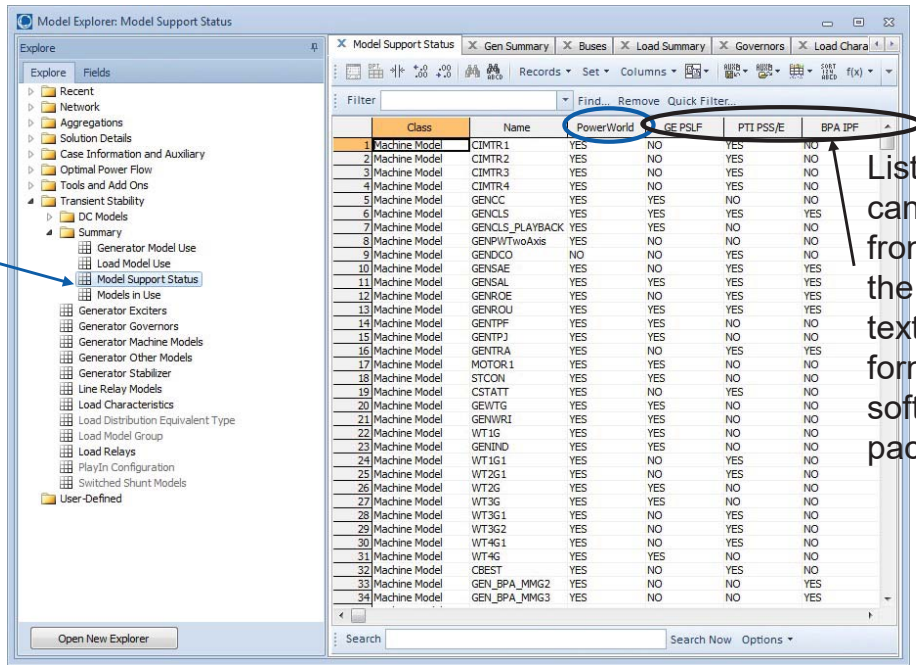



WestExample.pwb

# Model Support Status Example

- Open the Model Support Status page

Model support statuses for all models



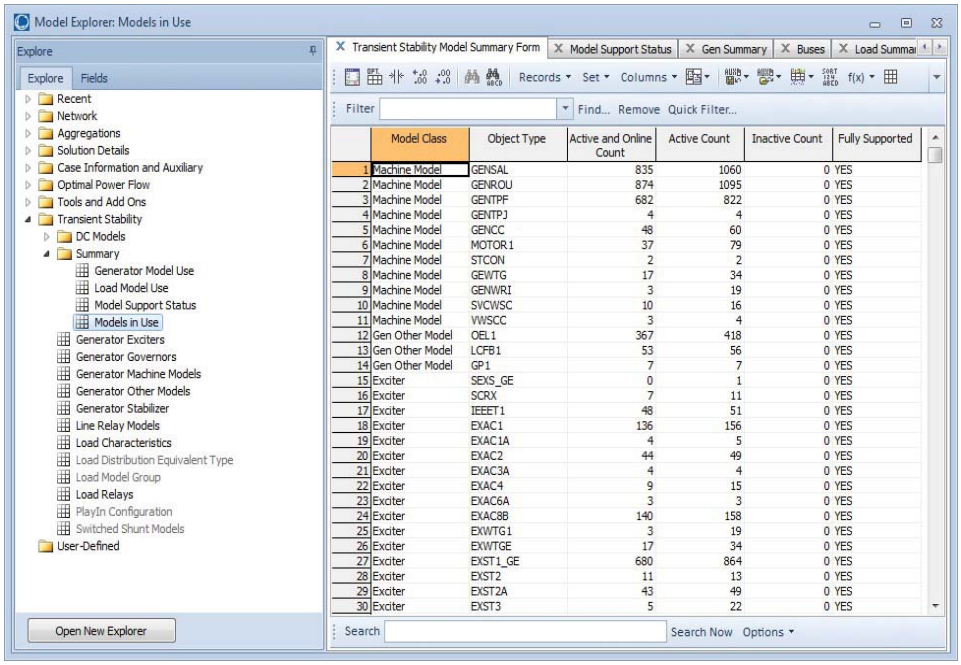

Listed models can be read from or written to the appropriate text based file format for other software packages



WestExample.pwb


# Models in Use Example

- Open the Models in Use page




A summary of the models defined in this case

Includes whether the model is active or inactive, and whether its associated object is online



WestExample.pwb

# Transient Stability Model Explorer: Model Classes

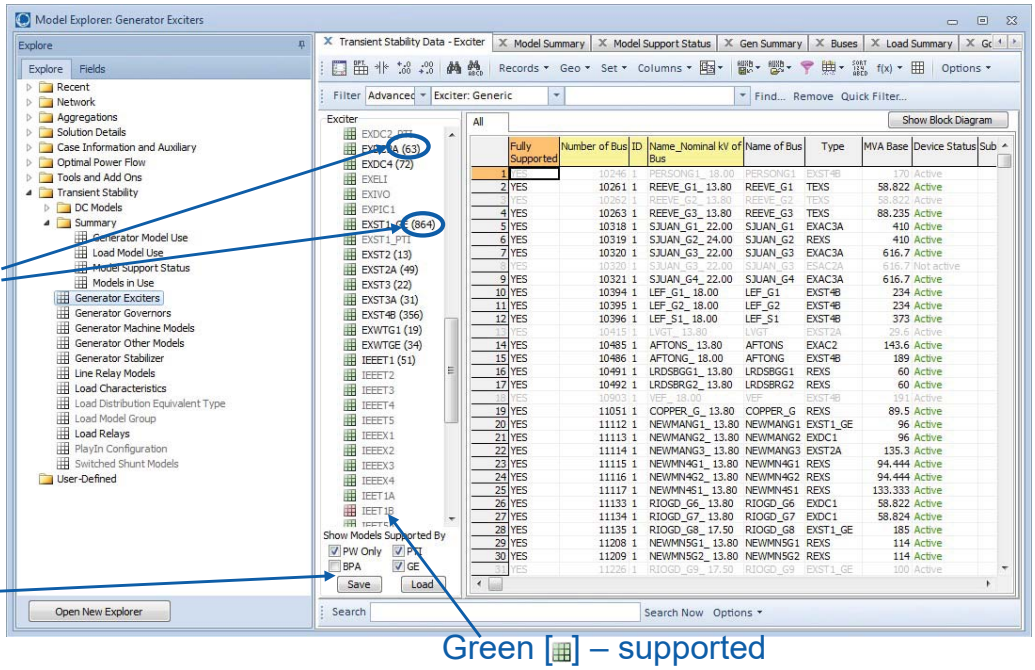
- Clicking on a particular model class opens a new pane in the right portion of the Model Explorer showing the available model types for that class
- Gray text indicates a model class or type not presently used by any device
- This pane has the following attributes
  - "All" shows all present models of the model class
  - Number in parenthesis indicates the number of models of that type which are present
  - Green icons indicate that a model is fully supported by Simulator
  - Red icons indicate that a model can be read/written but is not currently supported by the transient stability numerical integration
  - "Show Models Supported By" and a set of four check boxes- *PW Only*, *PTI*, *BPA*, and *GE* to filter the displayed list
  - At the bottom are buttons to save or load dynamic data from an external file





# Model Classes Example

- Open the Exciter page

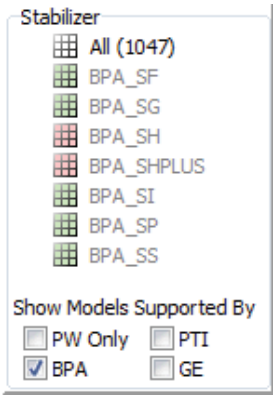


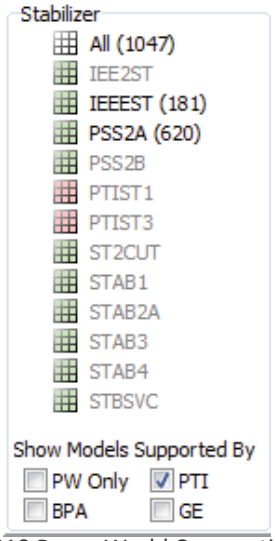


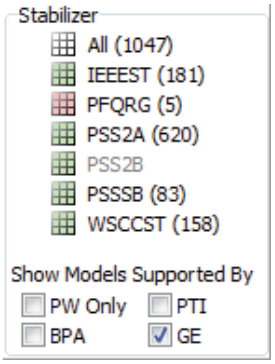

WestExample.pwb

# Model Classes- Filter the Shown Formats

- Types can be further filtered to show only those models supported by other formats



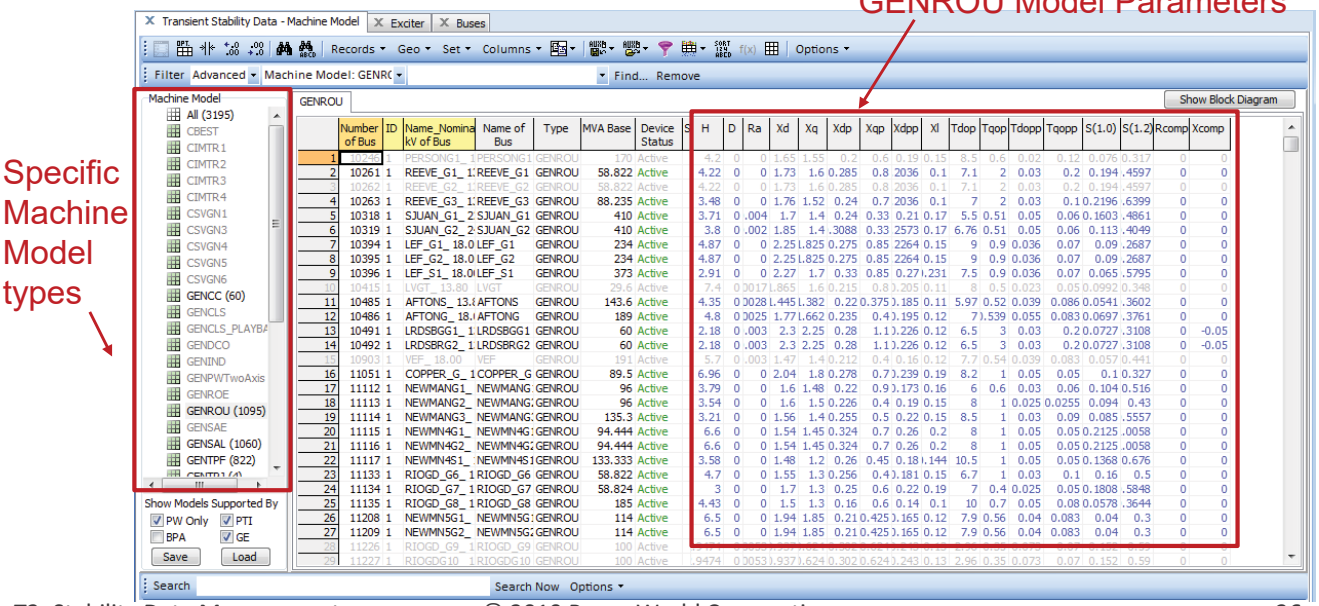






# Model Type Example

- When you choose a particular model type from a model class, additional columns will appear which show all the input parameters for that model type



# Transient Stability Data: Object Dialogs

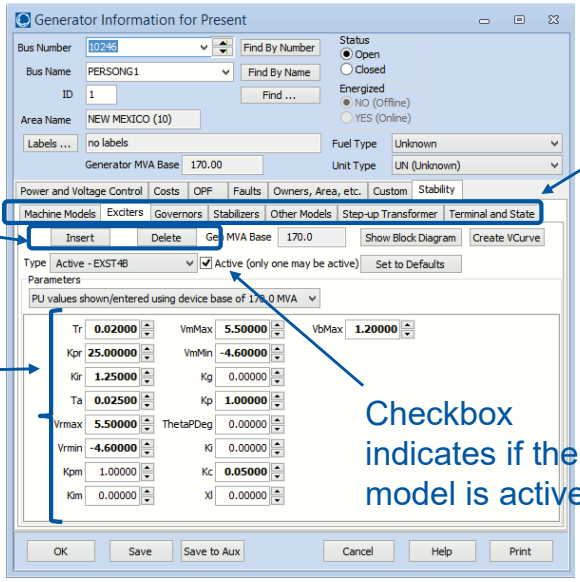
- In general, Simulator devices have Information Dialogs, and models can be edited both by using these dialogs and by using the Model Explorer
- On the various dialogs for devices such as Generators, Loads, Switched Shunts, etc., there will be a tab labeled “Stability”
- This tab can be used to define the transient stability models for the device
- Stability tab attributes
  - Insert button
  - Delete button
  - Type of model and whether it is active
  - Show Diagram (displays the model’s block diagram)
  - Parameter list





# Example Object Dialog

- Right click on a model in the Model Explorer and select “Show Dialog”
- An example of an exciter’s dialog is shown here

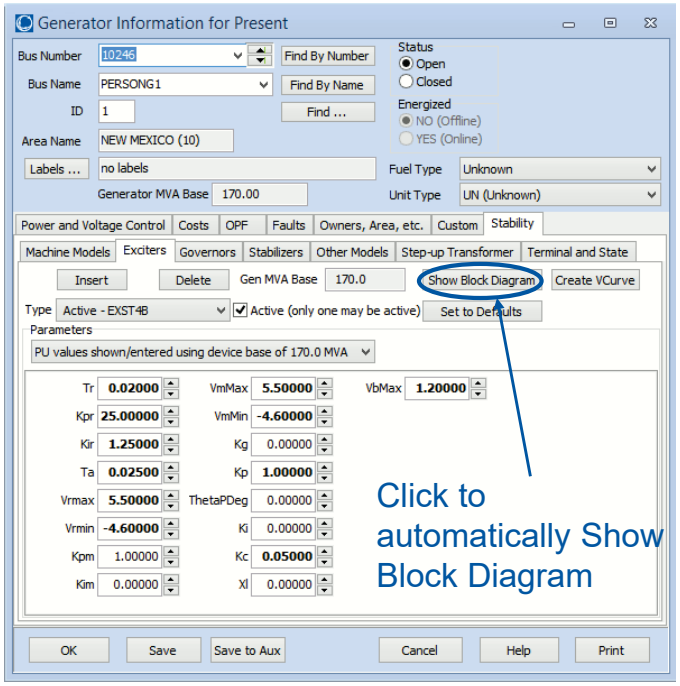





WestExample.pwb

# Object Dialog: Block Diagrams

- The “Show Block Diagram” button is available on the Stability tab of the individual dialogs for objects with Transient Stability models
- To view, click on the “Show Block Diagram” button

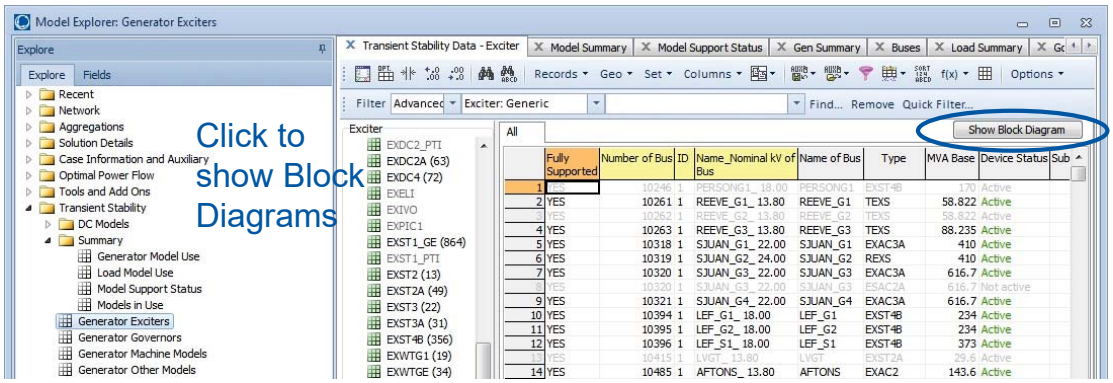





WestExample.pwb


# Block Diagrams

- The “Show Block Diagram” button is also available on the Model Explorer
- The block diagram document will be navigated to the page containing the model that is currently selected
- If “All” is selected, the list of the object models will open

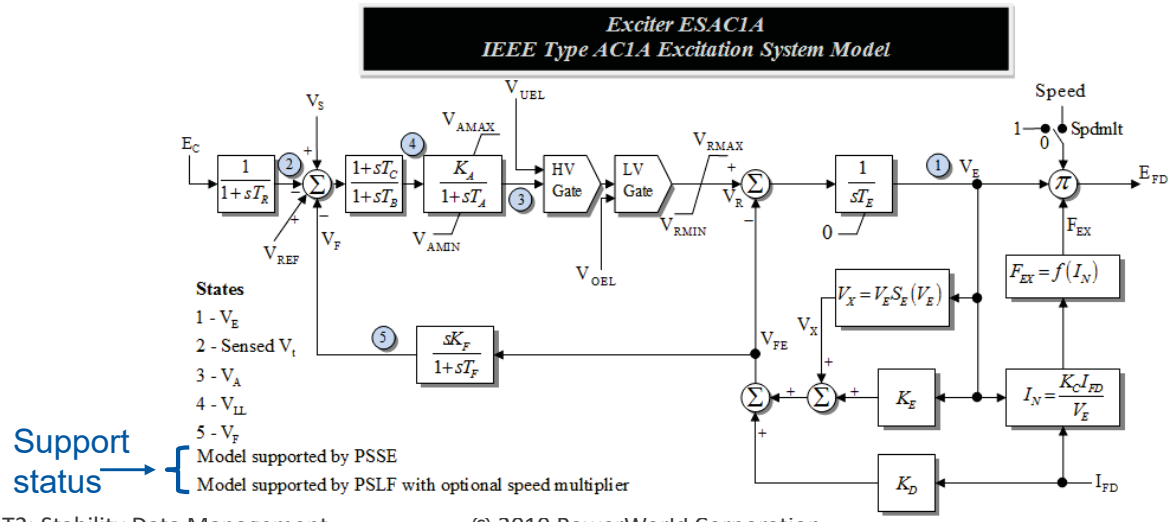





WestExample.pwb

# Block Diagrams

- Standardized block diagram format
- States will be labeled to match how Simulator numbers them
- There will be comments regarding whether another software product supports the model

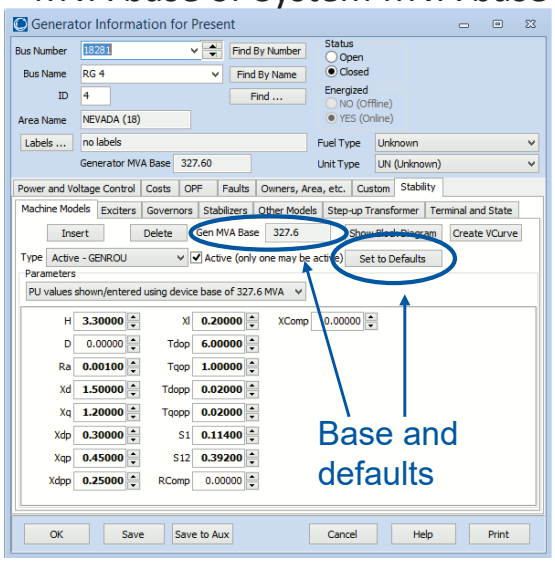


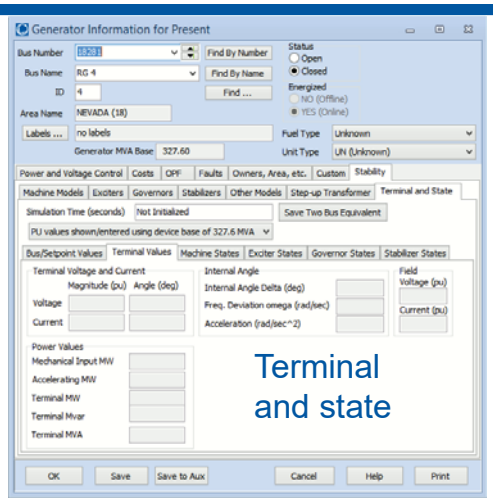





# Object Dialog: Other Special Generator Options

- Set to Default and Defaults drop-down
- Option to enter values in Device MVA base or System MVA base




- Step-up Transformer Tab
- Terminal and State Tab
  - Bus/Setpoint Values
  - Terminal Values
  - More Tabs for various classes of models



WestExample.pwb

# GE DYD Special Handling

- Generator Baseload Flag
  - When loading GE EPC files, a flag for each generator record exists called the *Baseload flag* which determines how governor limits are handled during a transient stability run
  - Supported by a Simulator generator field called *Transient Stability\Governor Response Limits*- options are *Normal*, *Down Only*, or *Fixed*
  - *Baseload flag* of *0* maps to *Normal*, *Normal* means that the limits specified in the governor model will be used for the simulation
  - *Baseload flag* of *1* maps to *Down Only*, *Down Only* means that the upper limit is set equal to the initial condition value (and thus control can only go down.
  - *Baseload flag* of *2* or more maps to *Fixed*, *Fixed* means that both the upper and lower limits are set equal to the initial condition, thus control will be approximately constant
  - The *Governor Response Limits* field is shown when looking at governor case information displays





# GE DYD Special Handling

- EPCMOD models
  - Often used to represent a user-defined model of a Series Capacitor Relay and a Capacitor Relay Model
  - Since these models were so common, PowerWorld added them as two new kinds of relay models
  - CAPRELAY can be assigned to a switched shunt record which, based on voltage, can open and close a switched shunt
    - Created when "MSC01.p" is read from an EPCMOD record
    - An appropriate log message will be written upon creation
  - SERIESCAPRELAY can allow a series capacitor to be bypassed during a fault and placed back in service when appropriate
    - Created when "MSC01.p" is read from an EPCMOD record
    - An appropriate log message will be written upon creation

# GE DYD Special Handling

- CMPLDW models:
  - Automatically split into separate Load Distribution Equivalent Type and CMPLDWNF models when reading a DYD file
  - Individual loads are assigned to a Load Model Group containing the CMPLDWNF model
  - Long ID field in the EPC file determine the names of the Load Model Groups and Load Distribution Equivalent Types
  - Three characters for climate zone separated by an underscore followed by three characters for the feeder type
  - First three characters used to name Load Model Group
  - Last three characters used to name the Load Distribution Equivalent Type
  - "HID_RES" for High Desert climate zone with Residential feeder type





# GE DYD Special Handling

- CMPLDW models:
  - Unique Load Distribution Equivalent Types
    - First 17 CMPLDW parameters
    - MVABase for the CMPLDW record
    - Last three characters (feeder type) of GE Long ID determine the Name
      - Name appended with numeric identifiers to ensure uniqueness
  - Unique Load Model Group
    - Parameters 18 through 129 of CMPLDW record
    - First three characters (climate zone) of GE Long ID determine the Name
      - Name appended with numeric identifiers to ensure uniqueness

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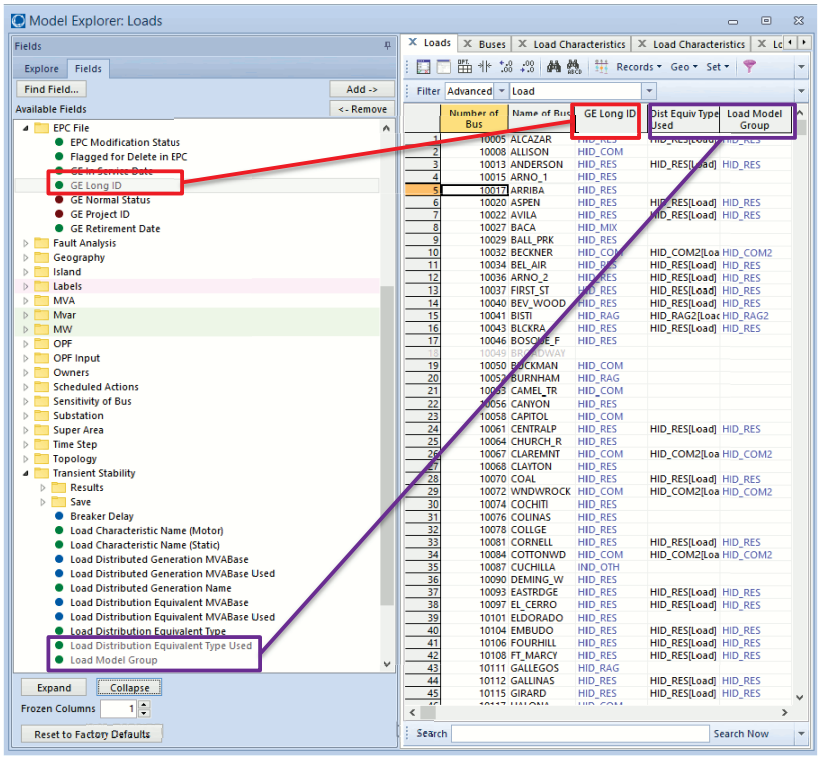
- CMPLDW models:



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