

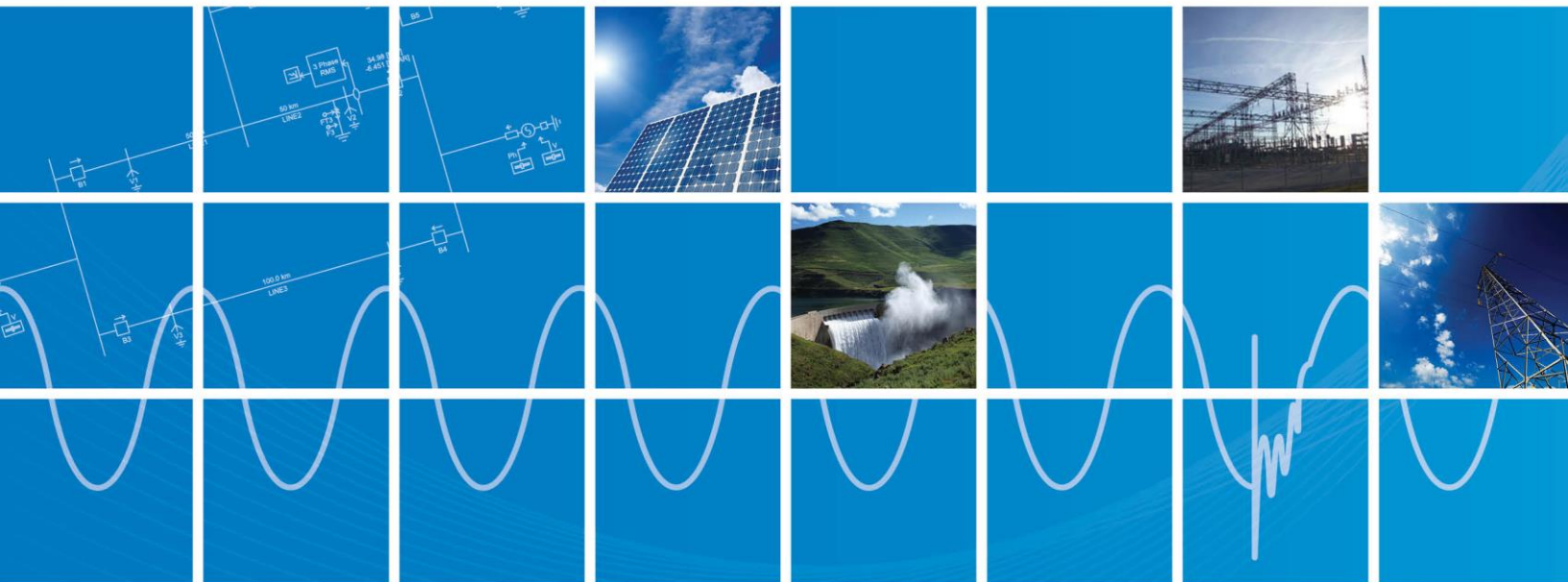


## What's New in PSCAD v4.6.0

*(since v4.5.4)*

Written for PSCAD™ X4 version 4.6.0

May 4, 2015



## Summary

New Features/Enhancements	New Master Library Models	Deficiency Fixes
Electric Network Interface (ENI)	Frequency-Dependent Network Equivalent (FDNE)	Subsystem Splitting Sub-Options
Volley Launch/Root Control	Frequency-Dependent Transfer Function (FDTF)	Transmission Line Circuit Overlay
Certificate Licensing	Programmable Breakpoint Components	New Sticky Note Dialog
Comparator Tool	Battery Model	Copy Transfer
Parameter Grid Pane	Statistical Breaker Model	File Paths Now Relative to Project Folder
Layers Pane	Dynamic Data Tap	Search History
Bird's Eye View Navigation Pane	Rank Number	Wildcard Characters Supported in File Paths
Intel Fortran 14 & 15 Support	Single-Phase, 3-Winding UMEC Transformer (Replacement)	Stop Individual Project in a Simulation Set
GFortran v4.6.2 Upgrade	MOD Function	Mono-Spaced Font in Message Table
Load Projects via Drag and Drop	MODULO Function	Viewing License Details
Blackbox Module Hierarchy Support	Hysteresis Model for Classical Transformers	Inter-Simulation Set Command Line Option
Show in Folder	Simplified Underground Cable	Added \$(INSTANCE) for Display of Module Name and Instance Number in Plot Panels
Horizontal Scroll via Shift + Mouse Wheel	Hysteresis Current Control PWM Generator	
Multiple Run 'Skip'	Maximum/Minimum Array Value and Location	
Runtime 'Slow-Motion'	Array Dot Product	
#LOCAL COMPLEX Declaration	Surge Generator (CIGRÉ, IEC or IEEE Standard)	
Workspace Progress Bars		
Freehand and Point Selector Tools		
Workspace Consolidator		
64-Bit EMTDC		
Automatic Project/Workspace Backup & Recovery		

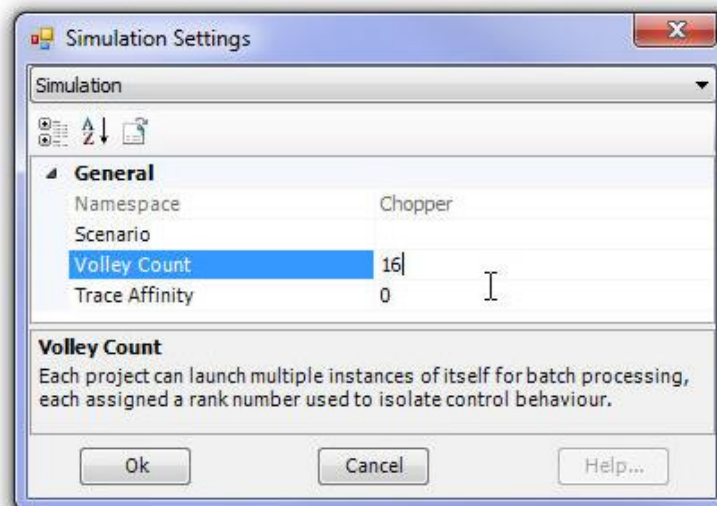
# PSCAD

## New Features & Enhancements:

1. **Electric Network Interface (ENI):** A new interface has been developed, which enables sub-networks in individual projects to be electrically connected to each other and simulated as one complete network. In essence, this provides a way to break large electric networks into sub-networks, interconnect them, and run each as a separate process, on an individual processor core. Communication is accomplished through TCP/IP sockets. Alterations have been made to the transmission segment components to facilitate the interface, along with changes to the EMTDC communication interface with PSCAD:

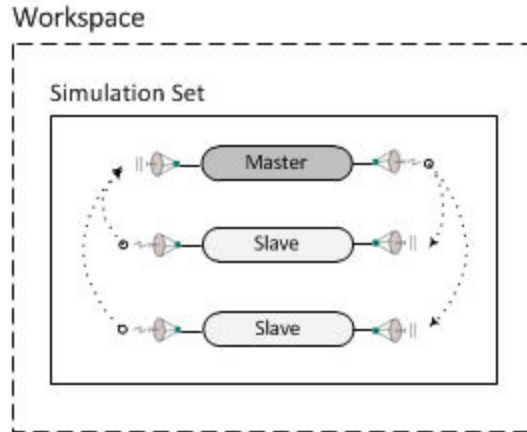


2. **Volley Launch/Root Control:** Volley launch provides the ability to launch multiple EMTDC simulation runs in parallel (up to a maximum of 64), based on a single PSCAD case project. To set up a volley, a simulation must first be added to a simulation set. Once added, simply invoke the Simulation Options dialog and adjust the Volley Count option. For example, if you want to launch 7 simultaneous runs of a single project, then set the Volley Count to 7. When you next launch the simulation set, 7 instances of that simulation will be launched in parallel, utilizing all available processor cores.

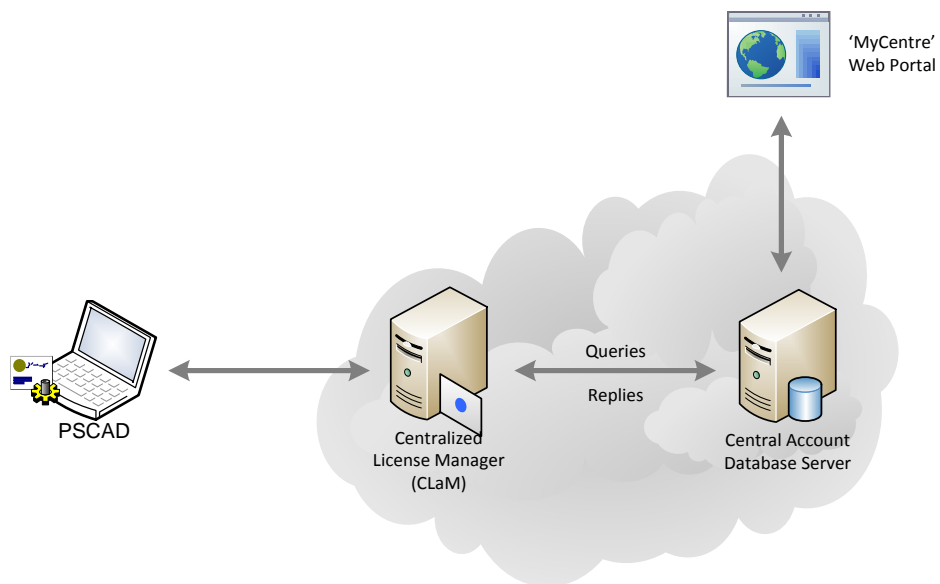


The Root Control Interface (RCI) was first released as part of the PSCAD v4.5 minor upgrade. Root control allows for one root, or master project, to control multiple slave projects, where both master and slaves must be part of the same Simulation Set. The idea behind the development of the RCI was to support both parameter sweep, as well as optimization-based, multiple-run studies.

Like the simulation sets, the RCI is an inherent part of the workspace, which enables inter-project communication within a single simulation set. This is accomplished using the already well defined Radio Link transmitter and receiver components, which were extended in v4.5 to include a provision field for a foreign namespace. This instructs the link to collect its value from a foreign source, and thus allows for a more sophisticated means of multiple run control.



3. **Certificate Licensing:** The first versions of PSCAD were licensed by binding it to the target machine hardware. Ever since the very first windows platform, this method was no longer feasible, so a new system was put in place to either license the software by a hardware lock or license manager installed on the customers network. The license manager model is essentially a distributed licensing model, whereby we enable the customer to license PSCAD using a server installed on their network. The rigidity of this system has led to a next generation licensing system that provides a renewable certificate strategy to manage a track licenses using a server.

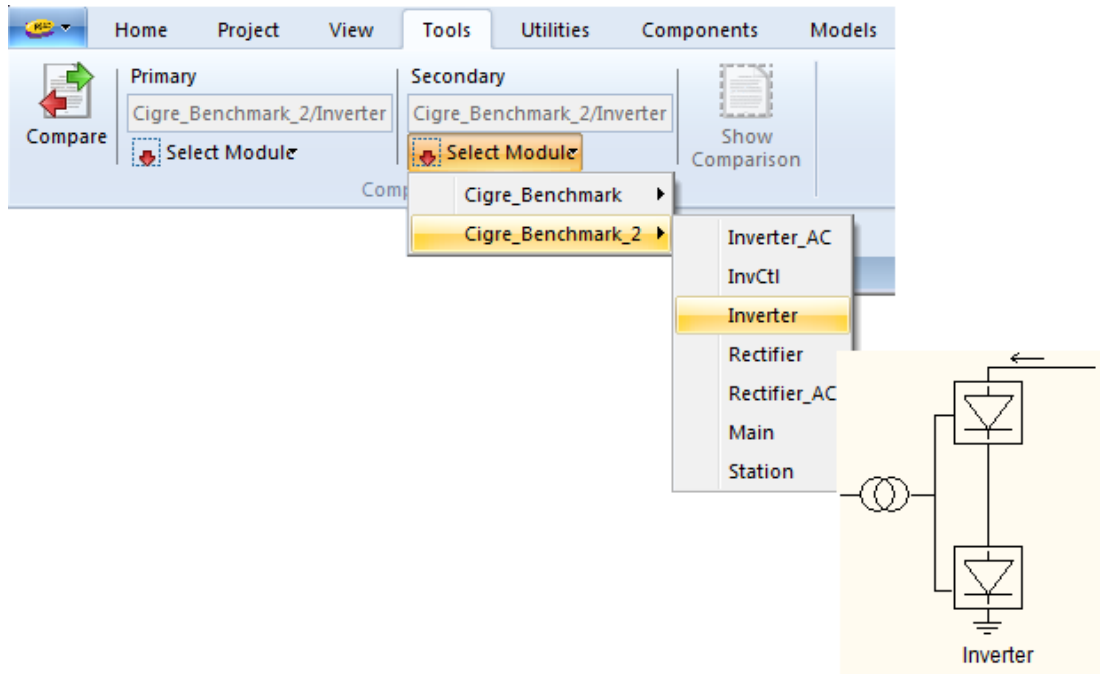


Centralized Licence Management (Advanced Licensing)

All PSCAD products now support cloud-based, *Certificate Licensing*, in addition to the intranet-based legacy licensing, which requires a *License Manager* on the client's premises. Certificate licensing provides a time-limited, license certificate from *MyCentre*, an internet-based user portal. This allows users to work off-site and off-grid without the need to connect to their *License Manager*, license files, nor a hardware lock.

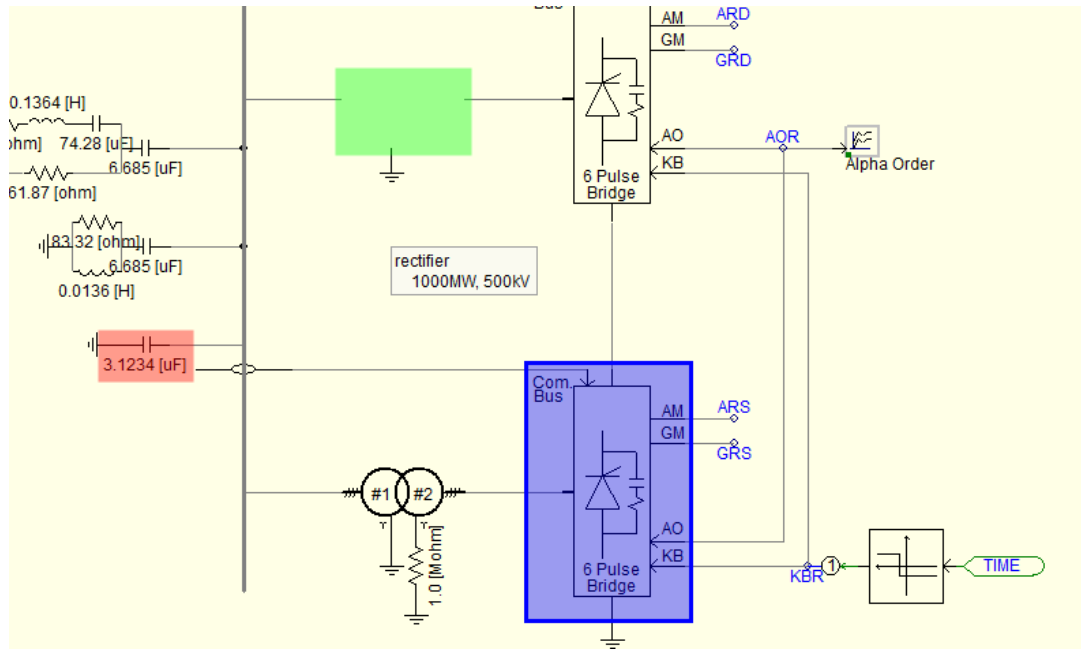
Certificate licensing is much more flexible, in that it opens the door to all sorts of new licensing concepts, such as the licensing of individual features for example.

4. **Comparator Tool:** The schematic comparator tool allows for quick and convenient visual differentiation between module component definitions. By selecting two sources for comparison (from the *Tools* tab in the ribbon bar), users can click the compare button to perform a comparison of the two definitions.



Selecting a Primary and Secondary Source

The user will be presented with a visual display of the differences between the two modules. A results table will give users a text description of the differences, along with the values that were found to be different. Additionally, components with differences will be surrounded in color coded highlighting boxes on the schematic canvas of the primary source.



Colored Highlighting Boxes

- Parameter Grid Pane:** The component parameter grid pane provides a convenient means to display the parameters for all instances of a given component or module definition. More importantly, it enables the ability to modify multiple parameter values in multiple component instances simultaneously.

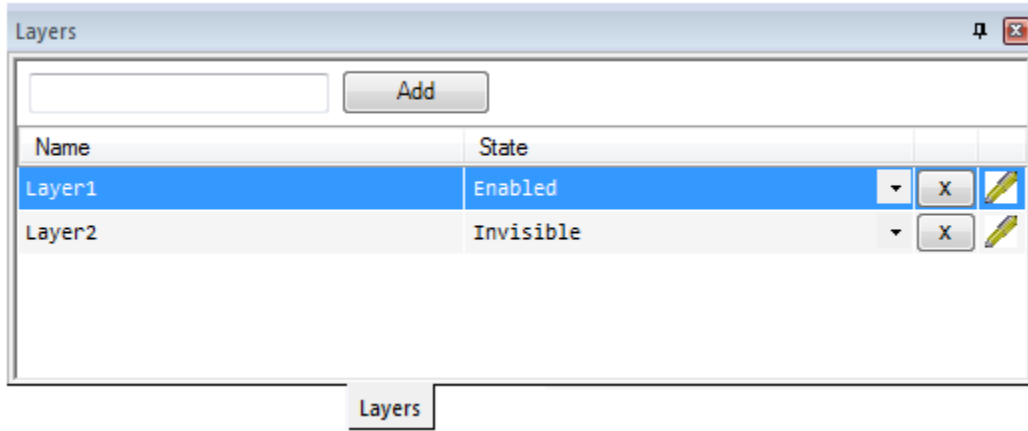
Parameter Grid

Select Module: All    Series\_AF: 'pgb'

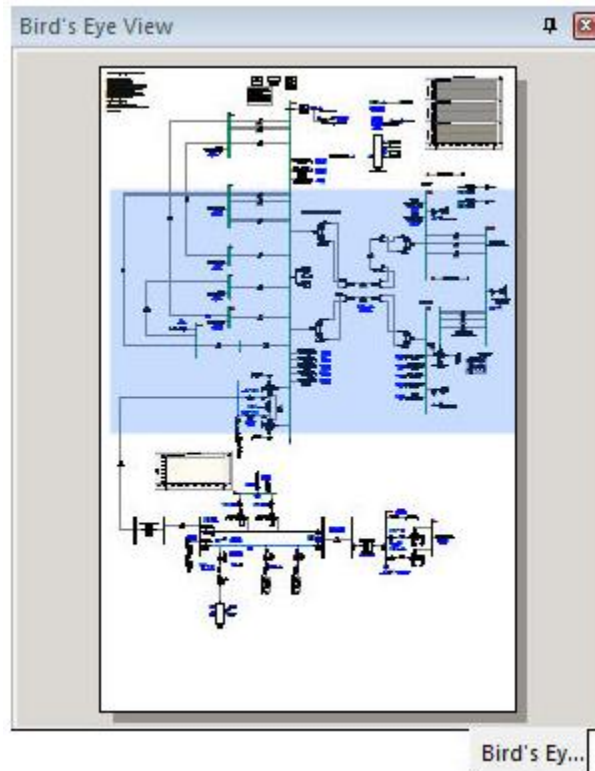
Id	Name	Group	enab	Display	Scale	Units	mrn	Pol	Max	Min	Layer
65194344	q_inst		Yes	Yes	1.0		Last run only	No	2.0	-2.0	Default
65213928	p_inst		Yes	Yes	1.0		Last run only	No	2.0	-2.0	Default
65214336	p_inst filtered		Yes	Yes	1.0		Last run only	No	2.0	-2.0	Default
65215560	q_inst filtered		Yes	Yes	1.0		Last run only	No	2.0	-2.0	Default
95928792	IaRef		Yes	Yes	1.0		Last run only	No	2.0	-2.0	Default
95929608	IbRef		Yes	Yes	1.0		Last run only	No	2.0	-2.0	Default
95930424	IcRef		Yes	Yes	1.0		Last run only	No	2.0	-2.0	Default
95931240	VaRef		Yes	Yes	1.0		Last run only	No	2	-2	Default

Parameter Grid

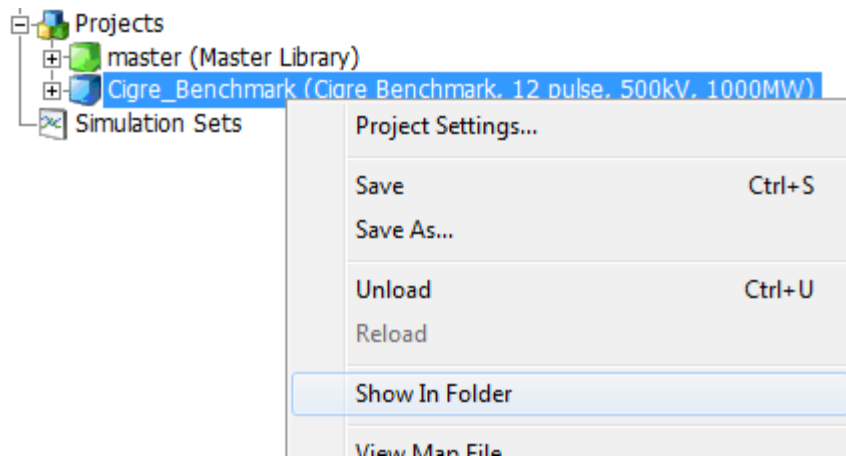
- Layers Pane:** The layers pane is the interface to the schematic canvas drawing layers feature. Drawing layers provide the ability to efficiently enable or disable components on the canvas, or to toggle the visibility of any objects that appear on the canvas.



- Bird's Eye View Navigation Pane:** The Bird's Eye View navigation pane provides an overview of the entire Schematic or Graphic canvas and indicates what is currently in view with a blue box. This tool is an important part of the collection of navigational tools in PSCAD, and is used to easily zoom and navigate. This pane is particularly helpful when working with very large projects (#1252).



8. **Intel Fortran 14 & 15 Support:** Official support has been added for the Intel® Visual Fortran Compiler for Windows (Versions 14 & 15).
9. **GFortran v4.6.2 Upgrade:** The free Fortran compiler supplied with PSCAD has been upgraded from v4.2.1 to v4.6.2. This upgrade also resolves multiple bugs that were inherent to the older GFortran version.
10. **Load Projects or Workspaces via Drag and Drop:** Projects or workspaces may now be loaded into the environment via drag and drop. Simply select a project or workspace file (from say Windows File Explorer) and drag it over the workspace window. Release the mouse button and the file will load (#3184).
11. **Blackbox Module Hierarchy Support:** The blackbox algorithm now supports the black-boxing of entire module hierarchies. The same rules still apply as when black-boxing a single module (i.e. no output channels, runtime components, etc.). Blackbox collects all unique module definitions and generates both a source file (\*.f) and a compiled object file (\*.obj) for each. It also goes one step further and binds all object files into a single static library (\*.lib) file (#4587).
12. **Show in Folder:** It is now possible to show both project and workspace files directly in their respective folders. Simply right-click on either a loaded project or the workspace and select *Show in Folder*. This will invoke Windows File Explorer and set it to the folder where the corresponding file resides (#4557).



13. **Horizontal Scroll via Shift + Mouse Wheel:** Users may now pan the schematic canvas horizontally by holding down the Shift key and rolling the mouse wheel (#2636).
14. **Multiple Run 'Skip':** When working with large simulations and multiple run scenarios, errors can be time consuming and costly. In the past we have been asked for the capability to execute a 'dry' simulation whereby the user can quickly check to make sure the configuration of each



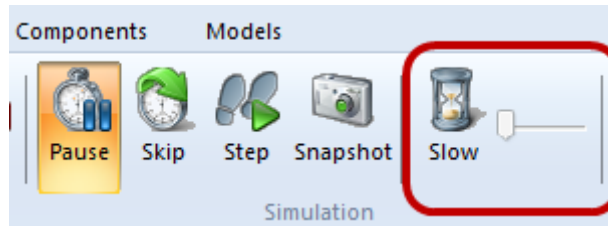
run is valid. Unfortunately, there was no way to run only a partial and then skip to the next run in the sequence.

A new button, called 'Skip', has been added to the ribbon, which sends a message to EMTDC instructing it to jump to the end of the run and begin the next one. In the case of simulation sets and master/slave batch configurations (including volley), the entire coordinated run will skip to the next iteration (#404).



- 15. **Runtime 'Slow-Motion':** While we always strive to run faster and larger simulations, sometimes it is the 'small ones' that matter. This is especially true when trying to demonstrate or study an event that occurs in a very short period of time. If the simulation is small, the plotting can fly by in just the blink of an eye, making it hard to experience the event as it occurs.

What is required to actually slow down the plotting is a kind of 'slow-motion' effect, similar to manually decreasing the time step. This has been accomplished using to slow control and slow factor slide control:

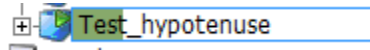


For presentation and teaching purposes, the user can now control how quickly the event is performed. A toggle button turns the slow mechanism on and off, while the slide control provides plotting delay of 1 ms up to a maximum of 10 ms (#1527).

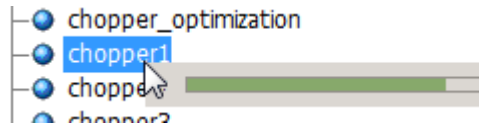
- 16. **Mono Spaced Font in Message Table:** In order to maintain compatibility with messages sourced from Fortran compilers, the font for the message table has been changed to a mono-spaced font. This will help with groups of messages that rely on a mono-spaced layout in order to make any sense (#2636).

- 17. **#LOCAL COMPLEX Declaration:** Local complex variables may now be declared in component definition script (#2099).

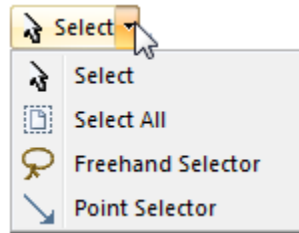
18. **Workspace Progress Bars:** Progress bars have been added to both the workspace project and the simulation trees. When running a standalone project, a project bar will appear directly behind the project name (if enabled) to indicate its runtime completion percentage. This option is disabled by default and may be enabled by adjusting the *Show quick run progress bar* option in the *Workspace* category of the *Application Options* dialog.



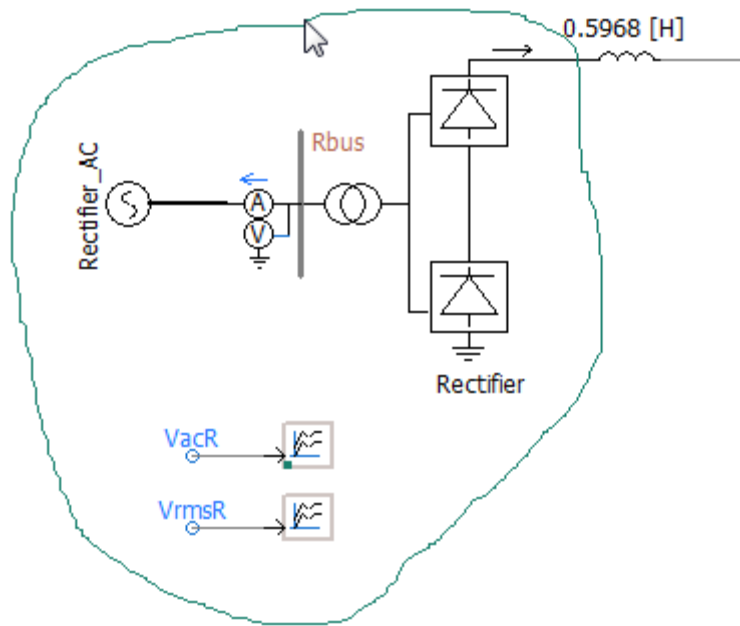
If running a root control simulation (i.e. master/slave configuration), progress bars will appear in the over the simulation tasks in the simulations tree.



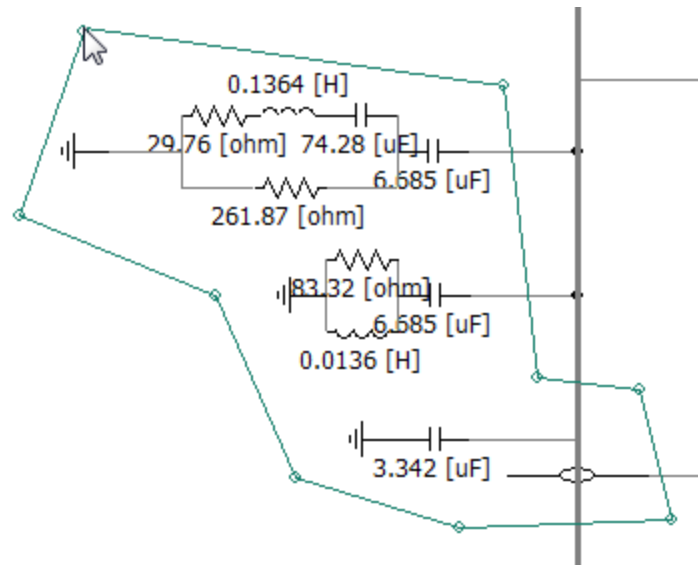
19. **Freehand and Point Selector Tools:** Two new selection tools have been added to the ribbon control bar: The *Freehand* and *Point* selectors.



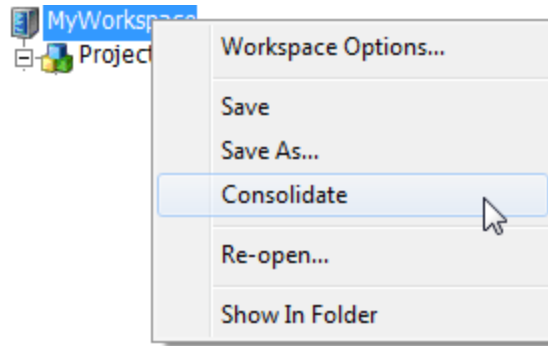
The freehand selector allows you to encompass a group of components in a freehand circle, similar to a 'lasso'.



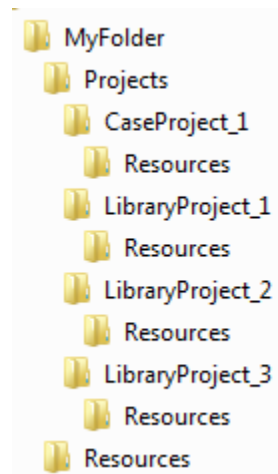
The other is a Point selector, where the components are encompassed with a polygon, or collection of points:



- Workspace Consolidator:** A new feature has been added to help consolidate and organize workspaces. Workspace can sometimes become unruly, containing several projects which may have links to additional source or binary files. Both the project and dependent files can be scattered throughout local folders, making it very cumbersome to transfer the workspace from one computer to another. The workspace consolidator alleviates this issue by allowing the user to consolidate, organize and reset all dependent file paths with a click of the mouse.



The consolidator moves all projects into an organized folder structure that looks similar to the following:

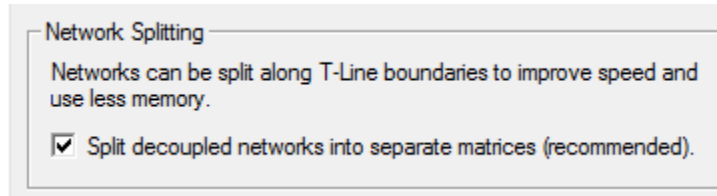


Library and case projects are sorted into individual folders and dependent files are placed in their own *Resources* folder. All file paths to dependent files are modified to point to these Resource folders. Any case projects in the consolidated workspace will build and run immediately with no additional modifications. If transferring via email, the entire folder structure can be easily zipped using a preferred archiving tool.

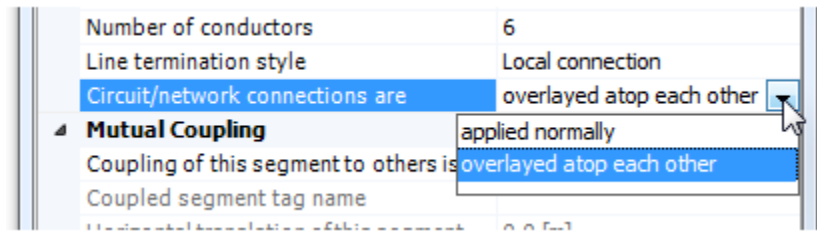
21. **64-Bit EMTDC:** A new 64-bit build version of EMTDC is now included with PSCAD. It is important to note that 64-bit EMTDC can only be used along with the *Intel® Visual Fortran Compiler for Windows* version 15 or greater, as well as the 64-bit version of PSCAD.
22. **Automatic Project Backup & Recovery:** PSCAD will now maintain a backup file for both the workspace and all loaded projects. This recovery file is updated every 30 seconds and is deleted upon exit of the application. In the event that the application crashes, the backup files will be detected on restart and the user will be asked if he or she would like to recover the backups.

**Deficiency Fixes:**

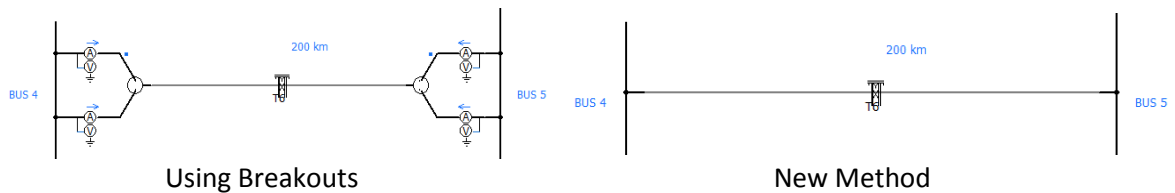
1. **Subsystem Splitting Sub-Options:** Subsystem splitting sub-options (blending and combining non-switching networks) have been removed from the project settings dialog, as they have been obsolete since the v4.3 release. When subsystem splitting is enabled, EMTDC memory usage is optimized by default (#4175).



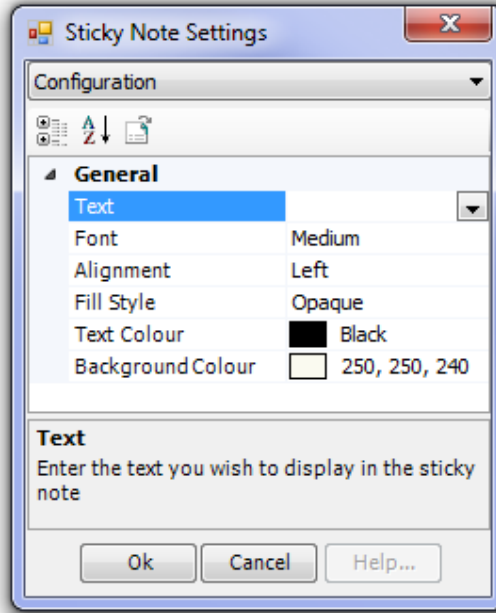
2. **Transmission Line Circuit Overlay:** A new parameter has been added to the *Transmission Line Configuration* component that enables the user to overlay multiple t-line circuits onto the same 3-phase bus. This parameter is enabled only if the line is 6, 9 or 12 conductors, and the line is in direct connection mode. When the parameter is selected as *overlaid atop each other*, you may connect a 6, 9 or 12-phase line to a single 3-phase bus or wire (#4639).



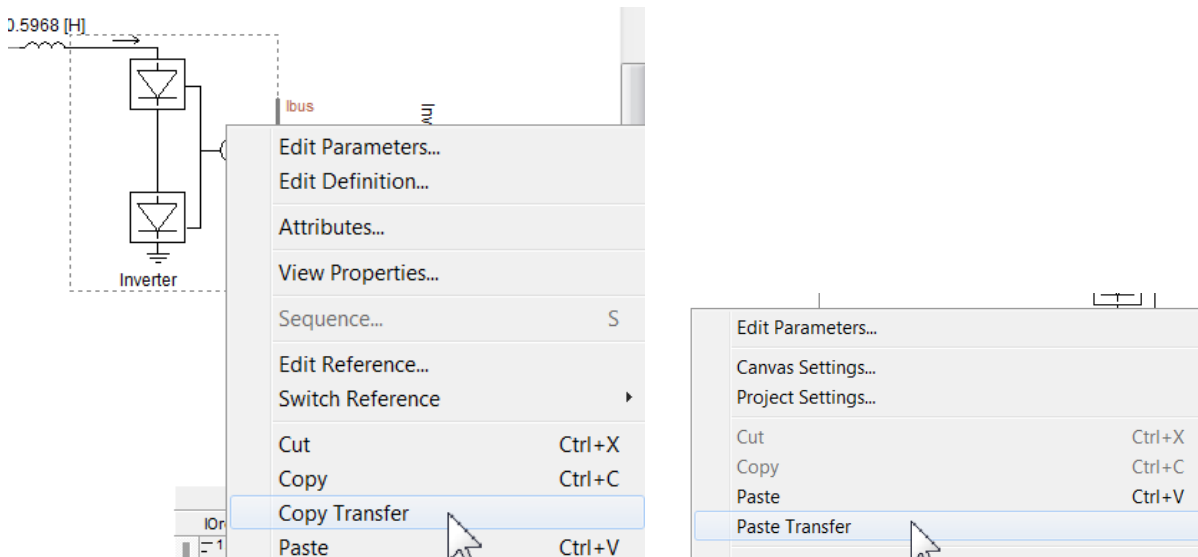
Essentially this feature does away with the need for 3-phase to 6-phase breakout components, which tend to clutter the circuit.



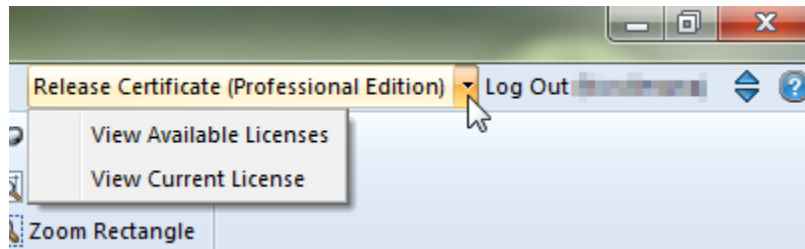
3. **New Sticky Note Dialog:** The sticky note dialog has been changed to the modern list format to maintain consistency with other components. The new dialog provides identical functionality to the old, but also includes a full colour palette for both font and background (#4762).



- Copy Transfer:** This feature builds on the foundation provided by the *Copy with Dependents* feature, introduced with v4.3. *Copy with Dependents* is a simple definition copy of a module hierarchy, which includes all dependent modules. Copy Transfer addresses the two major shortcomings of its predecessor: Instance information (i.e. parameter values) of the top-most module is included in the copy; and the module hierarchy is automatically relinked together on paste, even if some or all of the definition need to be renamed. In addition to these, Copy Transfer also provides the convenience of copying directly from the component instance, as opposed to having to use the definition tree (#3289).

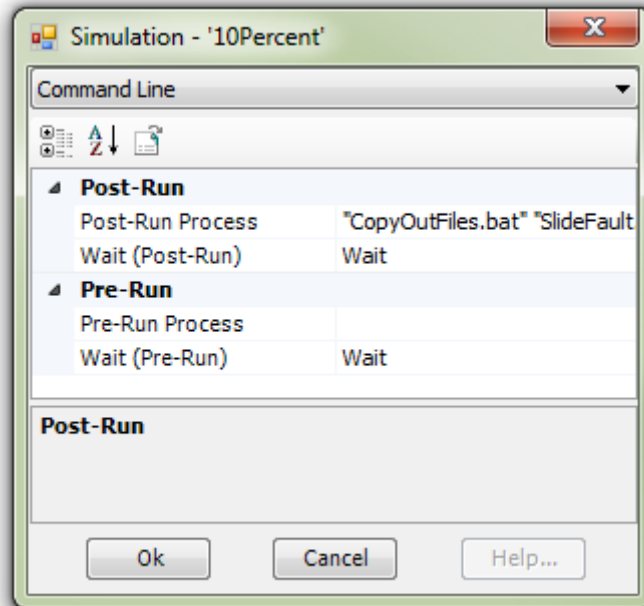
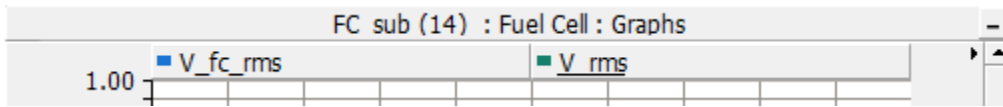


5. **File Paths Now Relative to Project Folder:** As of v4.6, relative file paths are read as relative to the project folder, not the temporary folder. When loading a legacy project, PSCAD will attempt to determine the correct location of the files. If the *My Projects* application option is specified, it will treat the relative path as though it were sourced from that folder using environment variables. (#5249).
6. **Search History:** PSCAD now maintains a search history in the Search For field in the Search pane (#4926/#4925).
7. **Wildcard Characters Supported in File Paths:** The ability to use wildcard characters within file paths (ex. \*.c, x.\*, \*.\* , abc\*def.s) has been added to the *Additional Source files (\*.f, \*.for, \*.f90, \*.c, \*.cpp)* and *Additional Library (\*.lib) and Object (\*.obj/\*.o) Files* project settings fields. This allows the user to specify a folder in which to look for source, without the need to specify an exact file name (#464).
8. **Stop Individual Project in a Simulation Set:** It is now possible to stop an individual project, if the *Run Configuration* of that project is set to *Standalone*. It is not possible to individually stop projects that are set as *Master* or *Slave* (#4193).
9. **Viewing License Details:** Viewing your licence details has been simplified by providing a drop list in the top-right corner of the ribbon control bar (#5574).



10. **Inter-Simulation Set Command Line Option:** It is now possible to execute custom commands, both directly before and immediately following a simulation set run. This allows users to push and pull information, and possibly run data analysis between sets. For example, a batch file can be launched to copy or move EMTDC output files to another folder before the next simulation set is started (#5453).

11. **Added \$(INSTANCE) for Plot Panels:** A new directive has been added for the purpose of displaying module name and instance numbers on plot panels. For example,  $\$(INSTANCE)$  :  $\$(GROUP)$  : *Graphs* results in:



**Bug Fixes:**

1. Added 'Delete' item to multiple section pop-up menu (#4349).
2. When the GFortran v4.2.1 compiler (supplied with PSCAD v4.3 – v4.5) is used in a multiple run environment, a bug in the compiler itself was causing the consumption of memory that was not released appropriately. This would result in a crash after a large number of multiple runs. This issue has been fixed by supplying the latest GFortran v4.6.2 with PSCAD v4.6 onwards (#3748).
3. A GFortran v4.2.1 (supplied with PSCAD v4.3 – v4.5) bug involving snapshot files has been remedied by the latest GFortran v4.6.2 with PSCAD v4.6 onwards. When attempting to launch a simulation from a generated snapshot file, when using GFortran v4.2.1 and Windows XP, the launch would fail. There was no work around for this, except to update to the latest GFortran (#3388).
4. The 'Relative Path' display under the 'General' tab in the project settings dialog is now shown relative to the corresponding workspace (#4799).
5. PSCAD now checks the validity of data entered '# runs' field in the ribbon 'Project' tab (#3883).
6. Ribbon text box and drop list inputs will now function properly when the ribbon view is shrunken (#4411).



7. New optimization techniques have been implemented to speed up compilation of very large projects (#4509).
8. Graphic artifacts are no longer left on the graphic canvas following a change to the properties of a graphic object using the ribbon control bar (#4753).
9. Removed the displayed MATLAB library path in the application options (#3194).
10. All plot step input fields now remain synchronized when one of them are modified (i.e. ribbon, project settings, etc.)(#3675).
11. Node number search results now point to the proper module instance when navigated to (#4951).
12. A manual refresh option has been added to the map/make file panes (#4392).
13. Search will now function properly when searching a current project with inter-namespace module instances. Previously, inter-namespace modules were ignored because their definition is not stored locally in the current project (#5164).
- 14. Multiple library projects (\*.pslx) possessing the same namespace can no longer be loaded into a single workspace. All namespaces in all projects must now be unique (#5321/#5336/#5389).**
15. Graphics editor canvas size is now stored as part of the component definition (i.e. the page size is now saved with the project)(#5257).
16. The path of a file that is referenced using a file reference component is now displayed properly in the build messages if the file cannot be found (#5412).
17. The ITXRX array is now declared and the NTXRX pointer is now incremented properly in code generated for slave projects when using root control (#5455).
18. PSCAD will now process custom component script segments and replace illegal characters (such as ' and ") with underscores. This ensures that component script code will conform to Xml standards (#5588).
19. A minor problem involving false positives in capitalization mismatch checking in t-lines and cables has been corrected (#5481).
20. Ctrl + left mouse drag to copy a sticky note now functions properly (#5576).
- 21. The graph y-axis grid in overlay graphs no longer gets reset when a simulation is launched. Previously, PSCAD would best fit the grid, even if manual scaling was employed (#5586).**
- 22. Transmission lines and cables situated within a module, whose definition is stored in an library project, but is instantiated in a case project, will no longer cause an error in the map file (#5592).**
23. Parameter values entered '.xx' without a preceding zero will now be automatically modified to '0.xx' (#5492).
24. The syntax colorizer no longer overruns its text buffer while reading. This was causing a crash under certain circumstances (#5582).
25. PSCAD no longer crashes when a user definition is named after a master library definition. On project compile, the offending component was added to an internal vector list illegally (#5409).
- 26. PSCAD no longer crashes when attempting to import SVG graphics into the graphic editor (#5645).**
- 27. PSCAD can no longer enter an invalid state and crash if a user unloads a case while the workspace is still loading (#5643).**

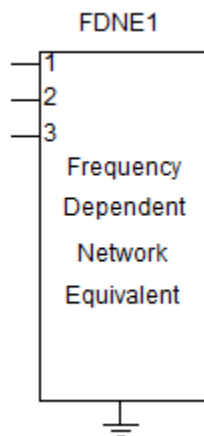
- 28. PSCAD no longer crashes following the action of deleting a bus and then using wire mode to reconstruct them (#5636).**
29. Project will now be immediately marked as modified following a scenario being modified (#5638).
30. Graph x-axis display name is now saved properly to the project file and is therefore, no longer lost when the case is reloaded (#5616).
31. Build messages sourced from definition objects are now navigable (#5380).
32. Error reporting in logic to control the total number of active EMTDC processes and port assignments has been corrected (#5590).
33. Animated graphics displays are now cleared at the start of the next run when the animated graphics project setting is turned off (#5498).
34. A new application option has been added to automatically move off-canvas objects, back on to the visible canvas during load (#5511).
35. PSCAD now warns the user via a pop-up window when the license certificate is about to expire. The warning time is adjustable via a workspace setting (#5503).
36. Projects are now indicated as modified following a change in module canvas setting (#5629).
37. A module bounding box that defines its location on the canvas is no longer incorrectly shifted over while navigating up to the parent canvas on which it resides, while the simulation is running (#5683).
- 38. Ctrl + mouse drag to copy now functions properly on wires, dividers, buses and file reference components. Previously attempting this would leave PSCAD in a bad state (#5685).**
39. The search results pane will now have its contents cleared on unload of a project (#5647).
- 40. A subsystem splitting bug involving a specific combination of connected modules and isolated electric networks has been fixed (#5686).**
41. Projects no longer appear modified in the workspace upon navigation into or out of a module (#5702).
42. The width of the data label dialog has been increased to accommodate longer signal names (#5712).
43. The manner which animated graphics refresh has been modified to allow the user to specify the rate. A new application option has been added under the Graphics category to allow adjustment to 1, 2 or 5 real-time seconds. This alleviates huge processing overhead, and can speed up runtime considerably (#5604).
44. Fixed a compile issue where PSCAD compiler would hang and become unresponsive in certain situations (#5362).
45. PSCAD no longer restores the previously accessed folder instead of going to the specified examples folder (#5731).
46. Master library no longer open twice when opening a project via a double-click from Windows file explorer (#5719).
47. The option to draw thin/thick lines has been removed from the polygraph properties. Alternatively, individual curves can be bolded using the curve bold function (#5742).
48. Simulation sets can now be deleted via the 'delete' key (#5687).

- 49. The status bar, while creating definitions and solving lines, will now display the correct total for each (#5628).
- 50. The entered snapshot file name in the project settings is now checked for validity (#5774).
- 51. Curious problem involving inability to move a custom component following project run has been fixed (#5753).
- 52. The application no longer crashes when attempting to run set where project is unavailable (#5789).**
- 53. PSCAD no longer winds up in a bad state following editing a definition, immediately backing out to the canvas and then attempting to delete the component instance (#5790).**
- 54. PSCAD now provides a more thorough check for project corruption on import/load. Some projects will no longer load if corruption (manual modifications) is detected (#5796).**
- 55. PSCAD will now synchronize the project namespace to the file name before checking for duplicate namespaces on load (#5825).

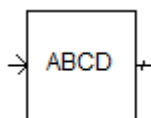
## Master Library

### New Models, Enhancements & Deficiency Fixes:

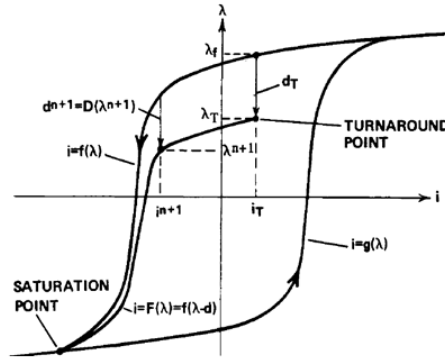
1. **Frequency-Dependent Network Equivalent Model (FDNE):** This component may be used to model the frequency-domain characteristics of an electrical circuit. In power systems, the FDNE model may represent a reduced-order network equivalent, a high frequency transformer model, short transmission lines, etc. (#2348).



2. **Frequency-Dependent Transfer Function Model (FDTF):** This component models a multi-port transfer function and may be utilized as part of any control system. The component I transfer function is constructed based on state-space realization using ABCD parameters.



- Transformer Magnetic Hysteresis:** A core magnetic hysteresis algorithm has been added to all classical transformer components. The algorithm includes two unique hysteresis modeling techniques: The Basic (Loop Width) model and the Jiles-Atherton model. Each model is configured differently of course; the basic model being the simpler of the two (#2352/5293).



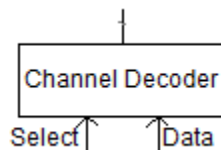
- Programmable Breakpoint Components:** Both a 'pause' and 'stop' component has been added to the master library to provide both pause and stop simulation functionality, based on simulated signals. Operating on an integer input, these components will either pause or stop the simulation upon detecting a rising-edge. This effectively provides 'run to' or 'breakpoint' functionality (#1645/#4290).



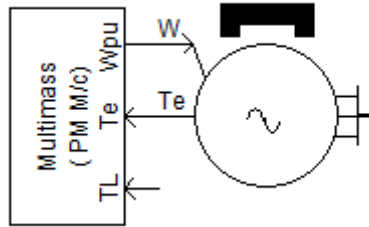
- Battery Model:** A battery model has been added to the master library, based on both an electro-chemical and a tabulated data battery model. The battery is modeled using a general approach, in which an ideal controlled voltage source, in series with a resistance, is used (#3481).



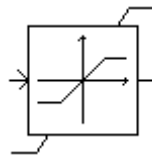
- 12-Channel Decoder Enhanced to N-Channel:** Formerly, the 12-channel decoder was of course limited 12 output channels. This component has been modified such that it can now possess an unlimited number (i.e. N-dimensional) of outputs (#4207, #4534).



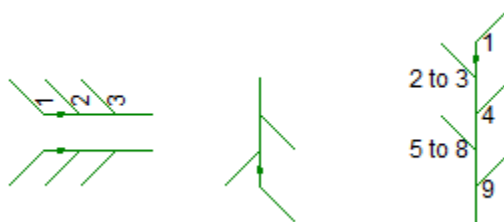
- 7. **Multi-Mass Interface to Permanent Magnet Machine:** An interface has been added to the permanent magnet machine from the multi-mass component (#4538).



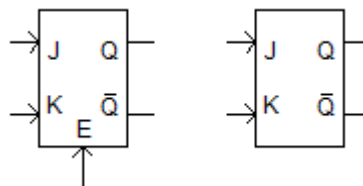
- 8. **Machine Speed/Mechanical Torque Input:** The DC and Permanent Magnet machines are now configured to accept either speed or mechanical torque input, similar to what is done in the synchronous and induction machines (#3625).
- 9. **External Input on Hard Limit Component:** External limit connections have been added to the Hard Limit component (#2789, #4533).



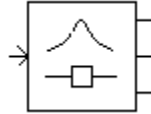
- 10. **Data Merge Component Now Supports Array Signals:** It is now possible to merge array signals together, in addition to scalars (#4531).



- 11. **Latch Mode Operation Added to Flip-Flop:** The flip-flop component now supports latch mode operation, complete with optional enable signal (#2821/4532).



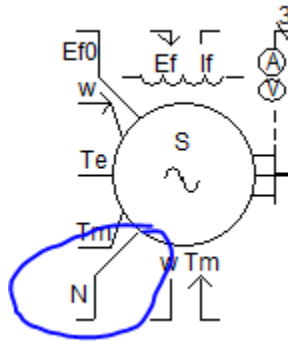
12. **Statistical Breaker Model:** A statistical breaker component has been added to the master library. This component is meant to be used in the single-pole operation of a 3-phase breaker, in a statistically distributed manner. (#3586).



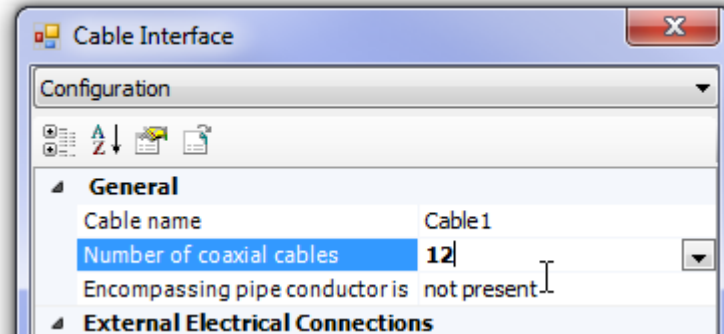
13. **Dynamic Data Tap Component:** This component outputs a signal (scalar or array), based on the connection input for the starting index. The dimension of the output is defined in the parameters section. If the selection of starting index and output dimension refers to elements outside the input array, the component will warn and output zero (or .FALSE.) depending on the data type (#4594).



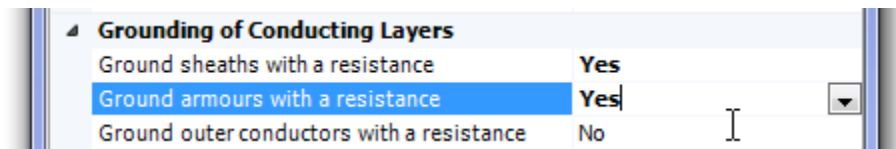
14. **Synchronous Machine Neutral Connection:** The synchronous machine has been extended to allow users access to the neutral connection point. Enabling the additional connection *N* is controlled via a new component input parameter (#2841).



15. **Maximum Number of Cables Increased:** The maximum number of cables per right-of-way has been increased from 8 to 12. These changes affect the cable interface component and the Line Constants Program (LCP) (#5014).



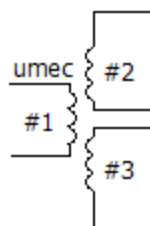
- 16. **Externally Connected Resistors on Cable Interface:** An option has been provided to the cable interface component to allow users to automatically connect resistors externally to ground (#5018).



- 17. **Rank Number:** This component outputs the rank number of a simulation that is part of a volley launch. Note that the rank number of non-volley simulation is 0. Combined with a look up table method, such as XY Transfer Function or XY Table, this component can be utilized to take different data for different runs in a volley launch simulation (#5131).

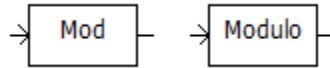


- 18. **Change to Multiple Run File Naming Format:** If the simulation rank number is 0, the current file naming behaviour is used. However, if the rank number is non-zero, the output filename is now formatted as `mrunout_##.out`, where ## is the 2-digit rank number. (#5122).
- 19. **Single-Phase, 3-Winding UMEC Transformer (Replacement):** This new component (`umec-xfmr-3w2`) replaces the previous Single-Phase, 3-Winding UMEC Transformer component (`umec-xfmr-3w`). In the new component, winding leakage and copper losses may be specified individually, as opposed to a total value being evenly distributed amongst all windings (#2746).

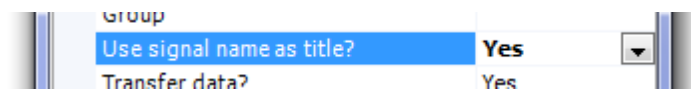


20. **Multi-meter:** The ability to measure RMS current has been added to the multi-meter component (#5169/#5476).

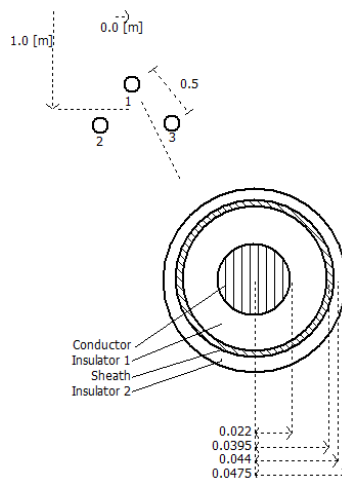
21. **MOD and MODULO Components:** Both MOD and MODULO components have been added to the CSMF section of the master library (#3127/#5181).



22. **Output Channel Can Assume Signal Name:** A new parameter has been added to the output channel component that allows for the channel to assume the name of the signal, to which it is attached. If this parameter is set to Yes, the next time the project is compiled, the output channel name will be replaced with that of its corresponding signal. Note that each time the signal name changes, so will the output channel name. Also note that the original output channel name will be lost if this parameter is enabled (#2792).

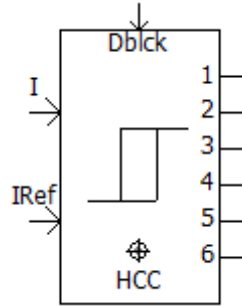


23. **Simplified Underground Cable:** This cable component is used to model typical underground cable systems. It is meant to simplify the construction of such cable system cross-sections, by taking advantage of data duplication to simplify data entry, as well as provide formats more aligned with typical cable data sheets. The component can be adjusted to easily represent the following typical system configurations: (#5239).

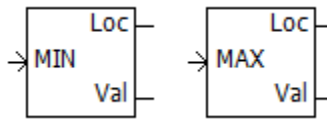


24. **Hysteresis Current Control PWM Generator:** This component generates a PWM signal, based on hysteresis current control (#5300).

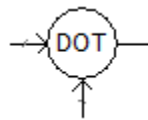




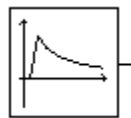
25. **Maximum/Minimum Array Value and Location:** The Maximum/Minimum Array Value and Location component allows the circuit designer to find the value and location of a minimum or a maximum element value in an array signal.



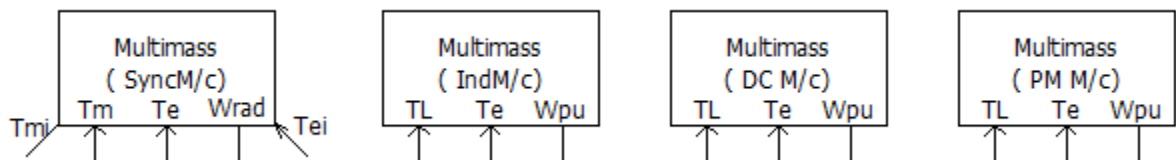
26. **Array Dot Product:** This component is meant to be used for the dot product of 2 arrays. For example, you can use the dot product of 3-phase voltages and currents to measure the instantaneous power (#5302/#5313).



27. **Surge Generator (CIGRÉ, IEC or IEEE Standard):** This component generates a surge waveform, typically used in lightning studies, and compliant with IEEE, IEC or CIGRÉ standards. (#5652).



28. **Updated Multi-Mass Component:** This updated component allows configurable generator and exciter positions. The previous component dictated that the generator and exciter had to be positioned at the end of the rotating mass (#5639).



**Bug Fixes:**

1. The *Frequency Scanner* component now gives correct results when the permanent magnet machine is scanned (#4459).
2. The first data point in the *File Reader* component may now be specified as something other than TIMEZERO (#4395).
3. Parameter options in the *Manual Entry of Y, Z* component are now consistent with category names (#4938).
4. The PSS2B stabilizer component will now accept 5<sup>th</sup> order, according to its upgrade to the IEEE Standard 421.5 (1992) (#1921).
5. The default name for new cable interface components, created with the component wizard, is now 'Cable\_1' (#5030).
6. The *Frequency and Incremental Phase Measurement* component now measures the frequency properly when the voltage of the node, where the frequency is being measured, is below the set rated voltage (#4160).
7. **Fixed an unused variable problem (namely having to do with the *Initial Source Magnitude* parameter input) in the *Voltage Source Model 1* components (#5053).**
8. The multiple-run component will now give an error if used in a master project and set to monitor output. If allowed, the output generated by the slave projects is out of sync and will produce an output file with incorrect information (#5138).
9. The multiple-run component will now give an error if used in a slave project (#5139).
10. EMTDC will now issue a message to the message table indicating that existing frequency scanner components are running when the project is launched (#4922).
11. The hydro governor 2 master library component (hy\_gov) now responds properly to the droop setting (#5167).
12. The multi-mass model will now initialize properly when used at non-unity speeds (#5215).
13. The check used in the lens21 and apple 21 components to determine whether the two circles, which comprise the lens or the apple shapes, are too far away from each other now works correctly when polar coordinate format is used (#5282).
14. The apple21 component no longer complains when substituting variables (#5278).
15. A problem was corrected in the fixed\_load component when it is used in constant power configuration. Previously a sudden jump in results would occur after about 10 cycles of simulation (#5277).
16. EMTDC no longer fails with T\_GOV5 when compiled with GFortran (#5312).
17. Added regex checks in the RTP/COMTRADE component to disallow the ability to enter a name longer than 8 characters. Also added a runtime warning message if the name is adjusted to follow 8.3 format (#2705).
18. The ctype filter master library model had both a parameter and a port with the same name ('C'), which resulted in incorrect Fortran script (#5435).
19. Leaving the multiple run output file name in the Multiple Run component empty, no longer crashes the simulation (#5176).

20. The multiple-run component no longer logs an incorrect initial seed value when there are no random variations in any of the outputs (#5258).
21. The washout time constant used in the frequency/phase measurement component is now checked to ensure it is greater than 1 ms. The phase output would become unstable smaller (#5486).
22. Corrected a no load losses issue in the 3-phase, 2-winding transformer component (#5715).
23. Fixed an issue with the delay component when configured for a single time step delay. Previously the component was producing a 2 time step delay (#5737).

## EMTDC

### Enhancements & Deficiency Fixes:

1. **Output File Format:** The EMTDC output file naming convention has been modified to include simulation rank number. The format has been changed from `<filename>_r#####_##(##).out` to `<filename>_r##_m#####_##(##).out`, where *r* is now used to denote the rank number and *m* is the multiple-run number (#5122/#5135).
2. **EMTDC Message Severity Levels:** EMTDC is now capable of submitting messages back to PSCAD at a pre-set severity level. Levels include *Information*, *Warning* and *Error*. This is accomplished via a new routine called EMTDC\_MESSAGE, which replaces EMTDC\_WARN and EP\_ERROR (#5324).
3. **Harmonic Impedance Interface for Custom Components:** A new, generalized interface to the harmonic impedance solution has been added. Now custom components may be included in frequency scans (#3489).
4. **Upgraded Pole/Residue Removal Algorithm:** A new two-sided integration method has been implemented for the removal of large pole-residue ratios in frequency-dependent, curve fitting results (#5240).

### Bug Fixes:

1. The band limit proximity detection algorithm is now functioning properly (#3036/#4899).
2. EMTDC now notifies PSCAD of actual plot step being used (#4119).
3. Spelling/grammar mistakes have been corrected in some EMTDC sourced messages (#5377).
4. EMTDC will now stop the simulation if a transmission segment travel time is less than 80% of the simulation time step. Previously the simulation would stop if a transmission segment travel time is less than 50% (#5085).

## LCP

### New Features, Enhancements & Deficiency Fixes:

1. The Line Constants Program now supports up to 12 cables, including all concentric conductors (#4917).
2. The minimum number of two coaxial cables within a pipe has been removed. Users may now model a pipe-type cable containing either a single, coaxial cable or an empty pipe (no internal cable) (#4856).
3. Multiple pipe-type cables are now supported within the same right-of-way (#4857).
4. The traditional functional form method, used by the DC Correction algorithm, has been replaced with a new method. The new method is simple and robust and does not require the use of a constrained optimization method. The new algorithm also appears to have resolved convergence issues that occurred when using the previous method (#4860).

### Bug Fixes:

1. Checks have been added to both the LCP and EMTDC to ensure the validity of calculated travel times (#4777).
2. The equivalent  $\pi$ -section component creator now works properly for large cable systems. A formatting error in the script segment was fixed (#5015).
3. The mutual earth impedance calculation no longer fails when two transmission lines or cables are separated by a significant distance (#4990).
4. The Line Constants Program now warns the user if negative or invalid time delays are calculated (#4328).
5. The Line Constants Program now checks for illegal, zero-length transmission segments (#5434).
6. The long line correction algorithm now provides the harmonic impedance solution with the correct hyperbolic functions at certain arguments (#5221).
7. The line constants program will now identify a zero DC resistance and stop further processing. Previously, a singularity error was output, but processing was not stopped (#5546).
8. The passivity check algorithm now displays the frequency range and corresponding maximum negative eigenvalue (#5556).
9. The Line Constants Program now provides the correct capacitance value when the last layer of cable is a conductor inside of a pipe (#5557).
- 10. The Line Constants Program now checks to ensure that the entered ground resistivity is non-zero. A zero ground resistivity was causing EMTDC to crash (#5408/5437).**
11. The Line Constants Program now checks for non-physical, or negative, inductance and capacitance values after performing long-line correction. If found, an error will be issued (#5664).
- 12. The DC correction algorithm now works properly when modeling aerial cables (#5622).**



## Licensing & Utilities

### Bug Fixes:

1. Silent install recording now works if the user is required to log in with administrator credentials (#5625).
2. Educational edition users now prompted to select certificate actions on exit of PSCAD (#5596).
3. Certificate licensing now supports a fallback, secondary server (#5606).
4. HTTP proxies are now supported by certificate licensing (#5626).
5. **Multiple instances of the PSCAD application, based on a single license, may now be opened simultaneously on the same workstation. This is possible only when using certificate licensing (#1686).**

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