



WHAT'S NEW IN PSCAD V5.0.0

SUMMARY

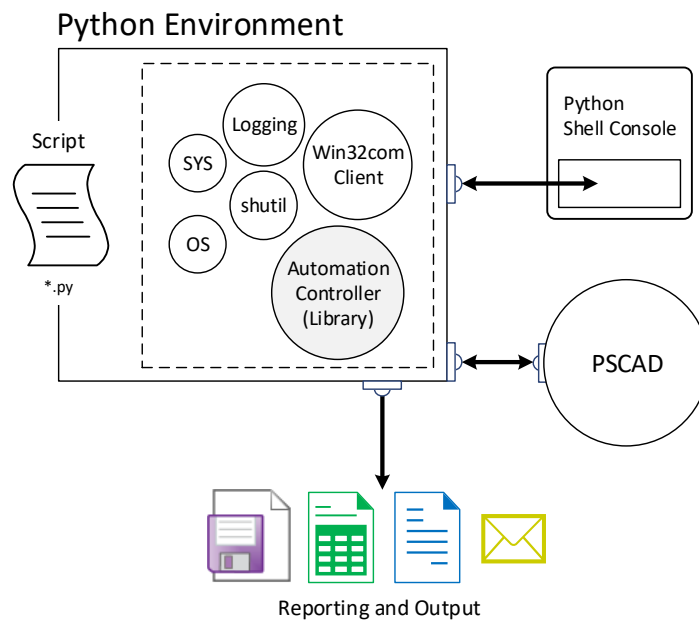
New Features	Enhancements to Existing Features	New/Improved Master Library Models
Automation: Embedded Python Scripting With Recording	New External Resource File Handling	MMC Model Library
New Binary EMTDC Output File (*.psout) Format	Parallel Multiple Run (PMR)	Single-Phase Induction Machine
Multi-Language Support in Sticky Notes (Unicode)	New Global Substitutions Design	Z-Domain Controls Library
Communication Fabric (ComFab)	New and Improved Parameter Grid	1-Phase, Multi-Winding (5-12), Transformer
Co-Simulation Interface	Blackbox Upgrade	3/5-Limb, Duality-Based Transformer
Cluster Launch System (CLS)	Smart Paste	Hysteresis Reactor
Improved Component Parameter Dialog	Enhanced Component Wizard Design	3-Phase Current Source
Tandem Lines: Sliding Faults	Component Graphics Editor Overhaul	IEEE Standard 421.5-2016 AC Exciters
Mixing of Overhead and Underground	Custom Configurations in Layers	IEEE Standard 421.5-2016 DC Exciters
Wire Drawing Enhancements	Signal Name Aliasing	IEEE Standard 421.5-2016 Static Exciters
COMPLEX Signal Type	Simulation Set Functionality Improvements	Individually Configurable, Delta-Connected Load
Project Navigation Enhancements	New Parameter Editor Design	Individually Configurable, Delta-Connected, 3-Branch Load
Component Grouping	Quick and Easy Component Enable/Disable	Individually Configurable, Y-Connected Load
Reload Project	Animated Graphics Patch	Individually Configurable, Y-Connected, 3-Branch Load
Message Log Pane	Status Bar Overhaul	Per-Unit Impedance Branch
Library Project Sections in Models Tab	Undo/Redo Expansion	Isolation Switch
Signal Rename	New and Improved Macro Functionality	TRV Envelope Generator
	Search Upgrades	Harmonic Signal Generator
	The Power of the Arrow Key	Pick-Up, Drop-Out Timer
	Zoom Enhancements	Clark/Inverse Clark Transform
	Graphing Improvements	Change Detector
	Component Scroll Using the Tab Key	Dead-Band Controller
	Schematic Tab Enhancements	Scale Changer
	Improved Ribbon File Tab	Discretizer
	Workspace Tree Multi-Select	Sort Indexer
	Table Parameter Improvements	Complex Conjugate
	Output Channel Limit Increased	Electrical Phase Tap
	#COMPONENTID Script Directive	Backlash
	\$#Type Script Directive	Complex Constant
	Component Parameter Condition Mode	Complex Signal Support
		Array Signal Support
		Multiple Run Additional Recording Statistical Summary
		FFT Increased to 1023 Harmonics
		B-H Core Characteristic for Saturable Reactor
		Permanent Magnet Machine Neutral Connection
		Mutually Coupled Three Wires – Zero Impedance

PSCAD

New Features

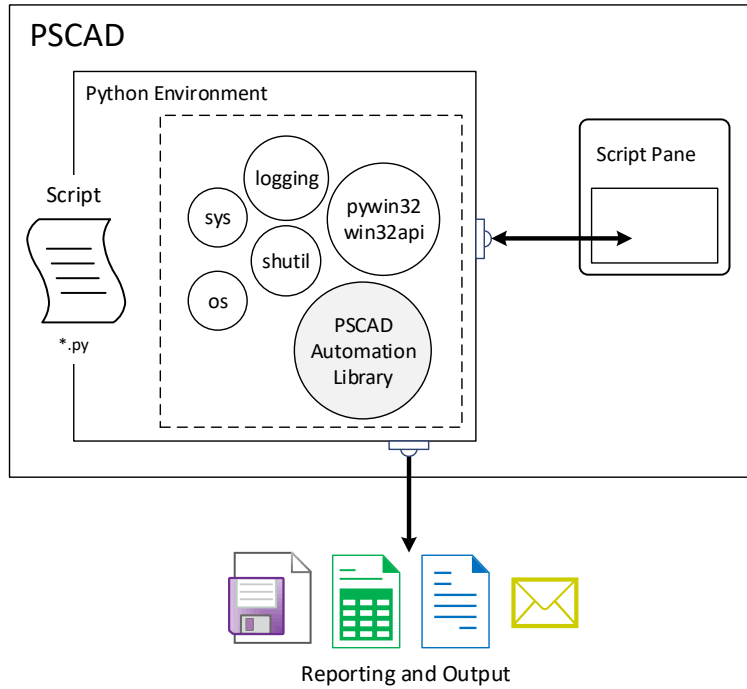
1. Automation: Embedded Python Scripting With Recording (#6983)

Automation of the PSCAD application, utilizing custom-made Python language scripts, was first introduced in v4.6.1. It included commands to launch the software, load and run simulations, change parameters, and analyse data, among many others. Installed as standalone software, an automation controller library was bound to other Python scripting libraries, to achieve control over application-level features through an automation interface (part of PSCAD).



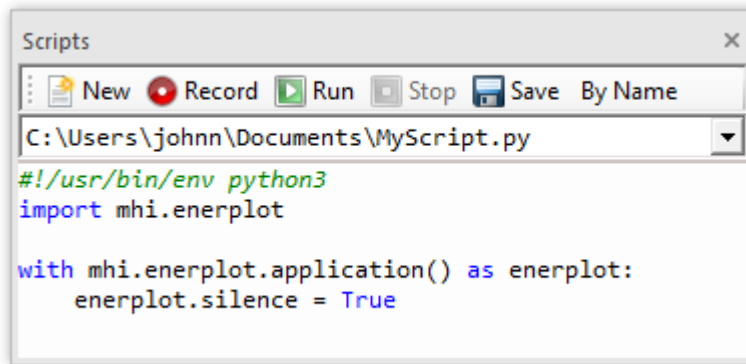
Non-Embedded Python Automation Interface, in PSCAD v4.6

In V5, automation utilizing the Python script language is embedded directly into the software, and is included with the installation of PSCAD.



Embedded Python Automation Interface, in PSCAD V5

Now users can maintain their scripts from within PSCAD, using a new *Script* pane, from which custom scripts may be recorded, edited or launched.



Script Pane

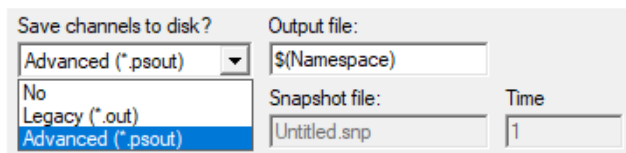
The new scripting interface comes complete with the ability to record actions – effectively writing the script for you for many of the available operations. Some manual tweaking of the file is usually required, but the bulk of it written automatically. The new interface is faster, and it alleviates the need to install Python separately (it comes ready to use with your PSCAD installation).

2. New Binary EMTDC Output File (*.psout) Format (#5442, #7056, #7801, #7754)

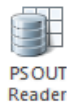
With the advent of renewable energy devices, PSCAD-based studies of the effect of these devices on existing grids has become a necessity in order to ensure smooth and uninterrupted operation during and after their insertion in the network. As such, PSCAD study projects are required to represent larger and larger network models, which of course leads to greater amounts of simulated data.

The present text file based system for storing EMTDC simulation output, which has been in use for the past 20 years, was originally designed assuming much smaller simulation projects, and is therefore no longer an efficient and memory-savvy system for simulation data storage. A redesign is needed.

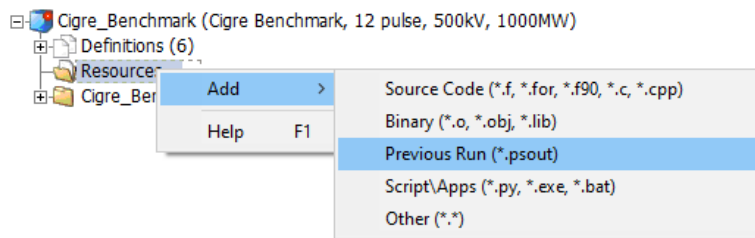
A brand new EMTDC output file format (*.psout) is included with the PSCAD V5 release. A proprietary design, this new format is binary, which ensures a much smaller storage footprint, as well as faster data access. Not only does it store all simulation curve and trace data, but it can also store all sequential or parallel multiple run data, as well as animated graphics information, all in a single file. For example, if you were to launch a volley of 100, parallel simulations, all EMTDC output data is stored in a single file named <project_name>.psout.



Given that binary files cannot be read using a simple text editor, a new utility, called the *PSOUT Reader*, is also included with PSCAD V5. This utility provides a convenient, tree-based data display environment, and includes appropriate file manipulation features, including the ability to export to the older EMTDC *.inf/*.out file format. The utility may be launched from the *Tools* tab of the ribbon control bar.

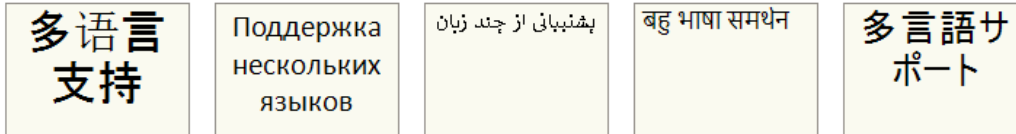


In addition, *.psout files from previous runs, may be added as a resource in the project it was originally run. When invoked, users can display the previously run data on the graphs within that project.



3. Multiple Language Support in Sticky Notes (Unicode) (#5569)

The PSCAD V5 code base has been updated to fully support Unicode, which enables users to use all known writing systems within sticky notes. This of course includes the Cyrillic alphabet, Chinese characters, etc. This is a very important new feature, which has been passionately requested by many of our Asian users.



4. Communication Fabric (ComFab)

A new inter-application communications control architecture, referred to as the *Communication Fabric* (or *ComFab* for short), is included with V5. In all prior windows versions of PSCAD going back to V3, Transmission Control Protocol/Internet Protocol (TCP/IP) had been the only protocol used by EMTDC and PSCAD to communicate during a simulation.

With the advent of high performance computing and the launching of multiple, inter-linked EMTDC simulations running in parallel, the communication overhead imposed by the TCP/IP protocol was found to be a serious speed impediment. Consequently, new means of communication were implemented to overcome this issue.

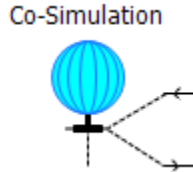
ComFab is a separate layer that acts as a middleware for communications between processes. It is generic enough to be expandable and can be utilized by third-party software to communicate with PSCAD and EMTDC, provided that protocol is adhered to. As of the V5 release, *ComFab* supports two types of communication interfaces: The legacy *TCP/IP* (default) and *Shared Memory*.

Mode	Restrictions (Scalability)	Performance	Details
TCP/IP	None	Local – 20 μ s Remote – 400 μ s	This is the default and legacy mode of communication between PSCAD and EMTDC.
Shared Memory	Single Computer	Local – 1-2 μ s	Shared Memory is memory that may be simultaneously accessed by multiple programs (i.e. in our case, PSCAD—EMTDC, and/or EMTDC—EMTDC) with an intent to provide communication among them. Shared Memory reduces the communication overhead to a near negligible level, but is best suited for running simulations on a <u>single</u> , multiple-core computer.

5. Co-Simulation Interface (#4598, #6778, #7064)

A general Application Programming Interface (API) is provided with PSCAD V5, enabling EMTDC to link to, and co-simulate with, just about any external application. Referred to as the *Co-*

Simulation API, it is in its basic form, a C-language structure called *EmtdcCosimulation_Channel*, which houses a collection c-functions. These functions can be used to customize an interface on the external application-side. At the same time, a new master library component called *Cosimulation*, may be utilized in a case project to quickly provide the PSCAD/EMTDC side of the interface.

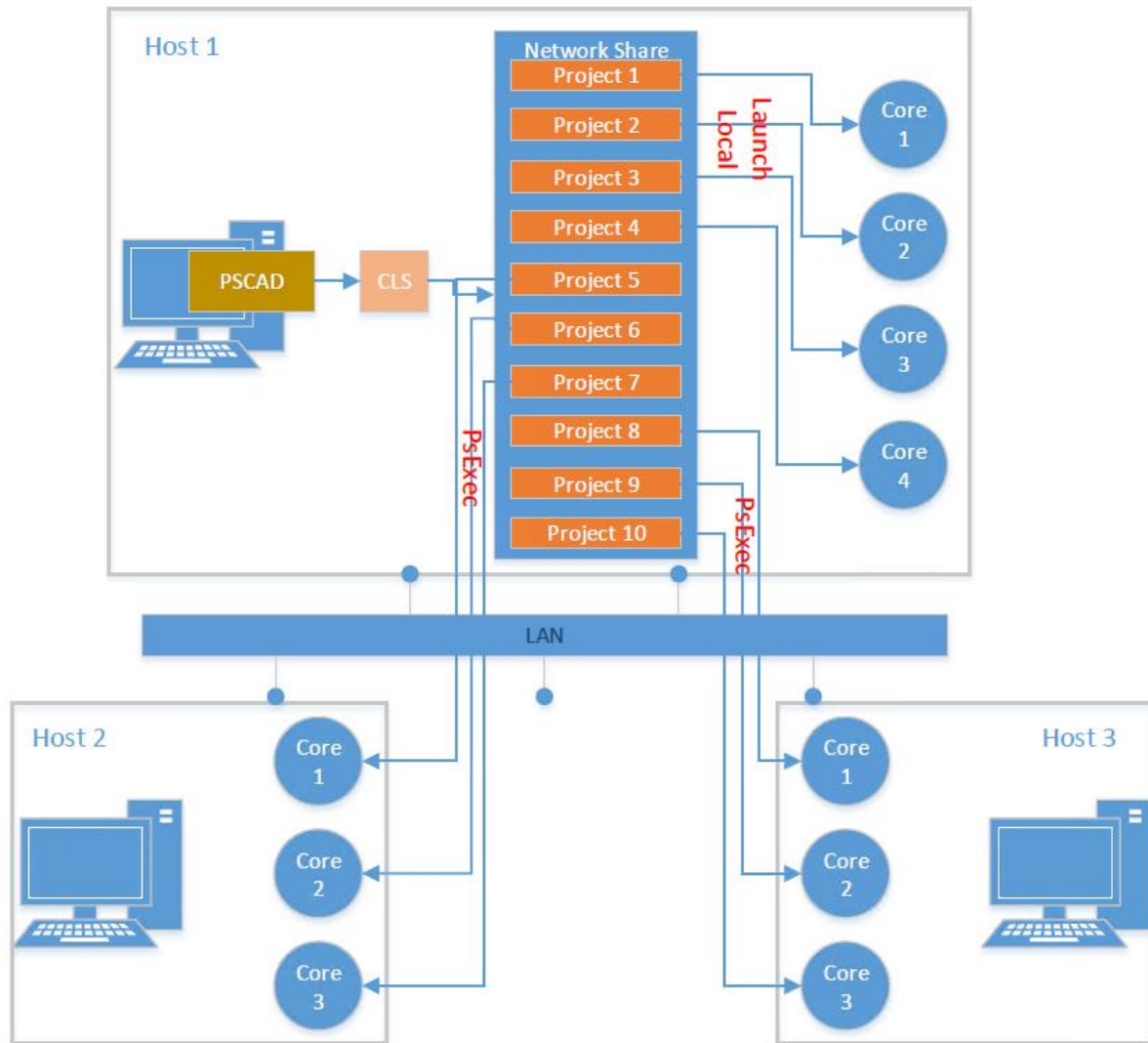


Note that the onus remains on the user to program the interface from the external application side, as all external applications differ in complexity and purpose. A complete description of the Co-Simulation API can be found in the PSCAD On-line Help.

6. Cluster Launch System (CLS)

The utilization of high-performance and parallel processing functionalities requires multiple processor cores – the number of which may exceed those available locally on a typical workstation. In such situations, users may either purchase a large and expensive, high-performance computer (ex. 64-core), or connect a collection of multi-core computers across a Local Area Network (LAN). The latter option is referred to as a *computational cluster*.

Running processes across multiple computers requires additional software to manage the simulation processes. Enter the *Cluster Launch System (CLS)*, a utility that can both launch and manage simulations on a computational cluster.



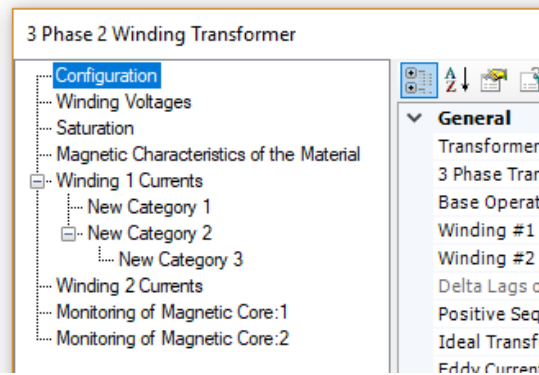
For example, a user wanting to run 10 simulations on a computer (*Host 1*) comprising of 4 cores, can use the CLS to configure a computational cluster and run 10 simulations using several multi-core computers connected across a LAN. As shown in the figure above, *Host 1* can be treated as the master, since PSCAD is running on this computer. PSCAD launches the CLS, which is then used to configure a computational cluster comprising of *Host 1*, *Host 2* and *Host 3*.

7. Improved Component Parameter Dialog (#7139, #7333)

In an effort to provide a more efficient means of organizing very large amounts of component input and output parameter data, the component parameter dialog has been greatly improved for the V5 release. Two huge improvements were made: The manner in which parameter category pages are organized, as well as the inclusion of a Java-based, dynamic display and feedback window, called the *Dynamic Help Pane*.

The flat, drop-list category page format, which has been a part of PSCAD since the V2 days of the 1990s, has been replaced by a multi-level, tree-based category window. The new tree style can

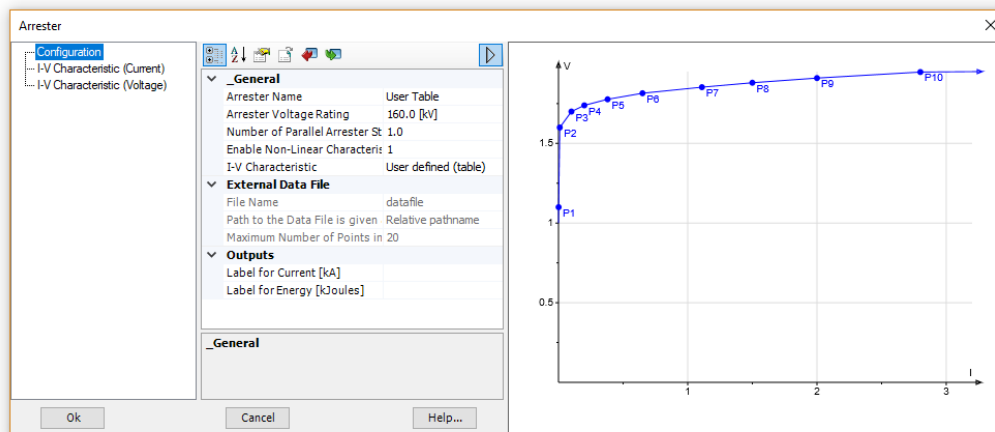
be extended to provide multiple branch levels (branches within branches), to provide a second dimension to the organization of categories.



New Style Category Tree

A very powerful and customizable display window, called the *Dynamic Help Pane*, is also included in the new parameter dialog. The new pane is simply a viewing mechanism to display the output of an associated, JavaScript-powered, HTML file. The power and flexibility of JavaScript and its libraries may be utilized to create a wide assortment of parameter data visualizations, from help text, to images and dynamic graphs that change as the data changes.

For example, the arrester component in the master library has associated with it an HTML file that defines a V-I curve plot, based on the V and I parameter data entered in the dialog. The curve is displayed in the side panel window as shown below. The graph is dynamic and will change immediately if the parameter data is changed.

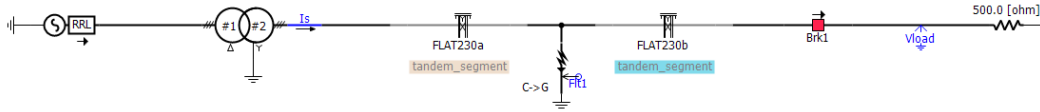


Arrester Component in the Master Library

8. Tandem Lines: Sliding Faults (#337, #2347, #7062)

Tandem line configuration (or Tandem Lines) for both underground cable and overhead transmission segments is introduced with PSCAD V5. This in response to numerous requests for

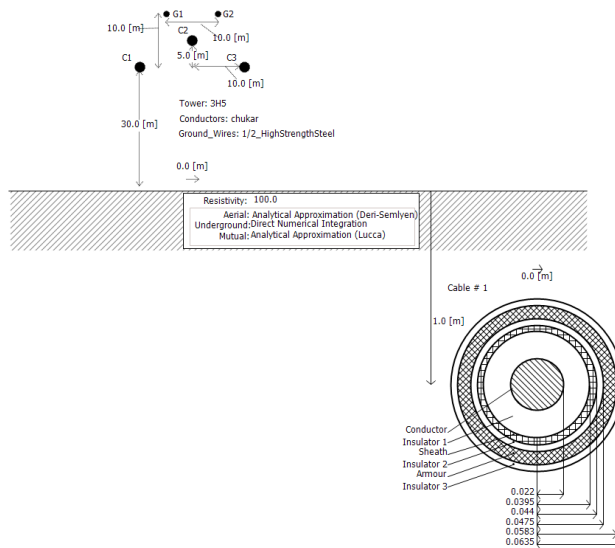
an easier way to automate a sliding-fault style study. The tandem lines feature combines multiple run control, parallel-processing and the transmission segment configuration components, to enable quick and efficient sliding-fault simulations.



Utilizing the basic, standalone multiple run control configured in the projects settings *Runtime* tab, a tandem line simulation involves a pre-solve of all possible transmission segment lengths (i.e. produces multiple *.tlo files, based on the tandem segment parameters) prior to launch. Then the simulation is run multiple times, each time using different segment lengths, creating the illusion of a sliding fault.

9. Mixing of Overhead and Underground Transmission Systems (#7588)

The underground cable transmission segment editor and line constants program (LCP) have been modified to allow the combination of overhead transmission tower and underground cable cross-sections, within the same right-of-way.

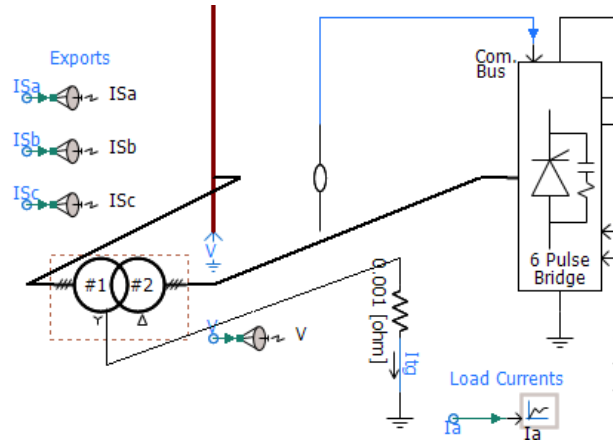


Additional formula in the LCP takes care of the mutual impedance between aerial and underground lines.

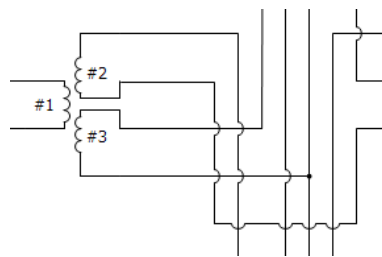
10. Wire Drawing Enhancements (#2897, #1092, #7185)

A couple wire-related enhancements have been included in PSCAD V5, to help alleviate some of the steps required when inter-connecting components on the schematic canvas. These new features bolster the already existing Wire Mode, which has been in use since V3:

- Rubber Banding (Sticky Wires):** A new, tri-segment 'sticky' wire component has been added to PSCAD V5. When either endpoint of this wire is attached to another object (component, bus or another wire), the wire's endpoint will 'stick' to the object. If the object is moved, the wire endpoint will remain 'stuck', and the sticky wire will stretch (like a rubber band), as the object to which it is attached is moved around.



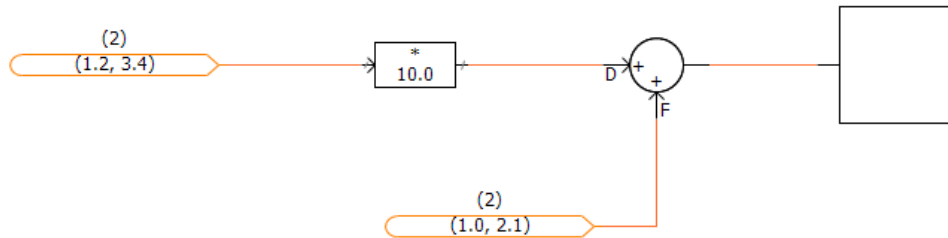
- Wire/Bus Snap-to-Grid:** A new application option has been added to provide control over how wire end-points are moved within the schematic canvas. In previous PSCAD versions, wire endpoints, when grabbed and moved, do so in a continuous motion, snapping to the drawing grid on release of the mouse pointer. The new option provides snap-to-grid functionality, while moving the wire endpoint, so that the wire position can be seen before the mouse pointer is released. The option can be found under *Application Options | Design Environment | When adjusting wires*, and affects both wires (orthogonal and sticky), and bus components.
- Wire Jumper Display Option:** Wires that overlap, but are not connected will now include a visual jumper display at the overlap point. If desired, this option may be disabled in the *Application Options* dialog.



11. COMPLEX Signal Type (#5792)

Complex-type signal variables, in addition to Real, Integer and Logical-types, are now supported in PSCAD V5. Support for #LOCAL-type, complex declarations in component definition script was introduced in v4.6, but did not include the creation and support of actual complex-type data signals. V5 includes the following enhancements to provide full support:

- A *Complex* data type option in component graphics port objects.
- A *Complex* parameter-type for both module and non-module components.
- Miscellaneous new and updated master library components, including a *Complex* constant tag. Also *Complex* signal support in many CSMF components.
- New colour **orange** to represent *Complex* signal wires.

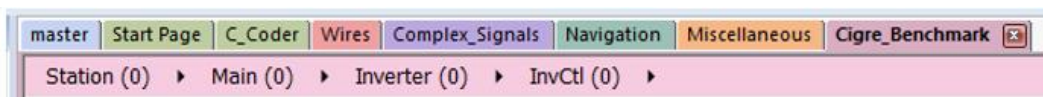


12. Project Navigation Enhancements (#1004, #5908, #3384)


Multiple enhancements have been included with PSCAD V5, to help users navigate projects quicker and more efficiently, as well as minimizing the risk of getting lost in larger projects. Prior to V5, project navigation was performed by drilling down through multiple module layers manually. Navigating upwards was accomplished in the same way. PSCAD V3 and V4 provided a sub-tree under each project, containing a clickable representation of the existing module hierarchy, allowing users to jump to specific modules. In X4 (v4.3 to v4.6), this navigation tree was brought out into its own area, referred to as the workspace secondary window.


V5 now boasts a handful of other navigation related niceties, in addition to the navigation tree, as described in the following bullets:


- **Navigation Bar:** Each and every schematic canvas tabbed viewing pane, possesses its own navigation bar. The bar shows the hierarchal path, including each navigation level, to the present viewing position. Each level itself is a navigable link, and displays the module definition name and instance number. Users may easily traverse up the path with a simple click of the mouse.



- **Bookmark Component:** Bookmarks essentially special type of a component that provides a clickable hyperlink to a xy-coordinate on a specific schematic canvas within a project. Bookmarked points are first defined, and then a bookmark component can be added from the ribbon bar that, when clicked, will navigate to that exact position from anywhere in the project.

 [Main \(1493,1147\)](#)

 [mod1 \(247,210\)](#)

 [mod2 \(559,355\)](#)

Bookmarks are also managed from within the Bookmarks pane. This pane provides a convenient and navigable list of bookmarks.

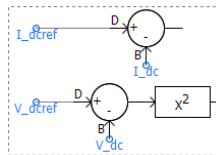


- **Hyperlink Component:** Hyperlinks are special components that may be used to set a URL to a specific webpage, for easy access to information related to the current study, for example. Simply add a URL to the project file and give it a name.



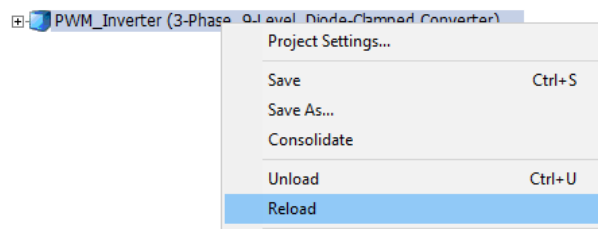
13. Component Grouping (#256, #7171)

The ability to combine collections of individual components into a cohesive group, is included with V5. Two or more components, once grouped, can then be moved around, copied, pasted, mirrored, flipped, rotated, or added to a layer as a single entity.



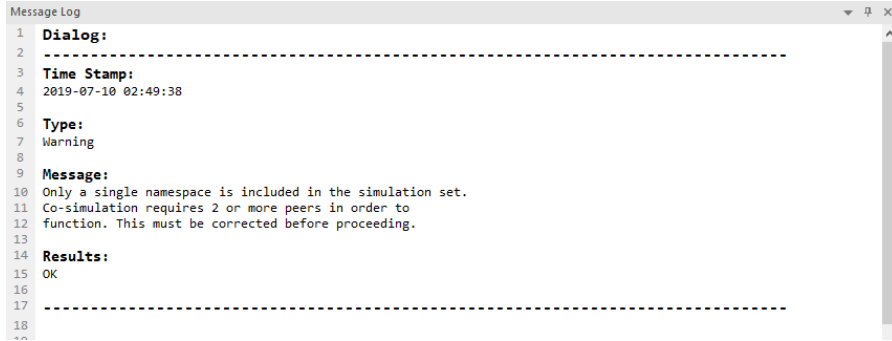
14. Reload Project (#4198)

Case and library projects may now be reloaded in the same fashion as workspaces. Reloading a project will result in any unsaved changes being lost, however the user is warned of this before the reload commences.



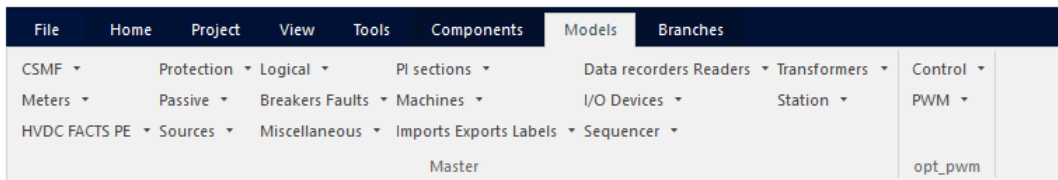
15. Message Log Pane (#7472)

A new type of message pane is included with PSCAD V5, called the message log. This pane simply displays all messages that have been displayed to the user during the current session.



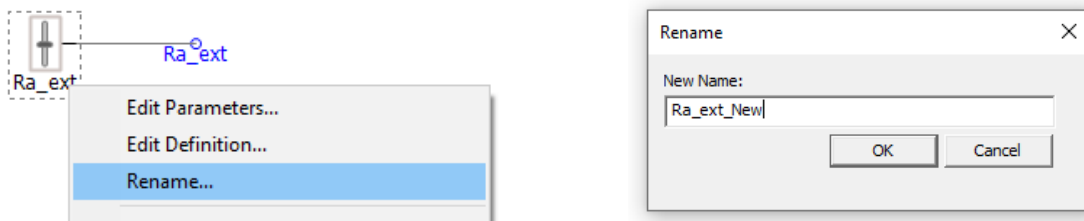
16. Library Project Sections in Models Tab (#6667)

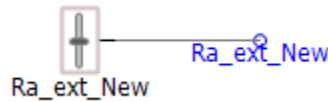
The *Models* tab in the ribbon control bar is now populated with component definitions stored in any user library project that is loaded into the current workspace. In previous versions, only component definitions from the master library would appear. Named drop list groups of definitions may be created by giving the definitions a label (edit the component definition settings). For example below, a user library project called *opt_pwm* is loaded into the workspace, in addition to the master library. *opt_pwm* contains two groups of labelled definitions called *PWM* and *Control*.



17. Signal Rename (#8253)

It is now possible to rename a signal source and all sinks that exist on a schematic, with a single action. It is designed to provide the ability to rename all buses or components that share a name, by simply right-clicking on the bus or component, and selecting **Rename....**





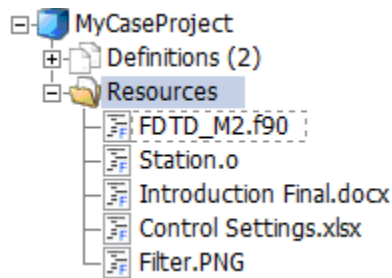
This feature operates by detecting components with a *Name* parameter on the component. If a Name parameter does not exist, then the function is disabled.

Enhancements to Existing Features

Based on feedback from users around the globe, many features and functionalities have been modified, and in some cases, completely redesigned in PSCAD V5.

1. New External Resource File Handling (#5383, #6704, #7798)

The addition of external source (*.f, *.c) and linking of compiled object and library (*.obj, *.lib) files to a project build has, since PSCAD V3, been accomplished via two separate input fields in the project settings, or via the *File Reference* component. In V5, this functionality has been overhauled and organized into a convenient and intuitive, central area called the *Resources Branch*.



Appearing as a sub-branch of every project in the workspace projects list, the resources branch provides a means to easily manage all resource files related to a specific project. The resources branch encapsulates the functionality of both the prior project settings fields, and the file reference component, enabling users to append all types of files related to the project; such as Microsoft Word or Excel files, images, Python files for automated scripting, as well any type of text file. All this in addition to the source and linked compiled files supported in previous versions. The operating system file association settings are utilized so that the proper application is launched when the file is viewed. Also, resource branch icon graphics will display the current status of the resource file, such as whether or not it is included in the build.

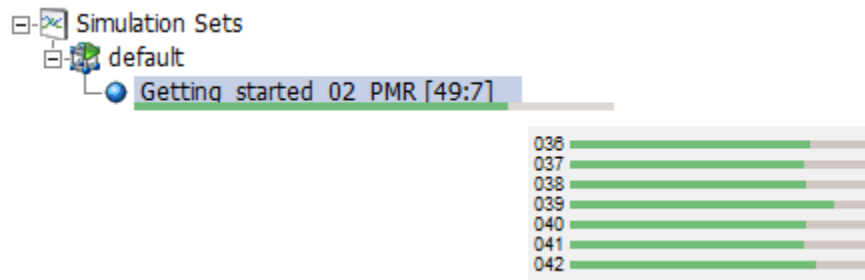
Note that the *File Reference* component will continue to be supported in V5.

A new *Application Option* has also been added to the *Environment* category called *Relative Path resolution*, which provides a means to specify folders where the compiler should look for dependent files. In this way, only the file name need be specified in the project, as long as the file resides in one of the specified folders.

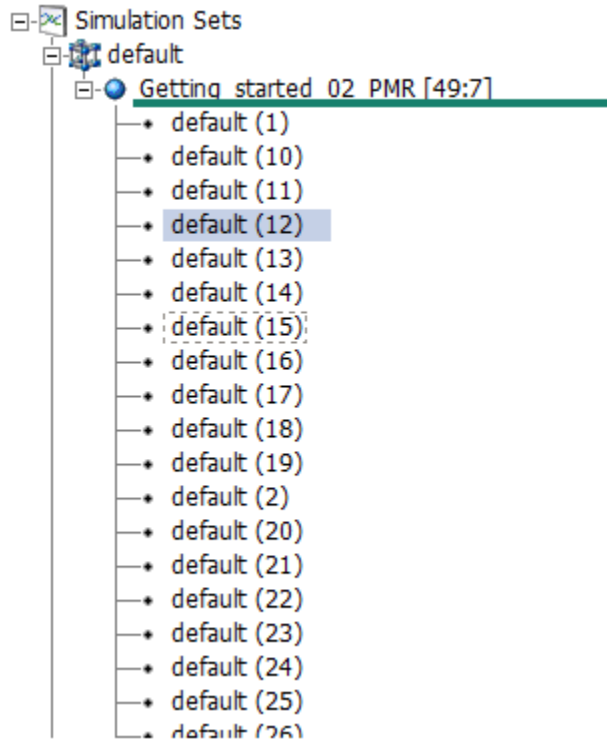
2. Parallel Multiple Run (PMR) (#5129, #6767)

In computing, the acronym SPMD (or 'spim-D') stands for Single Program, Multiple Data, and is one of several computer architectures described in a classification called Flynn's taxonomy. It is a technique used to achieve data parallelism, where multiple instances of a simulation are run simultaneously on multiple processor cores, given different input, in order to obtain overall results quicker and more efficiently than if running them sequentially. In PSCAD, the SPMD technique is referred to more affectionately as a Parallel Multiple Run (PMR).

The PMR feature enables users to launch multiple simulation runs in parallel, based on a single case project, but providing different data to each parallel simulation task. Each simulation is run independently on its own, unique processor core.



- Multiple Plotted Data Sets:** If the user chooses to enable tracing (passing plot data back to PSCAD for viewing) on all parallel tasks, a convenient list of data sets will appear under the simulation. These sets will represent each individual run, and when clicked, will display the data for that run in the project graphs. For example, if the tracing is enabled for all parallel tasks in the above simulation, all 49 runs will appear as follows:

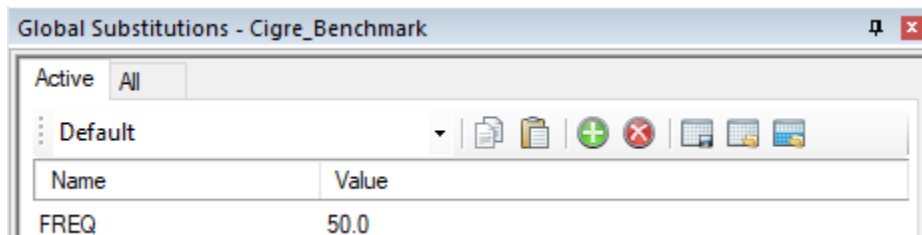


The simulation task with rank 12 is currently selected, so this data will be displayed in the project graphs.

3. New Global Substitutions Design (#4601, #6433)

The global substitutions feature, part of the PSCAD X4 family of products (v4.3 to v4.6), has been completely redesigned for V5. Based on feedback from users over several years, we have assembled an entirely new global substitutions functionality, much more flexible and intuitive than the previous design. Major changes include:

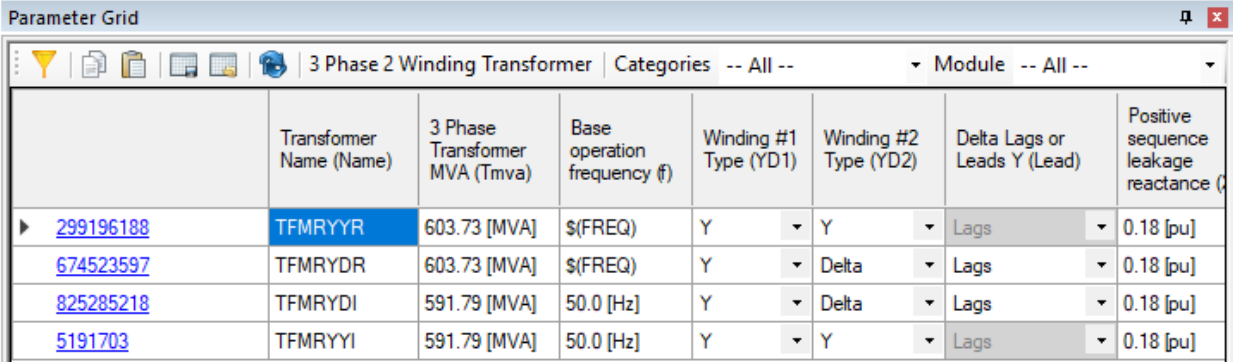
- A new global substitutions pane, which provides a central area to edit, add and delete all global substitutions related to a single project.
- Inclusion of alternate global substitution values (or sets of values) when running the project as a task, in the context of one or more simulation sets.
- Store, append and replace global substitutions to/from file in *.csv format.
- Set the min/max limits of slider components.



4. New and Improved Parameter Grid (#5609, #5976, #7410)

The immensely popular parameter grid feature has been completely re-architected in PSCAD V5, specifically to address the user-identified shortcomings of its predecessor in v4.6. For the most part, the new parameter grid looks and feels like the old one. However, under the hood we have made many changes that will facilitate functionality that was missing previously. Here is a list of some the more significant enhancements:

- Support for buses, transmission lines, simulation sets, file reference components and sticky notes: Virtually all schematic objects.
- Results may be filtered by parameter category page, in addition to page module.
- Disabled parameters (instance-based) are now displayed as such in the parameter grid results.
- Store, append and replace parameter grid results to/from file in *.csv format.
- Parameter grid results may be transferred directly to a spreadsheet, modified and then transferred back via copy/paste.
- Full undo/redo support.



The screenshot shows the 'Parameter Grid' window in PSCAD. The title bar reads 'Parameter Grid'. Below the title bar is a toolbar with icons for search, print, save, and refresh. The main content area shows a table with columns: Transformer Name (Name), 3 Phase Transformer MVA (Tmva), Base operation frequency (f), Winding #1 Type (YD1), Winding #2 Type (YD2), Delta Lags or Leads Y (Lead), and Positive sequence leakage reactance (X). The table contains four rows of data for transformers TFMRYR, TFMRYDR, TFMRYDI, and TFMRYI.

	Transformer Name (Name)	3 Phase Transformer MVA (Tmva)	Base operation frequency (f)	Winding #1 Type (YD1)	Winding #2 Type (YD2)	Delta Lags or Leads Y (Lead)	Positive sequence leakage reactance (X)
299196188	TFMRYR	603.73 [MVA]	\$(FREQ)	Y	Y	Lags	0.18 [pu]
674523597	TFMRYDR	603.73 [MVA]	\$(FREQ)	Y	Delta	Lags	0.18 [pu]
825285218	TFMRYDI	591.79 [MVA]	50.0 [Hz]	Y	Delta	Lags	0.18 [pu]
5191703	TFMRYI	591.79 [MVA]	50.0 [Hz]	Y	Y	Lags	0.18 [pu]

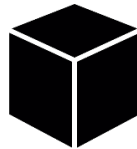
5. Blackbox Upgrade (#4599, #6364, #7149)

The blackbox module feature, first available in PSCAD v4.5 and v4.6, has been updated in V5 to include many new enhancements, including the support of electric networks in combination with control systems.

- **Electric Networks Support:** Starting from the top-level page module, an entire electric network, which may span across several module levels, can be collapsed into a single component, complete with multi-instance compatible, Fortran source code. The new component definition includes prefabricated graphical port arrays to represent the network, as well as pre-scripted Branch, Transformers and Matrix-Fill segments.
- **Global Substitutions:** If project-based global substitutions are used within a module hierarchy that is to be blackboxed, the user has two options on how to process them: The default is option is to embed (hard-code) the literal value of the global substitution upon creation of the blackbox component. These values will thereafter remain constant and

unchangeable. A second option allows users to make each global substitution available as a constant input parameter in the final blackbox component. Each parameter created is unique according to: 1) the actual substitution, and 2) the target unit of the parameter it is used in. For example, if a global called `FREQ` is used in two parameters, one whose target unit is [Hz] and the other [rad/s], two separate parameters are created.

- **Retention of Inner Definitions:** When blackboxing a page module hierarchy (a module with other modules inside it), it is now possible to retain the blackboxed component definitions of each, individual module, as opposed to keeping just the top-level component definition. If retained, each definition is itself a blackboxed component and may be utilized exclusively from all the others.



6. Smart Paste (#5895, #6629, #6195, #6093, #6880, #6420)

Cut/copy and paste just got a whole lot smarter in PSCAD V5. Now when an object is copied, PSCAD stores a great deal more information on the Windows clipboard, so that when it comes time to paste, an intelligent decision can be made, depending on the context of the where the object is being pasted. This can save click steps in many areas:

- **Copy/Paste of Output Channels:** Copy an output channel component. Depending on where it is pasted, PSCAD will intelligently perform the correct operation: Paste over a graph, and a curve will be created; paste on the schematic canvas to copy the component; paste over a blank graph panel and a new graph containing a new curve will be created; paste over a control panel to create a new meter interface.
- **Paste External, Copied Text Directly as Sticky Note:** Text copied from an external file, such as Microsoft Notepad or Word, is now formed directly as a sticky note, when pasted on the schematic canvas.
- **Multi-Select Copy Transfer:** Select a single module or multiple modules and select copy. Paste transfer into same project or a new project.
- **Layer Information Included in Copy/Paste:** All layer information is now included when a component is copied. On paste, the layer state will be maintained. If the layer exists already, the component is added to it; if not, a new layer is created.
- **Paste Rename:** When a component that contains a text input parameter with symbol name *Name* is copied, this text can now be given a new name, based on the original seed text. For example, a component with a *Name* parameter with value *MyComponent* can be automatically renamed to *MyComponent_1*. This is especially useful when copying data labels, node labels and xnodes. To make use of paste rename, right-click and select Paste | Paste Rename on paste of a copied component.

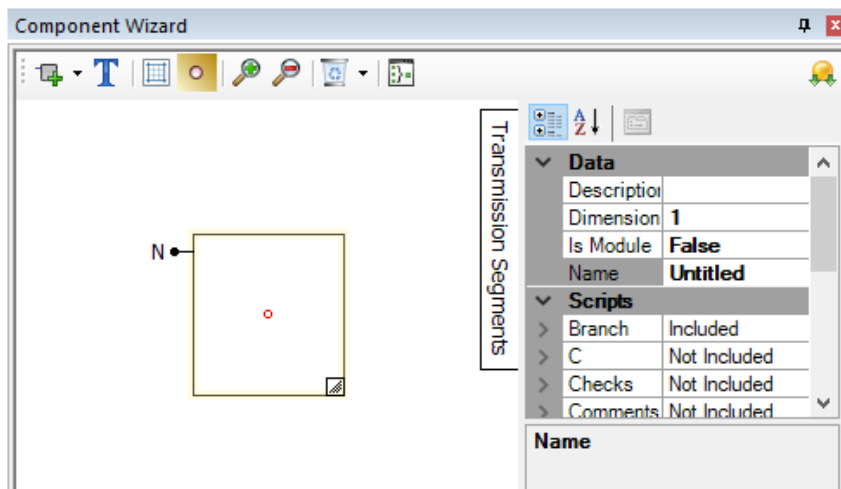
- **High-Resolution Bitmaps:** Copying of schematic canvas components now produces a high-resolution bitmap image, which when pasted into other applications, maintains a high image quality.



7. Enhanced Component Wizard Design (#5836)

The component wizard has gone through a few changes over the years: The original design, which survived through PSCAD V3, V4 and on through to X4 (v4.3), was redesigned for the v4.4 release, and then again in v4.6. PSCAD V5 includes a completely new and refactored component wizard, our best and most powerful iteration yet. Unlike its predecessors, the V5 component wizard provides a much higher level of flexibility, including the following user-requested enhancements:

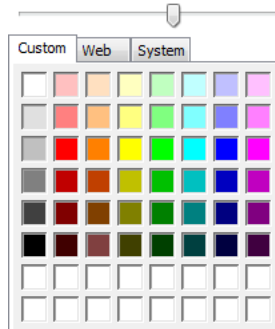
- Fully sizeable box graphic.
- Flexible port connection placement: Once a port is added, it can be moved around the box graphic to the desired position.
- Quick access property view.
- All component definition script segments may be optionally added at the time of creation.
- Automatic creation of a dummy language interface to either FORTRAN, C or MATLAB, upon creation of the Fortran, Dsdyn and/or Dsout segments.



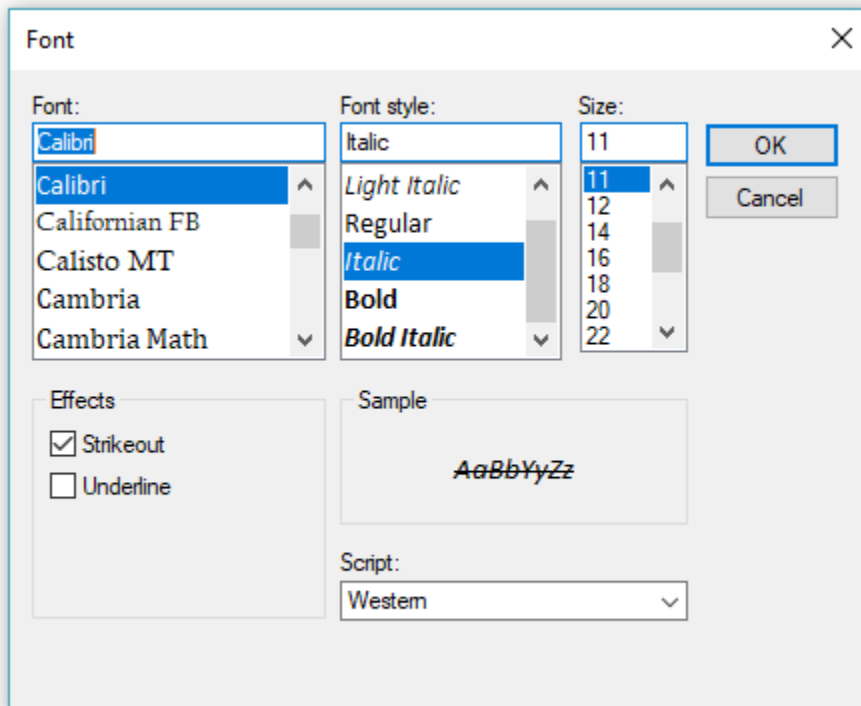
8. Component Graphics Editor Overhaul (#4212, #6419, #6795, #7710, #7709)

The component definition graphics editor has been renewed to include functional improvements and feature enhancements.

- Updated Graphics Colour Palette:** The *Waffleston's Revised 4-bit Color Palette*, originally included with the release of PSCAD V3, and maintained throughout the V4 and X4 product lines, is updated to a full *32-bit ARGB Color Palette*. This increases the number of available colours from 16 to 4,294,967,296.

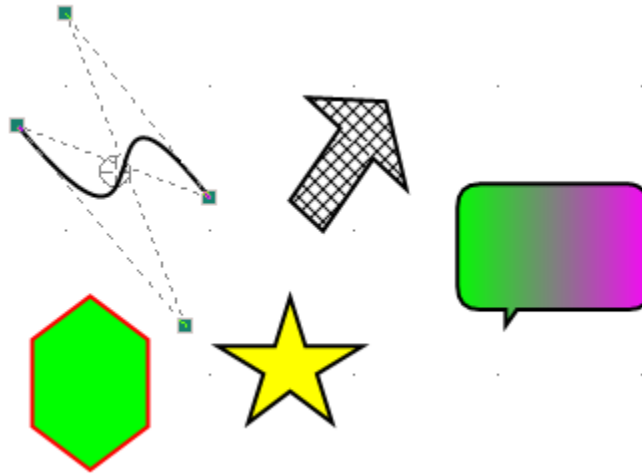


- Full Font Support for Text Elements:** It is now possible to adjust text elements to any font type, style and/or size (including underline and strikethrough) available through the operating system. Adjusting text elements to any angle, or applying any colour (as per the updated colour palette described above) is also now possible.



- New Collection of Adjustable Shapes:** A new standard collection of adjustable, drawing shape elements is now available, in addition to the original line, rectangle, arc and ellipse.

Each of the objects are stretchable, rotatable and come complete with a full array of adjustable properties, such as fill colours and styles (hatching and gradients).



9. Custom Configurations in Layers

Customizability has been added to the established drawing layers feature, first introduced in PSCAD v4.6.0. Custom configurations enable internal customization of a layer, by controlling the state of individual components within the layer. Users can accomplish this component state control by adding their own configurations to any layer.

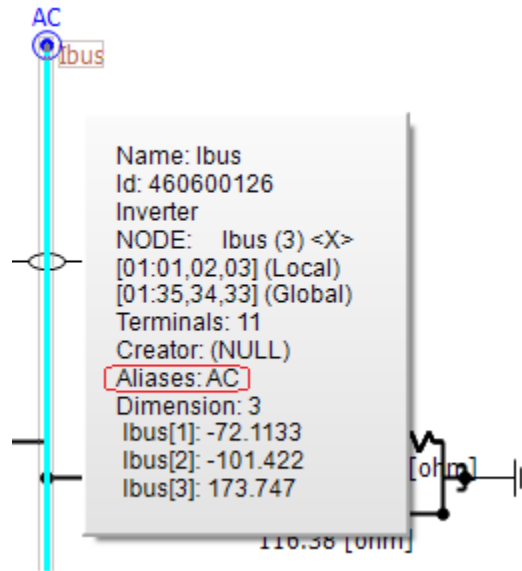
Layers						
MyConfiguration2 +						
	Enabled	Disabled	Invisible	MyConfiguration1	MyConfiguration2	
72575535	Enabled	Enabled	Enabled	Disabled	Invisible	
280552298	Enabled	Enabled	Enabled	Enabled	Disabled	
▶ 1699785180	Enabled	Enabled	Enabled	Invisible	Enabled	

Custom configuration options are stored with the project, as attributes to a particular layer, and will remain when layers are merged.

10. Signal Name Aliasing (#7630)

Schematic canvas signals are now allowed to possess multiple names or aliases. During compilation, signals that have different names (such as a bus and an xnode that have different names, but are connected to each other) are aliased together. When compilation is complete, aliased signals are designated a single name, based on a priority system that can include alphabetical.

Aliased signal names will be displayed in flybys, and each signal variable in the generated Fortran code that has multiple aliased names, are declared on a unique line with a comment section describing the aliased names that the variable is associated with.



This added intelligence to the PSCAD schematic compiler ensures compatibility with older PSCAD projects, while providing flexibility moving forward. Signal name aliasing solves the import issue addressed by the *Exported Signal Distinction* application option, and so therefore this option has been removed.

11. Simulation Set Functionality Improvements (#5665, #6152, #6247, #6294, #7059)

Simulation sets were introduced in PSCAD v4.5 in order to facilitate the launching of parallel simulations. They have been continuously enhanced in each version since, and V5 is no exception:

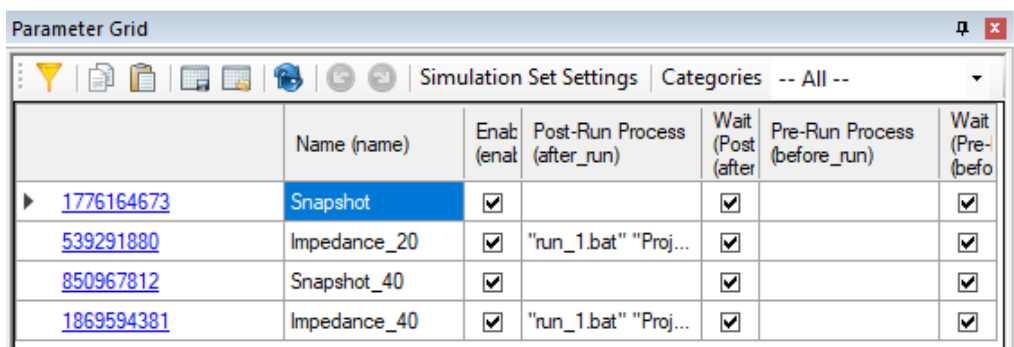
- **Project Settings Override:** The ability to override runtime project settings, in each simulation task, is now included.

▼ Snapshots	
Override Timed Snapshot(s)	Override
Override Snapshot File	Override
Override Time	Override

- **Layer Settings Override:** If a project contains layers, individual settings may be overridden on a per-simulation task basis. This feature provides a lot of flexibility, as project schematics can be modified between simulation set runs.

▼ Layers	
MEDICY	Enabled
ALMU	Disabled
MEDS	Not Set
MAHD	Not Set

- **Global Substitutions Set Select:** In PSCAD V5, it is possible to maintain multiple sets of global substitutions for each project. A single global set may now be associated with a simulation task, allowing users to modify global substitution values between simulation set runs.
- **Enable/Disable Set:** Use the enable/disable simulation set option to enable or disable individual simulation sets. Disabling a set will ensure it is not included when running all sets.
- **Parameter Grid Support:** Use the parameter grid to manipulate the options of multiple simulation sets simultaneously.



	Name (name)	Enab (enab)	Post-Run Process (after_run)	Wait (Post (after)	Pre-Run Process (before_run)	Wait (Pre-(befo)
▶ 1776164673	Snapshot	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
539291880	Impedance_20	<input checked="" type="checkbox"/>	"run_1.bat" "Proj...	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
850967812	Snapshot_40	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
1869594381	Impedance_40	<input checked="" type="checkbox"/>	"run_1.bat" "Proj...	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>

- **Force Re-Build:** The ability to force a re-build of the project, prior to launching the simulation, is now available as a *Simulation Task* option. When enabled, this setting will also ensure that the temporary folder is cleared between runs.
- **New Parallel Run Options:** New options, such as *Maximum Volley* (limits the number parallel tasks launched on a volley), and *Snapshot File* (allows the selection of specific snapshot files based on rank number), have been added.

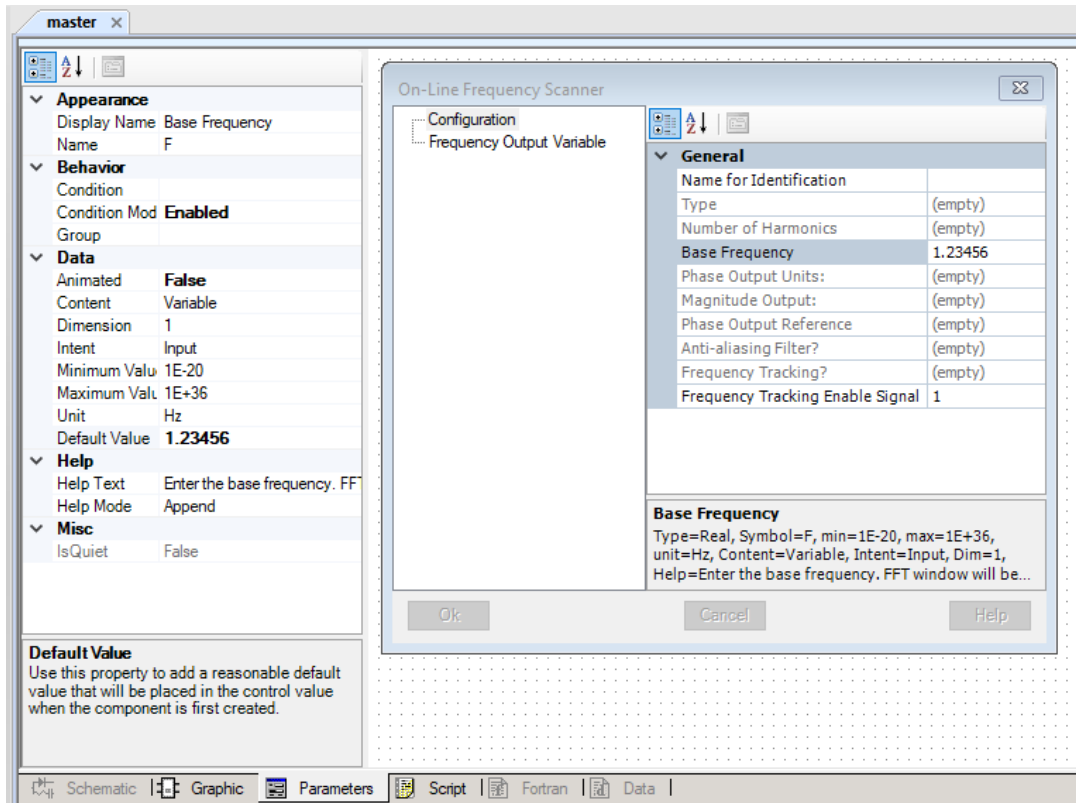
12. New Parameter Editor Design (#5509, #7497, #7619, #7676)

The parameter editor, part of the component definition design editor, is completely refactored in PSCAD V5. The original parameter editor, included as part of the V3 and V4.1/V4.2, was updated to a brand new, windows forms-based editor for the entire X4 product series (v4.3 to v4.6).

This same editor looks similar in V5 after the update, but has been reorganized so as to display the parameter dialog dynamically, while it is being edited. This enables the user to see exactly what the dialog will look like, without the need to exit the editor, or press the *Test Dialog* button (the *Test Dialog* is still necessary for actual functionality testing, however). Also, much of the underlying functionalities have been improved and cleaned up, resulting in a more intuitive and efficient work environment.

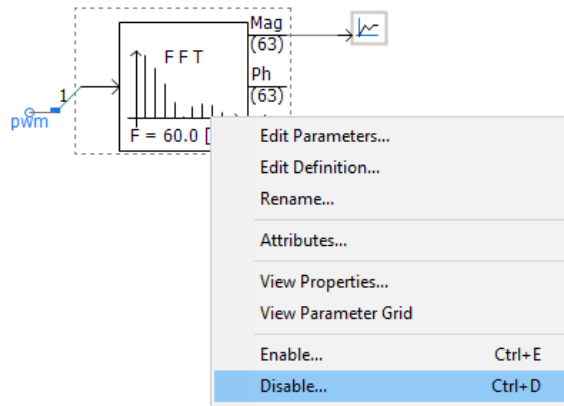
Some other specific enhancements are described as follows:

- It is now possible to control the visibility of an individual component parameter, based on a conditional statement, in addition to the existing enable/disable control. This is facilitated via a new parameter attribute called *Visibility*.



13. Quick and Easy Component Enable/Disable (#6136, #6794, #7073)

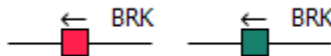
Components on the schematic canvas may now have they state quickly toggled between enable and disabled, without the need to set up a layer. Note that disabling or enabling a component in this manner remains completely distinct from whatever layer (if any) the component is currently a part of. However, a disabled component will still become invisible if its current layer is set as such.



14. Animated Graphics Patch (#2671)

The animated graphics feature has been in use since PSCAD V3, and has remained mostly unchanged since – until now. Prior to V5, the animated graphics display (ex. breaker state colour, multi-meter PQ text, etc.) would only update if the corresponding component was currently in view, during a simulation. This means that if the user was to navigate to another page module schematic after the run had finished, the graphical state of any components in that schematic may not be up to date. For example, if a breaker went from open to closed while not in view, it may still appear green if the user navigates into its page module following the end of run.

This issue has been rectified in V5, so that all animated graphics will show their last state in the simulation, regardless of whether they were viewed or not.



15. Status Bar Overhaul (#3008, #6671)

The status bar (horizontal strip along the bottom of the application) has been rebuilt in PSCAD V5 to soften the rigidity of the previous design, which has been in use since V3. The new status bar is more flexible, and several issues regarding display text truncation and other annoyances, have been resolved. Other highlights:

- User expandable display areas: Customize the status bar look and feel.
- Auto-hide and reset to default buttons.



16. Undo/Redo Expansion (#6949, #6973)

Undo/redo functionality has been expanded to additional areas of PSCAD that have not supported it in previous versions. First introduced in PSCAD V4, undo/redo has become an essential (and expected) feature in all software applications. In V5, undo/redo is now supported in the following areas, in addition to the schematic canvas:

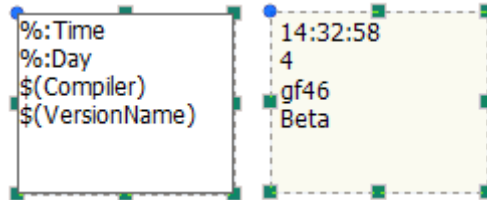
- Parameter Grid
- Component Definition Graphic Editor
- Workspace Definition Schematic Branch



17. New and Improved Macro Functionality (#2682, #6751, #6809, #6805)

A handful of enhancements to how and where, both static and animated macros can be used, have been included in the PSCAD V5 release.

- **Sticky Notes:** All static (ex. $\$(Compiler)$, $\$(ProjectDir)$, $\$(VersionName)$), as well as animated macros (ex. $\%:Time$, $\%:Month$, $\%:Userid$, $\%:Computer$) may now be used within sticky notes. Previously these macros could only be entered as a component parameter value, for display on its graphic.



- **Consolidator:** The consolidator was improved so that it makes use of the $\$(Compiler)$ static macro. This ensures proper folder creation to properly link compiled files when multiple compilers FORTRAN are involved.
- **New Static Macros:** A handful of new static macros have been added to the existing list:
 - $\$(PscadPlatform)$ – Resolves to x86 or x64 depending on the PSCAD build.
 - $\$(EmtPlatform)$ – Resolves to x86 or x64 depending on the selected FORTRAN compiler.
 - $\$(MatlabPlatform)$ – Resolves to x86 or x64 depending on the MATLAB build being used.

18. Search Upgrades (#4930, #6684)

The search facilities in PSCAD are constantly improving, and V5 is no exception. To the *Basic Search*, we have added the ability to enter direct *Regular Expressions (RegEx)*. This enables extremely specific searches, which when dealing very large cases, can be helpful in minimizing redundant hits. Also, double-clicking on a search result will directly open the corresponding component parameter dialog, reducing the clicks required to do this in the past.

Basic Search Node Search Brar

Search For:

Look In:

Match Case

Match Whole Word

Match Component ID

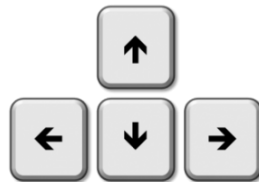
Use Regular Expressions

Filter Search

19. The Power of the Arrow Key (#5201, #5461, #4764)

The arrow keys, which in past versions of PSCAD were used mainly for schematic scrolling, as well as miscellaneous other minor purposes, have been enhanced to include new and powerful functionalities:

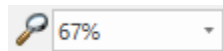
- **Nudge:** Move (or nudge) components on the schematic canvas, or graphics in the component definition graphics editor, by pressing one of the four arrow keys. Simply select the object first, and nudge away.
- **Traverse the Workspace Tree:** While in the workspace, navigate through the tree using only the arrow keys. In addition to up and down movements, pressing the right arrow key on a collapsed branch will expand it, and pressing the left arrow on an expanded branch will collapse it.
- **Shift and Ctrl Hold to Select:** Selecting text in script segments or elsewhere, is now enhanced to support the holding of the *Shift* and *Ctrl* keys, while moving in all four arrow key directions. Previously, text could only be selected via left mouse button hold.



20. Zoom Enhancements (#479, #7446)

A couple enhancements have been made to the schematic canvas zooming functionality.

- **Custom Zoom Level:** The ability to specify an exact zoom level (in 1% increments) has also been provided. Simply type in the zoom level and press enter.



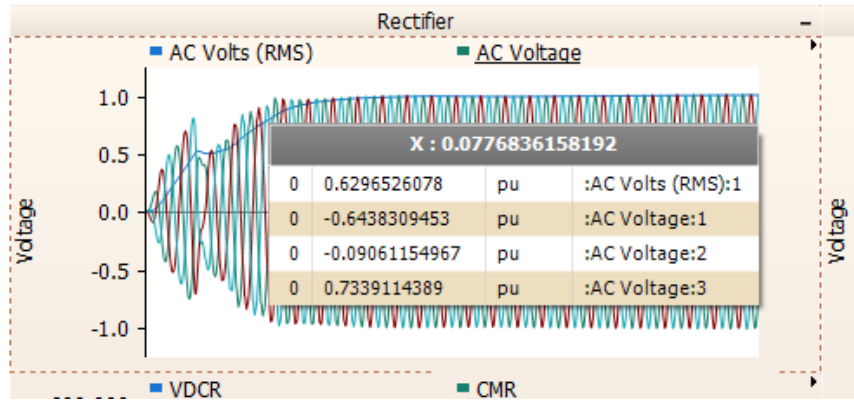
- **Continuous Zoom:** Zooming in and out of the schematic canvas is now continuous, in increments of 1%. Previously, zooming in or out (say by using the mouse wheel) would happen at pre-defined steps (i.e. 100%, 125%, 150%, etc.).



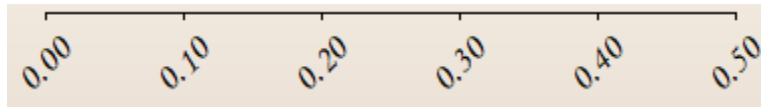
21. Graphing Improvements (#2154, #6500, #6226, #6148, #4786, #7281)

A few improvements have been made to the graphing tools, based on customer feedback.

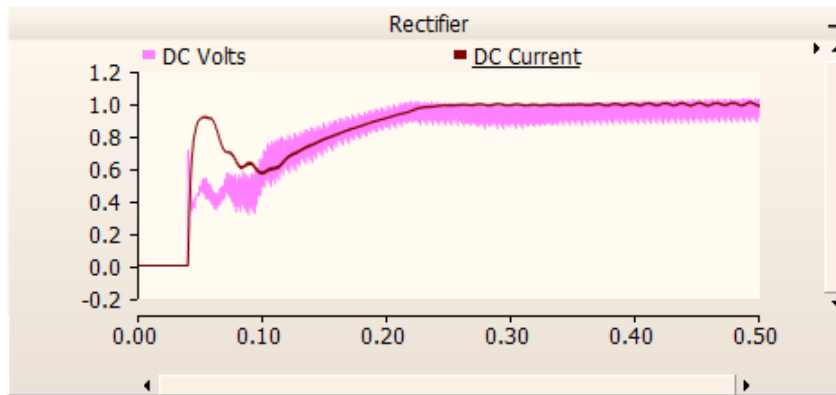
- Graph Flyby Displays:** The graphing tool data flyby viewing windows have been completely overhauled. Improvements include a table layout for clearer display of data, with display precision and column order adjustable in the *Application Options*. Note also, that the new flybys will no longer show off monitor, avoiding display clipping.



- Adjustable X-Axis Labels:** The x-axis labels on graphs may now be adjusted in terms of font, font size, and display angle.



- Curve Colours:** Curve colours are now fully customizable, based on the new 64-bit colour palette. Previously, curve colours were limited to 6 distinct colours.



- The x-axis grid increment setting can now be set to manual. Previously, PSCAD would recalculate the x-axis grid automatically upon zoom. With manual zoom enabled, the x-axis grid remains static, even when zooming.

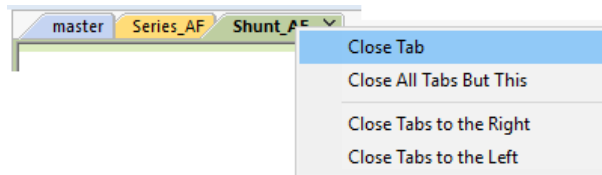
22. Component Scroll Using the Tab Key (#4752)

It is now possible to scroll (or tab) through components on the schematic canvas, using the *Tab* and *Shift + Tab* key combinations. Simply select a component and press *Tab* (*Shift + Tab* to reverse). Tab scrolling is performed top-down, left to right.



23. Schematic Tab Enhancements (#6647)

The schematic pane tabs have been provided with additional closing options to make tabbed pane cleanup more efficient. These include *Close Tab*, *Close All Tabs but This*, *Close Tabs to the Right*, *Close Tabs to the Left*.



24. Improved Ribbon File Tab (#4728)

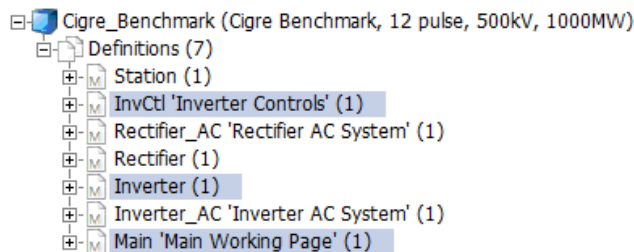
The File tab (formerly the PSCAD tab) in the ribbon control bar, has been completely redesigned to improve efficiency, and to add a bit more convenience to the user.

- **New Projects/Workspaces:** Create new projects or workspaces by simply double-clicking the icon. Project/workspace file name and folder location may be pre-set.
- **Open Projects/Workspaces:** PSCAD V5 maintains a list of recent case and library projects, workspaces, and recent folders visited. Find your files at lightening speed.

25. Workspace Tree Multi-Select (#2837, #4224, #5874)

Relevant branches of the workspace tree, have been enhanced to allow for the selection of multiple items, to enable compound operations.

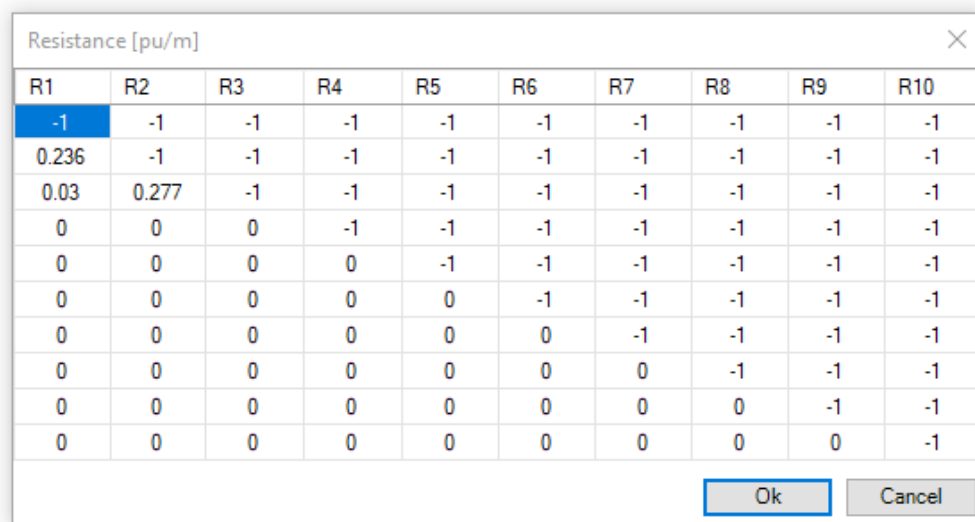
- **Definitions Branch:** In the *Definitions* branch under each project, multiple definitions may be selected and then deleted or copied simultaneously.



- **Simulation Sets:** Multiple simulation sets may be selected at once, allowing limited, compound operations.
- **Simulation Tasks:** Compound operations may now be performed on multiple simulation tasks at once. This includes options and overrides.

26. Table Parameter Improvements (#6762, #5271)

The usability and display of table-type parameters, first introduced in PSCAD v4.3.1, has been greatly improved in V5. When invoked, table parameters are now displayed in a separate pop-up dialog, which allows copy/paste of data, is resizable, and is generally easier to use with less pitfalls than the previous design.



R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
0.236	-1	-1	-1	-1	-1	-1	-1	-1	-1
0.03	0.277	-1	-1	-1	-1	-1	-1	-1	-1
0	0	0	-1	-1	-1	-1	-1	-1	-1
0	0	0	0	-1	-1	-1	-1	-1	-1
0	0	0	0	0	-1	-1	-1	-1	-1
0	0	0	0	0	0	-1	-1	-1	-1
0	0	0	0	0	0	0	-1	-1	-1
0	0	0	0	0	0	0	0	-1	-1
0	0	0	0	0	0	0	0	0	-1

27. Output Channel Limit Increased (#6267, #6905)

- The hard maximum limit for output channels per simulation has been increased from 2,048 to 65,536 in the professional edition only. The prior limit had been imposed, due to the fact that the PSCAD-EMTDC message buffer would become overrun (when more than 2000 output channels existed), resulting in message blocking and other annoyances. The PSCAD-EMTDC communication mechanisms have been enhanced in V5 to allow for increased message traffic, without overrunning the buffer.



28. #COMPONENTID Script Directive (#4223)

A new directive was added to the PSCAD Script, called `#COMPONENTID`. When this directive is encountered during processing, it is replaced directly with the following in the corresponding FORTRAN (*.f) file:

CALL COMPONENT_ID(ICALL_NO,<component_id>)

The use of the #COMPONENTID macro is recommended when building custom components, as it reduces the chance of typos, plus will ensure custom component script remains compatible in future versions.

29. \$#Type Script Directive (#6417)

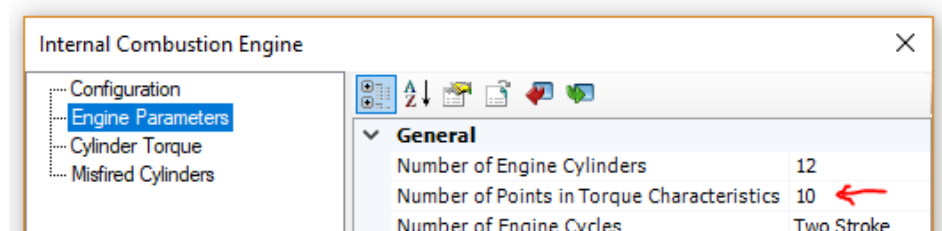
A new directive was added to the PSCAD Script, called *\$#Type(n)*. This directive can be used in logical statements when checking for the type (i.e. ELECTRICAL = 0, LOGICAL = 1, INTEGER = 2, REAL = 3 or COMPLEX = 4) of a port, parameter or computation variable. For example:

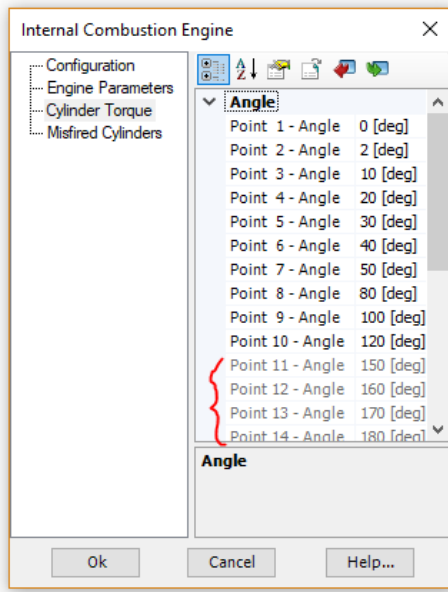
```
#IF $#Type(input)==2
```

In the above statement, the signal type of a port called *input*, is checked if it is of INTEGER-type (INTEGER = 2).

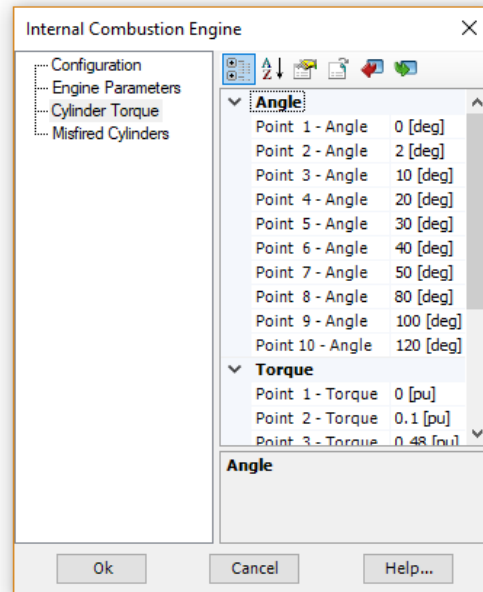
30. Component Parameter Condition Mode (#7094)

A new control attribute has been added to all component definition parameter types, called *Condition Mode*. *Condition Mode* may be set to *Enabled* or *Visible*, where *Visible* is the new functionality. When set to *Visible*, parameters will become invisible if the corresponding conditional statement in the *Condition* attribute is false, as opposed to simply being greyed-out if *Enabled* is selected (legacy).





Condition Mode Set To Enabled



Condition Mode Set To Visible

Bug Fixes

The following is a list of bugs that were discovered and fixed since the latest, previously released product.

1. The bolded (modified) state of parameter input field values is now reverted back to un-bolded, if the user reverts it back to its initial state (#6299).
2. The project compiler now checks for port dimension validity and posts an appropriate error if found (#6379).
3. **If more than approximately 150 projects are loaded into a single workspace, and each is opened, PSCAD would crash. This has been fixed, by not allowing more than 32, simultaneously opened project schematic panes (#6435).**
4. Modules possessing output parameters that are disabled, due to a conditional expression, are now properly dealt with. Previously a runtime error would occur with no valid messages (#6616).
5. It is no longer possible to copy a definition from the workspace tree and paste it onto the schematic canvas. Previously, doing this would add invalid (but harmless) XML elements to the project file (#6229).
6. The conversion of the letter 'C' or 'c' in the first column of component script, is no longer presumed to be a comment and replaced with an explanation point '!'. This was an older FORTRAN 77 to 90 conversion, which is no longer necessary (#6750).

7. Global substitutions may now be used to set parameter values in online controls components (i.e. sliders and switches) (#6652).
8. **The proper plotting context is now displayed when output channels, defined within a page module whose definition is stored within a library project, is instantiated in multiple different case projects, and each project is run separately. Previously in this situation, only curve data from the last project in the data stack was displayed in all projects (#5807).**
9. A padding margin of 0.25% is automatically applied to all graphs when zoom extents is used. This ensures that constant data close to the y-axis boundary is clearly displayed in the graph (#6846).
10. Conditional statements used for category pages or individual parameters, will now default to false if the statement is invalid for any reason. Previously they would default to true (#6827).
11. Node search is now set to global node number by default (#6856).
12. Clicking refresh on the models tab of the ribbon control bar, no longer renders the tab unresponsive (#6633).
13. Sequence order numbers are no longer displayed on data labels, xnodes and node labels. These components are not part of sequence ordering and display on them clutters the schematic (#6606).
14. **Fixed a crash point that could occur if a user manually adds transmission segment instances to a project, by manually editing the XML, and not including an accompanying definition (#6958).**
15. It is no longer possible to select a component, that resides under a graph pane, while performing graph related operations within that pane. An issue was fixed with the drawing layer ordering mechanism, which also fixed an issue the comparator tool display results (#6960/#6957).
16. The divider component now works properly in 2D mode. Previously, changes to parameters did not stick when the OK button was pressed (#6959).
17. **Fixed a crash point involving a certain sequence of navigation steps. This was caused by PSCAD attempting to access invalid cached information (#6963).**
18. Speed performance has been greatly enhanced in situations when performing PNI or PMR simulations, where the number of parallel simulations exceed to number of processor cores available (core overloading). There is still a speed performance hit in these situations; however, it is vastly improved over previous versions, where the simulation speed was decreased to almost a standstill. Ensuring there are more cores available than simulations is still a recommended practise (#6898).
19. Manually modified graph settings no longer revert to their previous state, upon resize of the schematic canvas, following the modifications (#6966).
20. EMTDC simulations are now prevented from running if the number of time steps exceeds 2^{31} . Anything higher than this exceeds the maximum allowable value for an integer (#6556).
21. A search is now performed, if the 'Filter Search' box is enabled, but no filter is selected. Previously no search was performed under this condition (#6975).

22. **Copy as metafile and copy as bitmap are now free of dysfunction, and have been added to the smart paste feature. Simply select, copy and paste in any external application (#5951, #6228).**
23. Case projects no longer get flagged as modified by simply running them (#6941).
24. PSCAD now provides options in the event that the user tries to re-run an EMTDC process that was not properly shut down (possibly due to a PSCAD crash). Previously there was no indication of such 'orphaned' processes, leading to confusion (#7034).
25. Issues with incorrect component text justification, following a mirror action, have been corrected (#7010).
26. The nodal matrix display now functions properly when viewing smaller systems, where optimal node ordering is not performed (#7077).
27. **A new application option has been added to allow users to control the status of the *Store feed-forward signals for viewing project setting*, while blackboxing. Previously, and still by default, blackbox forces this setting false, in order to optimize the generated source code. However in some instances, when custom models exist that contain improper storage read/write statements, forcing this project setting disabled would result in different simulated results after the blackbox component was substituted for the original module (#7093).**
28. The graph frame vertical scroll bar is no longer visible, when the graph is copied/pasted outside the application, while in plain paper mode (#4550).
29. The send-to-back and bring-to-front functions now work properly for schematic objects like components and sticky notes (#7109).
30. **PMR-I (root control) will now launch if the number of slave projects in the workspace exceeds the number of receiving transmitters on any slave (#7160).**
31. Graphs no longer draw curves (bleed through) when underneath other components or other graphs (#6249).
32. The size limit for both a single line of text in a component definition script segment, as well as the entire script segment, has been removed (#7161).
33. Dynamic zoom (Ctrl + mouse wheel) now centres properly on the mouse pointer, allowing a directed dynamic zoom (#4444).
34. Dynamic zoom (Ctrl + mouse wheel) now centres properly on selected components when component are selected (otherwise centres on the mouse pointer) (#7206).
35. **PSCAD now properly manages simulation data that is sourced from a module (online controls and output channels), whose definition is stored in a library project, and instances of that module exist in parallel tasks. Previously in situations where there are two or more tasks in a simulation set, and each task project contains a reference to the same module hierarchy, which is stored in a library project, jumbled results no longer occur (#6260).**
36. Users are no longer forced to verify saving every project, on selection of 'Save All Projects' from the workspace *Projects* branch menu (#6894).

37. The destination schematic canvas is now properly resized when pasting a group of components copied from a larger canvas (#7364).
38. Marker grips and lines no longer become unsynchronized when moving markers via the arrow keys (#7290).
39. **Subroutine calls in Fortran containing large numbers of arguments (longer than 2048 characters in a single line of script) no longer causes a crash (#7488).**
40. **Static library (*.lib) files now link properly on build, when a case project contains more than 10 modules (#7577).**
41. Newly added wire vertices now immediately appear when using the 'v' hotkey or the context menu item insert wire vertex (#6579).
42. Creating a new workspace, or loading or reloading an existing one will now reload the master library project, if it has been modified (#4768).
43. Both simulation sets and simulation tasks may now be manually ordered within the Simulations tree (#4758).
44. Mutual coupling distance to reference t-line/cable input parameter presumed is no longer presumed as kilometres, if entered as unit-less (ie. 60.0 no longer converts to 60,000 m) (#7541).
45. Plain paper mode for graph and control panels now displays properly. Previously, buttons were drawn with a black background when the environment was set to best quality graphics (#7135).
46. **PSCAD no longer crashes when obscure, invalid characters are used in the project namespace name, such as ' . This could occur when a project file is manually edited in a text editor (#7607).**
47. Blackbox no longer assumes the centre point of the component graphic (i.e. 0,0) as its starting point for electrical port placement. It now starts from the centre of the component graphic extents (#7648).
48. Copying of data from graphs no longer adds an extra column of data when *Copy Data to Clipboard | All* is selected. Also, no data is copied via *Copy Data to Clipboard | Between Markers*, if the X and O markers are atop each other (#6933).
49. PSCAD now sanity checks the *Transformers* script segment during compilation. Checks are made to determine if the number of transformer data sets equal the number of transformers indicated (#TRANSFORMERS), and if the maximum number of lines in all sets does not exceed the indicated maximum number of windings (#WINDINGS) (#7673).
50. PSCAD now prompts the user by default if legacy issues are detected on import of older cases, prior to actually modifying the project (#7054).
51. The signal from the receiving end of the control signal carrier may now be manually set for the first time step of simulation. Previously this number was always 0.0, without the ability to control its value (#7705).

52. EMTDC now displays the offending filename when issuing a runtime message sourced from OPENFILE1 (#7573).
53. **Port IP address binding is no longer an issue when multiple network adapter cards are installed on the same local host machine (#7819).**
54. PSCAD no longer fails to build if any other debug warnings are enabled, in addition to the *argument mismatch* debug warning (#7831).
55. **Curves may now be added to XY Plots via drag and drop (either move or copy) (#7842).**
56. The ability to directly copy graph panels by ID number (using python script) has been added (#6699).
57. PSCAD now displays the current product version in the project build messages pane (#7950).
58. Parameters of components residing within the transmission segment definition canvas, may now be modified using Python script automation (#6338).
59. Scenarios associated with controls that are part of a non-instantiated module, may now be managed via the scenario viewer (#7958).
60. Invalid namespace names are no longer accepted for library projects. Names must conform to Fortran naming conventions (#7907).
61. **Electrical ports identified as internal, can no longer be connected via a wire, or any other means (#1105).**
62. Flybys that result when hovering the mouse pointer over a component port, now properly display the port name and description (if it exists) (#7422).
63. Curve legends flybys now display a full path to their respective source modules (#8119).
64. When pasting components using the right-click context menu, the component is now pasted where the right-click occurred, not at the current mouse pointer position (#8387).
65. Support has been added to ensure proper type-casting on import/export signals on module components (#8418).
66. Blackbox now chops call statements to a reasonable length, using the inherent '+' operator in the component definition script (#6337).
67. Polygraphs containing multiple curves no longer misalign with labels if some traces are hidden (#8419).

EMTDC/MASTER LIBRARY

New Features and Enhancements

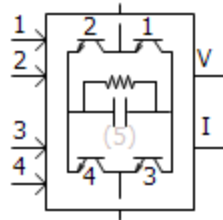
The following features outline some newly added functionality to the EMTDC solution.

1. Modified, Augmented Nodal Analysis (MANA) (#6604, #7085, #7086, #7671): Pending.
 - **PSCAD Interface to EMTDC:** PSCAD interfaces MANA data to EMTDC via the project *Map* and *Data* files. MANA data is entered individually in each component definition, using a new script segment called MANA.
 - Technical Specification: Pending.
 - **kLDU:** Pending.

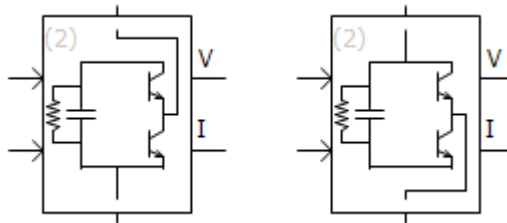
New Master Library Models

The following new models have been added to the master library:

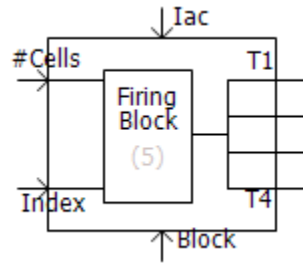
1. **MMC Model Library:** PSCAD V5 includes a library of Modular Multilevel Converter (MMC) component models.
 - **Full-Bridge Cell:** This component models a multi-valve, full-bridge MMC with Thévenin equivalent circuits, which effectively increases the computational efficiency.



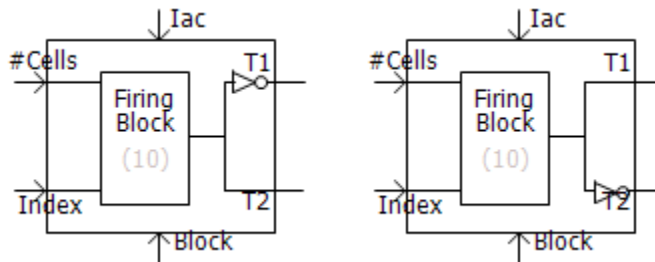
- **Half-Bridge Cell:** This component models a multi-valve, half-bridge MMC with Thévenin equivalent circuits, which effectively increases the computational efficiency.



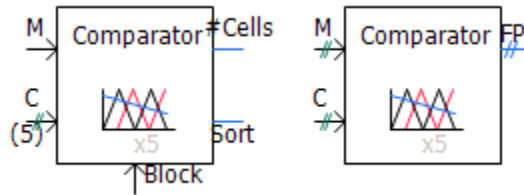
- Firing Signal Generator for MMC Full-Bridge:** This component generates firing signals to full-bridge cells based on the capacitor voltage balancing algorithm.



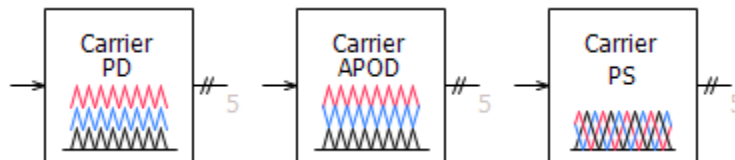
- Firing Signal Generator for MMC Half-Bridge:** This component generates firing signals for half-bridge cells, based on the capacitor voltage balancing algorithm.



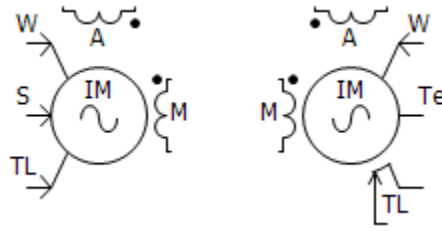
- Multi-Dimensional Comparator:** This component compares modulating waves against carrier waves generated by Carrier Signal Generator, and outputs control signals to MMC cells.



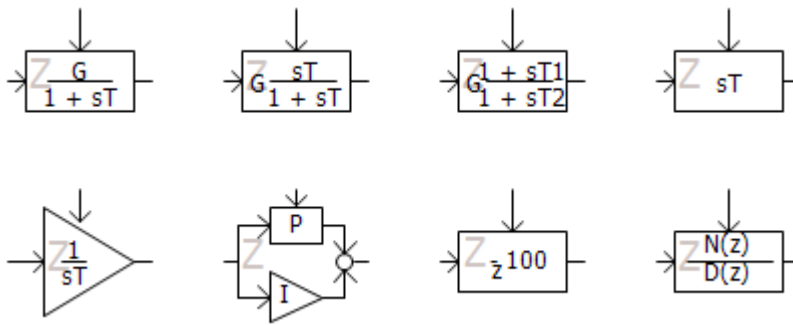
- Carrier Signal Generator:** This component generates a vector of PWM carrier signals for a specified fundamental frequency.



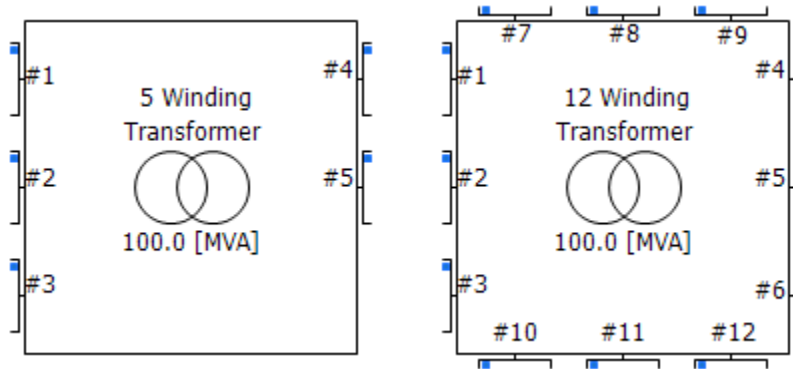
- Single-Phase Induction Machine:** This component models a single-phase induction motor.



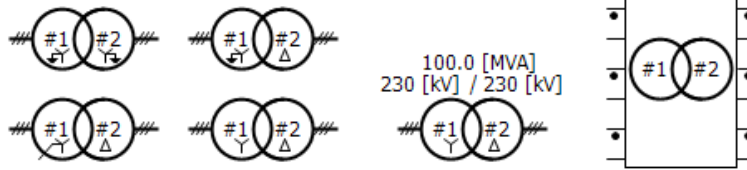
- Z-Domain (Discretized) Controls (#259):** A library of eight, commonly used controls components have are included in the master library. These include: Delay, Derivative, Differential Pole, Integrator, Lead-Lag Pole, Transfer Function, PI Controller and Real Pole.



- 1-Phase, Multi-Winding (5-12), Transformer:** This component models a single-phase, ideal transformer that can be configured to model from five to 12 windings. Options are provided to enable a simple saturation model on a user selected winding, as well as for adding a tap changer.



- 3/5-Limb, Duality-Based Transformer:** This component represents a mode of a 3-phase, 2-winding transformer, based on the principle of duality. It can be used to model a multi-limb transformer or a bank of single-phase transformers. Several methods of entering transformer core, nonlinearity parameters are available. Optional stray capacitances are also available.



- 6. **Hysteresis Reactor:** This component models a hysteresis reactor. It can be connected to a single-phase or 3-phase node.

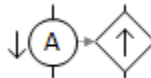


- 7. **3-Phase Current Source:** This component models a 3-phase, positive-sequence, ideal AC current source.

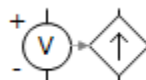


- 8. **Dependent Sources:** PSCAD V5 includes a collection of dependent source component models.

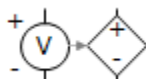
- **Current Dependent Current Source:** This component models a single phase or three-phase scalable current dependent current source.



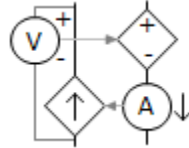
- **Voltage Dependent Current Source:** This component models a single phase or three-phase scalable voltage dependent current source.



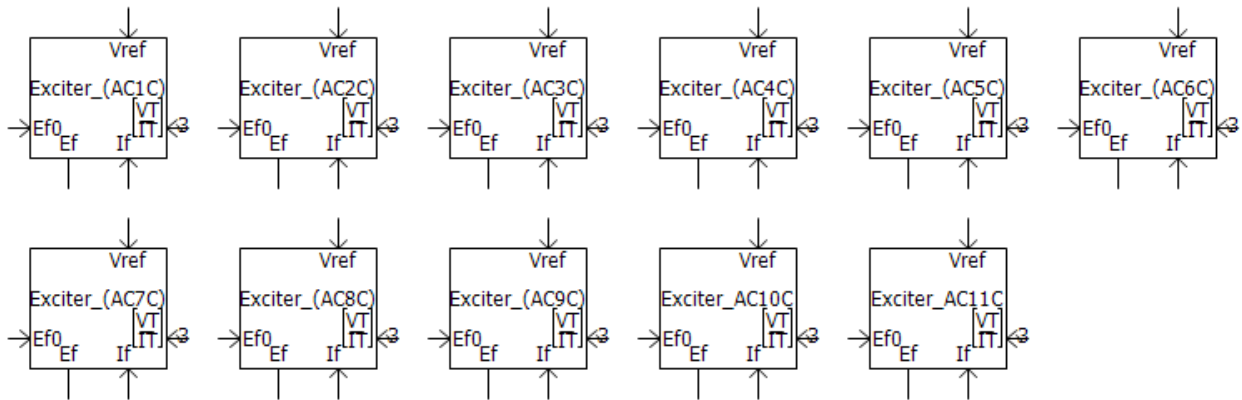
- **Voltage Dependent Voltage Source:** This component models a single phase or three-phase scalable voltage dependent voltage source.



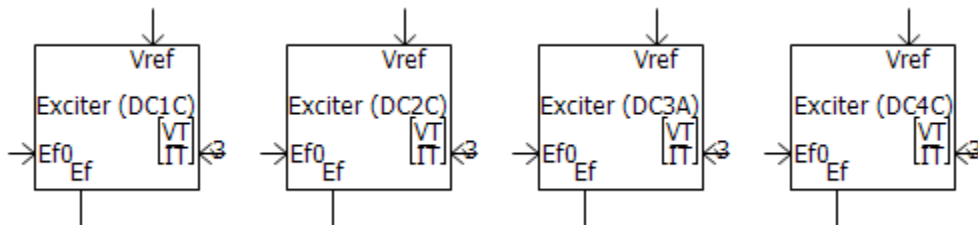
- **Ideal Ratio Changer:** This component models a single phase or three-phase scalable ideal ratio changer (i.e. a combination of voltage dependent voltage source and a current dependent current source).



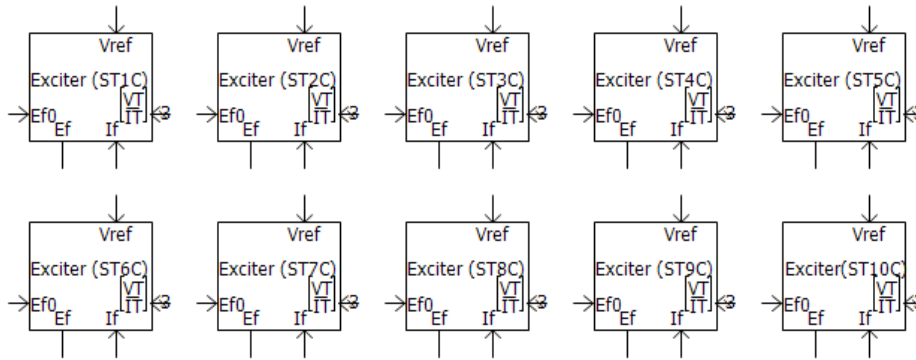
9. **IEEE Standard 421.5-2016 AC Exciters:** The collection of AC Exciters in the master library have been updated from the previous 1992, to the revised 2016 IEEE standard. Includes AC1C, AC2C, AC3C, AC4C, AC5C, AC6C, AC7C, AC8C, AC9C, AC10C and AC11C models.



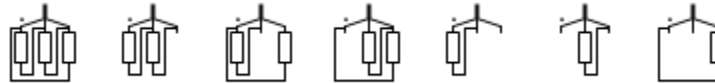
10. **IEEE Standard 421.5-2016 DC Exciters:** The collection of DC Exciters in the master library have been updated from the previous 1992, to the revised 2016 IEEE standard. Includes DC1C, DC2C, DC3A and DC4C models.



11. **IEEE Standard 421.5-2016 Static Exciters:** The collection of Static Exciters in the master library have been updated from the previous 1992, to the revised 2016 IEEE standard. Includes ST1C, ST2C, ST3C, ST4C, ST5C, ST6C, ST7C, ST8C, ST9C and ST10C models.



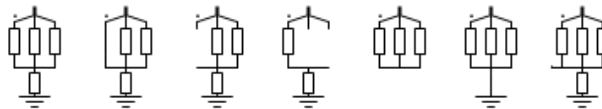
12. **Individually Configurable, Delta-Connected Load:** This component models a delta-connected load. Each branch can be individually selected to be any series combination of R, L and C elements, or as an open branch.



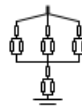
13. **Individually Configurable, Delta-Connected, 3-Branch Load:** This component models a delta-connected load. Each leg is a combination of two, parallel branches in series with another branch. Each branch can be individually selected to be any series combination of R, L and C elements, or as an open or shorted branch.



14. **Individually Configurable, Y-Connected Load:** This component models a Y-connected load. Each branch can be individually selected to be any series combination of R, L and C elements, or as an open or shorted branch.



15. **Individually Configurable, Y-Connected, 3-Branch Load:** This component models a Y-connected load with a neutral connection. Each leg is a combination of two, parallel branches in series with another branch. Each branch can be individually selected to be any series combination of R, L and C elements, or as an open or shorted branch.



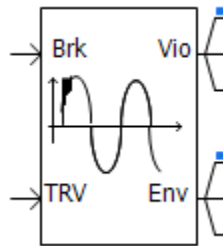
- 16. **Per-Unit Impedance Branch:** This component models a 3-phase passive branch of R, L and C elements. Parameters are entered as per-unit impedances, based on specified base values.



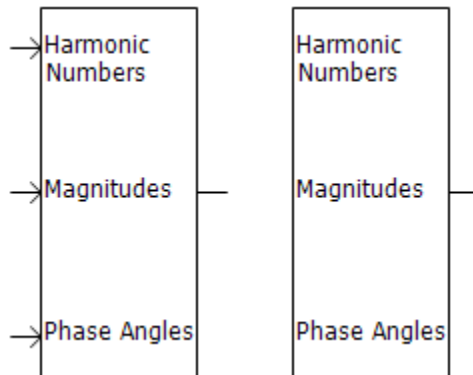
- 17. **Isolation Switch:** This component models an isolation switch for electric circuits. The status of the switch can not be changed during the run. The switch is modelled as an infinite or zero impedance branch.



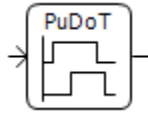
- 18. **TRV Envelope Generator:** This component generates standardized Transient Recovery Voltage (TRV) curves and outputs violations when the input voltage exceeds the envelope. This is a simplified approach to determining whether a breaker will restrike after a current interruption.



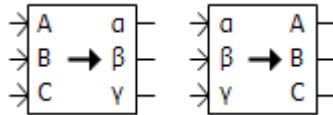
- 19. **Harmonic Signal Generator:** This component generates a signal composed of user-defined harmonics of varying magnitudes and phases. Harmonic numbers and associated peak magnitudes and phases can be input through ports as an array signal. Alternatively, the user can specify them from a file.



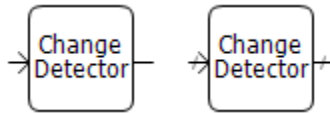
20. **Pick-Up, Drop-Out Timer:** This component models a pick-up, drop-out timer.



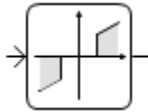
21. **Clark/Inverse Clark Transform:** This component performs Clarke or Inverse Clarke transformation.



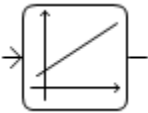
22. **Change Detector:** This component detects changes in the input. The output is 1 if a change is detected, otherwise it is 0.



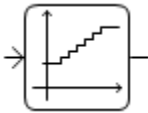
23. **Dead-Band Controller:** This component models a dead-band controller.



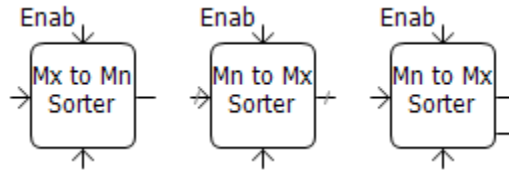
24. **Scale Changer:** This component does a linear transformation of the input signal in $y = mx + c$ form.



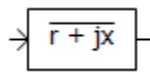
25. **Discretizer:** This component discretizes the input signal, from a specified range to a different discretized range.



26. **Sort Indexer:** This component examines an input data array and outputs the sorted indices of the array in ascending or descending order.



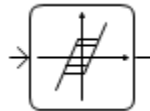
27. **Complex Conjugate:** This component outputs a complex conjugate signal, based on the input, complex signal.



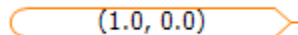
28. **Electrical Phase Tap:** This component may be used to tap off a single phase, from a multi-phase electrical wire.



29. **Backlash:** This component models a backlash controller.



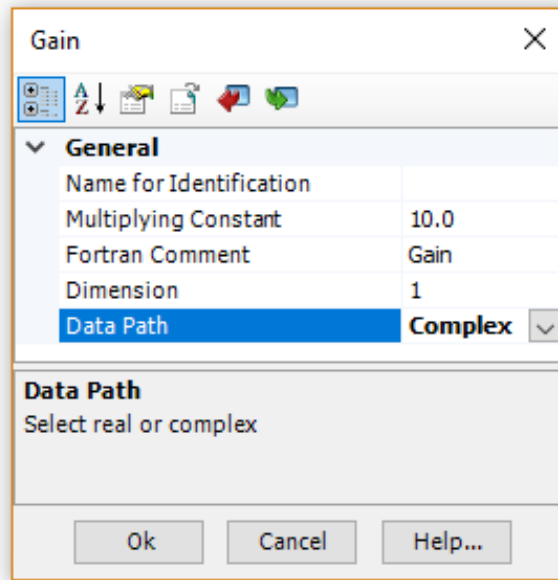
30. **Complex Constant:** This component is used to create a constant, COMPLEX data signal.



General Model Enhancements

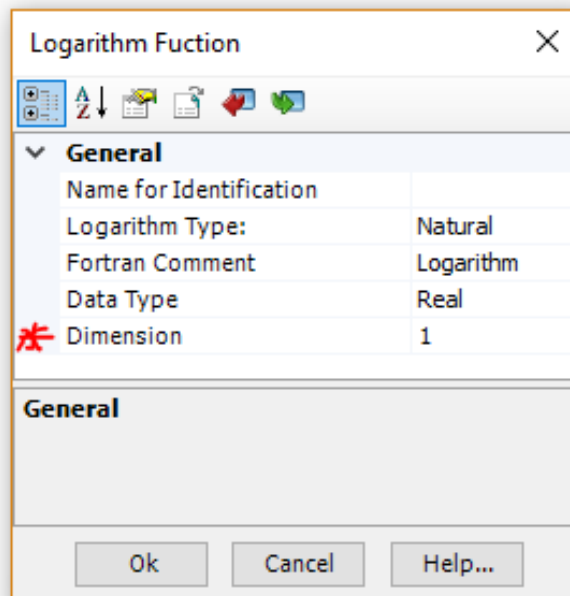
1. Complex Signal Support (#5792)

Most of the standard controls components (CSMF) have been updated to support the new complex signal type in PSCAD V5.



2. Array Signal Support (#4022)

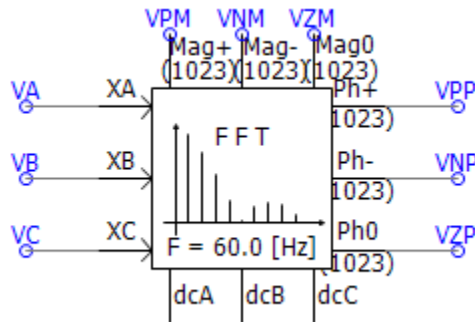
Most of the standard controls components (CSMF) have been updated to support array signal (vector) input and output. All components are by default scalar. To utilize array signal functionality, simply modify the component dimension parameter.



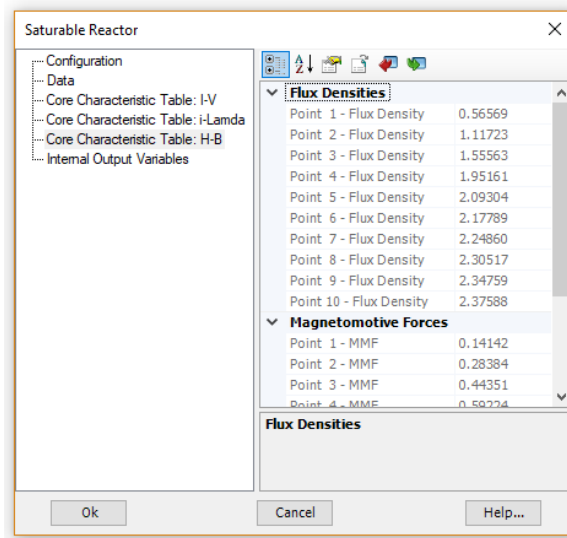
3. **Multiple Run Additional Recording Statistical Summary:** The ability to add a statistical summary to the output file has been added to the Multiple Run Additional Recording component.



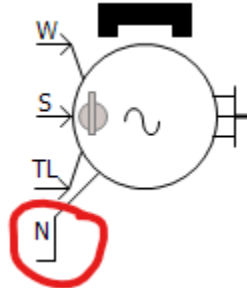
4. **FFT Enhancements:** The Fast Fourier transform component now provides support for output signals up 1023 harmonics. A new input parameter has been added to allow enable/disable control of frequency tracking using a signal variable.



5. **B-H Core Characteristic for Saturable Reactor (#3418):** The Saturable reactor core characteristic can now be represented as a B-H curve, where data is entered Flux Density (T) vs. MMF (A/m).



6. **Permanent Magnet Machine Neutral Connection:** The Permanent Magnet (PM) machine component has been provided with an external connection to the neutral point of the stator windings.



7. **Mutually Coupled Three Wires – Zero Impedance (#8233):** The Mutually Coupled, Three Wires component has been updated to provide the ability to model a zero-impedance transmission line. This is helpful when importing models from powerflow software.

Bug Fixes

1. The saturable reactor now removes the 1st point, rather than the 2nd point, when it encounters to successive, identical slopes in the piecewise linear saturation curve (#6885).
2. The conductor dc resistance input parameter in the transmission line towers has been changed to clearly state what values are expected (#6862).
3. A bug in the logarithm function script, which resulted malformed FORTRAN, has been fixed (#7048).
4. An RLC input data option has been added to the π -section component (#6970).
5. Differential, lead-lag and real pole components now accept negative gain input, with limits enabled (#7026).
6. Real pole component min/max limits are no longer used in the code, even when the limits are disabled (#7143).
7. In the photovoltaic (PV) source, a numerical overflow situation is now avoided by limiting the voltage when taking the exponential.
8. DC Machine: A potential situation to modify input parameters was avoided by copying the parameters to a different variable.
9. **An accurate amount of reactive power is now drawn, when hysteresis (both basic and JA) is enabled on a 4-winding transformer, during an open circuit test. Previously a glitch in the component parameters set the number of winding to 3 instead of 4 (#7625).**
10. The DC2A exciter component now properly enables the under excitation limit (UEL) input parameter when configured as such (#7626).

11. In a volley launch situation, the seed for random number generation is now unique (#7029).
12. Transformer tap changer was not working correctly in some specific situations (#7092).
13. Output of yoke flux in single-phase 3/4 winding transformer is no longer always zero (#7119).
14. Phase angle of FFT no longer oscillates between -90 and 270 instead of -180 and 180 when configured for Sequence/Sine/Degrees (#7238).
15. Basic hysteresis model was not working correctly with some compilers when the transformer is energized later than time = 0 (#7274).
16. The harmonic interface solution no longer gives incorrect values in open-circuit situations involving non-resistor/inductor or capacitor branches (#7237).
17. In a classical 3-Phase 2-Winding transformer model, when a delta winding is present and *Lead* is selected, internal outputs of fluxes and magnetizing currents are no longer out of phase (#7581).
18. The yoke flux output in 3/4 winding UMEC single-phase transformer, is no longer output as 0.0 (#7119).
19. The GFortran compiler flags have been revised for optimum run speed (#7452).
20. The calculated copper losses in the 2-winding auto-transformer have been corrected (#7987).
21. The modulator master library component now uses proper storage syntax (STOR change to REAL) (#8077).
22. Fixed errors in ST5B and ST7B exciter models (#8158).
23. The COMTRADE recorder now properly captures the trigger time (#8124).
24. Fixed a minor definition script formatting error in Inverse Time Over Current [51] Element component (#8187).
25. Arrestor: Fixed a problem with storage allocation being insufficient when used with an external data file (#8255).

LCP

Enhancements:

1. Passivity enforcement of transmission lines and cables, based on constrained optimization via spectral residue perturbation of propagation function, has been implemented.
2. It is now possible to model overhead towers and cables (aerial or underground) in the same cable model, with mutual coupling between them.
3. Extended earth return formula for aerial cables (calculates via efficient quadratic integration algorithm – Ametani/Liu). The aim is improved accuracy for GIS studies (frequencies up to 10 or 100 MHz, whereas the older formula is accurate up to only 1 MHz). More importantly this improves numerical stability of short, aerial GIS pipes. This algorithm calculates frequency-dependent ground impedance, as well as ground admittance.
4. Extended earth return formula for underground cables (Ametani). This improves the accuracy and stability of short cables. This algorithm calculates frequency-dependent ground impedance, as well as ground admittance.
5. Accurate cable insulation loss representation, using loss factor for cables (including pipe-type cables), where the loss is modeled as a property of the insulation material. The cable shunt conductance is now obsolete (shunt conductance is also not valid in pipe-type cables, due to the shape of the inner insulation). In earlier versions, there was an ill-condition in calculating parameters at very low frequencies in the absence of insulation resistance. Hence, the DC Correction algorithm could not be applied to pipe-type cables.
6. Cable algorithm now can handle large cable systems of more than 12 cables in parallel.

Bug Fixes

1. Fixed a problem with DC Correction when the first entry of fitted propagation function is a complex pole.
2. Fixed a problem in the pipe-type cable when calculating the pipe mutual impedance. A coding error in evaluating equations containing Bessel functions is fixed.

LICENSING

Enhancements:

1. PSCAD X4 uses machine-based certificate licensing, in which the acquired certificate is saved to a public certificate folder and is accessible to all logged in users. PSCAD V5 uses user-based certificate licensing, in which each user requires their own certificate and it is saved to their private certificate user folder. Additionally, when PSCAD V5 acquires a certificate, it will also copy that certificate to the public certificate folder so it can be seen and used by PSCAD x4. When PSCAD V5 returns a certificate, it will delete it from its private certificate user folder, and also from the public certificate user folder.
2. A new *Allow certificates to be used by PSCAD x4* setting is added to the *Licensing Options | Startup Behaviour* section. This allows the user to *Enable* PSCAD V5 to copy its private user certificate to the public certificate folder, so it can be used by PSCAD X4. If PSCAD X4 will not be used on the same machine as PSCAD V5, then this feature can be *Disabled*.
3. If PSCAD is unable to display the available certificates, it will now display why it is unable to.
4. Before PSCAD requests a license certificate, it will first check if it can encrypt and save that certificate.
5. A new *Release All* function will release the currently loaded V5 certificate, and if that is successful, it will release all private V5 certificates, and all public x4 certificates owned by the current PSCAD user if logged into their MyCentre account.
6. Improved detection and reporting of licensing issues.
7. Certificate licensing logging now logged to the PscadCerts.txt file.
8. The *Certificate Details* dialog now shows the license expiry date, if it has one, and the certificate check out expiry date.