# Quick Start for User Defined Models

Last Updated: June 11, 2013



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#### **Overview**

The purpose of this document is to provide a step-by-step guide to using the User Defined Models tab, which is located in the Options menu of the Transient Stability Add On in PowerWorld Simulator. The user defined model feature has been made available from version 17 onward. This tutorial aims to provide the basic steps for navigating the tabs of interest, loading, inserting, and using user defined models for transient analysis. Section 0 is geared towards basic users, and section 3 will provide a brief note for advanced developers.

### 1. Before you begin...

Download the sample files and projects from the PowerWorld website. The content is shown below.



The BasicUser folder contains four folders. The folders CppDLLs, FtnDLLs and ObjPsIDLLs have identical DLLs of the GENCLS machine, IEEEST stabilizer, IEEET1 exciter and TGOV1 governor. In addition, the TestCases folder contains a case for illustrating the use of these DLLs.

Corresponding to the DLLs from the BasicUser folder, the AdvancedDeveloper folder contains various subfolders containing the source code for generating the respective DLLs. The project structure of Cpp\_IEEET1UDM is shown on the right-side of this page.



## 2. Basic Users

It is likely that a basic user will receive a set of DLL files, each with one transient model of interest. (The development of these DLLs is left to the advanced developer.) This section will outline the steps in PowerWorld Simulator for loading, inserting and using user defined models.

1. Start PowerWorld Simulator, and navigate to File > Open Case...

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Fi	le			
¥ D	<u>N</u> ew Case		Recent Cases	Case Des
<b>P</b>	Open Case		1 WSCC_9_withNoDLLs	Case Sum
P	<u>S</u> ave Case	Open Simulatio	n Case (Ctrl+O) loDLLs	pr Custom C
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52	Save Oneline			al Power Flo ty Constraine
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2. Navigate to BasicUser > TestCases folder. Select the WSCC\_9\_withNoDLLs.pwb file, and click Open.

Open 🜔						E X
<b>@ -</b>	📙 🕨 BasicUser 🔸	TestCases	<b>-</b> ↓	Search		۶
🌗 Organize	▼ ■ Views ▼	🔡 📑 New Fold	der			?
Name	Date modified	Туре	Size			
WS0 PWI 21.4	CC_9_withNoDLLs.p B File KB	bwb				
	File <u>n</u> ame: W	SCC_9_withNoD	LLs.pwb	- Pov	verWorld Bina	y (*.pwb) 🔹
					Dpen ∣▼	Cancel

3. Once the case loads, navigate to the Case Information tab. In Model Explorer, navigate to the Transient Stability > Summary > Generator model use option in the left-side menu.



In the Generator Model Summary tab the machine, exciter, governor and stabilizer models in use are displayed. These models are built-in models supported by PowerWorld Simulator. In the subsequent steps, user defined models will be inserted to replace these models.

4. Ensure that Simulator is in Run Mode. Navigate to the Transient Stability in the Add Ons tab. In the left-side menu, click on Options > User Defined Models. This is currently empty because no user defined models have been selected/inserted.

🔘 🎬 - 🝠 🕼 👯 🖪 🎬	👔 🗐 🔞 💱 🗸 🔻 Transient Stability Analysis - Case: WSCC <u>9.</u> withNoDLLs.pwb Status: Initialized   Simulator 18 Beta	A
File Case Information	Draw Onelines Tools Options Add Ons Window	^ () = d ×
Edit Mode Script + S Mode Log S	Primal LP     Image: CopF.     OPF Case     QPF Options     Refine Model       PV     QV     Refine Model     ATC.     Transient     Stability.       Optimal Power Flow (OPF)     PV and QV Curves (PVQV)     ATC     Transient Stability.     Scheduled	
Simulation Status Not Initialized		
Run Transient Stability Pause Select Step	e Abort Restore Reference For Contingency: UDM_COMBINED_DEMO	
<ul> <li>Simulation</li> <li>Options</li> </ul>	Note: Changes made to option entries are saved immediately and will be applied during the next transient stability run.	
General     Power System Model     Result Options     Generic Limit Monitors     User Defined Models     Distributed Computing     Poresult Storage	Contract a rower system model result captors Letteric unit informations des de inter modes Lastratutes computing     Contract store of paths for finding User Defined Model DLs     Click on button below to define a browsing path     Place Liser Defined Model DLs in     these directories where they will be     automatically detected	
▷ · Plots ▷ · Results from RAM		
<ul> <li>Transient Limit Monitors</li> <li>States/Marual Control</li> <li>Validation</li> <li>Validation</li> <li>SMIB Eigenvalues</li> </ul>	User Defined Models User DefinedBoxerr User Define	

5. Click on the Edit Browsing Path button.

6. In the window below, click Browse.

Edit Browsing Path	
Ordered list of paths for finding User Defined Mod	del DLLs
	·
	Browse
Replace Add Delete	Delete Invalid Paths
	V OK Cancel

7. Then, browse for the BasicUser > CppDLLs folder. Click OK.

Browse For Folder	X
Browse for a folder	
> 🖟 AdvancedDeveloper	•
a 🌗 BasicUser	
CppDLLs	
J FtnDLLs	≡
🌗 ObjPsIDLLs	
TestCases	-
Eolder: CppDLLs	
Make New Folder OK Can	iel

8. Click Add. The path name should appear in the list. Then, click OK.

Edit Browsing Path	
Ordered list of paths for finding User Defined Mode	DLLs
C: \Users \saurav \Desktop \BasicUser \CppDLLs	
C: \Users\saurav\Desktop\BasicUser\CppDLLs	Browse
Replace Add Delete	Delete Invalid Paths
	V OK X Cancel

 Simulator scans the folder in the browsing path(s), and automatically loads and validates the DLLs. They are also categorized based on their model types. In this case, four DLLs are shown to have been loaded.



10. Click on Cpp\_IEEET1DM, and the following description should appear in the lower pane of this tab. This shows the DLL Functions' Names, Extra Objects Types, Default Parameter Values, States Description, Hard-Coded Signals Variable and Algebraic Variable Description. There should be no error message shown, and the dll should be ready for use. At this point, the user defined model is recognized by Simulator can be handled just like any built-in model.

Model Type UserDefinedExciter Model Name Cpp_IEEET1UDM	
DLL FunctionsExtra ObjectsParametersStatesHard-Coded SignalsAlgNamesType (Description)Name [Default]DescriptionVariable [Description]VaImplemented Functions0: Tr [0]0: EField0: Vref (Voltage Reference)VamodelClassName1: Ka [50]1: Sensed Vt1: Initial EfieldDLLVersion2: Ta [0.04]2: VR2: Field CurrentparameterName3: Vrmax [1]3: VF3: Voltage CompensatedstateName4: Vrmin [-1]5: Ke [0.06]5: Voltage Generator Speed Deviation (pu)allParamCounts5: Ke [0.06]5: Voltage Generator TerminalgetDefaultParameterValue6: Te [0.06]6: Stabilizer Input (Vs)SubIntervalPower2Exponent7: Kf [0.09]7: Flag for active OEL (1 if active)initializeYourself9: Switch [0]9: Flag for active UEL (1 if active)getNonWindUpLimits9: Switch [0]9: Flag for active UEL (1 if active)calculateFofX10: E1 [2.8]10: Under Excitation Limiter SignalPropagateIgnoredStateAndInput13: SE(E2) [0.03]14: Spdmlt [0]OtherObjectClass14: Spdmlt [0]14: Spdmlt [0]	Algebraics Variable [Description]

DLL Location C:\Users\saurav\Desktop\BasicUser\CppDLLs\Cpp\_IEEET1UDM.dll

11. Ensure you have clicked on the Cpp\_IEEET1DM, and then right click anywhere in the top-right pane, or on the word "None". Then, select Insert.

User Defined Models	All					
	N	lumber of	Bus I	D Model Na	me Name_Nominal kV of Bus	Name o
Gpp_IEEET1UDN     Govern     Govern		Ν	lone [	De		
Cpp_TGOV1UDN						
UserDefinedLoadMo			14 14 17 14	Show Dialo	)g	
Cpp_GENCLSUD				Display/Co	lumn Options	
UserDefinedMTDCC:	•		酋	Find	Ctrl+F	
4 🧾 UserDefinedStabilize	DULLocatio		ABCD	Search for	Text	TEE
Cpp_IEEESTUDN	Madel Too			Insert		
		e UserD		Delete		LIFE
	Names	ions		Geographi	c Data View	In the second secon

12. The Generator Information dialog box should be shown. Here, the built-in IEEET1 exciter model at Bus 1 will be replaced by an Cpp\_IEEET1UDM user defined exciter model. Click Insert.

C Generator	Information for Current Case							
Bus Number	1 Find By Number Stat	tus Open						
Bus Name	Bus1   Find By Name	Closed						
ID	1 Find Ene							
Area Name	1(1)	(ES (Online)						
Labels	no labels Fuel T	Type Unknown 🗸						
	Generator MVA Base 500.00 Unit T	ype UN (Unknown)						
Power and Vol	tage Control Costs OPF Faults Owners, Area, etc	Custom Stability						
Machine Mode	els Exciters Governors Stabilizers Other Models Ste	p-up Transformer Terminal and State						
Inse	rt Delete Gen MVA Base 500.0	Show Block Diagram Create VCurve						
Type Active	- IEEET 1    Active (only one may be active)	Set to Defaults						
Parameters								
PU values sl	hown/entered using device base of 500.0 MVA 🔹							
Tr	0.0000 Te 0.6000 E2 3.7	7300						
Ка	50.0000 🚔 Kf 0.0900 🚔 SE(E2) 0.3	3300						
Та	0.0400 Tf 1.4600 Spdmlt 0.0	0000						
Vrmax	1.0000 💌 Switch 0.0000 💌							
Vrmin	-1.0000 💌 E1 2.8000 💌							
Ке	-0.0600 💌 SE(E1) 0.0400 💌							
✓ OK Save X Cancel ? Help Print								

13. Here, select Cpp\_IEEET1UDM. Click OK.

Model Type	23
Select Model from the Below List	
- AC7B - AC8B - BBSEX1 - Cpp_IEEET1UDM - DC3A - DC4B - EMAC1T - ESAC1A - ESAC2A - ESAC2A - ESAC3A	< III
ESAC5A	-
Show Models Supported By          PW Only       PTI         BPA       GE         Limit Models by Machine Model	
V OK X Cance	

14. Now the Cpp\_IEEET1UDM user defined exciter model has been inserted at Bus 1, and is ready for use. The default parameter values have been loaded from the DLL, which can be altered if needed. For now, leave the values as the defaults, click Save, and then OK.

Machine Mod	els Exciters	Governors	Stabilizers	Other Models	Step-up Transformer	Terminal and State			
Inse	Insert Delete Gen MVA Base 500.0 Show Block Diagram Create VCurve								
Type Active	Type Active - Cpp_IEEET1UDM								
Parameters									
PU values s	hown/entered	l using device	base of 500	.0 MVA 🔻					
Tr	0.0000 🌲	Те	0.0600	E2	3.7300				
Ка	50.0000 🚔	Kf	0.0900 🚔	SE(E2)	0.3300 🚔				
Та	0.0400	Τf	1.4600 🚔	Spdmlt	0.0000				
Vrmax	1.0000 💂	Switch	0.0000						
Vrmin	-1.0000	E1	2.8000						
Ke	0.0600 🊔	SE(E1)	0.0400						
🗸 ок	✓ OK Save X Cancel ? Help Print								

15. The model is now ready for use. This test case already contains a Transient Contingency named UDM\_COMBINED\_DEMO, which contains a fault at Bus 7. To execute the simulation, click on the Run Transient Stability button.

## 3. Advanced Developers

For developers planning to create DLLs for new models, debugging will need to be done from the IDE in which the DLL is being built. Similar to instructions in Section 2, developers can point directly to a sub-folder within a DLL project folder. This will eliminate the need to copy-paste the DLL file to a different location, and will help with a smoother debugging experience.

The following are the folders of interest in the following programming languages (IDEs)

1. Object Pascal (Embarcadero® Delphi® XE Version 15.0)

~Debug\Win32

2. Visual C++ (Microsoft<sup>®</sup> Visual Studio 2010)

~\Debug

3. Fortran (Microsoft<sup>®</sup> Visual Studio 2010 with Silverfrost FTN95 plug-in)

~Debug\Win32

For debugging, the pwrworld.exe process can be attached to the debugger being used. This can also be done by specifying the location of the pwrworld.exe file (from the installation directory of PowerWorld Simulator, version 17 or later) as the launch target during the debugging process.

Note: While re-building DLLs during the debugging process, ensure that the attached PowerWorld Simulator is closed