

Transient Stability Development Overview



Tom Overbye
PowerWorld Corporation Client Conference
Champaign, IL
March 26-27, 2009



PowerWorld
Corporation

Presentation Overview



- Purpose of presentation is to explain the present state of development for the PowerWorld Transient Stability Application
- Also to receive feedback about desired functionality

Presentation Summary



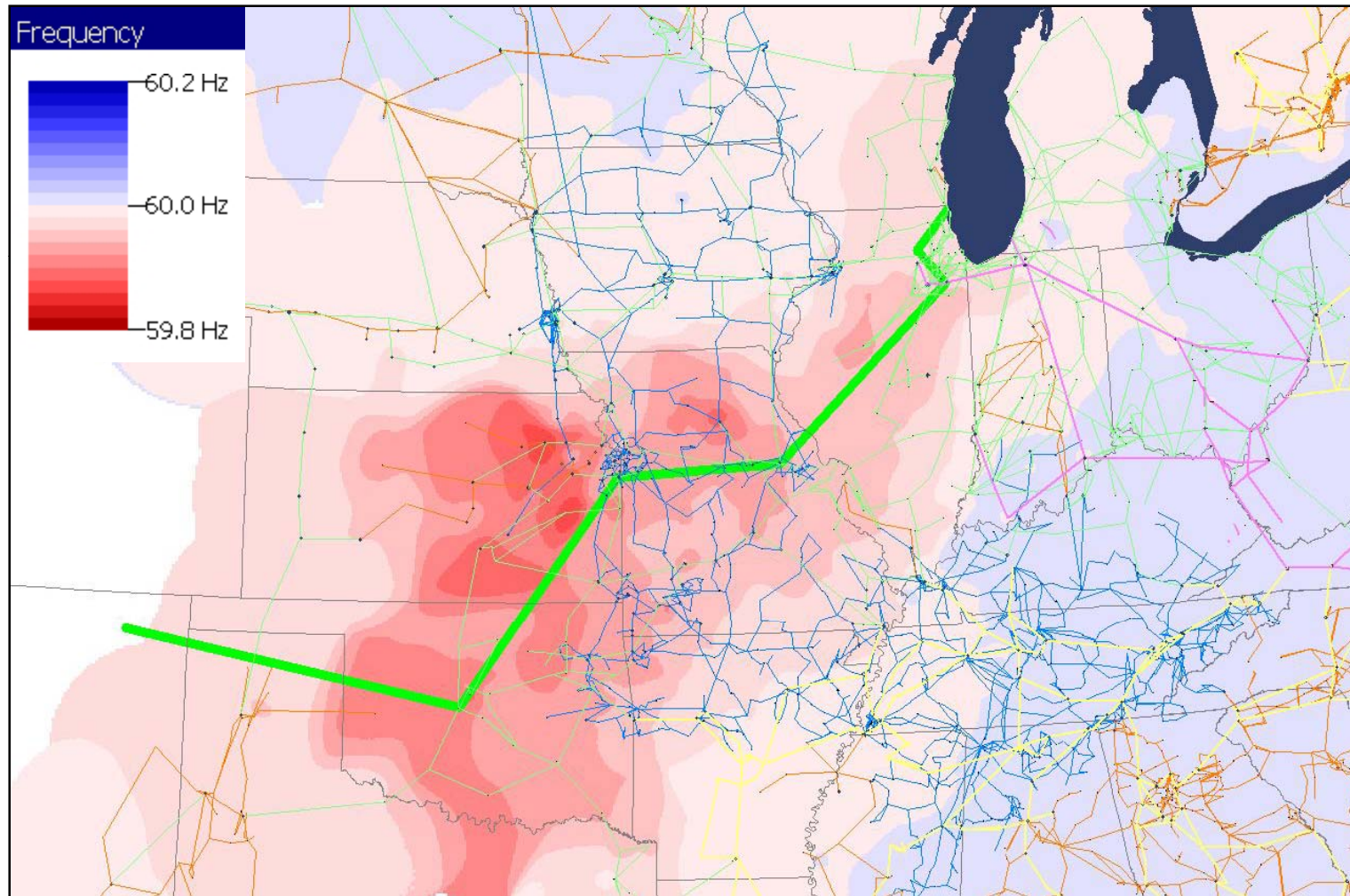
- Since the last conference we have made significant progress and can now run the Eastern and WECC systems with almost all the models included
 - PowerWorld probably now supports more models than any other vendor
- We have almost made great progress on the presentations of the results, primarily graphs

Presentation Summary, cont.



- We still need to add user defined models, get better models for the HVDC lines, and then fill in the remaining modeling gaps
- We'll will continue to work on the user interface, particularly on the ability to do batch runs
- A simple single machine, infinite bus eigenvalue analysis tool is also under development

Eastern Interconnect Frequency Propagation Animation Example



Using PowerWorld Transient Stability (TS)



- There are three key aspects to using PowerWorld for transient stability analysis
 - Defining the models
 - Solving the simulation
 - Interpreting the results
- Models can be read and stored in using four different formats (*.dyr, *.dyd, *.swi, *.aux)
- Models are defined using new Case Info Displays and Dialogs

Transient Stability Analysis Form



- Simulation is solved and results analyzed using the Transient Stability Analysis Form

Simulation Control

Simulation Time Values

Start Time (seconds) 0.000

End Time (seconds) 10.000

Time Step (seconds) 0.020000

Specify Time Step in

Seconds

Cycles

Transient Stability Events List

The below list shows the transient stability faults and other events.

Insert Event Clear All Events

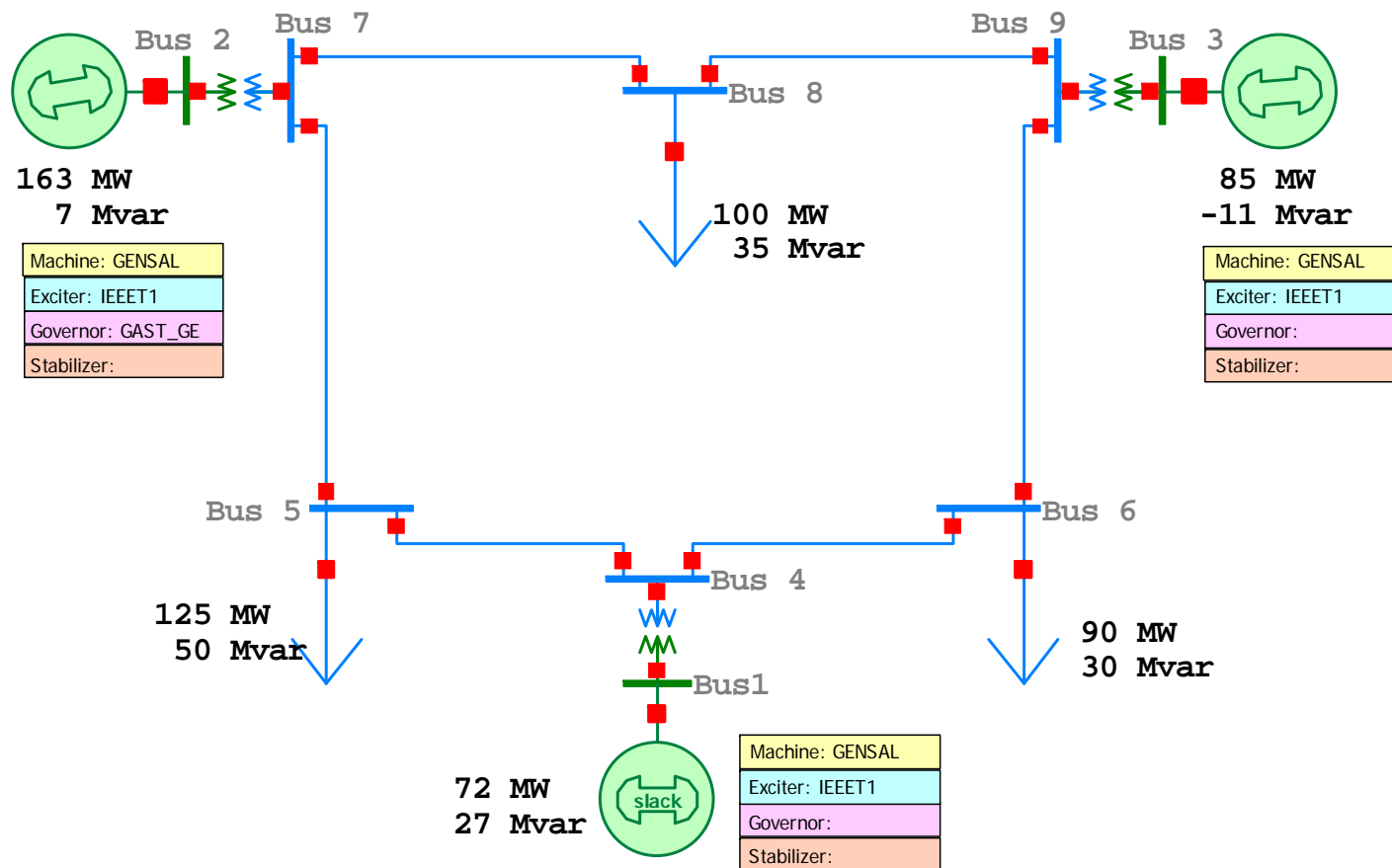
	Time (Seconds)	Enabled	Object	Event Description
1	1.0000	YES	Bus '5'	FAULT 3PB SOLID
2	1.1000	YES	Bus '5'	CLEARFAULT

Save To Auxiliary Load From Auxiliary Close

Transient Stability Examples



- Open TS9Bus Load Drop.pwb



What models are in TS9Bus?



- Each generator has a GENSAL machine model (Salient Pole)
- Each generator has an IEEE1 exciter model (1968 IEEE type 1)
- For this example, only the generator at bus 2 has a governor specified
- No stabilizers are specified.

View Stability Models



- Machine, Exciter, Governor, and Stabilizer models can all be added to Generators
 - Right-Click on a Generator
 - Choose Generator Information Dialog
 - Go to the Stability Tab

Generator Options

Bus Number: 2
Bus Name: Bus 2
ID: 1
Area Name: 1
Labels: no labels
Fuel Type: Unknown
Unit Type: UN (Unknown)

Display Information | Power and Voltage Control | Costs | Fault Parameters | Owner, Area, Zone, Sub | Custom | **Stability**

Machine Models | Exciters | Governors | **Stabilizers** | Other Models | Step-up Transformer | Terminal and State

Insert | Delete | Gen MVA Base: 100.0
Type: Active - GENSAI

Parameters
PU values shown/entered using device base of 100.0 MVA

H	6.4000	Xdpp=Xqpp	0.1198	S(1.2)	0.0000
D	1.2800	Xl	0.0599	RComp	0.0000
Ra	0.0000	Tdop	6.0000	XComp	0.0000
Xd	0.8958	Tdopp	0.5350		
Xq	0.8645	Tqopp	0.5350		
Xdp	0.1198	S(1.0)	0.0000		

OK | Save | Cancel | Help

Integrated Step-up Transformers



- Integrated generator step-up transformers are supported

Generator Information for Current Case

Bus Number: 2
Bus Name: Bus 2
ID: 1
Area Name: 1 (1)
Labels: no labels
Fuel Type: Unknown
Unit Type: UN (Unknown)

Power and Voltage Control | Costs | OPF | Faults | Owners, Area, etc. | Custom | Stability

Machine Models | Exciters | Governors | Stabilizers | Other Models | Step-up Transformer | Terminal and State

Gen MVA Base: 100.0

Machine Impedance
ZR: 0.00000
ZX: 1.00000

Step-up Transformer
Step-up Transformer Resistance: 0.00000
Step-up Transformer Reactance: 0.00000
Step-up Transformer Off-nominal Turns Ratio: 1.00000

PU values shown/entered using device base of 100.0 MVA

Note, the per unit MVA base used for displaying and entering all generator impedance values, including those for the step-up transformers can also be changed on the Options page of the main Transient Stability Form.

OK Save Cancel Help Print

Well-Featured TS Case Information Displays are Available



- Displays are available from Add Ons, Stability Case Info

Fully Supported	Number of Bus	ID	Name	Nominal Name of Bus	Type	MVA Base	Device Status
1	YES	1	1	Bus1_14.50 Bus1	IEEEFT1	100	Active
2	YES	2	1	Bus_2_18.00 Bus 2	IEEEFT1	100	Active
3	YES	3	1	Bus_3_13.00 Bus 3	IEEEFT1	100	Active

Interactive Model Summary Pages are Also Available



- Shown by selecting Stability Case Info, Transient Stability Case Summary, or Stability Case Info, Transient Stability Generator Summary
- Both displays allow easy access to dialogs with more information

Transient Stability Model Summary Form



Transient Stability Model Summary Form - Case: 10a1sap_WithCLOD_S5ecRamp_Dec28.pwb Status: Initialized | Simulator 14

Case Information Draw OneLines Tools Options Add Ons Window

Edit Mode Abort Primal LP SCOPF... OPF Case Info... QPF Options and Results... PV Curves... QV Curves... Refine Model Available Transfer Capability (ATC)... Transient Stability... Stability Case Info... Topology Processing...

Run Mode Log Script Log Optimal Power Flow (OPF) PV and QV Curves (PV/QV) ATC Transient Stability (TS) Topology Processing

Records Set Columns Options

Model Name	Active Model Count	Inactive Model Count	Fully Supported
1 Machine Model: GENSAI	928	36	YES
2 Machine Model: GENSAE	140	0	YES
3 Machine Model: GENROU	1640	54	YES
4 Machine Model: CIMTR4	0	91	NO
5 Machine Model: CSVGNS	7	0	YES
6 Machine Model: CSVGN6	5	0	YES
7 Gen Other Model: IEEEVC	550	5	YES
8 Exciter: SCRX	9	0	YES
9 Exciter: IEEE11	48	0	YES
10 Exciter: IEEE14	82	0	YES
11 Exciter: IEEE11	324	3	YES
12 Exciter: EXAC1	169	1	YES
13 Exciter: EXAC1A	5	0	YES
14 Exciter: EXAC2	55	0	YES
15 Exciter: EXAC4	16	0	YES
16 Exciter: EXELI	2	0	YES
17 Exciter: EXPIC1	3	0	YES
18 Exciter: EXST1	849	26	YES
19 Exciter: EXST2	17	0	YES
20 Exciter: EXST3	21	0	YES
21 Exciter: ESST2A	53	2	YES
22 Exciter: ESST3A	35	0	YES
23 Exciter: ESST4B	279	3	YES
24 Exciter: EXDC2_FT1	110	6	YES
25 Exciter: REXSYS	150	22	YES
26 Exciter: REXSYS1	2	0	YES
27 Exciter: ESAC3A	4	0	YES
28 Exciter: ESAC8B_FT1	94	0	YES
29 Governor: GGOV1	690	11	YES
30 Governor: HYGOV	209	2	YES
31 Governor: PIDGOV	23	0	YES
32 Governor: IEEEG3_FT1	383	5	YES
33 Governor: TGOV1	14	0	YES
34 Governor: WSIEG1	0	297	YES
35 Governor: URG33T	0	65	YES
36 Governor: WSHYDD	0	49	YES
37 Governor: WSHYGP	0	178	YES
38 Stabilizer: IEEE11	118	0	YES
39 Stabilizer: PSS2A	601	9	YES
40 Stabilizer: ST2CUT	191	2	YES

Model Name

Right-clicking Provides Access to All Instances of the Model Type

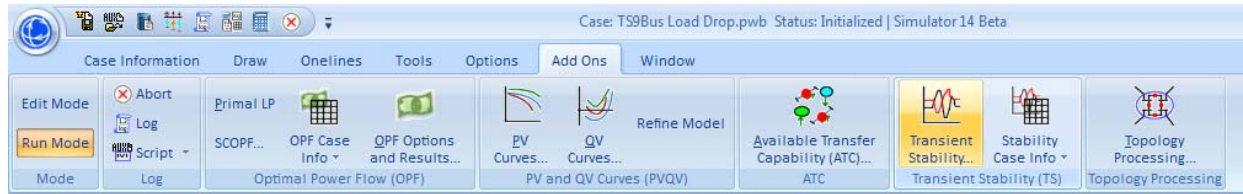


Transient Stability Usage of Model Type IEEET1

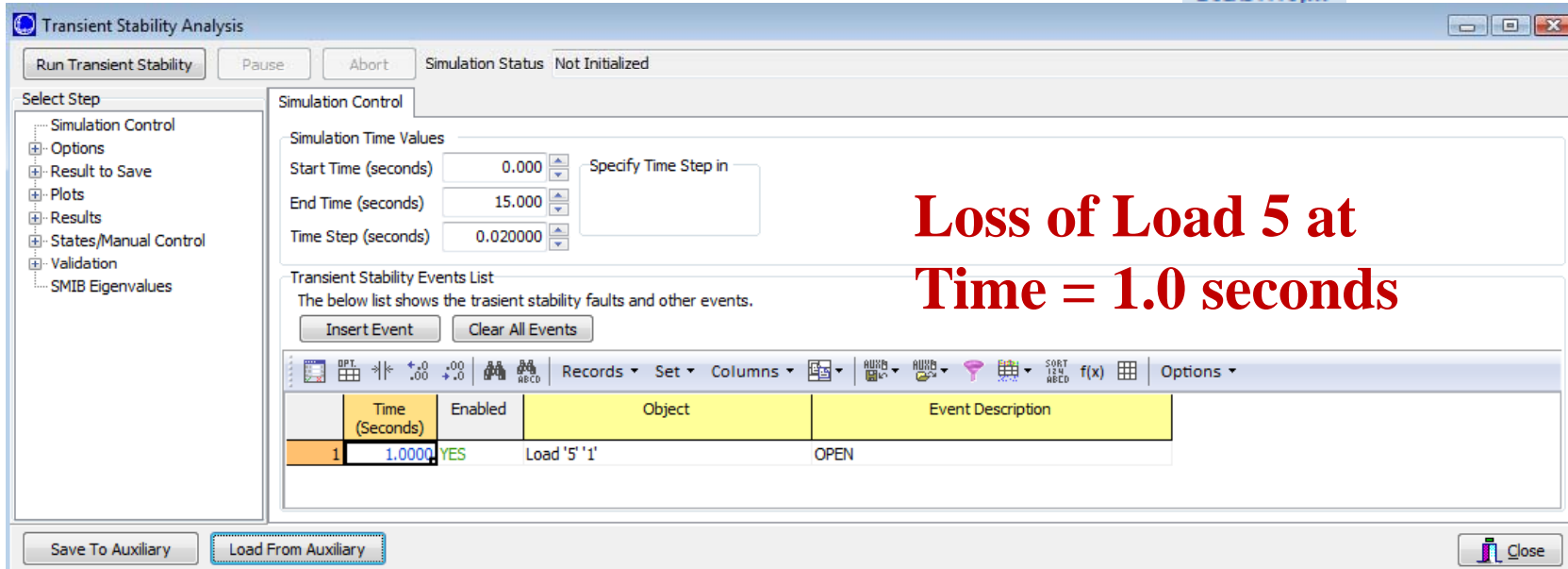
Number of Active Models: 48 Number of Inactive Models: 0

	Number of Bus	ID	Name_Nominal kV of Bus	Name of Bus	Type	MVA Base	Device Status	Tr	Ka	Ta	Vrmax	Vrmin	Ke	Te	KI
1	14921	1	OCOTGT1_13.8	OCOTGT1	IEEET1	62.5	Active	0.0167	400	0.02	7.23	-6.51	1	0.26	
2	14922	1	OCOTGT2_13.8	OCOTGT2	IEEET1	62.5	Active	0.0167	400	0.02	7.23	-6.51	1	0.26	
3	14943	1	SAG_CT2_13.8	SAG_CT2	IEEET1	62.5	Active	0.0167	400	0.02	7.23	-6.51	1	0.26	
4	14944	1	SAG_CT1_13.8	SAG_CT1	IEEET1	62.5	Active	0.0167	400	0.02	7.23	-6.51	1	0.26	
5	14954	1	WPHX GT1_13.8	WPHX GT1	IEEET1	62.5	Active	0.0167	400	0.02	7.23	-6.51	1	0.26	
6	14957	1	WPHX GT2_13.8	WPHX GT2	IEEET1	62.5	Active	0.0167	400	0.02	7.23	-6.51	1	0.26	
7	24950	1	MTNVIST1_15.5	MTNVIST1	IEEET1	153.125	Active	0	10	0.2	1	-1	0	1.2	
8	24951	2	MTNVIST2_15.5	MTNVIST2	IEEET1	153.125	Active	0	11	0.2	1	-1	0	0.5	
9	24714	1	ALTA 1G_13.8	ALTA 1G	IEEET1	76.8	Active	0.06	20	0.2	1	-1	0	0.27	
10	24715	2	ALTA 2G_13.8	ALTA 2G	IEEET1	96	Active	0.06	20	0.2	1	-1	0	0.27	
11	50000	1	CMS G1_13.8	CMS G1	IEEET1	80	Active	0	85	0.05	3.5	-3.5	0	1.825	
12	50001	1	CMS G2_13.8	CMS G2	IEEET1	80	Active	0	167	0.05	3.5	-3.5	0	1.825	
13	50002	1	COM G1_13.20	COM G1	IEEET1	31.58	Active	0	50	0.05	3.2	-3.2	0.24	0.95	
14	50298	1	ASH G1_13.80	ASH G1	IEEET1	28	Active	0	60	0.05	2.5	-2.5	0.3	1.165	
15	50299	1	PUN G1_13.80	PUN G1	IEEET1	30	Active	0	112	0.05	3.2	-3.2	0	0.85	
16	50300	1	LDR G1_13.80	LDR G1	IEEET1	30	Active	0	200	0.05	3	-3	0.9	1.2	
17	50301	1	LDR G2_13.80	LDR G2	IEEET1	30	Active	0	200	0.05	3	-3	0.9	2	
18	50304	1	SCA G1_13.80	SCA G1	IEEET1	37.5	Active	0	20	0.05	3.5	-3.5	0	1.1	
19	50305	1	SCA G2_13.80	SCA G2	IEEET1	37.5	Active	0	100	0.05	3.5	-3.5	0	1.1	
20	50963	1	BR2 G5_13.80	BR2 G5	IEEET1	65.25	Active	0	130	0.04	3.42	-3.42	0	2	
21	50964	1	BR2 G6_13.80	BR2 G6	IEEET1	65.25	Active	0	90	0.04	3.42	-3.42	0	2.6	
22	50965	1	BR2 G7_13.80	BR2 G7	IEEET1	65.25	Active	0	130	0.04	3.42	-3.42	0	2.5	
23	50966	1	BR2 G8_13.80	BR2 G8	IEEET1	65.25	Active	0	130	0.04	3.42	-3.42	0	2	
24	51414	1	FRC G1_13.80	FRC G1	IEEET1	12.66	Active	0.0167	50	0.02	3.5	-3	0	1	
25	54014	1	WESGEN 9_13.8	WESGEN 9	IEEET1	110	Active	0.02	50	0.06	3.5	-3.5	-0.17	0.95	
26	54054	2	DOW GEN2_14.0	DOW GEN2	IEEET1	110	Active	0.0167	50	0.06	3.5	-3.5	-0.17	0.95	
27	54172	1	HORS GEN_12.0	HORS GEN	IEEET1	6	Active	0.0167	50	0.05	3.5	-3.5	-0.17	0.95	
28	54172	2	HORS GEN_12.0	HORS GEN	IEEET1	4	Active	0.0167	50	0.05	3.5	-3.5	-0.17	0.95	
29	54172	3	HORS GEN_12.0	HORS GEN	IEEET1	4	Active	0.0167	50	0.05	3.5	-3.5	-0.17	0.95	
30	54172	4	HORS GEN_12.0	HORS GEN	IEEET1	6	Active	0.0167	50	0.05	3.5	-3.5	-0.17	0.95	
31	54196	1	KANANAS9_12.0	KANANAS9	IEEET1	4.5	Active	0.0167	50	0.05	3.5	-3.5	-0.17	0.95	
32	54196	2	KANANAS9_12.0	KANANAS9	IEEET1	4.5	Active	0.0167	50	0.05	3.5	-3.5	-0.17	0.95	
33	54377	1	INTERLA9_4.16	INTERLA9	IEEET1	6	Active	0	50	0.05	3.5	-3.5	-0.17	0.95	
34	54381	1	THREE S9_6.90	THREE S9	IEEET1	4	Active	0	50	0.05	3.5	-3.5	-0.17	0.95	
35	55037	5	RBWS_14.40	RBWS	IEEET1	60	Active	0.022	350	0.09	10	0	1	1.16	
36	55171	1	VALLEYV1_13.80	VALLEYV1	IEEET1	60	Active	0.022	350	0.09	10	0	1	1.16	
37	56218	G1	SUNC_G19_13.8	SUNC_G19	IEEET1	38.3	Active	0.0167	180	0.02	6.51	0	1	0.033	
38	58030	2	DOWSTG 9_14.7	DOWSTG 9	IEEET1	50.6	Active	0.02	50	0.06	3.5	-3.5	0.17	0.95	
39	58181	1	GHOST G9_2.30	GHOST G9	IEEET1	1.2	Active	0	50	0.05	3.5	-3.5	-0.17	0.95	
40	58218	G2	SUNC G29_13.8	SUNC G29	IEEET1	38.3	Active	0.0167	180	0.02	6.51	0	1	0.033	
41	58290	2	BALZ 1&2_13.80	BALZ 1&2	IEEET1	68	Active	0.02	750	0.02	12.9	0	1	1	
42	58304	1	PLAMOND9_25.0	PLAMOND9	IEEET1	71.2	Active	0.02	750	0.02	12.9	0	1	1	
43	58304	2	PLAMOND9_25.0	PLAMOND9	IEEET1	71.2	Active	0.02	750	0.02	12.9	0	1	1	
44	58304	3	PLAMOND9_25.0	PLAMOND9	IEEET1	20.3	Active	0.02	750	0.02	12.9	0	1	1	
45	58750	1	REDW GT_13.80	REDW GT	IEEET1	110	Active	0.02	20	0.06	3.5	-3.5	-0.17	0.95	
46	59145	1	BRDGE C9_25.0	BRDGE C9	IEEET1	7.2	Active	0.0167	400	0.05	8	0	1	0.4	
47	59247	1	CAVAL_A_13.80	CAVAL_A	IEEET1	68.44	Active	0.022	120	0.02	7.24	0	1	1.2	
48	59290	1	BALZ 3_13.80	BALZ 3	IEEET1	68	Active	0.02	750	0.02	12.9	0	1	1	

Transient Stability Analysis Dialog



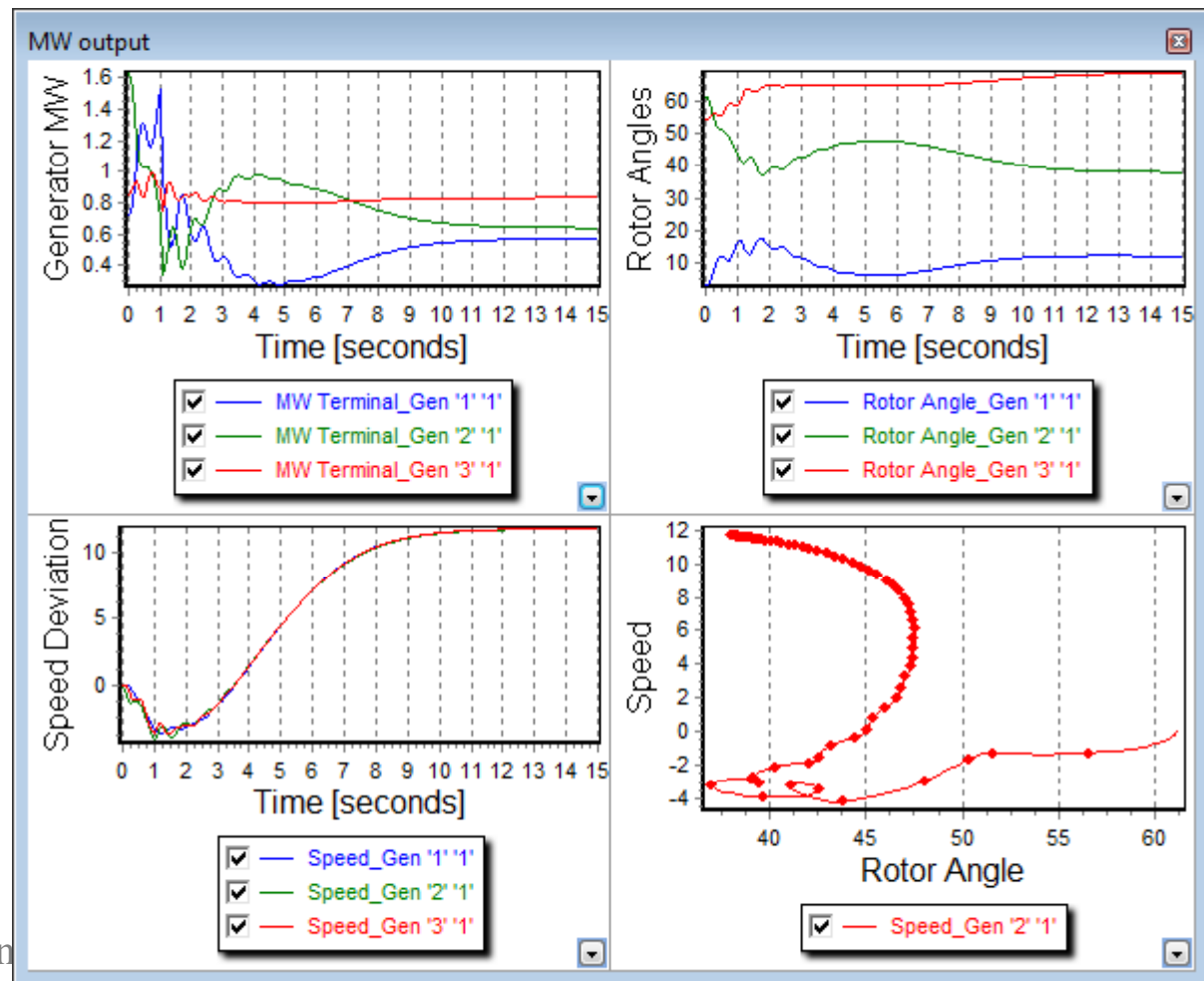
- Go to the Add-Ons Ribbon Tab
- Choose Transient Stability Icon



Run Simulation



- Click Run Transient Stability



Another Example of a Fault



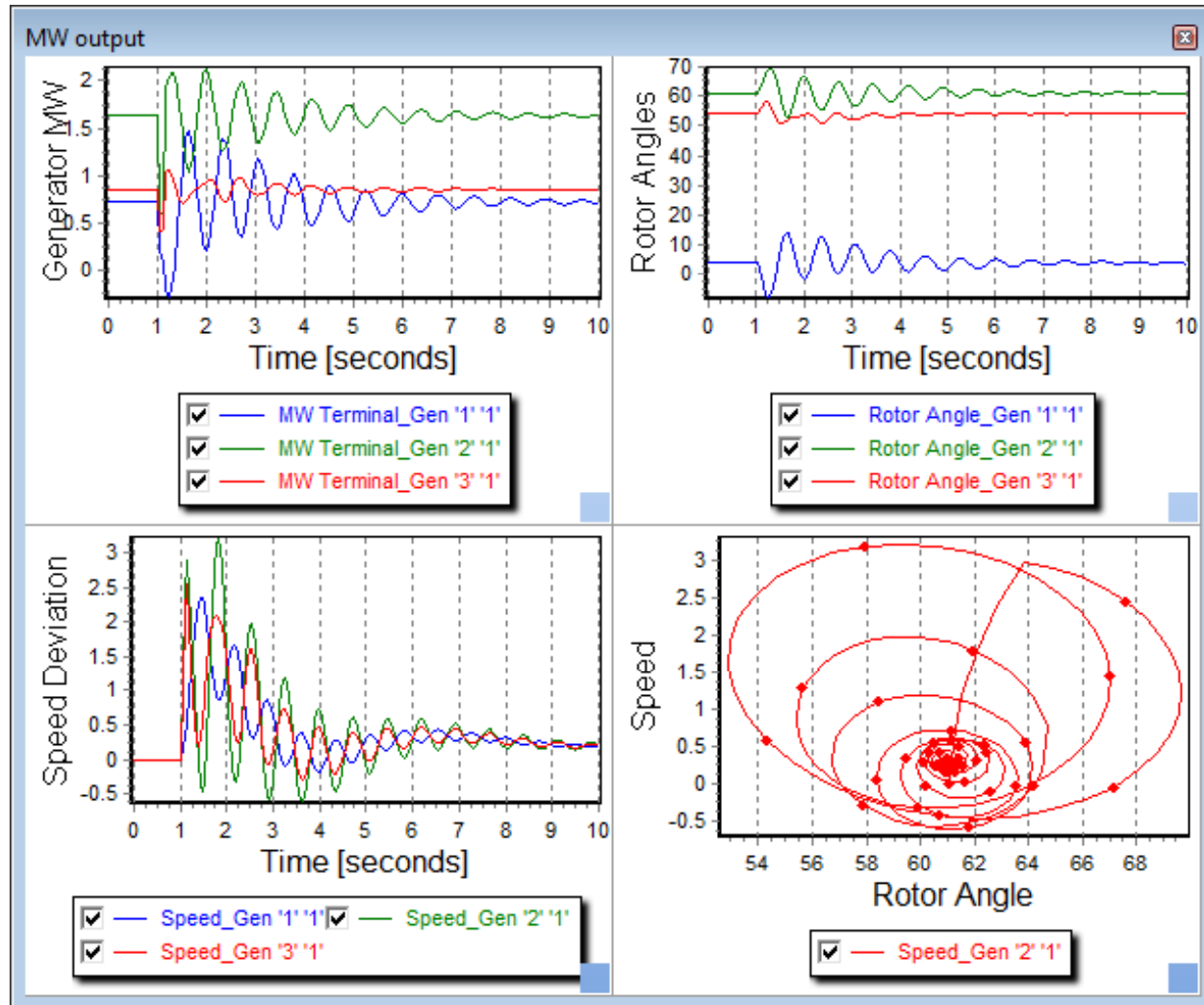
- Open TS9Bus Bus Fault.pwb
- Again, just open the Transient stability dialog and run it

SOLID fault at Bus 5 which start at 1.00 seconds and is cleared at 1.10 seconds

	Time (Seconds)	Enabled	Object	Event Description
1	1.0000	YES	Bus '5'	FAULT 3PB SOLID
2	1.1000	YES	Bus '5'	CLEARFAULT

TS9Bus Bus Fault

A 0.1 second bus fault at bus 5



- + Recent
- + Network
- + Aggregations
- + Solution Details
- + Case Information and Auxiliary
- + Contingency Analysis
- + Fault Analysis
- + Optimal Power Flow
- Transient Stability

Model Explorer: Transient Stability Folder



- Models Listed by “class” under folder
- Choose a class of models and you’ll see a list of the specific model types

Class of Model

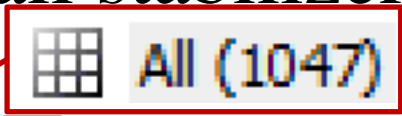
Specific Types

	Fully Supported	Number of Bus	ID	Name_Nominal kV of Bus	Name of Bus	Type	MVA Base	Device Status
1	YES	10246	1	PERSONG1_ 18.00	PERSONG1	PSS2A	170	Active
2	YES	10261	1	REEVE_G1_ 13.80	REEVE_G1	PSS2A	58.822	Active
3	YES	10262	1	REEVE_G2_ 13.80	REEVE_G2	PSS2A	58.822	Active
4	YES	10263	1	REEVE_G3_ 13.80	REEVE_G3	PSS2A	88.235	Active
5	YES	10318	1	SJUAN_G1_ 22.00	SJUAN_G1	WSCCST	410	Active
6	YES	10319	1	SJUAN_G2_ 24.00	SJUAN_G2	IEEEEST	410	Active
7	YES	10320	1	SJUAN_G3_ 22.00	SJUAN_G3	WSCCST	616.7	Active
8	YES	10321	1	SJUAN_G4_ 22.00	SJUAN_G4	WSCCST	616.7	Active
9	YES	10394	1	LEF_G1_ 18.00	LEF_G1	PSS2A	234	Active
10	YES	10395	1	LEF_G2_ 18.00	LEF_G2	PSS2A	234	Active
11	YES	10396	1	LEF_S1_ 18.00	LEF_S1	PSS2A	373	Active
12	YES	10485	1	AFTONS_ 18.00	AFTONS	PSS2A	143.6	Active
13	YES	10486	1	AFTONG_ 18.00	AFTONG	PSS2A	189	Active
14	YES	10491	1	LRDSBGG1_ 13.80	LRDSBGG1	PSS2A	60	Active
15	YES	10492	1	LRDSBRG2_ 13.80	LRDSBRG2	PSS2A	60	Active
16	YES	10903	1	VEF_ 18.00	VEF	PSS2A	189	Active
17	YES	11208	1	NEWMN5G1_ 13.80	NEWMN5G1	PSS2A	114	Active
18	YES	11209	1	NEWMN5G2_ 13.80	NEWMN5G2	PSS2A	114	Active
19	YES	11261	1	NEWMN5S1_ 18.00	NEWMN5S1	PSS2A	198	Active
20	YES	13311	2	TA-3-BL_ 13.80	TA-3-BL	PSS2A	30	Active
21	YES	14531	1	WPHX ST6_ 12.50	WPHX ST6	PSS2A	75	Active
22	YES	14800	1	GIL-CT1_ 18.00	GIL-CT1	PSS2A	205	Active
23	YES	14801	1	GIL-CT2_ 18.00	GIL-CT2	PSS2A	205	Active
24	YES	14802	1	GIL-ST1_ 18.00	GIL-ST1	PSS2A	319	Active
25	YES	14803	1	GIL-CT3_ 18.00	GIL-CT3	PSS2A	205	Active
26	YES	14804	1	GIL-CT4_ 18.00	GIL-CT4	PSS2A	205	Active
27	YES	14805	1	GIL-ST2_ 18.00	GIL-ST2	PSS2A	319	Active
28	YES	14806	1	GIL-CT5_ 18.00	GIL-CT5	PSS2A	205	Active

Navigating a List of Models



- Choose All to get a list of all stabilizers
- Choose specific type to get a list of all the parameters





Stabilizer	Fully Supported	Number of Bus	ID	Name_Nominal kV of Bus	Name of Bus	Type	MVA Base	Device Status
All (1047)	1	YES	10246	1	PERSONG1_18.00	PERSONG1	PSS2A	170 Active
BPA_SF	2	YES	10261	1	REEVE_G1_13.80	REEVE_G1	PSS2A	58.822 Active
BPA_SG	3	YES	10262	1	REEVE_G2_13.80	REEVE_G2	PSS2A	58.822 Active
BPA_SH	4	YES	10263	1	REEVE_G3_13.80	REEVE_G3	PSS2A	88.235 Active
BPA_SHPLUS	5	YES	10318	1	SJUAN_G1_22.00	SJUAN_G1	WSCCST	410 Active
BPA_SI	6	YES	10319	1	SJUAN_G2_24.00	SJUAN_G2	IEEEST	410 Active
BPA_SP	7	YES	10320	1	SJUAN_G3_22.00	SJUAN_G3	WSCCST	616.7 Active
BPA_SS	8	YES	10321	1	SJUAN_G4_22.00	SJUAN_G4	WSCCST	616.7 Active
IEE2ST	9	YES	10394	1	LEF_G1_18.00	LEF_G1	PSS2A	234 Active
IEEEST (181)	10	YES	10395	1	LEF_G2_18.00	LEF_G2	PSS2A	234 Active
PFQFG (5)	11	YES	10396	1	LEF_S1_18.00	LEF_S1	PSS2A	373 Active
PSS2A (620)	12	YES	10485	1	AFTONS_18.00	AFTONS	PSS2A	143.6 Active
PSS2B	13	YES	10486	1	AFTONG_18.00	AFTONG	PSS2A	189 Active
PSSSB (83)	14	YES	10491	1	LRDSBGG1_13.80	LRDSBGG1	PSS2A	60 Active
PTIST1	15	YES	10492	1	LRDSBRG2_13.80	LRDSBRG2	PSS2A	60 Active
PTIST3	16	YES	10903	1	VEF_18.00	VEF	PSS2A	189 Active
ST2CLUT	17	YES	11208	1	NEWMNSG1_13.80	NEWMNSG1	PSS2A	114 Active
STAB1	18	YES	11209	1	NEWMNSG2_13.80	NEWMNSG2	PSS2A	114 Active
STAB2A	19	YES	11261	1	NEWMNS1_18.00	NEWMNS1	PSS2A	198 Active
STAB3	20	YES	13311	2	TA-3-BL_13.80	TA-3-BL	PSS2A	30 Active
STAB4	21	YES	14531	1	WPHX ST6_12.50	WPHX ST6	PSS2A	75 Active
STBSVC	22	YES	14800	1	GIL-CT1_18.00	GIL-CT1	PSS2A	205 Active
WSCCST (158)	23	YES	14801	1	GIL-CT2_18.00	GIL-CT2	PSS2A	205 Active
	24	YES	14802	1	GIL-ST1_18.00	GIL-ST1	PSS2A	319 Active
	25	YES	14803	1	GIL-CT3_18.00	GIL-CT3	PSS2A	205 Active
	26	YES	14804	1	GIL-CT4_18.00	GIL-CT4	PSS2A	205 Active
	27	YES	14805	1	GIL-ST2_18.00	GIL-ST2	PSS2A	319 Active
	28	YES	14806	1	GIL-CT5_18.00	GIL-CT5	PSS2A	205 Active
























Stabilizer	Number of Bus	ID	Name_Nominal kV of Bus	Name of Bus	Type	MVA Base	Device Status	H	D	Ra	Xd	Xq	Xdp	Xqp	Xdpp	Xl	Tdop	Tqop	Tdopp	Tqopp	S(1.0)	S(1.2)
GENROU	1	10246	1	PERSONG1_18.00	PERSONG1	GENROU	170 Active	4.2	0	0	1.65	1.55	0.2	0.6	0.19	0.15	8.5	0.5	0.02	0.12	0.076	0.317
	2	10261	1	REEVE_G1_13.80	REEVE_G1	GENROU	58.822 Active	4.22	0	0	1.73	1.6	0.285	0.8	0.2036	0.1	7.1	2	0.03	0.2	0.194	0.4597
	3	10262	1	REEVE_G2_13.80	REEVE_G2	GENROU	58.822 Active	4.22	0	0	1.73	1.6	0.285	0.8	0.2036	0.1	7.1	2	0.03	0.2	0.194	0.4597
	4	10263	1	REEVE_G3_13.80	REEVE_G3	GENROU	88.235 Active	3.48	0	0	1.76	1.52	0.24	0.7	0.2036	0.1	7	2	0.03	0.1	0.2196	0.6399
	5	10394	1	LEF_G1_18.00	LEF_G1	GENROU	234 Active	4.87	0	0	2.25	1.825	0.275	0.85	0.2264	0.15	9	0.9	0.036	0.07	0.09	0.2687
	6	10395	1	LEF_G2_18.00	LEF_G2	GENROU	234 Active	4.87	0	0	2.25	1.825	0.275	0.85	0.2264	0.15	9	0.9	0.036	0.07	0.09	0.2687
	7	10396	1	LEF_S1_18.00	LEF_S1	GENROU	373 Active	2.91	0	0	2.27	1.7	0.33	0.85	0.27	0.231	7.5	0.9	0.036	0.07	0.065	0.5795
	8	10415	1	LVGT_13.80	LVGT	GENROU	29.6 Active	7.4	0	0.0017	1.865	1.6	0.215	0.8	0.205	0.11	8	0.5	0.023	0.05	0.0992	0.348
	9	10485	1	AFTONS_18.00	AFTONS	GENROU	143.6 Active	4.5	0	0.0038	1.744	1.6	0.256	0.4	0.17	0.1	7	0.75	0.03	0.05	0.05	0.3
	10	10486	1	AFTONG_18.00	AFTONG	GENROU	189 Active	5.78	0	0.0025	1.715	1.615	0.22	0.4007	0.18	0.1216	8.5	0.539	0.055	0.083	0.0745	0.3077

Specific Model Types



- If the model is listed, then Simulator is able to read this model from other file formats
 - Models that are not read from other formats will result in errors messages in the message log when the file format is read
- The number of models defined for each type is listed **PSS2A (620)**
- Gray Text indicates no models of this type are defined **PSS2B**
- Color of icon indicates whether Simulator fully supports the model in the transient stability solution engine
 -  Green means it is supported
 -  Red means it is not supported

Stabilizer

	All (1047)
	BPA_SF
	BPA_SG
	BPA_SH
	BPA_SHPLUS
	BPA_SI
	BPA_SP
	BPA_SS
	IEE2ST
	IEEEEST (181)
	PFQRG (5)
	PSS2A (620)
	PSS2B
	PSSSB (83)
	PTIST1
	PTIST3
	ST2CUT
	STAB1
	STAB2A
	STAB3
	STAB4
	STBSVC
	WSCCST (158)

Show Models Supported By

<input checked="" type="checkbox"/> PW Only	<input checked="" type="checkbox"/> PTI
<input checked="" type="checkbox"/> BPA	<input checked="" type="checkbox"/> GE

Specific Model Types



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

Stabilizer

- All (1047)
- BPA_SF
- BPA_SG
- BPA_SH
- BPA_SHPLUS
- BPA_SI
- BPA_SP
- BPA_SS

Show Models Supported By

PW Only PTI
 BPA GE

Stabilizer

- All (1047)
- IEE2ST
- IEEEEST (181)
- PSS2A (620)
- PSS2B
- PTIST1
- PTIST3
- ST2CUT
- STAB1
- STAB2A
- STAB3
- STAB4
- STBSVC

Show Models Supported By

PW Only PTI
 BPA GE

Stabilizer

- All (1047)
- IEEEEST (181)
- PFQRG (5)
- PSS2A (620)
- PSS2B
- PSSSB (83)
- WSCCST (158)

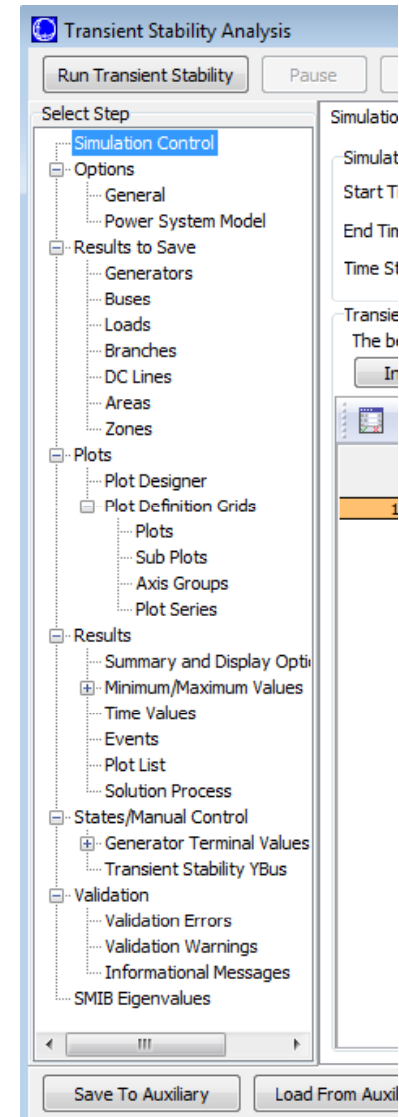
Show Models Supported By

PW Only PTI
 BPA GE

Navigating Transient Stability Analysis Dialog



- Simulation Control
- Options
- Results to Save
- Plots
- Results
- States/Manual Control
- Validation
- SMIB Eigenvalues



Simulation Control



- Specify Start and End Time
- Specify Time Step (in either seconds or cycles)
- Specify the events that occur during the simulation
 - Fault Bus
 - Open Line
 - Etc...

Simulation Control

Simulation Time Values

Start Time (seconds) 0.000

End Time (seconds) 15.000

Time Step (seconds) 0.020000

Specify Time Step in

Seconds

Cycles

Transient Stability Events List

The below list shows the transient stability faults and other events.

Insert Event Clear All Events

	Time (Seconds)	Enabled	Object	Event Description
1	1.0000	YES	Load '5' '1'	OPEN

Transient Stability Options



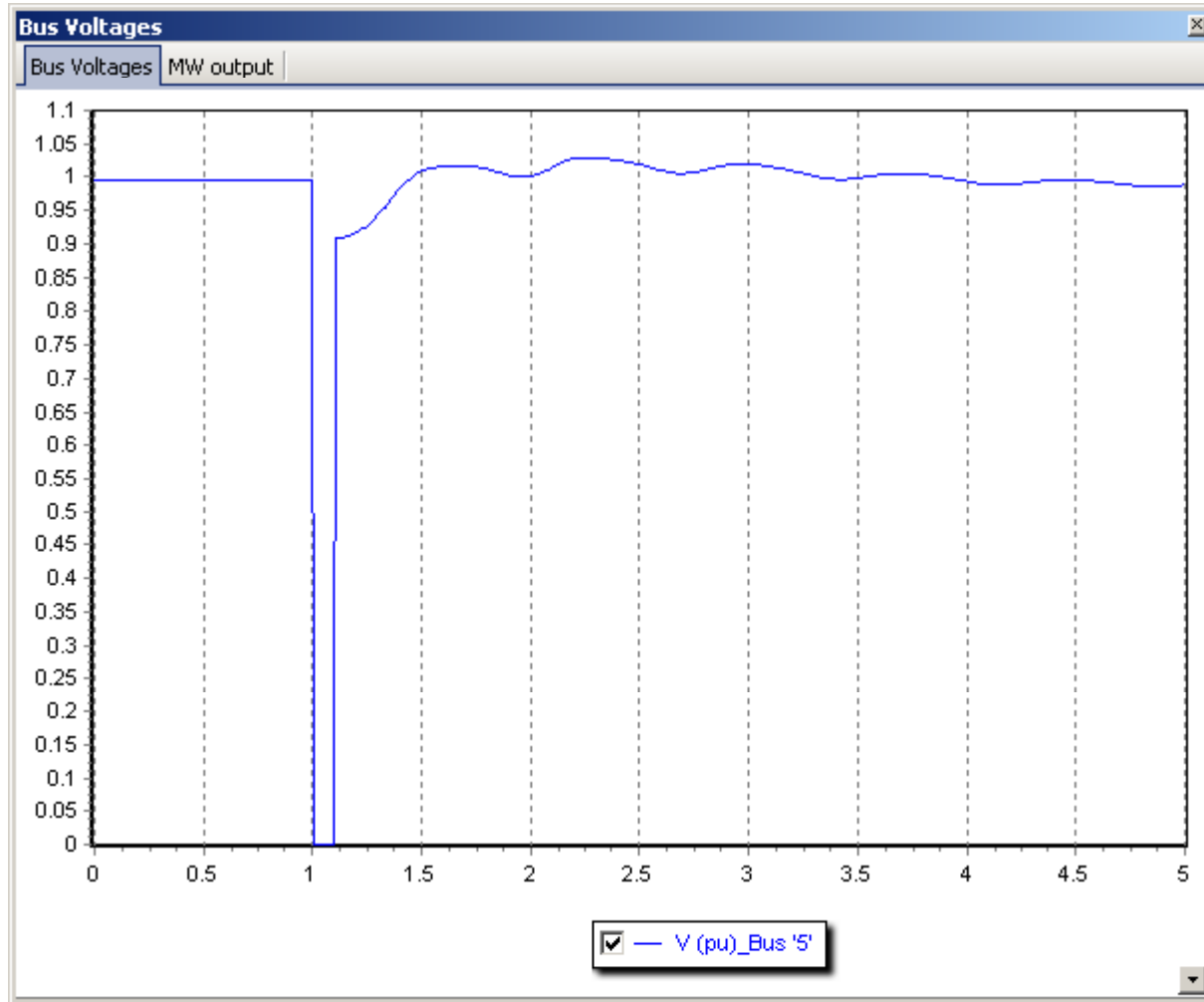
- General Options
 - Relate to the user-interaction with the tool
 - Should data be stored in PWB
 - Validation
 - When to start saving Min/Max information
 - When to view results
- Power System Model Options
 - Nominal Frequency
 - Default Load Models
 - Angle Reference

A Variety of Different Load Models are Now Supported



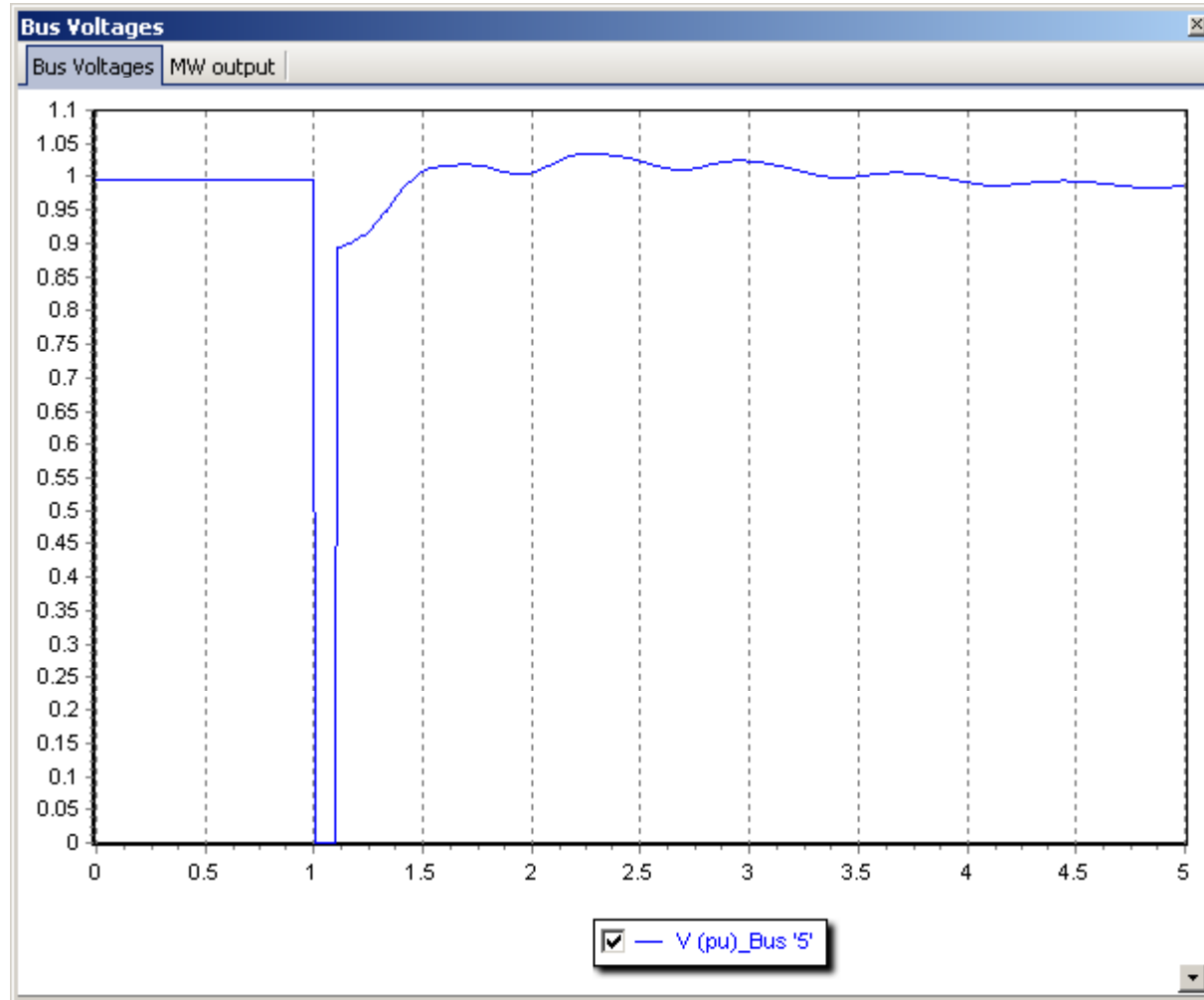
- Static load models (ZIP)
- Induction motor models, including either single cage or double cage motors
- Complex load models (constant power, impedance, large induction motors, small induction motors, and discharge lighting)
- Load models have a tremendous impact on the system voltage response

TS9Bus System Voltage Response Versus Load Model



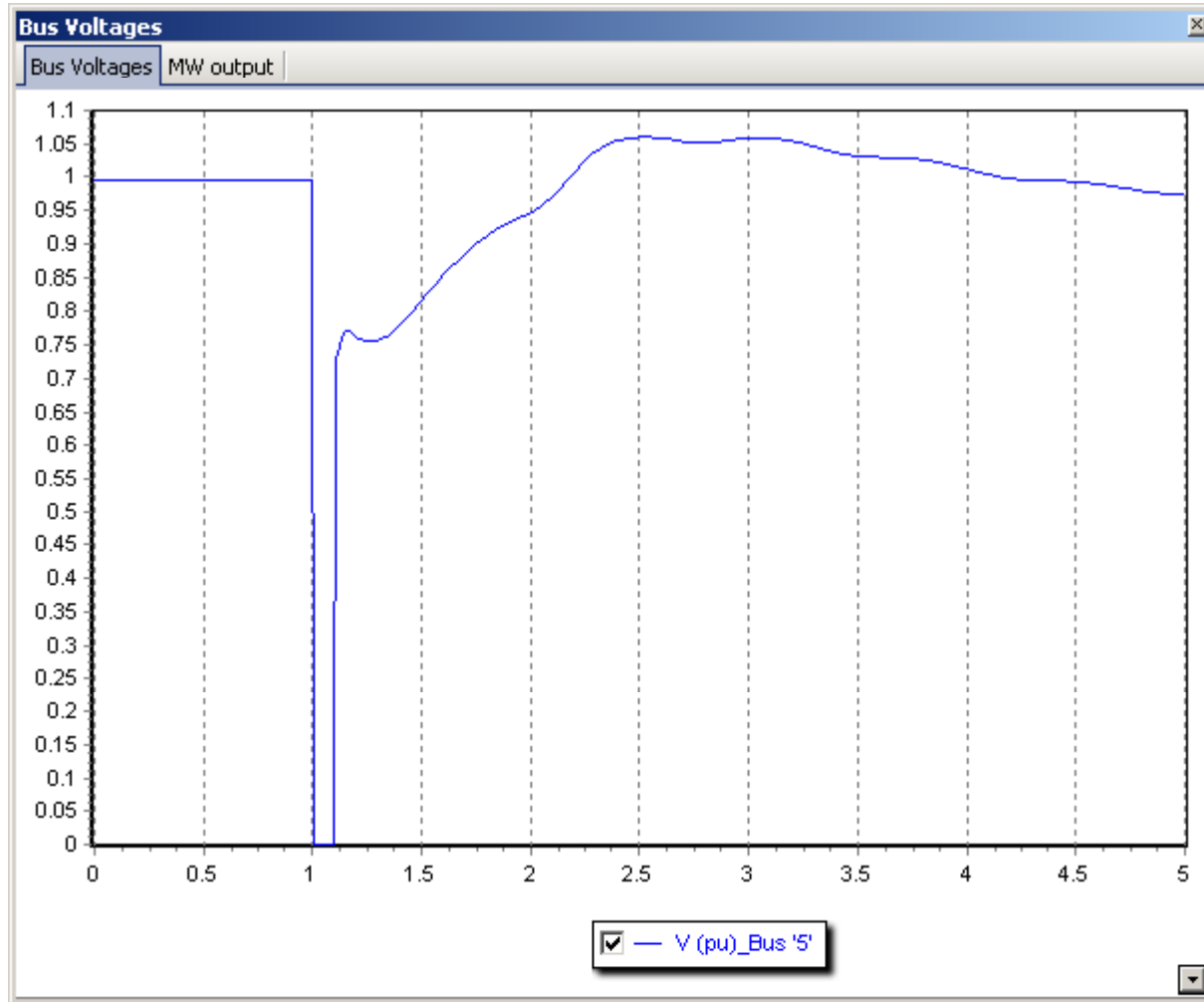
Bus 5
Voltage,
Constant
Impedance
Load Model

TS9Bus System Voltage Response Versus Load Model



Bus 5
Voltage,
Constant
Current
Load Model

TS9Bus System Voltage Response Versus Load Model

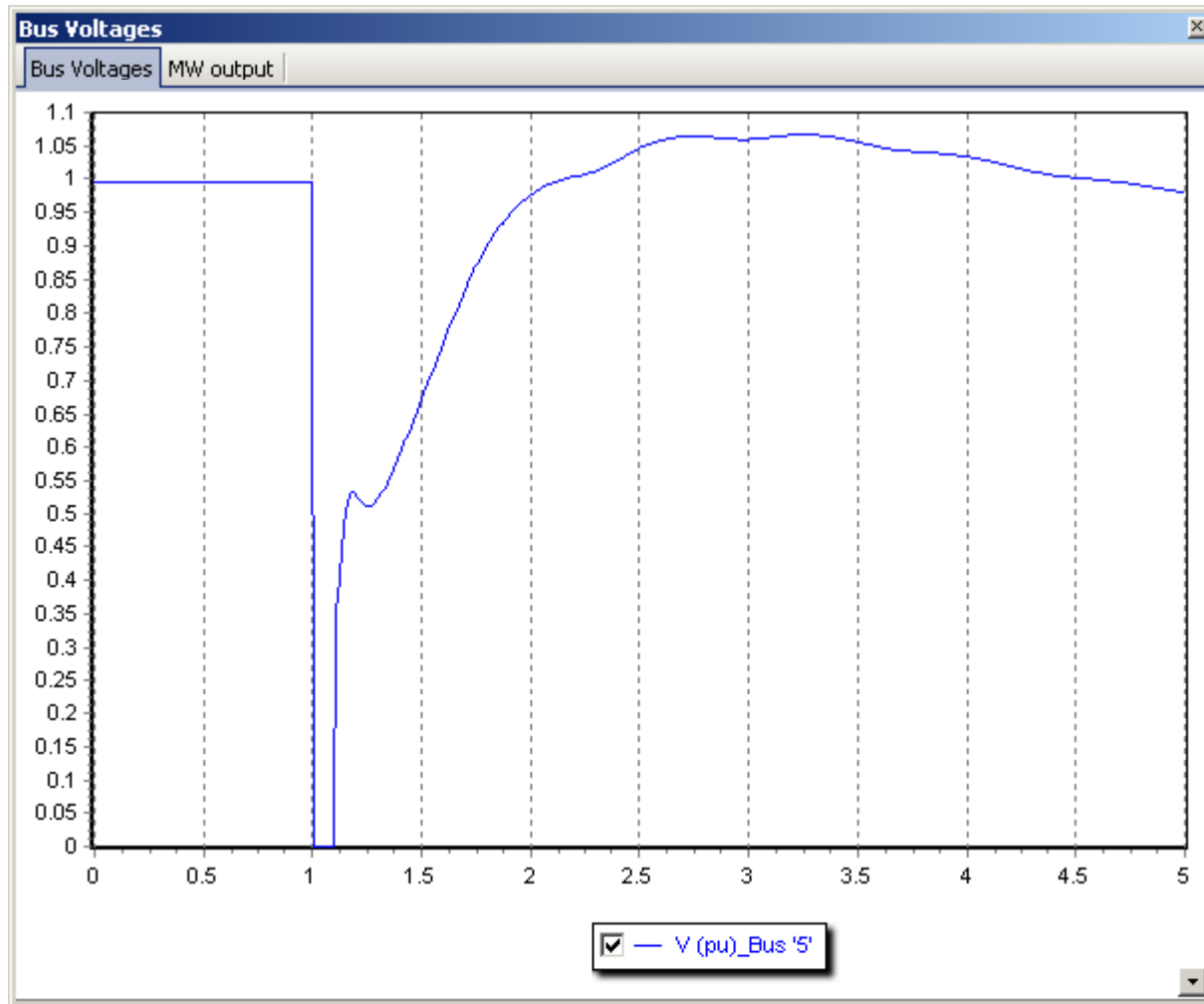


Bus 5
Voltage,
Complex
Load Model
(25% large
motors, 25%
small motors,
20% discharge
lighting,
remainder
constant current

TS9Bus System Voltage Response Versus Load Model



Bus 5
Voltage,
All Induction
Motor Load
Model



PowerWorld Makes it Easy to Step Through a Solution



- Select the States/Manual Control page to either run a specified number of time steps, or run to a specified time
 - Many of the variables can be directly examined
 - Results can also be automatically transferred to the power flow for a more detailed analysis/visualization

States/Manual Control



Transient Stability Analysis

Run Transient Stability | Continue | Abort | Simulation Status: Paused at 1.200

Select Step: Simulation Control, Options, Results to Save, Plots, Results, **States/Manual Control**, Validation, SMIB Eigenvalues

States/Manual Control

Reset to Start Time | Transfer Present State to Power Flow

Run Until Specified Time: 0.000 | Run Until Time

Do Specified Number of Timestep(s): 10 | Number of Timesteps to Do

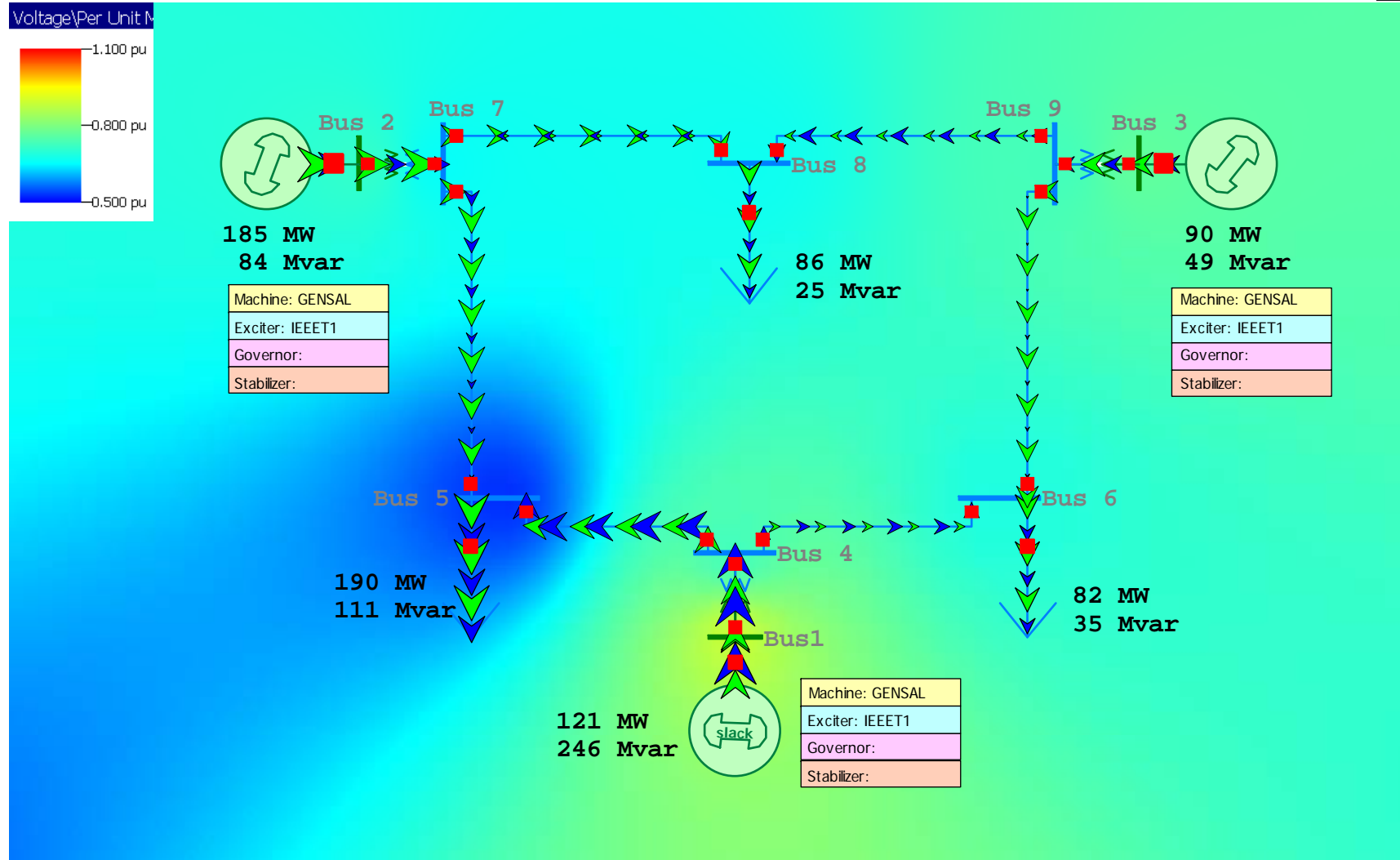
Restore Power Flow Model | Save Time Snapshot

Generator Terminal Values and States: Transient Stability YBus

Generators | Buses | All States

	Number of Bus	Name of Bus	ID	Area Name of Gen	V (PU)	Angle (deg)	Rotor Angle	Accel, rad/sec ²
1	1	Bus1	1	1	0.8849	-7.975	-2.210	-0.0104
2	2	Bus 2	1	1	0.7113	17.512	69.811	-0.0176
3	3	Bus 3	1	1	0.7642	3.233	51.219	-0.0087

Voltage Contour for Simulation Paused at 1.2 Seconds



Results to Save



- Presently the results of Transient Stability Run are stored in memory
- To specify what values are saved chose from the list of objects and fields available for saving

Results to Save

Data to Save
 Save All Results
 Save Specified Results

Save Results Every n Timesteps:

Save Results for Open Devices

Generators | Buses | Loads | Branches | DC Lines | Areas | Zones

Records | Geo | Set | Columns | Options

From Selection:	Number of Bus	Name of Bus	ID	Area Name of Gen	Save All	Rotor Angle	Rotor Angle, No Shift	Speed	Mech Input	MW Terminal	Accel MW	Mvar Terminal	Term. PU	Field Voltage (pu)	Field Current	Machine State	Exciter State	Governor State	Stabilizer Vs	Stabilizer State
	1	1 Bus 1	1	1	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	2	2 Bus 2	1	1	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	3	3 Bus 3	1	1	NO	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Plots



- You may also design plots of data prior to performing the transient stability run
- Any object fields included in a plot definition will automatically be saved by Simulator during the run
 - Thus you can also just ignore the “Results to Save” information and instead just design your plots
 - By designing your plots, you’re also specifying what to save

Elements of the Plot Definition

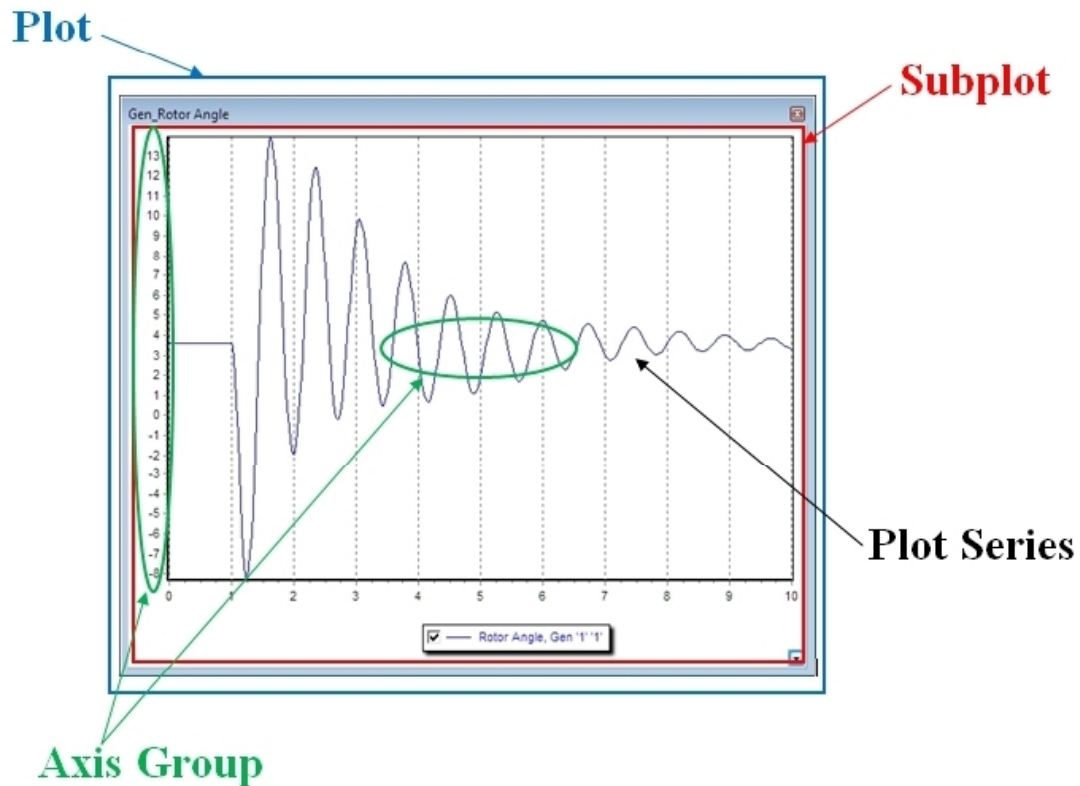


- Plot
 - A single window showing plotted results
 - A single plot can contains any number of subplots.
- Subplot
 - Represents the actual graphical chart
 - Contains the horizontal axis description
 - A single subplot contains one or more axis groups
 - All the axis groups then share the horizontal axis
 - For many plots, there will only be one subplot.
- Axis Groups
 - A single axis group may contain many plot series
 - Contains the vertical axis description
 - All the plot series then share the vertical axis
 - For many plots, there will only be one axis group.
- Plot Series
 - Actual graphical line representing one numerical data series.

A Simple Plot



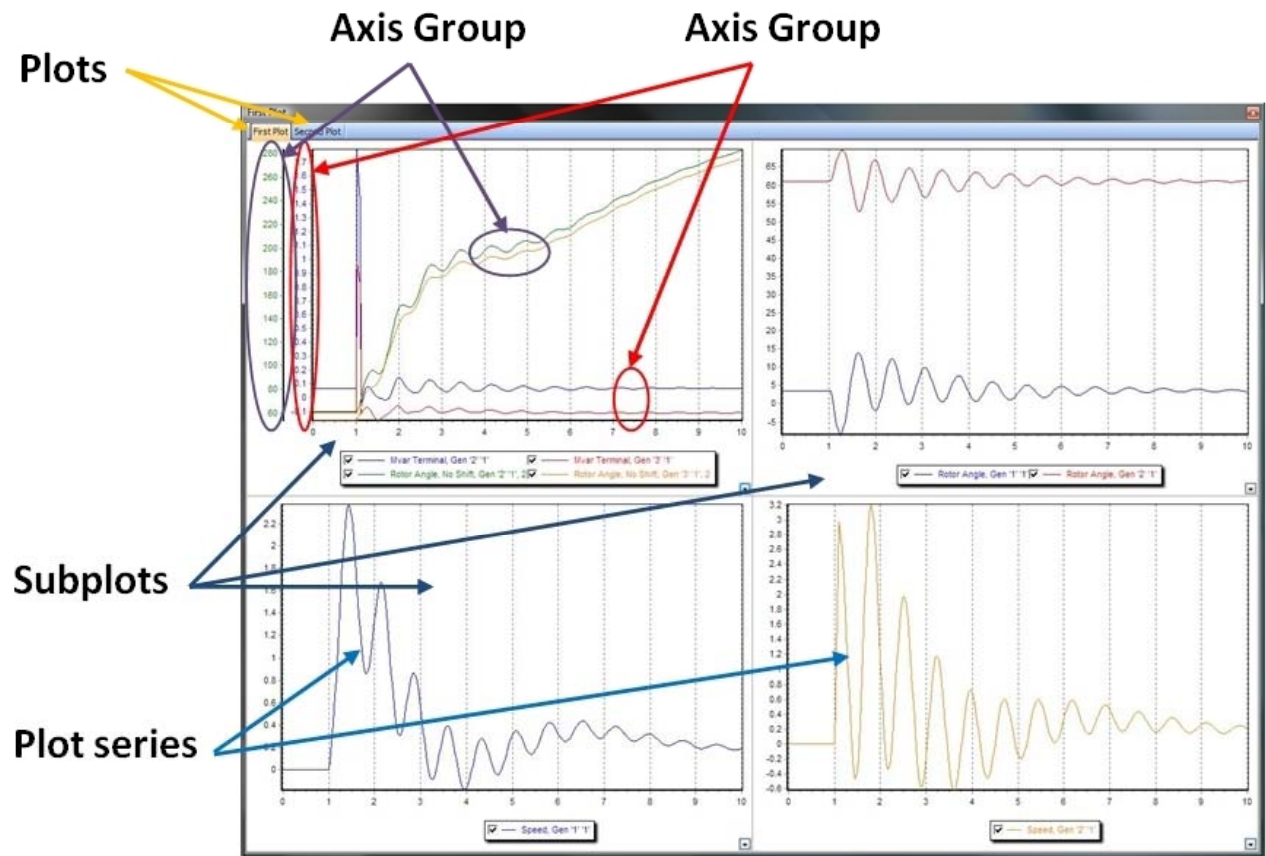
- A plot containing 1 subplot, that contains 1 axis group, that contains 1 plot series



A Complex Plot



- Four subplots with multiple axis groups and plot series



The Plot Designer



Transient Stability Analysis

Run Transient Stability | Pause | Abort | Simulation Status: Not Initialized

Select Step

- Simulation Control
- Options
- Results to Save
- Plots
 - Plot Designer
 - Plot Definition Grids
- Results
- States/Manual Control
- Validation
- SMIB Eigenvalues

Plots

Plot Designer | Plot Definition Grids

Device Type: Generator

Choose Fields

- Accel MW
- Field Current
- Field Voltage (pu)
- Mech Input
- Mvar Terminal
- MW Terminal
- Rotor Angle
- Rotor Angle, No Shift
- Speed
- Stabilizer Vs
- Term. PU

Choose Objects

Sort: By Name By Number

- 1 (Bus 1) #1 [16.5 kV]
- 2 (Bus 2) #1 [18 kV]
- 3 (Bus 3) #1 [13.8 kV]

Plots, Subplots, Axis Groups

- MW output
 - SubPlot 1
 - MW Terminal _ Gen '1' '1'
 - MW Terminal _ Gen '2' '1'
 - MW Terminal _ Gen '3' '1'
 - SubPlot 2
 - Rotor Angle _ Gen '1' '1'
 - Rotor Angle _ Gen '2' '1'
 - Rotor Angle _ Gen '3' '1'
 - SubPlot 3
 - Speed _ Gen '1' '1'
 - Speed _ Gen '2' '1'
 - Speed _ Gen '3' '1'
 - SubPlot 4
 - Speed _ Gen '2' '1'
- Gen_Rotor Angle,Speed

Plot

Plot Name: MW output

When to show the plot

- Completion of a stability run
- On the execution of a stability run
- Manually show plots

Tile Subplots Mode

- Left to Right, Then Down
- Top to Bottom, then Right
- None (user-specified locations)

Save Plot Definitions to Auxiliary File

Save To Auxiliary | Load From Auxiliary | Close

Choosing your Plot Series

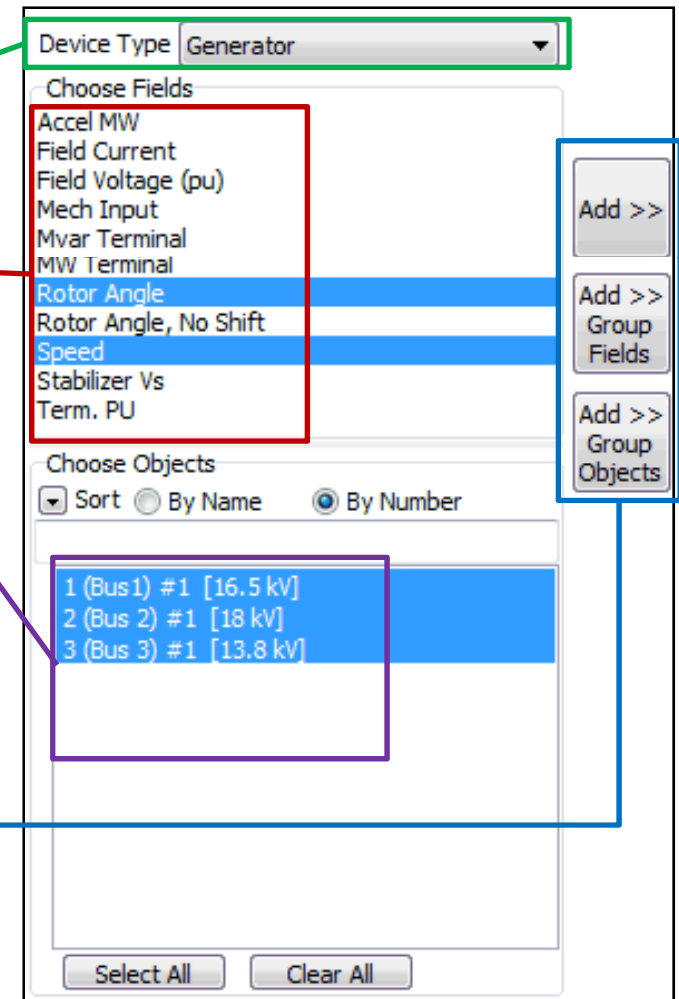


- Choosing your Plot series

- Choose Device Type
- Choose Multiple Fields
- Choose Multiple Objects

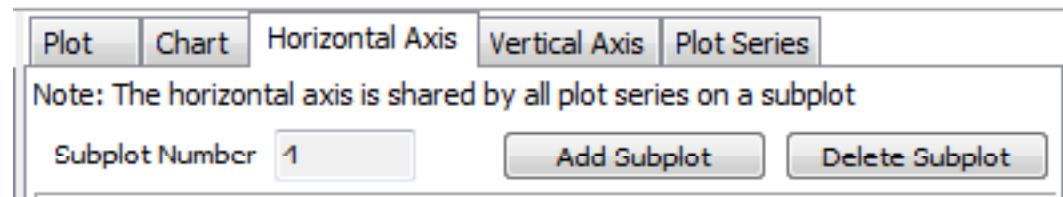
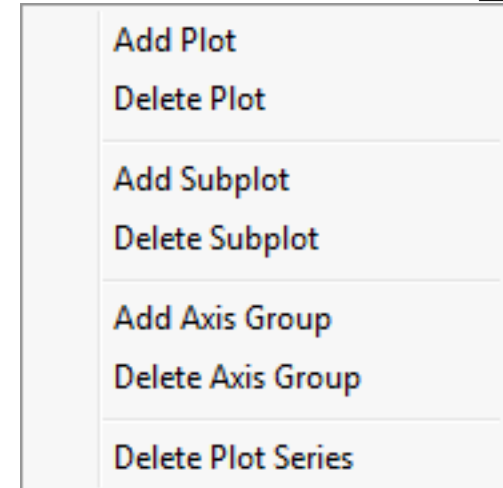
- Click **Add >>** buttons

- **Add >>**
- **Add >> Group Fields**
- **Add >> Group Objects**



Inserting and Deleting Plot Elements

- Right-Click on Plot Element to see options to Add or Delete
 - Options will be enabled based on where you right-click
- Add and Delete buttons are on the various tabs



- Drag/Drop to move plot elements between different plots

Creating Plot Definitions from Results to Save Grids



- Plot Definitions can be created on Results to Save grids
 - Select objects (rows)
 - Select fields (columns)
 - Choose Make Plot
 - Make Plot
 - Group by Field
 - Group by Object

The screenshot shows the 'Generators' table with the following data:

From Selection:	Number of Bus	Name of Bus	ID	Area Name of Gen	Save All	Rotor Angle	Speed	R
1	1	Bus1	1	1	NO	NO	NO	N
2	2	Bus 2	1	1	NO	NO	NO	N
3	3	Bus 3	1	1	NO	NO	NO	N

The 'Plots, Subplots, Axis Groups' dialog box shows the following structure:

- MW output
 - Gen Rotor Angle.Speed
 - PlotVertAxisGroup 1
 - Rotor Angle _ Gen '1' '1'
 - Rotor Angle _ Gen '2' '1'
 - Rotor Angle _ Gen '3' '1'
 - PlotVertAxisGroup 2
 - Speed _ Gen '1' '1'
 - Speed _ Gen '2' '1'
 - Speed _ Gen '3' '1'

Plot Designer: Plot Tab



- Plot Name
- When to show the plot
- Tile subplot mode

The image shows a screenshot of the 'Plot Designer' software interface, specifically the 'Plot' tab. The interface is divided into several sections:

- Plot Name:** A text input field containing 'MW output'. Below it are three buttons: 'Rename Plot', 'Add Plot', and 'Delete Plot'.
- When to show the plot:** A section with three radio button options:
 - Completion of a stability run
 - On the execution of a stability run
 - Manually show plots
- Tile Subplots Mode:** A section with three radio button options:
 - Left to Right, Then Down
 - Top to Bottom, then Right
 - None (user-specified locations)

At the top of the window, there are four tabs: 'Plot', 'Chart', 'Horizontal Axis', 'Vertical Axis', and 'Plot Series'. The 'Plot' tab is currently selected.

Plot Designer: Chart Tab



- Visible
- Color
- Title, Footer
- Location
 - Used when plot is *not* set to one of the “Tile” modes
- Advanced Options
 - A file location

In GUI, the Subplot Number is managed internally, but when using AUX files this is the key field for the subplot

Plot Chart Horizontal Axis Vertical Axis Plot Series

Note: The chart attributes are assigned to one subplot.

Subplot Number 3 Add Subplot Delete Subplot

Visible Background Color Change

Title Visible Font Size 12

Footer Visible Font Size 12

Location Plot is set to automatically tile the subplots
 Top 50.0
 Left 0.0 Right 50.0
 Bottom 100.0

Advanced Options Filename Browse... Clear

Plot Designer: Horizontal Axis Tab



- Show Axis
- Inverted
- Logarithmic
- Title
- Scale
- Horizontal Axis Value
 - Defaults to time
 - Change for a “State Space” plot

In GUI, the Subplot Number is managed internally, but when using AUX files this is the key field for the subplot

Plot
Chart
Horizontal Axis
Vertical Axis
Plot Series

Note: The horizontal axis is shared by all plot series on a subplot

Subplot Number
Add Subplot
Delete Subplot

Show Horizontal Axis on Plot

Inverted

Logarithmic

Title

Visible Font Size

Scale

Automatic Round

Maximum

Increment

Minimum

Automatic Round

Horizontal Axis Value

Clear

Object plotted Choose...

Field plotted Choose...

Plot Designer: Vertical Axis Tab



- Show Axis
- Inverted
- Logarithmic
- Title
- Scale

In GUI, the Axis Group Number is managed internally, but when using AUX files this is the key field for the axis group

The screenshot shows the 'Vertical Axis' tab in the Plot Designer GUI. At the top, there are tabs for 'Plot', 'Chart', 'Horizontal Axis', 'Vertical Axis', and 'Plot Series'. Below the tabs, a note states: 'Note: The vertical axis is shared by all plot series in an axis group'. The 'Axis Group Number' is set to 2, with 'Add Axis Group' and 'Delete Axis Group' buttons. The 'Show Vertical Axis on Plot' checkbox is checked. The 'Inverted' and 'Logarithmic' checkboxes are unchecked. The 'Title' section has 'Visible' checked, 'Font Size' set to 12, and a text field containing 'Speed Deviation'. The 'Scale' section has 'Automatic' checked and 'Round' unchecked for both 'Maximum' and 'Minimum' values, which are both set to 0.00. The 'Increment' is also set to 0.00.

Plot Designer: Plot Series Tab



- Object/Field is the key field for plot series
- Visible
- Color
- Type
 - Line Series
 - Point Series
- Line Attributes
- Point Attributes

The screenshot shows the 'Plot Series' tab in a software interface. At the top, there are tabs for 'Plot', 'Chart', 'Horizontal Axis', 'Vertical Axis', and 'Plot Series'. Below the tabs, a note states: 'Note: The plot series represents ONE actual line on a chart'. The 'Object plotted' field contains 'Gen '3' '1'' and the 'Field plotted' field contains 'Speed'. A 'Delete Plot Series' button is located to the right of the 'Field plotted' field. Below this, there is a checked checkbox for 'Plot Series Visible'. The 'Color' field shows a red color swatch with a 'Change' button. The 'Plot Series Type' is set to 'Line Series' in a dropdown menu. There are two main sections: 'Line Attributes' and 'Point Attributes'. The 'Line Attributes' section includes 'Style' (Solid), 'Thickness' (1), 'Stairs' (No), and 'Symbol Every' (0). The 'Point Attributes' section includes 'Style' (Diamond), 'Height' (5), and 'Width' (5).

Plot Definition Grids

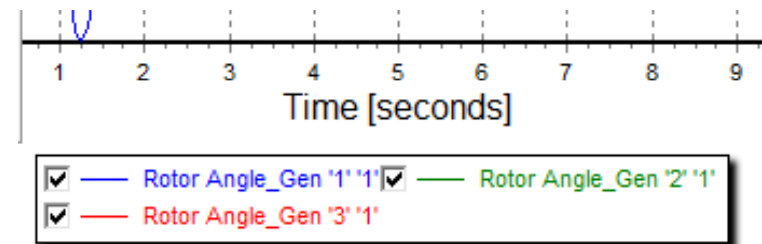


- Case Information Displays which show provide access to all the attributes of the plot elements
- Use all the functionality of the case information displays
- Convenient location to Save/Load Auxiliary files with Plot Definitions

User Interaction with Plots



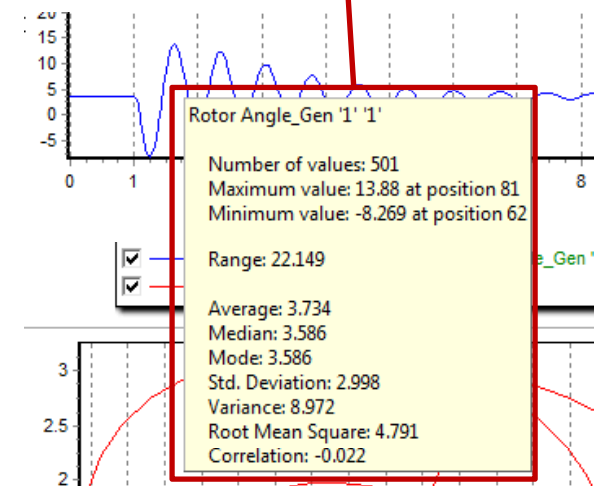
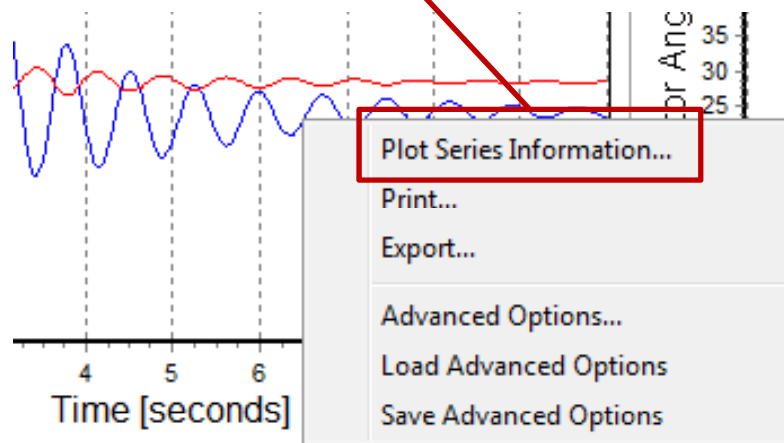
- Panning: **Right-Click** and Drag on the plot
- Zoom In: **Left-Click** and Drag to the left
- Zoom Out: **Left-Click** and Drag to the Right
- Making Plot Series visible or invisible: Checkboxes on Legend



User Interaction with Plots



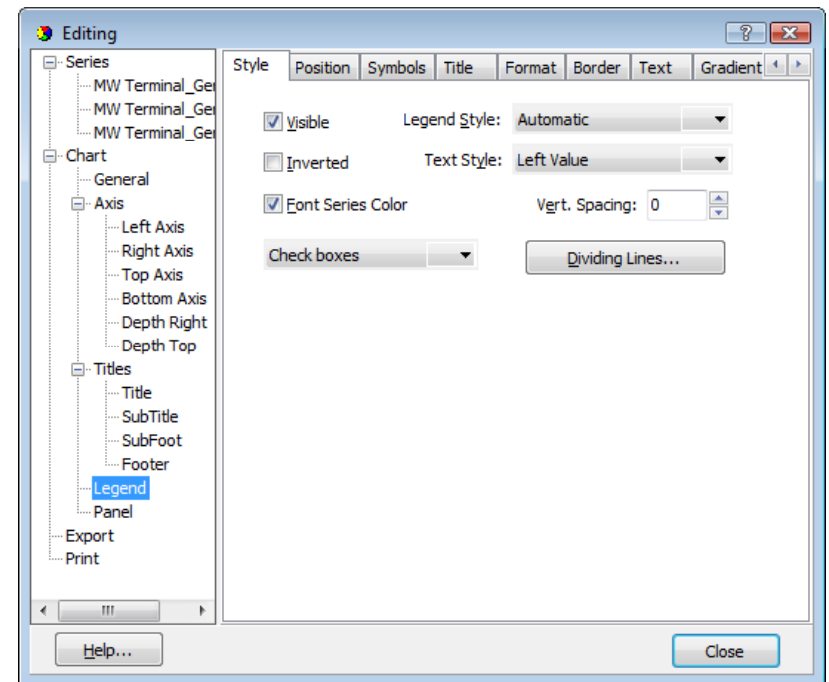
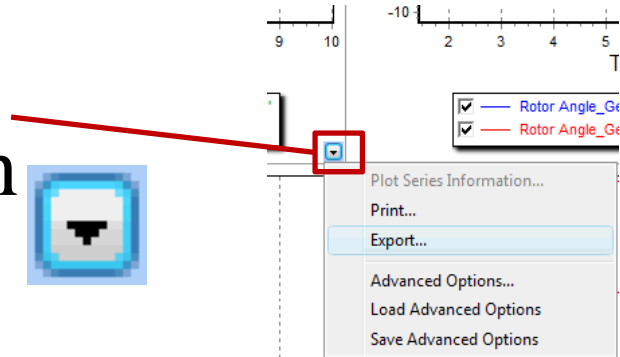
- Get Information about a Plot Series
 - Hover mouse over series and wait for a Hint
 - Right-Click on the series and choose Plot Series Information



Advanced Options



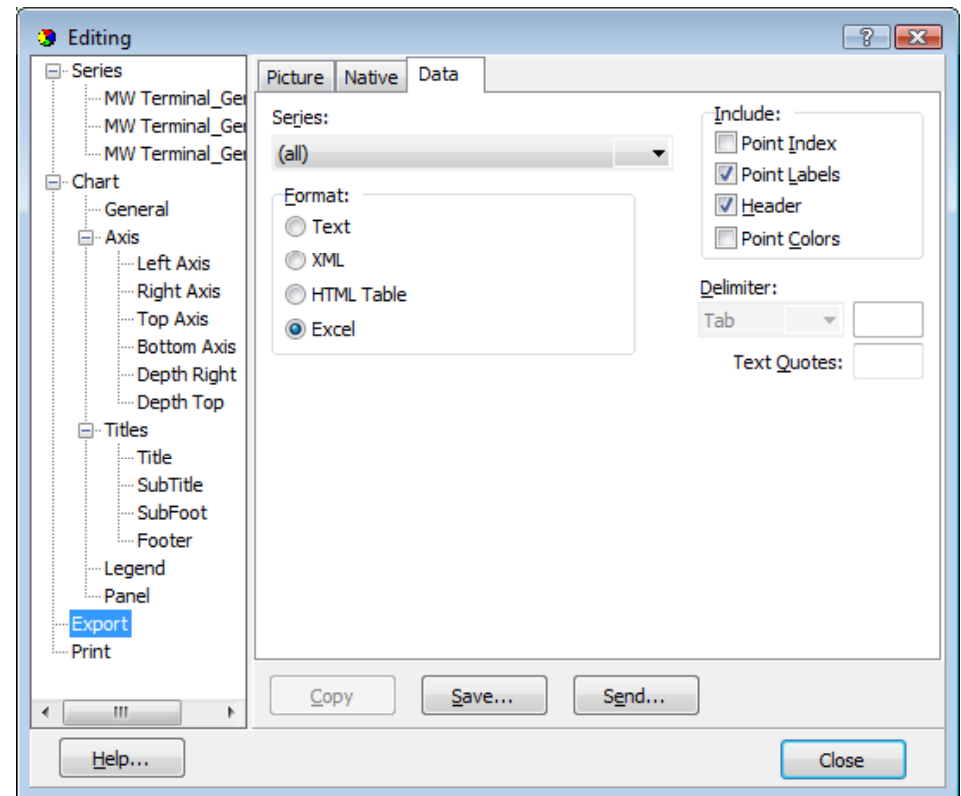
- Click on the button in the lower-right of each subplot and choose Advanced Options...
 - Or right-click on the axis or legend
 - Thousands of more obscure options
 - Advanced options can only be stored in a file referenced by a subplot



Exporting Data



- Data behind a particular chart (subplot) can be exported directly to another format
 - Text, XML, HTML, or Excel
 - Accessed from the Advanced Options dialog



Result:

Summary and Display Options



- Provides a summary of the stability results
- Display Options
 - Display Angular speed in
 - Deviation from Synchronous Speed
 - positive numbers mean more than synchronous
 - negative mean less than synchronous speed
 - Absolute Speed : just show the speed
 - Either Radians/second or Cycles/second (Hertz)
 - Display Rotor Angles in Radians or Degrees
 - On Results grids, each column represents one Object/Field pairs for which results were saved
 - Option is available to group columns by object or field

Time Values Display Options

Display Angular Speed in	Display Angles in
<input checked="" type="radio"/> Deviation from Synchronous Speed	<input checked="" type="radio"/> Degrees
<input type="radio"/> Absolute Speed	<input type="radio"/> Radians
Display Angular Speed in	Show Time Values Grouped By
<input checked="" type="radio"/> Rad/s	<input checked="" type="radio"/> Object then Field
<input type="radio"/> Cycle/s (hertz)	<input type="radio"/> Field then Object

Results:

Minimum/Maximum Values



- Shows the Minimum and Maximum Value that a particular generator or bus experienced during the stability run
- Note: There is a general option which determines at what time we start checking for minimum and maximum values.

Saving Min/Max Values

Time to Begin Checking

- After last event
- Immediately
- Custom Time

Results															
Summary and Display Options															
Minimum/Maximum Values															
Time Values															
Events															
Plot List															
Solution Process															
Buses															
Generators															
Records															
Set															
Columns															
Options															
	Number of Bus	Name of Bus	ID	Area Name of Gen	Original Angle	Minimum Angle	Time Min Angle	Maximum Angle	Time Max Angle	Maximum Angle Change	Minimum Freq, Hz	Time Min Freq	Maximum Freq, Hz	Time Max Freq	Maximum Abs Hz
1	1	Bus 1	1	1	0.000	-8.269	1.240	13.880	1.620	13.880	-0.028	3.960	0.377	1.440	0.377
2	2	Bus 2	1	1	0.000	52.884	1.640	69.635	1.280	69.635	-0.096	3.600	0.509	1.800	0.509
3	3	Bus 3	1	1	0.000	50.911	1.520	58.101	1.200	58.101	-0.046	3.620	0.405	1.120	0.405

Results: Time Values



- Case Information Displays showing the actual saved results
 - Each column represents an object/field pair for which values were saved.
 - Each row represents a time point
- You can make the normal Case Information Display Plots from here
 - These plot definitions aren't saved but just prove a quick and dirty way for you to look at the results.