

2nd Generation Wind Turbine Models in PowerWorld Simulator



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Jamie Weber

weber@powerworld.com

217 384 6330 ext 13



PowerWorld
Corporation

**2001 South First Street
Champaign, Illinois 61820
+1 (217) 384.6330**

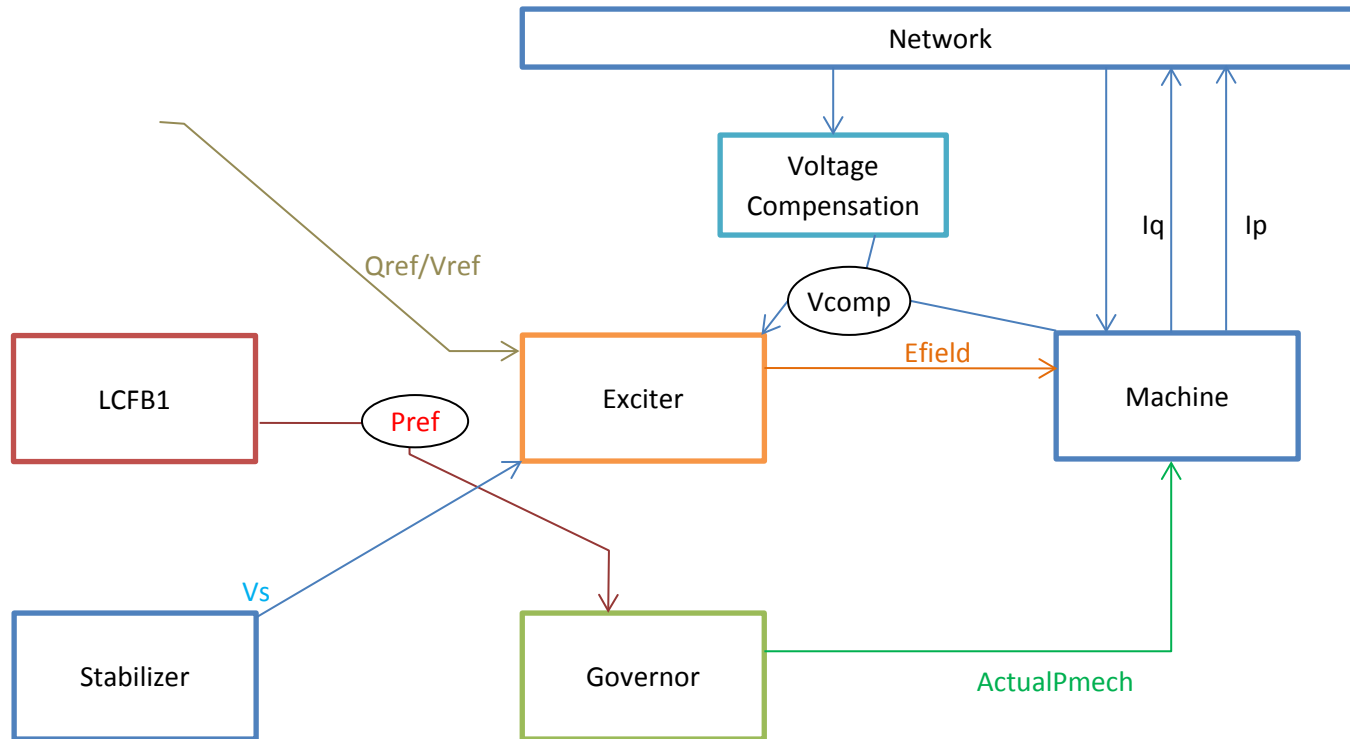
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Modular Approach to Generator Modeling



- Industry has always used a modular approach for generator models
 - Machine
 - Exciter
 - Governor
 - Stabilizer
 - Under Excitation Limiter
 - Over Excitation Limiter
 - Relay Model
 - GP1, LHFRT, LHVRT
 - Compensator Model
 - Often is part of the machine model, but can also be a separate model

Synchronous Machine Modules



Modular Approach to Generator Modeling



- First generation wind turbine models stuck with this structure
 - Added additional signals to pass between modules
 - Don't get hung up on nomenclature "Exciter" just means the electrical control
- Unrelated to wind turbine modeling, a new module was added recently for better modeling of large steam plants
 - LCFB1 – extra controller feeding the governor allowing control of *Pref*

Limitations of First Generation Wind Models

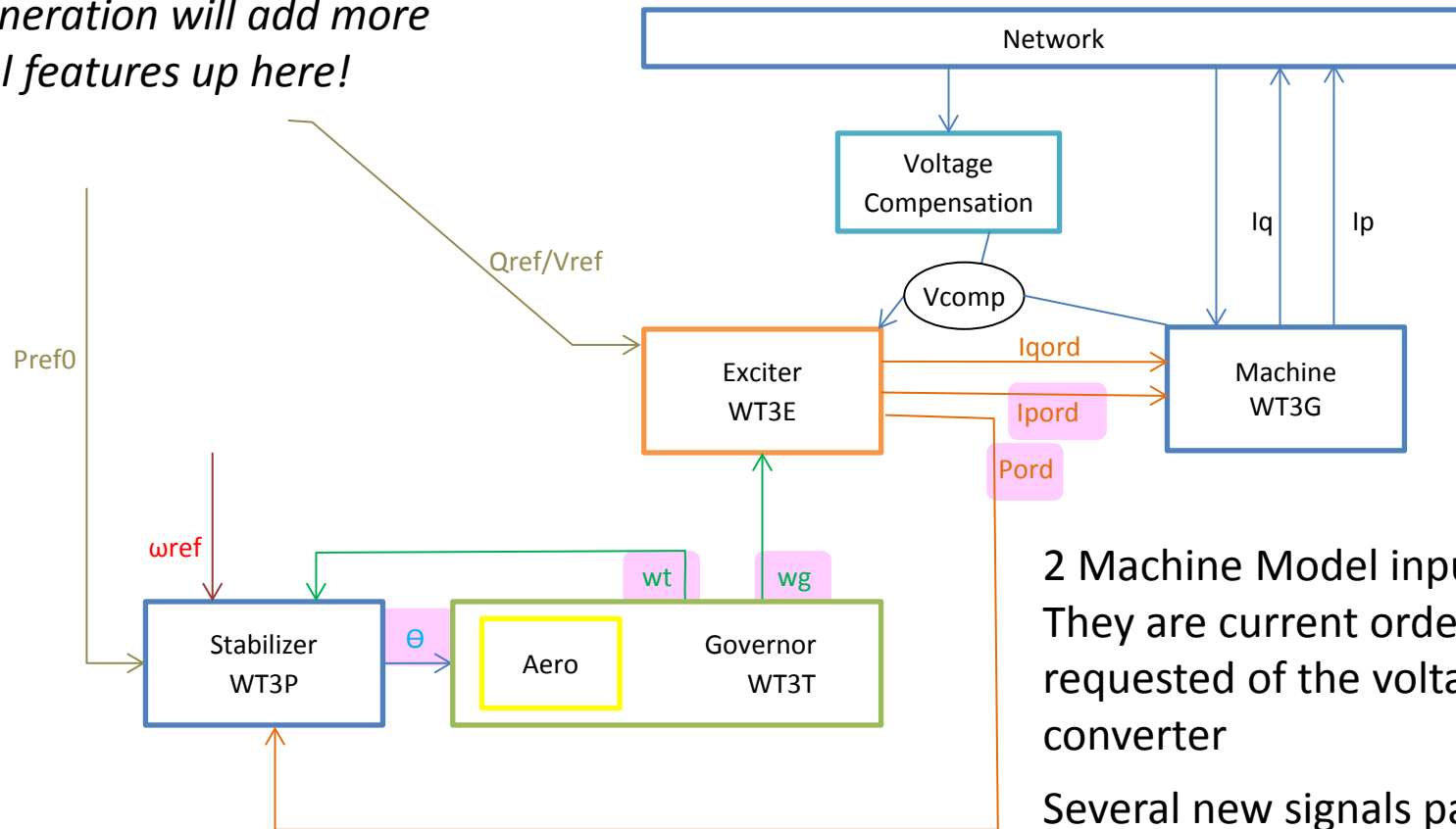


- There are no mechanisms to provide control features of
 - Real Power Control / Torque Control
 - Reactive Power
 - Voltage Control
 - Basically, the wind turbine just tried to bring values back to the initial condition
 - Pref bring power back to initial
 - Qref or Vref or PowerFactorRec

First Generation Type 3 Wind Turbine



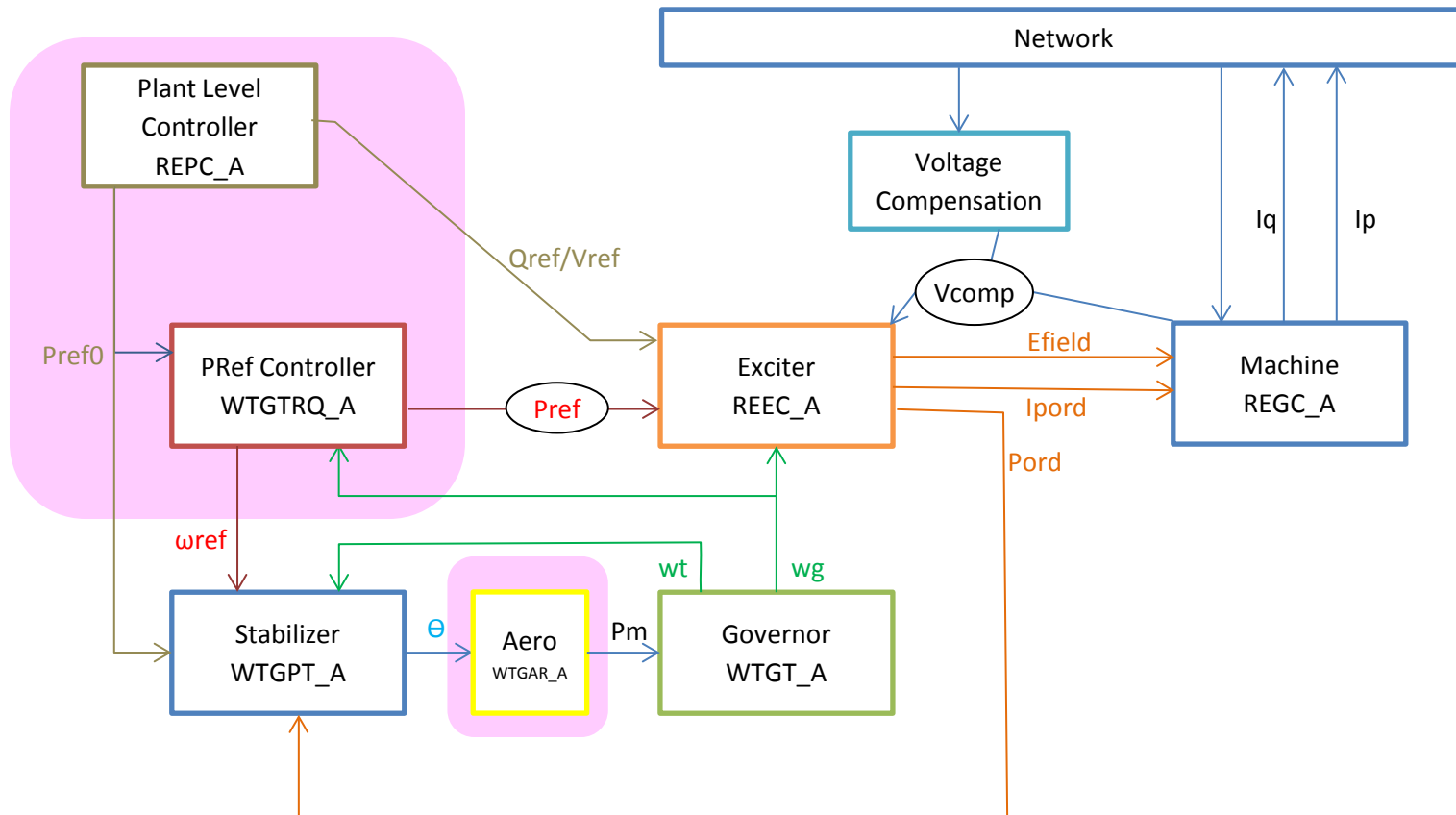
2nd Generation will add more control features up here!



2 Machine Model inputs now.
They are current orders
requested of the voltage source
converter

Several new signals passing
around

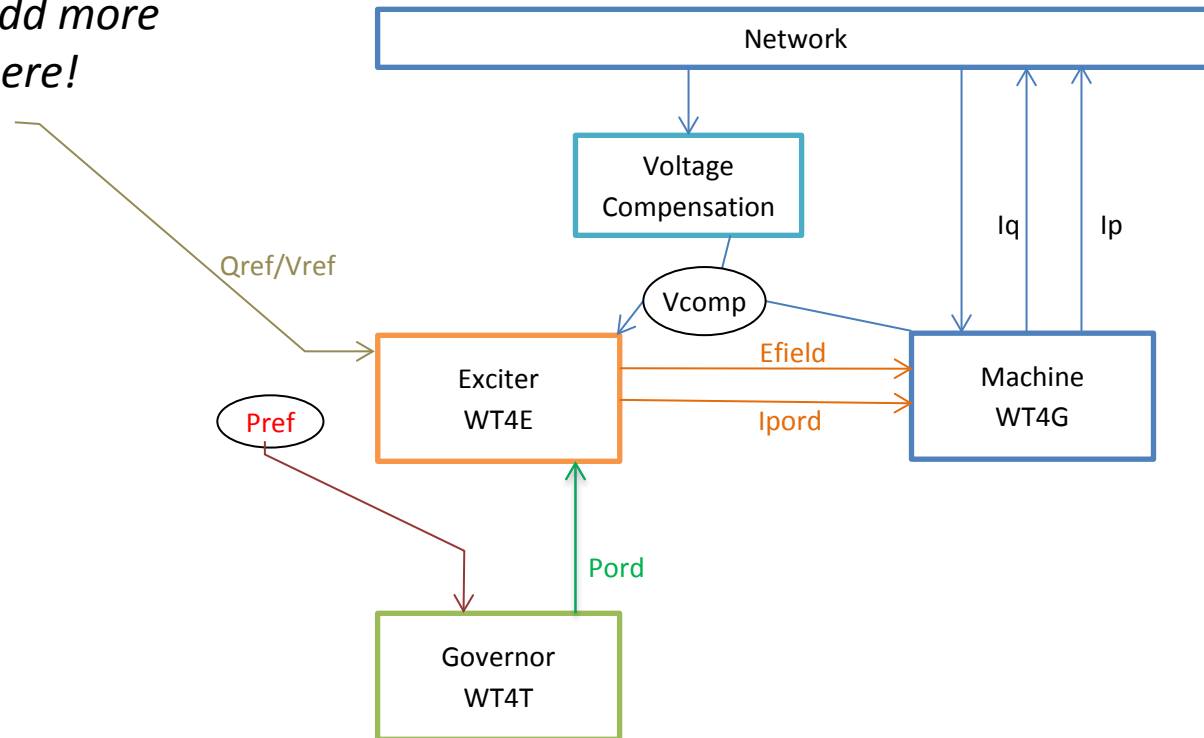
Second Generation Type 3 Wind Turbine



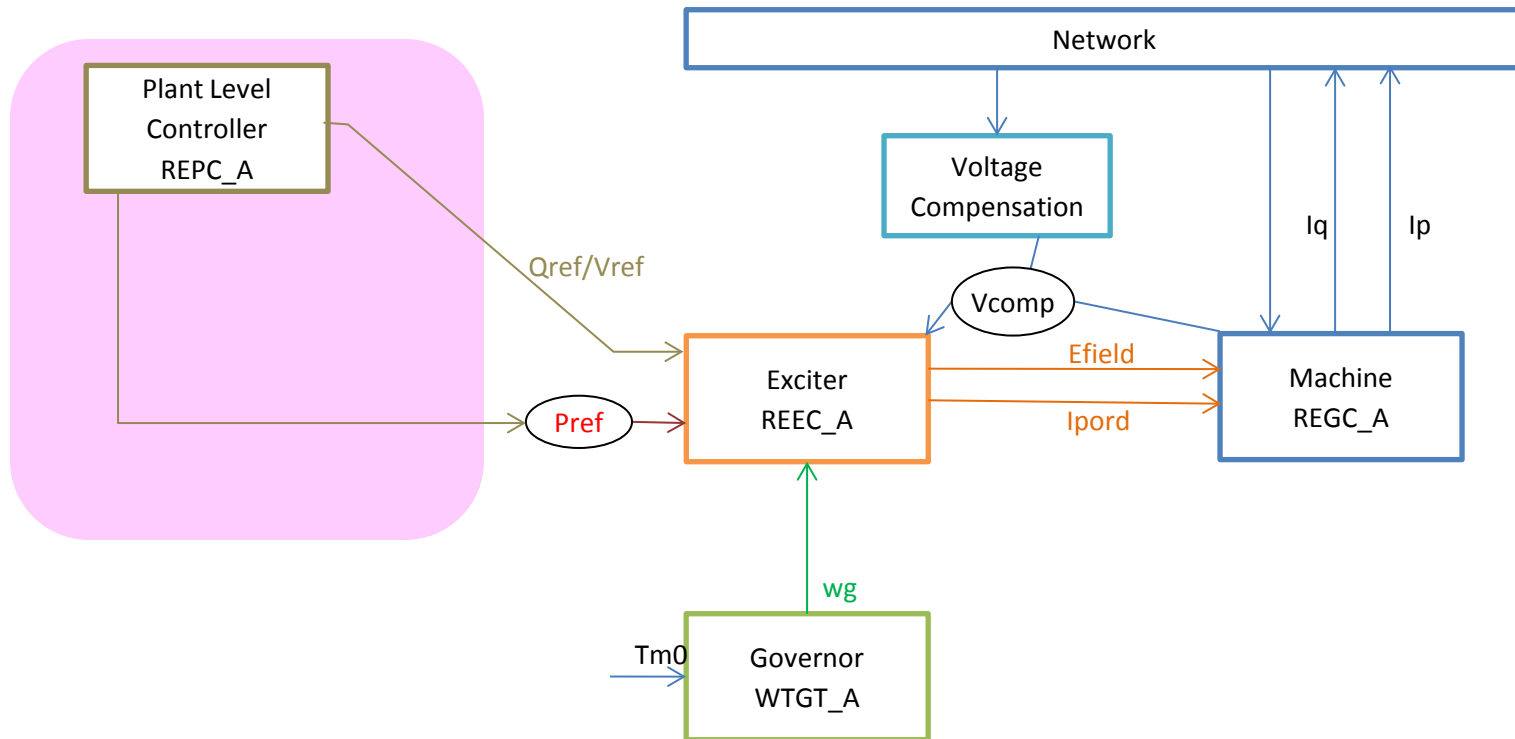
First Generation Type 4 Wind Turbine



2nd Generation will add more control features up here!



Second Generation Type 4 Wind Turbine



Software Implementation



- PowerWorld has kept the existing general classes of generator models
 - Machine (Generator/Converter Model)
 - Exciter (P and Q controller)
 - Governor (Drive Train)
 - Stabilizer (Pitch Control)
 - Relay Model
 - Under Excitation Limiter
 - Over Excitation Limiter
 - Compensator Model
- Added 3 new types of generator modules
 - Aerodynamic Model
 - Pref Controller
 - Plant Controller

Scope of new Modules



- Aerodynamic Model
 - Can only be used with Type 3 wind turbine
- Pref Controller
 - Can be used with any type of generator
 - Existing model LCFB1 is now a Pref Controller
 - Pref Signal Output
 - Feeds into Governor if governor accepts Pref
 - Else feeds into Exciter if exciter accepts Pref
- Plant Controller
 - Can be used with any type of generator
 - Existing model PLAYINREF is now a Plant Controller
 - Vref/Qref Signal Output
 - Vref/Qref signal will feed into Exciter if the exciter accepts it
 - Pref Signal Output
 - Pref feeds into Pref Controller if it exists
 - Else feeds into Governor if governor accepts Pref
 - Else feeds into Exciter if exciter accepts Pref

Error Checking

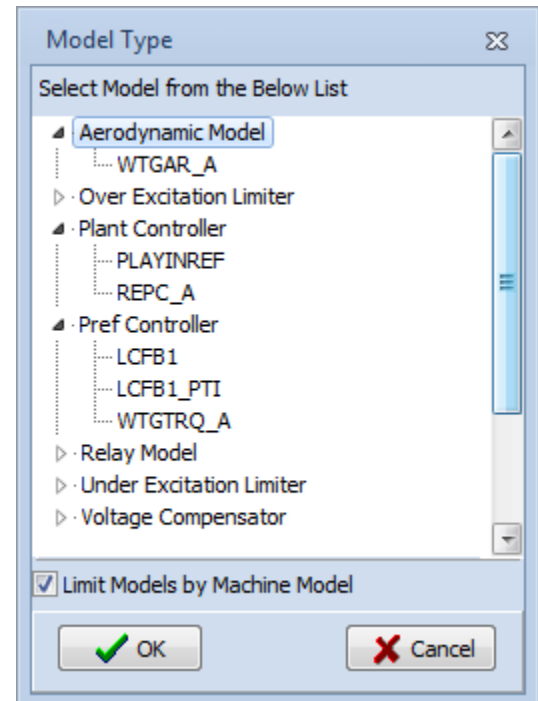


- Error checking is performed when validation is done
 - Ensure there is only 1 Pref controller defined
 - Ensure there is only 1 Plant controller defined
 - Ensure there is only 1 Aerodynamic model
 - Also note, if an aerodynamic model is required between the stabilizer and the governor (WTGPT_A and WTGT_A), but one is not defined, Simulator assumes a WTGAR_A exists with $K_a = 0.007$ and $\Theta = 0$
- General error checking is done to make sure the model mix makes sense
 - GENTPF can't have a REEC_A “exciter”

Where does it appear in GUI



- Machine, Exciter, Governor, and Stabilizer remain prominent
- *Other Models* contain the other categories of modules
- You see it in the Model Explorer
- When inserting a new *Other Model* from the generator dialog
- Plot Designer in Transient Stability Dialog



Model Explorer



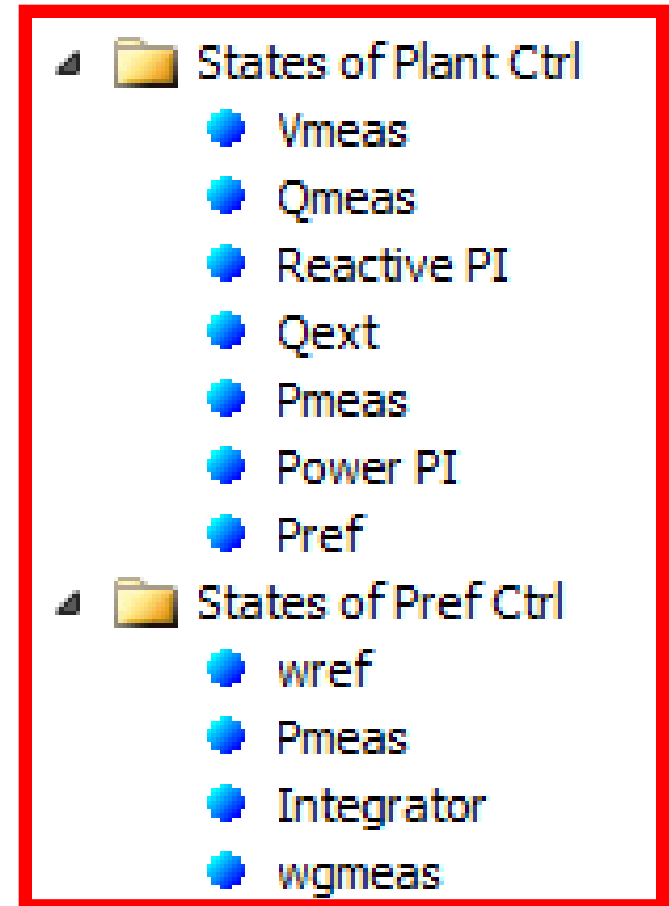
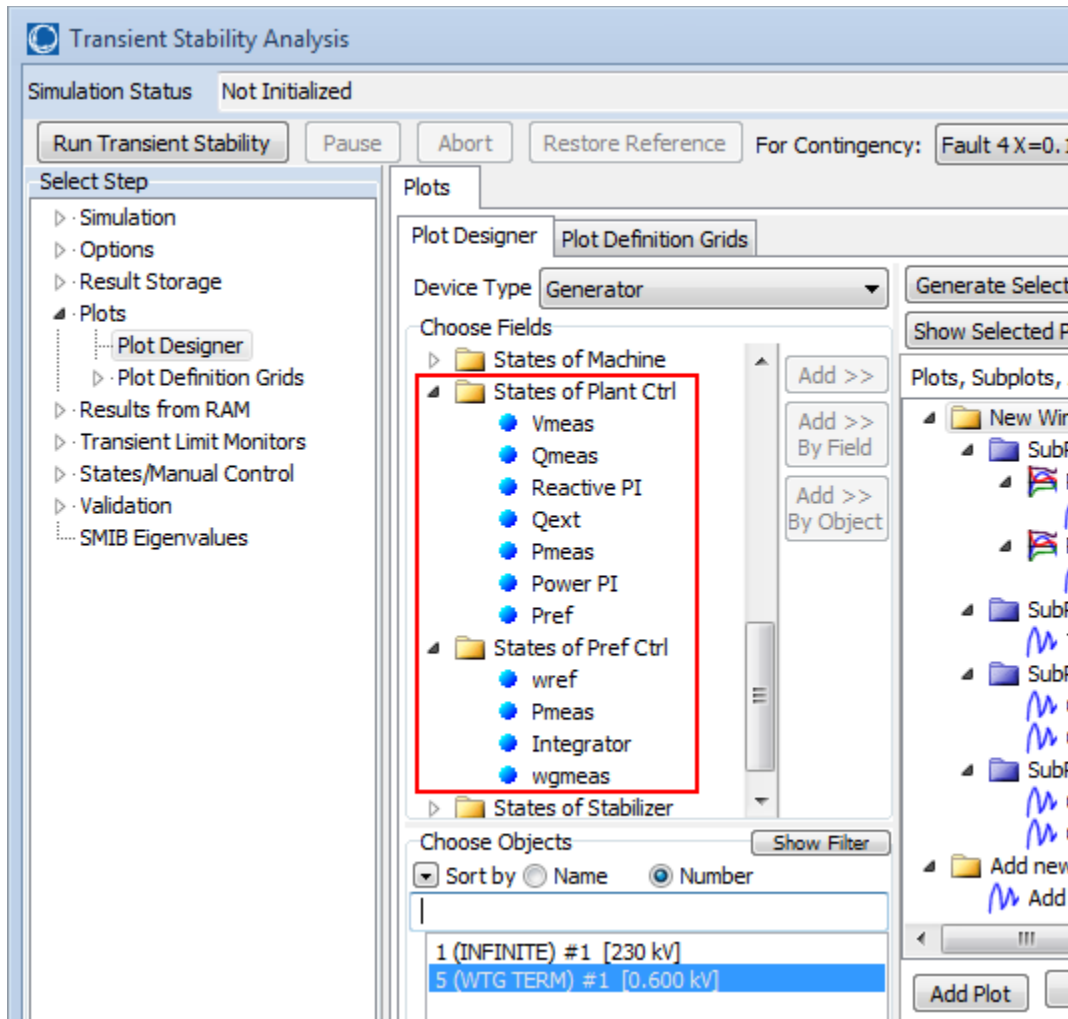
The screenshot displays the 'Model Explorer: Generator Other Models' window. The left pane shows a tree view of model categories, with 'Generator Other Models (2)' selected. The main pane shows a detailed view of the 'Gen Other Model' tree, which is highlighted with a red box. A red arrow points from this box to a larger, zoomed-in view of the same tree structure, also highlighted with a red box. The zoomed-in view shows the following model categories and their sub-models:

- All (2)
- Aerodynamic Model
 - WTGAR_A (1)
- Over Excitation Limiter
 - MAXEX1
 - MAXEX2
 - OEL1
- Plant Controller
 - PLAYINREF
 - REPC_A
- Pref Controller
 - LCFB1
 - LCFB1_PTI
 - WTGTRQ_A (1)
- Relay Model
 - GP1
 - LHFRT
 - LHVRT
- Under Excitation Limiter
 - MNLEX1
 - MNLEX2
 - MNLEX3
- Voltage Compensator
 - COMP
 - COMPCC
- Relay Model (from zoomed view)
 - GP1
 - LHFRT
 - LHVRT
- Under Excitation Limiter (from zoomed view)
 - MNLEX1
 - MNLEX2
 - MNLEX3
- Voltage Compensator (from zoomed view)
 - COMP
 - COMPCC
 - IEEEVC
 - REMCMP

The right pane shows a table with the following data:

Fully Supported	Number of Bus	ID	Name_Nominal kV of Bus	Name of Bus	Type	MVA Base	
1	YES	5	1	WTG TERM_0.600	WTG TERM	WTGAR_A	10
2	YES	5	1	WTG TERM_0.600	WTG TERM	WTGTRQ_A	10

Plot Designer



Implementation Status

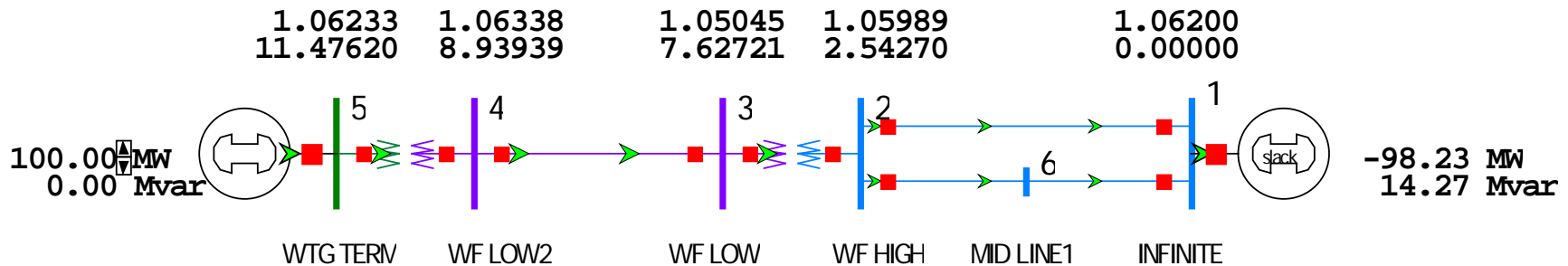


- New Wind Turbine Models
 - Completed and initial testing has been done
 - REGC_A, REEC_A, WTGT_A,, WTGPT_A, WTGAR_A, REPC_A, WTGTRQ_A
 - Will be officially released in Version 18 in Spring 2014
 - Available in Version 18 Beta of Simulator now
 - Some customers have been using already
- Solar Models
 - Have not yet started these models, but the hard work is done in getting the generic modules implemented

Demonstration

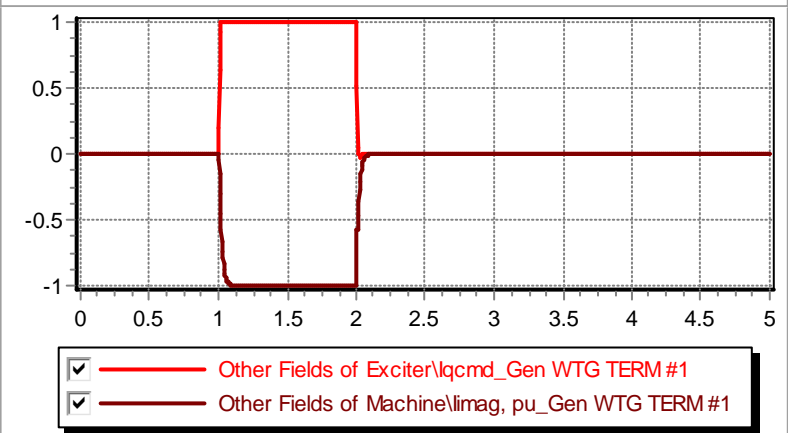
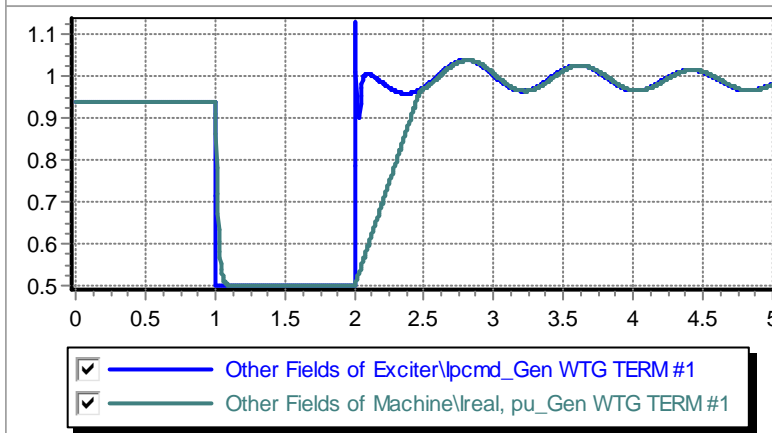
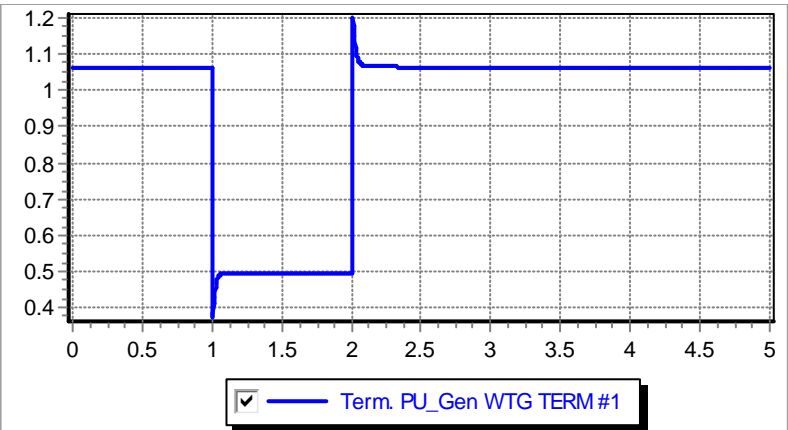
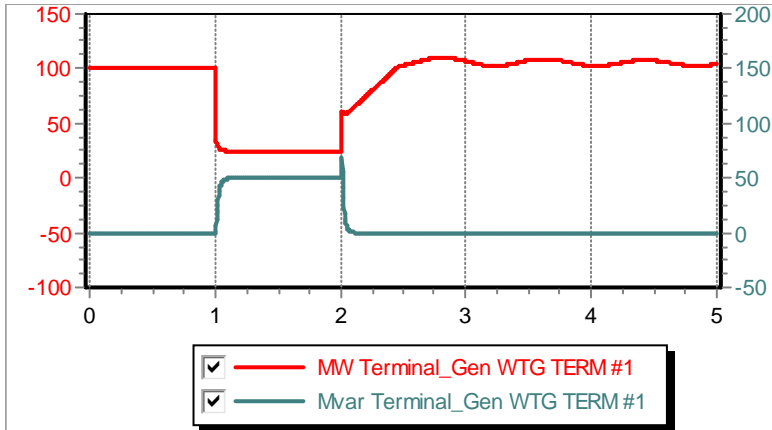


- Pouyan Pourbeik created a small system to test these models



- Model the wind turbine on the left and then an infinite bus on the right
- Testing is showing agreement among all software treatment of the new models

Sample Results



Set1, Type 4 Torsion.pwb
Fault 4 X=0.100

October 14, 2013 12:43:20