

# Transient Stability Analysis with PowerWorld Simulator

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## T4: Model Validation



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

[support@powerworld.com](mailto:support@powerworld.com)  
<http://www.powerworld.com>

## Model Validation

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- It is not uncommon for cases to contain multiple errors or inconsistencies in their input data
- Simulator allows validation and error corrections to be preformed independently of running the simulation
- Validation page of Transient Stability Dialog
  - Validation Options
  - Logging of Error Messages, Warnings, and Informational Messages
- Types of Validation Checks Performed
  - Time constants
  - Machine parameters
  - Limit consistency

# Validation Options



The validation tab provides some built-in model validation

## Validation: Unsupported Models

Determines what is done with the models which are not fully supported for the transient simulation

## Minimum Time Constant Size

A specified multiple of the integration time step, generally between 2 and 4

Element Type	General Type	Model Type	Who Am I	Validation Message
1 Generator	Machine Model	GENROU	WPCC4ST1_ 13.8 (14950) #1	Tqop > 5*Tqopp is recommended.
2 Generator	Machine Model	GENROU	SANTAN 1_ 13.8 (15921) #1	Tqop > 5*Tqopp is recommended.
3 Generator	Machine Model	GENROU	SANTAN 2_ 13.8 (15922) #1	Tqop > 5*Tqopp is recommended.
4 Generator	Machine Model	GENROU	SANTAN 3_ 13.8 (15923) #2	Tqop > 5*Tqopp is recommended.

Many time constants must not be too small or they introduce numerical problems.

# Validation Options



- Specify how Simulation should handle unsupported Models
  - Raise Error – Provide an error message and prevents analysis from running
  - Raise Warning – Provide a warning message and set unsupported models to inactive
  - No Error/Warning - Set unsupported models to inactive but provide no message

# Validation



- Click “Run Validation” to validate the model
  - “Errors” will list errors with the model data specified
  - “Warnings” will list suggestions about strange or missing data
  - “Information Messages” will report any changes made to the model by the AutoCorrection routine
- Errors prevent the transient stability analysis from being run
- Click “Run AutoCorrection” to automatically correct many data errors
- Note that this may result in changes to the data

# Limits on Time Constants



- For an integration block  $\frac{1}{sT}$ 
  - Must be greater than specified multiple of the time step and nonzero
- For a filter block  $\frac{1}{1+sT}$ 
  - Same as above, but allowed to be zero
  - If zero, this becomes an ignored state
- For a lead-lag block  $\frac{1+sT_1}{1+sT_2}$ 
  - $T_2$  must be greater than specified multiple of time step
  - If  $T_2$  is zero,  $T_1$  must also be zero for causality

# Machine Model Reactance Validation



- For synchronous machine models, there are d-axis and q-axis reactance values
- Synchronous reactance -  $X_d$  and  $X_q$
- Transient reactance -  $X_d'$  and  $X_q'$
- Sub-transient reactance -  $X_d''$  and  $X_q''$
- Leakage reactance -  $X_l$
- The following two relationships must be satisfied (physically impossible to violate)
  - $X_l < X_q'' < X_q' < X_q$  and
  - $X_l < X_d'' < X_d' < X_d$
- These types of model errors are not uncommon

## Machine Reactance Auto-Correction



- When machine reactance model errors are found and auto-correction is applied, the following changes will be applied to the data
  - If  $X_q' > X_q$  then  $X_q' = 0.8X_q$
  - If  $X_d' > X_d$  then  $X_d' = 0.8X_d$
  - If  $X_q'' > X_q'$  then  $X_q'' = 0.8X_q'$
  - If  $X_d'' > X_d'$  then  $X_d'' = 0.8X_d'$
  - If  $X_l > X_q''$  then  $X_l = 0.8X_q''$
  - If  $X_l > X_d''$  then  $X_l = 0.8X_d''$

# Limit Consistency



- For Min/Max limits, Run Validation checks consistency of the limits – the Min limit must be less than or equal to the Max limit
- Clicking “Run AutoCorrection” when these types of errors are present will swap the Min and Max limit
- Initial limit violations are also indicated and handled using these validation tools

# Limit Consistency



- Some limit pairs must *surround zero*
  - Limits on Stabilizer Output (stabilizer output MUST be zero at steady state)
  - Limits on the derivative of a state (derivative must be zero at steady state)
    - Many governors have these types of limits
- Some limit pairs are specified by a single number and the limitation is +/- this limit

# Validation: Errors



- Many time constants must be a certain multiple of the integration time step
- Some time constants are not allowed to be zero and will result in an error
- If a model that Simulator can read is not supported, this may list an error

Summary Tables      Number of Errors

Validation Object	Validation Message
198 Generator LOW_MON_13.8_1003 (6774) #1, Stabilizer: PSS2A	Parameter Tw3 must be 2.0 times the time step (0 not allowed)
199 Generator LOW_MON_13.8_1005 (6776) #1, Stabilizer: PSS2A	Parameter Tw3 must be 2.0 times the time step (0 not allowed)
200 Generator LOW_MON_13.8_1006 (6777) #1, Machine Model: GENSAL	Parameter Tqopp must be 2.0 times the time step (0 not allowed)
201 Generator LOW_MON_13.8_1006 (6777) #1, Governor: IEEEG3_GE	Parameter Tg must be 2.0 times the time step (0 not allowed)
202 Generator LOW_MON_13.8_1008 (6779) #1, Machine Model: GENSAL	Parameter Tqopp must be 2.0 times the time step (0 not allowed)
203 Generator LOW_MON_13.8_1008 (6779) #1, Governor: IEEEG3_GE	Parameter Tg must be 2.0 times the time step (0 not allowed)
204 Generator LOW_MON_13.8_1009 (6780) #1, Machine Model: GENSAL	Parameter Tqopp must be 2.0 times the time step (0 not allowed)
205 Generator LOW_MON_13.8_1009 (6780) #1, Governor: IEEEG3_GE	Parameter Tg must be 2.0 times the time step (0 not allowed)
206 Generator MAPLE_VL_19_2200 (7004) #1, Machine Model: SVCWSC	SVCWSC model not supported in this version; contact PowerWorld for more information.
207 Generator MCNARY_115_139 (7293) #1, Machine Model: GENTPF	Parameter Xop must be >= 0.15 (0 not allowed)
208 Generator MCNARY_13.2_8003 (7306) #1, Stabilizer: PSS2A	Parameter Tw3 must be 2.0 times the time step (0 not allowed)

# Validation: Warnings



- Generator may not have a machine model
- Generators may be connected to buses with zero voltage
- Parameters may be outside of their expected range

Summary Tables      Number of Warnings

Validation Object	Validation Message
75 Generator CHELAN_F_11_1001 (12736) #1, Machine Model: GENTPF	Parameter Tdopp is usually < 1
76 Generator CHELAN_F_11_1001 (12736) #1, Machine Model: GENTPF	Parameter Tqopp is usually < 1
77 Generator NINECNYN_34.5_514 (12784) #1	Generator does not have machine modeled defined; treated as negative load.
78 Generator NINECNYN_34.5_513 (12785) #1	Generator does not have machine modeled defined; treated as negative load.
79 Generator NINECNYN_34.5_512 (12787) #1	Generator does not have machine modeled defined; treated as negative load.
80 Generator NINECNYN_34.5_511 (12788) #1	Generator does not have machine modeled defined; treated as negative load.
81 Generator NINECNYN_34.5_506 (12792) #1	Generator does not have machine modeled defined; treated as negative load.
82 Generator NINECNYN_34.5_501 (12794) #1	Generator does not have machine modeled defined; treated as negative load.
83 Generator ROCKY_RH_15_1003 (12896) #1	bus voltage is equal to zero; generator dynamic models set off
84 Generator ROCKY_RH_15_1001 (12898) #1	bus voltage is equal to zero; generator dynamic models set off
85 Generator ROCK_ISL_13.8_1020 (12939) #1, Machine Model: GENTPF	Parameter Tdopp is usually < 1
86 Generator ROCK_ISL_13.8_1020 (12939) #1, Machine Model: GENTPF	Parameter Tqopp is usually < 1
87 Generator ROCK_ISL_13.8_1020 (12939) #1	bus voltage is equal to zero; generator dynamic models set off

# Generator with no Machine Model



- What does Simulator do if a generator has no machine model (or model is inactive)?
  - Ignore exciter, stabilizer, governors, etc...
  - Treat the generators as a constant current based on the initial condition
    - Impedance is calculated from P, Q, and bus voltage from power flow solutions used as initial condition.
  - There is no special command to ask that this be done

# Validation: Informational Messages



- Parameters may be outside of their expected range
- Time constants may be increased to multiple of the time step or set to zero if allowed
- Messages will appear regarding any auto-corrections made when using the auto-correction tool

Summary Tables
Informational Messages

Validation Object	Validation Message
224 Generator CARMEN_S_11.5_1002 (12047) #1, Machine Model: GENTPF	Parameter Xqp must be >= 0.15 (0 not allowed); auto-corrected to 0.15
225 Generator TRAILBRG_11.5_1000 (12189) #1, Machine Model: GENTPF	Parameter Xqp must be >= 0.15 (0 not allowed); auto-corrected to 0.15
226 Generator WALTVILLE_66_604 (12190) #1, Machine Model: GENTPF	Parameter Xqp must be >= 0.15 (0 not allowed); auto-corrected to 0.15
227 Generator CHELAN_F_11_1002 (12735) #1, Machine Model: GENTPF	Parameter Tdopp is usually < 1; autocorrected to 1
228 Generator CHELAN_F_11_1002 (12735) #1, Machine Model: GENTPF	Parameter Tqopp is usually < 1; autocorrected to 1
229 Generator CHELAN_F_11_1002 (12735) #1, Exciter: EXST4B	Parameter Ta must be 2.0 times the time step; autocorrected to 0.01667
230 Generator CHELAN_F_11_1001 (12736) #1, Machine Model: GENTPF	Parameter Tdopp is usually < 1; autocorrected to 1
231 Generator CHELAN_F_11_1001 (12736) #1, Machine Model: GENTPF	Parameter Tqopp is usually < 1; autocorrected to 1
232 Generator CHELAN_F_11_1001 (12736) #1, Exciter: EXST4B	Parameter Ta must be 2.0 times the time step; autocorrected to 0.01667
233 Generator ROCKY_RH_15_2001 (12904) #1, Governor: GPWSCC	Parameter Td must be 4.0 times the time step; autocorrected to 0.03333
234 Generator ROCKY_RH_15_2001 (12904) #1, Governor: GPWSCC	Parameter Tf must be 4.0 times the time step; autocorrected to 0
235 Generator ROCKY_RH_15_3003 (12906) #1, Governor: GPWSCC	Parameter Td must be 4.0 times the time step; autocorrected to 0.03333

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