Compliance Bulletin – MOD-026, MOD-027 & Tariff

Provision of Validated Dynamics Models to ISO New England

ISO New England Inc.
Reliability and Operations Compliance
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ISO New England Compliance Bulletin for MOD-026, MOD-026 and Tariff Provision of Validated Dynamics Models

EFFECTIVE DATE: August 2016

REFERENCES:

NERC Standard MOD-026-1 — Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions

NERC Standard MOD-027-1 —Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions

Schedule 22 to the ISO New England Open Access Transmission Tariff – Large Generator Interconnection Procedures

Schedule 23 to the ISO New England Open Access Transmission Tariff – Small Generator Interconnection Procedures

ISO New England Transmission, Markets and Services Tariff Section I.3.9

ISO New England Operating Procedure No. 5 Generator, Dispatchable Asset Related Demand and Alternative Technology Regulation Resource Maintenance and Outage Scheduling (OP 5)

ISO New England Operating Procedure No. 14 - Technical Requirements for Generators, Demand Response Resources, Asset Related Demands and Alternative Technology Regulation ResourcesISO/NPCC Corroborating Evidence Interpretations and Compliance Guidance (CEICG)

In case of a discrepancy between this Compliance Bulletin and a NERC Reliability Standard or an ISO New England Operating Document, the NERC Reliability Standard or the ISO New England Operating Document shall govern.

1.0 Introduction

The ISO New England Transmission, Markets and Services Tariff and NERC Reliability Standards MOD-026 and MOD-027 have requirements for the provision of updated generator dynamics data based on testing and analysis. This compliance bulletin provides a guideline for how to provide that information to ISO New England (ISO) and how to contact ISO regarding questions.

2.0 MOD-026-1 and MOD-027-1

Summary

The MOD-026-1 (MOD-026) and MOD-027-1(MOD-027) Reliability Standards require that verified models for dynamic characteristics be provided. MOD-026-1 includes requirements for the provision of verified generator and excitation system models and associated components. MOD-027 also includes requirements for the provision of verified governor models. Lead Market Participants (Lead MPs) shall submit models for MOD-026 and MOD-027 at the same time so that ISO can review all models simultaneously.

Lead Market Participant Submittals via Dynamics Data Management

While the NERC standards refer to Generator Owners, this compliance bulletin refers to Lead MPs that submit data on behalf of Generator Owner. Lead MPs must submit all dynamic data by using the ISO's Dynamics Data Management System (DDMS). The Lead MP's Security Administrator for the ISO's Customer Asset Management System (CAMS) assigns the role of "DDMS Compliance Officer" to the person or persons that the Lead MP selects to submit and review DDMS data. Once a DDMS Compliance Officer(s) is designated in CAMS, the Lead MP can use the DDMS system to submit new data pursuant to the MOD-026 and MOD-027 standards or Generator Interconnection Agreements. Lead MPs are required to submit models for MOD-026 and MOD-027 at the same time so that the ISO can review all models simultaneously, and entries should include all backup information to model the generator. Training for DDMS is available using ISOTen and questions can be addressed to ISO Customer Support.

MOD-026 and MOD-027 Requirement R1

Requirement R1 requires the Transmission Planner (ISO) to provide information to the Lead MP on how to obtain listings of acceptable models and existing generator models. ISO has a CEICG statement (CEICG-23) that discusses R1 and obtaining information regarding acceptable models.

MOD-026 and MOD-027 Requirement R2

Requirement R2 requires the Lead MP to provide to the Transmission Planner verified models for the generator, excitation and governor, along with associated equipment including power system stabilizer (if equipped) and representation of governor real power response effects for of outer loop controls (such as operator set point controls, and load control, but excluding AGC control) that would override the governor response (including blocked or nonfunctioning governors or modes of operation that limit Frequency Response), if applicable. The standards provide further details on modeling requirements.

Lead MPs must submit the verified models to ISO using the DDMS. Lead MPs are required to submit verified models for MOD-026 and MOD-027 at the same time so that ISO can review all models simultaneously in order to reduce review time. Lead MPs shall submit PSS/e dyr and raw files in addition to a pdf file with documentation demonstrating the applicable unit's simulated model response matches the recorded voltage and MW response from either a staged test or a measured system disturbance. The ISO DDMS User Guide includes details on entering information.

Note: A completed MOD-026 and MOD-027 data submittal to ISO includes

- ✓ PSS/e .dyr and .raw files
- ✓ PDF file demonstrating a comparison of simulated model response to actual from either a staged test or measured system disturbance.
- ✓ And is considered submitted when moved from Draft in DDMS to Submitted

The standards allow Lead MPs to provide documentation that demonstrates the models response in a simulation matches the recorded response for either a staged test or measured system disturbance. To perform a staged test for excitation system verification (that includes Power System Stabilizer, when equipped), typically Generator Owners change the voltage regulator reference by a nominal step and then compare generator actual response with a simulation using the model to ensure that the simulated response matches the step test response. For governor testing, an on-line speed governor reference test and/or partial load rejection test is performed. Generator Owners perform the on-line speed reference test by changing the governor reference by a set step and then comparing the simulated response using the governor model with the actual response. For the partial load rejection test, the generator is brought to a small MW and under-excited MVAR load. The generator is then tripped and the speed is recorded during coast-down. Generator Owners can verify the generator inertia constant and some governor model parameters using this test. The staged testing described here is typical and the actual testing methods selected are the responsibility of the Generator Owner.

When staged testing is performed then Lead Market Participants shall submit an application for the testing using ISO Outage Software at least two weeks prior to the scheduled test. The ISO Outage Software application shall include a summary of the testing procedure.

Generator Owners may also decide to compare simulations with verified models to actual events. ISO New England does not provide event recordings for comparison and makes no prediction regarding the adequacy of events for comparisons. Generator Owners may decide to purchase PMUs to assist with this method of verification if it selected.

MOD-026 and MOD-027 Requirement R3

Requirement R3 requires the Lead MP to provide a response within 90 calendar days of receiving a notification from the Transmission Planner that a model is not "usable," if there are technical concerns with a model or evidence is provided by the Transmission Planner indicating that a model's response is not representative of system events.

The Lead MP's written response must contain either the technical basis for maintaining the current model, the model changes, or a plan to perform model verification. This response must be submitted to the ISO by the DDMS Certification Officer using DDMS.

MOD-026 and MOD-027 Requirement R4

Section I.3.9 of the Open Access Transmission Tariff (OATT), which is Section II of the ISO New England Transmission, Markets and Services Tariff requires each Market Participant to submit plans to modify equipment prior to making a change. Similarly, MOD-26 and/or MOD-027 require that Generator Owners provide revised model data or plans to perform model verification for applicable units within 180 calendar days of making changes that alter the equipment response characteristics. Lead MPs must submit plans to the ISO in accordance with Section I.3.9 of the OATT for ISO review prior to modifying equipment. Because the requirements of Section I.3.9 of the OATT are more stringent than MOD-026-1 and MOD-027-1, by complying with Section I.3.9 of the OATT, Lead MPs will also comply with MOD-026-1 and MOD-027-1.

MOD-026 Requirement R5

MOD-026 Requirement R5 requires the Lead MP to provide a written response to its Transmission Planner, within 90 calendar days following receipt of a technically justified unit request from the Transmission Planner to perform a model review of a unit or plant. These submissions must be made by the Lead MP to the Transmission Planner (*i.e.* the ISO) using DDMS.

MOD-026 Requirement R6 and MOD-027 Requirement R5

MOD-026 Requirement R6 and MOD-027 Requirement R5 require the Transmission Planner to provide a written response to Lead MPs regarding the "usability" of a model within 90 calendar days of receiving dynamics models under MOD-026 and MOD-027. If a Lead MP has a question about the status of a model review or model usability they can be made by contacting ISO New England Customer Support at (413) 540-4220 or custserv@iso-ne.com and referencing the MOD-026 or MOD-027 standards and the generator.

3.0 ISO Generator Interconnection Obligations

Large Generator Interconnection Agreement

Article 24 of the Large Generator Interconnection Agreement requires entities to provide the ISO with any and all "as-built" Large Generating Facility information and "as-tested" performance information that differs from the initial submissions or, alternatively, written confirmation that no such differences exist. The Interconnection Customer shall conduct tests on the Large Generating Facility as required by Good Utility Practice such as an open circuit "step voltage" test on the Large Generating Facility to verify proper operation of the Large Generating Facility's automatic voltage regulator.

Submissions under Article 24 must be made to the ISO using DDMS. Training for DDMS is available using ISOTen and questions can be addressed to ISO Customer Support. The ISO New Gen Coordinator or ISO Customer Support can provide additional information on registering to use DDMS and entering models using DDMS. Appendices 1 through 3 show the information required for new generation facilities.

Appendix 1 – New Unit Dynamics Verification with DDMS

Subject: Dynamics Verification for new units

Pursuant to Section II.A.6 of ISO Operating Procedure OP-14, dynamics models for Generators 5 MW or greater can be required when ISO determines it to be necessary for ISO to carry out its responsibility of reliably and efficiently operating the power system. For new resources, NERC Standard MOD-032 also requires this data for generators, HVDC lines, and other power electronic devices which are a part of the Bulk Electric System. For resources in the ISO-NE Interconnection Queue, this data must be submitted through the DDMS once the results of the System Impact Study (SIS) have been accepted by the Developer at the Results Meeting.

DDMS can be accessed via the SSO/SMD home page by selecting the Dynamics Data Management System. A short ten-minute training video for DDMS is available here using ISO-TEN.

A summary of the DDMS submissions required for new generators is as follows:

1. The New Interconnection Developer (Developer) will assign the DDMS Compliance Officer role to an individual in CAMS, if this role is not already assigned. In the event that the Developer does not have a CAMS Security Administrator who can assign this role, ISO-NE Customer Service will perform this step.

2. Once the SIS are presented at the results meeting and accepted by the Developer, then the Developer's DDMS Compliance Officer shall enter the dynamics model and parameters from the SIS into DDMS.

3. When "As-Purchased" data becomes available, the Developer will be responsible for submitting the new data by entering a new "issue" in DDMS. An ISO Tech Lead will then review the data and approve the models or request additional information. If this data is considered a Material Modification from the data studied in the SIS, the project will be required to re-enter the ISO's Interconnection Queue as described in Schedule 22 of the OATT.

4. When "As-Built" data becomes available, the Developer will be responsible for submitting the new data by entering a new "issue" in DDMS. An ISO Tech Lead will then review the data and approve the models or request additional information. This information is required prior to ISO approval for Commercial Operation. If this data is considered a Material Modification from the data studied in the SIS, the project will be required to re-enter the ISO's Interconnection Queue as described in Schedule 22 of the OATT.

If you have additional questions on this process, please contact ISO New England Customer Support at (413) 540-4220 or custserv@iso-ne.com.

Appendix 2 – Conventional Unit "As-Built" data

Requirement for Provision of Dynamic and Other Generator Data

Generator Owners are required to provide updated generator characteristics in accordance with Article 24 of the ISO New England Large Generator Interconnection Agreement, Sections 4.4 and 11.1 of the ISO New England Small Generator Interconnection Agreement, and/or Section I.3.9 analysis model or model assumptions. This letter outlines requirements for updating generator data relative to data from the initial study process or the Section I.3.9 analysis. Updated generator dynamic characteristics are very important from both reliability and economic standpoints. Accurate generator dynamic information helps to ensure that the system remains stable during a disturbance event and individual generators remain stable during transmission line outages. In addition, transfer and generator dispatch limits are set based on this stability data. Accurate information is required to operate the system in a reliable economic manner. Factory start-up engineers should be able to provide considerable assistance in providing this information during the construction and commissioning process. Generator Owners are also required to update other information prior to commencing Trial or Commercial Operation.

Under the requirements listed here, the Generator Owner will verify generator data on two occasions after a project has proceeded under a Large Generator Interconnection Agreement and/or under the Section I.3.9 application review and determination process. For the first submission, per Article 24.3 of the Interconnection Agreement "as-purchased" generator manufacturer data should be submitted 180 days prior to Trial Operation. The second submission will include verification data from an actual excitation system test and confirmation of "as-built" data during Trial Operation. Under the terms of the Interconnection Agreement, a Generator must submit this data and studies, as required, must be performed by the ISO prior to the Generator being allowed to begin Commercial Operation. Article 24.4 of ISO New England Large Generator Interconnection Agreement contains specific contract language about the requirements for this submission. Submission of correct data is crucial, as FERC and NERC have imposed large civil penalties on entities for failure to ensure the reliability of the electric system.[1]

Submittal per Section I of this document: For the first submission, per Article 24.3 of the ISO New England Large Generator Interconnection Agreement, "as-purchased" generator manufacturer data shall be submitted at least 180 days prior to Trial Operation. It is in the best interest of the Generator Owner to submit this data at the earliest possible convenience as review may be required if the data differs from what was provided in the Interconnection Request or under the System Impact Study or the original Section I.3.9 application stability study or stability model provision. The Generator Owner shall submit this information as provided by the manufacturer. Information submitted for stability models shall be compatible with Interconnecting Transmission Owner and System Operator standard models. If there is no compatible model, the Interconnection Customer will work with a consultant mutually agreed to by the Parties to develop and supply a standard model and associated information. The models

[1] http://www.ferc.gov/enforcement/civil-penalties/civil-penalty-action.asp
FERC Enforcement/Civil Penalties/Civil Penalty Actions
http://www.nerc.com/filez/enforcement/index.html NERC Enforcement Actions

provided must be compatible with Siemens PSS/E and if the interconnection is into a Transmission Operator that uses General Electric PSLF then models must be compatible with both PSS/E and PSLF. If the model provided is not directly compatible with PSS/E and PSLF then a mutually agreeable consultant shall be selected to provide a model compatible with both PSS/E and PSLF.

Submittal per Section II of this document: The Generator Owner shall provide factory Start-up Engineers with the study models and parameters determined via the original Section I.3.9 study or subsequent updates to models and parameters based on the requirements of Article 24.3 of the ISO New England Large Generator Interconnection Agreement, provided for in Section I of this document with subsequent ISO review. This will ensure that the generator is set up during commissioning as studied. Generators have become unstable in real-time operation when actual values are different from those values studied.

Once system commissioning with study values is complete in accordance with Article 24.4 of the Large Generator Interconnection Agreement, the Generator shall provide actual excitation system step-test data and the Generator shall provide "as-built" data or written confirmation that no difference from previous submissions is required per Article 24.4 of the ISO New England Large Generator Interconnection Agreement. This data will be available during Trial Operation. **This data is required prior to a Generator being available for Commercial Operation.** Also, the Generator Owner is required to provide the section of the generator step-up transformer manufacturer's test report showing tap impedances and load losses as shown below.

Submittals of Generator Dynamic Characteristic Information:

Submit all generator dynamic characteristic information using DDMS in PDF documents as outlined in this document based on actual manufacturer information.

Other Requirements for Trial or Commercial Operation and Submittals: Market Participants must ensure that other requirements are in place prior to or during Trial Operation and Commercial Operation in accordance with the ISO Tariff, Large Generator Interconnection Procedures and other procedures. These requirements include, but are not limited to, the documentation shown in Table 1 below. This documentation is required in some cases prior to Trial Operation. Failure to provide the required information will result in suspension of Trial Operation and Commercial Operation will not commence. Generators should submit other information to the ISO in accordance with practices as outlined further in documentation provided for that information.

Appendix 2 – Conventional Unit "As-Built" data

Table 1 – Summary Table of Required Generator Data to Participate in ISO-NE Markets		
Data Requirement	ISO-NE Procedure	NERC/FERC Requirement
Generator Dynamic Stability & Ratings Information As-Bought	**This Transmittal**	**LGIP Article 24.3** **NERC MOD-012/013**
Generator Dynamic Characteristic Step Test Results and As-Built	**This Transmittal**	**LGIP Article 24.4** **NERC MOD-012/013**
NX-9	**OP-16**	**NERC FAC-009, MOD-010/011**
NX-12	**OP-14**	**NERC FAC-009, MOD-010/011/024**
NX-12D	**OP-14**	**NERC FAC-009, MOD-010/011/025**
Telemetering including Automatic Voltage Regulator Status *	**OP-18**	**NERC COM-002, VAR-002**
Electronic Dispatch	**OP-14**	**NERC COM-002**
Revenue Metering	**OP-18**	
Auto Ringdown (unit > 50 MW)	**OP-14**	
Station One-Line Diagram with appropriate Nomenclature	**OP-16**	
Voltage Schedule	**OP-12**	**NERC VAR-002**

* NERC Registered Generators should be aware of all applicable standards and requirements including Standard VAR-002 Requirement R1:

R1. The Generator Operator shall operate each generator connected to the interconnected transmission system in the automatic voltage control mode (automatic voltage regulator in service and controlling voltage) unless the Generator Operator has notified the Transmission Operator.

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Data Required – Provide PDF Copy of Manufacturers Data

GENERATOR RATINGS:
Rated MVA:
Rated MW:

COMBINED TURBINE-GENERATOR-EXCITER INERTIA DATA

Inertia Constant, H (kW sec/kVA)
Moment-of-Inertia, WR2 (lb. ft.2)

REACTANCE DATA (PER UNIT-RATED KVA)

	DIRECT AXIS	QUADRATURE AXIS
Synchronous – saturated	Xdv	Xqv
Synchronous – unsaturated	Xdi	Xqi
Transient – saturated	X’dv	X’qv
Transient – unsaturated	X’di	X’qi
Subtransient – saturated	X”dv	X”qv
Subtransient – unsaturated	X”di	X”qi
Negative Sequence – saturated	X2v	
Negative Sequence – unsaturated	X2i	
Zero Sequence – saturated	X0v	
Zero Sequence – unsaturated	X0i	
Leakage Reactance	Xlm	

FIELD TIME CONSTANT DATA (SEC)

Open Circuit	T’do	T’qo
Three-Phase Short Circuit Transient	T’d3	T’q
Line to Line Short Circuit Transient	T’d2	
Line to Neutral Short Circuit Transient	T’d1	
Short Circuit Subtransient	T”d	T”q
Open Circuit Subtransient	T”do	T”qo

ARMATURE TIME CONSTANT DATA (SEC)

Three Phase Short Circuit	Ta3
Line to Line Short Circuit	Ta2
Line to Neutral Short Circuit	Ta1

Data Required – Provide PDF Copy of Manufacturers Data

MW CAPABILITY AND PLANT CONFIGURATION
LARGE GENERATING FACILITY DATA

ARMATURE WINDING RESISTANCE DATA (PER UNIT)

Positive	R1
Negative	R2
Zero	R0

Rotor Short Time Thermal Capacity - $(I_2)^2t$
Field Current at Rated kVA, Armature Voltage and PF (amps)
Field Current at Rated kVA, Armature Voltage and 0 PF (amps)
Three Phase Armature Winding Capacitance (microfarad)
Field Winding Resistance (ohms at °C)
Armature Winding Resistance (Per Phase) (ohms at °C)

CURVES

Provide Saturation, Vee, Reactive Capability, Capacity Temperature Correction curves. Designate normal and emergency Hydrogen Pressure operating range for multiple curves.

EXCITATION SYSTEM DATA

Provide factory documentation that identifies the appropriate IEEE model block diagram of excitation system for computer representation in power system stability simulations and the corresponding excitation system constants for use in the model.

Include information on optional systems provided with excitation including:

Power System Stabilizer
Line Drop Compensation
Reactive Current Compensation
Over or Under Excitation Limiter

GOVERNOR SYSTEM DATA

Provide factory documentation that identifies appropriate IEEE model block diagram of governor system for computer representation in power system stability simulations and the corresponding governor system constants for use in the model. Provide the control system manufacturer and type data.

INDUCTION GENERATORS

(*) Field Volts:

(*) Field Amperes:

(*) Motoring Power (kW):

(*) Neutral Grounding Resistor (If Applicable):

(*) I_2^2t or K (Heating Time Constant):

(*) Rotor Resistance:

(*) Stator Resistance:

(*) Stator Reactance:

(*) Rotor Reactance:

(*) Magnetizing Reactance:

(*) Short Circuit Reactance:

(*) Exciting Current:

(*) Temperature Rise:

(*) Frame Size:

(*) Design Letter:

(*) Reactive Power Required In Vars (No Load):

(*) Reactive Power Required In Vars (Full Load):

(*) Total Rotating Inertia, H: (Per Unit on KVA Base)

Generator Step-Up Transformer

Load Losses and Impedance Voltage from Transformer Factory Test Report.

Provide information as shown in the following section directly from the test report.

Section 1 - Sample Submittal of Generator Data
Provide Actual PDF Copy

REACTANCE DATA (PER UNIT)	DIRECT AXIS		QUADRATURE AXIS	
Saturated Synchronous	(Xdv)	1.167	(Xqv)	1.896
Unsaturated Synchronous	(Xdi)	1.166	(Xqi)	1.696
Saturated Transient	(X'dv)	0.155	(X'q)	0.530
Unsaturated Transient	(X'di)	0.227		
Saturated Subtransient	(X"dv)	0.126	(X"qv)	0.116
Unsaturated Subtransient	(X"di)	0.179	(X"qi)	0.166
Saturated Negative Sequence	(X2v)	0.115		
Unsaturated Negative Sequence	(X2i)	0.161		
Saturated Zero Sequence	(Xov)	0.053		
Unsaturated Zero Sequence	(Xoi)	0.071		
Leakage Reactance	(XLM,OEX)	0.165		
	(XLM,UEX)	0.169		

Field Time Constant Data (Sec. at 125 C)				
Open Circuit	(T'do)	5.315	(T'qo)	0.303
Three Phase Short Circuit Transient	(T'd3)	0.389	(T'q)	0.303
Line to Line Short Circuit Transient	(T'd2)	0.951		
Line to Neutral Short Circuit Transient	(T'd1)	1.061		
Short Circuit Subtransient	(T"d)	0.021	(T"q)	0.023
Open Circuit Subtransient	(T"do)	0.031	(T"qo)	0.053

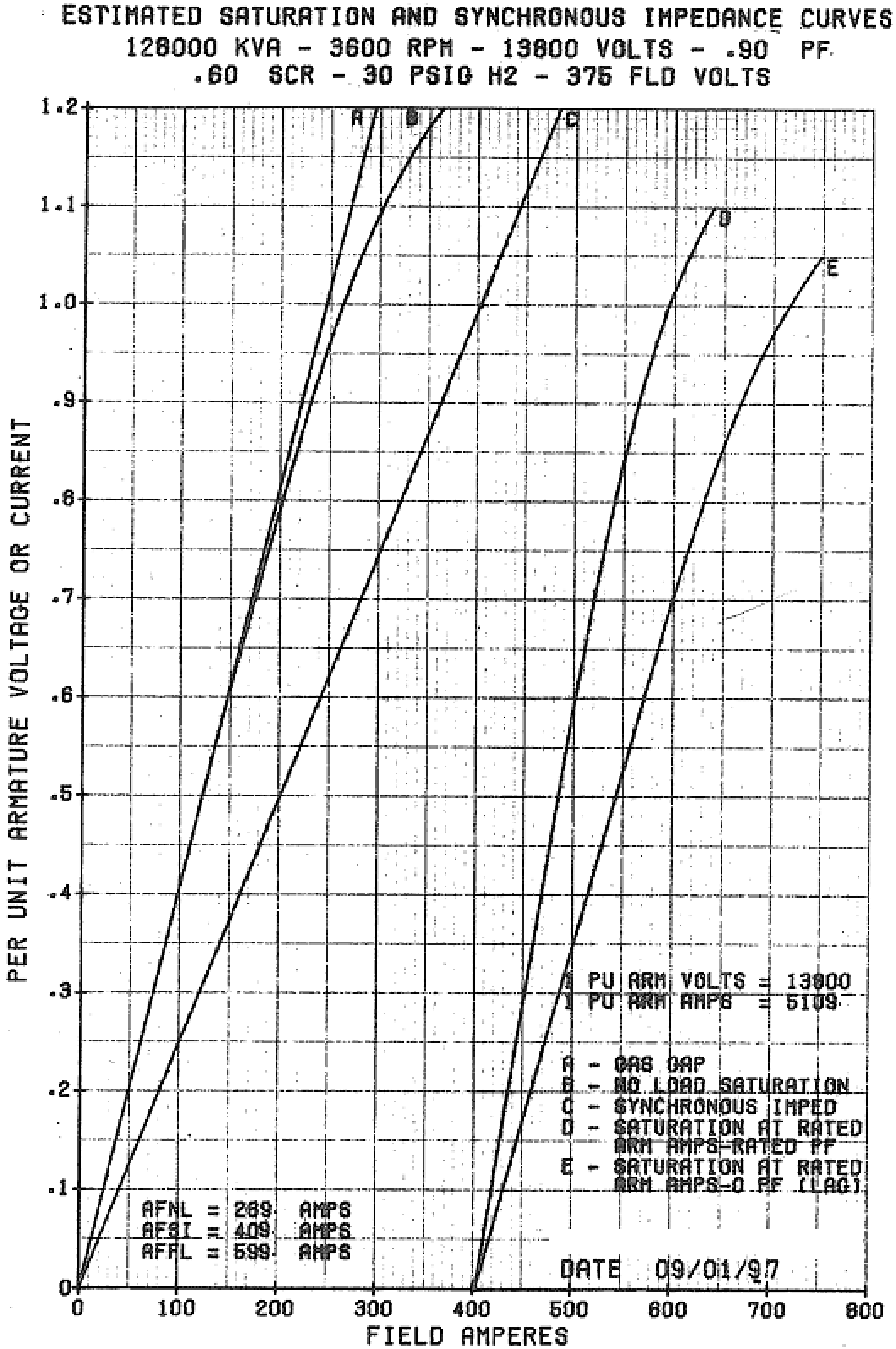
Armature DC Component Time Constant Data (Sec. at 100 C)		
Three Phase Short Circuit	(Ta3)	0.243
Line to Line Short Circuit	(Ta2)	0.244
Line to Neutral Short Circuit	(Ta1)	0.205

Per Unit Armature Winding Sequence Resistance Data		
Positive	(R1)	0.002
Negative	(R2)	0.012
Zero	(Ro)	0.002

Rotor Short-time Thermal Capacity $(I_2)^2t$ 33
Turbine and Generator Combined Inertia Constant (H) . . . . 3.33 KW Sec/KVA
Three Phase Armature Winding Capacitance . . . . 0.803 Microfarads
Armature Winding DC Resistance (per phase) . . . . 0.00163 Ohms (100 C)
Field Winding DC Resistance . . . . 0.551 Ohms (125 C)
Field Current at Rated KVA, Rated Armature Voltage, Rated PF . . . . 554.3 Amps
Field Current at Rated KVA, Rated Armature Voltage, 0 PF Lagging . . . . 705.7 Amps*

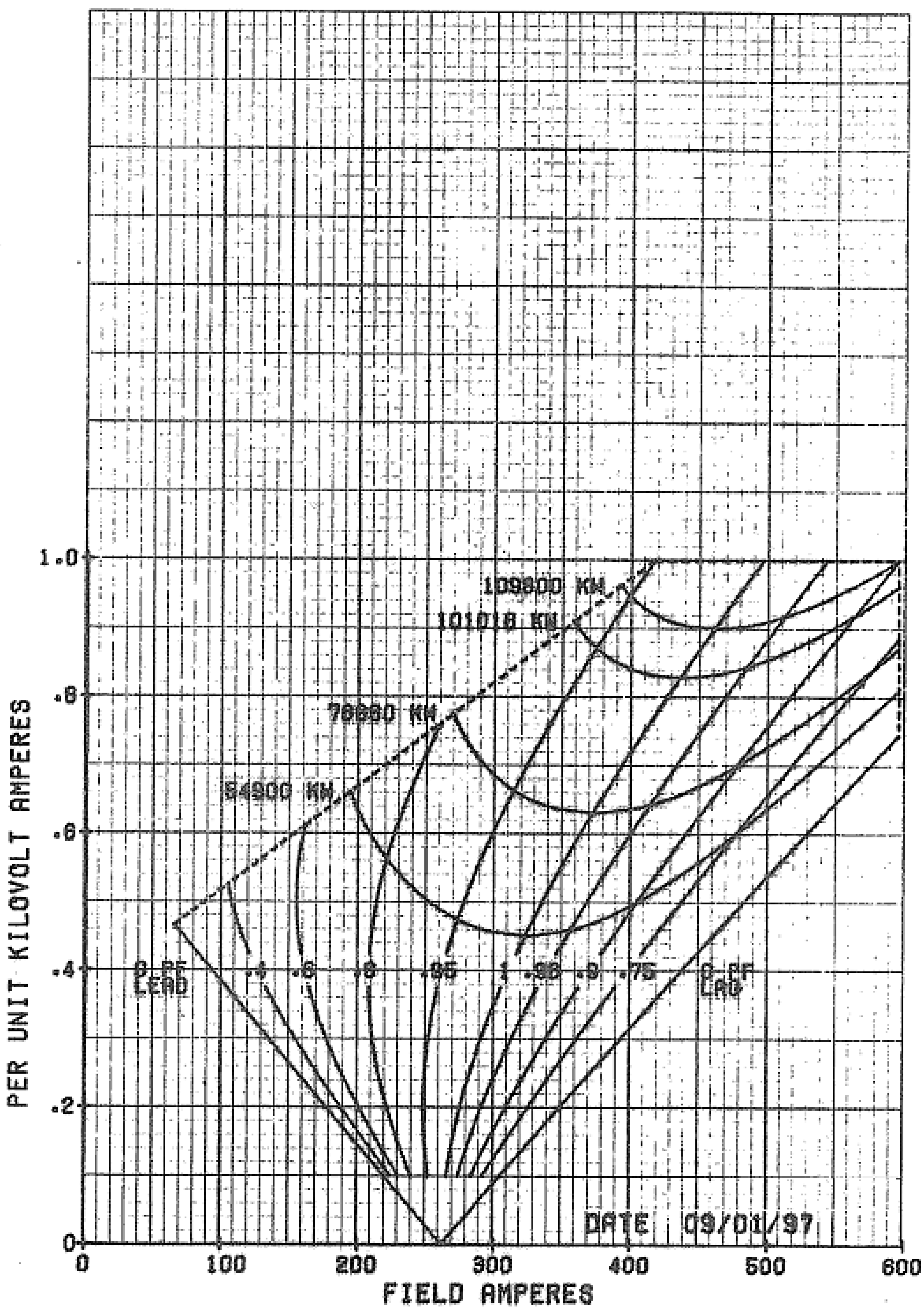
*This is not an allowable operating point for the generator. Value is supplied for systems study only.

Section 1 - Sample Submittal of Generator Data
Provide Actual PDF Copy



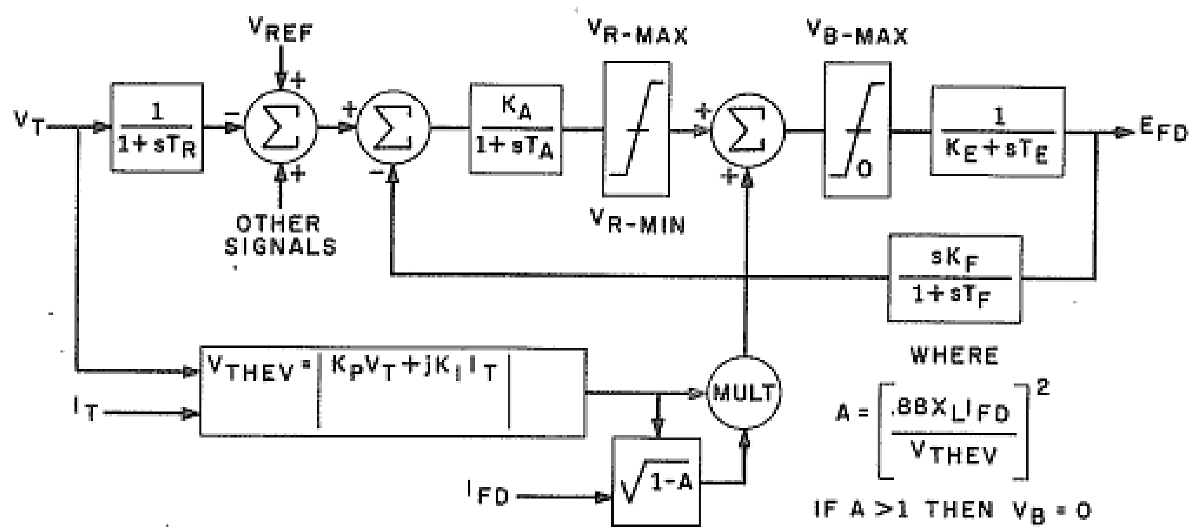
Section 1 - Sample Submittal of Generator Data
Provide Actual PDF Copy

ESTIMATED EXCITATION V CURVES
128000 KVA - 3600 RPM - 13800 VOLTS - .90 PF
.60 SCR - 30 PSIG H2 - 375 FLD VOLTS



Section 1 - Sample Submittal of Generator Data
Provide Actual PDF Copy

EXCITATION SYSTEM CONSTANTS – SCT-PPT STATIC EXCITATION

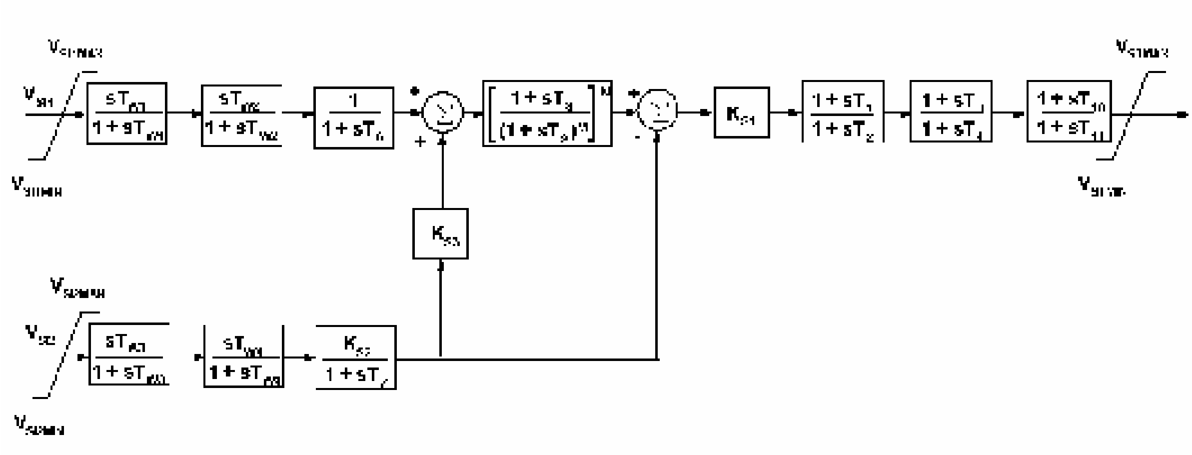


Ref: Generator Design Dated 090197 KVA 128,000 Volts 13,800

	Minimum design response ratio	0.5
	Regulator type	SCR
E_F	Nominal field voltage	375
TYPE	IEEE definition	3
T_R	Regulator input filter time constant	0
K_A	Regulator gain	125
T_A	Regulator amplified time constant	.15
V_R-Max	Maximum value of V_R	1.3
V_R-Min	Minimum value of V_R	−1.3
K_F	Regulator stabilizing circuit gain	.03
T_F	Regulator stabilizing time constant	0.66
K_P	Potential circuit gain of type 3 system	1.13
K_E	Excitation constant related to self-excited field	1.3
T_E	Exciter time constant	0.3
$V_{B_{Max}}$	Maximum value of field voltage (saturated value)	3.63
K_I	Current circuit gain	2.18
X_L	Exciter reactance value	0.88
I_{FD}	Generator field current	
I_T	Generator terminal current	
V_R	Regulator output voltage	
V_{REF}	Regulator reference voltage setting	
V_T	Generator terminal voltage	
V_{THEV}	Voltage obtained by vector sum of potential and current signals	
E_{FD}	Exciter output voltage	

Typical

IEEE Type PSS2B Model of
"Integral of Accelerating Power" Type Power System Stabilizer



PSS Constant	Value	Comments
VSI1	Δω (p.u.)	Rotor speed deviation
VSI2	Pe (p.u.)	Gen. electrical power
VSI1max	0.4 p.u.	
VSI1min	-0.4 p.u.	
VSI2max	2.5 p.u.	
VSI2min	-2.5 p.u.	
Tw1	18 sec.	
Tw2	18 sec.	
Tw3	18 sec.	
Tw4	0	bypass washout block
T6	0	
T7	1.8 sec.	
KS2	0.68 p.u.	= T7/2H; H=6.66
KS3	1.8 p.u.	

PSS Constant	Value	Comments
Ks1	22 p.u.	Typical Values. Final Values determined during PSS commissioning
T1	0.14 sec.	
T2	0.013 sec.	
T3	0.12 sec.	
T4	0.013 sec.	
T10	0	
T11	0	
T8	0.62 sec.	
T9	0.15 sec.	
M	5	
N	1	
VSTmax	0.10 p.u.	
VSTmin	-0.10 p.u.	

<u>Reference</u>: IEEE Standard 421.5-2005, "IEEE Recommended Practice for Excitation System Models for Power System Stability Studies"

1. HARDWARE-BASED TURBINE-GOVERNOR MODEL PARAMETERS
(See Figure 1)

A. BLOCK DIAGRAM INPUTS AND OUTPUTS

Turbine Speed

Turbine speed is expressed in units of Revolutions Per Minute (RPM).
Synchronous speed = 3600RPM.

Combuston Turbine Power Ouput (MWs)

Combustion turbine power output is expressed in units of megawatts.

MW Req

MW request is expressed in units of megawatts.

Droop

Droop is expressed in units of megawatts.

B. DIGITAL CONTROL SYSTEM

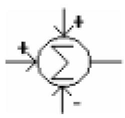
All items in Figure 1 contained within the box designated with a dashed (----) border are implemented within a digital control system. The control system samples turbine speed every 6 milliseconds, MW request every second, and the MW feedback every 6 milliseconds. The PID error signal is calculated every 6 milliseconds, as is the output from the parallel PID controller. Inputs to the PID controller must be scaled between 0-100% and the output from the PID controller will be a number from 0-100%. Note that, although not shown, the output from the PID controller is limited such that megawatts can not be increased instantaneously by more than 10% rated load and that after that increase, unit loading is limited to the normal unit load rate.

C. BLOCK DIAGRAM PARAMETERS

f(x)

The droop function generator has turbine speed as its input and megawatts as its output. The droop has a default setting of 4% which yields the following function:

Turbine Speed	Droop Output
3456 RPM (4% decrease)	+220 MW (increase MW)
3600 RPM	0 MW
3744 RPM (4% increase)	-220 MW (decrease MW)



Summer which produces error signal every 6 milliseconds.

K_1

K1= 0.60. This gain is required in order to scale the inputs to the PID controller to be 0-100%.

$$K_p + \frac{S}{T_i S}$$

This is a parallel PID controller which has an output range of 0-100%. Typical settings are:

Kp = 0.66
Ti = 6 (seconds per repeat)

Note that these parameters are defaults which may be tuned to obtain the appropriate response.

$$\frac{\ddot{S}2}{T_v S \ +1}$$

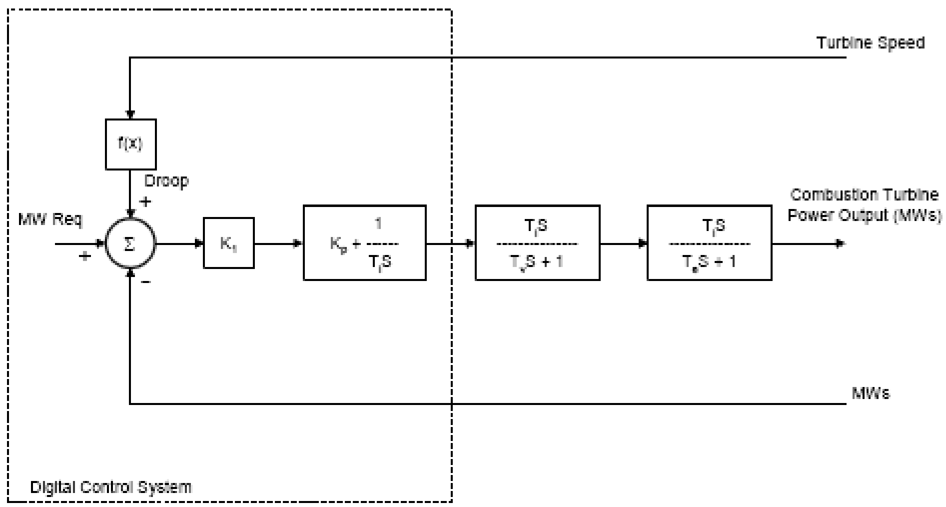
This block represents the throttle valve dynamics and additionally incorporates a gain factor in order to scale the final megawatt demand output appropriately. Values are:

K2 = 4.4
Tv = 0.4 seconds

Section 1 - Sample Submittal of Generator Data
Provide Actual PDF Copy

$$\frac{1}{T_e S + 1}$$

This block represents the transfer function for piping and combustion. Settings are:
Te = 0.59 seconds



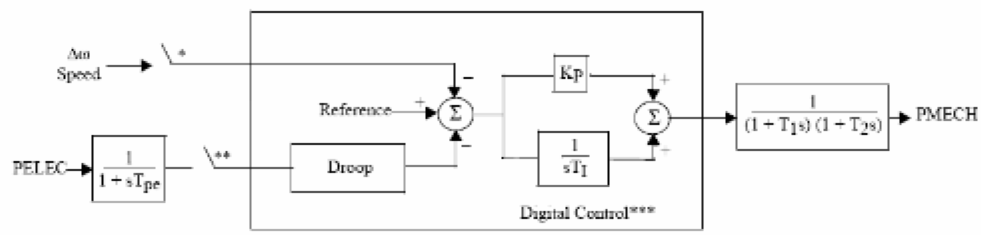
COMBUSTION TURBINE GOVERNOR BLOCK DIAGRAM

Figure 1

2. ALTERNATIVE MODEL PARAMETERS FOR USE WITH THE PTI PSS/E SIMULATION SOFTWARE "WESGOV" (OR SIMILAR) MODEL STRUCTURE (See Figure 2)

The hardware-based turbine governor model in Figure 1 expresses the speed input in terms of revolutions per minute (rpm) and the power input and output in terms of megawatts (MW). It is recognized that some turbine governor models express speed and power inputs and outputs in terms of per unit (p.u.) of rated values. This is the case for the Power Technologies International (PTI) "WESGOV" model structure in the PSS/E program package.

Figure 2 shows the "WESGOV" model structure, in which the input and output values are expressed in per unit (p.u.). Table 1 shows how the model constants for Figure 1 can be converted into equivalent model constants for the model in Figure 2. Table 1 also provides typical "WESGOV" (or similar model) constants, based on typical control settings and characteristics for the combustion turbine.



*Sample hold with sample period defined by ΔTC.
**Sample hold with sample period defined by ΔTP.
***Maximum change is limited to A_{LIM} between sampling times.

Figure 2 - "WESGOV" Model Structure.
(Note: Speed, PELEC, and PMECH values expressed in p.u.)

Table 1 -- Derivation of "WESGOV" Model Constants and Typical Values

WESGOV Model Constant	Value Derived from Hardware-Based Model	Model Constant using typical data
Droop	= p.u. value of droop setting = %Droop/100	0.09 p.u.
Kp	= K_1*K_p*K_2 / Droop	29.6 p.u.
T_I	= Ti * Droop / (K_1*K_2)	0.19 sec.
T_1	= Tv	0.39 sec.
T_2	= Te	0.51 sec.
T_{pe}	= Electric power transducer lag time constant	0.19 sec.
ΔTC	= Sample/hold period for speed input	0.09 sec.
ΔTP	= Sample/hold period for electrical power input	0.09 sec.
A_{LIM}	= 0.9 * 0.63 * K_1*K_p*K_2	0.69 p.u.

3. ALTERNATIVE MODEL PARAMETERS FOR USE WITH THE GE-PSLF SIMULATION SOFTWARE "GGOV1" (OR SIMILAR) MODEL STRUCTURE (See Figure 3)

The hardware-based turbine governor model in Figure 1 expresses the speed input in terms of revolutions per minute (rpm) and the power input and output in terms of megawatts (MW). It is recognized that some turbine governor models express speed and power inputs and outputs in terms of per unit (p.u.) of rated values. This is the case for the latest version of the "ggov1" model in the General Electric PSLF program package,

Figure 3 shows the "ggov1" model structure, in which the input and output values are expressed in per unit (p.u.). Table 2 shows how the model constants for Figure 1 can be converted into equivalent model constants for the model in Figure 3. Table 2 also provides typical "ggov1" (or similar model) constants, based on typical control settings and characteristics for the combustion turbine.

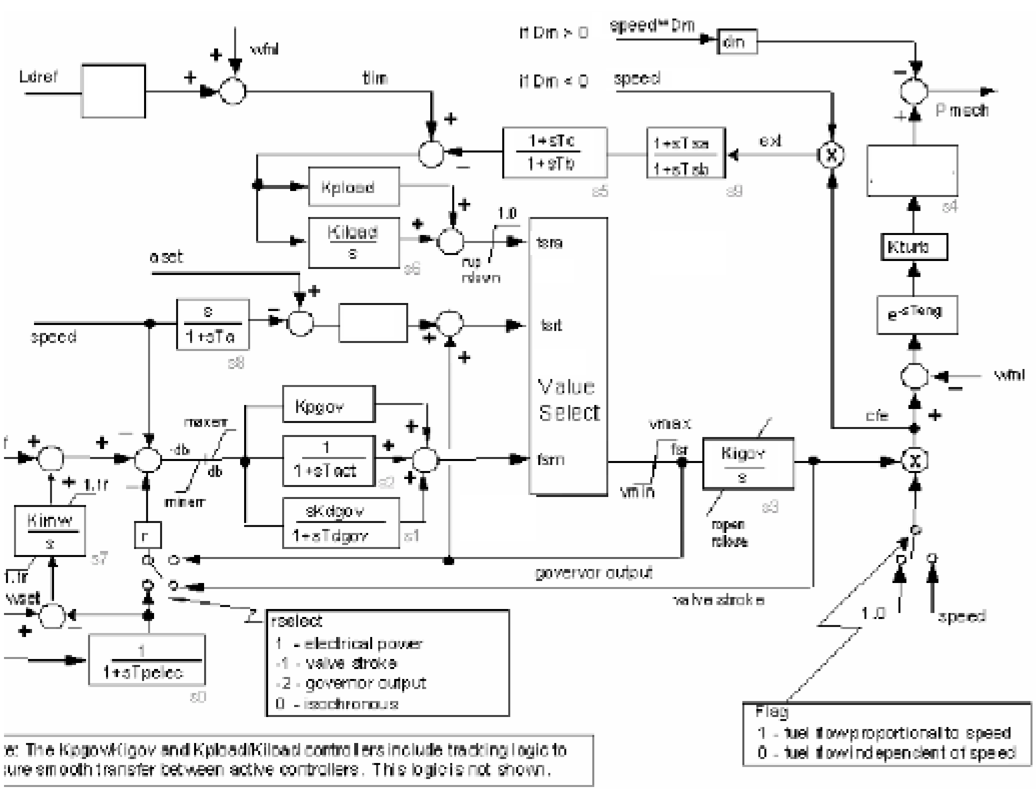


Figure 3 - "GGOV1" Model.
(Note: Speed, Pe, and Pmech values expressed in p.u.)

SECTION I –FILL IN FORM FOR EACH GENERATOR

Generator Name:____
Generator ISO Asset ID:_________________________________
Generator Nameplate (MVA):______________________________
Year Generator Commissioned:___________________________

Enter Excitation System Type and manufacturer (static, brushless, ac rotating, dc generator, G.E., Siemens, etc.)

____

Does the voltage regulator have line drop compensation/reactive current compensation (Yes / No)

If generator provided with current compensation have characteristics been provided **(Yes / No)**

Has over-excitation limiter (OEL), under-excitation limiter (UEL) or stator current limiter information been provided if machine so equipped (Yes / No / Not Equipped)

Enter Control System Type (i.e. G.E. Mark IV, Siemens-t3000):____

The Power System Stabilizer, if provided, is in operating condition and of characteristics as provided here (Yes / No/ Not Equipped)

SECTION I - FILL IN FORM FOR EACH GENERATOR

Steam-Turbine:

- Boiler type (drum-type or once through):___________________________________
- Normal fuel type (coal, oil, gas, other):____________________________________
- Indicate whether the turbine is tandem-compound or cross-compound:__________
- Rated steam pressure (HP):____ psi
- Governor type and manufacturer:____
- Boiler controller type and manufacturer:____
  ____
- Describe the normal turbine control and operating practice (base loaded, turbine follow, boiler follow, coordinated controller, sliding pressure, etc):____
- Provide a copy of the manufacturers block diagram of the unit:
- **(Note if in Combined Cycle (CC) mode and fill out GT section also)**
  ____

Gas Turbine:

Gas turbine type and manufacturer (e.g. GE Frame 7, W-501, GE LM6000, etc):

____

For combined cycle plants:

If the plant has a steam cycle, describe how steam is used from a heat recovery steam generator (HRSG), e.g.:

- All steam is used by a steam-turbine generator, or
- 40% of steam is for industrial use, or
- The project is using supplementary duct firing, all steam is used by a steam-turbine generator.
- Provide a copy of the manufacturers block diagram of the unit:
  ____
  ____
  ____

SECTION I - FILL IN FORM FOR EACH GENERATOR

Hydro-turbine generators:
Hydraulic Turbine
Turbine type (e.g., Francis, Kaplan, Pelton):_____________________________________
Nominal head ______________ ft typical range of operating heads________________ ft

- Turbine capacity at full gate opening, nominal head ___________________ MW
- Provide the "Power versus Gate Position" characteristic at expected operating heads (for Kaplan turbines with blade on the cam). For Kaplan turbines, provide the "Blade angle versus Gate Position" characteristic at expected operating Heads:____
- Provide contact information for a person for reference regarding hydraulic profile of the plant:____
- Water inertia starting time Tw_____________________________________ sec
- Hydro governor type (e.g. Asea analog electronic, Woodward dash-pot, Woodward 505H, Voest Alpine electronic):______________________________

SECTION I - FILL IN FORM FOR EACH GENERATOR

Factory Test Report

TRANSFORMER TEST REPORT

Autotransformer
1-phase, 60 Hz

250 MVA (65°C rise)
345/115/34.5 kV
Cooling class OA/FA/FA

SECTION II – TRANSFORMER TEST REPORT

Transformer Test Report

Load Losses (kW) and Impedance Voltage (%) HV/LV				
HV/LV (kV)		362.25/115.0	345.0/115.0	327.75/115.0
Tap position		1	3	5
MVA		150	150	150
Measured	at 21.2 °C	151.93	153.18	161.57
DC - loss	at 21.2 °C	104.10	104.64	112.45
Stray - loss	at 21.2 °C	47.83	48.55	49.12
Stray - loss	at 85 °C	38.29	38.87	39.33
DC - loss	at 85 °C	130.02	130.69	140.45
Load - loss	at 85 °C	168.32	169.56	179.78
Guaranteed loss	at 85 °C	-	167.00	-
Impedance Voltage	at 150 MVA	10.96	11.17	11.42
Guarantee		-	11.06	-
Impedance Ω / phase		31.96	29.55	27.26

Load Losses (kW) and Impedance Voltage (%) HV/TV and LV/TV					
HV/LV (kV)		362.25/34.5	345.0/34.5	327.75/34.5	115.0/34.5
Tap position		1	3	5	-
MVA		40	40	40	40
Measured	at 21.2 °C	88.63	89.30	90.45	107.25
DC - loss	at 21.2 °C	65.40	65.66	66.47	67.65
Stray - loss	at 21.2 °C	23.23	23.64	23.98	39.60
Stray - loss	at 85 °C	18.60	18.93	19.20	31.70
DC - loss	at 85 °C	81.69	82.01	83.02	84.50
Load - loss	at 85 °C	100.28	100.94	102.22	116.21
Guaranteed loss	at 85 °C	-	-	-	-
Impedance Voltage	at 40 MVA	16.33	16.32	16.33	24.48
Guarantee		-	-	-	-
Impedance Ω / phase		178.58	161.88	146.18	26.97

SECTION II – EXCITATION STEP RESPONSE TEST

Commissioning Data to be provided during Trial Operation

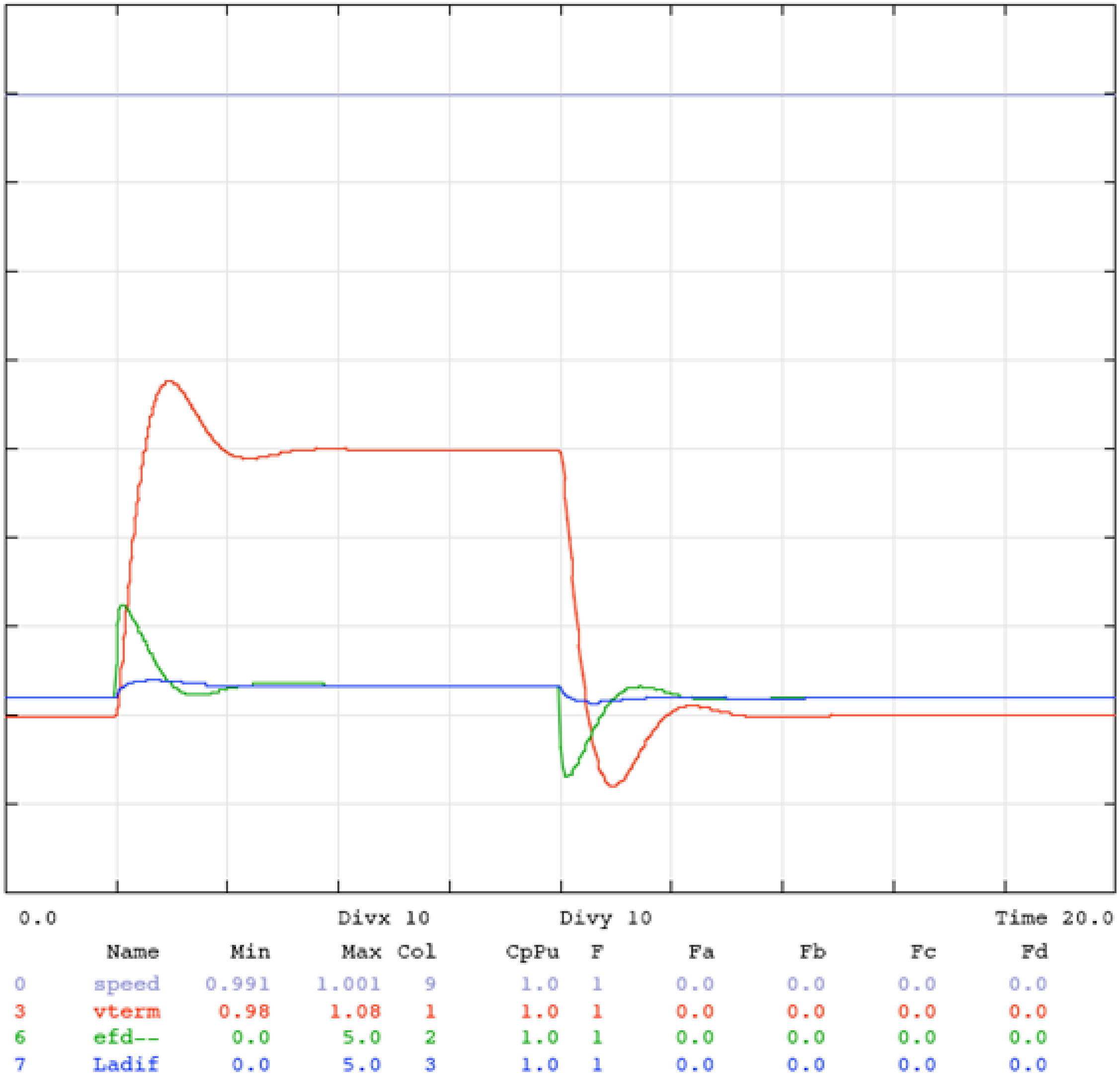
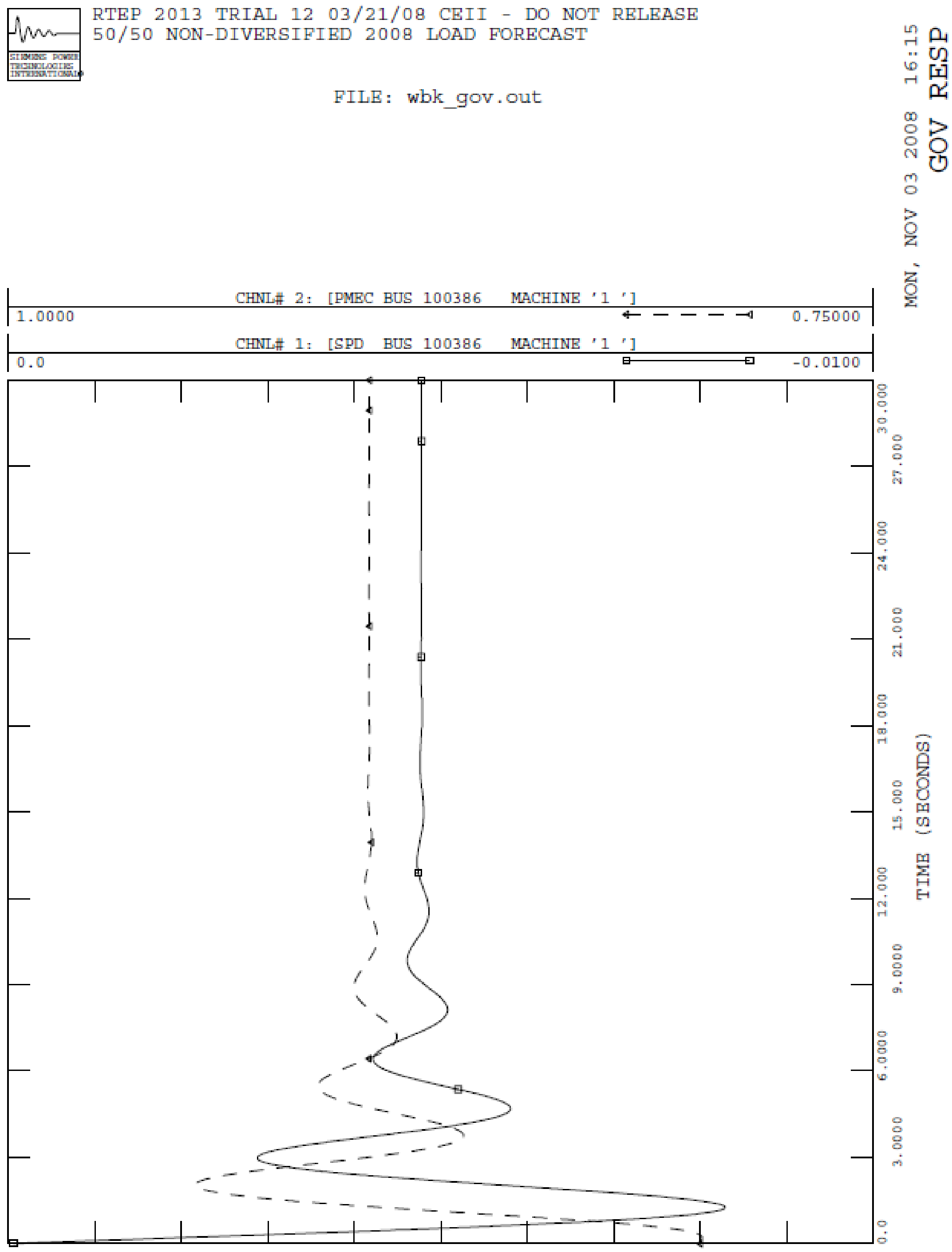


Figure 1

Response of excitation system to 5 percent step of voltage regulator reference

Generator on Open Circuit

Open Circuit Governor Response Test



Governor Response Test

Activity GSTR and GRUN execute simulations of governing response of individual units in isolation. The principal purpose of the governor response test is to ensure that the governor gain and time constant parameters correspond to correctly-tuned well-damped response. The user initiates the governor test with activity GSTR, which initializes each governor to a load level specified by the user. Activity GRUN is then used to simulate the response of the governors to a step change in load. The load electrical power is held constant (independent of frequency) after the step so that the response indicates the damping due to the turbine and governor loop only. The governors should be initialized to about 0.8 per-unit load and the load step should be approximately 0.1 per unit. The damping of hydro governing loops is usually decreased with increasing load and hence that response tests should normally be made near full load for these units. Governor response tests should be run for at least 5 sec for steam turbine units (TGOV1) and for at least 15 sec for gas turbine (GAST) and hydro units (HYGOV). All three types of units should have well damped response. Hydro governors will generally show a somewhat greater overshoot than steam turbine governors, but should still be well damped, showing no persistent oscillations. The governor testing simulation output shows the transient variation of turbine power. A small negative change in hydro turbine power before it follows a positive change of load power is normal and does not indicate incorrect governor tuning.

- **Requirement for provision of Dynamic and other Generator Data**

- Generator Owners are required to provide updated generator characteristics in accordance with Article 24 of the ISO New England Large Generator Interconnection Agreement ("the Interconnection Agreement") or provisions of section 4.4 and 11.1 of the ISO New England Small Generator Interconnection Agreement and/or Section I.3.9 analysis model or model assumptions. This letter outlines requirements for updating generator data relative to data from the initial study process or the I.3.9 analysis. Updated generator dynamic characteristics are very important from both reliability and economic standpoints. Accurate generator dynamic information helps to ensure that the system remains stable during a disturbance event and individual generators remain stable during transmission line outages. In addition, transfer and generator dispatch limits are set based on this stability data. Accurate information is required to operate the system in a reliable economic manner. Factory start-up engineers should be able to provide considerable assistance in providing this information during the construction and commissioning process. Generator Owners are also required to update other information including documentation as shown in Table 1 prior to commencing Trial or Commercial Operation.

- Under the requirements listed here, the Generator Owner will verify generator data on two occasions after a project has proceeded under a Large Generator Interconnection Agreement and/or under the Section I.3.9 application review and determination process. For the first submission, per Article 24.3 of the Interconnection Agreement "as-purchased" generator manufacturer data should be submitted 180 days prior to Trial Operation. The second submission will include verification data from an actual excitation system test and confirmation of "as-built" data during Trial Operation. Under the terms of the Interconnection Agreement, a Generator must submit this data and studies, as required, must be performed by the ISO prior to the Generator being allowed to begin Commercial Operation. Article 24.4 of the Schedule 22 ISO New England Large Generator Interconnection contains specific contract language about the requirements for this submittal. Submission of correct data is very important, as FERC and NERC have imposed large monetary civil penalties on entities for failure to ensure the reliability of the electric system[2].

Effective 1/1/2017, ISO New England will no longer accept user models for new generators

-

[2] http://www.ferc.gov/enforcement/civil-penalties/civil-penalty-action.asp
FERC Enforcement/Civil Penalties/Civil Penalty Actions
http://www.nerc.com/filez/enforcement/index.html NERC Enforcement Actions

Appendix 3, As-Purchased/As-Built data for Solar and Wind Farms

1. Each asset as defined in the ISO registration process must provide the exact specification for each wind turbine and its exact location (Lat and Lon and elevation) as part of the data requirements. For each turbine provide the following information:

   1. Turbine #___

   Siemens PTI PSS/e models and parameters (See Appendix A for Sample & Details):

   Provided on separate letterhead with DDMS...

   Frequency and Voltage Protection Settings:

   ____

   ____

   Exact location (Lat and Lon and elevation)

   ____

   ____

2. Detail the ramping capabilities of the wind plant including any ramp limiters that are in place at the plant

   ____

   ____

   ____

3. Specify any deviations from the planned and approved project by ISO New England and the as built facility(s)

   ____

   ____

   ____

4. In certain cases ISO New England will request PSCAD models of the Wind Farm or individual Wind Turbines for EMTP studies. Has this data been provided as required Yes/Not Required

Appendix 3, As-Purchased/As-Built data for Solar and Wind Farms

Table 1 – Summary Table of Required Generator Data to participate in ISO Markets		
Data Requirement	ISO Procedure	NERC/FERC Requirement
Generator Dynamic Stability & Ratings Information As-Bought	**This Transmittal**	**LGIP Article 24.3** **NERC MOD-012/013**
Generator Dynamic Characteristic Step Test Results and As-Built	**This Transmittal**	**LGIP Article 24.4** **NERC MOD-012/013**
NX-9	**OP-16**	**NERC FAC-009, MOD-010/011**
NX-12	**OP-14**	**NERC FAC-009, MOD-032**
NX-12D	**OP-14**	**NERC FAC-009, MOD-032**
Telemetering	**OP-18**	**NERC COM-002**
Electronic Dispatch	**OP-14**	**NERC COM-002**
Revenue Metering	**OP-18**	
Auto Ringdown (unit > 50 MW)	**OP-14**	
Station One-Line Diagram with appropriate Nomenclature	**OP-16**	
Voltage Schedule	**OP12 Appendix B**	

Appendix 3, As-Purchased/As-Built data for Solar and Wind Farms

In accordance with ISO Operating Procedure 18 (OP-18) and the Interconnection Agreement Generator Owners must provide *site specific* Windfarm Dynamic Characteristic Models *and* Parameters for wind turbine installations. This data must be provided before Commercial Operation status is granted and ISO New England must be provided with adequate time to access changes to models and parameters representing “As-Built” conditions. The Generator Owner must certify that the models and parameters accurately represent the generators in ongoing dynamic studies. The data shall be provided on the Wind Turbine Generator Manufacturer’s Letterhead. Below is a sample of the type data that is required for Wind Turbine modeling that shall be prepared for *“As-Built” site specific installations.* The data shall be submitted in the PSS/E version used by ISO New England and the NERC MMWG, and include all necessary and relevant software code. The data shall also be formatted for use with PSLF for host utilities using that program (CMP and Velco) at this time.

Data provided shall be site specific. For instance, an example of the data required for WT3 Wind Model PSS/E dynamics models and associated data is shown below. The original parameter values in the WT3E (Doubly-fed Induction Generator Electrical Control) model are set for terminal voltage control mode.

One Sullivan Road, Holyoke, MA 01040-2841
www.iso-ne.com **T** 413 535 4000 **F** (Enter Fax #)

Revision History

Rev. No.	Date	Reason
Rev 0	August 17, 2016	Initial Issue
Rev 1	April 26, 2017	Add language regarding testing and Outage Software Requirement for R2, add language on DDMS User Guide.
Rev 2	March 10, 2020	Periodic Review

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