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AN OVERVIEW OF GENERATOR MODEL VALIDATION PROCEDURE

Using GENQEC Model

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MODEL VALIDATION PROCEDURE

- NERC Reliability guideline – Power Plant Model Verification and Testing for synchronous Machines July 2018
  - Generator Open Circuit Magnetization (Saturation) Test (i.e. Open Circuit Saturation Test)
  - V-Curve and Reactive Limits (i.e. Online Measurement Test)
  - Stator Current Interruption Test (i.e. D-axis Test)
  - Etc.

- Field testing procedure is no different between GENQEC model and other models

OPEN CIRCUIT SATURATION TEST

Test Procedure:

1. Unit is operated at full speed, no load (FSNL) with the generator main breaker open

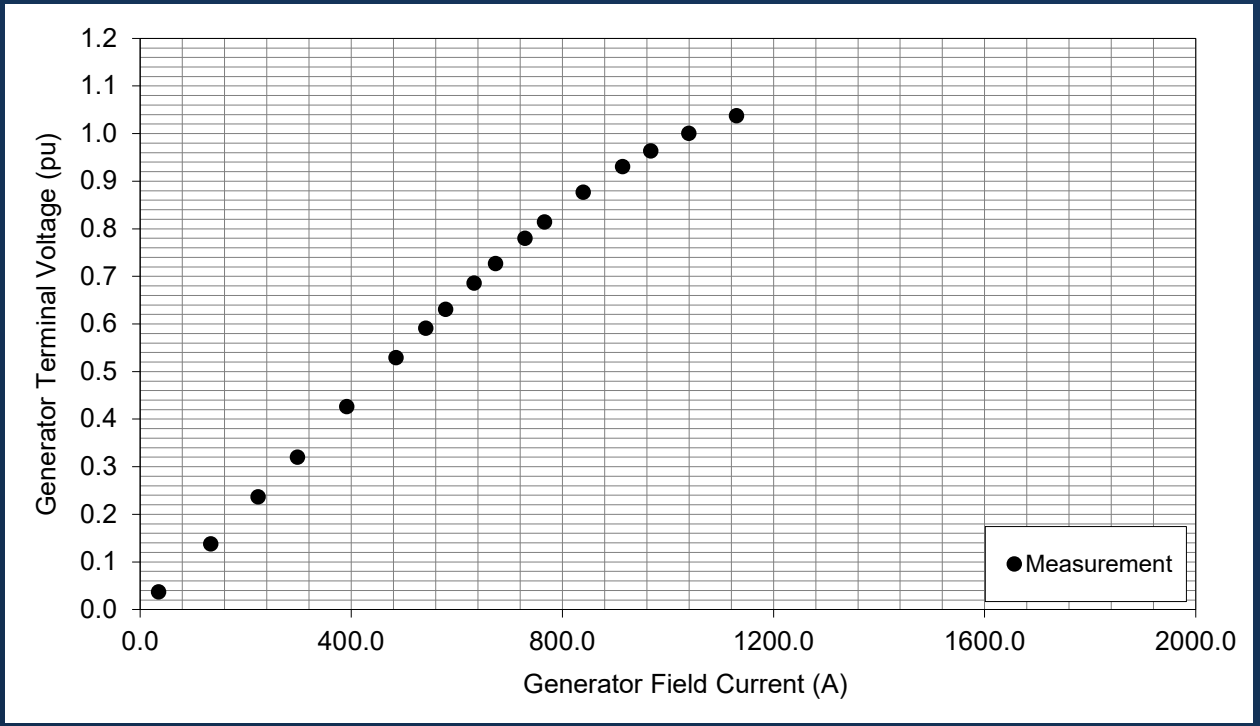
2. AVR is typically in manual mode and at minimum setpoint

3. Raise the terminal voltage from minimum to maximum with sufficient samples in air-gap and saturated region.

OPEN CIRCUIT SATURATION TEST

Validation Steps:

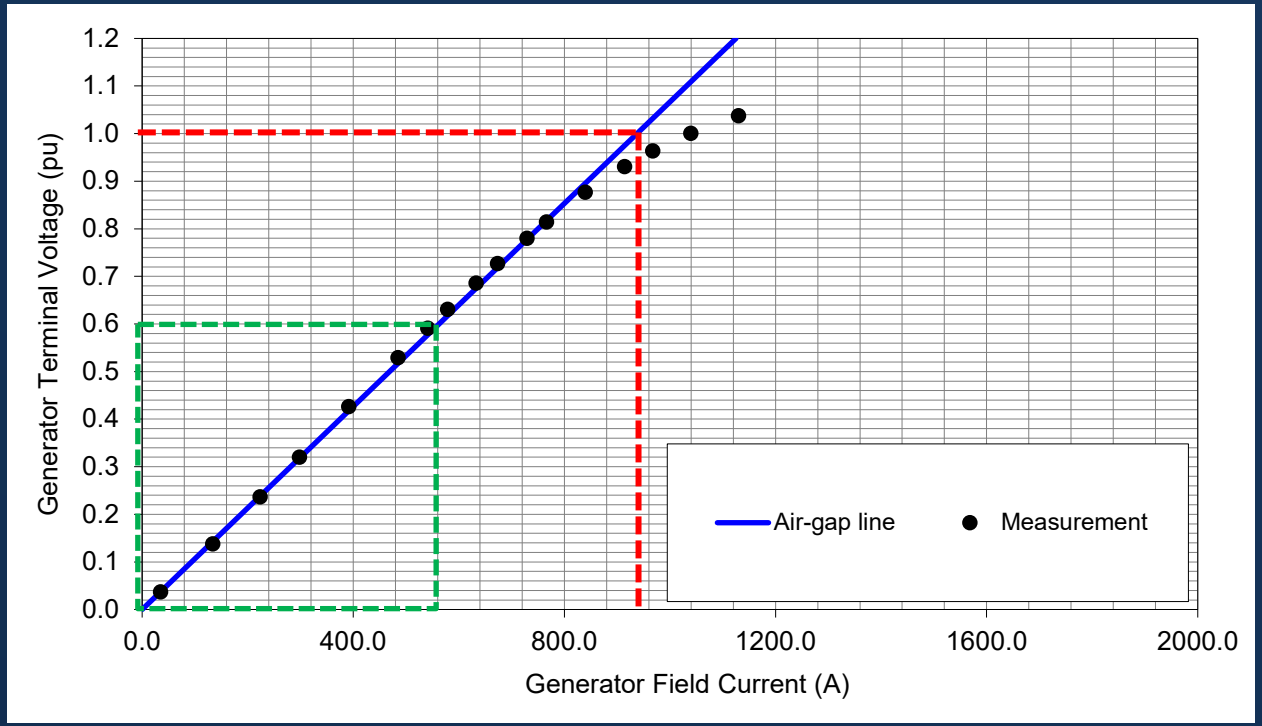
- Plot the Vt (generator field voltage) vs If (generator field current) curve



OPEN CIRCUIT SATURATION TEST

Validation Steps:

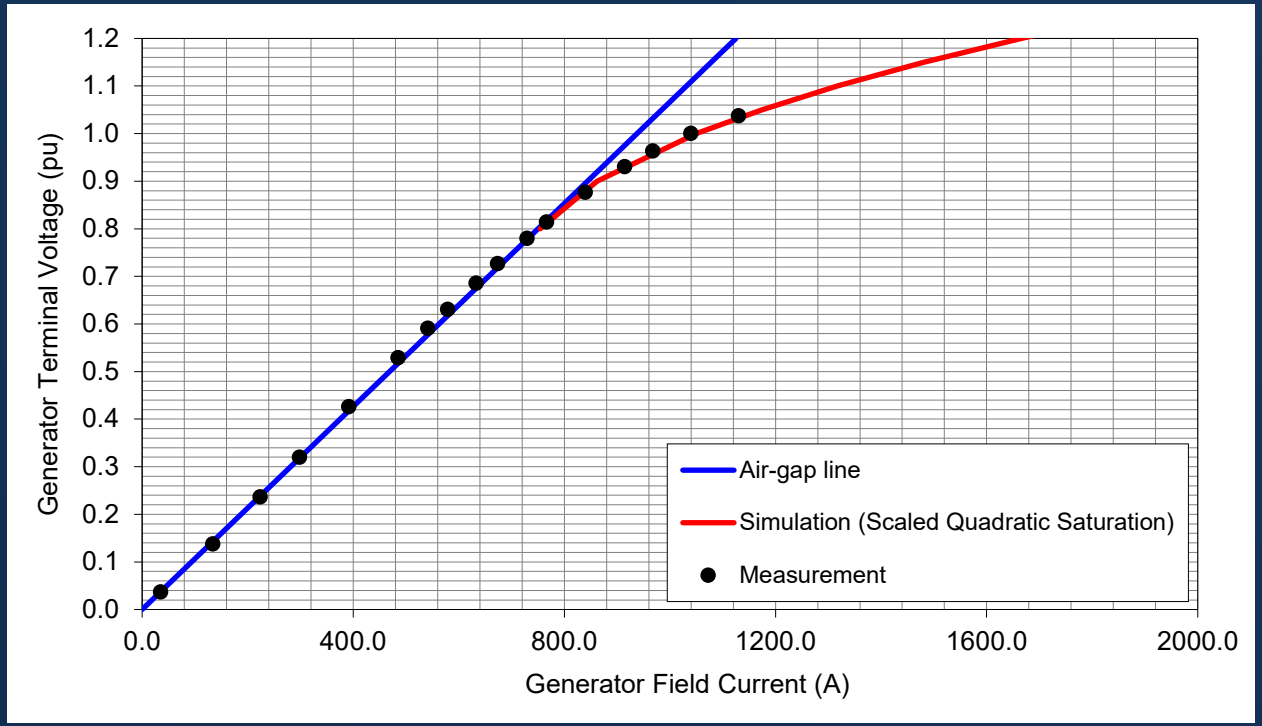
- Determine Air-gap line - Vt/If ratio
  - Generator field current base - Ifbase
  - Generator field voltage base - Vfbase



OPEN CIRCUIT SATURATION TEST

Validation Steps:

- Determine Saturation
  - Type: Exponential, Scaled Quadratic, Quadratic
  - S(1.0) and S(1.2)



ONLINE MEASUREMENT TEST

Test Procedure:

1. Dispatch unit at different loading conditions (e.g., minimum, 50% and full load)

2. At each loading level, swing reactive power output from maximum leading to lagging or vise versa

3. Take measurement at each steady state condition

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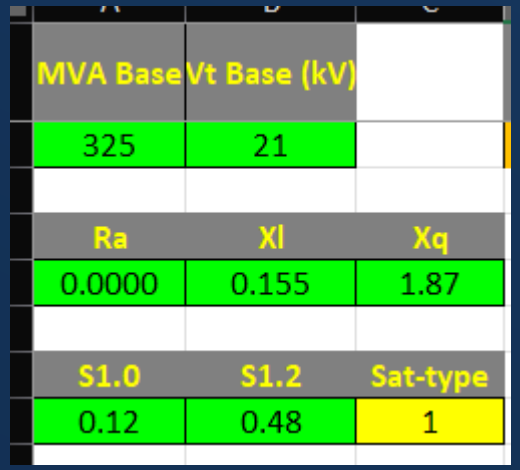
Vt (kV)	P(MW)	Q(MVA)	Ifd (Amps)
21.11	12.31	8.42	1107.76
21.10	1.06	8.50	1104.68
20.27	0.72	-59.83	582.54
20.82	49.24	-15.86	969.45
20.98	49.50	-1.22	1075.35
21.68	49.49	59.6	1558.23
20.35	49.12	-50.09	729.59
21.04	103.28	1.45	1229.52
21.83	103.22	71.06	1745.77
20.25	102.68	-55.86	894.78
20.24	157.42	-55.06	1160.5
20.99	159.17	5.13	1453.53
21.73	160.32	70.39	1879.05
21.49	219.56	53.6	1959.95
21.04	220.05	14.18	1754.57
20.91	220.05	3.57	1706.06
20.15	219.32	-56.7	1484.99
19.97	249.29	-70.94	1628.12
20.90	250.22	2.85	1859.76
22.02	249.36	101.99	2426.2
21.87	248.83	90.17	2330.96
20.45	0.71	-48.33	670.32

ONLINE MEASUREMENT TEST

Validation Steps:

- Input generator model information
  - MVA base
  - Vt base
  - Ra
  - Xl
  - Xq
  - S(1.0), S(1.2), Sat-type (from previous validation test)



MVA Base	Vt Base (kV)	
325	21	
Ra	Xl	Xq
0.0000	0.155	1.87
S1.0	S1.2	Sat-type
0.12	0.48	1

ONLINE MEASUREMENT TEST

Validation Steps:

- Input test data
  - Vt (kV)
  - P (MW)
  - Q (MVAR)
  - If (ADC)

Vt (kV)	P(MW)	Q(MVA)	Ifd (Amps)
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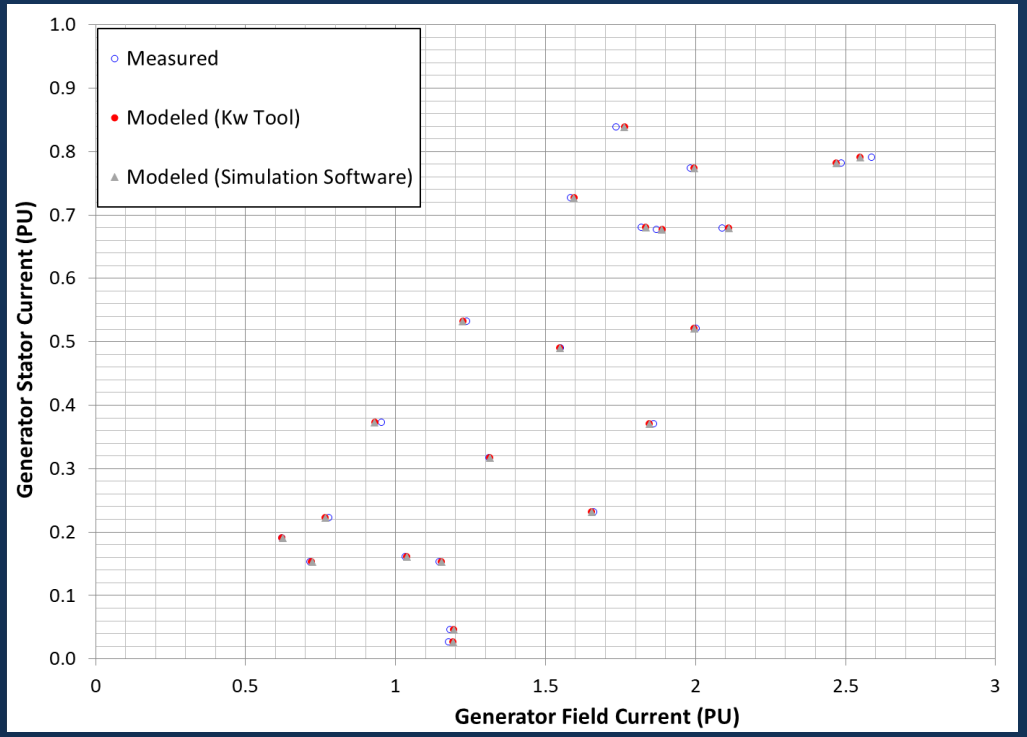
ONLINE MEASUREMENT TEST

Validation Steps:

- Estimate Xd, Ifbase and Kw
- Estimated Xd and Kw can also be validated via simulation software
  - Setup the power flow for each steady state condition
  - Simulate no fault flat run
  - Export generator field current result



D-AXIS TEST

Test Procedure:

1. Operate the unit close to 0 MW and leading reactive power

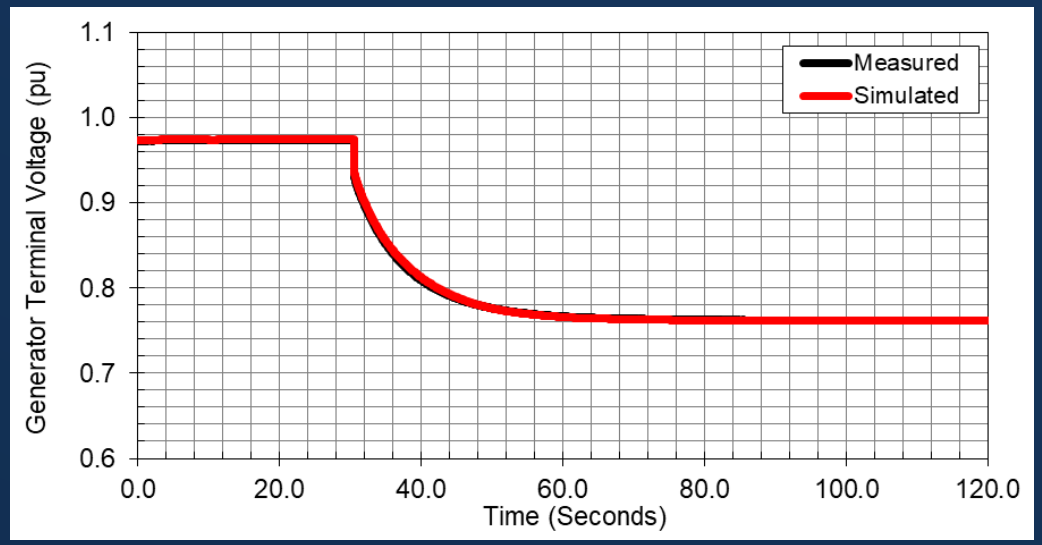
2. AVR is in manual mode (field voltage, field current or firing angle control)

3. Open the generator breaker to reject load and keep unit FSNL

D-AXIS TEST

Validation Steps:

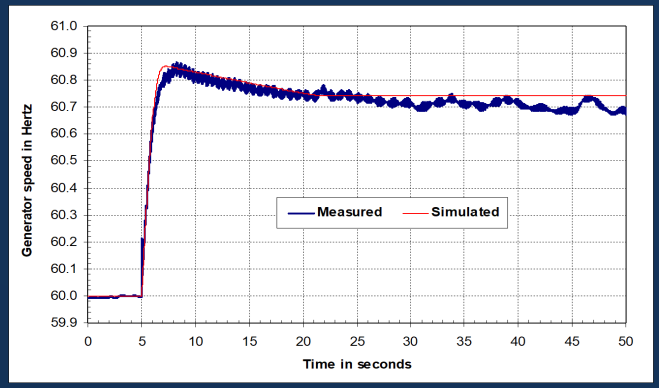
- Setup the power flow matching the pre-test condition
- Create load rejection contingency and other simulation file
- Use estimated Xd, Kw and rest model parameters to perform simulation

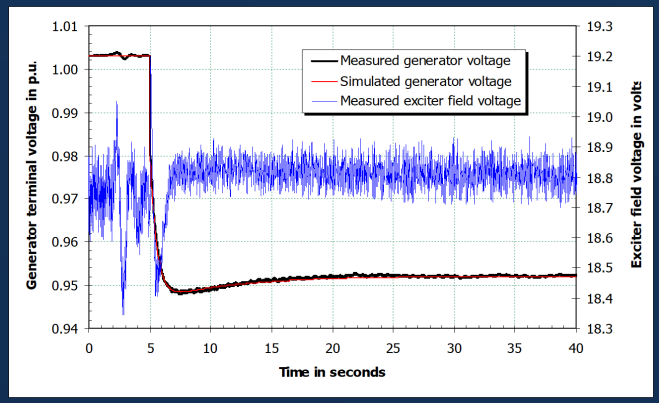


OTHER TYPICAL TESTS

Load rejection test - To Validate H and Q-axis parameters:

- Test procedure
  - Operate the unit at partial load (5% to 20%) and leading reactive power (such that It is on q-axis)
  - AVR is in manual mode
  - Open the generator breaker to reject load and keep unit FSNL
  - Record Vt, P, Q, If, Vf, and F
- Validation steps
  - Setup the power flow matching the pre-test condition
  - Create load rejection contingency and other simulation file
  - Compare F simulation result to validate H
  - Compare Vt simulation result to validate q-axis parameters

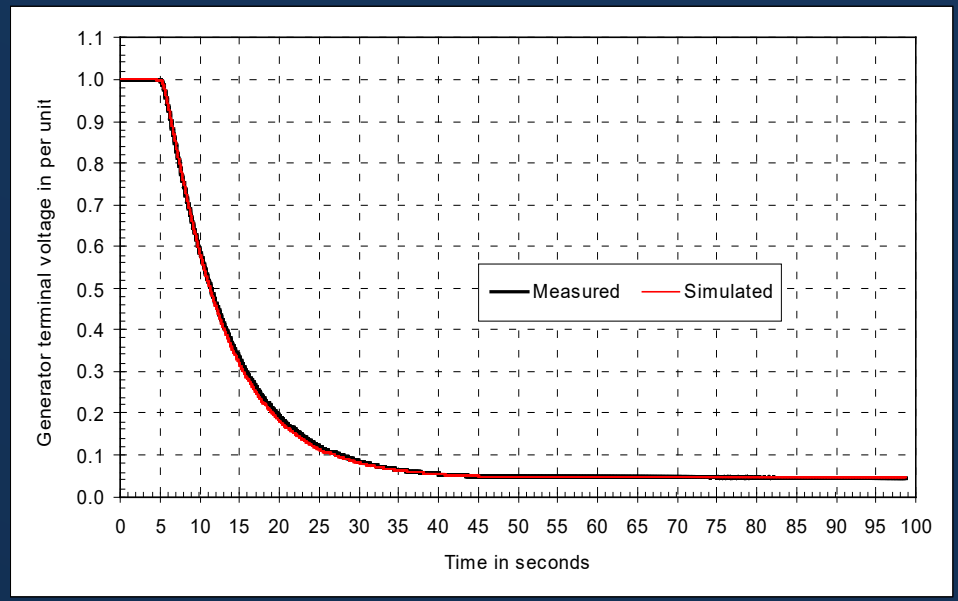




OTHER TYPICAL TESTS

Excitation removal test - To Validate T'do:

- Test procedure
  - Operate the unit at full speed no load with GCB open
  - Operate the generator terminal voltage at around 1 pu
  - Turn off excitation and keep turbine running
  - Record Vt, If, Vf, and F
- Validation steps
  - Setup no load power flow case
  - Create excitation removal contingency
  - Compare Vt simulation result to validate T'do
  - Correct T'do to standardized temperatures for thermal or hydro unit



REFERENCES

[1] Reliability Guideline – Power Plant Model Verification and Testing for Synchronous Machines, NERC, July 2018

[2] IEEE Guide for Test Procedures for Synchronous Machines Including Acceptance and Performance Testing and Parameter Determination for Dynamic Analysis, IEEE 115-2019

[3] “A new high accuracy generator dynamic model”, Quincy Wang, Song Wang, IEEE PES Asia-Pacific Power and Energy Engineering Conference (APPEEC) 2018, October 7-10, 2018, Kota Kinabalu, Sabah, Malaysia

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