Comparison of GENROU versus GENQEC Models for a Round Rotor Machine

A Case Study Highlighting the Value of Choice in Synchronous Machine Modeling

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Thesis*

- For this test machine – a 1008 MVA, 3600 rpm, 0.85 PF, 27 kV steam turbine-generator – the GENROU model provides an overall better match to tests than the GENQEC model
- Language in the literature (WECC Approved Dynamic Model List , January 2024) presently seems to strongly discourage the use of GENROU

* Based on a full white paper “Comparison of GENROU Versus GENQEC for a Round Rotor Machine,” by Wayne Cassidy, Peregrine Engineering Consulting, October 8, 2024. Copies available upon request.

Excerpt from WECC Model List January 2024

GENERATOR MODELS

GE PSLF	PTI PSS/E*	PowerWorld Simulator	IEEE Standard	Status	Comments	Modifications/Actions Needed
gentpf	GENTPF	GENTPF		unapproved 1/27/2022	MVS encourages the use of the GENQEC Model. This model has been unapproved and are transistioning to the GENQEC model. WECC will no longer accept this model after the **December 31, 2024**, this date has been extened to 2024 due to an issue found in one of the software platforms. this issue has been corrected, however we felt this was approriate to extedn the uapporved date from 2023 to 2024 to make sure we are confident in the GENQEC model. This was unapproved at the January 2022 MVS meeting and was revisited on November 2023. Please see the Retirement Plan for Gentpj document https://www.wecc.org/Reliability/Retirement%20Plan%20for%20GENTPJ.pdf?Web=1	This model is still approved but should be transitioned to GENQEC model after future testing.
genrou	GENROU/IEEEVC	GENROU		approved 8/11/06	Round rotor generator model. USE GENQUE INSTEAD	This model is still approved but should be transitioned to GENQEC model after future testing.
gensal	GENSAL/IEEEVC	GENSAL		retired 1/11	Salient pole generator model, Use for Hydro generator models, no longer approved Jan 2011, staff converts to gentpj with KIS=0	No longer approved 2011
gentpj	GENTPJU1, GENTPJ1	GENTPJ		unapproved 1/27/2022	MVS encourages the use of the GENQEC Model. This model has been unapproved and are transistioning to the GENQEC model. WECC will no longer accept this model after the **December 31, 2024**, this date has been extened to 2024 due to an issue found in one of the software platforms. this issue has been corrected, however we felt this was approriate to extedn the uapporved date from 2023 to 2024 to make sure we are confident in the GENQEC model. This was unapproved at the January 2022 MVS meeting and was revisited on November 2023. Please see the Retirement Plan for Gentpj document https://www.wecc.org/Reliability/Retirement%20Plan%20for%20GENTPJ.pdf?Web=1	This model is still approved but should be transitioned to GENQEC model after future testing.
gencc	GENROU/IEEEVC	GENCC		.	Cross Compound generator model	This model is still approved but should be transitioned to GENQEC model after future testing.

Models and Data

- Synchronous Machine Model
  - GENQEC
    - Sat Flag = 1 (Quadratic), Kw = 0.0
    - Sat Flag = 0 (Exponential)
  - GENROU
- Excitation System Model: ESST4B
- Power System Stabilizer Model: PSS2B

- Single-Machine connected through 23.7% impedance to an Infinite Bus (SMIB)

Most of the subsequent simulation results were performed using GE PSLF. However, for several cases, the Siemens PTI PSS/E program was benchmarked and showed similar results.

Field Tests

The following tests were compared to simulations:

1. Online Voltage Step Tests, including Impulse Step (with & without PSS)
2. Load Ramp Test
3. Current Interruption Tests*
4. Offline Voltage Step Test*
5. Open Circuit Saturation Test

For these tests, the GE EX2100e excitation system trending and data capture capabilities were used to capture the test data.

* These simulations were performed and compared to tests, but are omitted from this presentation for brevity

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Open-Circuit Saturation Curves

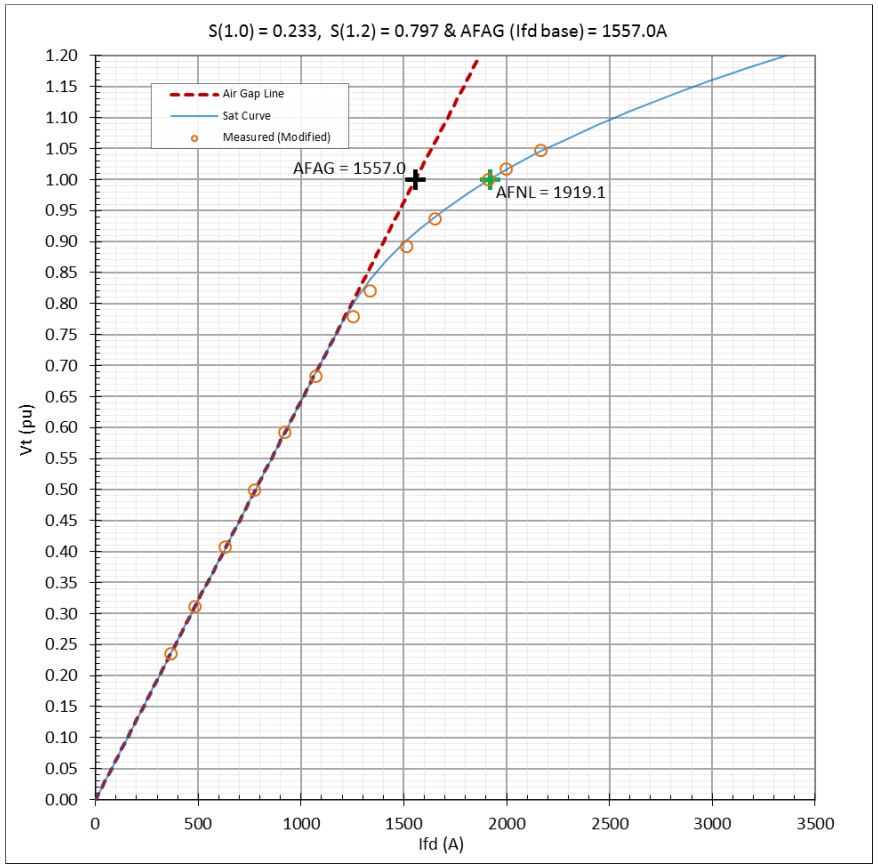

Figure 2.5.1 – Open Circuit Saturation Curve (Quadratic Saturation) - Test Data Modified to Account for Generator PPT and GSU Loading Effects

Used in GENROU and GENQEC (Sat Flag = 1)

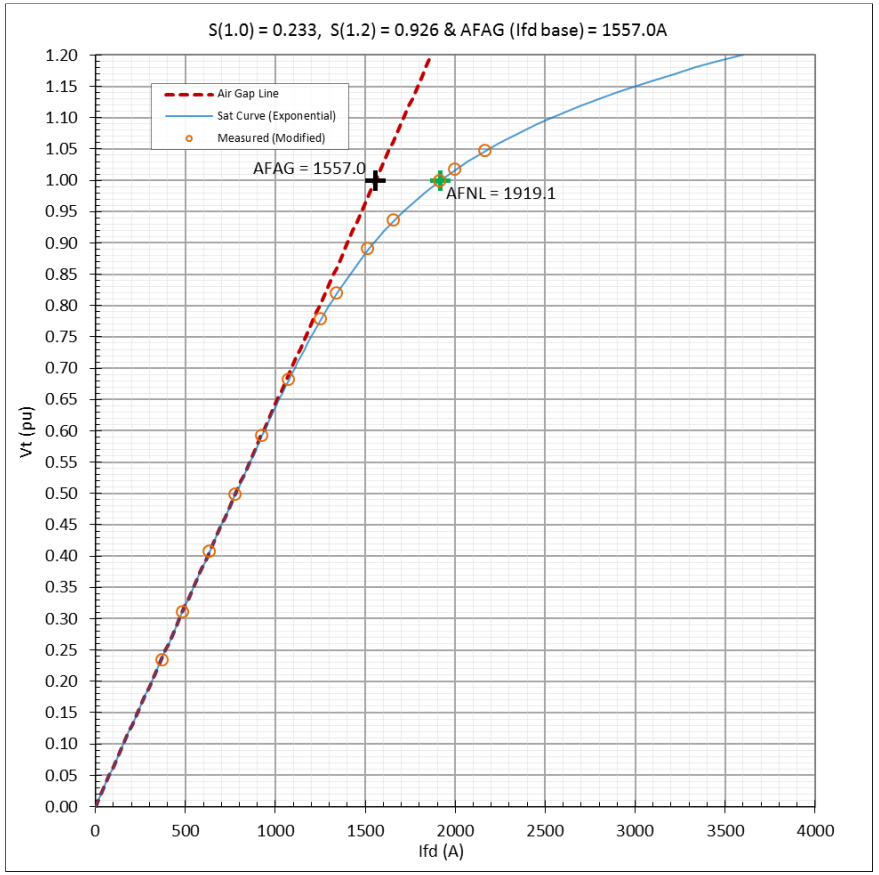

Figure 2.5.2 – Open Circuit Saturation Curve (Exponential Saturation) - Test Data Modified to Account for Generator PPT and GSU Loading Effects

Used in GENQEC (Sat Flag = 0)

PSLF vs. PSS/E GENQEC Steady-State Results

P (MW)	Q (MVAR)	Vt (kV)	Efd (V)	Ifd (A)	Ifd-sim (pu)	Ifd-meas (pu)	Diff (%)
PSLF GENQEC SATFLG=0 Kw=0							
807.60	261.42	27.651	448.97	4569.10	2.826	2.935	-3.8%
802.28	212.04	27.294	417.16	4306.70	2.689	2.766	-2.8%
503.03	167.16	27.459	317.71	3372.40	2.125	2.166	-1.9%
501.59	-155.60	25.632	203.16	2210.40	1.413	1.420	-0.5%
PSS/E GENQEC SATFLG=0 Kw=0							
807.60	261.42	27.651	448.97	4569.10	2.826	2.935	-3.8%
802.28	212.04	27.294	417.16	4306.70	2.689	2.766	-2.8%
503.03	167.16	27.459	317.71	3372.40	2.125	2.166	-1.9%
501.59	-155.60	25.632	203.16	2210.40	1.413	1.420	-0.5%
PSLF GENQEC SATFLG=1 Kw=0							
807.60	261.42	27.651	448.97	4569.10	2.836	2.935	-3.5%
802.28	212.04	27.294	417.16	4306.70	2.701	2.766	-2.4%
503.03	167.16	27.459	317.71	3372.40	2.137	2.166	-1.3%
501.59	-155.60	25.632	203.16	2210.40	1.395	1.420	-1.7%
PSS/E GENQEC SATFLG=1 Kw=0							
807.60	261.42	27.651	448.97	4569.10	2.836	2.935	-3.5%
802.28	212.04	27.294	417.16	4306.70	2.701	2.766	-2.4%
503.03	167.16	27.459	317.71	3372.40	2.137	2.166	-1.3%
501.59	-155.60	25.632	203.16	2210.40	1.395	1.420	-1.7%

Results from the two platforms show identical results.

Based on these findings, for simplicity, subsequent analyses were completed in PSLF.

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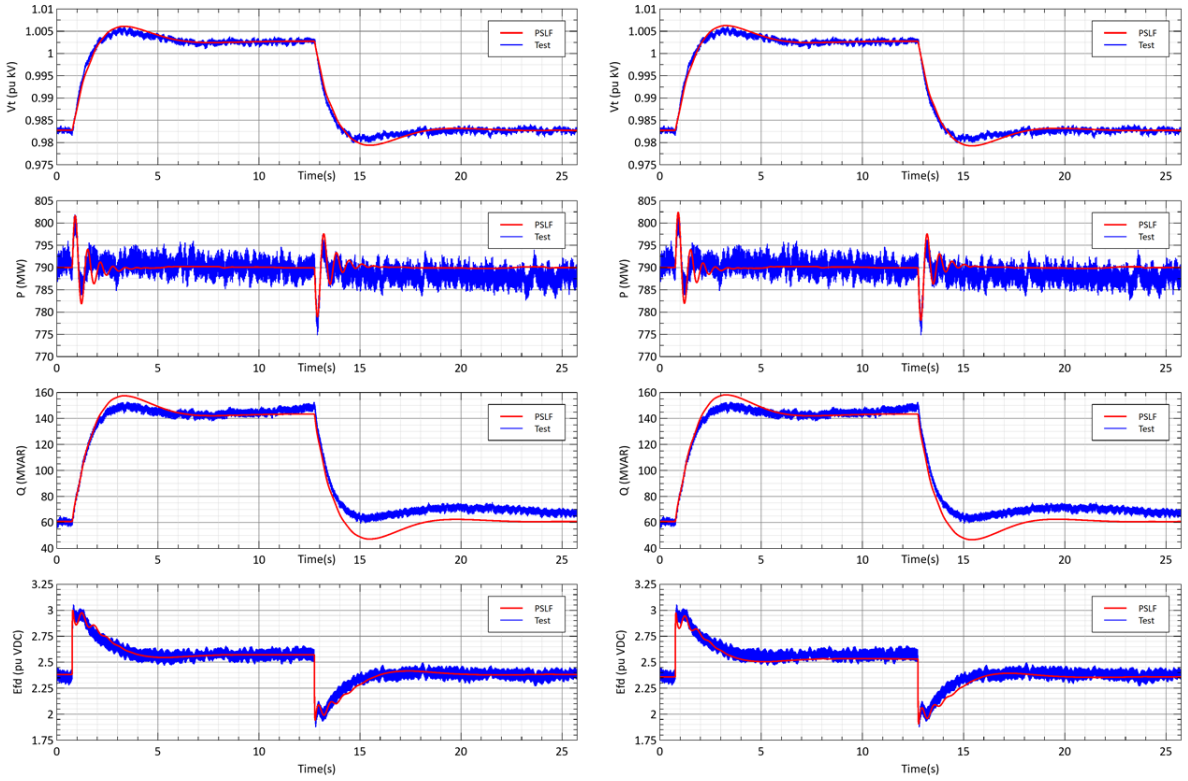
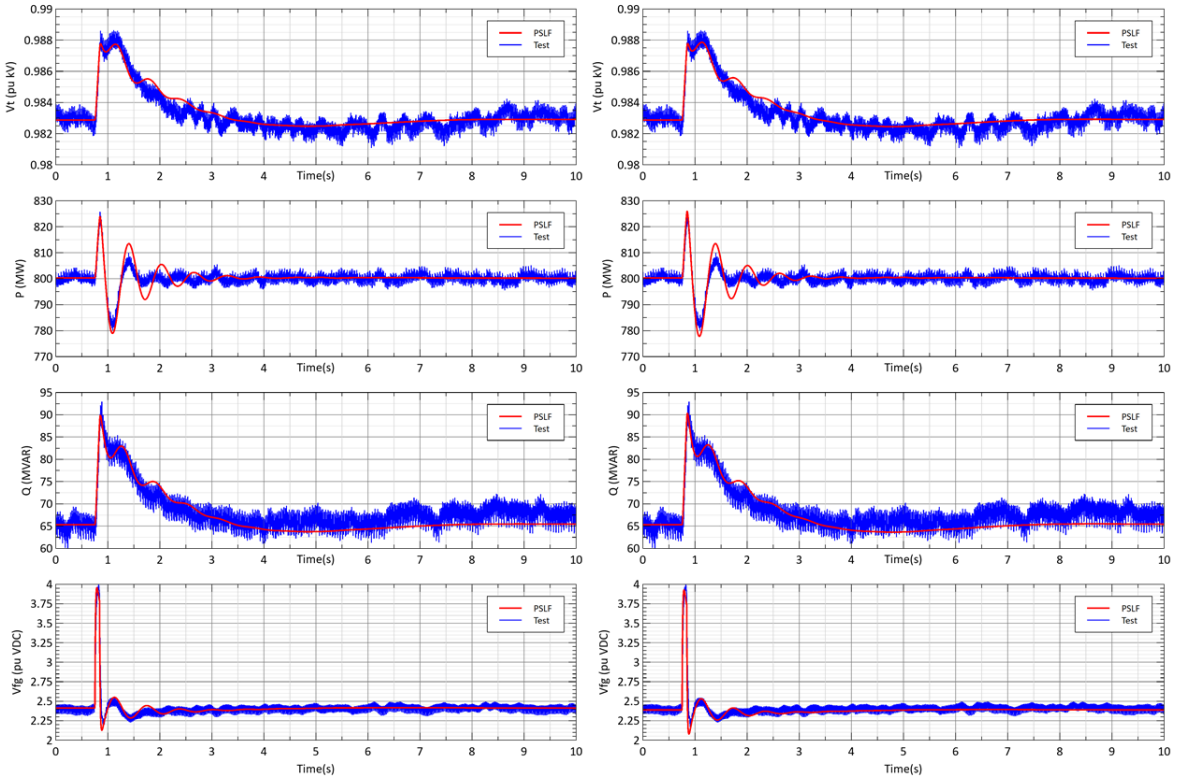
GENROU vs. GENQEC AVR Step/Impulse Results



GENROU GENQEC

2% AVR Vref Steps



GENROU GENQEC

5% AVR Vref “Impulses”

Step and Impulse Simulation Results Are Similar, Slightly Better Fit for GENROU => GENROU = A Good Model

GENROU vs. GENQEC Steady-State Results

P (MW)	Q (MVAR)	Vt (kV)	Ifd (meas) (A)	GENROU % Difference (sim - meas)	GENQEC Satflg = 0 Kw = 0 % Difference (sim - meas)	GENQEC Satflg = 1 Kw = 0 % Difference (sim - meas)
803.36	267.84	27.605	4574.3	-0.6%	-3.8%	-3.5%
807.60	261.42	27.651	4569.1	-0.7%	-3.8%	-3.5%
798.38	-80.09	25.625	3378.0	0.1%	0.5%	0.0%
802.28	212.04	27.294	4306.7	-0.1%	-2.8%	-2.4%
801.38	143.44	26.935	4013.9	0.4%	-1.7%	-1.3%
798.45	72.25	26.535	3753.5	0.5%	-0.7%	-0.6%
791.56	-38.53	25.894	3437.7	0.2%	0.2%	-0.2%
791.40	-69.28	25.718	3372.7	0.1%	0.4%	-0.1%
790.28	-1.22	26.121	3518.3	0.3%	0.0%	-0.2%
702.96	39.91	26.341	3349.7	0.4%	-0.3%	-0.4%
703.10	0.36	26.087	3230.5	0.3%	0.1%	-0.2%
646.41	7.22	26.313	3079.2	0.2%	-0.1%	-0.4%
577.21	4.38	26.453	2871.8	0.1%	-0.3%	-0.4%
497.38	-1.14	26.637	2646.4	-0.1%	-0.4%	-0.6%
503.03	167.16	27.459	3372.4	0.3%	-1.9%	-1.3%
501.10	128.67	27.321	3191.5	0.5%	-1.4%	-0.8%
503.48	83.57	27.043	2988.8	0.5%	-0.9%	-0.5%
495.23	41.38	26.819	2799.1	0.2%	-0.7%	-0.6%
501.69	-50.43	26.357	2492.3	-0.6%	-0.3%	-0.9%
505.42	-89.58	26.128	2389.0	-1.2%	-0.4%	-1.2%
500.27	-138.54	25.768	2244.6	-1.8%	-0.5%	-1.6%
501.59	-155.60	25.632	2210.4	-1.9%	-0.5%	-1.7%
59.71	-11.17	26.604	1814.2	-0.2%	0.3%	-0.3%
39.27	-4.74	26.677	1841.1	0.3%	0.6%	0.1%
20.88	-137.15	25.823	1145.4	-2.7%	1.3%	-2.7%

Table 4.1 – Steady-State Excitation Data Comparison of Model Results

GENROU Model shows an overall better match to the full range of test points.

Note: GENQEC with non-zero Kw (results not shown) provided a worse “fit”

Thesis and Request

- For this test machine – a 1008 MVA, 3600 rpm, 0.85 PF, 27 kV steam turbine-generator – the GENROU model provides an overall better match to tests than the GENQEC model
- Given this finding, we request that the GENROU model be **clearly** allowed in ongoing and future WECC database submittals.

Questions?

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