

# Industry Webinar: Modeling Notifications

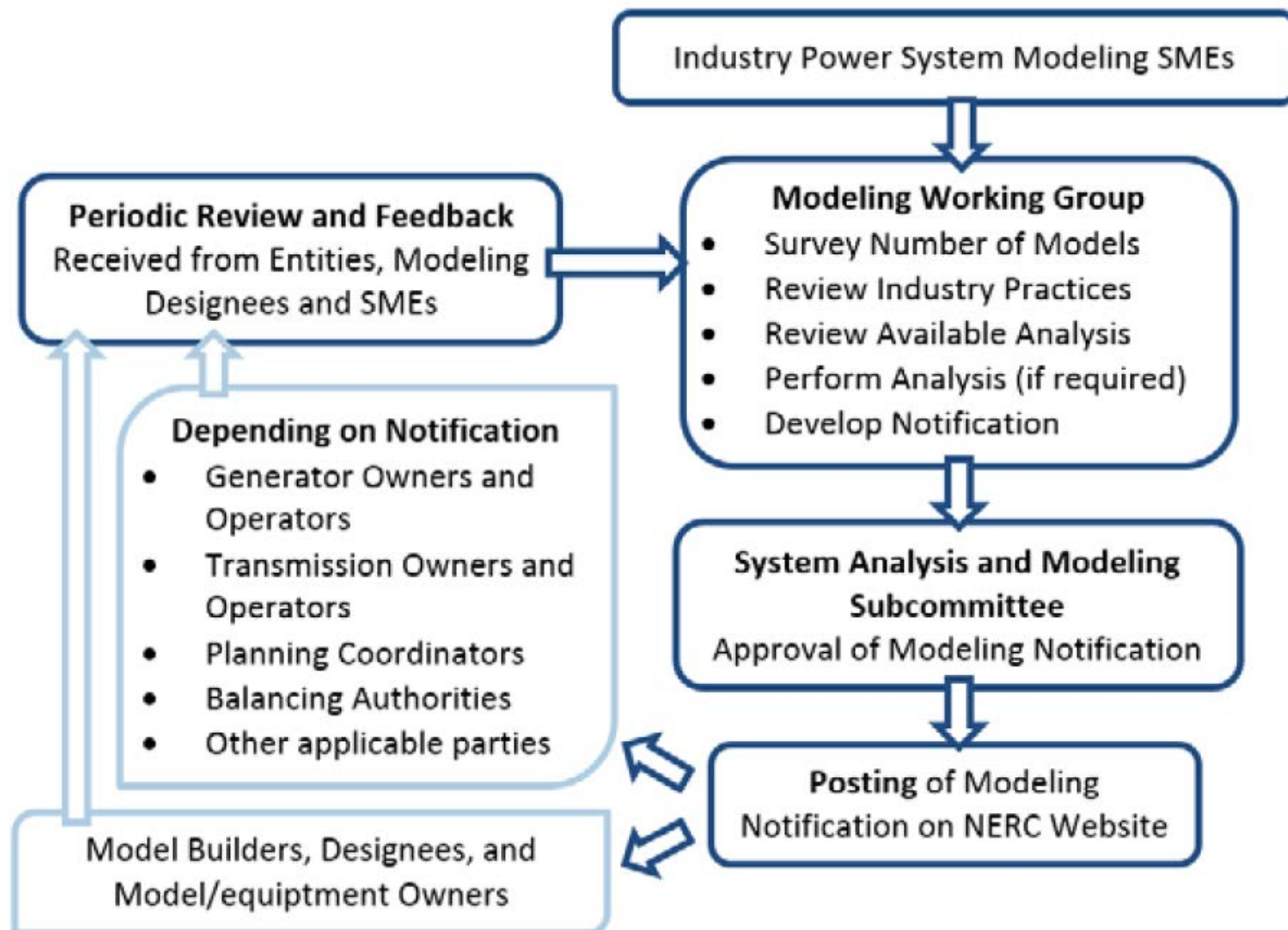
EX2000 and GENTPJ

December 2016

**RELIABILITY | ACCOUNTABILITY**



# Modeling Notification Process

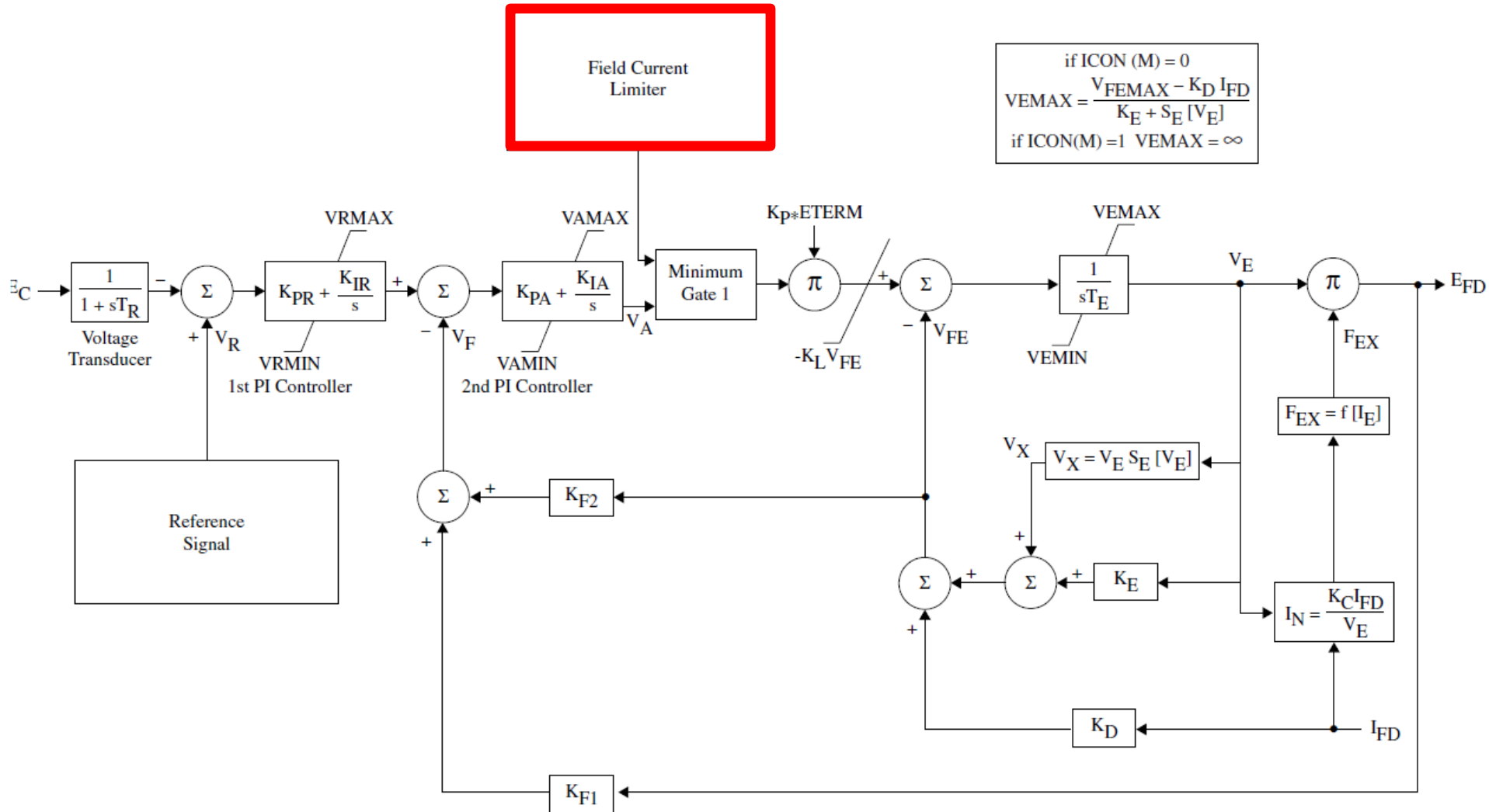


- Amir Najafzadeh, *NERC*
- Kannan Sreenivasachar, *ISO-NE*
- Ryan Quint, *NERC*
- John Undrill, *Consultant*
- Pouyan Pourbeik, *Peace, PLLC*

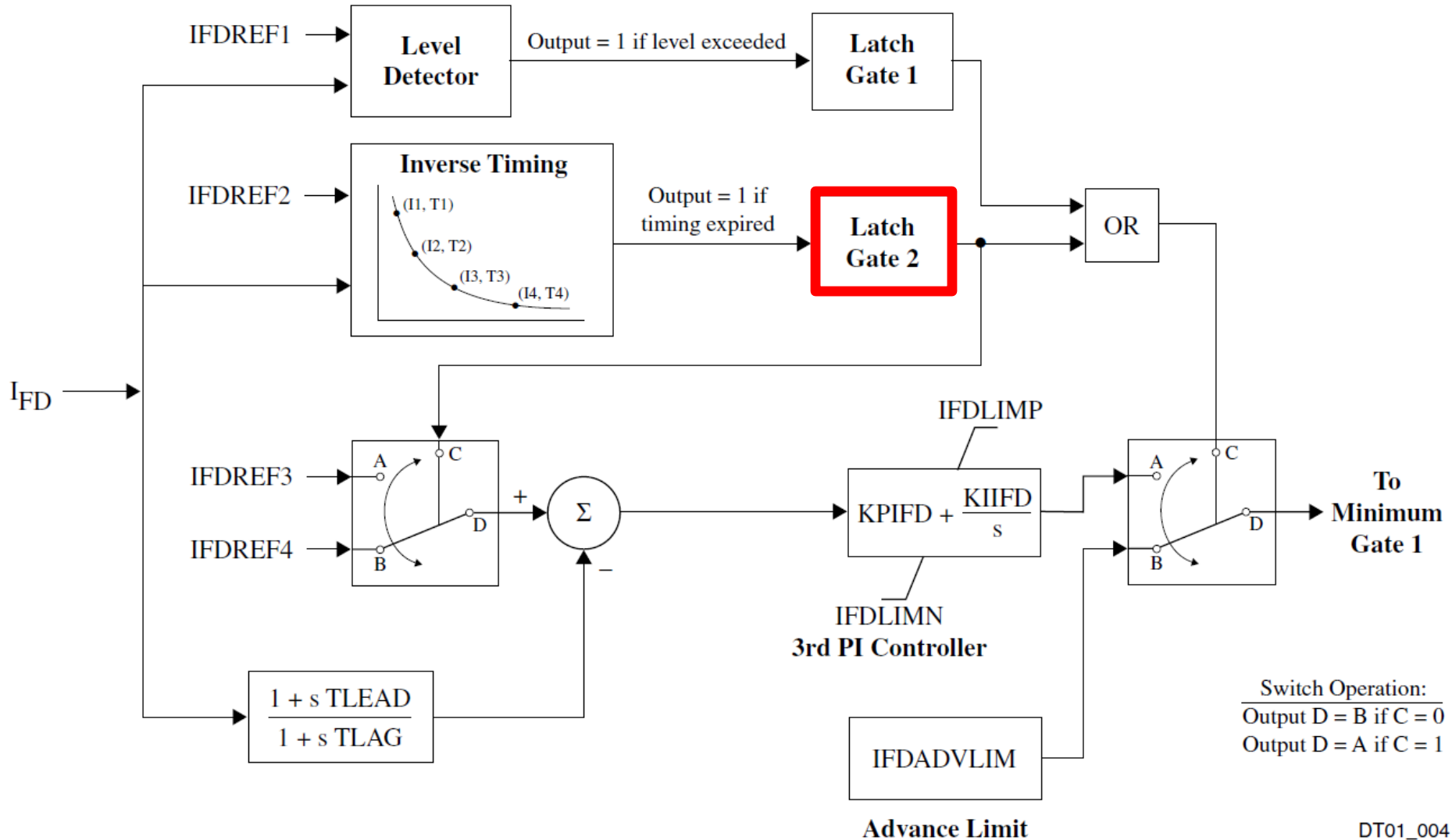
- Generator Owners (GOs)
- Generator Operators (GOPs)
- Transmission Operators (TOPs)
- Transmission Planners (TPs)
- Planning Coordinators (PCs)
- Reliability Coordinators (RCs)
- MOD-032 Designees

# **Modeling Notification: EX2000 Excitation System Model**

- EX2000, EX2100, and EX2100e are AC excitation systems for synchronous generators manufactured by GE
- In Siemens PTI PSS<sup>®</sup>E simulation software, there is a dynamic model named EX2000 intended to represent these systems
- Field current limiter reset action modeled in EX2000 in PSS<sup>®</sup>E is based on information provided when model was first written
  - This is not how the actual equipment works
- Specifically, once the Latch 2 gate in field current limiter portion of EX2000 model is set, it will never reset, even if field current falls below value IFDREF2



# Field Current Limiter (Overexcitation)





- Entities using EX2000 model in PSS®E should be aware of field current limiter implementation
- For simulations that do not involve field current limiter action, model can be used without any issue
  - Or EX2000 model may be replaced with AC7B model from IEEE 421.5 standard
- If necessary to represent OEL action of EX2000, EX2100, or EX2100e systems in PSS®E simulations, a user-written EX21BR model may be downloaded for PSS®E versions 32 and 33.
  - ex21br model in GE PSLF may be used to represent EX2000, EX2100, or EX2100e excitation systems, including field current limiter actions

- PSS®E implementation questions:

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- GE PSLF implementation questions or model support:

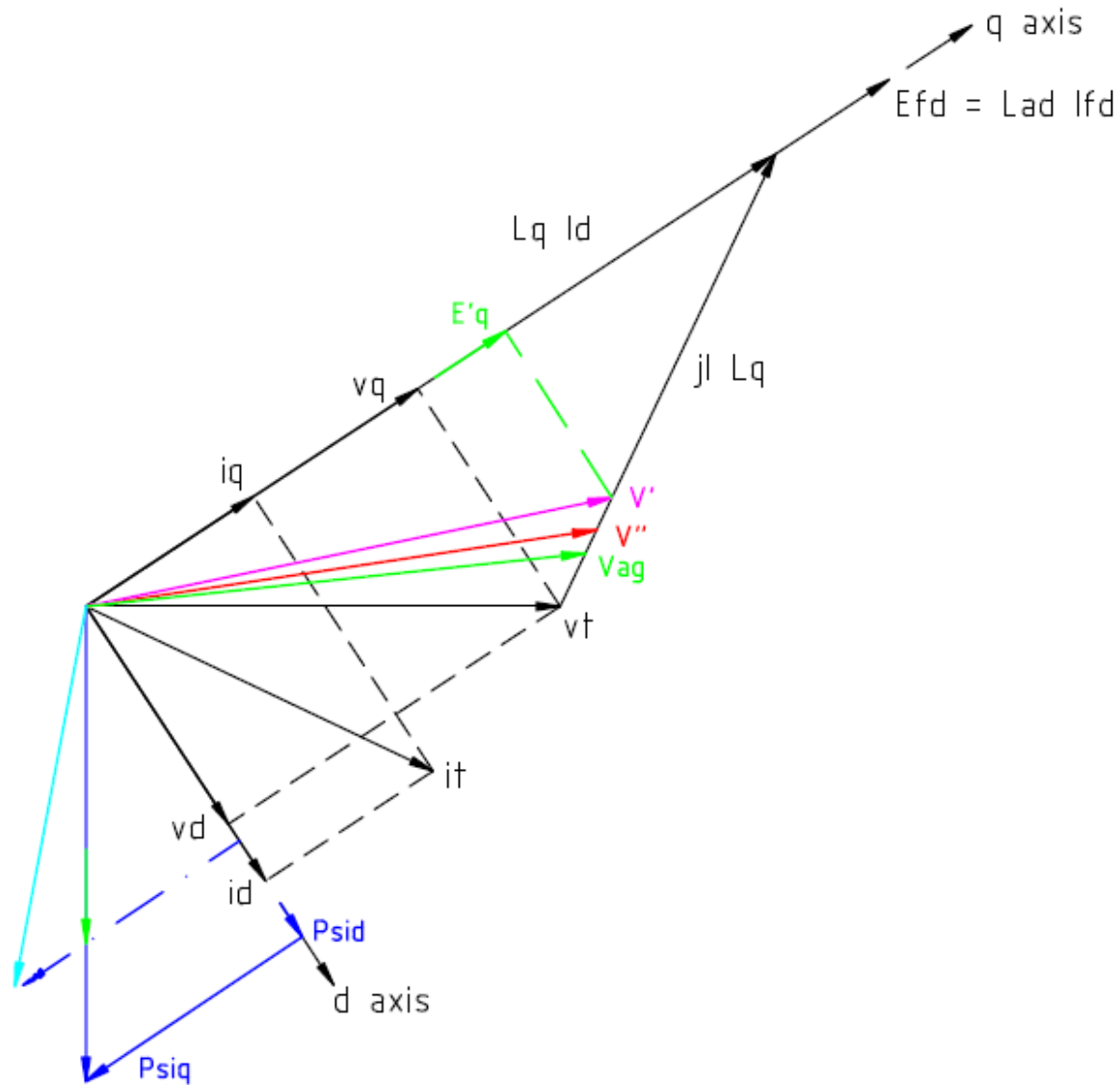
Dan Leonard (GE) – [daniel1.leonard@ge.com](mailto:daniel1.leonard@ge.com)

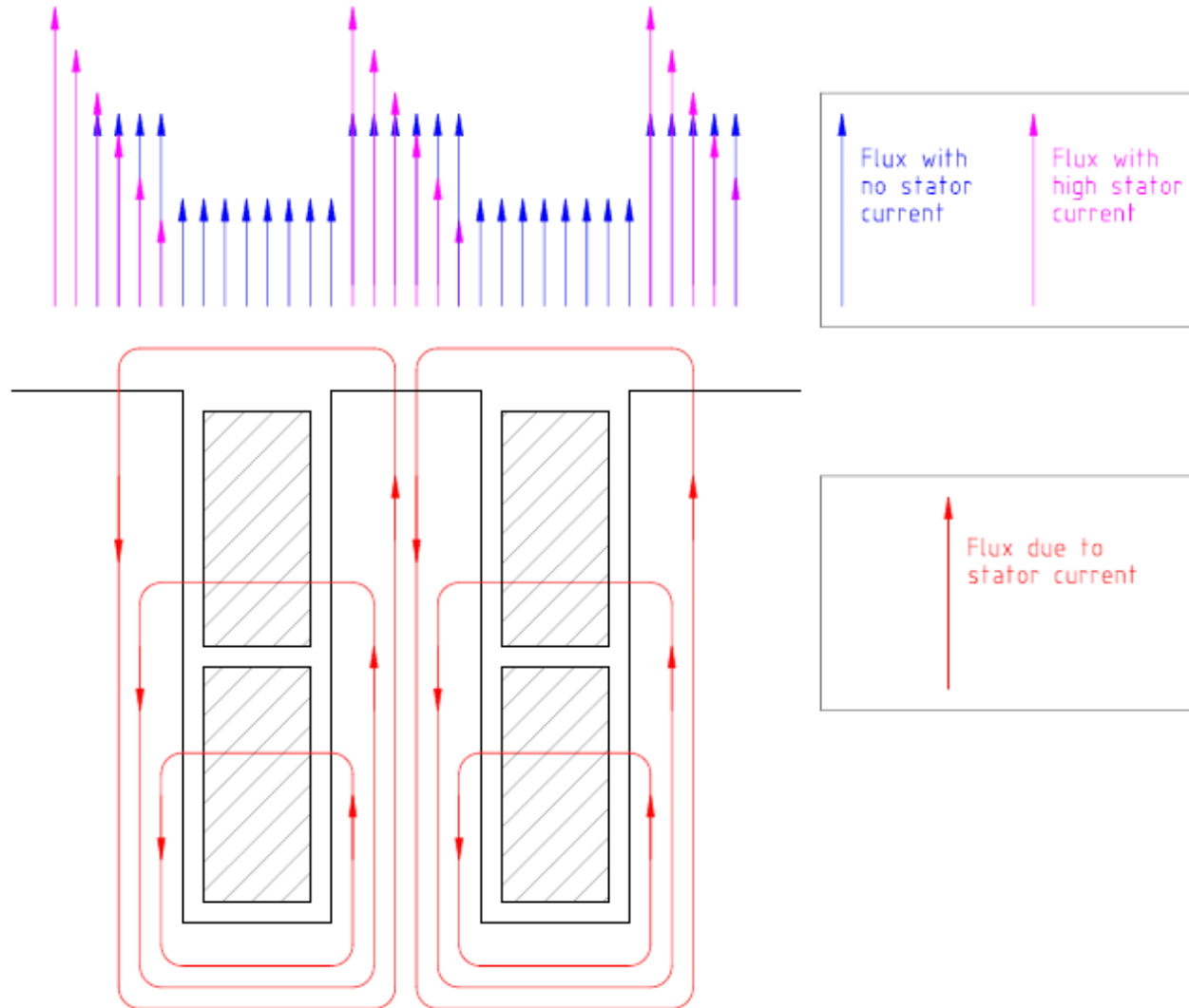
# **Modeling Notification: Use of GENTPJ Generator Model**

- GENROU, GENSAL, GENTPF, and GENTPJ models represent round rotor and salient pole synchronous machines
- Predominant difference between GENSAL/GENROU and GENTPF/GENTPJ models is how they account for saturation
  - GENSAL model uses simplifying approximations that significantly compromise treatment of magnetic saturation
  - GENSAL model ignores saturation on q-axis completely
  - In GENSAL and GENROU, saturation is a single additive term
  - In GENTPJ and GENTPF, saturation is multiplicative on all inductance terms; approximations of saturation, but more accurate than GENSAL and GENROU
  - GENROE and GENSAE use same treatment of saturation as GENROU and GENSAL; only difference is exponential saturation curve rather than quadratic curve

- GENTPJ model recognizes the effect of stator current by including additional parameter,  $K_{is}$ , in the saturation function
- Modeling improvements and more accurate representation of saturation drive the need for industry to move towards use of GENTPJ generator model
- Generator testing in connection with MOD-026 has proved that GENSAL, GENROU, and GENTPF may underestimate field current needed to support rated reactive power output and could introduce errors for simulations studying reactive power support



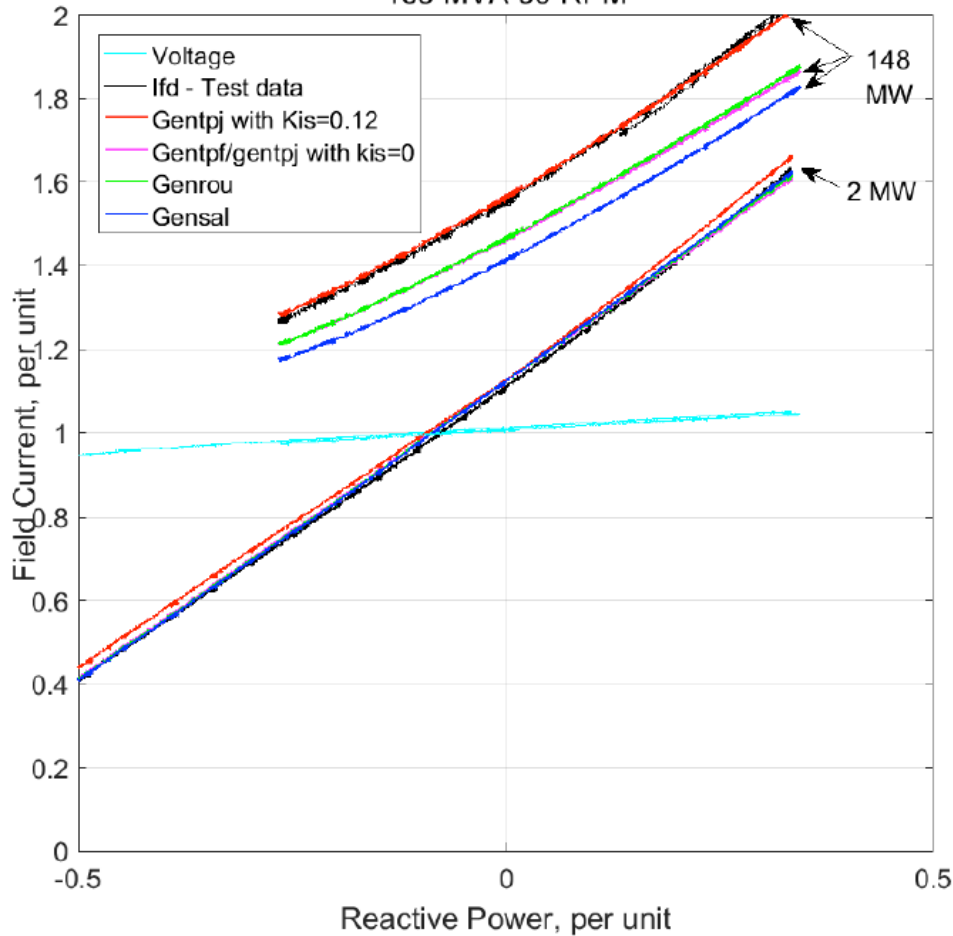






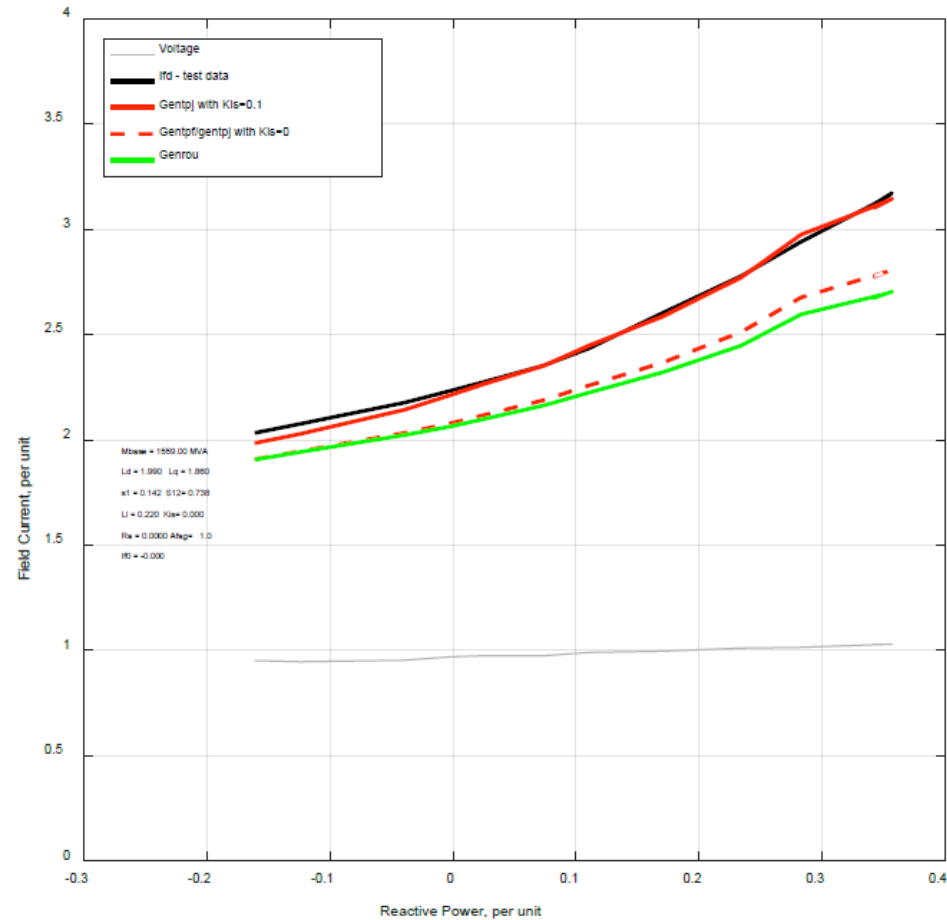
## Low Speed Hydro Unit

163 MVA 90 RPM

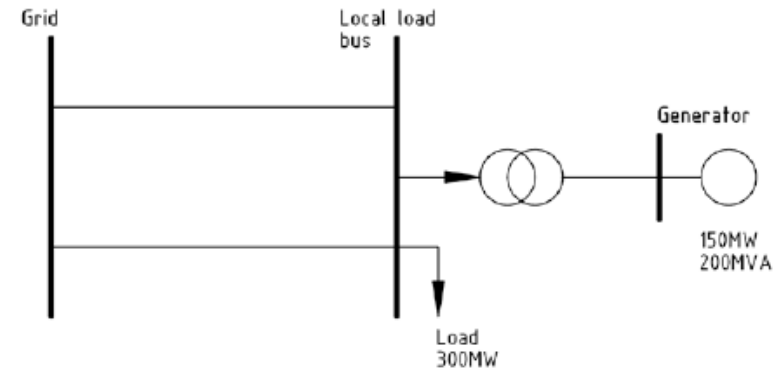
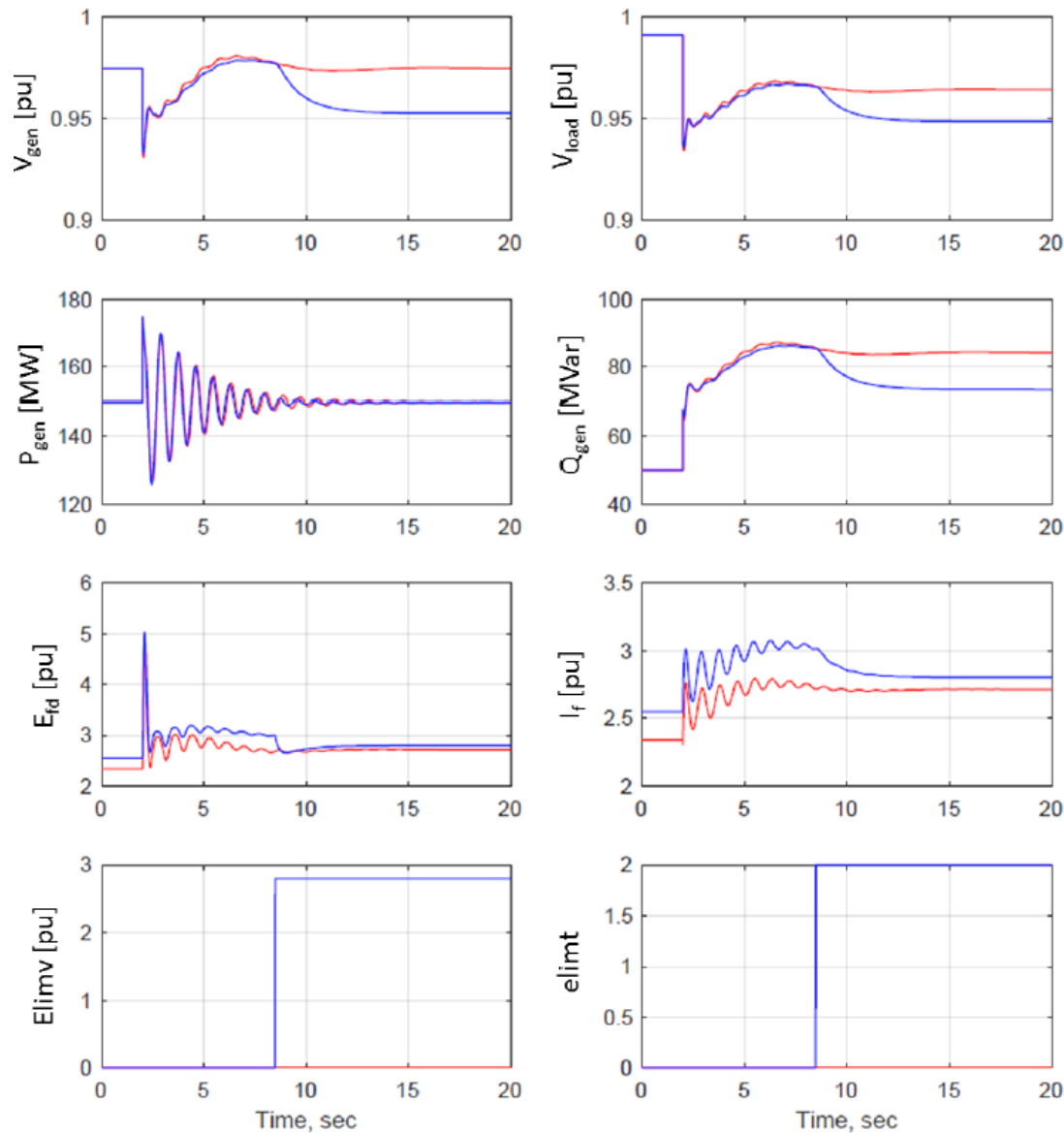


## Large 1800 RPM Unit

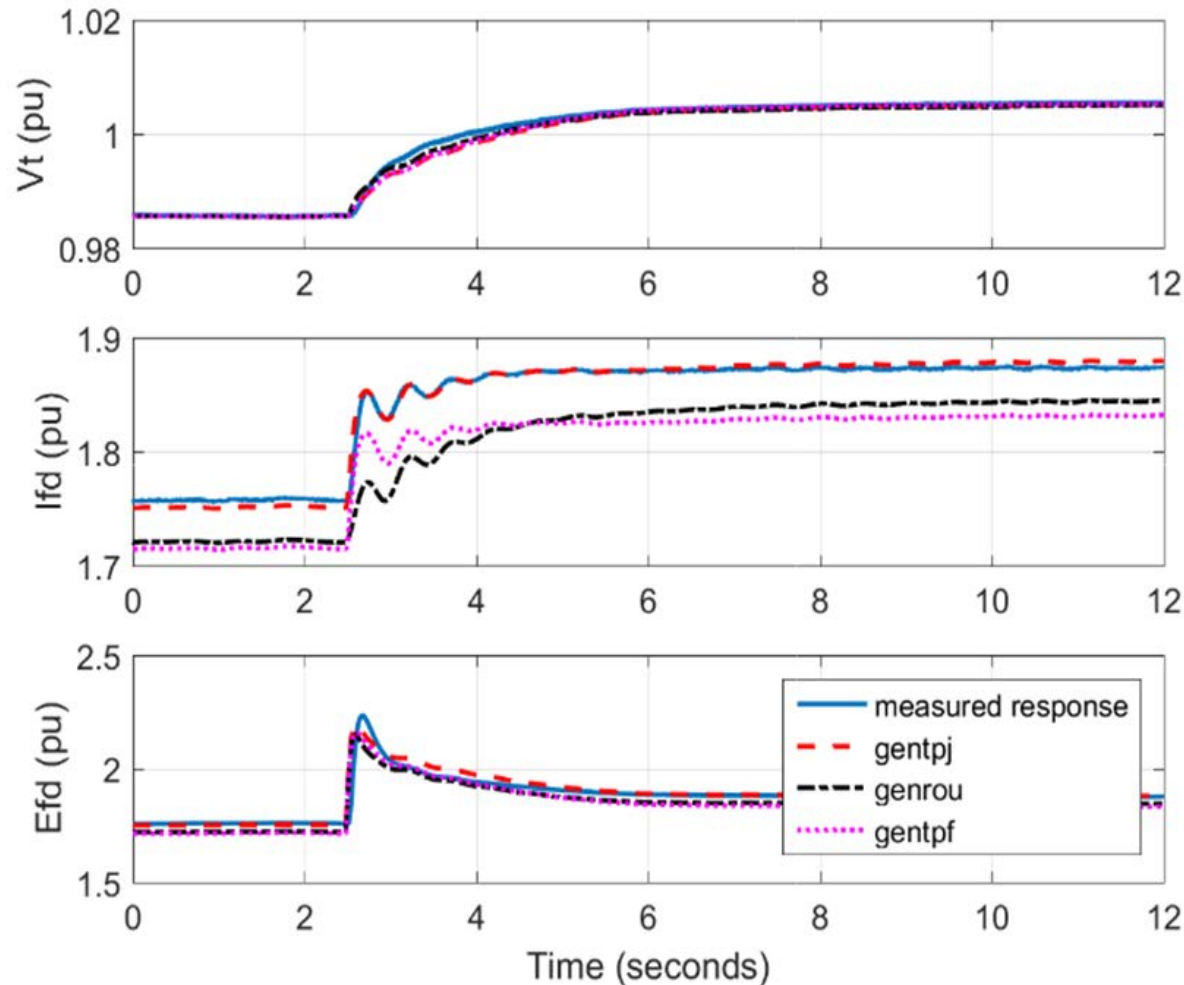
1559MVA 1800RPM



# Example Simulation Field Current Limiter Action



## 618 MVA Round Rotor Generator Online at 500 MW



[1] P. Pourbeik, B. Agrawal, S. Patterson and R. Rhinier, "Modeling of Synchronous Generators in Power System Studies", CIGRE Science and Engineering Journal, October 2016, Volume 6, Online: [HERE](#).

- Entities using the GENSAL or GENROU model are advised to consider using the GENTPJ model for new generators and where generator data is to be newly (re)verified.
- The following are recommended:
  - Upon (re)verification for compliance with applicable MOD standards, it is recommended that the GENTPJ model be used to represent salient pole and round rotor machines rather than GENSAL or GENROU based on assumptions made to account for magnetic saturation.
    - Model parameters can be determined and/or verified by original equipment manufacturer (OEM) specs, baseline testing, or disturbance-based verification. Typically, using OEM data and fitting the  $K_{is}$  parameter using measured V-curve data tends to yield good results.

- The following are recommended (cont.):
  - GOs are encouraged to consider timely, prioritized (re)verification of generators currently modeled using GENSAL, and to use the GENTPJ model upon (re)verification of these units. GENSAL is considered an obsolete model in the [\*NERC Library of Standardized Dynamic Models\*](#).
    - $K_{is}$  should be estimated from V-curve ( $I_t$  vs.  $I_{fd}$ ) data whenever possible. Use of  $K_{is}$  more accurately captures the variation of saturation with machine loading.
    - V-curve data may not always be easily measured (e.g., where reactive power maneuvering is not possible because of local operating concerns); therefore, it is not required but should be determined whenever possible for more accurate modeling.

- The following are recommended (cont.):
  - Where round rotor generator data has been verified using GENROU, the GENROU model should be retained. For new generators and where data is to be newly (re)verified, GOs are recommended to use GENTPJ.
    - However, GENROU may be used so long as a suitable match of simulations to the available measured data is achieved.
    - Particularly V-curve test results in conjunction with MVAR rejection and open circuit saturation curve test results.
  - PCs and TPs are recommended to put in place modeling data requirements, per MOD-032-1, that disallow new GENSAL models from entering any future base cases used for interconnection-wide studies.
  - TPs, PCs, and GOs are recommended to perform disturbance-based power plant model verification (PPMV) on any unit regardless of models used to ensure that operational performance to grid events can be matched with a modeled response.

- NERC MWG Webpage – [HERE](#)
- Process Document – [HERE](#)
- Notification: EX2000 Excitation System Model – [HERE](#)
- Notification: Use of GENTPJ Generator Model – [HERE](#)



# Questions?

Modeling Notification Questions:  
[NERC System Analysis](#)