



## Generator Modeling Base On Disturbance Recordings Using PPPD

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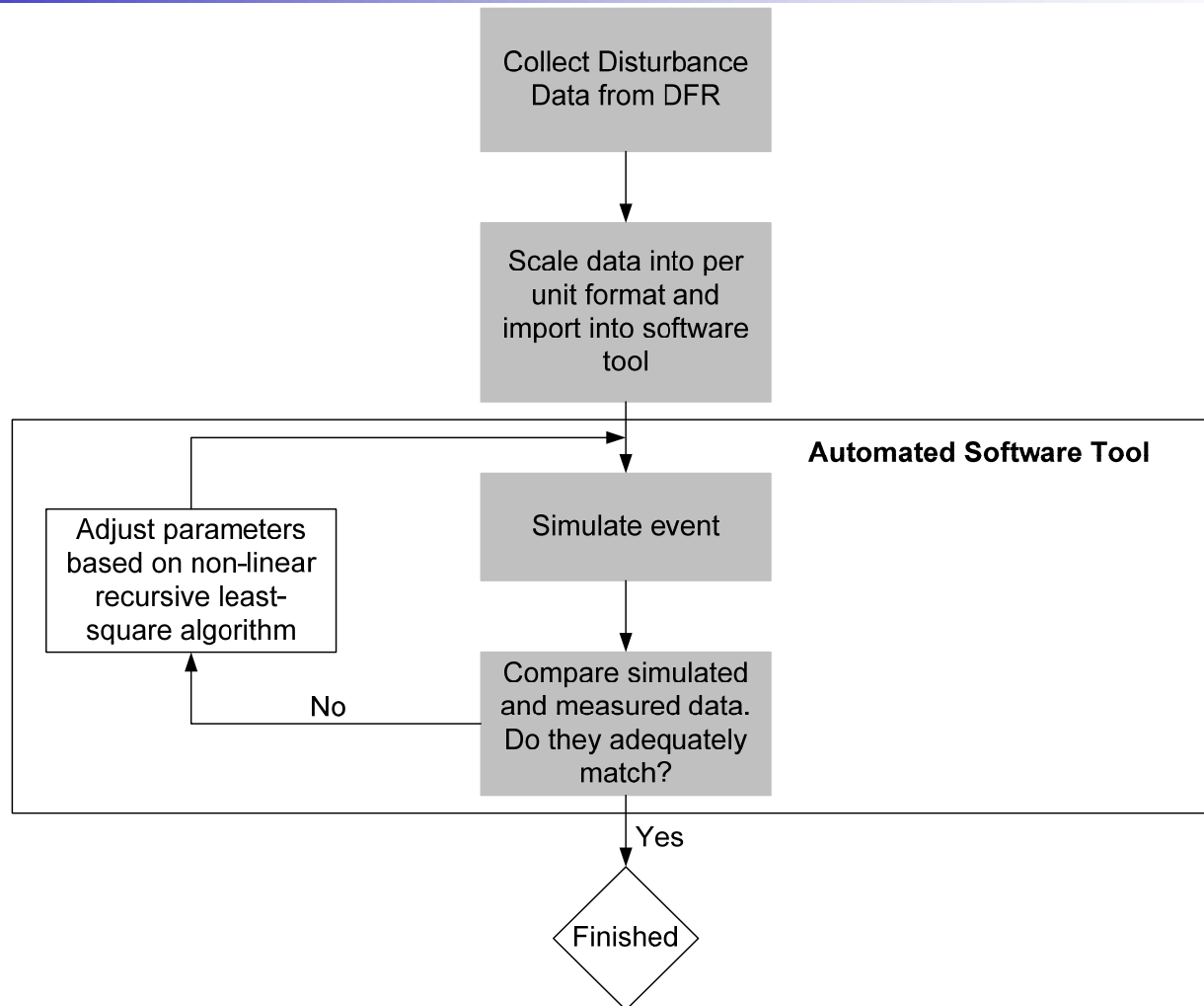
**NERC Meeting**

**December 8 – 9<sup>th</sup>, 2009**

## QUICK REVIEW

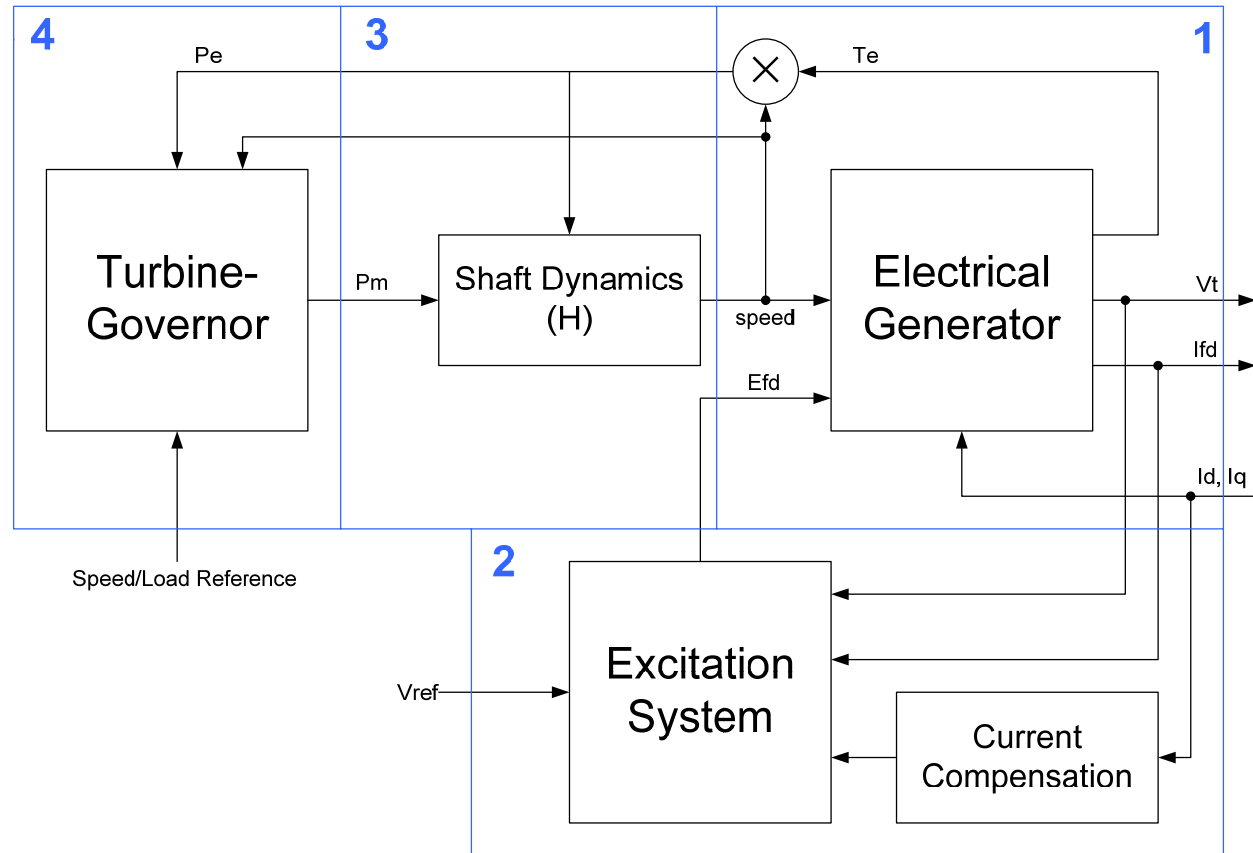
- EPRI has developed the PPPD software over the last few years
- It takes both field “staged test” data and “on-line disturbance recordings” (e.g. from DFRs) to validate/fit model parameters
- We will be creating a User’s Group for the tool next year
- 25 utilities participated in funding its development and thus have a license to it

# The Algorithm

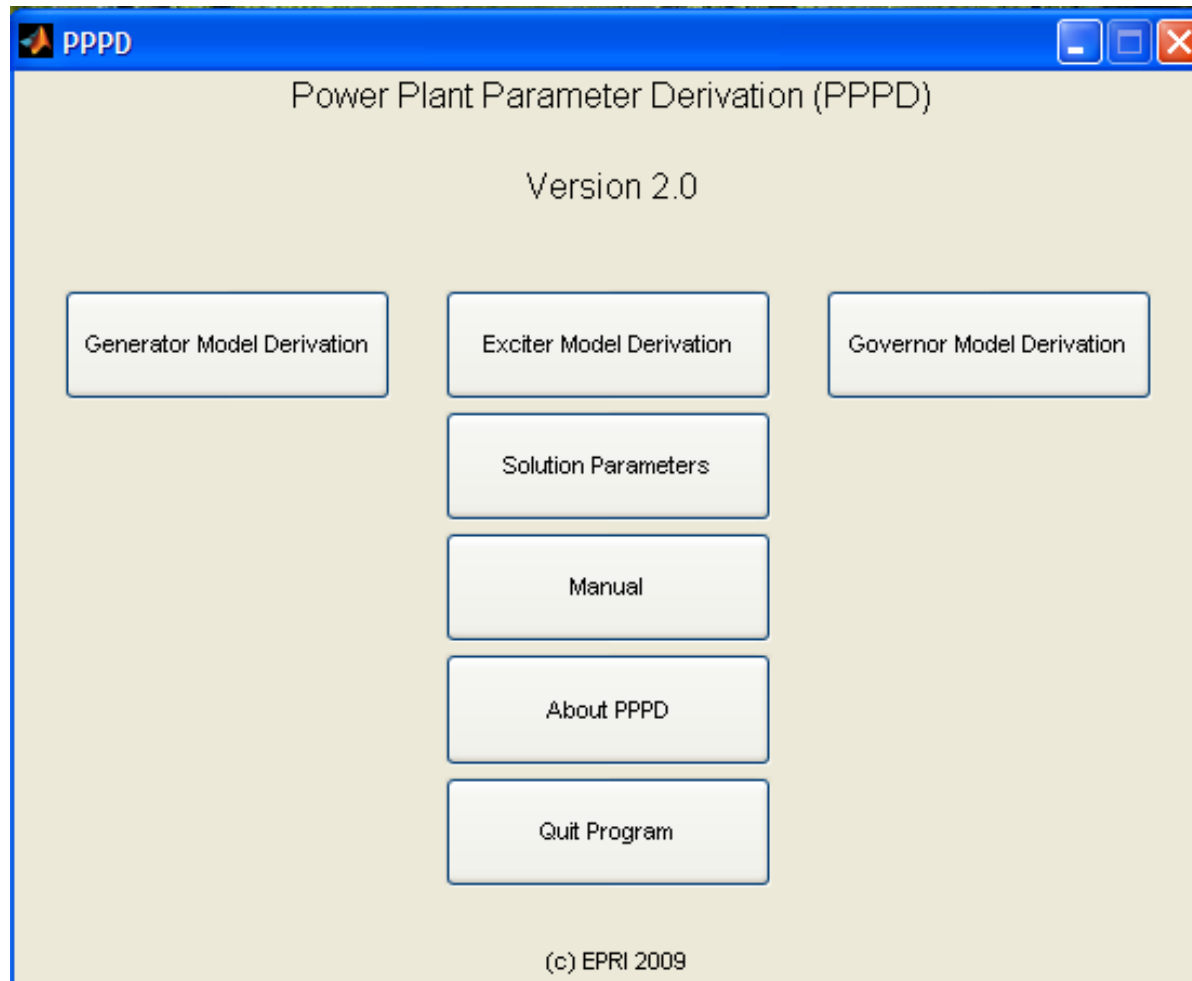


(reproduced from, P. Pourbeik, "Automated Parameter Derivation for Power Plant Models From System Disturbance Data", Proceedings of the IEEE PES GM 2009, Calgary July 2009 © IEEE 2009)

# PPPD



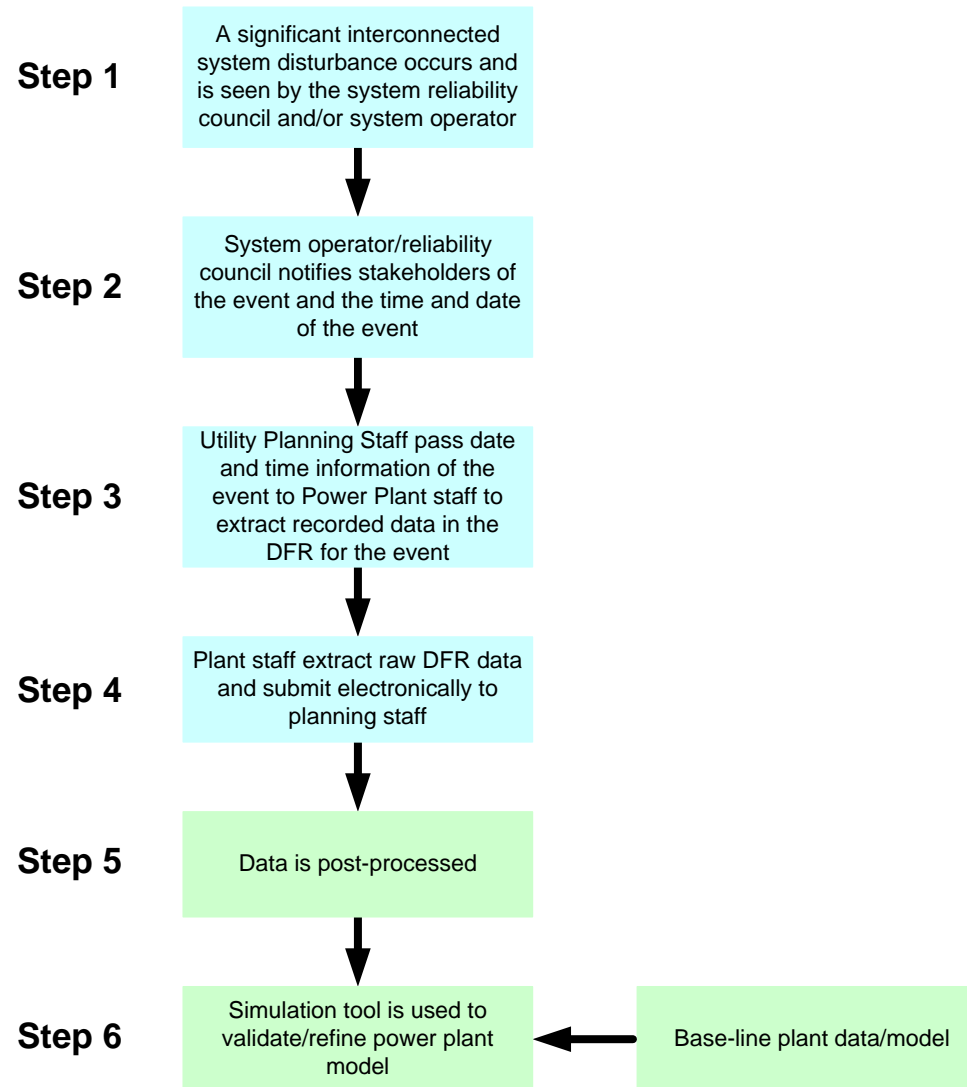
# FIRST SCREEN IN PPPD





## **Steps in The Process**

# Steps Involved In On-Line Monitoring Based Model Validation



# Steps Involved In On-Line Monitoring Based Model Validation

## Baseline Data

- Need to have good base-line data to be able to identify the models to be used and have a good initial set of parameter estimates
- Sources of base-line data
  - Field tests upon commissioning
  - Field tests for WECC certification performed previously
  - Verified original equipment manufacturer (OEM) data sheets
  - All (or a combination) of the above

## What do we mean by baseline data?

- Basic name plate information (MVA, kV, pf, rpm etc.)
- Generator electrical parameters
- Generator saturation parameters and open-circuit saturation curve
- Excitation system model and parameters
- Turbine-governor model and parameters
- If PSS exists, the actual tuned field settings of the PSS and its model

**Base-line Data is Critical**



# Steps Involved In On-Line Monitoring Based Model Validation

## Monitoring Equipment

- Need to have monitoring equipment to monitor unit specific data:
  - Stator voltage
  - Stator current
  - Generator real and reactive power output
  - Field current and voltage
  - Generator terminal voltage frequency (or generator shaft speed)

Above is the minimum data to be recorded at a sampling rate of preferably 60 samples per second.
- This can be achieved by:
  - Dedicated digital fault recorders (DFRs) in the power plant (presently implemented by utilities such as Tri-Stat and APS)
  - Some modern digital excitation systems have inbuilt DFRs which can achieve this

Other approaches may also be employed, but it is critical to monitor the minimum signals listed.

## Triggering Points

- Should typically trigger for events leading to frequency deviations greater than about 80 mHz and/or voltage deviations (at the generator terminals) of greater than a few percent (typically 5%).
- Should be able to capture and store events for future retrieval and analysis

# Steps Involved In On-Line Monitoring Based Model Validation

## Validation

1. Take data from the DFR recordings (export electronically) and put into format needed for simulation work
2. Import data into software tool
3. Compare simulation with measured results and validate; or iterate to get good fit and thus identify where discrepancies may lie

We perform steps 2 and 3 using a software tool developed in EPRI through its R&D program called Power Plant Parameter Derivation (PPPD).

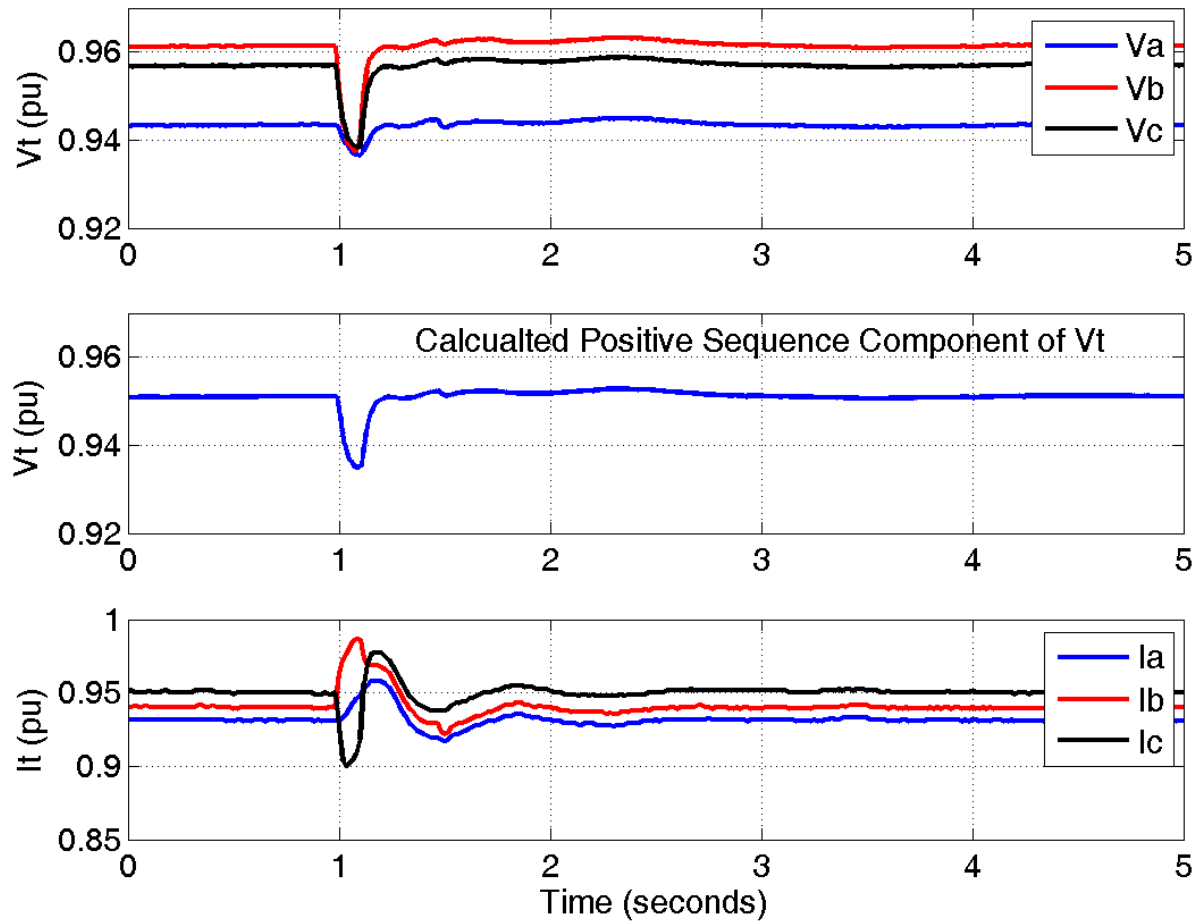


## **Some Example Results**

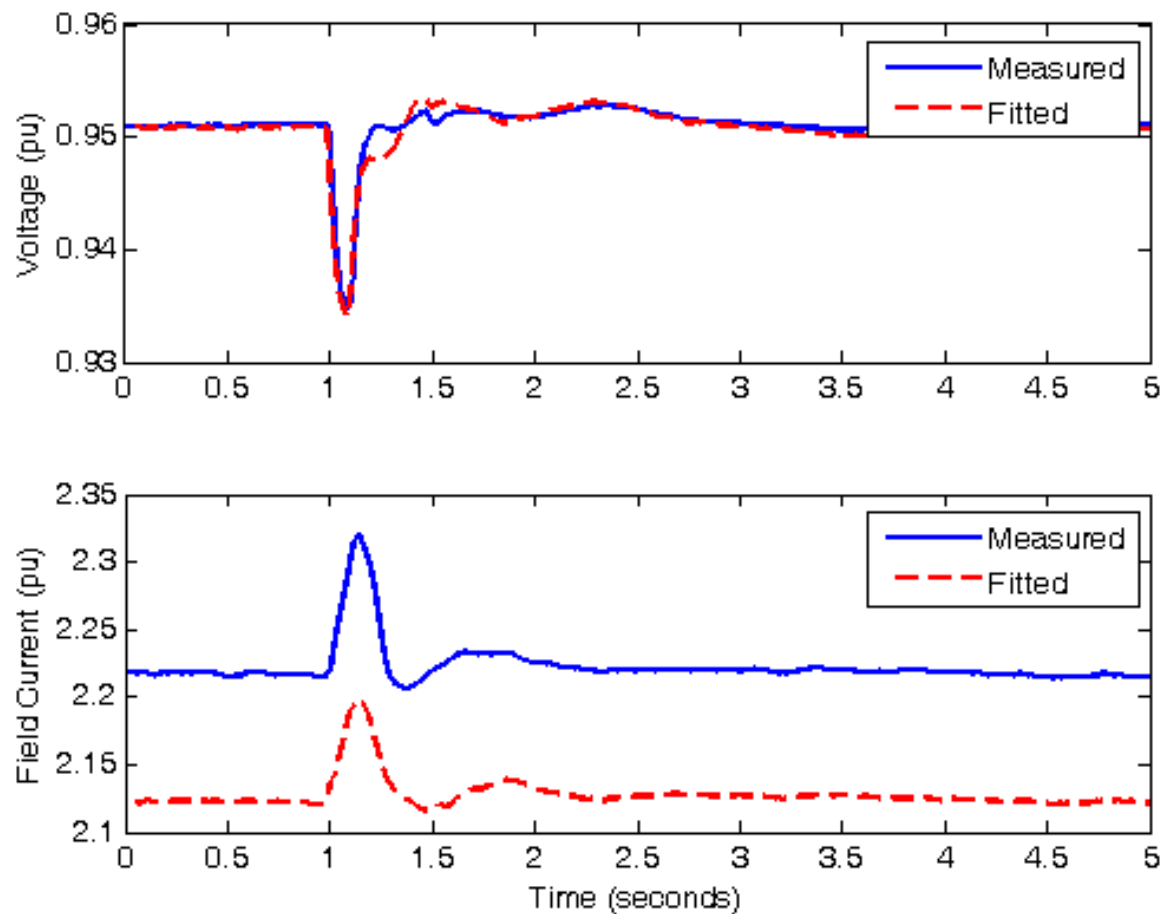
# Unbalanced Faults

- Caught a case recently on a 496 MVA steam-turbine generator unit
- Had reasonably good success by extracting the +ve sequence data from the event

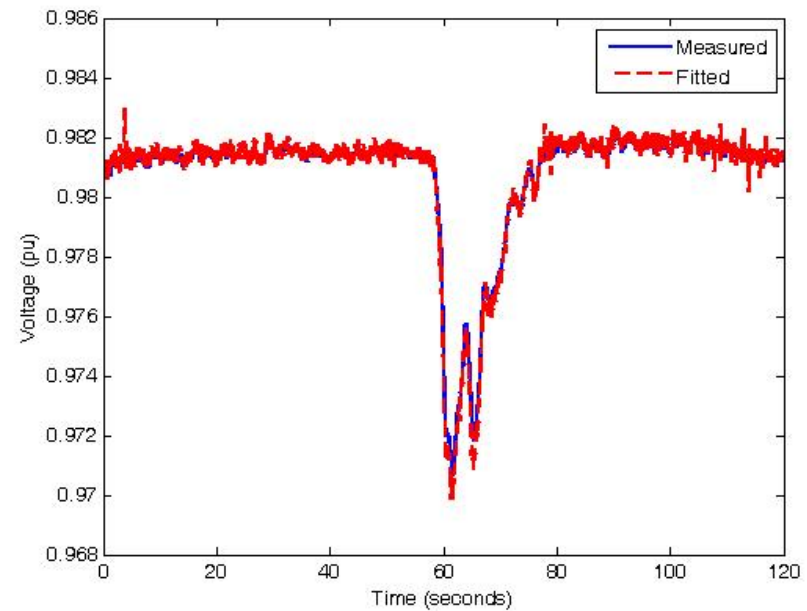
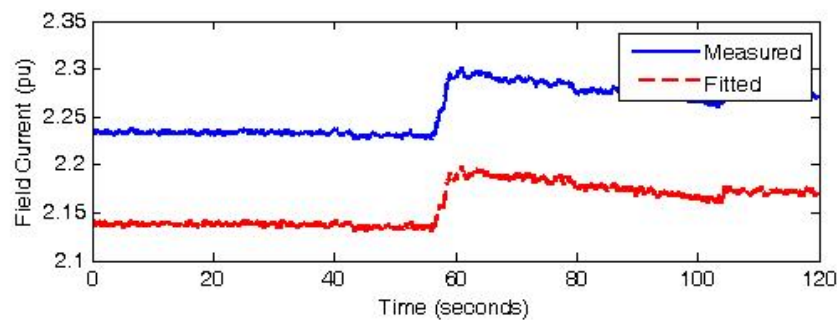
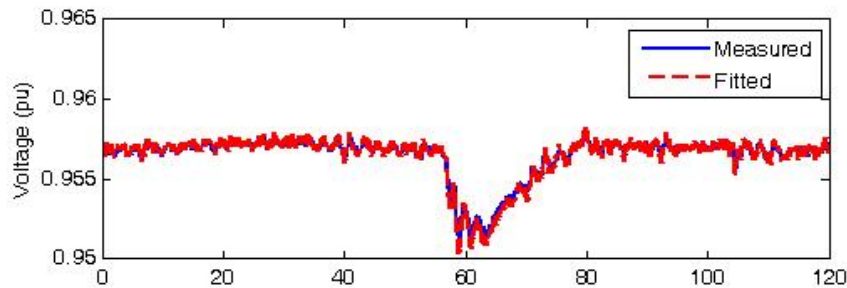
# Unbalanced Faults



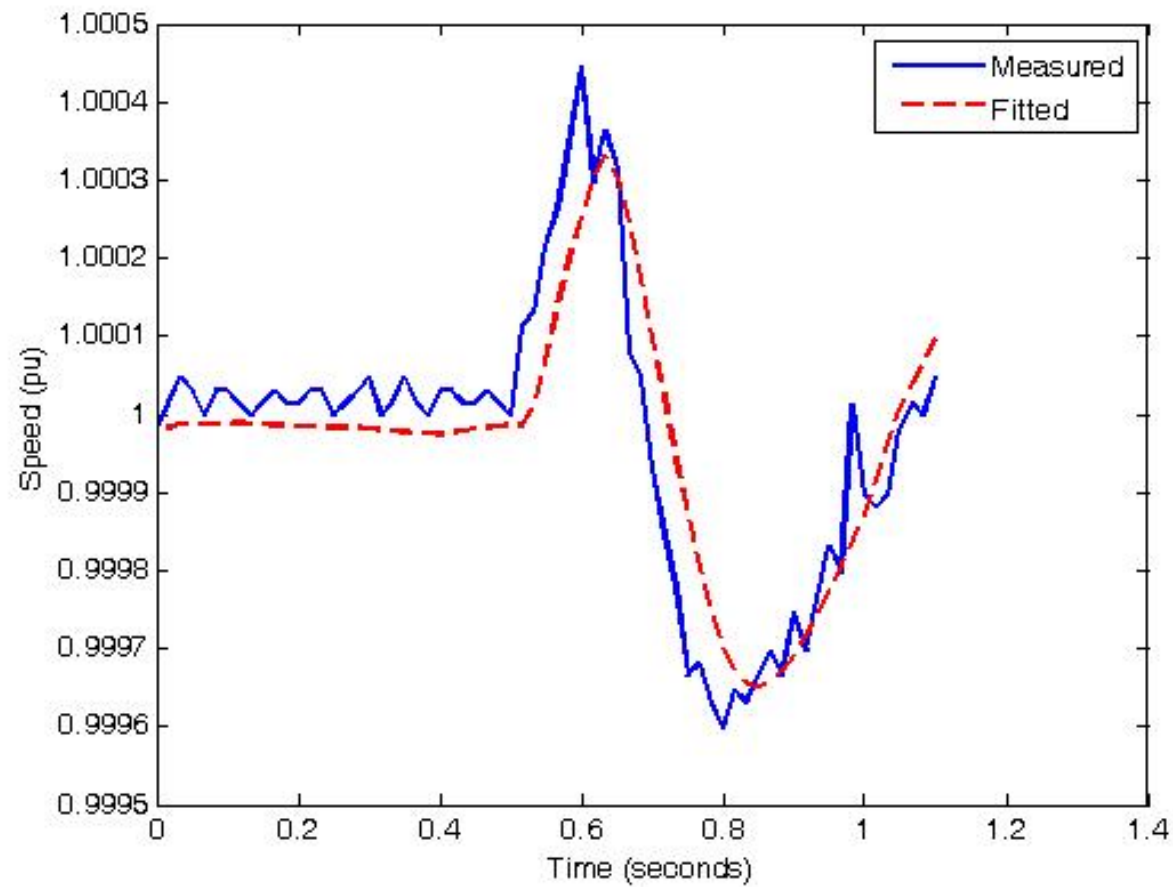
# Unbalanced Faults



# Balanced Event Same Unit



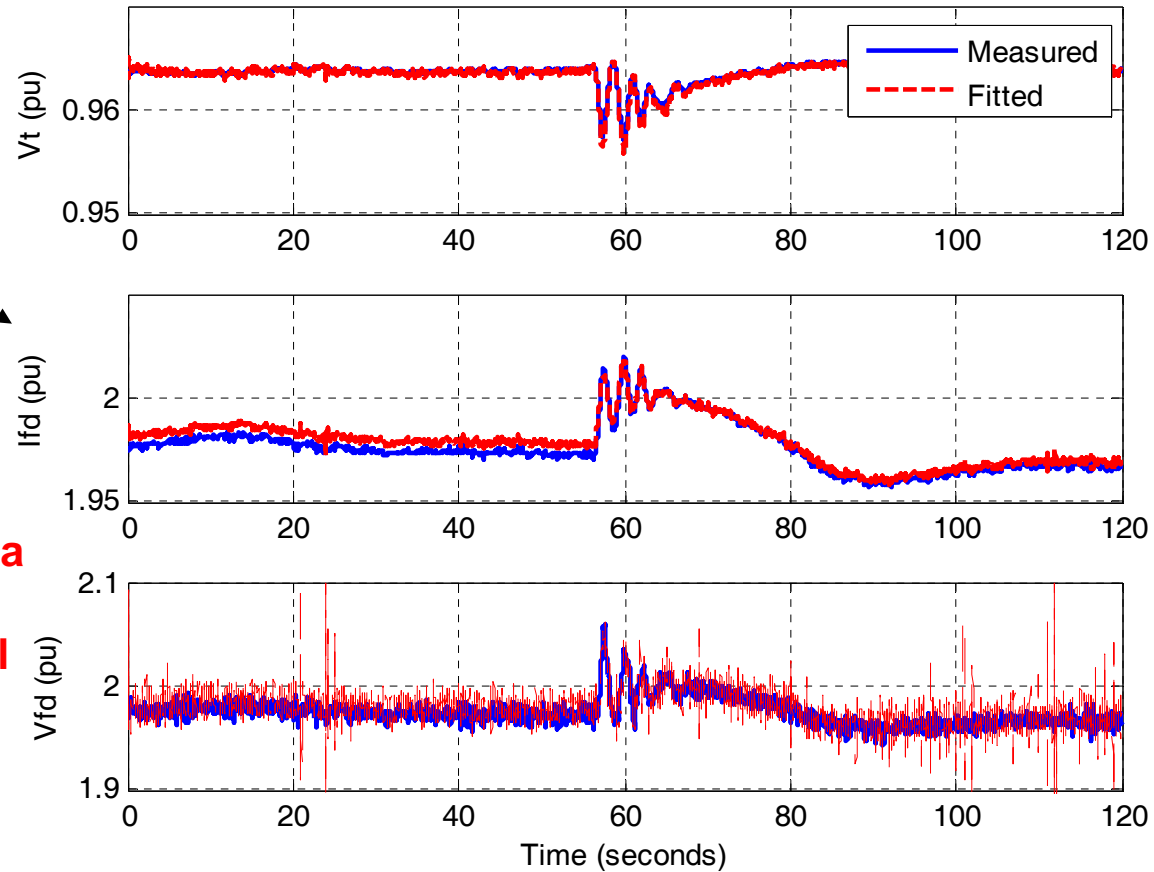
# Inertia





# Excitation System Response – Balanced Event

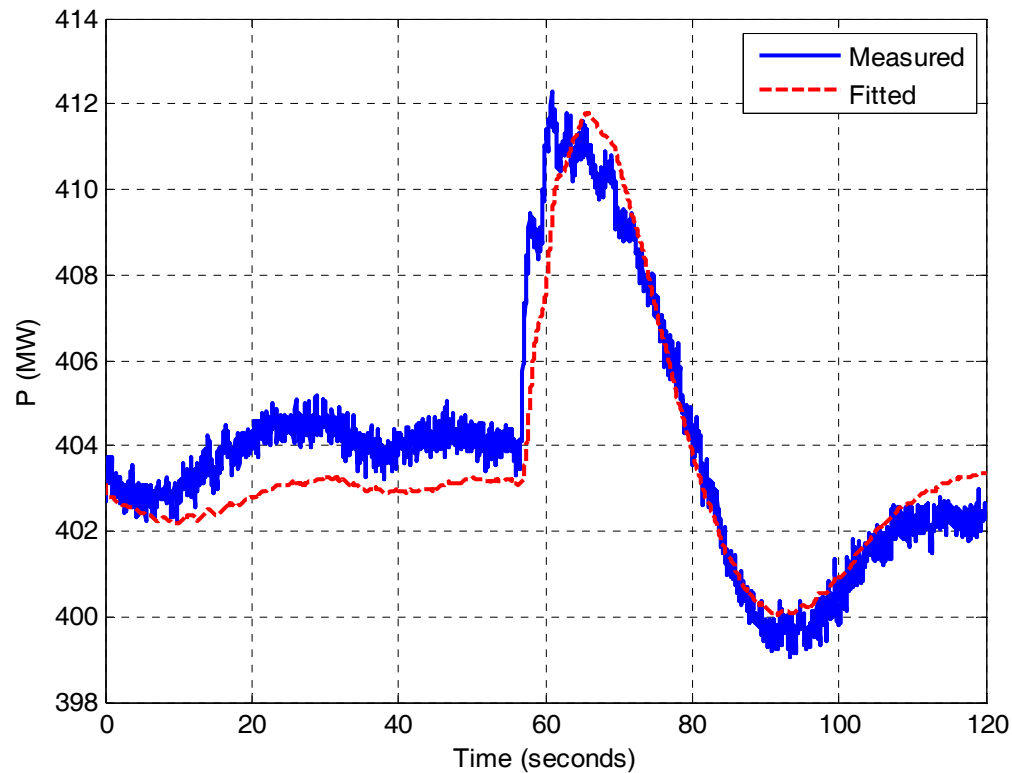
Removed off-set error in  
Field quantities



**This case actually revealed a  
gain difference between  
field and assumed model  
setting.**

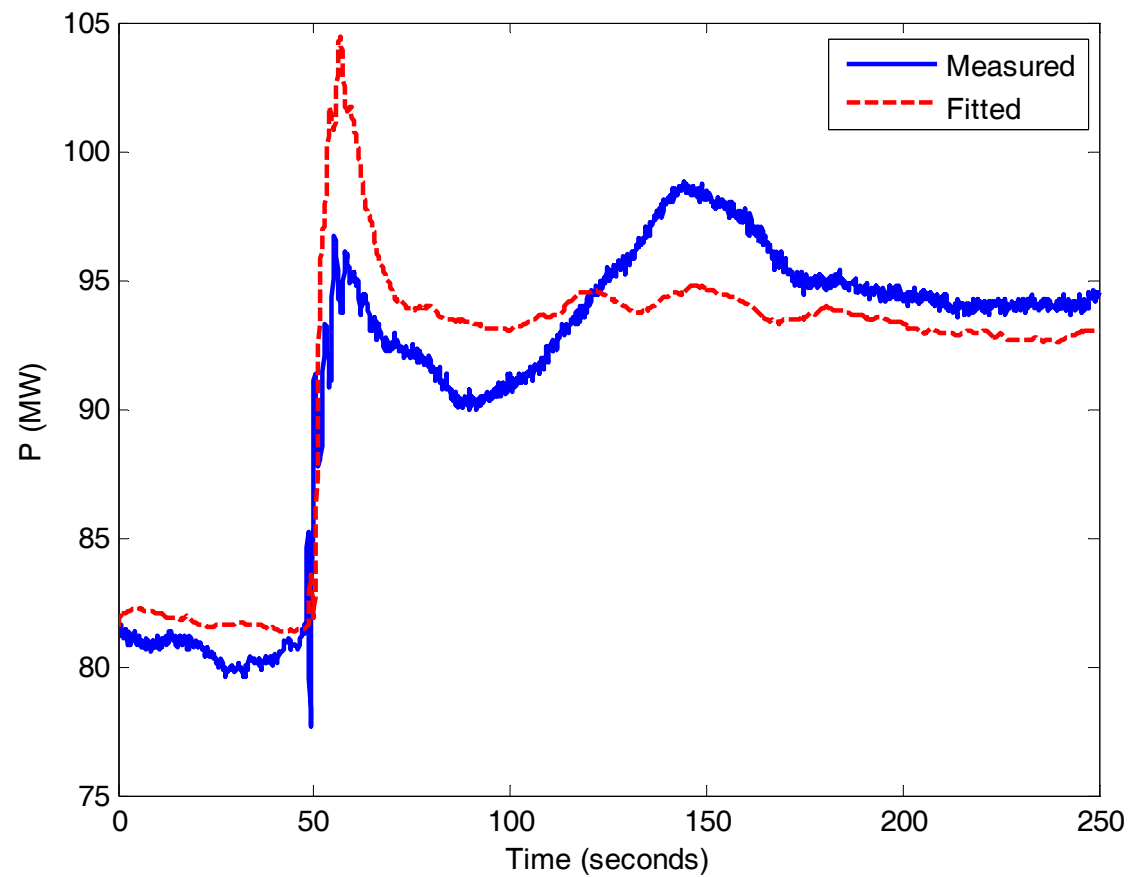
# Turbine-Governor Response

Fit for a large steam turbine showing outer-loop MW controller action;  
response to a system disturbance resulting in a frequency dip due to large generation loss



# Turbine-Governor Responses

GT Response fit with GGOV1  
using PPPD





## **Future of PPPD – User's Group in 2010**

# PPPD USER'S GROUP

- The scope is:
  - Share experience of various user's with the tool (face-to-face meetings as needed and through webcasts/calls)
  - Provide further training sessions (face-to-face meetings as needed and through webcasts/calls)
  - Discuss enhancements and the choice of additional models to be added to the tool
  - Release further releases of the tool with new models, or bug fixes
  - Provide general support and guidance on program including bug fixes, if any, and general Q&A through calls and emails.

# Future Base Fund R&D Projects

- Program 40
  - [P40.012] Determination of Load Composition using Smart Meter Data
  - [P40.013] Development of Standard Models for Dynamic Components
    - FACTS, HVDC and any further work on generator modeling (e.g. turbine-boiler related work and hydro generators)
- Program 173
  - [P173.003] Grid Performance and Modeling of Variable Generation and Evolving Power System Resources
    - Model and model validation for Wind Turbines, PV etc.



**Questions, Comments, Concerns?**