Testing and Related Topics

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Gait - Key Behavior

- Is required and done worldwide in nations at varied levels of development.
- Objectives and uses are varied.
- There is valuable experience here - largely WECC.
- There is different valuable experience elsewhere - UK - Singapore - Ireland - Turkey.
Objectives

• UK-UCTE-Asia
  • Verification that dynamic performance meets standards

• WECC
  • Verification that plant is represented properly in grid simulations
Approaches

- Studies done on basis that plants perform to standards - details of how performance is achieved inside the fence are secondary in analysis of the grid

- Studies done on basis that simulation of plant internal details will reveal pertinent aspects of grid behavior - grid performance expectations based on presumed accuracy of simulation details
Both are Needed

• Neither approach is satisfactory if relied on alone

• Grid analysis based on performance standards alone can fail to anticipate problems arising from internal characteristics of plants

• Detail-based simulation can give false impression that simulations are correct and will reveal all potential problems

• Both of these limiting factors are continually
Dilemma of Detail

• Increasing detail of a simulation does not inherently make it more accurate

• We must be clear about the meaning of “accuracy”
Dilemma of Detail

- Detail in simulations improves the ability of the engineer to understand the phenomena that will influence the grid.
  - as to the nature of the phenomena
  - their general relative influence

- but this gives no assurance of improved quantitative information on their effects in a specific proposed power system event.
Therefore --

• Are we testing generators in the hope of making our grid simulations more quantitatively accurate ??? or

• To make sure we understand the way our plants behave at the level of phenomena ??? or

• To make sure that our plants deliver static and dynamic performance in accordance with expectations set by standards ??? or

• For clinical value - to establish the norm and detect those plants that deviate from that norm
All of the Above

• No simulation is trustworthy until validated by test and/or operational experience

• Plant testing validates parts of the overall simulation

• Grid level validation, once impossible, is now both possible and practical

• Regardless of standards, both owners and suppliers have strong interest in knowing that expected performance is produced

• Clinical work is always valuable - potentially the most beneficial aspect of dynamics related test
Thus

The real value lies in testing that is

• simple enough to be done regularly
• able to reveal both the required dynamic characterization
• likely to detect out-of-norm equipment
Testing Details

• Generator
  • Magnetization curve
  • Reactive power range - V-curve
  • Current Interruption

• Excitation system - Stabilizer
  • Step tests
  • Current Interruption

• Turbine governor
  • Step tests

• Limiters
  • Ramp approach
Reactive Power range
$L_d = \frac{dV_q}{dl_d} = \frac{(V_o - V_f)}{I_o}$  \text{ Synchronous Reactance}$

$L'_d = \frac{dV_q'}{dl_d} = \frac{dV_q'}{I_o}$  \text{ Transient Reactance}$
Imperfections and Cautions

Speed can vary significantly
• affects determination of Ld
• readily compensated in analysis of test result

Circuit Breaker poles do not open simultaneously
• affects determination of L"d and T"do

Unclear final voltage
• affects determination of Ld
• can be compensated in analysis of test result

Field voltage is not constant
• exciter/rectifier regulation
• field current regulator
Fly in the Ointment
Fly in the Ointment

\[
\frac{dVq''}{dld} = \frac{(V_0 - V_f)}{I_0} \quad \text{Synchronous Reactance}
\]

\[
\frac{dVq'}{dld} = \frac{dVq'}{I_0} \quad \text{Transient Reactance}
\]

\[
\frac{dVq''}{dld} = \frac{dVq''}{I_0} \quad \text{Subtransient Reactance}
\]
Simulation is the Invaluable Tool in Interpretation of Test Results

- Accommodation of saturation
- Correction for speed deviation
- Correction for imperfect field voltage control
Voltage Regulator Response
Turbine Governor Response

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Turbine Governor Response

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Test Planning

- Operational Planning
  - Advance site visit
  - MW / MVAR Chronogram
  - Startup / shutdown planning

- Emissions / Air Quality
  - Limited time at part load
  - Severe limitation of operational flexibility
  - Severe elapsed time constraints

- Turbine issues
  - LP heating / vacuum
  - Combustion transitions

- Protection
  - Volts / Hz excitation system / generator relay / transformer relay
  - Reverse power
Precautions

• Protections should not be disabled

• Person doing analysis should be present at tests
Technical Points

• Should our particular testing built in to commissioning protocols
• Is it necessary to test to verify control constants in a digital controller
• Built-in test recording
• Built-in disturbance recording
• Type testing - certification
Administrative Points

• Emissions difficulties
  • assured variances?
  • compensation of costs?

• Quality control
  • test work
  • data administration

• Data administration
  • dissemination of data
Thankyou
Basic Test Recording
Final value is unclear, Speed varies
Test Recording – log(Vq)

Vq (Log)

AVR Output

Efd
Variation of voltage signal is known to be exponential and asymptotic to a well-defined final value.

This logarithm of transient component of voltage must be linear as voltage approaches the asymptote.

Curvature of logarithmic plot indicates error in estimate of asymptote.