Study Committee B5

Protection and Automation

Paper ID: 10622

Impact of low network inertia on system transient stability

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Motivation

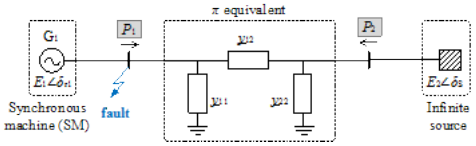
- CIGRE JWG B5/C4.61
- *Impact of low inertia network on Protection and Control*
- Check the *transient stability* analysis in networks with high penetration of converter interfaced generation (**CIG**)
- Expected impacts on critical clearance time (**CCT**)

Calculations

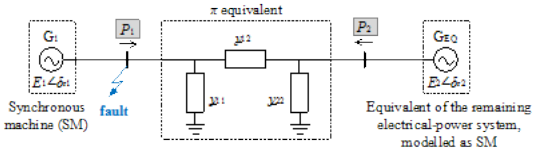
- Static (equal-area criterion) in Matlab environment
- Dynamic (RMS simulations) in Matlab/Simulink environment

Simulation models

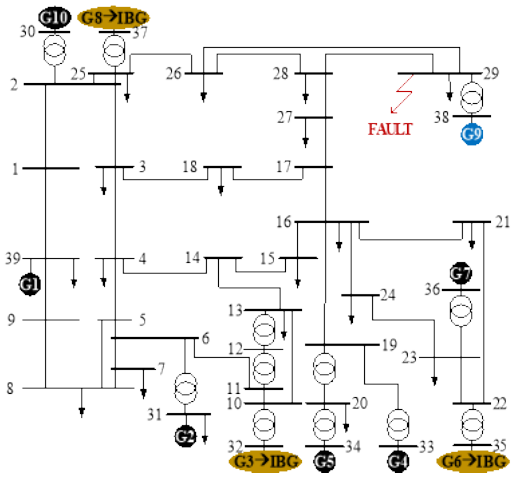
- Single-Machine Infinite Bus (**SMIB**) model



- Two-Machine model



- IEEE 39-bus model

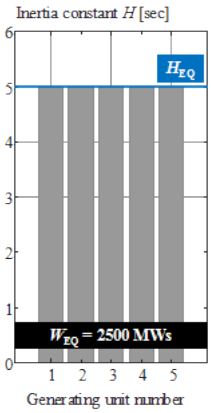


Decreased-inertia modelling

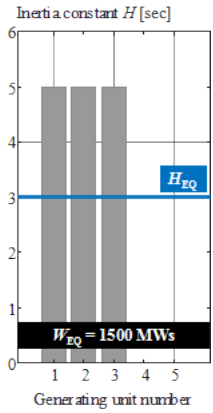
- Fictitious power system with five generating units
- Identical installed apparent power 100 MVA

$$S_{EQ} = \sum_{i=1}^{n} S_{r,i} \qquad H_{EQ} = \frac{\sum_{i=1}^{n} H_i \cdot S_{r,i}}{S_{EQ}}$$

All five generating units are synchronous machines



Two out of five generating units are replaced by CIG



- Decreased inertia of the remaining network was modelled by decreasing H_{EQ} in seconds

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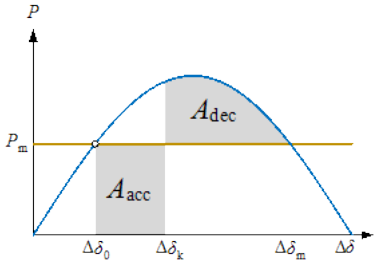
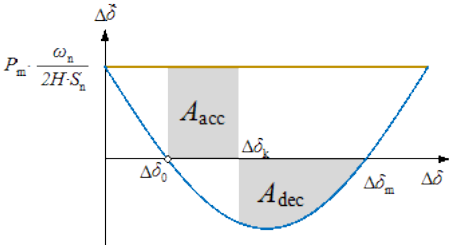
Equal area criterion

$$P_1 \approx \frac{|\underline{E}_1| \cdot |\underline{E}_2|}{X_{12}} \cdot \sin\underbrace{(\delta_{r1} - \delta_S)}_{\Delta\delta}$$

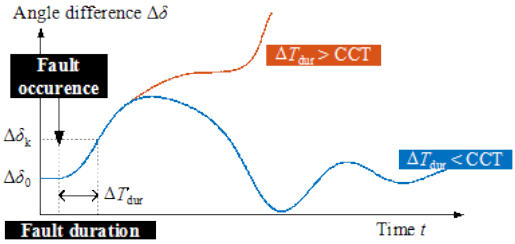
- Conventional *P*-Δδ diagram



- Improved δ - Δδ diagram

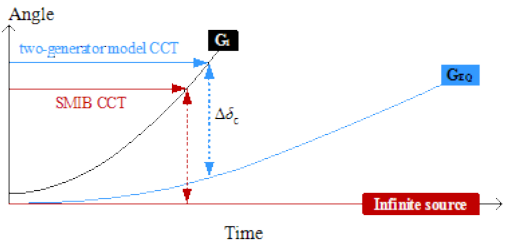


Dynamic RMS simulations

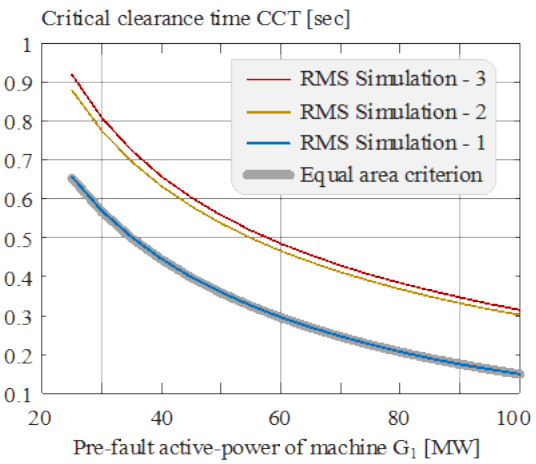


Expectations

- CCT increases
- Critical angle remains the same (see contribution to special reporter question 1.05)



Model validation



a sub-transient model with excitation/governor

a sub-transient model without excitation/governor

voltage source behind a fixed impedance

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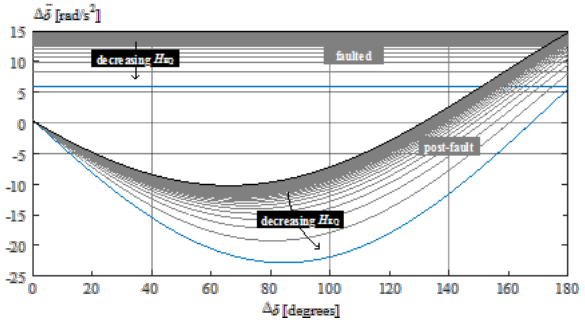
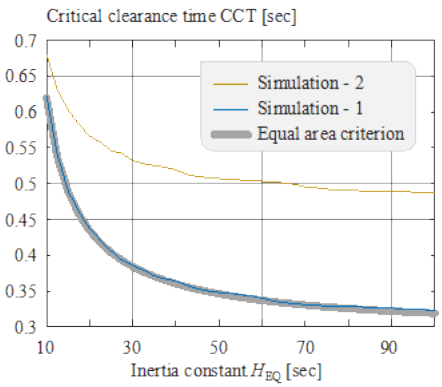
Results

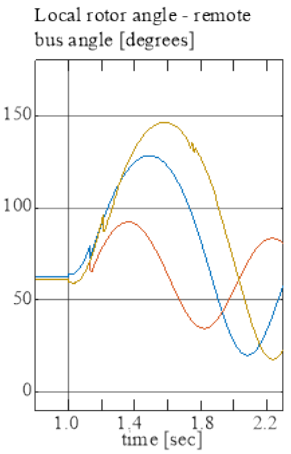
- Variation of inertia in the remaining network
- Decrease in acceleration area
- Increase in deceleration area



Two-machine network



IEEE 39-bus model



Network without CIG (CCT = 130 msec)
Fault duration equals CCT

Network with CIG (CCT = 210 msec)
Fault duration equals 130 msec

Network with CIG (CCT = 210 msec)
Fault duration equals 210 msec

Conclusions

- Critical clearance times of synchronous machines are expected to increase with reduced network inertia
- This may be positive news since more time is given for protection relays to clear faults
- Longer clearance times may also lead to the frequency problem
- It is important to consider the existing levels of inertial masses in the electrical-power systems (effect may become saturated at high values of inertia)
- In contribution to special reporter question 1.05 the impact on distance relay blocking due to power swings is provided