Thu 9/3 Readings posted.

California Independent System Operator (CAISO) control room

Siemens

- Efficiency
- OPF
- SS-VJ
- Reliability
- Planning
- Unit commitment
- Economic dispatch
- Operating reserves
- Protection
- TS
- Weeks
days
hours
minutes
seconds

- Static
- Dynamic

1-2 weeks
days
hours
minutes
seconds

- Powerflow
- Transient stability
- Voltage stability
- Power tech
- Power flow
- Small signal
- Voltage security
- Assessment tool
- Small signal analysis tool
- Transient security assessment tool
- Powerflow & Short Circuit Analysis Tool
- Harmonics Analysis Module
- Simulated PMU data generator
- Design and tuning of power system stabilizers
- User-Defined Model Editor
- Study Mode for On-line DSA
- Interface Module for On-line DSA Systems
- Powerflow, contingency analysis, voltage stability (PV/QU), reliability assessment
- Dynamics / transient stability simulation
- Optimal power flow
- Geomagnetically induced currents (GIC)
- Short circuit analysis

PSS®E for Transmission Operations and Planning

- Challenges
- Operations planning
- System reliability and security
- Regulatory compliance
- System studies

- Our Solution
- Powerflow, contingency analysis, voltage stability (PV/QU), reliability assessment
- Dynamics / transient stability simulation
- Optimal power flow
- Geomagnetically induced currents (GIC)
- Short circuit analysis

- Advantages
- Trusted results from “benchmark” tool in the industry
- Easy exchange of data and comparable results with neighboring TSOs
- Time savings from scripting and automation via APIs
- Industry-leading dynamics library, saves model development effort
- Interoperability with other tools in the utility IT landscape
Optimal power flow - whirlwind tour.
Last time: use power flow to satisfy voltage limits.

Try changing:
- gen voltage
- gen power
- load power

Optimization in disguise.

Parameter:
- (10 MW, 11 kV)
- (10 MW, 5 MVAR)

\[ f \rightarrow \text{power flow} \rightarrow \text{load voltage}. \]

Find \( x \) such that
\[ |f(x) - 11\text{kV}| \leq 5\% \cdot 11\text{kV} \]
feasible
\( x \) has sensible values.

Optimal power flow.

\[ \text{minimize } \text{cost}(x) \quad \text{s.t. } x \text{ is feasible.} \]

Don't have function. Cost of electricity is variable.
- multiple solutions, nonconvexity.

\[ \text{NP-hard.} \]

ECE 573.
OPF in Econ Dispatch & Unit Commitment.

Last time: Voltage stability & N-1.

Security-constrained ED:
* loss of any one component, the system stays alive.

Generator submits own cost curve.

Unit commitment: ED one day ahead, commit generators to be online, on/off constraints, ramp constraints.

Power flow on parameters.

AC power flow too hard $\rightarrow$ solve DC model.

Main idea: Powerflow is the engine for power system analysis.
Protection design.

Current transformers: CT & VT

Voltage transformers: VT

Logic: Relays

Circuit breakers: Circ.

Communication: Comms.

Take into account sensitivities of the lines.
- Could trip during normal operating conditions.

Loads series with the breaker.
- Tripping one component can trip multiple components.
- CTs, VTs not sensitive, could have noise.
- "Bugs" in other relays.


How to compute short circuit current? Power flow.
Transient Stability \(\rightarrow\) comparable to PF for static analysis.

Manapouri Station - New Zealand.

\[
\frac{d\omega}{dt} = \text{Mech} - \text{Elec}
\]

Mass \(\times\) speed = force.

\[
M \cdot \frac{d\omega}{dt} = \text{Mech} - \text{Elec}
\]

\[
\frac{d}{dt} S = \omega - 60 \text{Hz}
\]

governor (very slow). goal: fixed P

generator (very fast) goal: fixed V

exciter directly controls E.

Machine model

PV bus!
Operating reserves

- Spinning and non-spinning reserve
- Replacement reserve

Failure occurs

Minutes

[Graph showing time versus reserve types]