GE Energy

Workshop on Voltage Coordination for High Voltage Grids

XA/21™ Voltage Coordination

Rod Sulte

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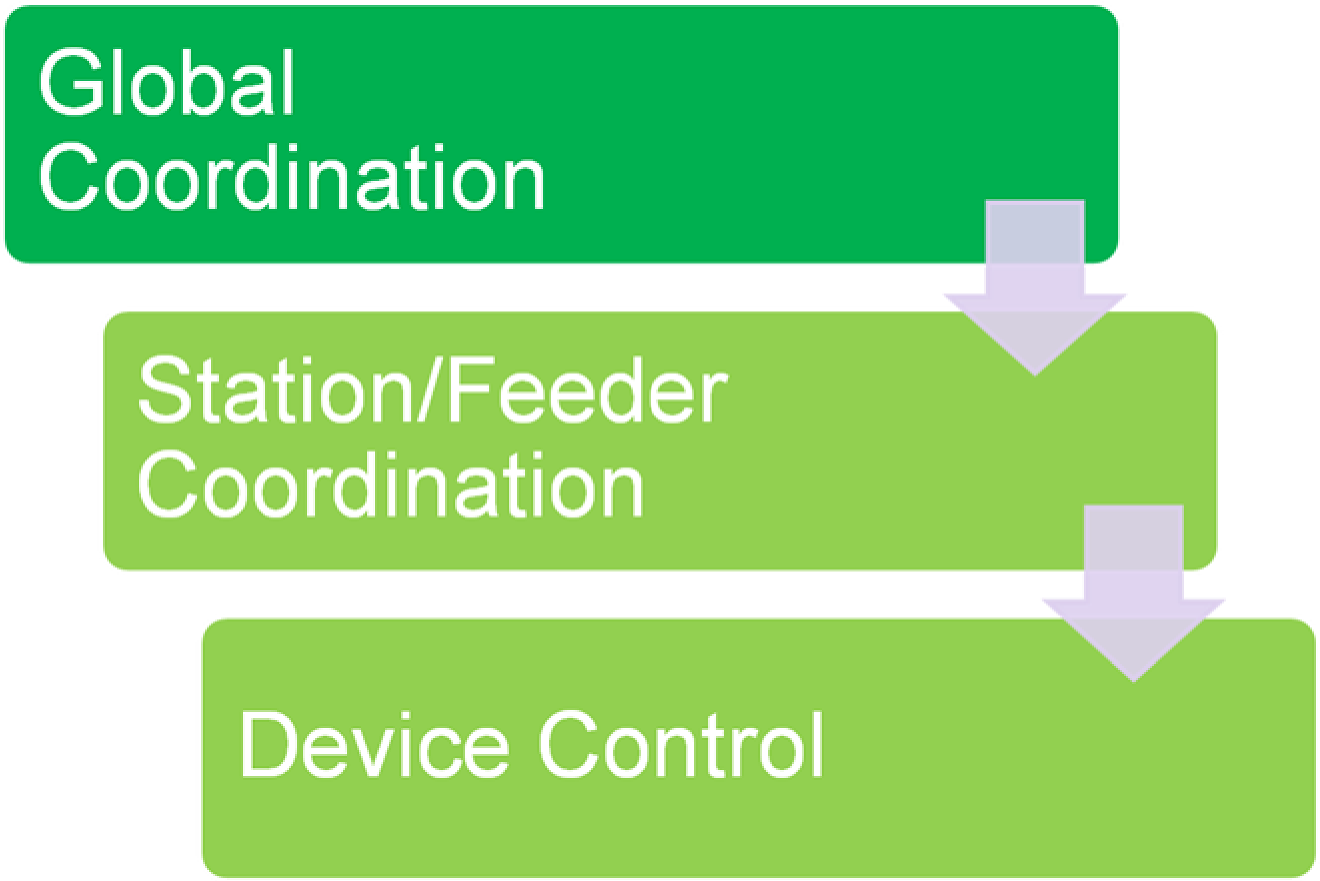
Grid Wide Voltage Optimization



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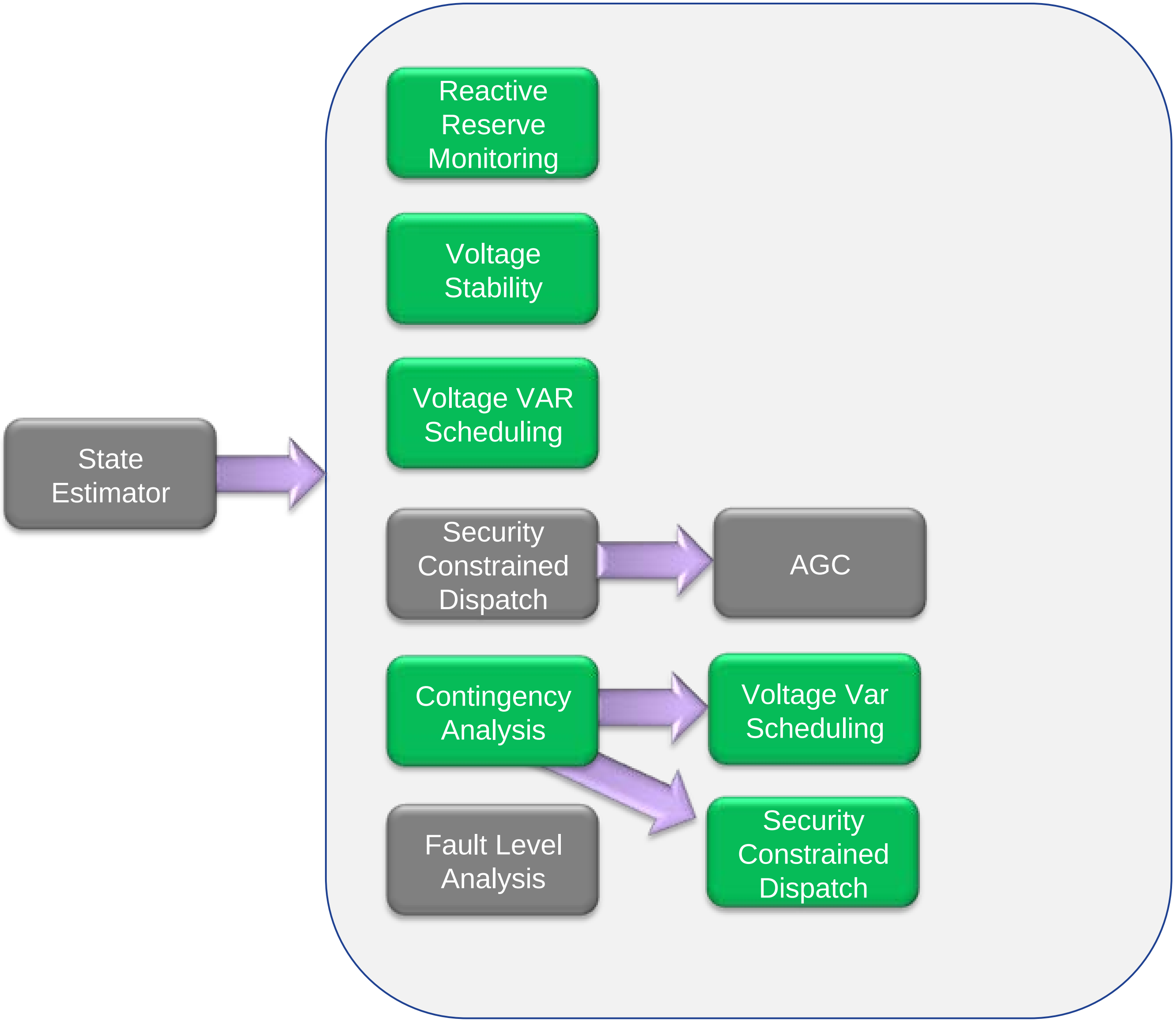
Global Voltage Resource Scheduling



Global Voltage Resource Scheduling

Utilizing Nexant's SCOPE Engine

Industry proven multi-function package supporting grid capabilities such as:

- Power Flow
- Contingency Analysis
- Optimization of grid operation:
  - Voltage/Var Scheduling (VVS)
  - Security Constrained Dispatch (SCD)
  - Contingency Constrained Remedial Action (RA)
  - Contingency Constrained Preventative Action (PA)

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Voltage/Var Scheduling

Objectives

- Minimize MW Loss
- Minimize MVAR Loss
- Minimize Number of Controls
- Minimize Control Shift
- Minimize MVAR Costs (Option)

Constraints

- Bus Voltages
- Generator MVAR
- MVAR Corridor Flows
- MVAR Reserves
- Net MVAR Interchange
- Voltage Magnitude Differences

Controls

- Generator Terminal Voltages
- Tap Changing Transformers
- Capacitor/Reactor Switching
- Static VAR Compensator Voltages
- Phase Shifting Transformers (for Min Loss)

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Security Constrained Dispatch

Objectives

- Minimize Cost
- Minimize Number of Controls
- Minimize Control Shift
- Maximize MW Transfer (Option)

Constraints

- Branch Flows
- MW Corridor Flows
- MW Reserves
- Net MW Interchange
- Voltage Angle Differences

Controls

- Generator MW
- Phase Shifting Transformers
- MW Purchases
- Sheddable Loads
- Dispatchable Loads (Option)
- HVDC

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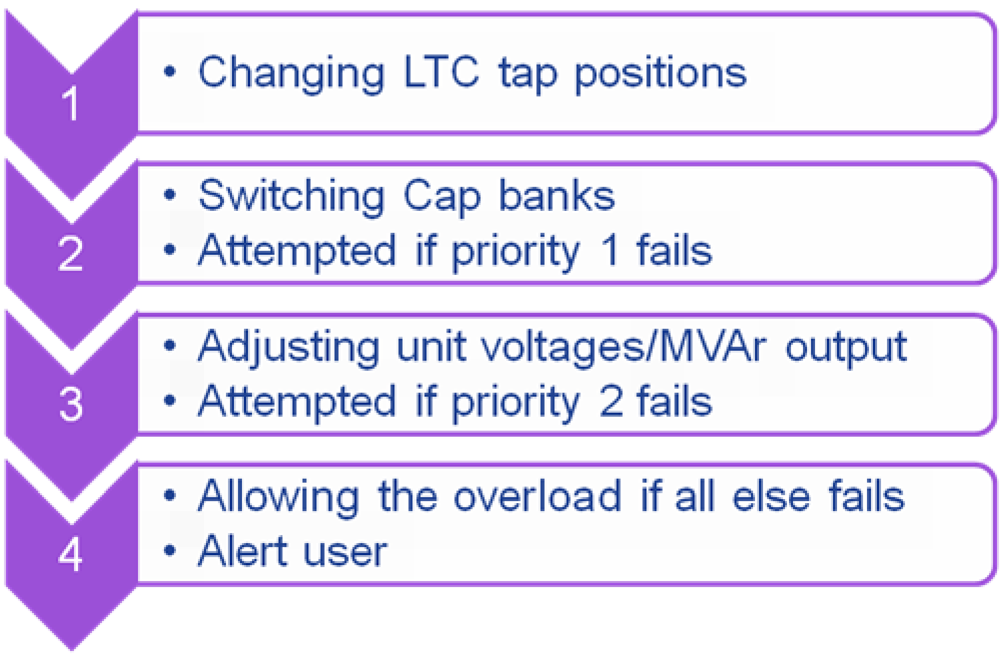
Incorporating Priority Schemes

Priority levels are specified to alleviate the overload or voltage problem

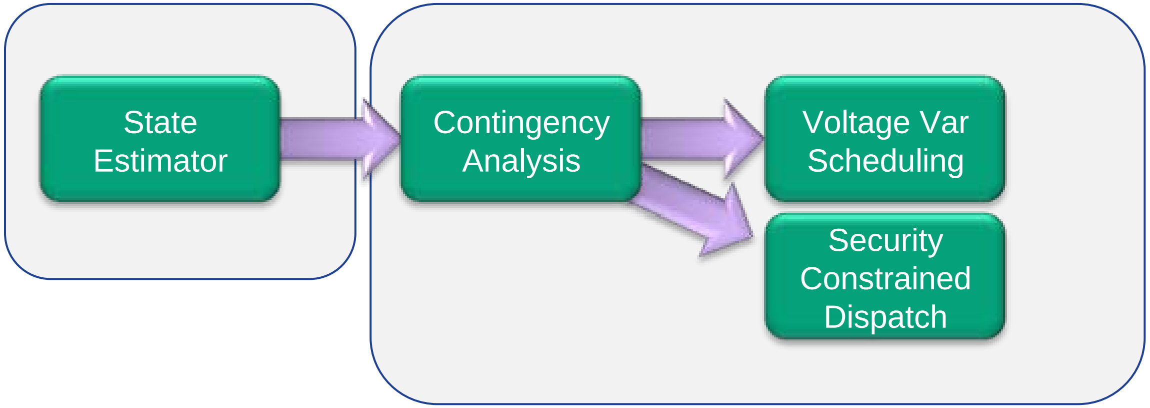
- Controls enabled at different levels
- Time allowed to correct overloads specified at each level



Contingency Analysis

Determine the sets of contingency cases causing voltage and thermal problems via severity index

- Separate recommendations are obtained for each problem contingency case
- The user is alerted if normal operation cannot be re-obtained in a pre-specified time for one or more of the contingency cases
- Voltage problems can be analyzed by reactive power remedial action
- Thermal problems can be analyzed by active power remedial action
- Voltage problems that cannot be resolved by reactive power remedial action can be addressed in active power remedial action



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Correcting Voltage/Thermal Problems

Post-contingency voltage problems corrected by recommending changes to:

- Generator voltages and MVAr output
- Transformer tap
- Shunt status
- System configuration

Post-contingency overloads corrected by:

- Committing fast-start units
- Reducing imports from external areas
- Adjusting phase shifter taps
- Reconfiguring the network topology
- Re-dispatching generation
- Shedding load (in extreme emergencies)

Remedial action can also be configured to correct voltage problems with the above (e.g. after all reactive controls have been exhausted)

Voltage Stability

Utilizing Powertech's Voltage Stability Assessment Tool (VSAT^{TM}):

- Highly automated steady-state analysis tool
- Designed for comprehensive voltage security assessment
- Flexible specification of voltage security criteria
- Handles a large number of contingencies, power transfers, and scenarios

Network Sensitivity – Real time guidance

- Computes and ranks the sensitivities (effectiveness) of the controls for any selected monitored constraint.
- Each sensitivity is defined as the change in the monitored quantity produced by a unit change in the control, all other controls remaining fixed or regulating a local target in the normal power flow manner.
- Users can use these calculated sensitivities as a guideline to relieve violations in the network.

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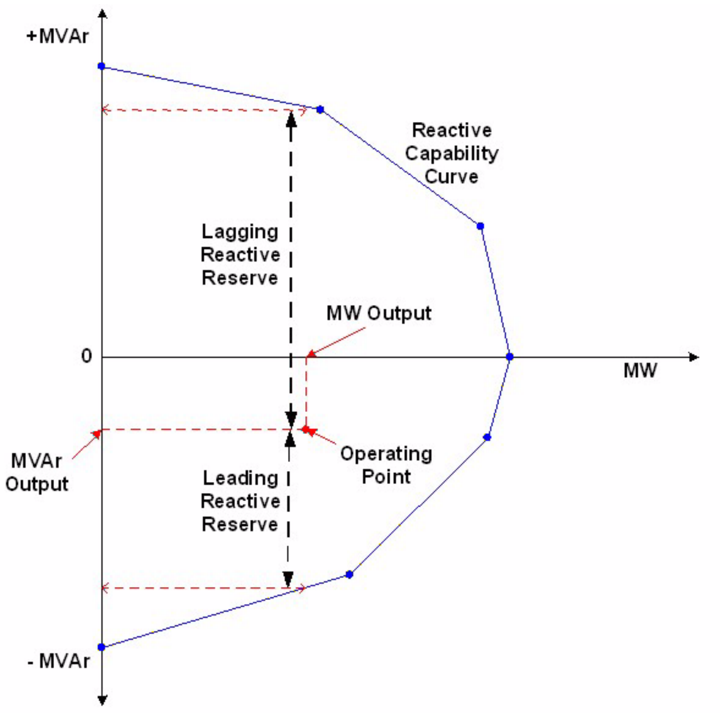
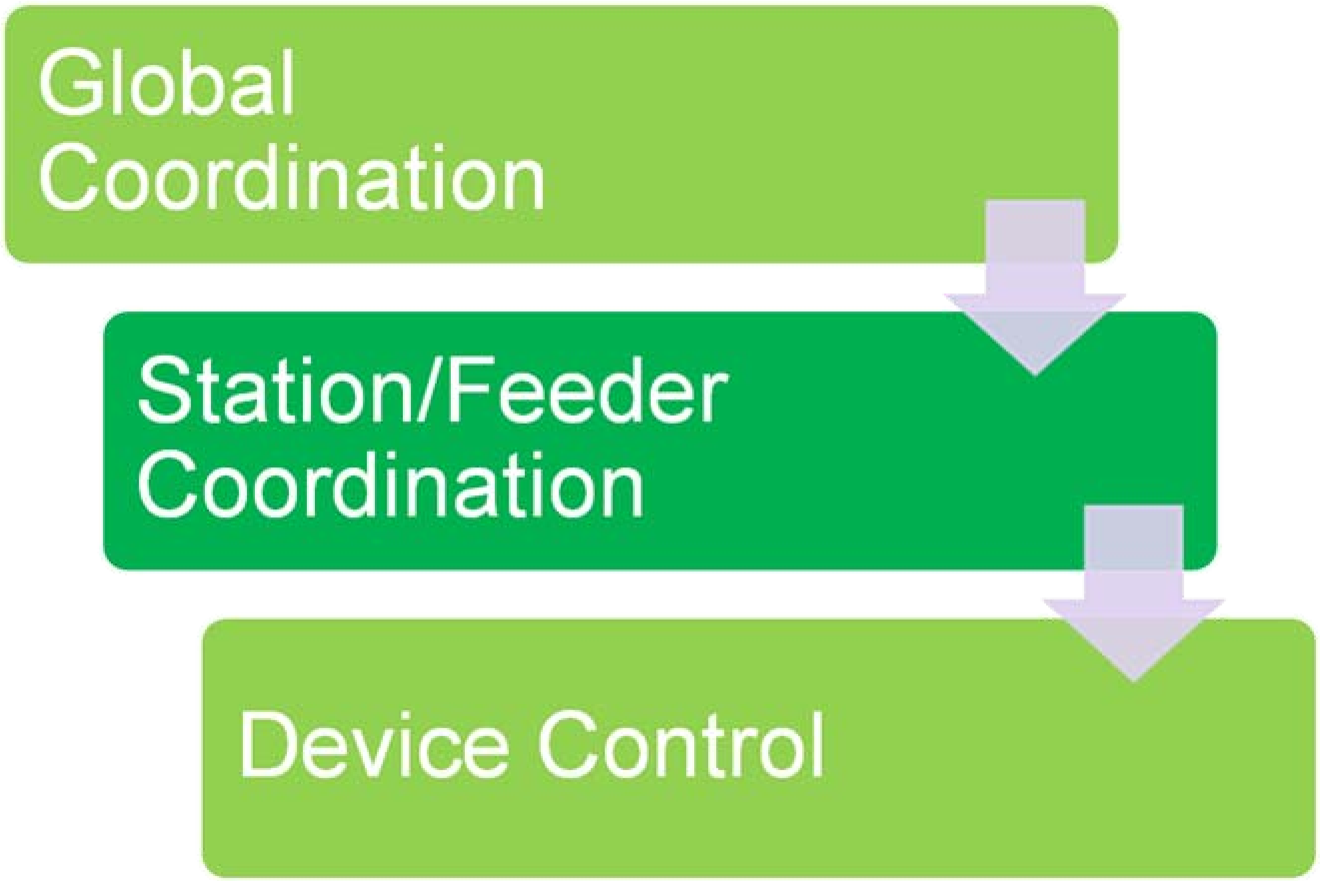
Reactive Reserve Monitoring

- Reactive reserve groups - generators, capacitors/reactors, static VAr compensators
- Utilizes capability curves
- Leading/Lagging reserves calculated for each device type and group total
- Alarmed if insufficient leading/lagging requirement not met



Local Voltage Scheduling



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Voltage Control with MVAR Balancing

- Provides simultaneous and coordinated operation of AGC with AVC to balance MVAR generation (avoiding circulating VARs) while keeping units within MW/MVAR/KV Limits
- Coordinates closed loop control of MW and MVAR generation within operational and Generator PQ Curve Capability Limits for improving generator stability and voltage regulation range as generator tracks MW load changes
- Bus Voltage or MVAR Targets (or Local/Remote schedules) derived from VVS function (future) for coordinated operation between global Bus Voltage/VAR optimization and local generator Voltage/Var balancing controls.
- Operator selected System, Bus and Unit Control Modes

Distribution Voltage Control Offerings

Voltage Var Control (EMS based)

Closed loop substation transformer control to:

1. Reduce excessive MVAr backfeed (trip limit)
2. Maintain substation voltage
3. Eliminate MW backfeed
4. Eliminate MVAr backfeed
5. Transformer load balancing

System-wide voltage reduction override

Distribution Var Dispatch (EMS based)

Feeder capacitor control (non-load flow, non-connectivity model based) to:

1. Provide substation voltage support
2. Enforce feeder reactive loading limits
3. Maintain substation Power Factor targets

System-wide var support through priority groups

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Distribution Voltage Control Offerings

Voltage Var Control (DMS based)

Option 1: Load flow based

- Feeder loss minimization with voltage and flow limitations
- Capitalizes on feeder connectivity model and load flow solution
- Controls:

❖Substation transformers
❖Substation capacitors
❖Feeder capacitors

Option 2: Non-load flow based (future)

- Minimize average capacitor voltages within voltage limits
- Non-load flow based, no connectivity model required.
- Controls:

❖Substation capacitors
❖Feeder capacitors

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Questions ?

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