GTC Breakout Session
Smart Controls

Motivation

The integration of any new technology into the system is a crucial step in the transition of such devices into operation. A controllable device is of no use to the system if it is not controlled in an appropriate way and will only provide the most benefits if the control is carefully defined to achieve optimal performance and impact on the system level. Hence, the focus of this session is on how such controls should be designed and what are the breakthroughs needed with regards to control and optimization to enable optimal usage of these new technologies.

Outline

- Generate Ideas / Brainstorming – 10min
- Record Ideas, identify themes – 30min
- Group discussion – 60min
  - Defining Potential Research Projects
- Prioritizing – 10min
- Presentation – 30min

What are open Research Questions?

- Specific to Controls of Power Electronic devices
- Procedure:
  - Notes on Post-its
  - Collection of ideas
  - Identify common themes
  - Metric such as time scales, system level

Potential Research Projects

- What is the research question?
- What are potential technical approaches?
- What is the expected outcome?
- What are the collaborators or potential supporters?
- What are the key aspect to make sure that it is of value to industry?
- How can transition to actual application happen?

Collection of Individual Ideas

- Multiple device coordination
- Dynamic parameter control
- Real-time adaptive fault protection
- Visibility and control over distributed assets (from the distribution level at the transmission level)
- Improved control system to coordinate time scales between mechanical systems with newer electronic systems
- Using existing data to perform predictive analytics (e.g., off grid data that impacts grid dynamics)
- Two-way power flow – setting metrics for reliability vs.. cost tradeoffs…
- DER optimization – optimization around various constraints: regulatory, operational, economic, markets…
- Control of active/reactive power, two way power flow, local level control (distribution automation…)
- Utilizing hi-res data for real-time control/optimization for geographically smaller regions (substation/feeder level)

Collection of Individual Ideas (cont)

- Identifying the role of the RTO/ISO in developing the overall architecture characteristics
- Coordination of PEVs seamlessly
- Control of multiple energy converters
- Coordination and control of islanding
- Integration/balance of distributed and centralized intelligence
- Understanding inefficiencies in the power flow from emerging higher resolution data
- Preparing the infrastructure for advanced technology deployment
- Optimizing multilevel control
- Power flow optimization on the transmission system where long distance variable generation and storage require coordination
  - Storage requirements to meet the need??
- Improved forecasting granularity
- Stochastic optimization

Collection of Individual Ideas (cont)

- Determining the role AMI plays
- Federal role??
- Determining the value proposition to the consumer and the utilities
- Optimization of power flow based on emerging data across various load centers
- Coordination of load shedding (smart load shedding)
- Determining which services come from each/specific devices (e.g., protection schemes)
- Improved restoration from control of advanced power electronics

Research buckets

1. Large scale optimization
2. **Coordination of central verses local**
3. Adaptive control
4. **Data mining and analytics**
5. *Control enabled markets – creation of new markets and the integration of new control schemes into new markets*
6. System performance enhancement
7. Infrastructure and control coordination
8. **Coordination across time scales**
9. Coordination of existing with emerging technologies
10. *Value proposition of implementing control (business case)*

Bold: Chosen as top three topics => define possible research project

Red: Determined to be topics more related to economics

Coordination of Central and Local

- What should be the control methodology that enables locally controlled (distributed) resources to help accomplish objectives of a centrally controlled (transmission/broad distribution areas) entity?
- Techniques
  - Bidirectional communication
  - Adequate computational resources
  - Examining RTO/TO and local entity(utility_)
  - Within the utility (e.g., substation and distributed control)

Coordination of Central and Local

- Outcomes:
  - Advanced control algorithms/software
  - Improved existing system efficiency
  - Integration of new technologies
  - Improved/new planning tools – parametric analyzing the system
  - Market enhancements
- Collaborations: Universities, DOE, ISO/RTO, utilities, GOs, TOs

Coordination across Time Scales

- How do we integrate controls technology across time scales (sub-second, seconds, minutes, hours, etc.) for DER monitoring, control & forecasting in aggregate and granular?
- Technical approaches
  - Monitoring
  - Modeling & simulation
  - Validation
  - Develop control algorithm
  - Develop forecasting algorithm (weather & historical data)
- Outcomes
  - Model with multiple DER input => load, storage supply
  - Integrated control algorithm for load/supply/storage
  - Forecasting algorithms

Coordination across Time Scales

- Collaborators or potential sponsors
  - University,
  - Utility (regulated/unregulated)
  - Major vendors (power electronics, software, communication providers)
  - Regulators
- Key aspect to give value to industry?
  - Fits VIU model, municipalities and co-ops
  - Regulatory acceptance
- How can transition to actual application happen?
  - Convert algorithm into working code, pilot deployment

Data mining and analytics

- How can we effectively use various data types to improve the system efficiency?
  - Utility intentionally measure data
  - Traffic, weather, financial, etc, data
- Data analytic outcomes
  - Improved/efficient forecasting and control methods
  - Improving the efficiency of the system with higher resolution data such as PMU
  - Identifying important data and data gaps
- Technical approaches:
  - Interdisciplinary approach for social, economic and power systems
  - Available data mining approaches for power systems
  - Identifying needed data mining approaches

Data mining and analytics

- System improvements:
  - Stability and efficiency improvements
  - Results of analytics integrated into the control scheme
- Collaborators – Universities, federal/state entities industry (electric utility), Data mining companies (e.g., IBM)
- Key Aspects – work expected to produce results in a reasonable time, improved system response

Control Enabled Markets

- Devices need specific controls which cannot be captured in current market structures => new markets?
- Coordination of control methods/technologies and existing markets
- Devices can provide various types of services, e.g. frequency control, volt/VAR optimization, etc. => which devices for which services?
- Role of RTOs/ISOs in providing suitable markets?

What is need to coordinate the technical control of power electronic devices and the electricity markets and what are the roles of the individual players?

Adaptive control

- Control parameters should not be static but adjust to real time situation
- Integration of multiple objectives into the controller design for power electronic applications
- Fast response of power electronic devices to changing situations
- Real time adaptive fault protection algorithms incorporating bi-directional power flows

What algorithms are needed to enable stable adaptive control in electric power systems where the system state is constantly changing?

Large scale optimization

- Optimization problems will become huge due to
  - Increasing number of decision variables due to control capabilities of power electronic devices
  - Integration of uncertainties via stochastic optimization
  - Multi-time step optimization, i.e. integration of multiple time steps
- Coordination of plug in electric vehicles, distributed storage devices, loads, etc.

How will we solve these large scale optimization problems within a reasonable amount of time?

System performance enhancement

- Control of multiple distributed inverters with and without storage for the purpose of blackout prevention including intelligent load shedding but also efficient system restoration
- Coordination across the range of assets for the integration of variable generation
- Targeted Benefits: enhanced stability, support of variable generation penetration, improved system reliability, enabling islanding
- Finer level of control down to distribution level

What are the controls needed to take advantage of power electronic devices to improve system performance / resiliency and how should they be designed?

Coordination of existing with emerging technologies

- Integrating new technologies, specifically power electronic devices, with legacy systems
- Design of devices and corresponding controls needed to smoothly integrate such new technology into existing system
- Current controls e.g. for circuit breaker not suitable for new technologies such as HVDC lines
- Mechanical vs. electronic switching - slow, inefficient, arcing, unreliable

How to adjust controls / common practices to make them suitable for emerging technologies?

Infrastructure and control coordination

- Controls and infrastructure planning needs to go hand in hand
- Preparation of distribution system infrastructure to enable efficient and effective implementation of smart grid technology
- Identification of infrastructure needed to carry out the fancy controls we intend to do
- Controls not as an afterthought but as integrated part of the planning stage

How to optimally prepare infrastructure for envisioned system capabilities and how to coordinate infrastructure and control development?

Value Proposition of Implementing Controls (Business Case)

- Two way power flow – what should be the compromise between reliability and cost
- Identifying and overcoming non-technical implementation barriers
- Determination of the government role to incentivize implementation of technologies
- Interoperability for distributed resources
- Making business case for emerging control technologies

How to address non-technical questions / policies in the transition from research to implementation and how to make a business case?