

# A Grid Forming Converter Future Without Frequency Droop Control

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#### Frequency in a conventional system...

- Conventional system:
  - Electromagnetic properties of the network and machines lock their behavior to be in sync
  - A change in load is automatically/naturally reflected in speed of rotation of the machine
  - System frequency is **governed** by speed of rotating machines





## Traditional frequency response trajectory...



- Single isolated machine with 10% load increase
- Typical values used for all parameters
  - Default 'large' RoCoF
- Faster control can be obtained in isochronous mode:
  - Increased torsional stress
  - Ramp rate considerations
  - Possible fighting in interconnected mode due to speed being controlled





#### Frequency in all inverter system...

- All converter system:
  - Break in the electromagnetic link between source and network
    - Lock has to be obtained through a controller
  - No physical link between generation/load balance and frequency/
  - Converters can operate at any frequency



#### Can ideal L shaped frequency response, or better, be achieved?



But, can the natural

electrical properties

of the network be

used to sustain

## Frequency control in a high IBR system...

#### Would we still need it ...?

- Traditional needs for frequency control
  - Motor drives
  - Clocks
  - Transformer magnetics
  - Machine torsional stress
  - And many more...

#### Can we do it in a better manner...?

- Changes in the system
  - Lower source time constants due to static generators
  - Faster control capability
  - Loads interfaced through power electronics
  - Smart transformers
  - Power flow control devices
  - Increased observability

#### Just because it can be done, should it be done?



# With high percentage of IBRs, do we need to hold onto to frequency droop control...?



Further reading: Deepak Ramasubramanian and Evangelos Farantatos, "Constant Frequency Operation of a Bulk Power System with Very High Levels of Inverter Based Resources," *CIGRE Science & Engineering*, vol. 17, pp. 109-126, February 2020. [Online]

- Lower (to zero) inertia sources allow for faster movement
- Since mechanical speed is not the controlled variable, reduced chance of fighting in interconnected mode.
- Distributed slack bus concept used for sharing of power
- Better than ideal L shaped response



#### Small system test setup...

= 85% of load met by IBRs, 15% met by a single rotating machine



All IBR power control (distributed slack bus method) is carried out by the BESS



### Response for an increase in load...



Does this response however have a greater transient impact than conventional droop control?



## For Bus 4, comparing with conventional droop control...





#### Reliability Implications of Constant Frequency Operation Generation Trip - Frequency Response

#### System Stability:

- What will be stability definition, mechanism, and metrics?
- In a 100% converter system instability relates to current injection deficit due to limited power reserves (low wind/solar)
- Can (and should) UFLS operate?

#### • Power sharing upon a disturbance:

- Just frequency droop is not applicable
- Newer control schemes required
   Angle droop as self-automated control
  - •Next generation monitoring and control for area wide control





## **Hierarchical Decentralized Frequency Control**



Contingent Area Detection and Imbalance Estimation



Stage 1: Autonomous Primary Local Area Control

Stage 2: Coordinated Secondary Area Control



## **Demonstrating Results - Self Sufficient Contingent Area**



## **Demonstrating Results - Self Deficient Contingent Area**



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## Summary...

- As the power system transitions with increased IBR percentage, it could be possible to take advantage of quick and highly flexible IBR response characteristics
- Frequency droop control was a necessity with mechanical speed being the controlled variable
  - It may not be a necessity with electrical frequency and angle
- Power sharing across balancing areas can still be achieved
- Additional energy/power burden to bring about this operation paradigm is minimal



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