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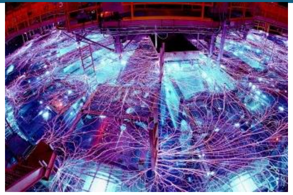
A Resource Aware Droop Control Strategy for a PV, Wind, and Energy Storage Flexible Power (Flexpower) Plant



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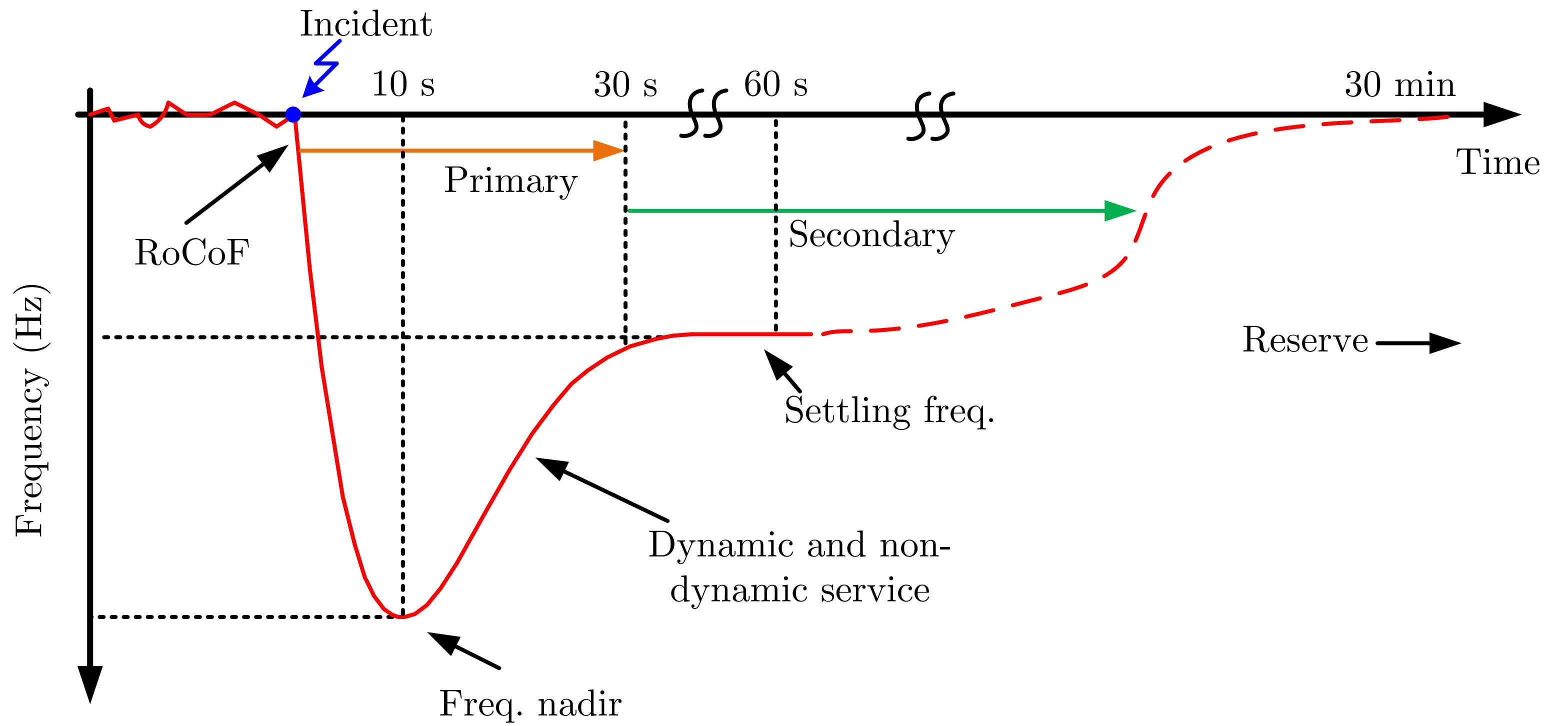
Outline

- Introduction and motivation
- Frequency Regulation in Power Systems
- Flexpower Plant Concept and Test System
- Control Strategies for Droop Control with the Flexpower Plant
- Results
- Summary and Conclusions

Introduction and Motivation

- Solar PV and wind energy conversion systems interface with the grid via inverters with dynamics that are significantly different than those of conventional generation (rotating machines).
- Power system dynamics and operations are being affected by the continuous increase of inverter-based resources. This effect is important in the frequency regulation of the system
- Research and development has been performed so that each technology (e.g. wind or solar) provides frequency regulation.
- This works focuses on developing a control strategy so that a cluster of solar PV, wind energy system, and a battery energy storage system provides primary frequency regulation in a similar fashion as a conventional generator
  - Main objective: make this cluster of different technologies (called Flexpower plant) operate for frequency regulation provision as a convectional generator (system operator should be able to interface with the cluster as a whole and request a particular droop action)

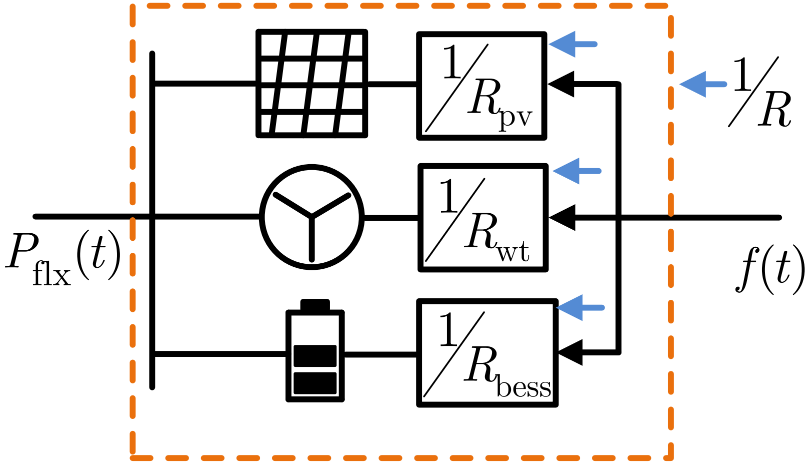
Frequency Regulation in Power Systems



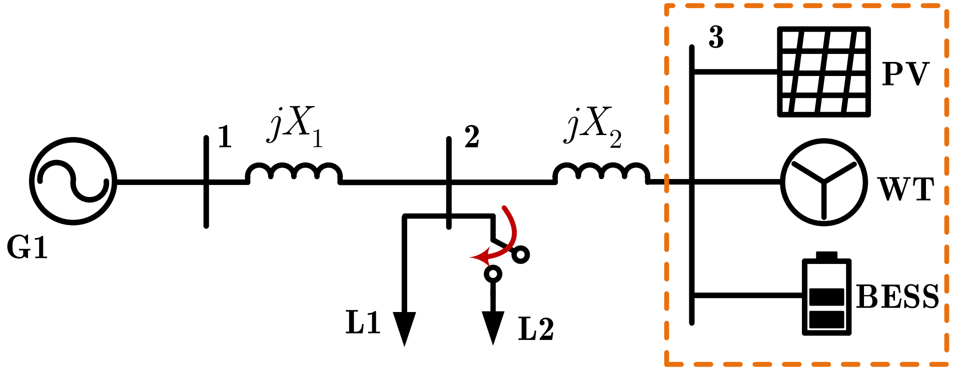
- Inertial Response
- Primary Frequency Control (PFR / Droop Control / Freq. Watt Function) ←
- Secondary Frequency Control (AGC Control)

FlexPower Plant and Test System

- This work uses a Flexpower plant with:
  - Solar PV
  - Wind Turbine Generator (Type 4)
  - Battery Energy Storage System (BESS)



- Test power system:



Component	Rating (MVA)	Output (MW)
G1	300	160
Flexpower Plant Components		
WT	60	55
PV	40	35
BESS	10	0
Loads		
L1		250
L2		10

Droop Control in the Flexpower Plant

- This work presents control strategies to ensure the provision of droop control by the Flexpower plant at the plant-wide level

Control strategies

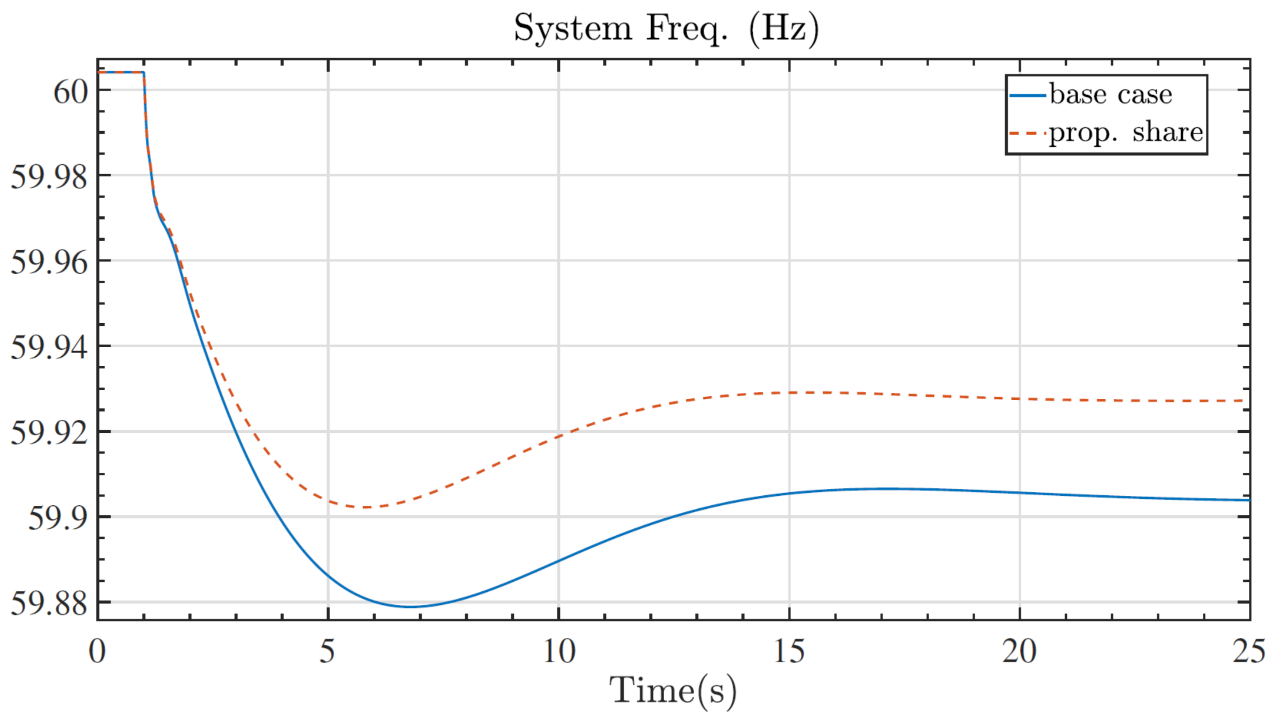
- Proportional share droop - the action of the Flexpower plant is divided among its generating components in proportion to their power ratings
- Single technology droop - the droop action of the entire Flexpower plant is performed by only one of the component technologies
- Equal share droop - the droop action of the Flexpower plant is split equally between its components irrespective of their power ratings.

Resource Awareness

- It corrects the individual "droop dispatch" for each actuating technology based on the ability to provide the action (which in turn is defined by the availability of the resource or the State of Charge SOC in the case of the BESS)

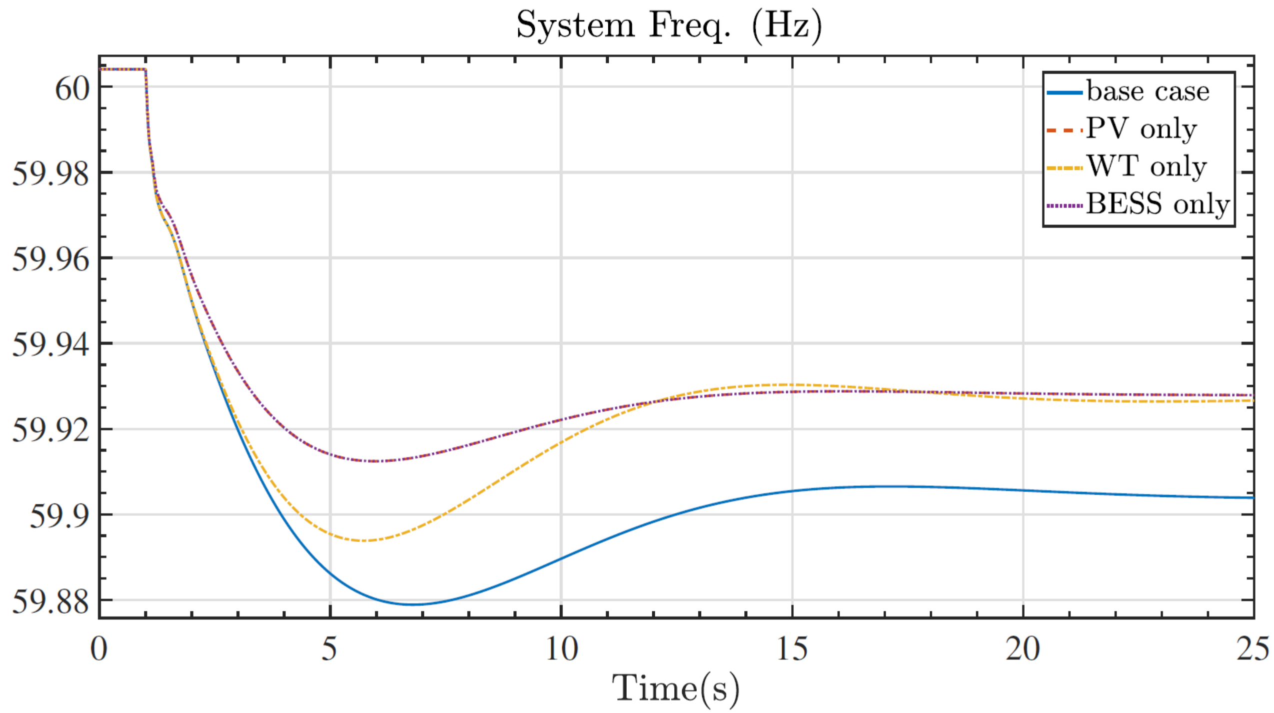
Results

- Base case – the Flexpower plant does not provide any frequency regulation, i.e. it has no droop response. The conventional generator has a droop of 5% which is the same for all cases.
- Proportional share droop – in this case the Flexpower plant has a 5% droop accomplished by the proportional share configuration.



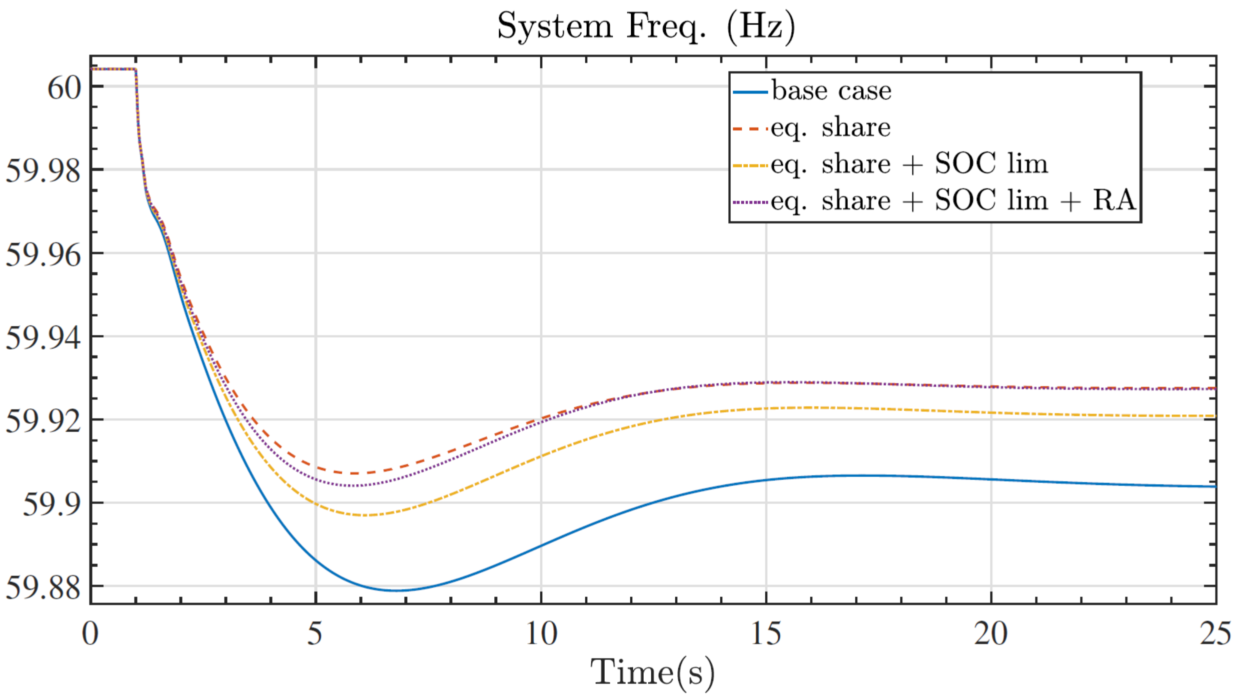
Results

- BESS-only droop – in this case the Flexpower plant has a 5% droop but is provided only by the BESS.
- WT-only droop – in this case the Flexpower plant has a 5% droop but is provided only by the WT.
- PV-only droop – in this case the Flexpower plant has a 5% droop but is provided only by the PV.



Results

- Equal share droop – in this case the Flexpower plant also has a 5% droop but is accomplished by splitting the effort equally among its components.
- Equal share droop SOC constraint – this is the same case as the previous item but in a case where the SOC of the BESS is at a value below SOC min.
- Equal share droop SOC constraint with resource awareness – this is the same case as the previous case but with the resource awareness corrections explained earlier.



Results

- Table summary:

Case	Freq. Nadir (Hz)	Settling Freq. (Hz)
Base	59.879	59.904
Prop. share	59.902	59.927
WT only	59.894	59.927
PV only	59.912	59.928
BESS only	59.912	59.928
Eq. share	59.907	59.927
Eq. share + SOC lim.	59.897	59.921
Eq. share + SOC lim. + RA	59.904	59.927

Summary and Conclusions

- Large scale installation of inverter-based generation such as wind energy systems and solar PV systems deteriorates the frequency regulation of power systems
- This work proposes several control strategies to enable Flexpower plants (clusters of solar PV, wind, and energy storage) with frequency regulation capabilities
- Proposed control strategies account for resource availability limitations within the component technologies of the Flexpower plant
- Resource awareness in the control strategy is important to ensure the successful provision of primary frequency regulation by the Flexpower plant at all conditions

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Thank you!

Questions?

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