Microgrid Frequency Resilience

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Microgrid Frequency Resilience

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Microgrids are small-scale power systems that deliver power to the grid or an isolated network

The microgrid's frequency is maintained by the inertia of spinning machines:

$$\Delta\omega_{machinery} = \frac{Power_{generated} - Power_{output}}{J\omega_{machinery}}$$
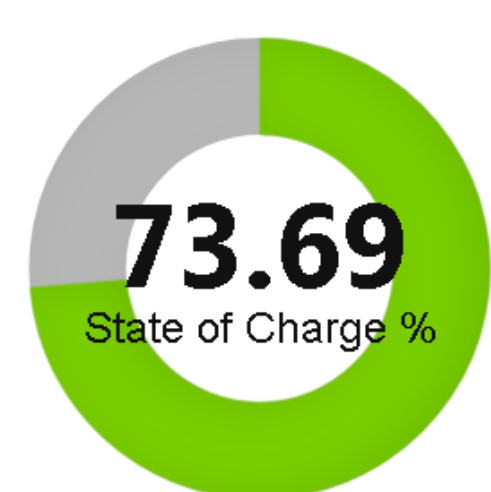
Swing Equation Approximation
https://gridgame.inl.gov/doc/SwingModel.pdf

Maintaining Grid Frequency

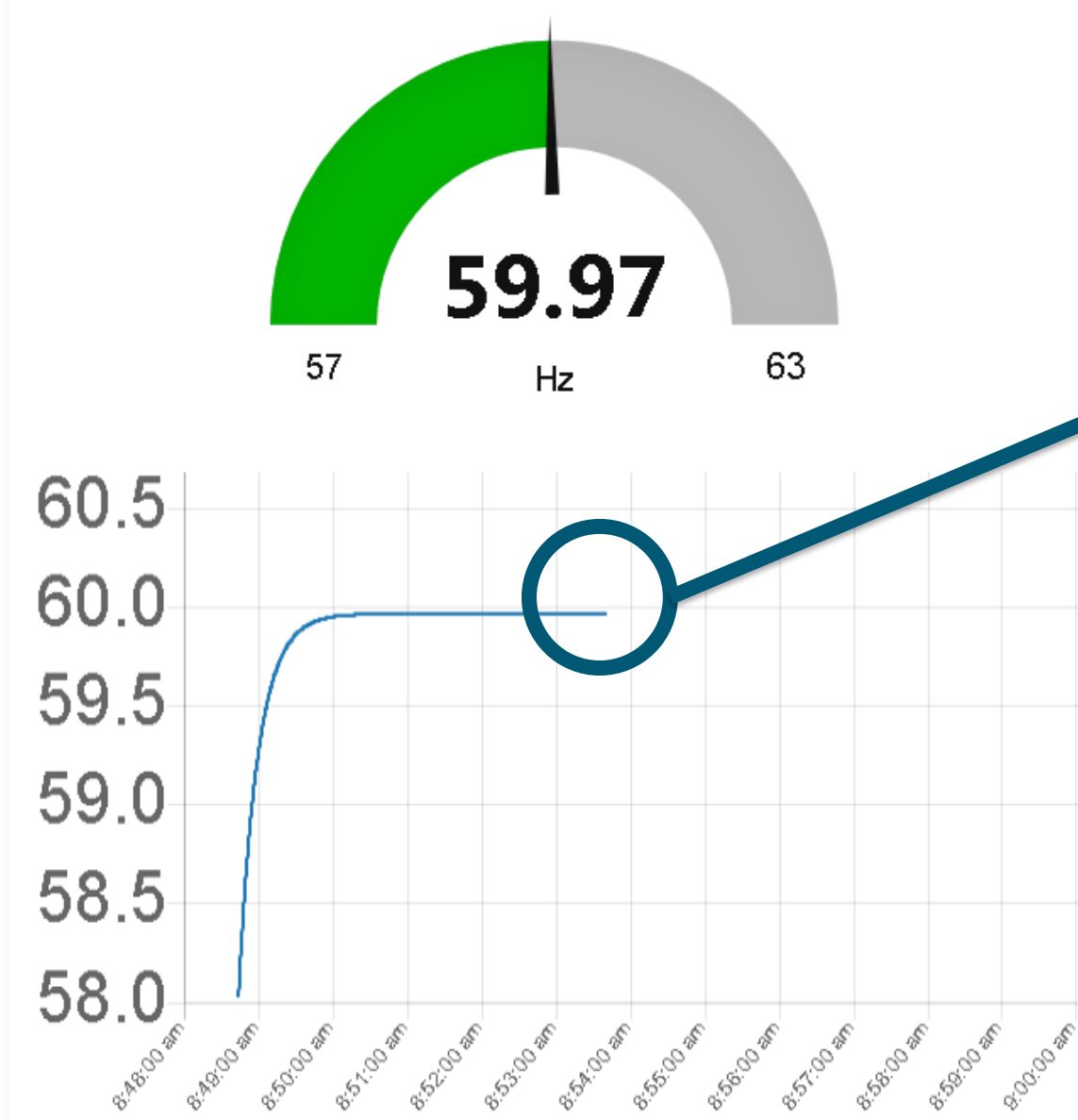The primary controller maintains a balanced frequency of 60 Hz using closed loop control

Controller Human-Machine Interface (HMI)

Battery

73.69
State of Charge %

Frequency

59.97
57 Hz 63

The Primary Controller's HMI displays the status of the microgrid

60.5
60.0
59.5
59.0
58.5
58.0

Control Loop Block Diagram

Controller guides system via frequency error signal
(60 Hz – Measurement) = Error Signal

Power Balance is Generated for System
(Generated Power – Requested Output) = Delivered Power

Desired Output: 60 Hz → **Primary Controller** → **Net Power** → Frequency Output

Closed loop control allows the system reach a desired output

Closed loop control feeds the output back to the controller so it can make adjustments

Frequency Measurement

Primary Controller

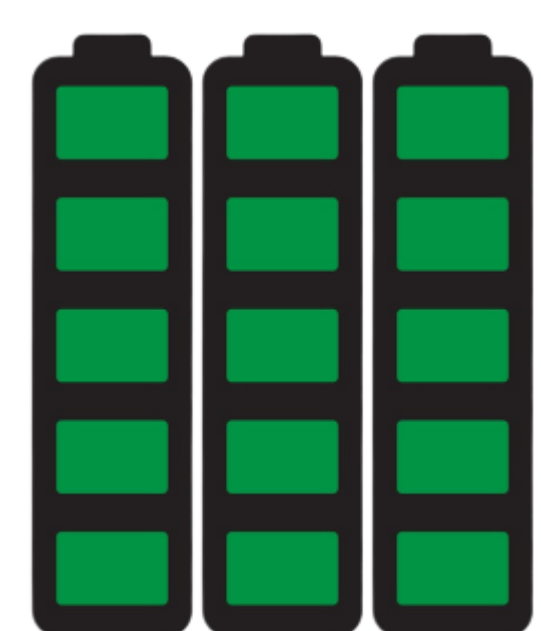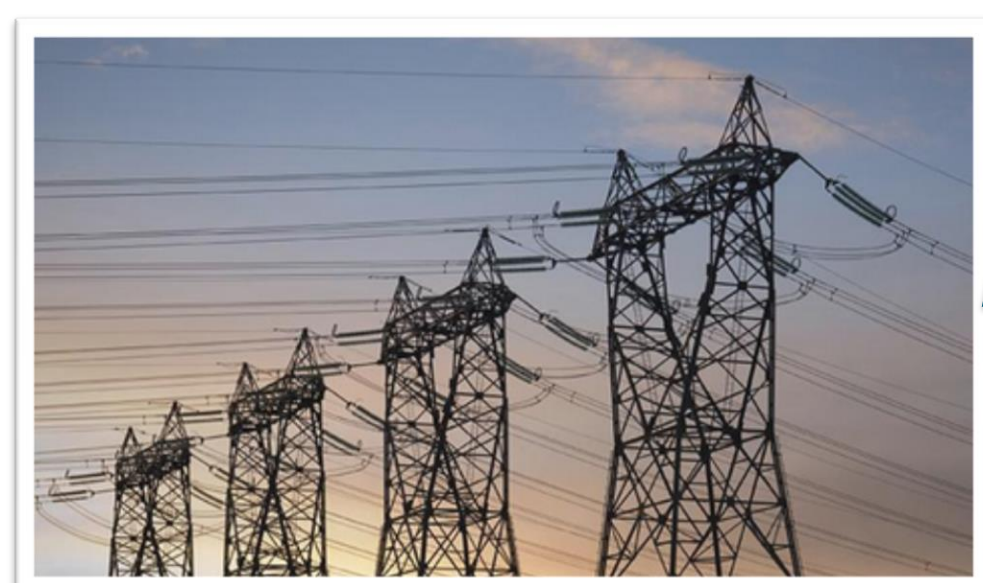- Maintains Grid Frequency
- Manages Battery Storage

https://en.wikipedia.org/wiki/Settling_time

V_2
V_1
ERROR BAND
t_2 t_3
t_1
SETTLING TIME

Raspberry Pi Computers

- Simulate Generation Sources
- Open Source Framework

https://www.raspberrypi.org/

Hydro Generation
https://tinyurl.com/hydrogenerator

Power Generation

Battery Storage
https://tinyurl.com/BatteryCharged

Power Output

Grid Connection
https://www.elp.com/
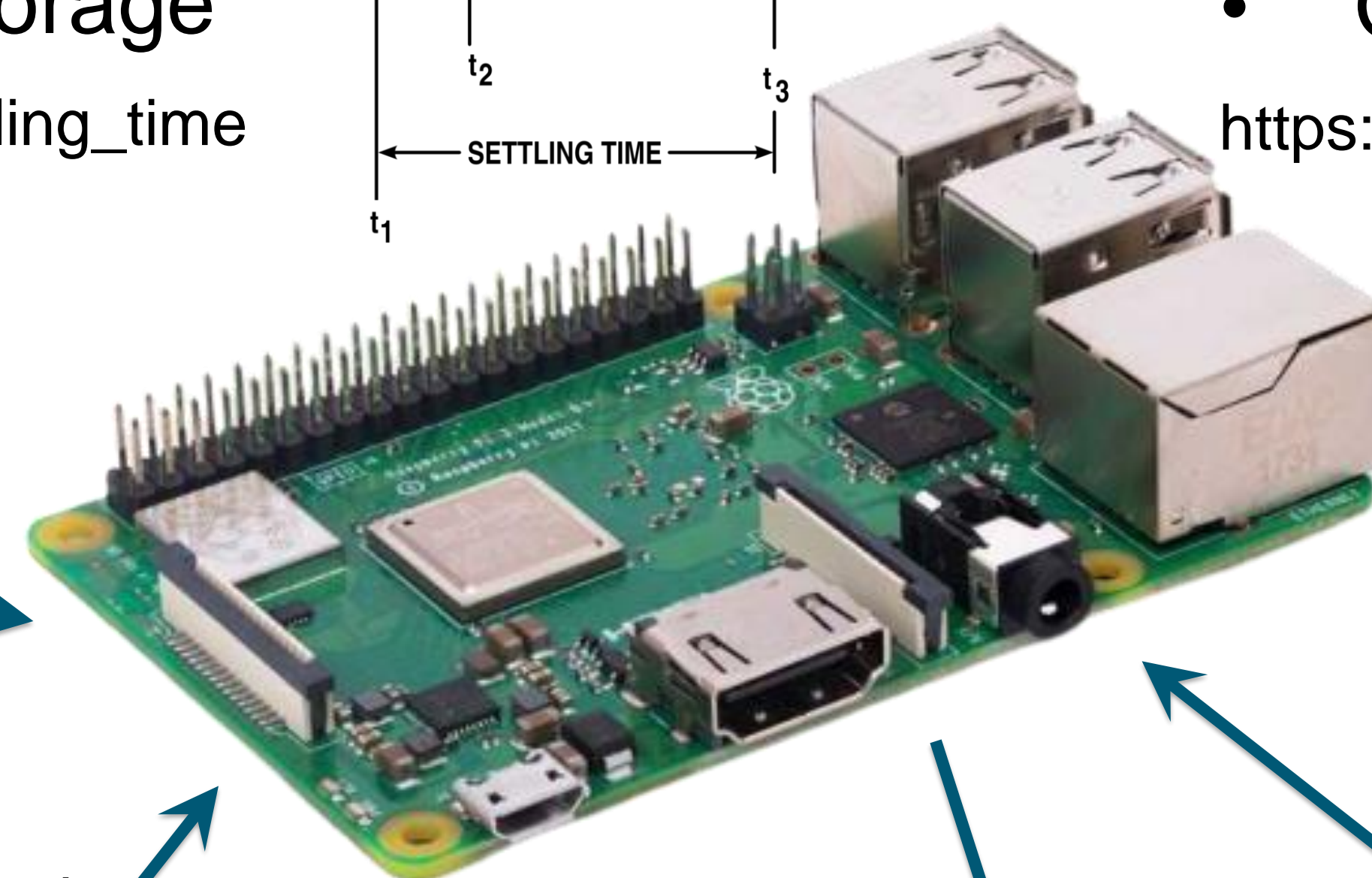
Solar and Wind Generation
https://tinyurl.com/UtahSolarWind

Industrial Load
https://www.bellmer.de/

Residential Load
https://tinyurl.com/lightedhouse

More about Control Theory:

https://www.youtube.com/watch?v=UR0hOmjaHp0