A Low-pass Filter Method to Suppress the Voltage Variations Caused by Introducing Droop Control in DC Microgrids

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1. Microgrid Configurations

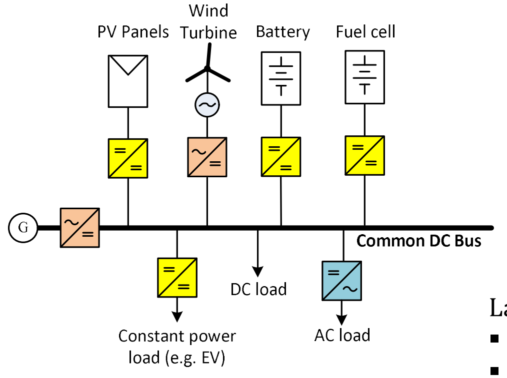

Fig.1: Single DC Bus microgrid configuration

- Contains:
  - ✓ Distributed sources
  - ✓ Energy storage
  - ✓ DC load/AC load
- Control methods:
  - ❑ Droop control
  - ❑ DC bus signalling
  - ❑ Master-salve control

Large droop coefficient → bus oscillations

- Exceed the designed margin → instability
- Variations in introduced output current

2. Control blocks of Two Nodes

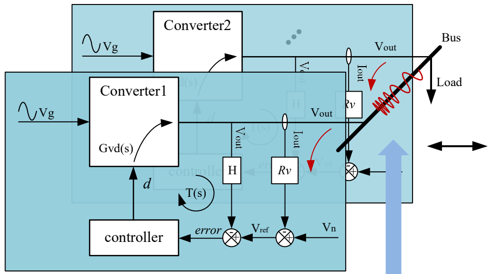

Fig.2: Control blocks of droop control

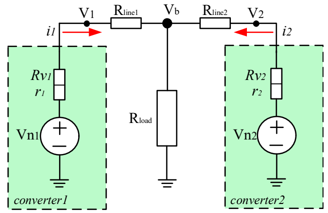

Fig.3: Two-node equivalent circuit model

$$V_b = V_{n1} - i_1(R_{v1} + R_{line1} + r_1)$$

$$V_b = V_{n2} - i_2(R_{v2} + R_{line2} + r_2)$$

$$V_{out} = \underbrace{(V_n - I_{out}R_v)}_{V_{ref}}\frac{1}{H}\frac{T}{1+T} + V_g\frac{G_{vg}}{1+T} - I_{out}\frac{Z_{out}}{1+T}$$

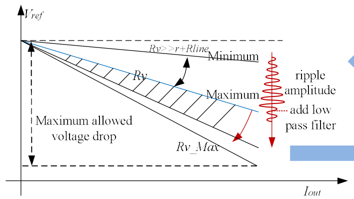

Fig.4: Droop curve and ripple variations

Variation in output current Δi → $*Rv$ → ΔV

❖ Large droop coefficient will lead to large voltage variations

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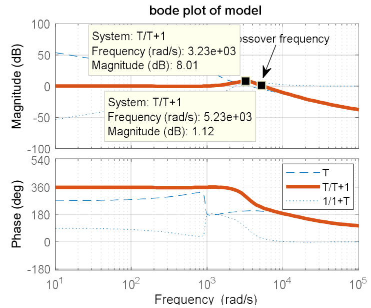
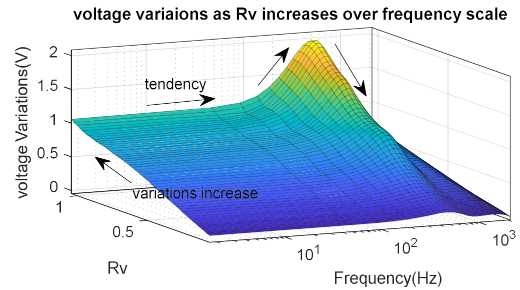
3. Analysis

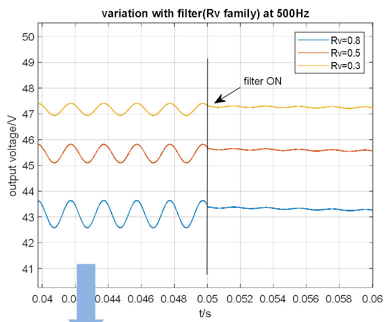


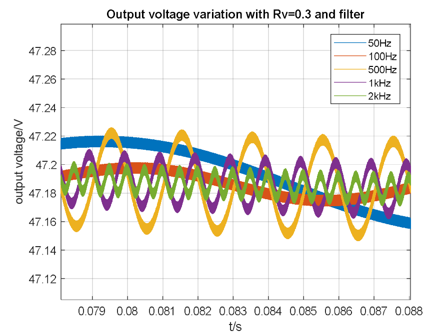


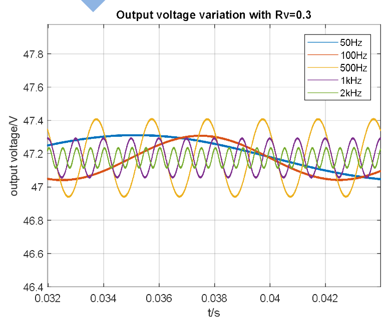
❖ Lack the immunity on frequencies lower than crossover frequency

❖ Adding low-pass filter can compensate the unavailability over lower frequencies

4. Simulation Results







- Conclusions:

1. Introducing droop control can cause voltage variations
2. Larger droop coefficient can cause larger variations
3. Low-pass filter on output current path can reduce variations