# Operation of Parallel Grid-Supporting PVs

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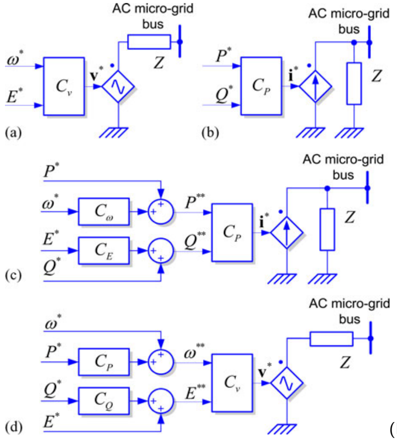
## Introduction

- ∗ Today's power system has more and more renewable energy penetration.
- ∗ With the high penetration of distributed generator sources (DG), the concept of Microgrid is introduced.
- ∗ A microgrid can be characterized as an interconnection of loads and DG sources such as photovoltaic PV sources, wind-turbines and energy storage systems (ESS).
- ∗ Two operation modes: grid-connected modes and islanded modes. An appropriate control of microgrids is required to ensure stable and coordinated operations among grid source, DGs and distributed loads.

## Control of Inverter in AC Microgrid:

Inverters control can be categorized as:

a) Grid-forming ($a$).
b) Grid-following ($b$).
c) Grid-supporting:
   - As a current source ($c$).
   - As a voltage source ($d$).



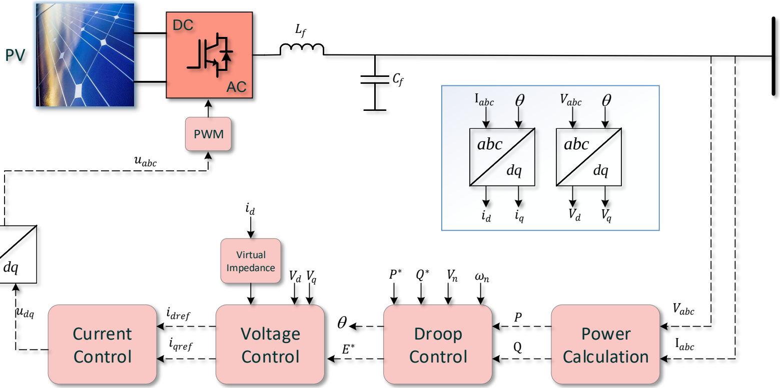

(By [5])

## Objectives

- Investigate the performance of the voltage source grid-supporting inverter with two parallel-connected PV sources in a microgrid. Two operation modes are considered:
  (i) Grid-connected mode.
  (ii) Islanded mode.

- Investigate the effect of load transients during stand-alone operation on PV performance, including dc side voltages.

# Control structure:



## Power Calculation:

The real and reactive power can be calculated based on equation

$$P = (V_d i_d + V_q i_q)$$

$$Q = (V_q i_d - V_d i_q)$$

## Droop Control

The inverter droop control is based on the the conventional $P$-$f$ and $Q$-$V$ droop controller

$$\omega^* = \omega_n + M_p(P^* - P)$$

$$E^* = V_n + M_q(Q^* - Q)$$

## Voltage Control

$$i_{dref} = \left[K_{p1} + \frac{K_{i1}}{s}\right](E^* - V_v - V_d)$$

$$i_{qref} = \left[K_{p1} + \frac{K_{i1}}{s}\right](-(I_d R_v + V_q))$$

## Current Control

$$u_d = \left[K_{p2} + \frac{K_{i2}}{s}\right](i_{dref} - i_d) - \omega L_f i_q + V_d$$

$$u_d = \left[K_{p2} + \frac{K_{i2}}{s}\right](i_{qref} - i_q) - \omega L_f i_d + V_q$$

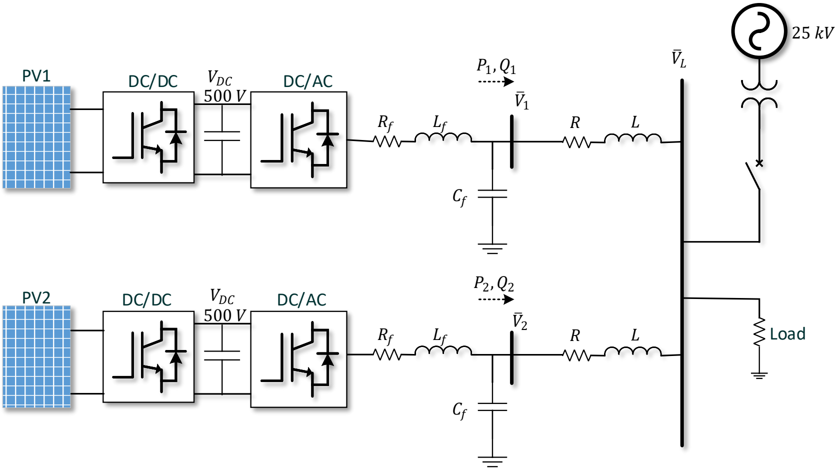
Introduction

Voltage Source Grid-Supporting Inverter

Case Studies and Results

conclusion

# Studied Microgrid Configuration



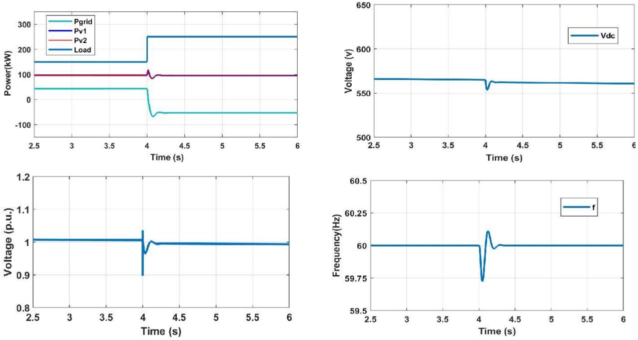
# Case 1: Grid-connected mode:

(i) Both PV units operate at their maximum power generation.

(ii) They supply the local loads and the excessive power is exported into the grid.

(iii) First stage: Load is 150 kW. Load demand is less than the PVs power generation, 50 kW, is fed to the grid.

(iv) At $t = 4$ s , the load is increased to 250 kW. The grid picks up the load and imports power to the microgrid to supply the load.



# Case 2: Islanded mode

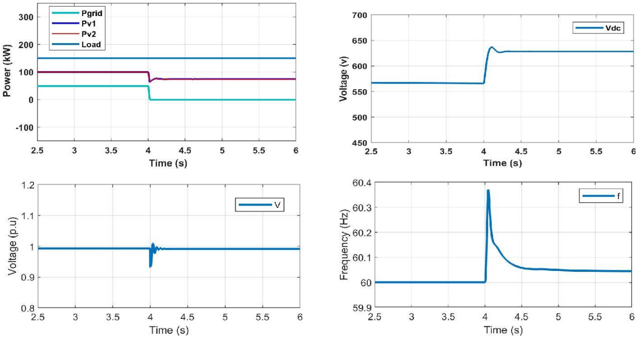
(i) In the stand-alone mode, frequency and voltage are dependent on the PV sources only.

(ii) Before the transition, both PV outputs 200 kW, the load is 150 kW and 50 kW is imported to the grid.

(iii) Transition occurs at $4\ s$,each PV source backs off its output power by 25 kW.

(iv) Since the droop parameter $M_p$ is $0.0053$ pu, we expect to see frequency rise of $0.125 \times 0.0053 \times 60 = 0.04$ Hz.

(v) The DC-link voltage increases in response to decreased P for each PV.

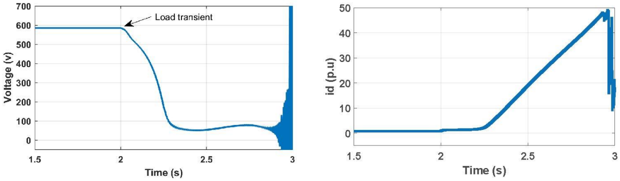


# Load transient:

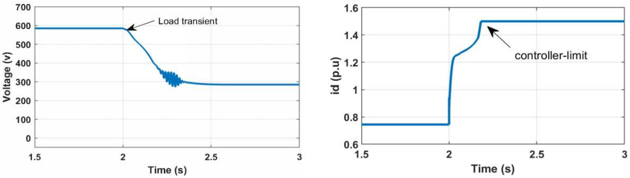
(i) During islanded mode operation, the microgrid may encounter sudden load increase which can exceed the PV generation capabilities. It could lead to voltage collapse.

(ii) The current limitation have influence during the load transient which can prevent the inverter from collapsing.

Without current limiter




With current limiter



## Conclusion

- In this paper, the voltage source grid-supporting PV inverters for two parallel-connected PV sources in a microgrid is presented.
- A Matlab/SimPowerSystems testbed is built to analyze the feasibility of the control. The presented simulation results demonstrate that the reliability of the described control
- Furthermore, load transient effect on the DC-link voltage is investigated.

# Thank You