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Study on a Control System Design Method for Inverter-based DGs in Microgrids

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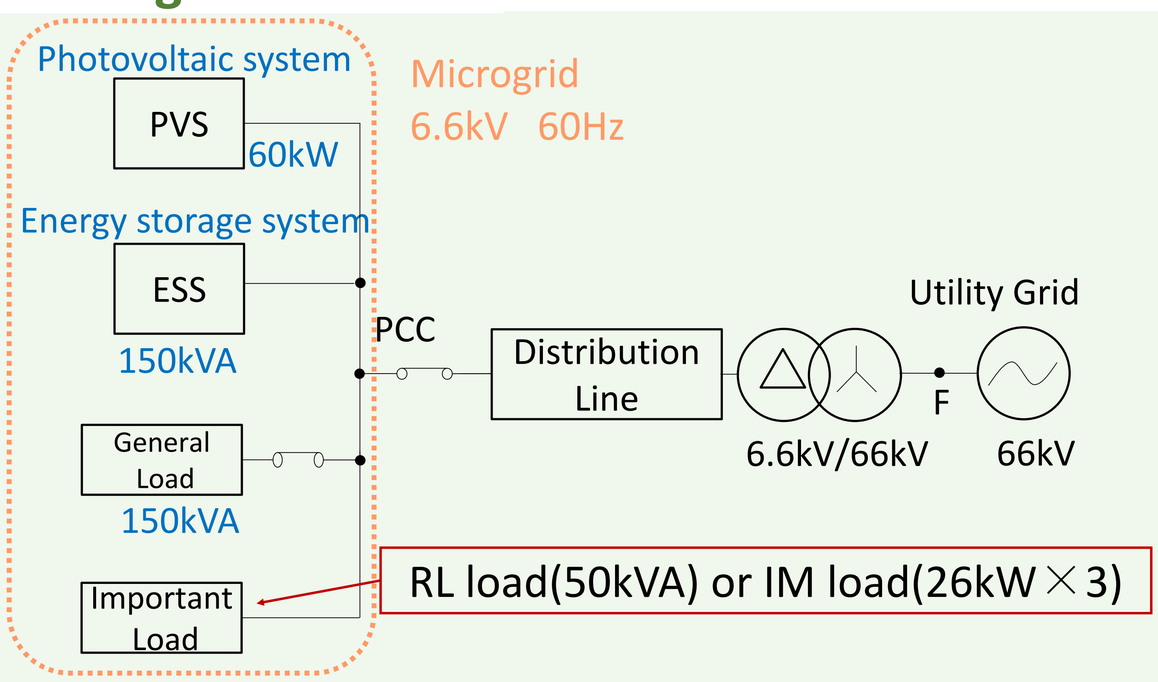
<Background & Objective>

Due to high penetration of renewable energy, more microgrids composed of only Inverter-Based DGs are expected to be applied. It is assumed that Microgrid is capable of continuous power supply by switching to isolated mode from grid-connected mode without interruption at power failure. However, it is required to have fast transient response, robust stability and controller to decrease the over-shoot of the voltage and frequency during transition from grid-connected to isolated mode in inverter control system.

Objective

To investigate the impact of a switching without interruption at fault event on power quality for designing inverter control system.

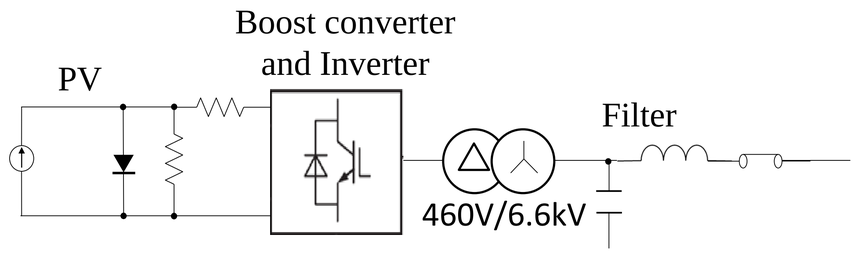
<Microgrid model>



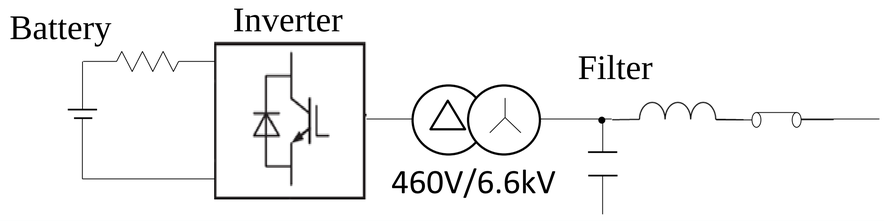
Usually PVS and ESS are in grid-connected mode. When fault accident and disturbance occur, ESS is switched into isolated mode uninterruptedly. Therefore, voltage and frequency in microgrid is controled by ESS.

<PVS, ESS model>

PVS ⇒ Grid-connected mode

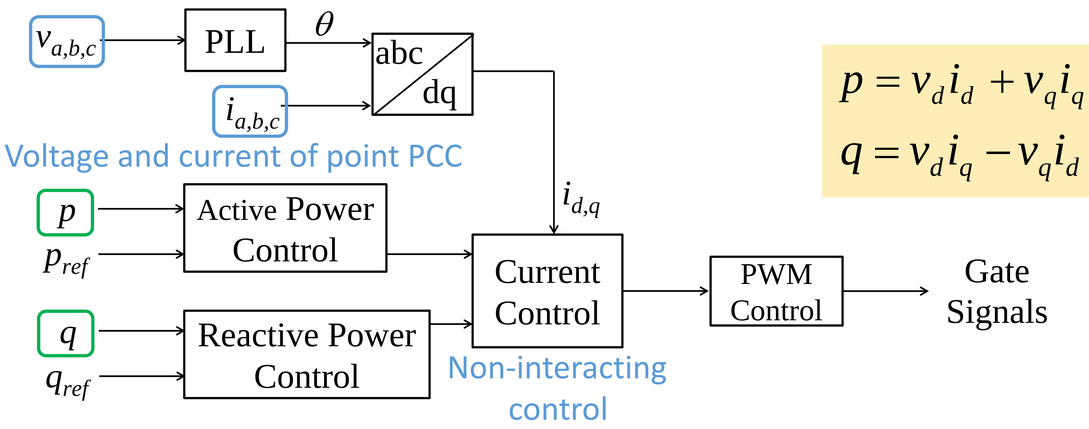


ESS ⇒ Grid-connected mode or Isolated mode



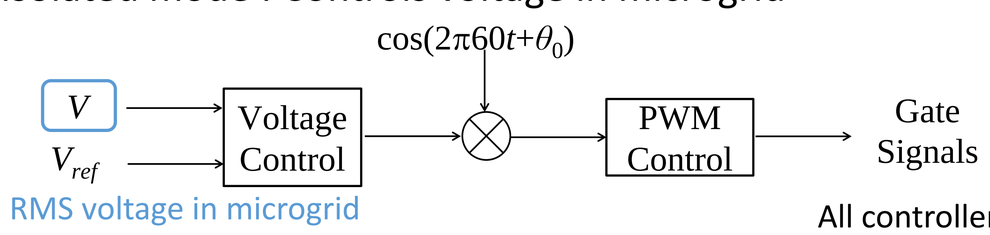
<Inverter control method>

Grid connected mode : Controls real power and reactive power



$$p = v_d i_d + v_q i_q$$
$$q = v_d i_q - v_q i_d$$

Isolated mode : Controls voltage in microgrid



All controllers are PI control.

<Criteria of Power Quality>

	Grid-connected mode	Isolated mode
Voltage	1pu±5% (Base:6.6kV)	1pu±5% (Base:6.6kV)
Frequency	±0.1Hz	±0.5Hz
Harmonics	Overall current distortion factor Less than 5%	Overall voltage distortion factor Less than 5%

Voltage and frequency drops are unavoidable from fault event occurrence to the time ESS becomes isolated mode. Therefore, these control targets do not consider its reduction.

<Simulation and Results>

Step1

Microgrid is initially operated in grid-connected mode. Islanding takes place as a result of a three-phase fault occurring at t=0.93s at point F and voltage of the utility grid drops to 0.3pu.

Step2

Circuit Breaker is opened and microgrid is islanded after 10 or 200 ms.

10ms : Ass0muing high speed circuit breaker

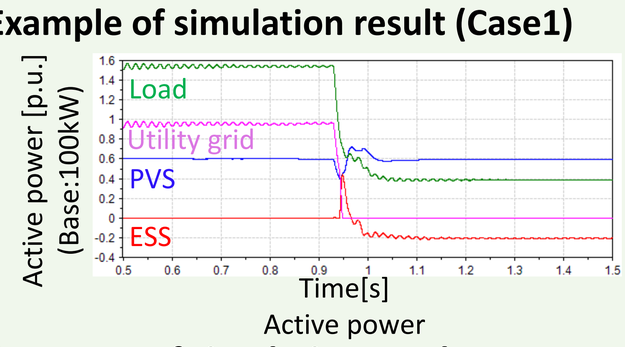
20ms : Assuming general breaker used in distribution system

Step3

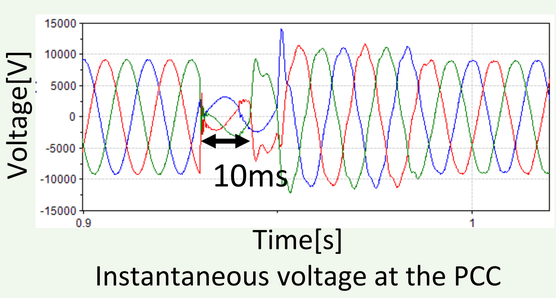
At the same time, ESS is switched to isolated mode from grid-connected mode and general load is disconnected from utility grid.

For simplicity, PVS output is fixed at 60kW and ESS did not perform charge and discharge at grid connected mode.

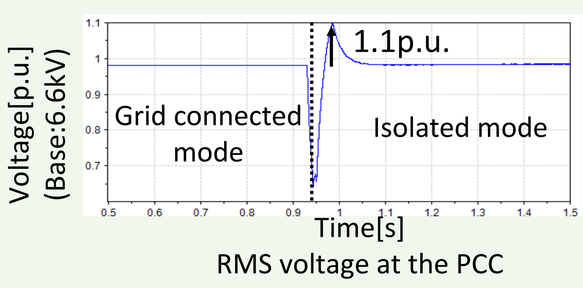
Example of simulation result (Case1)



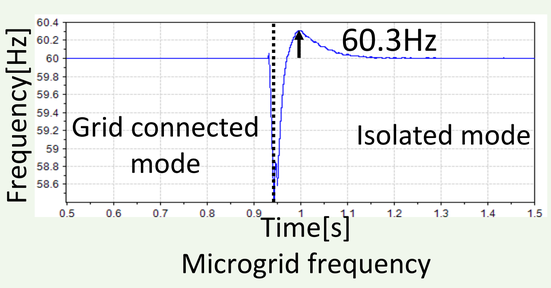
Active power



Instantaneous voltage at the PCC



RMS voltage at the PCC



Microgrid frequency

Summary of simulation result

Important load	Case	Breaking Time[ms]	Stability	Maximum value of voltage[p.u.]	Maximum value of frequency[Hz]	Harmonics of voltage[%]
RL load	1	10	○	1.10	60.3	<5
	2	200	○	1.32	62.5	<5
IM load	3	10	○	1.04	60.2	<5
	4	200	×	-	-	-

Microgrid can be transferred into isolated mode without interruption in case 1,2,3. However, criteria of power quality do not meet in case 1,2. In future works, we will design inverter control system to decrease voltage and frequency over-shoot and improve stability.

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