A Control Method of Parallel Inverter for Smart Islanding of a Microgrid

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1. Introduction

Various types of distributed generators based on renewable energy become available today. The trends enhance a lot of attractive researches on advanced power network[1]. As a consequence of the researches, some small-scale power networks can stand alone with an individual style and benefits, which is referred to as a concept of microgrid[2]. To achieve its stable operation, a parallel inverter which is installed at the coupling point of the microgrid and utility can provide good performance.

This paper deals with a control system of the parallel inverter to support islanding operation of a small-scale local power system. The main function of the parallel inverter is to help the local system to be disconnected and reconnected to the grid under stable conditions. In this paper, a proposed control system is tested under various situations with simulation studies.

First, mode transition from the interconnected operation to the islanding one is tested. The tests are executed under distinctive situations from the viewpoint of output power variation of the distributed generator. Next, disconnecting and reconnecting operations are studied when a constant impedance load is supplied. In this case, some active power control is required. For the sake of simplicity, the parallel inverter is assumed to have sufficient energy source, such as batteries. A phase shift is also assumed at the time of reconnection. Load variations are also considered in the simulation.

Key words: microgrid, energy storage system, distributed generation, electrical power distribution network, power quality, voltage source converter

2. System Model of a Microgrid

Fig. 1 shows a small-scale power system model as a microgrid. The small power network, which is enclosed by dotted line, is connected at one point with a conventional power grid. It employs a photovoltaic generation system as a DG and supplies a system load assumed to be constant impedance.

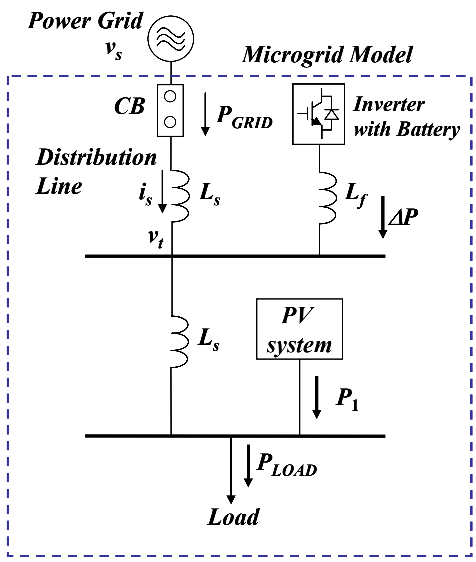

Fig. 1. A system model of a microgrid.

In this paper, a voltage sourced inverter with a battery is connected at the point near the point interconnected with the utility. The inverter is connected in parallel with the conventional grid and it works like an uninterruptible power supply (UPS). During the autonomous or islanding operation, some shortage or excess of generated power may occur because the active power generated by the PV system often fluctuates inherently. The UPS cannot have sufficient energy source to be equal to the conventional power grid. It will compensate the shortage or excess of active power of the PV system appropriately. As a result, active power is balanced in the microgrid by the UPS.

3. Simulation Studies

The operations of the parallel inverter are confirmed by following simulation studies. TABLE I shows the system

TABLE I. System parameters for simulation studies.

Source voltage: $200V_{l\text{-}l,\,rms}$, 60Hz
Line inductance L_s : 2.0mH
Phase shift just before the reconnection: 10deg
Ac link inductance of the inverter L_f : 1.6mH
Ac filter capacitance of the inverter C_f : 16μF
Dc voltage of the inverter E_d* : 326.6V
Dc capacitance of the inverter C_d : 5000μF
Switching frequency f : 10kHz
System load: $(R_L, L_L) = (100\Omega, 54\text{mH})$ [$0 \le t < 0.3$ s]
$= (50\Omega, 27\text{mH})$ [$0.3\text{s} \le t$]

parameters which are used in the simulation. For testing the robustness to the load variation, the load impedance was changed as a step input.

Fig. 2 shows the result in order to confirm the stable mode transition in case that the PV system supplied active power smaller than the load. The condition means that some amount of the load requirement is supplied by the PV system but the rest must be provided by the parallel inverter during the islanding mode. The operating waveforms are displayed in Fig. 2. During the interconnected operation, the parallel inverter does not supply active power. In this case, 600W is supplied by the conventional power grid and 200W is provided by the PV system. In the islanding mode, the active power is supplied by the parallel inverter as shown in Fig. 6. Any disturbance cannot be found in this operation, too. The inverter can also work well at the load variation.

The next case study as shown in Fig. 3 is similar to the previous one except that the PV output is larger than it. In this case, the parallel inverter absorbs the surplus active power and charging the battery. 2kW active power is supplied by the PV system, and 800W of the power is consumed at the load and the rest of 1.2kW is used to charge the battery at the parallel inverter. The microgrid also shows stable operation in this case.

4. Conclusions

This paper deals with a control method of the parallel inverter for islanding operation of a microgrid. It is confirmed that the parallel inverter can successfully support the islanding operation of the microgrid with a PV system and impedance load. The parallel inverter shows good performance in the simulation studies, even if the load or PV output variation is applied. In the full paper, the re-interconnecting operation is also tested when some phase shift is assumed at the time of re-connection.

References

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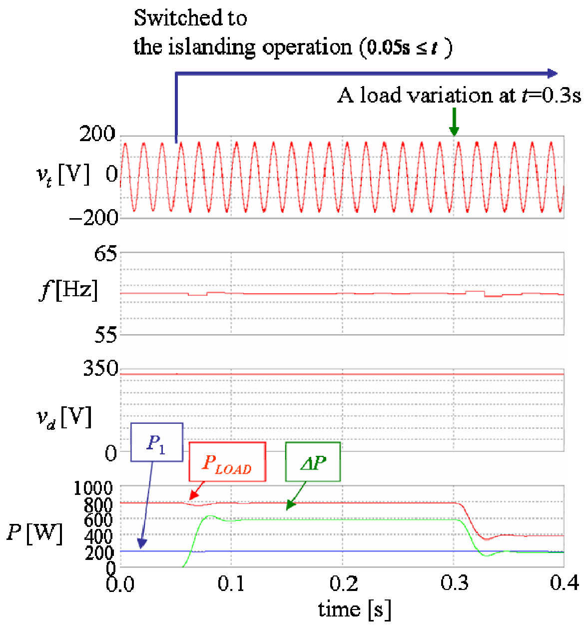

Fig. 2. Operating waveforms in case that the microgrid switched the operation mode from interconnected to islanding at t=0.05s and a load variation occurred at t=0.3s with the small output of the DG .

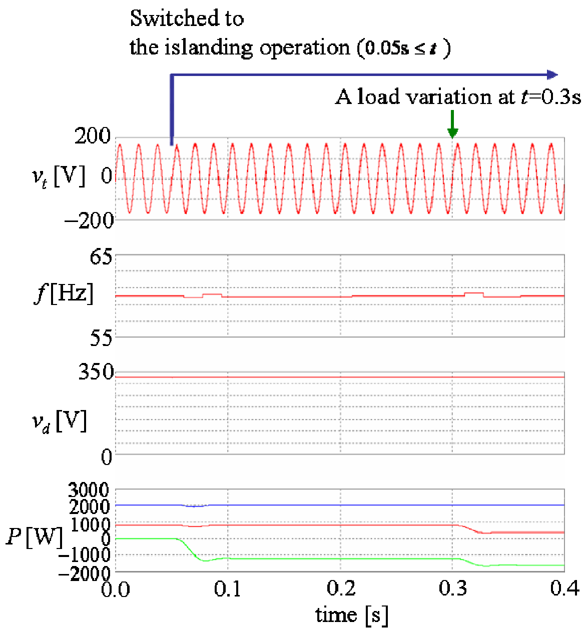

Fig. 3. Operating waveforms in case that the microgrid switched the operation mode from interconnected to islanding at t=0.05s and a load variation occurred at t=0.3s with the large output of the DG.