Chage in Active Power Output of Grid-Following Inverter Controled with P-f Droop by Step Change in Output Frequency of Grid-Forming Inverter

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Introduction

In recent years, with the expansion of renewable energy adoption, numerous inverter power sources have been connected to power grids. Consequently, the portion of rotating machinery has decreased, and reduced grid inertia has led to stability challenges. Research on GFM/GFL inverters is advancing to improve grid stability. These inverters are expected to perform frequency measurement and vary their output based on the measured frequency.

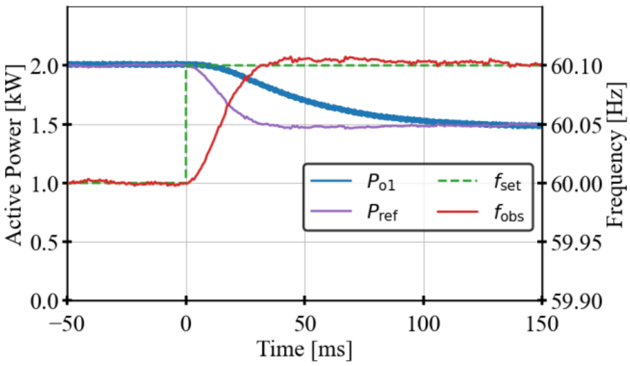
Furthermore, community microgrids (MG) integrating photovoltaic systems and battery storage systems are gaining attention as a means to enhance resilience against large-scale blackouts caused by natural disasters. In such small-scale microgrids, configurations without rotating machines are conceivable. In this case, the frequency would be fixed at the frequency determined by the GFM inverter. Therefore, it is conceivable that the GFM could actively vary its frequency to communicate output setting change instructions to the GFL. This study investigated the effectiveness of a control method of GFL inverter utilizing frequency modulation via a GFM inverter.

Method

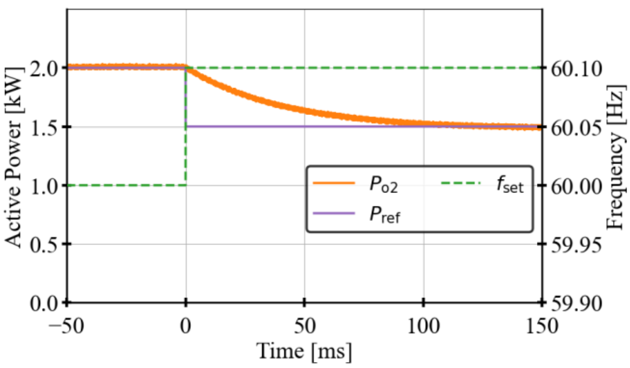
In GFM frequency modulation control, changing the frequency can serve as an incentive. One example is step changes in the GFM frequency. Therefore, we verified the response of the GFL output when the GFM frequency undergoes step changes by constructing a three-phase 200V simulation model in PSIM. We clarified whether the responsiveness of the GFL output when the frequency is changed stepwise depends on the circuit time constant or on the tracking accuracy of the frequency measurement.

Simulation Results

After the GFM power supply was operated autonomously and the GFL power supply was connected at P_{ref} = 2 kW to reach steady state, the output voltage frequency fset of the power supply was changed from 60 Hz to 60.1 Hz at time t = 0 s. Figure.1 (a) shows the GFL output P_{o1} when incorporating frequency modulation control. Figure.1 (b) shows the output P_{o2} when directly reducing the active power command value P_{ref} by 0.5 kW without using P-f droop control. Both P_{o1} and P_{o2} decrease to approximately 1.5 kW around t=100 ms. Therefore, it was confirmed that the responsiveness of P_{o1} to this frequency step change via frequency droop control is not so different to that achieved by directly stepping P_{ref}. Consequently, since this depends on the circuit time constant of the system rather than on the tracking accuracy of the frequency measurement, the effectiveness of frequency modulation control in terms of response speed was demonstrated. We will conduct experimental investigations using actual equipment, and this presentation will report on those results.



(a) Frequency Modulation Control



(b) Directly change output settings

Figure 1 Simulation Results