

# Frequency Stability Analysis for Inverters in Low Voltage Distribution Systems

Chung-Ching Chang

## 1 Introduction

In recent years an increasing number of distributed generators (DG), such as rooftop solar panels, are connected to the conventional power grid. These power generators are different from the traditional generators in many aspects. First, they are connected to the grid at the power distribution, which is closer to the load and under low voltage level. Second, these generators are connected to the grid through inverters, which convert DC power from their source to the AC power that can be injected into the grid.

In the conventional power grids, the balance between the supply and the demand of the power are balanced by the torque, or the rotating inertia, at the conventional generators. When the demand is larger than the supply, the rotors slow down, resulting in the power frequency to drop. The primary control in conventional generators, utilize droop control, control the frequency deviation linearly in proportional to the unmet power. A secondary control would actuate the steam valve to restore the rotating inertia and the frequency back to the nominal value in a later time.

The inverters, however, do not have such mechanical balance for the frequency. A gridtie inverter measures the grid frequency using phase-locked loop (PLL) and injects all its real power at this frequency. A droop inverter, on the other hand, imitates and adopts a similar approach, droop control, as in the primary control in a conventional generator. However, it is not known whether these inverters, when interconnected at the power distribution system, would cause instability to the power system.

## 2 Problem

An aggregated model, as in Fig. 1, with a single inverter is first considered. We aggregate the load in the distribution system as a lumped load  $Z_L$ , and the line impedance for the low voltage grid as  $Z_G$ . The inverter is connected to the grid from the right, with voltage  $V_N$  and current  $I_N$ . Since the line impedance is in proportional to the line distance, we may neglect the line impedance between the inverter and the load as they are close to each other. We would like to know, under such topology, will the frequency disturbance from the grid induce instability to the local inverter system?

For practical purposes, we will not design new inverters, instead, we will analyze existing inverter designs. We would like to analyze whether a gridtie inverter or a droop inverter will be stable under an aggregated model as in Fig. 1. We would also like to know when multiple inverters are connected in the power distribution network, can frequency stability be guaranteed. The project may contain several components, including modeling the inverter systems, modeling the grid topology, theoretical analysis, and numerical simulations.

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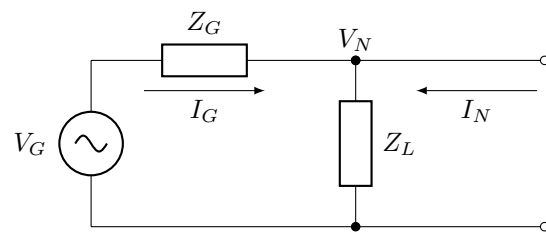


Figure 1: Grid Interface Circuit