### Introduction

Due to fast development of renewable energy resources, the concept of distributed generation (DG) is gaining an important role in future smart power grids. DG has many advantages such as closeness to customers, increased efficiency and reduced transmission loss, better reliability, and improved energy management. The majority of DG resources are interfaced to grid/loads via power electronic converters. A cluster of DG units connected to the grid via power electronic interfaces form a microgrid (MG).

The main goal of a grid-connected MG is to supply real and reactive powers under high power quality injection constraints. In the islanded mode, MG is required to supply “regulated power” under controllable voltage and frequency while maintaining accurate power sharing among different DG units. Thus the general objectives of a general universal control topology for microgrid are as follow:

1. Ability to work in both islanded and grid connected modes;
2. Grid synchronization without need to grid information;
3. Optimal power generation of DG units to minimize operating cost and enhance stability;
4. Generation of the preset real and reactive powers in islanding;
5. Enhanced stability in islanding and grid connected modes and transitions between them;
6. Operation and control in islanding just based on local information;
7. Accurate real and reactive power sharing.

### Synchronverter Concept

The basic idea is to mimic back-EMF generation principle and rotor dynamic of a SG, including its rotor momentum of inertia (J) and friction (m). The utilization of emulated rotor dynamics improves the converter dynamics and it yields a control structure that is more suitable for MG operation. In this VSC model, the virtual rotor plays this role in controlling the frequency dynamics, which is not accessible in the conventional current/voltage control loops. As it is seen, the controller has three control loops, namely angle loop, frequency loop and torque loop which is called MG stabilizer afterward. The angle controller generates the reference frequency deviation and the frequency loop is responsible to determine the required torque as a function of angle error and frequency error. The nonlinear MG stabilizer, which can be considered as torque controller, attempts to set torque error equal to zero using a supplementary voltage control.

Nonlinear Input control law:

\[
\eta_f = -\frac{3}{2} \frac{\partial f}{\partial \phi} \sin \theta + f + \frac{4}{3} \frac{\partial f}{\partial \Delta f} \sin \phi \Delta f + (\Delta f \sigma + \Delta \phi \Delta f) + \frac{1}{2} \left( \frac{3}{2} \frac{\partial f}{\partial \Delta f} \sin \phi \Delta f + \frac{1}{2} \frac{\partial f}{\partial \phi} \sin \phi \Delta f \right)
\]

### Simulation Results

1. Grid Synchronization:
   - Real power waveforms
   - Angle tracking
   - Reactive powers

2. Transition to islanding:
   - Real power waveforms

3. Grid restoration

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### References