A NOVEL CONTROL APPROACH FOR MICROGRIDS ISLANDED OPERATION – LOAD STEP PRE-ANNOUNCEMENT AND BANG-BANG CONTROL

Yi GUO[1], Wolfgang GAWLIK[1]

Introduction

The Microgrid (MG) concept has been proposed due to the high penetration of distributed energy resources (DER) in electrical network systems. Diverse MG projects [1] are carried out globally focusing on their different technology aspects. To ensure a more reliable and secure energy supply system, different control strategies of MGs are researched. In this paper, an islanded microgrid implementing frequency control is modelled. In addition, a novel control method including load step pre-announcement n(LSP) and a bang-bang controller (BB controller), which intends to improve the frequency response of islanded MGs, is presented.

Method

An islanded Microgrid simulation model, which consists of a conventional generator, a photovoltaic (PV) system and lumped load, is built up in the Matlab Simulink environment. The simulation model uses a per unit (p.u.) base. The schematic block diagram of the islanded MG system is presented in figure 1.

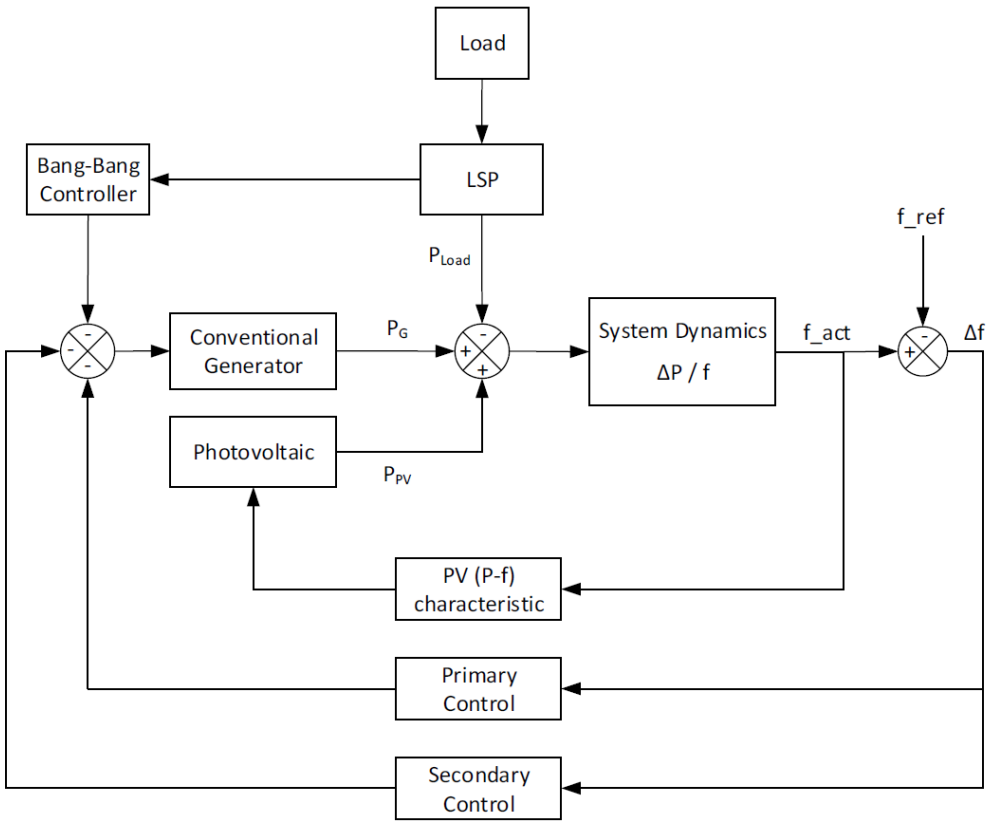

Figure 1: Schematic block diagram of the microgrid model (P_G: the active power of the conventional generator; P_{PV}: the active power of the PV system; P_{Load}: the active power consumption of the load; ΔP: the active power deviation; f: the system frequency; f_act: the current frequency; f_ref: the nominal frequency; Δf: the frequency deviation).

[1] Technische Universität Wien, Institut für Energiesysteme und Elektrische Antriebe, Gußhausstraße 25/370-1,1040 Wien, Tel.: +43 1 58801-370128, Fax: +43 1 58801-370199, guo@ea.tuwien.ac.at, www.ea.tuwien.ac.at

Frequency control [2] is one important control method to maintain the frequency within the nominal operating conditions. In a large power system, frequency control loops, including primary control, secondary control, tertiary and emergency control, are usually available. In the MG simulation model, primary and secondary control are applied. However, frequency control of MGs is difficult to be implemented without the support from the overall network because they normally have a low inertia in island mode. Therefore, additional control strategies have been considered.

To smoothen the dynamic effect of an imbalance between load and generation, load step preannouncement and a bang-bang controller are considered for the simulation model. LSP receives signals from the load side and delivers them to the overall system continuously. However, when the load is about to change, LSP will delay the command signals for a short period and maintain the previous load to the system. Meanwhile, LSP gives an announcement signal within the preset time of the delay period to the BB controller to control the conventional generator. A BB controller is a feedback controller which switches between two states, on and off. After it receives the signal from LSP, it gives a command to the conventional generator to either generate full power or decrease its power output, before the load change is realized. It only works during the preset time of the delay of LSP, which is set to be 40 ms in the simulation model.

Conclusion

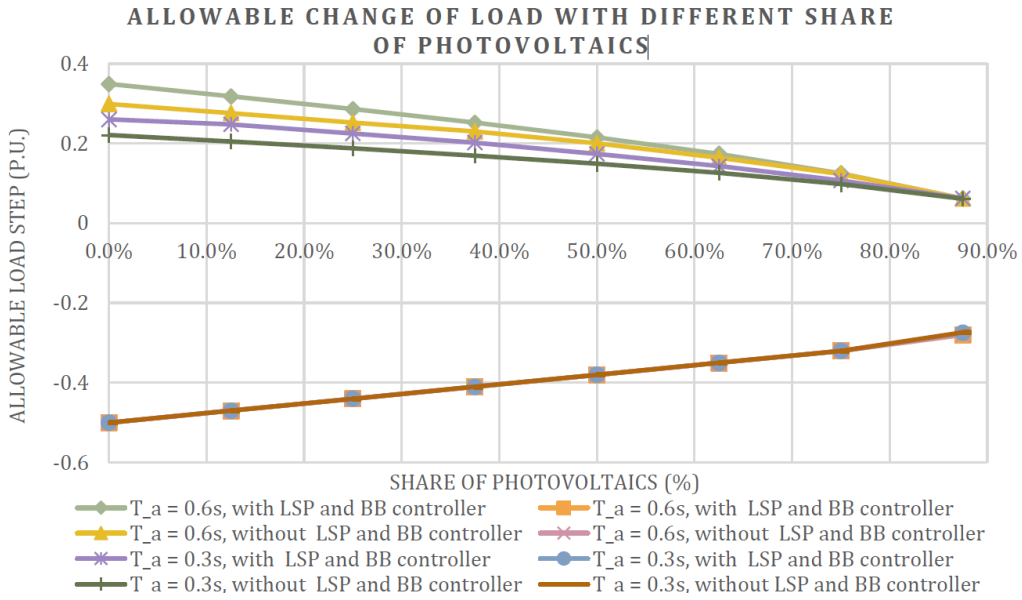

Figure 2: Allowable change of load with different shares of PVs (T_a: system starting time constant).

As it is shown in figure 2, when the LSP and BB controller are applied in the islanded microgrid system, they improve the maximum possible positive load step depending on the share of PVs. Furthermore, the application of the LSP and BB controller has a greater impact on islanded MG systems with a lower system starting time constant. However, they do not have any impact on a large negative load step. The allowable load decrease is mainly influenced by the capacity of the conventional generator and the share of PVs.

In conclusion, the LSP and BB controller have a positive effect on the maximum load increase in islanded microgrids, and the BB controller is only activated during the preset delay time of the load change from LSP, which does not affect the other control actions. Additionally they both are simple and easy to be designed, implemented and operated in case of a communication-enabled MG. It is reasonable to add them into MGs during the islanded operation to improve the control ability, yet since the system frequency swings after the reconnection of the integrated PVs, other control methods for decreasing a large amount of load or a big load loss in MGs should be developed.

References

[1] Guo, Yi, and Wolfgang Gawlik. "A Survey of Control Strategies Applied in Worldwide Microgrid Projects." Tagungsband ComForEn 2014 (2014): 47.

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