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ScienceDirect

Journal of the Franklin Institute 353 (2016) 3407–3427

Journal of The Franklin Institute

www.elsevier.com/locate/jfranklin

Distributed cooperative control for multiple photovoltaic generators in distribution power system under event-triggered mechanism

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Received 2 November 2015; received in revised form 11 April 2016; accepted 13 June 2016
Available online 23 June 2016

Abstract

This paper investigates the distributed event-triggered cooperative control for multiple photovoltaic (PV) generators in distribution power system. Considering the issue of limited bandwidth of communication network in practical application, two types of novel distributed event-triggered mechanism are introduced to reduce the information transmission pressure, and the distributed cooperative controllers are designed for PV generators based on the proposed triggering schemes. Under the control strategy, the fair utilization of all PV generators is realized, and the active power flow across certain transmission line and the voltage of critical bus can be restored. Simulation results show the effectiveness of the proposed method.

1. Introduction

Today, the world is facing with mounting challenges posed by the energy crisis and environmental degradation, which make the power system changes dramatically. The most notable fact is that an increasing number of distributed generators (DGs) are integrated into the distribution power system due to their low environmental costs, renewability and world-wide distribution characteristics [1,2]. Therefore, how to design the control protocol for DGs in order to drive the power system to the steady state is a core problem. Conventionally, the control of DGs is realized in a centralized mode, which

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http://dx.doi.org/10.1016/j.jfranklin.2016.06.015
0016-0032/

needs to collect system-wide information and send control command globally. This centralized control mode is inappropriate because of the DGs' wide distribution and large quantity characters. Recently, much attention has been paid on the study of the distributed cooperative control of DGs. The distributed cooperative control method has been intensively studied in multi-agent system, the typical topics of which include consensus [3–6], formation control [7–9], and flocking [10–12]. To realize the distributed cooperative control for multiple DGs, a multi-agent system based architecture can be employed. Each DG is considered as an agent and the control strategy for DGs is implemented locally though the information transmission between neighbors. The distributed control mode can avoid the shortcomings of centralized control strategy [13–19].

As a typical kind of DG, photovoltaic (PV) generator is becoming an increasingly attractive source of renewable energy in certain areas. From a practical perspective, the PV generators in the distribution power system are usually expected to be controlled synergistically such that, all the PV generators in a group are fairly used, and the active power consumed by loads in a concerned area and the voltage at some critical bus are kept constant [20]. The cooperative control strategy for multiple PV generators was firstly designed in a distributed architecture in [21], where the above control purpose can be realized and only the local information transmission between PV generators is needed.

It should be mentioned that, the existing distribute cooperative control strategy for multiple PV generators assumes that the information of each PV generator can be transmitted through the communication network continuously. However, for the practical communication network with band-width constraint, it would be desirable to reduce the communication burdens between PV generators. Furthermore, the conventional sampled-data control, in which the information is transmitted periodically among PV generators, is too conservative since the sampling rate is chosen for the worst case. To solve this problem, the event-triggered control strategy may be a feasible scheme. Under the event-triggered mechanism, the unnecessary redundant communication can be mitigated since it emphasizes that the information broadcasting is executed only when it is needed rather than elapse of a certain period of time [22]. The event-triggered control has been developed to reduce the traffic in networked control system in [22,23], where an event-triggered condition was constructed to determine the information broadcasting time. And then it was utilized in the distributed cooperative control of multi-agent system [24–29].

This paper focuses on the development of the distributed event-triggered cooperative control law for multiple PV generators in distribution power system. In order to drive the utilization ratios of all PV generators to achieve consensus and make the voltage of a critical bus and the active power flow across certain transmission line converge to the specific values, a novel kind of distributed cooperative control law for PV generator is constructed. The main contributions of this paper are summarized as follows.

1. The event-triggered mechanism is introduced in the PV generator's controller design. The information broadcasting time of each PV generator is determined by the constructed event-triggered conditions. This method can reduce the amount of information transmission, which implies that less pressure in communication network can be expected. To the best of the authors' knowledge, it is the first time to introduce the event-triggered scheme in the study of distributed cooperative control for multiple PV generators.
2. Either the implementation of the designed event-triggered mechanism or controller needs only the local information and discrete triggered information broadcasted from neighbors. This implies that the novel event-triggered control strategy can be executed in a distributed architecture, which can avoid the shortcomings of centralized control strategy as mentioned before.