Supplemental File of Adaptive Voltage Control to Coordinate Multiple PV Inverters as a Cluster

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# Detailed Description of the System Model

To further clarify the system model, the detailed PV inverter interface configuration with inner control loop is illustrated in Fig. 1. For the th PV inverter, the reference value of the reactive power  is obtained from the LC, and the reference value of the active power  is set by any MPPT algorithm or a utility specified power schedule. Then, the reference values of the d-axis and q-axis component currents , are calculated by , , where  denotes the d-axis component of the measured grid voltage at the th PV node. The current components  are calculated through abc-to-dq frame transformations of their corresponding measured three-phase signals, and they are regulated to independently follow corresponding reference values  respectively. Consequently, the inner current controller generates the voltage d-axis and q-axis components reference , which are subsequently converted into phase voltages to generate the PWM vector  accordingly.



Fig. 1. A typical PV inverter interface configuration with inner control loop.

In this paper, the RMS value of the voltage at PV node  is represented by , and its corresponding reference value  is dynamically generated by the cluster CC. Each adaptive LC for PV inverter  receive the control command  from the CC, and then calculates the control command for PV reactive power  at each LC control step, thus realizing regulating the voltage at the local point of coupling  to follow its local voltage reference .

As for the cluster CC, the input/output measurements of the cluster, including the RMS value of the cluster PCC voltage  and voltages of all the PV nodes , are collected. The data-driven adaptive coordination algorithm is devised for CC to calculate the voltage references for local PV nodes  at each CC control step, which serve as the inputs for the corresponding LCs.

# Convergence of the Identification Algorithm

The convergence analysis is similar to [1]. For the newly introduced system output data  and input data  at the th step, suppose



Define the parameter estimation error as





Define the predicted output error as .

So we have



According to (15) in the paper, we have



can be rewritten as



According to the definition of , we have



Premultiplying by , we have



Therefore,



Combing and , we have



From , we have



Now we define 



Combine and , we have



From (14) in the paper, we have



Therefore, can be written as



Since  is a nonnegative, nonincreasing sequence, it converges to a nonnegative number. Hence, , which implies that , where  =  is positive definite. Since , it follows that . Therefore, the convergence of the chunk updating RLS algorithm is verified.

References

[1] A. Goel, A. L. Bruce, and D. S. Bernstein, “Recursive Least Squares With Variable-Direction Forgetting: Compensating for the Loss of Persistency [Lecture Notes],” *IEEE Control Syst.*, vol. 40, no. 4, pp. 80–102, Aug. 2020, doi: 10.1109/MCS.2020.2990516.

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