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An aggregate model of plug-in electric vehicles including distribution network characteristics for primary frequency control

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Abstract— In the future, the number of plug-in electric vehicles (PEVs) that will participate in the primary frequency control (PFC) is likely to increase. In our previous research, the computational complexity of the PFC problem for a large number of PEVs was reduced using aggregate models of PEVs. However, in the literature on the PFC, the distribution network characteristics have not been included in the aggregate models of PEVs for the PFC, despite the fact that PEVs will be dispersedly connected to the distribution network. This paper proposes an aggregate model of PEVs for the PFC that further incorporates distribution network characteristics, i.e., the distribution network power loss (DNPL) and the maximum allowed current (MAC) of the lines and transformers. The DNPL variation is formulated according to the line and transformer impedance, spatial distribution of PEVs and loads, and active power variation of PEVs.
Then, DNPL variation together with the MAC of the lines and transformers are incorporated in the proposed model of PEVs. Finally, the simulation results show an excellent agreement of
98% between the detailed model and the proposed aggregate model of PEVs.

Index Terms— Aggregate model, detailed model, distribution network, plug-in electric vehicle, power losses, primary frequency control.

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