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REVIEW ARTICLE

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Recent control techniques and management of AC microgrids: A critical review on issues, strategies, and future trends

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Summary

Distributed generation is considered as a key component of the emerging microgrid (MG) concept, enabling the integration of renewable sources in a distributed network. The MG has been accepted globally as a new approach that provides a flexible, reliable, sustainable, and economical solution for green and clean power generation. Microgrid is constituted by distributed energy resources (DERs) and is a combination of parallel connection equipped with suitable control and protection scheme for the operation in both islanded and utility grid-connected mode. Microgrid structure with various hierarchy control techniques is categorized into three layers such as primary control, secondary control, and tertiary control techniques. A comprehensive literature review of these control techniques in AC microgrid is presented. In addition, the technical challenges of existing MGs affect real-time applications around the globe.

List of Symbols and Abbreviations: AC, alternative current; ACMG, alternative current microgrid; BESS, battery energy storage system; BMS, battery management system; CAES, compressed air energy storage; CC, centralized control; CHP, combined heat and power; CPL, constant power load; CSI, current source inverter; DC, decentralized control; DC, direct current; DCMG, DC microgrid; DER, distributed energy resources; DFC, direct-flux control; DFIG, double-fed induction generation; DG, distributed generation; DGU, distributed generation unit; DMS, distributed management system; EMS, energy management system; ESS, energy storage system; EV, electric vehicle; FBC, frequency based controller; FC, fuel cell; FQB, frequency reactive power boost; GHG, greenhouse gases; HMG, hybrid-microgrid; HPF, high pass filter; IDER, integrated distributed energy resource; IDG, integrated distributed generation; IG, IG; IGBT, integrated gate bipolar transistor; KE, kinetic energy; LC, local controller; LMS, load management system; MAS, multi agent system; MG, microgrid; MGCC, mg central-controller; MLCT, multiple-layer control technique; MMG, multi-microgrid; MOSFET, metal-oxide semiconductor field effect transistor; MPC, model predictive control; MPPT, maximum power point tracking; MSC, master-slave control; PC, primary control; PCC, point of common coupling; PEC, power electronics converter; PG, power generation; PHS, pumped hybrid storage; PI, proportional integrated; PLL, phase lock-loop; PMSG, permanent magnet synchronous generation; PR, proportional resonant; RES, renewable energy sources; SC, secondary control; SC, super capacitor; SEPIC, single-ended primary-inductor converter; SMES, superconducting magnetic energy storage; SPV, solar photovoltaic; TC, tertiary control; THD, total harmonic distortion; VBD, voltage based droop; VFD, virtual flux droop; VID, virtual impedance droop; VPD, voltage real power droop; VSI, voltage source inverter; WT, wind turbine; $\mathcal{P}_{\mathrm{m}}$, turbine power; ρ, ρ is the density of the water; e_{h}, efficiency factor; k_{p}, proportional gain; k_i, integral gain; ω, frequency resonant; ω_{ref}, reference values of angular frequency; U_{ref}, reference values of voltage amplitude of the grid; m; n, droop coefficient factors; P_{ref}, reference value of active power; Q_{ref}, reference value of reactive power; $\omega_{\max}$ and $\omega_{\min}$, maximum and minimum value of angular frequency limits; $U_{\max}$ and $U_{\min}$, maximum and minimum value of output voltage limits; X, output reactance; δ, phase angle; E_{rated}, nominal value of voltage; f_{rated}, frequency; m_p and n_q, droop coefficients; $Z_{\mathrm{U}}(s)$, output impedance of VSC; $\hat{c}_{\mathrm{p}}$ and $\hat{c}_{\mathrm{Q}}$, adaptive transient coefficients; δ_i^n and ψ_{Ui}^n, nominal phase angle and inverter o/p virtual flux amplitude; $P_{i,\mathrm{rated}}^n$ and $\psi_{i,\mathrm{rated}}^n$, active and reactive power-sharing rated values of the DG units.

