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Editorial

Advanced Control Techniques for Wind/Solar/Battery Systems

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Abstract: This Editorial summarizes the papers of the Special Issue entitled 'Advanced Control Techniques for Wind/Solar/Battery Systems' published in *Energies*. The Special Issue includes four scientific articles published in 2021 and 2022 in the field of quasi-Z-Source inverter control, photovoltaic energy conversion, battery charge control, wind turbine speed control, and solar irradiance prediction. New scientific achievements with experimental verifications of the achieved results are presented in all articles.

Keywords: quasi-Z-source inverter; photovoltaic source; pulse-width modulation; solar irradiance prediction; batteries; wind energy

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The growing need for energy in conjunction with the restricted supply of its conventional sources is a problem faced by many countries around the world. Renewable energy sources can alleviate energy problems, but their variable nature and availability pose challenges to their integration into the power grid. These challenges can be overcome by applying advanced control and energy storage systems.

Solar and wind energy systems are the most popular renewable energy sources, with large market shares and promising growth. Significantly, their contribution to global electricity has doubled since 2015. Solar and wind energy systems are often equipped with battery systems intended to store excess energy and supply energy in the absence of wind or sunlight.

Topics of primary interest in this Special Issue included:

- Active and reactive power control in wind/solar energy systems;
- The control of wind turbine blades;
- Maximum power point tracking in wind/solar energy systems;
- Partial shading in photovoltaic systems;
- Power converter control in wind/solar energy systems;
- The control of voltage and frequency in wind/solar microgrids;
- Battery control and monitoring systems.

This Special Issue includes four scientific articles in the field of quasi-Z-source inverter control, photovoltaic energy conversion, battery charge control, wind turbine speed control, and solar irradiance prediction.

In [1], a photovoltaic (PV) system containing a quasi-Z-source inverter (qZSI) and battery is analyzed. The analyzed control algorithm enables both grid-tied and stand-alone operation. The control system design is based on three transfer functions obtained from the novel small-signal model. For the maximum power point tracking, a perturb-and-observe algorithm is utilized that does not require the measurement of the PV source current, but it instead utilizes the battery current during the stand-alone operation and the d-axis reference current during the grid-tied operation. Numerous laboratory experiments were performed. As an example, a maximum settling time of 0.4 s was noted for the abrupt decrease in the PV source power of 1000 W during the grid-tied operation, whereas the static tracking efficiency of the proposed MPPT algorithm ranged from 96.9% to 100%.

In [2] a novel shoot-through injection method with dead-time is introduced for quasi-Z-source inverter control. In this method, the shoot-through state occurrence is synchronized with the beginning of the zero switching states of the three-phase sinusoidal pulse-width modulation. In this way, the total number of switchings per transistor is reduced and, consequently, the switching losses are reduced too. As a result, the authors found that efficiency was increased by up to 12% and the IGBT-diode pair case temperature was reduced by about 50 °C, in comparison to the conventional method.

Radovan et al. [3] propose a solar irradiance prediction method based on the prediction of solar shading by clouds. The method is based on determining the current cloud position and estimating the velocity from a sequence of multiple images taken with a 180° wide-angle camera that takes a picture of the sky every 5 s. The simplicity and speed of the described algorithm make the approach for estimating direct solar irradiance suitable for use in solar-based power plants.

An islanded power generation system with a squirrel-cage induction generator and a battery-assisted quasi-Z source inverter (qZSI) is presented in [4] for the very first time. The maximum power is captured from both the wind turbine and the squirrel-cage induction generator through the adjustment of the wind turbine speed and the generator operating flux, respectively. The performance of the system was tested experimentally over wide ranges of wind speed, load power, battery state of charge, DC link voltages, and AC load voltages.

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