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Editorial

Energy Harvesting and Energy Storage Systems, Volume II

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Systems for sustainable development are built on three pillars: economic development, environmental stewardship, and social value. One of the core principles of finding harmony between these support points is to restrict the utilization of non-environmentally friendly power sources [1]. The process of extracting energy from the surrounding environment and converting it into electrical power looks like a promising solution to this problem [1–3]. To make it easier to switch from fossil-fuel energy sources to cleaner renewable ones, new energy generation technologies like solar, wind, and thermal energy are rapidly being developed [2–7]. Energy-harvesting systems have emerged as a significant area of research, and continue to advance.

Despite the fact that the world has seen critical development in the creation of power from sustainable sources, these sources do not yield a standard stock that is sufficiently versatile for different prerequisites of utilization, so they cannot answer various demands. Thusly, the development of this decentralized creation requires a large energy capacity, which is normally made of lead batteries; this is the expected answer to the issue of organizations' load strength. That said, lead batteries cannot store a lot of energy in a small volume or endure high cycling rates. New capacity innovations are therefore being created and trialed. Along these lines, load limits have emerged as an undeniably significant aspect of developing environmentally friendly power; higher limits allow energy to be conveyed to organizations during the busy times at which it is generally required.

Within this Special Issue, sixteen papers are published, covering various aspects of optimization algorithms, evaluations of wind energy turbines, electrostatic vibration energy transducers, battery management systems, thermoelectric generators, distribution networks, issues of renewable energy micro-grid interfacing, fuzzy-logic-controller-based direct power controls, parameter estimations of fuel cells, and ultra-low-power supercapacitors.

An improved artificial bee colony (I-ABC) algorithm for the maximum power point tracking (MPPT) of a photovoltaic module array was proposed [Contribution 1]. The I-ABC algorithm was proven able to solve the issue of getting stuck when tracking the local maximum power point (LMPP), and could quickly and stably track the global maximum power point (GMPP), thereby improving power generation efficiency. The proposed I-ABC algorithm could search for the higher power point of a PVMA using a small bee colony, determine the next tracking direction through the perturb-and-observe (P&O) method, and keep tracking until the GMPP was obtained. This method could prevent the tracking of the GMPP continuing for too long, due to the application of a small bee colony. First, in this study, the photovoltaic modules produced by Sunworld Co., Ltd., Dongguan, China, were used, and were configured as a PVMA with four series and three parallel connections under different numbers of shaded modules and different shading ratios, so that corresponding P–V output characteristic curves with multi-peak values were generated. Then, the GMPP was tracked using the proposed MPPT method. The simulation and experimental results showed that the proposed method performed better both in dynamic response and steady-state performance than the traditional artificial bee colony (ABC) algorithm. According to the experimental results, the tracking accuracy for the GMPP, based on the proposed MPPT with one hundred iterations under five different shading ratios, was about 100%; on the other hand, that of the traditional ABC algorithm was 70%, and that of the P&O method was lower, at about 30%. A hybrid particle swarm optimization (PSO) algorithm

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for parameter assessment of photovoltaic (PV) cells/modules has also been discussed [Contribution 2]. This review paper presents how much work is currently being conducted in this field, and how much work can additionally be carried out to improve this strategy and create more ideal solutions to this issue. Algorithms are compared on the basis of their used objective function, type of diode model, irradiation conditions, and types of panels. More importantly, a qualitative analysis of algorithms was performed on the basis of computational time, computational complexity, convergence rate, search technique, merits, and demerits.

One-dimensional MPPT designs of switched-capacitor charge pumps were studied for thermoelectric energy harvesting [Contribution 3]. The proposed design only requires the measurement of one parameter (the input voltage of a switched-capacitor charge pump) for calibrating a power converter, including the charge pump and thermoelectric generator. Building upon this, a thermoelectric energy harvester was designed [Contribution 4]. The relationship between the thermoelectric generator (TEG) electrical parameters, the power efficiency of the converters, and the power consumption of loads in autonomous sensor modules was studied. A practical design flow to minimize TEG cost is proposed and demonstrated, taking the maximum open circuit voltage of TEG and the dependence of the power conversion efficiency of the converter on the input voltage of the converter into consideration. The entire system, including a TEG and Dickson charge pump converter designed through the proposed flow, was validated using SPICE.

A bicycle-embedded electromagnetic harvester was developed and studied [Contribution 5]. The proposed harvester allows for the generation and storage of harnessed kinetic energy to power low-power electronic loads when required by the user. A small-scale linear Fresnel reflector-based sawtooth V-trough cavity for low-concentration photovoltaic systems was designed and studied [Contribution 6]. The proposed design ensured the uniform distribution of solar irradiation and significantly reduced the height of the cavity. The significant decrease in the height of the proposed cavity has the following advantages: (i) a decrease in the dimensions of the fixed structure of the small-scale linear Fresnel reflector, which reduces its cost; (ii) a significant decrease in the surface area exposed to wind loads, which reduces the cost of the fixed structure and the secondary system structures; (iii) a reduction in the difficulty of the manufacture, maintenance, and transportation of the cavity's reflecting walls; and (iv) an increase in the cooling surface area, which increases the electrical efficiency of the photovoltaic cells.

A electric power generation plant based on gas turbines with agricultural biomass fuel was analyzed [Contribution 7]. The plant's rotor speed variation was continuously corrected according to the simulation's findings; the control system that links power and demand is balanced when there is an increase or decrease in this speed. This helps to fix situations wherein power production is insufficient to meet demand, or when power production is too high. As a result, it was possible to stabilize the speed in the simulations, which is one of the plant control system's primary responsibilities. Parametric analysis of floating photovoltaic systems coupled with pumped hydroplants (PHS) revealed that increasing the number of PHS plant operating hours above 4 h per day decreases the economic benefit derived from the joint operation mode, regardless of the total process efficiency parameters and the size of the FPV plant [Contribution 8]. The economic benefit decreases as the number of operating hours increases. Phase-locked loops (PLL) were studied for frequency measurements within a low-inertia power grid with wind generation [Contribution 9]. No specific PLL execution can be suggested as the ideal answer for recurrence estimation in a low-idleness power framework. The best PLL version is determined by the system's particulars, as well as the voltage level and location of the generator that will utilize the measurements. A comprehensive frequency measurement analysis should be used to choose the best PLL for a given application.

The stability of 2D-NLs is one of the most significant challenges that limits their commercialization. Easily tunable distinctive 2D-NLs that are based on the synthesis process, surface functional groups, and modification with other materials/hybrid materials thereby improve the stability of the 2D-NLs and their applicability to the hole transport layer (HTL) and the electron transport layer (ETL) in solar cells. Moreover, metal/non-metal-based dopants significantly enhance the band gap ability and subsequently improve the efficacy of dye-sensitized solar cells (DSSCs). In this context, research has focused on 2D-NL-based photoanodes and working electrodes that improve the photoconversion efficiency (PCE) and stability of DSSCs [Contribution 10].

It was proposed that an additional inductor–capacitor–inductor filter may increase the oscillation amplitude of the enhanced swing Colpitts oscillator (ESCO) [Contribution 11]. This topology is referred to as a more enhanced swing Colpitts oscillator (mESCO). The DC–DC boost conversion ratio can be increased when it is connected to a rectifier, especially for energy-harvesting or low-voltage sensor ICs. This paper centers around the electrical attributes of mESCO. The wavering recurrence was demonstrated to be a component of the circuit boundaries of mESCO [Contribution 11]. Switched-capacitor converters are the best candidate for creating small-form-factor technology, and are a low-cost solution because of their capability to fully integrate into sensor/RF ICs [Contribution 12]. Switched-capacitor DC-DC voltage-down converters were designed, driven by highly resistive energy transducers [Contribution 12]. A single Cuk–Luo integrated DC-DC converter was proposed for the purpose of integrating solar and wind energy sources into an increasingly efficient system [Contribution 13]. The proposed framework is demonstrated utilizing MATLAB/Simulink, and checked under different blends of sunlight-based breeze energy sources without compromising the expected power. A prototype piece of hardware was built and put through its paces to make sure that the energy management controller system and the proposed Cuk–Luo integrated converter are compatible. The small-signal stability performance of a multi-converter-based direct current microgrid (DCMG) was studied [Contribution 14]. The studied DCMG has inherent weak modes with a wide range of oscillations, as shown by the simulation results, which have the potential to destabilize the system when disturbed. The weak modes that cause oscillations, interactions, and resonance are significantly influenced by controller gains and the DC-link capacitance, which have been identified as the most critical parameters based on a sensitivity analysis. Finally, performance comparisons between the various control synthesis techniques have been made. A multi-converter DC microgrid based on this examination would assist researchers, planning engineers, and design engineers in designing and sustaining operations. The full-duplex two-way relay system with energy harvesting was investigated [Contribution 15]. The numerical results therein demonstrated the accuracy and the effectiveness of new analytical framework, and the authors showed that the SABS algorithm can derive accurate throughput results.

A compact battery-less node architecture suitable for the backscattering communication (BackCom) approach was proposed [Contribution 16]. Its key functional blocks are demonstrated at 5.8 GHz, making use of commercially available components involving a DC/DC step-up converter, a 3.3 V data generator, and an ASK backscattering modulator based on a single GaAs HEMT in a cold-FET configuration.

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List of Contributions

1. Chao, K.-H.; Li, J.-Y. Global Maximum Power Point Tracking of Photovoltaic Module Arrays Based on Improved Artificial Bee Colony Algorithm.
2. Singh, A.; Sharma, A.; Rajput, S.; Bose, A.; Hu, X. An Investigation on Hybrid Particle Swarm Optimization Algorithms for Parameter Optimization of PV Cells.
3. Nono, K.; Tanzawa, T. One-Dimensional Maximum Power Point Tracking Design of Switched-Capacitor Charge Pumps for Thermoelectric Energy Harvesting.
4. Koketsu, K.; Tanzawa, T. A Design of a Thermoelectric Energy Harvester for Minimizing Sensor Module Cost.
5. Urbina et al. A Bicycle-Embedded Electromagnetic Harvester for Providing Energy to Low-Power Electronic Devices.
6. Fernández-Rubiera, J.Á.; Barbón, A.; Bayón, L.; Ghodbane, M. Sawtooth V-Trough Cavity for Low-Concentration Photovoltaic Systems Based on Small-Scale Linear Fresnel Reflectors: Optimal Design, Verification, and Construction
7. Rico-Riveros et al. Modelling of Electric Power Generation Plant Based on Gas Turbines with Agricultural Biomass Fuel.
8. Barbón, A.; Aparicio-Bermejo, J.; Bayón, L.; Georgious, R. Floating Photovoltaic Systems Coupled with Pumped Hydroplants under Day-Ahead Electricity Market Conditions: Parametric Analysis.
9. Guerrero-Bermúdez et al. Comparison of Phase-Locked Loops Used for Frequency Measurements in a Low-Inertia Power Grid with Wind Generation.
10. Ashfaq, M.; Talreja, N.; Singh, N.; Chauhan, D. 2D-Nanolayer (2D-NL)-Based Hybrid Materials: A Next-Generation Material for Dye-Sensitized Solar Cells.
11. Nomura, T.; Tanzawa, T. More Enhanced Swing Colpitts Oscillators: A Circuit Analysis.
12. Demura, Y.; Tanzawa, T. Design of Switched-Capacitor DC-DC Voltage-Down Converters Driven by Highly Resistive Energy Transducer.
13. Nalina et al. Design and Implementation of Embedded Controller-Based Energy Storage and Management System for Remote Telecom.
14. Zhong, K.; Fu, L. Throughput Maximization for the Full-Duplex Two-Way Relay System with Energy Harvesting.
15. Habibullah et al. Investigation of Oscillation and Resonance in the Renewable Integrated DC-Microgrid.
16. Collodi, G.; Righini, M.; Passafiume, M.; Cidronali, A. Energy Efficient Enhancement in a 5.8 GHz Batteryless Node Suitable for Backscattering Communications.

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