Indonesian Journal of Electrical Engineering and Computer Science
Vol. 32, No. 3, December 2023, pp. 1318~1326
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v32.i3.pp1318-1326

Independent swarm grid vehicle charging by a logical DC-DC converter with hybrid boundary conduction mode

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Article Info

Article history:

Received Jul 2, 2023
Revised Aug 3, 2023
Accepted Oct 10, 2023

Keywords:

DC-DC converter
Gated community
MATLAB Simulink
Swarm network
Vehicle charging

ABSTRACT

A modern and expanding civilization now takes for granted that future environments will be clean, efficient, and carbon neutral. Energy-efficient electrical loads, such as vehicle charging now often used in schools, companies, and gated communities. Recent articles have focused more on Swarm smart grid technology as a way to transmit power from rooftop solar installations. A major issue with the system is the necessity for inverters and other conversion equipment. The mechanism consumes part of the power generated by this process. It is possible to utilize the DC supply to power the vehicle chargers in smart houses, although some tweaks may be necessary. The charging Vehicle is a common task that can share by different converter by swarm network. This study demonstrates the feasibility of using a swam nano grid to interconnect buildings inside a campus or other large business or residential complex, as well as within a gated community. The electricity grid is monitored by the swam nano grid system, which eliminates the need for costly equipment. The DC-DC converter was being controlled directly by the simple logic controller. MATLAB Simulink simulates the controlled converter under load and shows the performance of a bidirectional DC-DC converter using waveforms.

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1. INTRODUCTION

Sustainability and energy availability concerns have motivated the surge in the installation of photovoltaic energy production systems over the past few years. A further enhancement of the economic viability of installed photovoltaic (PV) systems has occurred because falling prices for PV modules and increased power conversion efficiency have helped drive down system costs. In 2014, almost 42 GW of new PV capacity was installed worldwide, bringing the global total to 180 GW [1]–[5].

This highly complex process is referred to as maximum power point tracking (MPPT). Every PV energy production system must use an MPPT process to ensure that the available PV energy production is efficiently utilised. More energy is produced at a lower cost, and at the same time, there is also more production [6]–[8]. To accurately calculate power production, the primary choice is whether to use a stand-alone MPPT process or an energy management algorithm in the control unit. In this way, the energy generated by the PV system can be stored in an energy storage unit such as a PV system vehicle charging as shown Figure 1. To prevent the batteries from becoming overcharged, the charging control is turned on while the batteries are charging [9]–[12].

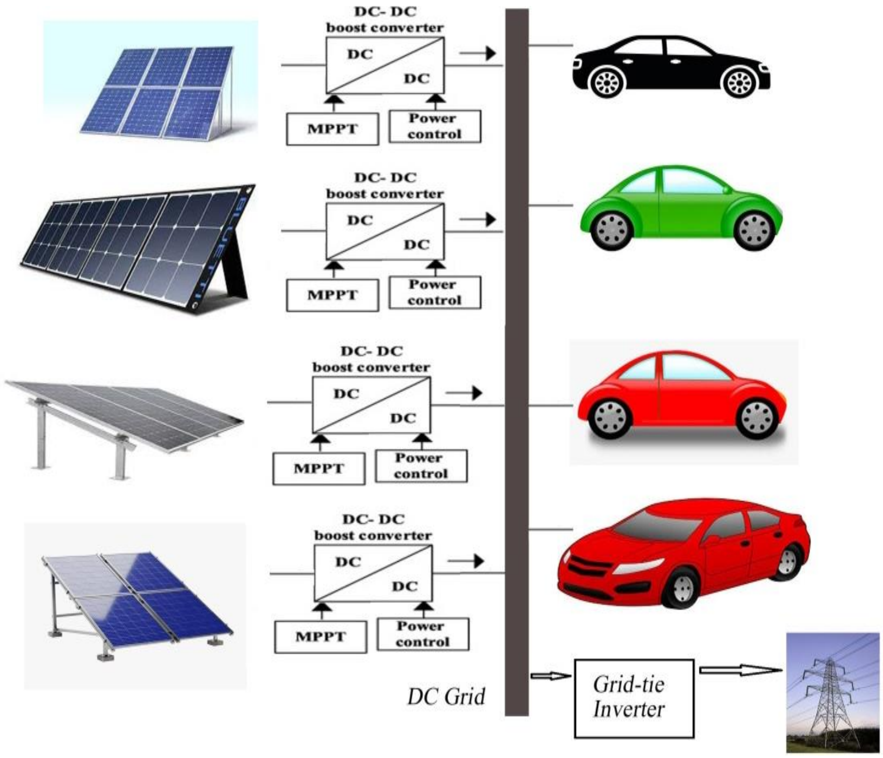

Figure 1. Basic diagram of swarm vehicle charging system with converters

To meet the different needs for residential and commercial market pressures in the contemporary world, an increasing amount of work is required. Hydrocarbons, a traditional energy source, contribute considerably to the present period's carbon emissions. Green power generation using a combination of biodegradable materials will be strongly favored and investigated to best solve these issues [13].

As illustrated in Figure 1, the output voltage of solar panels from various locations with various types of specifications is stabilized by converters, and the output of the converters is linked to the public grid to charge the electric car in the carport [14]. Through a pulse width modulation (PWM) inverter, the DC grid is linked to the utility grid to transmit any extra energy [15], [16]. The swarm grid vehicle charging system refers to a group of panels and converters that have the shared objective of recharging a vehicle that is parked in a garage. The output of each unit linked to the grid and used for car charging is developed using MATLAB Simulink, and the results of the experiment are reported in this work [17].

2. PROPOSED CONVERSION SYSTEM

2.1. Solar photovoltaic unit

In PV systems, minimum operating point (MPPs) is the maximum power point, which is the point where output power is greatest. It is therefore crucial to achieve the most effective outcome. The global MPP is less powerful than an equal amount of the total power output of many PV modules working at their maximum power points, but it has more power output than if all of the PV modules were working at their maximum power points. An array's MPPs are the values where the power on the array's power-voltage arc is the minimum. The MPPs vary based on things like the architecture of an array (whether it is in series or parallel) and the changing shading pattern on each photovoltaic panel [18]–[20].

2.2. Fuzzy logic controller

In the vast majority of control situations, mathematics is just not enough. If a large body of knowledge about the control system exists, it is possible to develop fuzzy control in this situation. Adjustable parameters and an embedded mechanism for adjusting these parameters are referred to as parameterization in adaptive control. Online controller performance has primarily been improved with adaptive controllers as shown in Figure 2. Three basic steps are followed for each control cycle, in the following order: In order to make gradual changes to the controller's settings, this modification is guided by the results of each cycle. Most controllers are made by one of the available techniques [21].

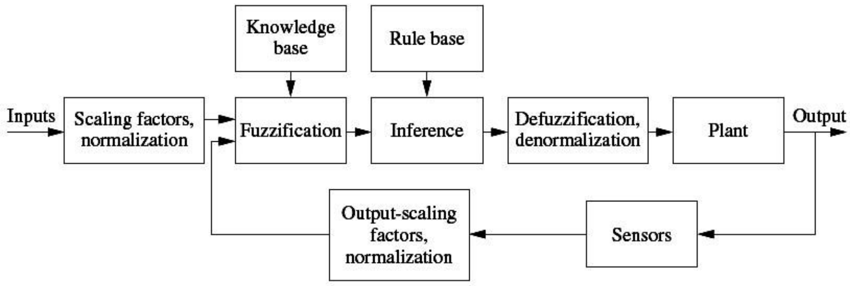

Figure 2. Basic block diagram of logical controller

2.3. DC-DC converter

The massive majority of research up to this point has been on Z-source network-based power conversion, but the Z - source system can also be utilized for alternating current-based power conversion through the employment of alternating current-alternating voltage conversions [22]. The diagram includes a depiction of a chopper using the Z supply as shown in Figure 3. Different input current levels as well as fluctuations in input current should be completely isolated from the input and output grounds (Figure 3). To get the most out of the proposed system, put it in a dc chopper [23].

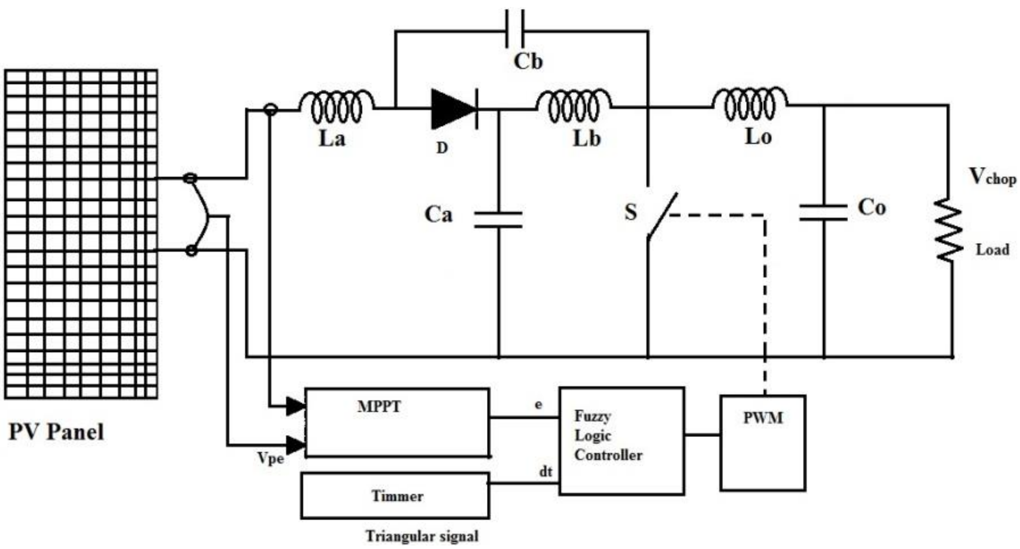

Figure 3. Circuit diagram of propased converter with solar panel

3. MODELLING FOR THE WHOLE ELECTRICAL INSTALLATION OF THE PROPOSED CONVERTER

3.1. Proposed DC converter

This conversion is broken up into three sections: Vei, the input portion, and the output section. This picture describes the proposed dc chopper network, which consists of inductors La and Lb and capacitors Ca and Cb. The two modes that are available when S=1 (when the diode D is off) and when S=0 (when the diode D is on) are implemented using the suggested conversion. In describing this complex system, you may use the (1) and (2).

When describing the switching cycle of the converter, we use the symbol T to represent the time period, and the letter S to represent the duty ratio. The circuit is shown in Figure 4. The result is that the equation system seems to be as follows: While they are at rest, the average voltage and current of the inductors and capacitances all move in the same direction throughout a single switching cycle. Thus, the equation system was created [24]–[27]. In a realistic scenario, the DC-to-DC converter may provide a significant enhanced voltage, with a duty cycle between zero and 20% of the overall duty ratio. Updating its diode D or each toggle S including a second switch S1 and S2 may end up creating a 0.5 V buck-boost voltage.

S=1

$$La = \frac{diL_a}{dt} = V_i + V_{Cb} \quad 1.1$$
$$Lb = \frac{diL_b}{dt} = V_{Ca} \quad 1.2$$
$$Lo = \frac{diL_o}{dt} = V_{in} \quad 1.3$$
$$Ca = \frac{dVC_a}{dt} = -iL_b \quad 1.4$$
$$Cb = \frac{dVC_b}{dt} = -iL_a \quad 1.5$$
$$Co = \frac{dVC_o}{dt} = i_{chop} \quad 1.6$$

(1)

S=0

$$La = \frac{diL_a}{dt} = V_{ei} + V_{Ca} \quad 2.1$$
$$Lb = \frac{diL_b}{dt} = -V_{Cb} \quad 2.2$$
$$Lo = \frac{diL_o}{dt} = V_{ca} - V_{cb} - V_{in} \quad 2.3$$
$$Ca = \frac{dVC_a}{dt} = iL_a - iL_o \quad 2.4$$
$$Cb = \frac{dVC_b}{dt} = iL_b - iL_o \quad 2.5$$
$$Co = \frac{dVC_o}{dt} = iL_o - i_{chop} \quad 2.6$$

(2)

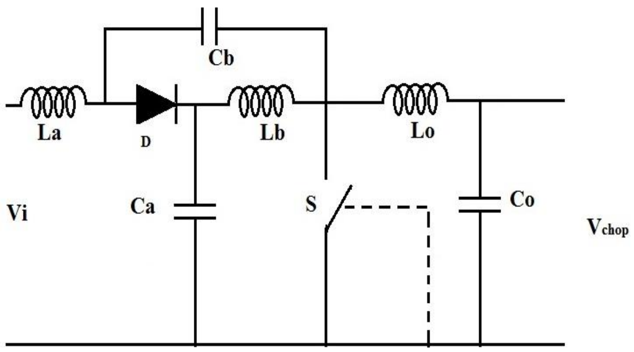

Figure 4. Basic circuit diagram of proposed converter with switch

$$V_{Ca} = \frac{1-S}{1-2S}V_{pe} \quad 3.1$$
$$V_{Cb} = \frac{1-S}{1-2S}V_{pe} \quad 3.2$$
$$V_{Chop} = \frac{1-S}{1-2S}V_{pe} \quad 3.3$$
$$i_{La} = i_{Lb} = i_{Pe} = \frac{1-S}{1-2S}i_{chop} \quad 3.4$$

(3)

3.2. Proposed controler unit for individual system

The techniques were developed to be used with a specific class of dynamic systems, and in most cases, they cannot be applied to other classes of dynamic systems. In order to control a wider range of dynamic systems, the controller is adjusted following data collected during the experiment as shown in Figure 2. Once formed into a number of fuzzy rules, a process has emerged is show in Figure 5.

Controller with two inputs and one output. Compared to a reference value, buck converter output voltage is evaluated. The error is the difference between two numbers, not the change in error. The fuzzy control circuit calculates buck converter power based on input current. Algorithm-generated duty cycles drive the buck converter MOSFET. MOSFET generates output voltage in response to PWM. Fuzzy inference, modeling, and defuzzification include controls. Fuzzification and fuzzy inference system are parameters. The membership function is the system's fuzzy set memberships for fuzzy variable representatives. Membership values range from 0 to 1 depending on the parameter being assessed [28].

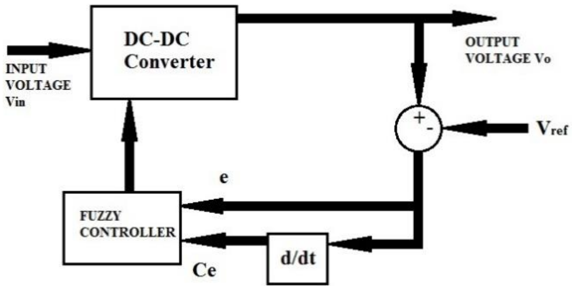

Figure 5. Basic block diagram of a designed controller

3.3. Swarm grid vehicle charging

Swarm nanogrid systems provide various benefits over conventional, centralized power grids. Decentralized power production and delivery improve energy security. The system could still be able to provide power even if one of the nano generators failed. Localization increases energy efficiency by minimizing transmission losses. The swarm grid system reduces the carbon impact of electricity production by using renewable energy sources. Smaller-scale distributed energy production has less of an effect on the environment since fewer massive power plants and transmission lines are required [29].

4. SIMULATION RESULT WITH DISCUSSION

In order to accurately simulate the proposed conversion unit on photovoltaic scheme, the simulation was completed with MATLAB/Simulink. A variety of scenarios were simulated using different numbers. Table 1 shows contain a short summary of the main parameters that were studied in this study as shown in Table 1. In the following section, you will discover the study's performance analysis [30].

The simulation diagram is separated as two catagries one is individual system which consist of solar panel, converter and filters shown in Figure 6. The second one is main simulation which is swarm sytem which consist of total individual system is in sybsystem as shown in Figure 7, Dc grid, vehicle charging, grid-tie inverter and grid connections with the filter and measuring systems. This makes the sytem stable and easily viewable on and understandable. Figure 8 illustrate the output of the converter-side simulation waveform and Figure 9 shows Inverter with grid voltage, respectively.

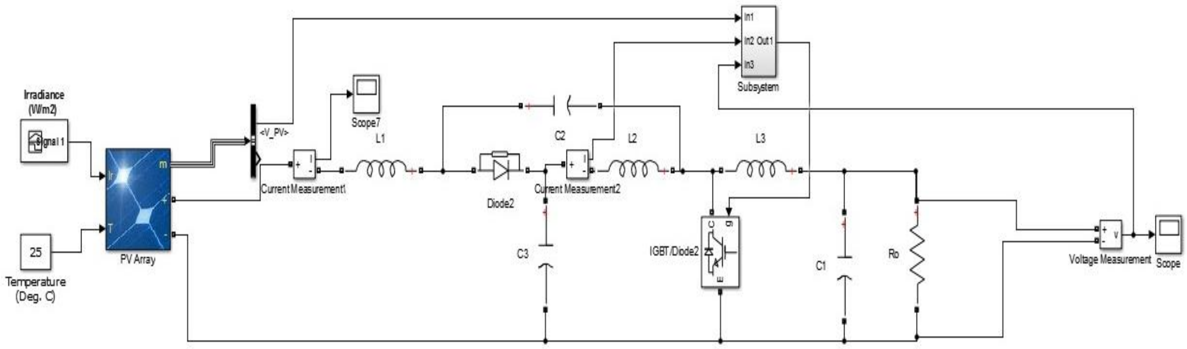

Figure 6. Simulation diagram of proposed individual system with controller

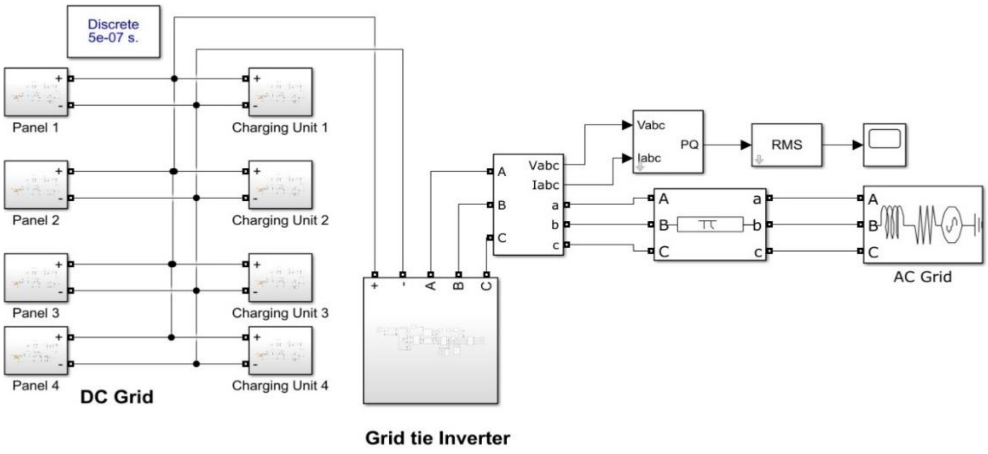

Figure 7. Simulation diagram of swarm grid vehicle charging by DC-DC converter using hybrid boundary conduction mode in a logical approach

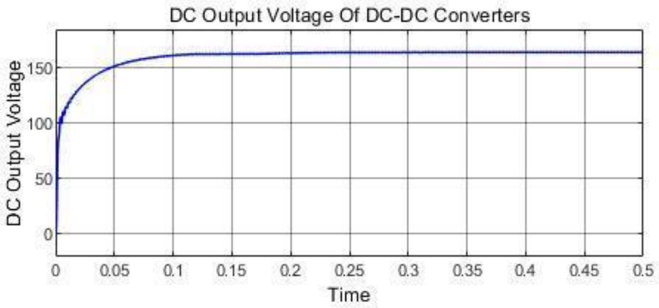

Figure 8. Simulation output of the proposed DC converter output

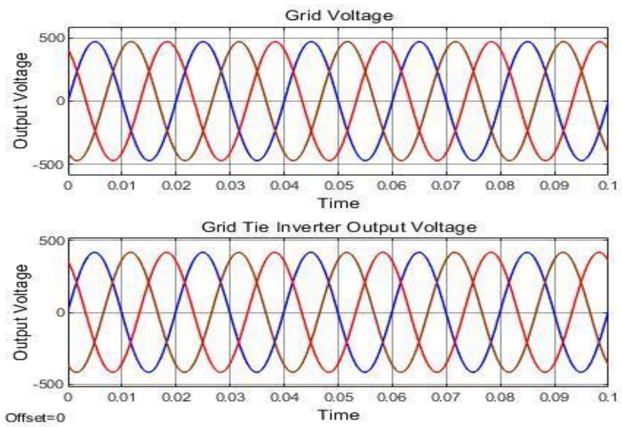

Figure 9. Simulation output of the proposed inverter output and grid voltage output

Table 1. Design parameter of the proposed converter

Basics	Values
Max solar power obtained (Pmax) (W)	365
System inductance La Lb (mH)	0.56
System capacitance Ca Cb (μF)	148
Output side inductance Lo (mH)	0.98
Output side capacitance Co(μF)	169
Load (Ω)	100-150
Switching frequency	10 kHz

5. RESULTS AND DISCUSSION

A "swarm" of solar cells and converters is capable of generating enough energy to charge a car. In the event that a converter or panel is harmed by the elements or technology, an electric car may be charged in a variety of alternative methods. Shadowing could result in lower panel output. Although the converter-maintained voltage, the system became unstable and needed the assistance of other healthy systems to return to stability. The converter might stop working due to an environmental calamity or a technical breakdown. Sharing power with other systems might be advantageous. Switch electricity to the swarm grid to charge your vehicle. The auxiliary system then took over to generate the power and control the voltage required to charge the automobile and feed solar energy into the grid once the swarm system had fixed the problem. We accurately simulated every scenario, even down to the various lighting conditions, and the converter controller maintained a constant output throughout. The stage of input the voltage rises from zero to 150 volts in 0.05 seconds and from 150 volts to 180 volts in 0.1 seconds. As seen above, solar electricity may be produced under a variety of light intensities while exhibiting the least variance in performance.

The DC chopper conversion has a few minor issues, including a harvest voltage that varies around the ideal value (V_{opt} = 61 V) and an output voltage that varies around the optimal value. This method, which works under favorable lighting circumstances (V_{opt} = 61 V) (Figure 9), would give us a voltage increase of (V_{ch}=V_{ca}=180 V) under normal settings (G=1,000 W/m2, T=25 C). The voltage gain may be modified by adjusting the duty cycle (D 0 to 0.5). When D, C_a, and C_b are calculated relative to V_{pv}, C_a and C_b have higher values than V_{pe}. It was discovered that the voltage at the input of the converter is opposite to that of the circuit. On the other side, if the input current fluctuates, the converter's output will likewise increase significantly. Power is dissipated between input and output due to a little voltage disparity (Figure 7). From this, we may infer that a DC-to-DC converter with a duty cycle of 0.45 is optimal. However, the same outcome is achieved with a duty cycle of 0.8. The inductor will be overworked and operate less optimally if the final number reached is more than this threshold.

6. CONCLUSION

The workload will be evenly distributed across four distinct systems, which are interconnected by a swarm microgrid distribution system. Several subsystems are involved in the construction of each system, including the solar panel, the DC-DC converter, and the series parallel filters. Despite the anthropogenic disturbances, such as fluctuations in temperature ranging from 25 to 36 degrees Celsius and variations in irradiance between 700 and 1,000 kilowatts per square meter, the solar arrays of each building continue to provide a consistent output of 8.37 kilowatts of power. Light has the effect of increasing the outputs of system 1. The present circumstances need a comprehensive assessment of the Grid's efficacy, since each modification made to a panel has a unique influence on output. The field of power electronics has not yet conducted a comprehensive examination of DC-to-DC conversion. The voltage produced with this approach has a higher magnitude compared to the voltage generated by solar panels. The design, modeling, and control of an autonomous solar power system are conducted using the approved conversion approach. The modification of the switching frequency in the semi-Z source power converter ($0 < S < 0.5$) enables the delivery of the desired voltage level, but does not enhance the system dynamics, unlike the DC-to-DC boost conversion method. As a result, the voltage reaches its optimal level. The avoidance of inductor saturation occurs when the duty ratio is greater than 0.5. The duty cycle in this particular configuration exceeds 0.5, which stands in contrast to the standard design. To assure the stability of the system, the standard components of the system have been modeled using MATLAB Simulink.

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