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DUAL ACTIVE BRIDGE FOR PV-BASED RESIDENTIAL NANO-GRIDS: ANALYSIS, DESIGN, AND SIMULATION

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Abstract
The paper presents theoretical modelling, design, and numerical simulations of a PV-based nanogrid requires the conversion is accomplished by a pair of active bridges that switch between converting DC to DC. Every single nanogrid task uses the same underlying infrastructure. We will examine a scenario in which Three photovoltaic (PV) modules are connected to a regulated DC bus by means of three DC-DC converters. In order to control the input voltage, DAB converters make use of a natural sampling-based fixed-frequency pulse-width modulation system. In order to carry out active power quality control, a dc-ac converter that is linked to the grid injects PV electricity. DAB converters are used to connect DC to storage batteries. bus so that the battery may be charged and discharged from the bus. All of these functions can be accomplished by a PV-based nanogrid's DAB converter, as demonstrated by the simulation results.

Keywords: DAB converter, PV systems, Nano grid, DAB converter.

I. INTRODUCTION

Because of its winding-turn structure, the transformer may provide galvanic isolation resulting in a high voltage-conversion ratio. Over the course of the past few years, the power electronics community has demonstrated a considerable amount of interest in the DAB converter as a direct consequence of the benefits described above. In point of fact, the DAB topology incorporates a number of the benefits that are offered by a variety of separate dc-dc converters. These benefits are available in a wide range of different dc-dc converters. These advantages include, but are not limited to, bi-directionality, galvanic isolation, the capability to function with a high input-to-output voltage differential, the capacity to perform tasks using soft switching, and so on. Due to this, DAB dc-dc converters have exploded in favour over the last two decades [9]-[16] for a wide range of uses. This converter may also be readily expanded to multiterminal topologies, making it suitable for integrating dc sources, energy storage devices, and loads according to nanonagrid or microgrid requirements. An in-depth look at the DAB converter's architecture, functioning, and control during steady state has been offered. As a direct response to these challenges, a novel approach to the generation of electrical energy is currently in the process of being developed. It consists of producing power on a small scale locally by making use of renewable energy sources to form either a microgrid or a nanogrid [1, 2]. Solar panels or wind turbines may be used to do this. Microgrids and nanogrids, supported in the production of electrical power in the contemporary world. We anticipate this pattern to persist. This is as a result of the fact that these resources are plentiful and almost never have a detrimental impact on the environment that they are located in [3]. When referring to a collection of loads, sources, and distributed storage elements, the terms "microgrid" and "nanogrid" are commonly used. A nanogrid is able to control an amount of power that is less than one hundred kilowatts. With an input of less than 25 kW, a home nanogrid can work. Both are able to function in a configuration that is independent of any other grids or microgrids, in addition to being able to connect to such grids and microgrids. The upkeep of a dc bus falls under the purview of a dc nanogrid, which is then put to use to supply power to dc loads. PV generators are connected to a dc bus in a nanogrid that receives its power from photovoltaic cells through the use of power converters that are dc to dc. During the time that the MPPT process is being carried out, these converters act in the capacity of connectors for the generator and the bus (MPPT).

II. **LITERATURE SURVEY**

[1] “A maximum power point tracking technique for partially shaded photovoltaic systems in microgrids" If you want your photovoltaic (PV) system to work better while it's partly shaded, try using a controller that tracks the a fuzzy logic-modified maximum power point (MPP). Instead of scanning the PV system and storing its maximum power, the controller determines the MPP of the system by perturbing and monitoring it. The controller enables accurate convergence to the global maximum operating point even when there is partial shading present. It is shown how to simulate the PV system mathematically when it is partially obscured by the sun. Results from simulations and experiments are presented to verify the accuracy of the suggested controller based on modified fuzzy logic.

[2] “Scalable solar photovoltaic microgrids for use in the electrification of rural areas in underdeveloped countries,” In this study, we describe the planning, analysis, and construction of a decentralised solar photovoltaic dc microgrid architecture that can power remote areas in third-world nations. When compared to current rural electrification architectures, the proposed one excels in four key areas: To supply power for larger communal loads without large, dedicated generation by extracting the benefit of usage diversity, a hyst can be used for four reasons: 1) scalability of generation and storage; 2) distribution efficiency (due to distributed generation and distributed storage for lower line losses); 3) localised control; and 4) scalability of usage. The suggested microgrid idea allows for several nanogrids to generate, store, and exchange electricity in both directions. The duty cycle management of a modernised flyback converter regulates voltage drop and controls power flow in both directions. For dc power flow with different distribution voltages, conductor diameters, and connection methods among the contributing nanogrids, the Newton-Raphson method was used to analyse the flow, loss, and system efficiency.

[3] “The integration of renewable energy sources and electric vehicles: a review of modelling techniques”, By switching to EVs and renewable energy, we can drastically cut down on carbon emissions from the transportation and power generation sectors of the economy. As one of the many possible benefits, broad EV adoption may make it easier to integrate renewable energy sources like solar and wind power into existing electric grids. Here we take a look at what's been written recently on plug-in electric vehicles, the power system, and the incorporation of renewable energy sources. The primary approaches and underlying assumptions of the literature are analysed. This article examines the financial, ecological, and grid effects of EVs. There have been a lot of studies looking at electric vehicles and their potential to incorporate research shows EVs may significantly reduce the excess renewable energy produced in an electric grid, which is a major benefit of using renewable energy sources. The interplay of air currents and electric vehicles has been studied in considerably greater depth than that between solar PV and EVs. Conclusions and suggestions for further study are provided.

[4] " DC microgrid DC-to-DC multilevel modular capacitor clamped converter with electrical grounding separation and bidirectional power flow", This research presents a dc-to-dc multilevel modular capacitor clamped converter (M 2 C 3) for a dc microgrid with electrical grounding separation and bidirectional power flow. This M 2 C 3 functions like a dc transformer by balancing capacitors in a modular cell. Battery and dc grid interfaces are possible with the. In addition, a high frequency transformer may be used to connect two in order to provide grounding separation and facilitate energy exchange between and. In the event that an is malfunctioned, the transferred energy would offer fault tolerance. One of the most important features of dc microgrid applications is the ability to provide grounding separation while still allowing for bidirectional power flow. PSIM is used to carry out the simulation analysis. The kilowatt prototype is also created to study the potential of a dc microgrid.

[5] "Cascaded DC-DC converter connection of photovoltaic modules, Typically, a dc-ac inverter links a series string of pv panels or several tiny inverters link a single or two panels directly to the ac grid in new residential-scale PV installations. In this study, we offer a different architecture in which nonisolated per-panel dc-dc converters are coupled in series to provide a high voltage string that is then wired to a simpler dc-ac inverter. Without the high price tag and low efficiency of standalone dc-ac grid-connected inverters, this method provides the benefits of a "converter-per-panel" approach. We analyse the cascadability of several dc-dc converters, including but not limited to buck, boost, buck-boost, and Cu/spl acute/k converters. Each topology's performance is compared using Matlab simulations, and the costs and advantages of further increases in both are weighed. It is shown that, for a given cost, buck converters are the most efficient, followed by boost converters, with the former being particularly well-suited to lengthy strings.

III. METHODOLOGY

Dual active bridge (DAB)

As a result of their erratic nature, renewable energy sources also need a storage component. A second dc-dc converter is needed for storage element-dc bus power regulation. A dc-dc converter connects the dc bus to backup or electric vehicle batteries. This converter's power flow must be adjusted in many modes [4, 5]. The dc bus needs an inverter to connect to an ac load or the utility power grid. PV systems are connected to the dc bus in two ways. The first includes connecting PV modules in series to a power inverter to reduce high-step up conversion ratios caused by mismatch and losses in a centralised maximum power point tracking system. The second technique uses mismatched PV modules may make it difficult to obtain the desired output voltage [7]. An adaptation stage with a high-voltage conversion ratio (above 10) and robust static and dynamic performances is needed to match the PV generator's impedance regardless of load or weather. Recent research has reported various high conversion ratio converters, but one dc-dc converter architecture, the Dual Active Bridge (DAB), has grabbed power electronics attention. We model and regulate nanogrid MPPT and battery charger/discharger nodes using DAB converters.

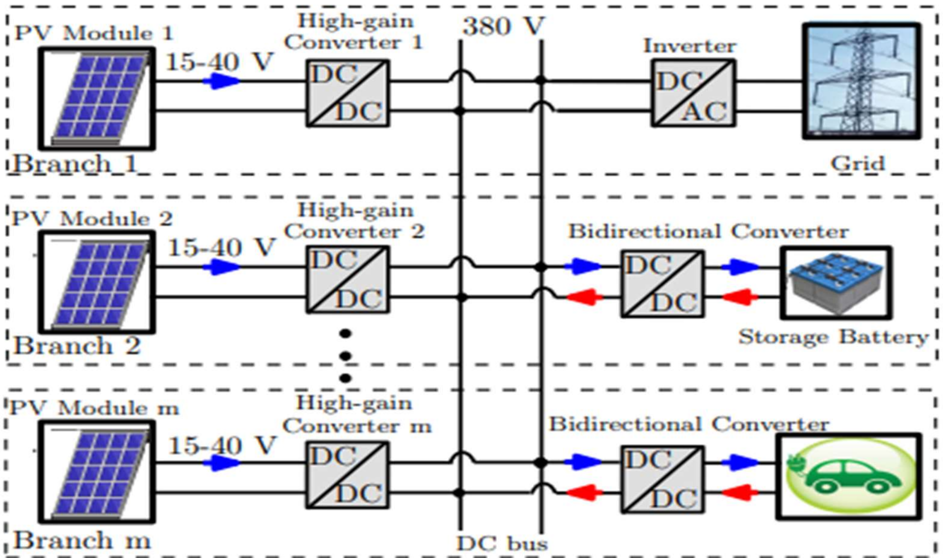

Figure 1: PV-based dc-Microgrid schematic

1.3. SYSTEM DETAILS

In this analysis, we focus on a nanogrid powered by photovoltaic cells, or PVs, that is built from m PV modules wired together through a controlled dc bus. In Figure 1 we see a simplified block representation of the system. One DAB converter connects each PV module to the dc bus. P&O Maximum Power Point Tracking maximises PV module energy. A second DAB converter charges and discharges the battery S3 S2 S1 S4.

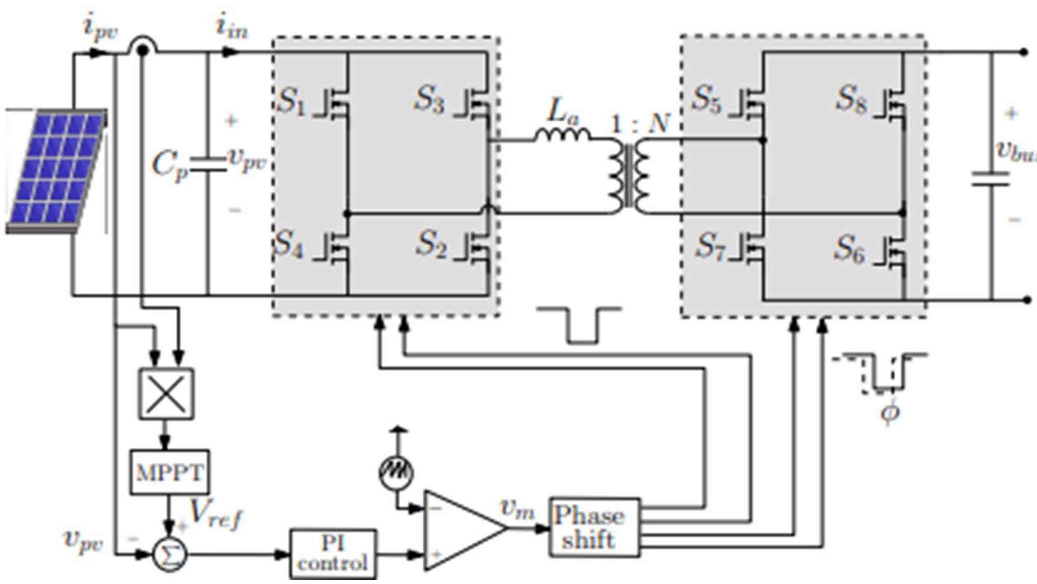

Figure 2: Solar photovoltaic direct current (DAB) converter with DC input schematic

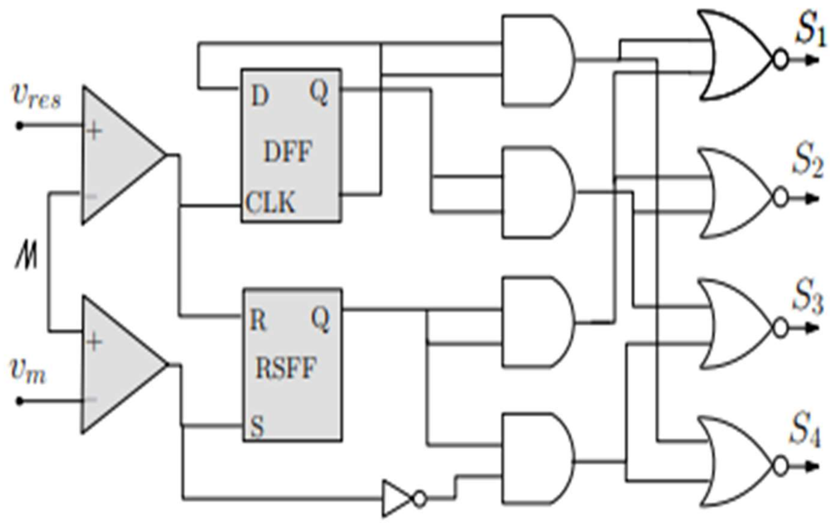

Figure 3: Schematic of the Phase Shift Modulation

A simple direct current-to-direct current (DAB) converter with dc bus management is shown below. A dc-ac inverter links the nanogrid to the larger utility grid. Digitized Audio Broadcasting to Analog Adapter Two active semiconductor bridges are shown in Fig. 3 as part of the DAB design. Each entire bridge is isolated by a high-frequency transformer. It regulates the primary-secondary conversion ratio and guarantees galvanic isolation. The name Lac stands for itself. Operating frequency and rated power of a transformer may be adjusted thanks to its leakage inductance. All primary and secondary switching components are controlled with a 50% duty cycle by a basic phase-shift controller, which is suitable for a narrow input and output voltage range. Toggle S1 and S2 (S3 and S4) on/off in tandem, but control S1 and S4 (S5 and S7) in a complementary fashion. The voltage across the energy transfer inductor La and the amount of power transmitted between input and output are both controlled by the phase-shifted angle of operation of switches S5 and S6. The direction of power flow in a bidirectional converter is determined by the phase difference between the primary and secondary full bridges. The diagonal switching mechanisms of both bridges are controlled by a single signal. Square wave impulses are sent to the transformer's primary and secondary windings. Modulation in the B-phase As long as the square wave signals on each side of the transformer are in phase, power may flow in either way. A technique for modulating the gate signals of MOSFETs used in DAB converters is shown in Fig. 3. The triangle waveform is indicative of the one-cycle controller's modulating signal vm. The leading-edge modulation controls the rising time of the pulse in switch S4,whereas switch S2's rise time is determined by falling-edge modulation. To create the timekeeping signal, a tiny voltage vres is compared to the triangle waveform. D Flip-Flops (DFFs) produce 50% duty-cycle square waves.

Photovoltaic (PV) systems used in DC Nano grids

The usage of photovoltaic (PV) systems in DC Nano grids offers notable benefits related to reduced maintenance demand and operating expenses. Due to the PV module's low output voltage, high-voltage gain DC-DC converters are necessary for connecting to the DC nano grid. This study introduces a new architecture for DC-DC converters with current source characteristics, which may be used for PV applications and current injection in DC nano grids. We present a converter that employs linked inductors and switched capacitors to obtain significant voltage gain with a small number of components and without resorting to very high duty ratios. Plus, the primary switch is activated at virtually zero current, thus reducing switching losses. The circuit's qualitative and quantitative assessments are described in depth, and a prototype with a power output of 200 W is built and tested in a controlled environment.

DC-DC CONVERTER BASICS

Electronic engineers often use DC-to-DC converters to change the voltage of a direct current source. This kind of power converter is a subset of the industry. DC to DC converters serve a crucial function in battery-powered electronics like mobile phones and laptops. These electrical gadgets often include several sub-circuits that demand different voltages than the battery can offer (sometimes higher or lower than the battery voltage, and possibly even negative voltage). As the energy in a battery is used up, its voltage drops as well. DC to DC converters is a space-saving alternative to requiring several batteries to power various components of a device, since they allow for the generation of multiple controllable voltages from a single changeable battery voltage.

A DC-DC converter that takes in DC power and outputs a constant current has an output voltage that is determined by the load's impedance. Different DC-to-DC converter topologies are able to provide output voltages that are greater than, less than, equal to, or more than and less than the input voltage, respectively.

- ✓ Buck
- ✓ Boost
- ✓ Buck-boost
- ✓ Ćuk

It is safe to assume that whenever you hear the phrase "DC to DC converter," you are really referring to one of these switching converters. There is a broad selection of input and fixed or adjustable output voltages for switching DC to DC converters. Nowadays, DC to DC converters may be purchased as integrated circuits, reducing the number of necessary parts. Complete hybrid circuits with DC to DC converters are also commercially available for integration into electrical devices.

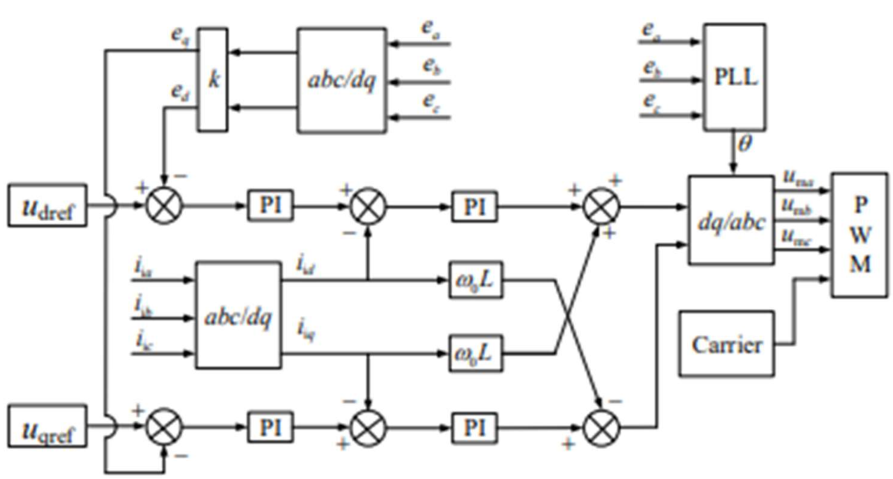

Figure 4: V-f control block diagram of interface converter

The coordinated control strategy

It is clear from the foregoing that the interface converter requires the charging current and SOC information of the energy storage battery in order to modify its management strategy based on the detected status of the hybrid grid. The coordinated management of the interface converter and DC/DC converter is shown graphically in Figure 6.

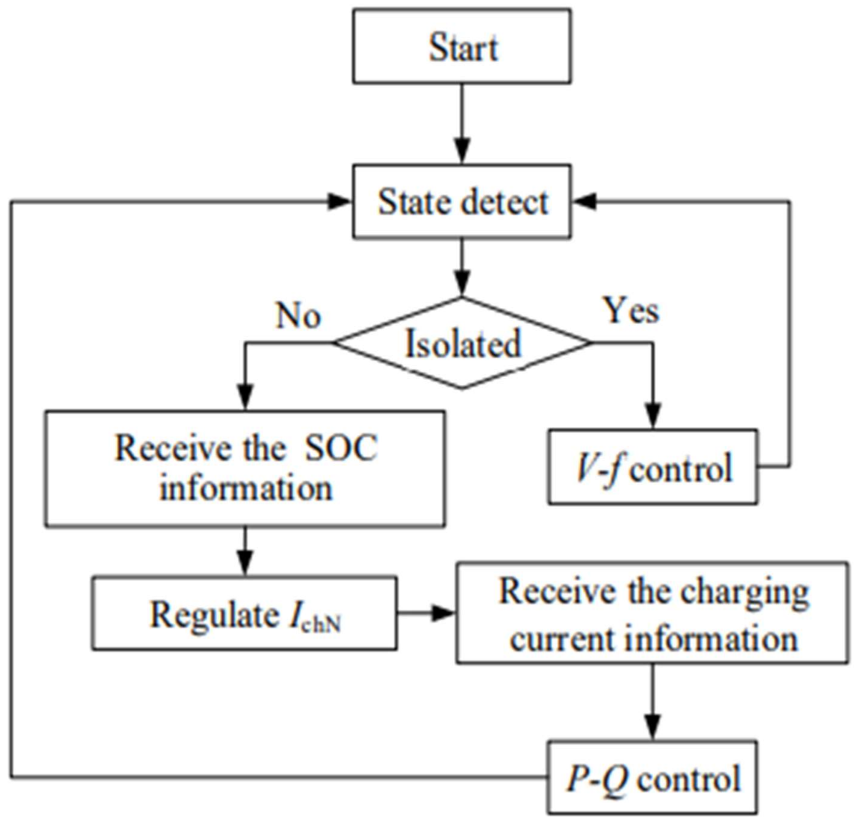

Figure 4: Flow chart of the coordinated control

Applications

It is common practise for battery-powered devices to stack cells in series to increase voltage. In many high voltage applications, however, there is not enough room for cells to be stacked in a dense enough manner. Boost converters are able to enhance voltage while decreasing cell count. Hybrid electric vehicles (HEV) and lighting systems are two examples of battery-powered applications that make use of boost converters.

The hybrid version of Toyota's Prius car runs on a 500 V motor. The Prius's motor would require almost as many batteries to run without the use of a boost converter. Prius's battery voltage is increased from 202 V to 500 V while only using 168 cells. Boost converters are not only used to power large-scale installations, however; they may also be used to power smaller items, such portable lights. White LEDs normally need 3.3 V to generate light, however a boost converter may increase the voltage from a single 1.5 V alkaline battery to power the light. Cold cathode fluorescent tubes (CCFL) used in devices like LCD backlights and certain torches may be powered by the higher voltages generated by boost converters.

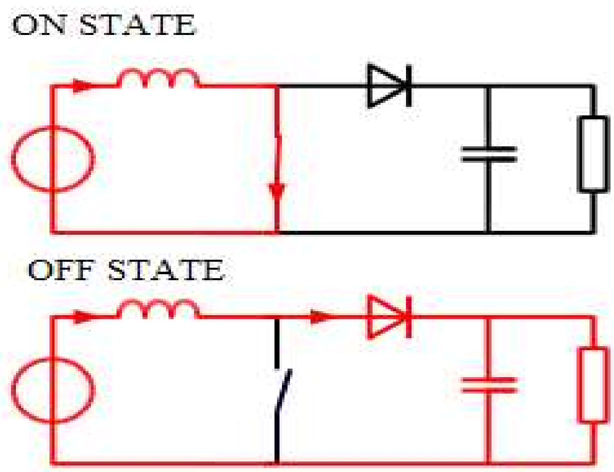

Figure 5: Boost converter schematic

Circuit analysis

Operating principle

For the boost converter to function, the fundamental premise is the inductor's resistance to current variations. When it is full, it behaves like a resistor and draws energy from the source; when it is empty, it provides energy to the world (somewhat like a battery). Since the discharge phase voltage is proportional to current rather than charging voltage, a broad variety of input and output voltages is possible.

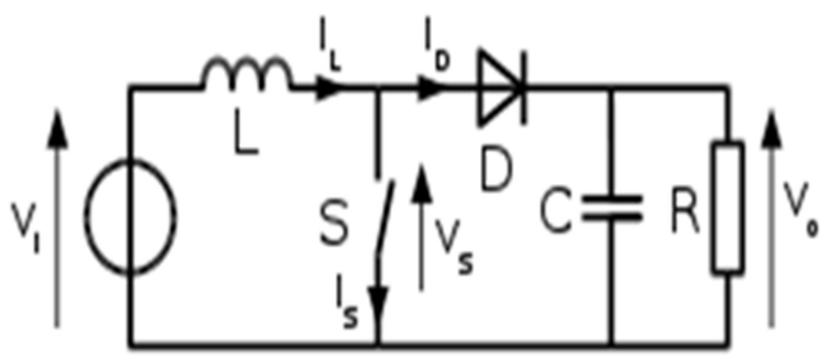

Figure 6: Boost converter operation

Boost converter schematic

The boost converter may be in any of these two states, determined on the position of switch S.

- In its most basic form, a Boost converter operates on a binary concept (see Figure 2):
- In Figure 1, Switch S closes to increase inductor current and opens to confine it to the flyback diode D, capacitor C, and load R.
- The capacitor's On-state energy is transferred. Figure 2 shows the identical input and inductor currents. Therefore, unlike a buck converter, there is no abrupt transition, and the input filter may be less stringent.

Continuous mode

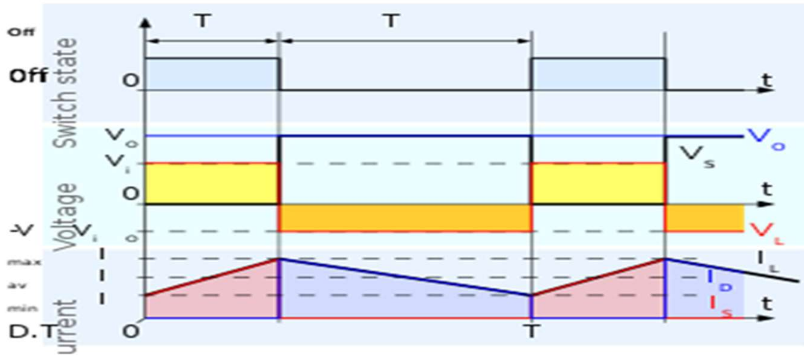

Figure 7: Continuous mode

Typical current and voltage waveforms produced by a boost converter in continuous mode. While in continuous mode, the current through the inductor (IL) of a boost converter is always greater than zero. Current and voltage waveforms typical of a converter in this mode are seen in Figure 3. Under steady-state circumstances, the output voltage of an ideal converter (one whose components all have ideal characteristics) may be determined using the formula below.

III. RESULTS & DISCUSSION

Modelling, design, and numerical simulations of a PV-based nano grid requires a dc-dc dual active bridge (DAB) converter. Tasks on the nano grid have a common network infrastructure. As an example, a nano gird with three PV modules and three DAB converters coupled to a regulated dc bus will be discussed. The input voltage of these DAB converters is regulated by a fixed-frequency pulse width modulation scheme based on natural sampling. The gathered PV electricity is injected into the grid through a dc-ac converter, enabling active power quality control. A DAB converter, which can switch between positive and negative DC, connects a storage battery to the DC bus. The simulation findings show that the PV-based nano grid's DAB converter can do all of these tasks.

Simulation & output response:

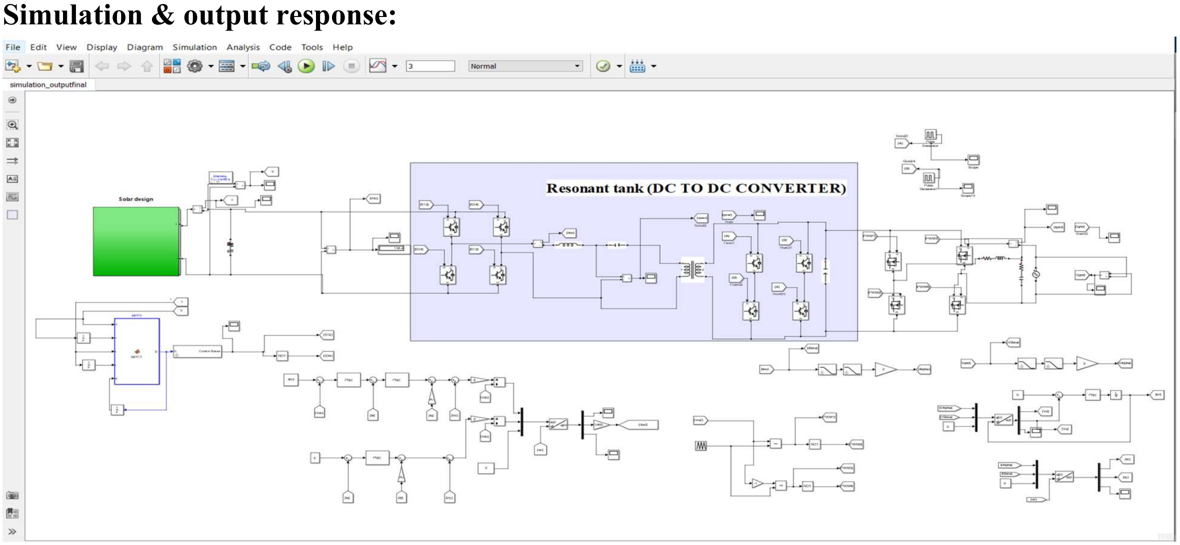

Figure 5: Simulink for Solar panel

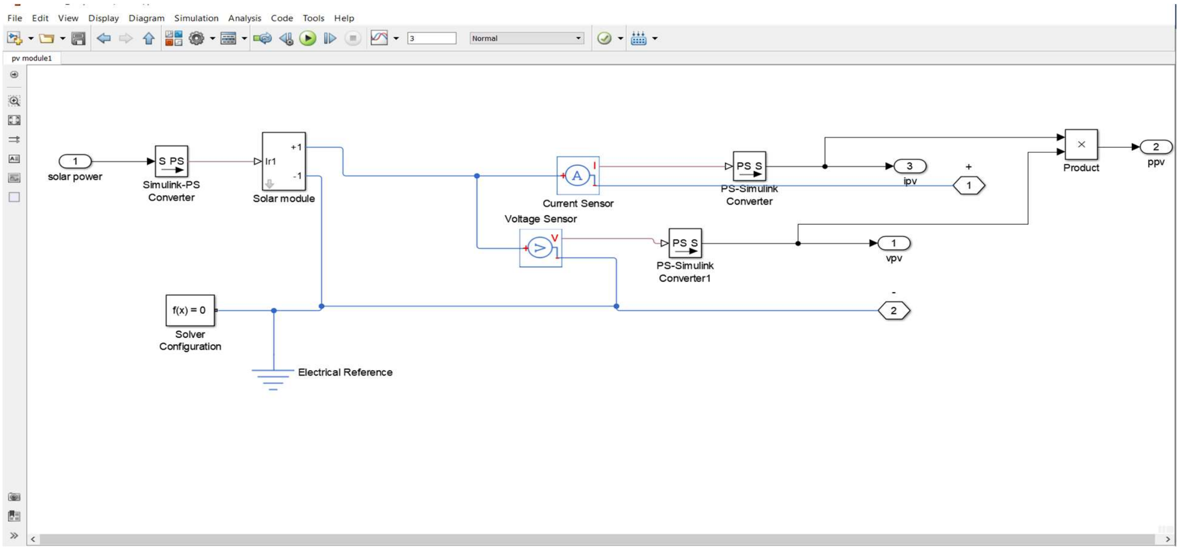

Figure 6: Simulink for Mppt

Editor - Block: simulation_outputfinal/ MPPT

```
function D = MPPT(V,v,I,i,d)

d = 0.5;
dv=V-v;
di=I-i;
if (dv == 0)
    if (di == 0)
        D = d
    else
        if (di > 0)
            D = d+0.05;
        else
            D = d-0.05;
        end
    end
else
    if (di/dv == (I/V))
        D = d;
    else
        if (di/dv > I/V)
```

Editor - Block: simulation_outputfinal/ MPPT

```
    else
        if (di > 0)
            D = d+0.05;
        else
            D = d-0.05;
        end
    end
else
    if (di/dv == (I/V))
        D = d;
    else
        if (di/dv > I/V)
          D = d+0.05;
        else
            D = d-0.05;
        end
    end
end
```

Figure 7: Solar output voltage

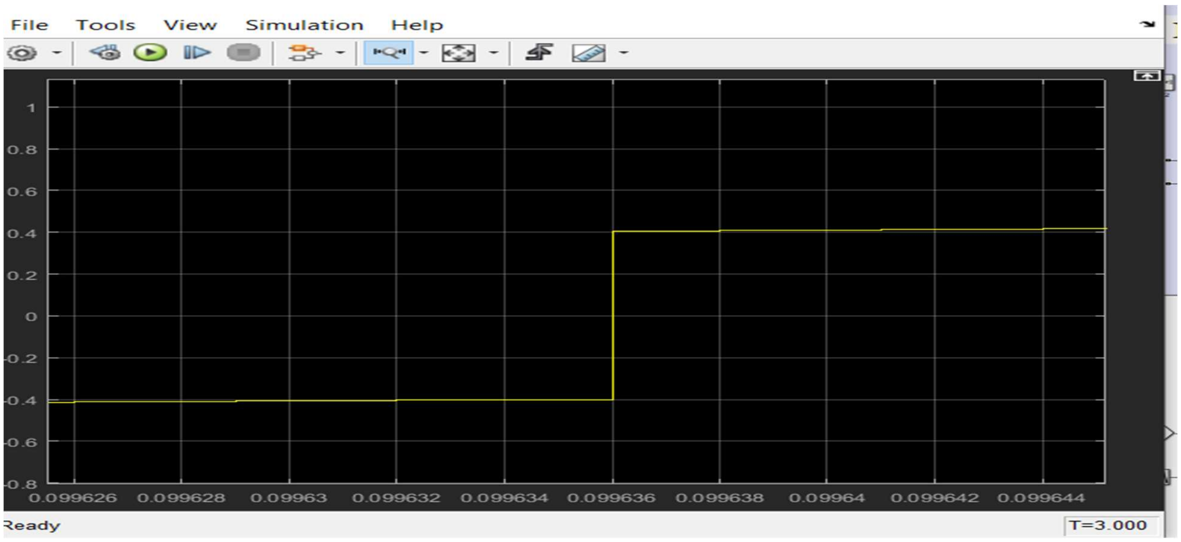

Figure 8: Solar current

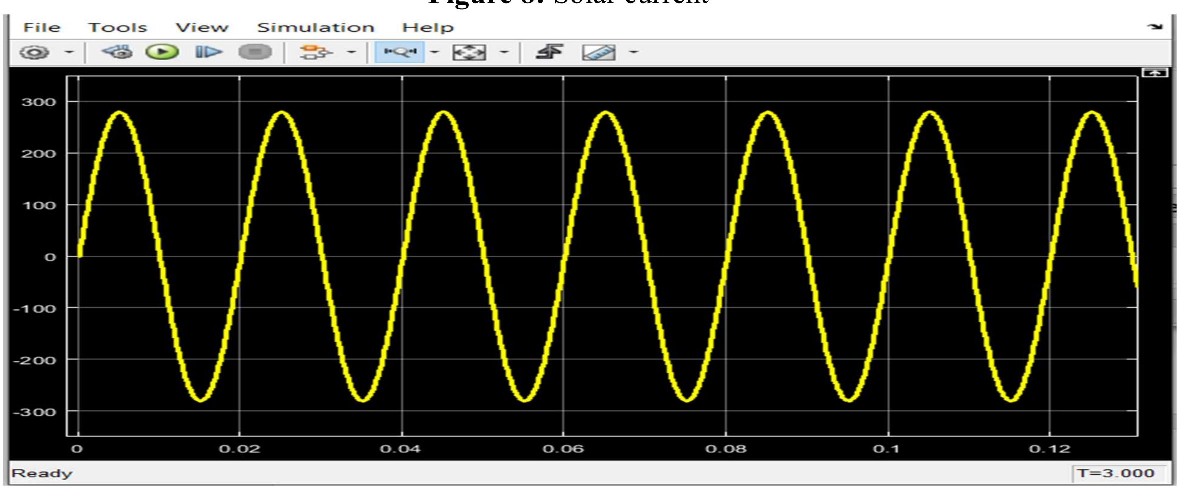

Figure 9: Grid output voltage

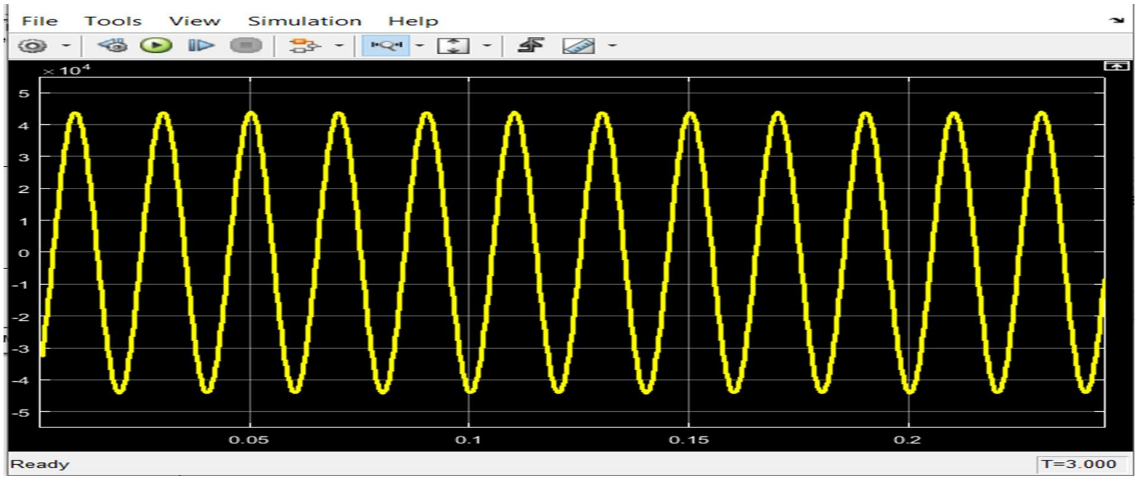

Figure 10: Grid output current

IV. CONCLUSION

We test a regulated-to-dc bus-connected PV-fed DAB converter with maximum power point tracking for a PV-based nano grid application. The converter offers a low-signal-intensity model. To provide a quick response to changing input parameters, a voltage mode control technique employing a Type II compensator and a P&O maximum power tracking algorithm prescribes the best PV voltage. DAB converters are nanogrid-integrated. Three PV modules, each with their own DAB converter, form the nano grid and are linked to a regulated dc bus. The nano grid can be linked to the main power grid with the help of a dc-ac inverter. Each converter's design is complete. Model and method of design have been validated via numerical simulation. The nano grid has been subjected to varying levels of sunlight. In subsequent work, we will report on an in-depth investigation into fine-tuning the MPPT algorithm's tuning parameters for use with the DAB converter fed by photovoltaic cells. Furthermore, experimental confirmation of the presented results is an area worthy of investigation.

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