Controller Design and Stability Analysis Constructed on the Virtual Impedance of Microgrids DC with Load Constant Power

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Abstract- A novel solar cell stand-alone photovoltaic power system based on a bi-directional DC/DC converter is presented. When compared to a standard stand-alone solar power system, this system needs to provide superior protection and more efficient management of battery charge and discharge. Furthermore, it can produce a higher proportion of solar energy and achieve system energy management. The important element of energy management for the system is to efficiently operate the Bi-directional converter, which must manage bi-directional voltage and current. The MPPT system is made up of a DC-DC converter (an electrical scheme that transfers DC energy from one voltage level to another) and a controller. MPPT employs a tracking algorithm to locate and sustain operation at the location of greatest power during changes in meteorological conditions. Many other MPPT algorithms have been presented and explored in the source material; however, most of them have drawbacks in terms of efficiency, accuracy, and adaptability. The intended effect of the given task is to build and implement a maximum power point tracker using techniques from the Artificial Bee Colony Algorithm. Simulink created and simulated an MPPT system comprised of solar modules, DC-DC converters, batteries, and controllers created on the Artificial Bee Colony Algorithm. Characterize the buck, improvement, and fault-increase converters to determine which is best constructed for the PV system. To get the necessary expertise to construct and adapt the PWM controller, the integrated ideal of the PV module with the specified converter and battery was simulated in MATLAB.

Keywords: DC Source, Bidirectional DC-DC Converter, DC-AC Converter, Artificial Bee Colony Algorithm.

1. INTRODUCTION:  
The DC to single phase AC crossing point and vice versa is a typical constraint for submissions such as uninterrupted power supplies, renewable energy grid integrations, energy storage systems, and micro grids. Power converters with improved effectiveness, high power compactness, high dependability, bi-directional power flow, and flexibility are more common in these applications. An ideal topology is a DC-DC converter cascaded with an inverter. There is currently global agreement on the development and integration of Renewable Energy Sources (RES) into the electric power grid.
The efficient power of electronic interface converters and their control has increased the adoption of RES. The traditional distribution power system architecture has given way to Active Distribution Systems and Microgrids. In terms of the grid, microgrids function as controlled units composed of a set of interconnected loads and distributed energy resources that can operate in both grid-connected and isolated modes. DC microgrids, on the other hand, are a logical outcome of the fact that most renewable energy sources output DC power and may be directly linked to the dc bus supporting current DC loads, enhancing operational efficiency. Typically, soft switching approaches are used to lower the corresponding switching losses. Because four to approximately nine power switches are necessary for these mechanisms with separated transformers, they have large conduction losses. However, some applications demand high-step-up converters without isolation, such as the front-end converter with dual inputs.

As a result, installation is difficult and expensive. Switched-capacitor DC-DC converters have drawn a lot of interest as a different way to provide bidirectional power flow regulation. Power electronics are displacing previous electromechanical and electronic systems in applications requiring motion control due to their higher efficiency and tighter control capabilities. High-voltage DC (HVDC) converter stations, flexible AC transmission systems (FACTS), static Var compensators, and batteries for energy storage are used for power transmission and energy production from renewable sources. These include frequency transformation, dynamic filters, DC-to-AC conversion, and specialized power systems in the context of power transmission.

1.2 Objective

The major goal is to enhance the motor's efficiency as well as the power flow in both directions, which also increases efficiency during regenerative braking mode. Various types of bidirectional DC-DC converters have been investigated. As we all know, regenerative braking happens during converter buck mode operation, which charges the battery, but in boost mode, the battery gives sufficient power to operate the motor. To achieve these requirements, the energy storage system must be capable of operating in both grid-connected and stand-alone modes. To fulfill the fluctuating power demand of the load, the system must run in parallel with other DG systems in the latter mode of operation.

2. PREVIOUS RESEARCH WORK:

When specific requirements are fulfilled, a bi-directional fly back direct current to direct current (BDFBDC) can operate in one of the following modes: when solar PV is present, the energy storage device is fully charged and power flows to the usage; when solar PV is absent, the battery is drained and power runs across the battery to the load. Analysis of the BDFBDC's performance in both directions [1]. Different algorithms and ANN topologies are used to evaluate and determine the PV Cell MPPT's effectiveness. When MPP is established, the performance of an ANN-based regulator is at its peak. Thereafter, the controller operates in either Down Mode or Up Mode [2]. The implementation of a Photovoltaic (PV) system with a boost converter with Perturb and Observe (P&O) control. The battery is charged using an isolated DC-DC Dual Active Bridge (DAB) in one mode of operation, and the battery can be used as an energy source to power the load in the other. A guide for the bidirectional converters for more effective and affordable use of the device [3].

Despite the bi-directional DC/DC converter (BDC), which is linked to the battery, the boost converter is directly connected in series to the PV array. The PV array's maximum power point tracking (MPPT) is controlled by the boost inverter. Employment of the Perturb & Observe technique (P&O) is required for MPPT from the solar array. The bi-
directional converter controls the power flow for battery storage and charging. The battery is drained to feed the load when the amount of PV electricity generated falls short of what is needed to fulfil demand [4]. DC-DC buck-boost converter with three ports for heavy step-up/step-down applications. For capturing solar energy and recharging the battery, it includes two unidirectional ports (ports 1 and 3), as well as one bidirectional port (port 2). With a certain configuration of switches and inductors, the combined buck and buck-boost converter construction is employed at port 1[5] - [6] In some situations, DC microgrids have a preference over their AC counterparts to avoid extra DC-AC-DC conversion steps for controlling DC voltage and boosting RES efficiency. The two types of bidirectional DC-DC converters are isolated DC-DC converters and non-isolated DC-DC converters [7].

A four-port bidirectional dc/dc converter that can deliver power to DC loads, charge batteries, link to external DC Microgrids, and store or transmit solar energy. Four DC/DC converters are combined into one Multiport DC/DC converter using a four-port converter. Additionally, the converter's calculated power flow calculations are created and validated in a model using the renowned Power Electronics Simulator PSIM. [8]. To increase the system's efficiency by lowering the source current's total harmonic distortion (THD). The bi-directional converter charges the battery when the photovoltaic (PV) module generates more electricity. When there is less sunshine, the load is provided by the battery. Utilizing the battery's State of Charge (SOC) management helps to keep the battery from completely discharging [9]-[10]. The control approach for a virtual DC machine (VDCM) is provided. Therefore, ESS is charged and discharged through the converter to increase the system's virtual inertia. The interface converter between ESS and DCMG implements a first-order inertia loop for inertia management. According to the CBBC and VDCM control units' tiny signal model, the stability of the system has been examined [11]. An application-specific Dual Active Bridge (DAB) DC-DC converter. A battery storage system is connected to the DC microgrid via a converter system. It is shown how a control system enables the converter to charge a lithium-ion battery by applying various charging methods. Additionally, the converter's capacity for bidirectional power flow is confirmed. Using PSIM, the intended converter is simulated, and several operational situations are examined [12]-[13]. The LLC converter is typically preferred over the DAB type because of the increased system efficiency for applications requiring high power densities. CLLC-type converters with integrated transformers and resonant tanks (integrated magnetics) have problems operating in both directions with a wide choice of input-output voltage variations. For a greater range of gain fluctuation, a bidirectional feature such as a CLLC type with a linear output voltage variation array is recommended. [14], to control the battery voltage/current and the power movement across the energy sources and the DC microgrid, three regulators have been created. The converter connects the DC microgrid, a PV panel, a battery, and a wind turbine output. The four-port DC-DC converter could deliver bidirectional power movement between the DC microgrid two sources of sustainable energy in addition to conducting Maximum Power Point Tracking (MPPT) for them with the specified controllers [15]- [17].

An islanded hybrid AC/DC microgrid (MG) with two renewable energy electrical systems, an energy storage system (ESS), and a bidirectional virtual inertial control (BVIC) technique. A wind farm, a solar farm, a bidirectional DC-DC converter, and a bidirectional interlinking converter (BIC) make up the hybrid AC/DC MG under consideration. A bidirectional DC-DC converter connects the vanadium redox flow battery (VRFB)-based ESS to the DC MG, and the BIC connects the DC MG to the AC MG [18].

To accomplish power distribution between the DC and AC MGs and to reduce variations in the AC side's frequency and DC-link voltage, this method adopts the BVIC approach based on the dependent variables. To extract the most wind power, a maximum power point tracking method based on watching and perturbing is also used [19]. Additionally, maximum power point tracking based on fuzzy logic is used to collect the highest power possible from PV solar cells under a variety of climatic conditions. Additionally, when a unique solar-PV is available, a bidirectional converter is included inside the batteries for charging needs. The main issue is that the integrated solar-PV inverter may charge or drain the batteries, which lowers asset utilization and profitability [20].

1.2 Problem Statement

Because many renewable sources, energy-storage technologies, and current loads are dc, integrating resources and loads in a dc bus is appealing in terms of minimizing the footprint of the installations; boosting efficiency, and ultimately lowering the cost of the microgrid. Energy storage devices inside a microgrid are critical for increased dependability. When the micro grid's Distributed Generation (DG) devices create extra power while in grid-linked mode.

3. MATERIALS AND METHOD:

Grid-connected means linked to the primary DC grid via a grid-following DC/AC converter. In the voltage control mode, the DC grid voltage is controlled using pulse width modulation (PWM), and the reference powers are tracked by the DC/AC converter. This system alternates between PWM and DC/AC converter depending on the control mode being used. The DC-DC converter bidirectional block's DC supply is linked to a converter, under the supervision of a gate-signal generator and associated controller. Where, Pulse width modulation, sometimes known as Bidirectional DC-DC converter PWM, is a typical control technique that generates analogue signals using digital devices such as
microcontrollers. In this scenario, Artificial Bee Colony Algorithm-based PWM is linked to a DC/AC converter as well as a bidirectional dc-dc converter. Using the Artificial Bee Colony (ABC) approach, which replicates honey bee foraging behavior, several real-world problems have been effectively handled. The proposed technique is tested using a MATLAB model under various loading conditions to validate the proposed analysis and control system. Figure 2 shows discharge and charge modes, the Pulse Width Modulator (PWM) driver independently controls the modulating switches respectively. To design various closed-loop control systems based on linearized models, the transfer functions obtained in the prior sections can be applied. To regulate the voltage of the DC grid during grid formation, the Artificial Bee Colony (ABC) is often utilized. The power is injected or absorbed in grid-following operation, in contrast, to follow the reference power signals set by the Power Management System (PMS). A reference power is used to create the reference current in the power mode control, which is based on the current controller.

Figure 2 Block diagram for the proposed system

3.1 Bi-Directional DC-DC Converter
The bidirectional DC-DC Converter block symbolizes a converter that alters the DC voltage from one side of the inverter to the other. A gate-signal generator and a controller operate this converter. There are three types of bidirectional DC-DC converters: dual-active bridges, isolated converters, and non-isolated converters. Bidirectional DC-DC converters without an electrical barrier are known as non-isolated converters. One inductor, two switches, and two capacitors make up this converter. An isolated converter is a bidirectional DC-DC converter with an electrical barrier. This converter has four additional switches that, when put together, provide a complete bridge. The high-voltage (HV) side of the converter, sometimes referred to as the input of the converter, is where the whole bridge is located. The final two switches are located on the converter's output side, sometimes referred to as the low-voltage (LV) side.

Figure 3 Bi-Directional DC-DC Converter

Dual Active Bridge Converter: This bidirectional DC-DC converter has two complete bridges. The converter's input side, also known as the High-Voltage (HV) side, is represented by the left bridge. The converter's output side, also known as the Low-Voltage (LV) side, is represented by the right bridge. Each switching device has an inbuilt safety diode in the block. The integrated diode safeguards the semiconductor device by providing a conduit for reverse current to flow. When a semiconductor device abruptly shuts off the voltage supply to the load, an inductive load can cause a large reverse-voltage spike. A Direct Current (DC) source is transformed from one voltage level to another by a DC-to-
DC converter, which is either an electronic circuit or an electromechanical device. It belongs to a certain type of electric power converter.

3.2 Pulse Width Modulation (PWM)

Pulse width modulation is a tried-and-true method for controlling devices made of semiconductors in power electronics. PWM, sometimes referred to as pulse width modulation, is a typical control method that produces analogue signals from digital devices like controllers. A sequence of pulses in the shape of square waves will make up the resultant signal. This implies that the wave will either be high or low at any given time. Pulse width modulation divides the electrical signal into numerous segments, lowering the average power generated by the transmission. Instead of an analogue signal that fluctuates continuously, the PWM approach distributes the signal's energy over several pulses. A signal that alters the pulse width is sent through the use of a comparison. One portion of the comparator's input is made up of the modulating signal, and the other portion is made up of a saw tooth or non-sinusoidal wave.

A PWM signal is the comparator's output waveform after two signals have been compared. If the sawtooth signal is greater than the modulating signal, the output signal is in the "High" condition. The magnitude value determines the comparator output, which specifies the width of the pulse created at the output. There are three common types of pulse width modulation techniques. Trail Edge Modulation - In this approach, the signal's lead edge is modified while the trailing edge remains constant. Lead Edge Modulation - In this approach, the signal's lead edge is fixed while the trailing edge is modified. Pulse Center Two Edge Modulation - In this approach, the pulse centre is fixed and both edges of the pulse are modified. The PWM technique is employed in a wide range of power applications due to its high efficiency, minimal power loss, and ability to accurately manage power.

3.3 DC/AC Converter

A power electrical device known as a converter is used to change DC into AC. Changing a DC power source to an AC power supply is the main purpose of DC-to-AC converters. In this context, a DC power source is a relatively steady source of positive voltage while an AC power source oscillates around a base value of 0V, often in a sinusoidal, square, or pattern. The basic circuit for an inverter consists of a transformer coil system and a switch. It is possible to fast oscillate back by connecting a conventional transformer through a switch to the input of a DC signal. The primary coil of the transformer's current flow is bidirectional, and as a result, the secondary coils of the transformer get an output of alternating current. A current that alternates between flowing forward and backwards is known as an alternating current. Alternating current (AC) is the name for a current whose direction fluctuates regularly.

Direct current is a type of current that always travels in one direction via a conductor. It has no frequency. It is created using cells, batteries, DC generators, etc. simple steps to convert dc to ac Input Filter—To deliver a pure voltage to the inverter circuit, the input filter smooths out any ripples or frequency disturbances on the D.C. supply. The primary power circuit consists of an inverter. A multilayer PWM waveform is created here using the D.C. Output Filter. To create a virtually sinusoidal output, the output filter subtracts the high-frequency components from the PWM wave.


3.4 Grid

A networked system for transferring electricity from generators to consumers is known as an electrical grid. Electrical networks may cover whole regions or even entire countries, depending on their size. It is made up of power stations, which are usually located close to energy sources and away from highly inhabited regions. Voltage stepping substations for electrical power. Long-distance power transfer using electricity. Distribution of electricity to particular consumers, followed by a step-down in voltage to the needed service voltage(s). Voltage swings frequently happen at the same time since all distribution zones employ synchronized three-phase Alternating Current (AC) patterns. In addition to linking a large number of energy providers and consumers, this enables the transfer of AC power throughout the region, which may facilitate redundant generation and more efficient electricity markets.

To manage a growingly complex distribution environment, the GMS is a State Of Charge (SOS) that provides a full grid management solution. Both the antiquated legacy Distribution Management System (DMS) and the present Outage Management System (OMS) are replaced by it. By providing situational awareness and carrying out several real-time studies, the GMS solution will be able to adapt to SCE's changing business objectives and will let grid users respond to real-time information effectively. The Electric Programmed Investment Charge (EPIC), which supports technical demonstrations

4. RESULT AND DISCUSSION

Using a bidirectional buck-boost converter with battery charging and discharging characteristics, the energy control system of independent solar power generating systems may offer a reliable power source for small-scale conditioning units. A power semiconductor switch is used in place of the boost converter's diode component in the context of generic bidirectional buck-boost converters. As a result, the converter is given a synchronous rectification architecture and bidirectional energy flow qualities.

Synchronous rectification can raise the energy conversion efficiency provided compared to that of conventional boost converters while decreasing switch conduction losses. In the present investigation, a lithium-ion rechargeable battery and a bidirectional buck-boost converter were developed to effectively employ the solar power-producing system's output power. In Figure 5, the current controller can be shown sensing the input current and comparing it to a sinusoidal current reference. To establish the current reference, one has to know the utility voltage or current's phase information. This data is gathered via a phase lock loop.
Figure 5 Mat Lab Simulation Output

Figure 6 Solar DC Output Waveform

Figure 6 shows the Solar Dc output waveform concerning voltage.
Figure 7 shows As an AC output waveform, sinusoidal or sine waves are used. An EMF whose polarity alternates between positive and negative states on a regular basis is created by a voltage source with a periodic AC waveform; the length of time it takes for one complete flip is referred to as the waveform’s interval.

Figure 8 shows that Harmonics are sinusoidal voltages or currents with integer multiples of the fundamental frequency. On the power system as a whole harmonic distortion often results from the nonlinear properties of equipment and customers. The whole harmonic spectrum, including the magnitudes and phase angles of each harmonic component, is used to define harmonic distortion values is 1.44%.

6. CONCLUSION:
A closed-loop control technique for Six Pulse Modulation (SPM) on a bidirectional cascaded converter connected to an AC grid is provided. Because successful implementation of the Six Pulse Modulation (SPM) modulation is necessary, the design and implementation of a high bandwidth connection controller are provided. The dominant fifth and seventh harmonic components are identified after evaluating the errors generated in the pole voltages of a Six Pulse Modulation (SPM) modulated dual active bridge cascaded three-phase converter due to inverter dead time, and a sixth harmonic resonant controller in the asynchronous structure is designed to eliminate them whenever essential. It
has been demonstrated that compared to a sine PWM modulated converter, a well-constructed Artificial Bee Colony Algorithm modulated inverter places less current demand on the dc link capacitor. An experimental prototype is used to validate the efficacy of the proposed Six Pulse Modulation (SPM) modulated closed loop controlled dual active bridge cascaded three-phase converter, and the results of the experiment supported the effectiveness of the suggested methodology.

6.1 Future scope
Micro grids may deliver dependable and economical electricity to rural or off-grid locations, as well as cut energy costs and carbon emissions for companies and institutions, as well as increase energy security and resilience for important infrastructure and military facilities. So, utilizing solar and wind energy as renewable energy sources, this suggested hybrid micro grid's power management is examined. It may be expanded to employ multiple sources and super-capacitors in conjunction with batteries for energy storage systems. A large-scale distribution system might be built using the micro grid as well. In grid-connected mode, the problem of reactive power-sharing and tertiary control may also be examined. Transition mode, which may also be taken into consideration, is how the micro grid functions between islanding and grid-connected modes. The experimental system can be expanded to support hybrid storage systems in smart grid applications for smart energy management.

REFERENCES:


