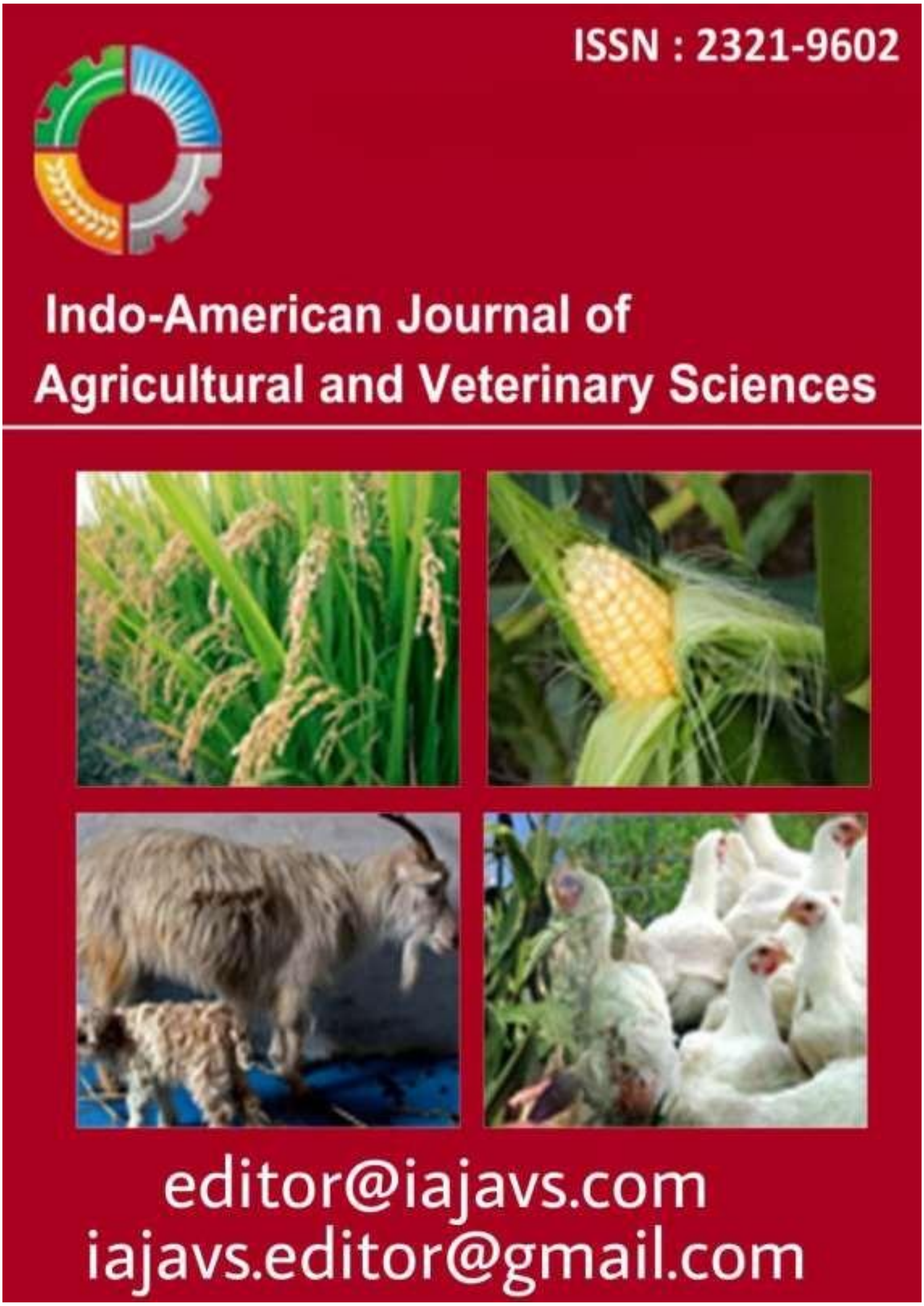


ISSN : 2321-9602

Indo-American Journal of Agricultural and Veterinary Sciences

editor@iajavs.com
iajavs.editor@gmail.com

Indo-Am. J. Agric. & Vet. Sci., 2023

ISSN 2321–9602 www.iajavs.com
Vol. 18, Issue 2 May 2023

Indo-American Journal of Agricultural and Veterinary Sciences

Enhanced Power Control Approach for Tie Converter Based AC-DC Microgrids

[1]D. Shekshavali, [2]K. Suresh Kumar

Article Info

Received: 09-02-2023 *Revised: 01 -03-2023* *Accepted: 25-04-2023*

Abstract

There are a number of technical flaws in the current AC-DC microgrid power management systems. Controlling the voltages of linked microgrids depending on their loading circumstances is a key focus of certain control systems while others are more concerned with regulating the currents of interconnected microgrids. On the other hand, current systems are unable to achieve these objectives. To tackle these issues, an autonomous power management strategy is proposed that evaluates the DC microgrid's individual loading condition before importing power from the associated AC microgrid. DC microgrid voltage may be controlled using this method while using fewer converters. The suggested system is completely self-contained while yet allowing generators and tie-converters to be easily installed and removed. Several operational situations have shown the effectiveness of the proposed control method. The results reveal that the proposed approach is capable of efficiently and autonomously regulating the DC microgrid's power shortfall while maintaining increased voltage resilience.

Keywords: *Smart grids and microgrids that are connected together are all forms of distributed energy systems that may be controlled by a single central system or by a network of distributed systems.*

Introduction

Renewable and alternative energy sources have been extensively implemented in a variety of network topologies and configurations as a result of advances in powerelectronics [1]. Additionally, they have been regulated and managed utilising a variety of control systems and structures. Most of their network configurations and management tactics are based on optimising performance while also keeping up with the expected amount of network traffic. Microgrids are increasingly incorporating renewable and alternative energy technology. There are several benefits to adopting new technology in the form of a microgrid, including better use of resources, greater power quality and increased supply dependability [4]. Zone-based grid designs [5], multi-microgrids [6], interconnected AC-AC microgrids [7], and interconnected AC-DC microgrids [8] are recent examples of more complex grid systems. The primary goal of these cutting-edge network designs is to maximise the advantages of renewable and alternative energy sources. For example, integrating two or more microgrids will allow reserve sharing, support voltage and frequency, and eventually boost the overall dependability and resilienceof interconnected microgrids.

[1]PG Scholar, [2]Associate professor
[1,2]Department of Electrical and Electronics Engineering, Dr. Samuel George institute of engineering and technology, Prakasam, A. P, India
[1]shekshavalidudekula99@gmail.com, [2]spandu625@gmail.com

A microgrid's interconnections with other microgrids or utility grids are largely determined by its general goals and the control andmanagement schemes utilised in individual microgrids. The microgrids may be connected directly or through tie-converters that harmonise their outputs. When the operational voltages and/or frequencies of two or more microgrids vary, harmonising tieconverters are often utilised. If the microgrids to be interconnected have tieconverters, they are also necessary.

[8] Different control techniques and the flow of power between them must be managed. Other functions of the tie-converters, such as controlling power flow, have been studied in the published literature [9] when connecting a DC grid to either the utility grid or another AC grid. Demand droop control was suggested in [10] for the AC-DC microgrid interconnecting or tie converters. The normalised terminal voltage and frequency of the interconnected AC-DC microgrids, controlled by droop, are used to estimate the power flow action. It is possible to transmit electricity between two interconnected microgrids depending on their respective load conditions using this method of power transfer. Interlinking converters might experience needless operating losses when power flow decisions are made based on relative loads. Microgrids that are connected together and include a battery storage system may use the same power sharing method [11]. With the progressive auto-tuning, the energy flow via interlinking converters may be minimised even further with this design. Only when one microgrid is heavily-loaded and the other microgrid is lightly-loaded can the suggested auto-tuning be used to transfer electricity. Differentoperating situations of interconnected AC and DC microgrids have been studied using the droop-based power sharing concept [12]. There is a three-port system with AC, DC, and a storage network in [12] that uses a power management method. The interconnected networks' loading diction is used to make the power sharing choice, which is much the same as that described in [20]. To cut down on the number of interlinking converters, a multilayer supervisory control system based on communication is also being considered. Another power management strategy for the interconnected AC-DC microgrid has the goal of regulating the voltage of the DC microgrid without regard to the particular loading level of the generators. Plug-and-play functionality is therefore severely hampered since this design can only be executed on a single tie-converter. Interconnected AC-DC microgrids have also been studied using a few centralised power management techniques.

The dependability of the rapid communication lines is a major problem with centralised methods. This is why decentralised systems are more popular. Decentralized power sharing techniques for interconnected AC-DC microgrids based on droop or voltage management have so far been described. A power sharing system based on droops distributes electricity according to the relative load of the interconnected microgrids. A contingency or unequal load state does not govern the voltage and/or frequency of the linked microgrids, but the power transfer does.However, the interconnecting converters are able to plug and play with various schemes. If there are many interlinking converters, all converters will be operational regardless of the total power transfer need, thanks to this characteristic This might lead to unwarranted losses in the converter's functioning. But instead of plug-and-play tie- converters for a DC microgrid, voltage regulation techniques do not take generator loads into account while regulating voltage.

This paper's suggested controlmethod expressly addresses these flaws. The suggested autonomous power management method for interconnected AC-DC microgrids takes into account the individual loading situation of the generators, and transfers power from AC to DC microgrid during its peak-load demand and also manages the voltage of the DC microgrid.. In order to eliminate excessive losses, a plug-and-play function for tie converters has been provided in the proposed design. There is insufficient generating capacity for the DC microgrid, owing to the significant fluctuation of demands and renewable energy, in the studied scenario The AC microgrid is regarded to have controlled voltage and frequency as well as excess power to transfer to the DC microgridduring its peak demand or contingency scenario.. The tie- converters in interconnected AC-DC microgrids may be controlled using a hybrid droop and voltage regulation mode control. A droop-controlled DC microgrid's overall loading status is determined using data from the tie-converter terminal voltage. The automatic initiation of the tie converter occurs when the predefined loading threshold is met. When the DC microgrid is experiencing a spike in demand or a contingency, it sends electricity to the DC microgrid. The DC microgrid's voltage is maintained at a predetermined nominal level using the hybrid control mode. It'salso possible to connect more thanone tie-converter with the proposed system, but unlike the current setup, which operates all tie-converters simultaneously regardless of the amount of power being transferred, the second tie-converter only kicks in once the first one's power capacity is fully depleted. The new design is completely self-contained and has additional functionality.

Secondly, a photovoltaic inverter

P-n junction diodes are used to convert sunlight into energy in PVcells. PV cell equivalent circuit diagram shown in Fig.1. The PV cell produced current is represented by a current source, a diode is connected in series with the current source, a shunt resistance and a series resistance are all included in this model.

Figure 1. Equivalent circuit diagram of the PV cell

1. **DC-DC Converters**
2. Battery backup systems for uninterruptible power supply and fuel cell energy conversion systemsemploy high step-up voltage DC-DC converters with a wide range of applications, including automotive lighting. It is theoretically possible to get a high step up voltage with a high effective duty ratio using a DC-DC boost converter. Power switches and inductors' and capacitors' equivalent series resistance (ESR) limit the step- up voltage gain in practise.
3. When a high voltage gain and a big duty ratio are required, traditionalboost converters are often utilised. Diodes' reverse recovery difficulty limits the efficiency and voltage gain, as do the losses of power switches and the corresponding series resistance of inductors and capacitors. In these converters, considerable voltage stress and power dissipation are caused by the active switch because of the transformer's leakage inductance. It is possible to decrease the voltage surge by using a resistor-capacitor-diode snubbed combination. However, as a consequence, efficiency suffers. Converters with low input ripple current are being developed based on the coupled inductor. One way these converters achieve their low input current ripple is by the use of an extra LC circuit that includes a connected inductor.
4. 3. Inverter
5. **With the use of transformers, switches, and control circuits, an inverter may convert direct current (DC) to alternating current (AC). This AC can be at any desired voltage and frequency. With no moving components, static inverters are utilised in a variety of**

applications, from tiny computer power supply to big electric utility high-voltage direct current (HVDC).current applications that transport bulk power. Inverters are commonly used to supply AC power from DC sources such as solar panels or batteries. The electrical inverter is a high power electronic oscillator. It is so named because early mechanical AC to DC converters made to work in reverse, and thus "inverted", toconvert DC to AC.

Cascaded H-Bridges Inverter

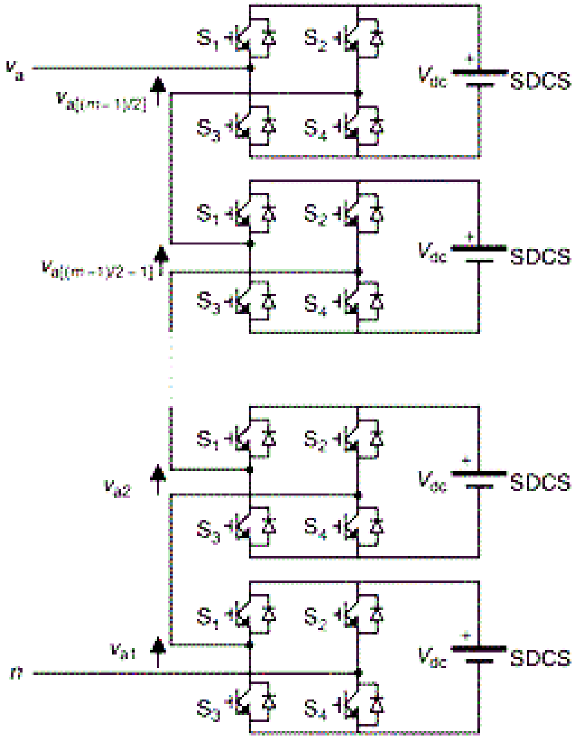
An m-level cascaded inverter's single-phase construction is seen in Figure 2. A single phase full bridge inverter, often known asan H-bridge inverter, is used to link each individual DC source (SDCS). +Vdc, 0, and –Vdc may be generated by connecting the DC source to the ac output using various combinations of S1, S2, S3, and S4 switches at each inverter level. It is possible to acquire +Vdc by switching switches S1 and S4 whereas – Vdc is possible by switching switches S1 and S3. When S1 and S2 are turned on, or when S3 and S4 are turned on, the output voltage is 0. The resulting voltage waveform is equal to the total of the individual inverter outputs, with the AC outputs of each full bridge inverter level being coupled in series. For an inverter with multiple DC inputs, the formula m = 2s+1 gives the number of output phase voltage levels m. Figure 3 shows a phase voltage waveform for an 11-level cascaded H-bridge inverter with five SDCS and five complete bridges. volts on the phase

+ … (4.1)

Figure 2 shows a stepped waveform with s steps. The Fourier transform

The following is the waveform's transform.

Figure 2. Single-phase structure of a multilevel cascaded H-bridges inverter



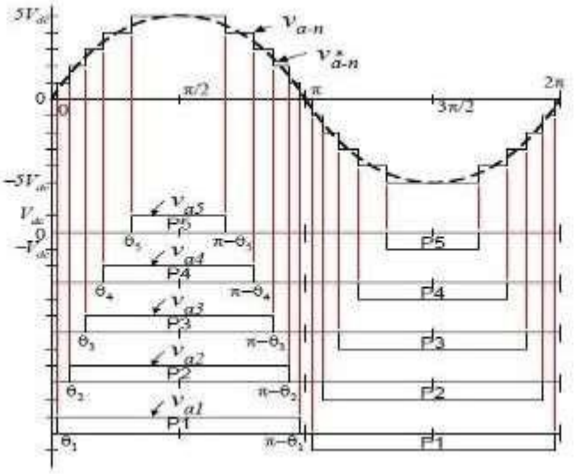
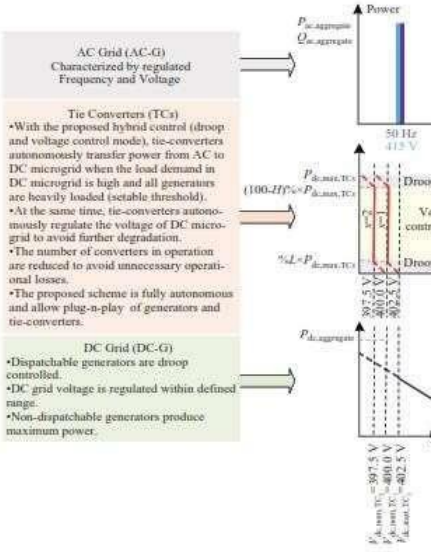


Figure 3. Output phase voltage waveform of an 11 level cascade inverter with 5 separate dc sources

6. Control of AC and DC Microgrids

Solar-PV and dispatchable generators (micro turbine, fuel cell) are included in the DC micro grid, as seen in Fig. 4. All the while, the nondispatchable-solar PV system is programmed to run in current control mode, resulting in maximum power extraction from the system. Decentralized or centralised control schemes may be utilised to manage the dispatchable generators, which are often employed to firm up the renewable capacity. As a result of its simplicity and dependability, the decentralised droop system is the most often used and appreciated. The classic droop (P-V) method has been adopted for the DC microgrid's dispatchable generators.

The power sharing accuracy is impacted by a voltage mismatch at the generator terminals, which must be corrected usingone of many compensation techniques.Vdc,ref,i = Vdc,max dc,iPdc,i + idc,iXi maybe used to rewrite the droop equation with correction for the feeder voltage drop. (5) The droop-controlled DC microgrid's voltage will fluctuate with the changing demand, but it will stay within the rangethat has been set as acceptable. Figure 4 depicts the voltage range for the DC microgrid under consideration as the aggregated load increases (bottomleft). Droop-controlled generators have a voltage range of 395 V to 420 V, which means that the generators will supply no power at 420 V and full power at 395 V. Tie converters manage the DC microgrid voltage by importing electricity from the AC microgrid when the DC generators are fully loaded (402.5 V at 80% generator loading, for example). AC microgrid voltage and frequency are considered stiff in Fig. 4's example of interconnected microgrids. Secondary voltage and frequency regulation or grid connection may be used to manage the droop of the AC microgrid. AC microgrid characteristics are shown in Fig. 4, where the voltage and frequency are maintained at their nominal values (e.g., 50 Hz and 415 V). AC microgrids have adequate generating capacity to fulfil local demand and export excess power to the DC microgrid, which has been proved by the proposed autonomous control of the tie-converters.



AC Grid (AC-G)
Characterized by regulated Frequency and Voltage

Tie Converters (TCs)
•With the proposed hybrid control (droop and voltage control mode), tie-converters autonomously transfer power from AC to DC microgrid when the load demand in DC microgrid is high and all generators are heavily loaded (setable threshold).
•At the same time, tie-converters autonomously regulate the voltage of DC micro-grid to avoid further degradation.
•The number of converters in operation are reduced to avoid unnecessary operational losses.
•The proposed scheme is fully autonomous and allow plug-n-play of generators and tie-converters.

DC Grid (DC-G)
•Dispatchable generators are droop controlled.
•DC grid voltage is regulated within defined range.
•Non-dispatchable generators produce maximum power.

Figure 4. Interlinked AC-DC microgrids and their control strategy

7. Proposed Hybrid Control of Tie-Converters

Because of the interdependence of renewable energy and loads in a microgrid, dispatchable generators and storage systems have varying power ratings for stabilising renewable capacity. Since renewables and loads are so variable, high-power dispatchable generators or storage devices may or may not be a feasible alternative. An alternative would be to link a microgrid with insufficient generating capacity directly or through harmonising converters to another microgrid or utility grid. Only tie-converters, as seen in Figure 4, can connect a DC microgrid to an AC utility grid. Compared to the AC microgrid, theDC microgrid is described as a droop- controlled system with insufficient generating capacity because to the significant unpredictability of the renewable and loads in the proposed interconnectedsystem.

In times of high demand or low renewable power production, the DC microgridimports electricity from the AC microgridto meet its power needs. The suggested control of the tie-converters should be able to perform this effectively and autonomously. The tie-converter control technique is designed to achieve the following goals: In order to minimise powertransfer losses, for example, tie-converters should only be used during times of peak load in the DC microgrid and the number of tie-converters should be determined by power transfer demand; in order to regulate the voltage of the droop controlled DC microgrid; and finally, in order to achievefully autonomous control of the DC microgrid wi The suggested control method for the tie-converters differs from the current strategies for interconnected AC-DC microgrids [18–22]. The mathematicalstructure of the proposed control scheme is provided by:

Tieconverter x has droop 2 gain at high power Droop 1 control mode is initiated when the DC microgrid's voltage drops below the predefined threshold of Vdc,start,TCx. As a result of this voltage threshold, all of the DC microgrid's generators are significantly loaded (e.g. over 80 percent loaded). The droop control mode of the tieconverter allows for a seamless transition to the voltage regulation mode at the specified condition, i.e., Pdc,TCx > L percent Pdc,max,TCx. For peak power supply and voltage management, the tie-converter imports electricity from the AC microgrid and regulates its voltage to match the DC microgrid's normal values.

It has also been prioritised for the converters, as opposed to previous approaches that ran all tieconverters in concurrently. When all of the DC microgrid's generators are running at full capacity, the first tie-converter is activated. As soon as the first tie-power converter's capacity nears saturation, its control mode is changed from voltage regulation to droop 2 control mode to enable slight voltage drop to occur. The droop 2 control mode causes a little voltage drop, which allows the following tie-converter to begin working. Inthe event that the first tie-converter fails, the second tie-converter will immediately take over, resulting in a voltage decrease. Since all operating circumstances are covered by the proposed control method, it does notimpair the inherent adaptability of theexisting droop-based design.

Choosing the percentages of L and H for thetie-power converter's allocation for droop 1 and droop 2 control mode is up to the user and should be calibrated to provide smoothtransitions between modes while taking into account the voltage and power measurement tolerances/errors in thesystem.

that's been given some thought: the microgrid. The DC microgrid's overall voltage regulation performance may be enhanced with the new suggested voltage regulation mode. At peak demand, the DC microgrid's voltage is controlled at itsnominal value, which is not the case with the current power management systems.

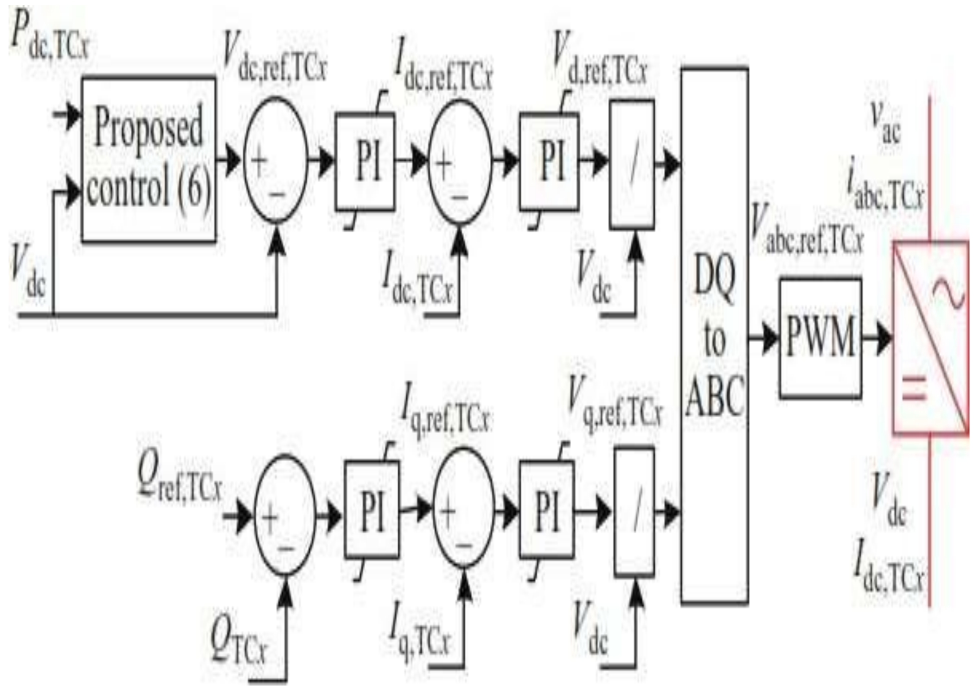


Figure 5. Control block diagram of tie-converter

8. Simulation Results

Steps of 5 kW, 10 kW, 15 kW, 20 kW, and then 10 kW are used to vary the DC microgrid's load. The DC microgrid's voltage is below the predetermined threshold of Vdc,start,TC1 = 402.5 V at the 15 kW load demand since the projected loadings of generators 1 and 2 are more than 80%. TC1 will be able to import electricity from the AC microgrid and maintain the DCmicrogrid's voltage at the nominal value of Vdc,nom,TC1 = 400.0 V, if this condition is met. It is clear from the outcomes that this predicted performance has been achieved. To get to the first highlight point, the DC microgrid voltage drops to below 400 V for 8 seconds, followed by a step load increase from 10 to 15 megawatts. Tie-converter 1 goes into droop control mode at point 2 when the voltage drops below a certain level. To begin with, I was droop 1.

Since Pdc,TC1 > 10 percent Pdc, max, TC1 is met, the tie-converter control mode quickly transitions to the voltage regulation mode at point 3. As the DC microgrid's demand rises from 15 to 20 kW in 12 s, so does the amount of AC microgrid electricity being transmitted. Tie-converter 1 adjuststhe DC microgrid's voltage during periods of high peak demand (from 8 s to 12 s). A short time later, at point 5, the tie-converter automatically shuts off after a brief delay after the demand for power in the DC microgrid drops to the level shown at point 4. When all the DC generators are significantly loaded, tie-converter 1 is activated. The DC microgrid maintains a constant voltage of 400 volts throughout operation. Because of this, the suggested approach has improved voltage control and is more effective.

Figure 6. Simulink circuit of proposed system

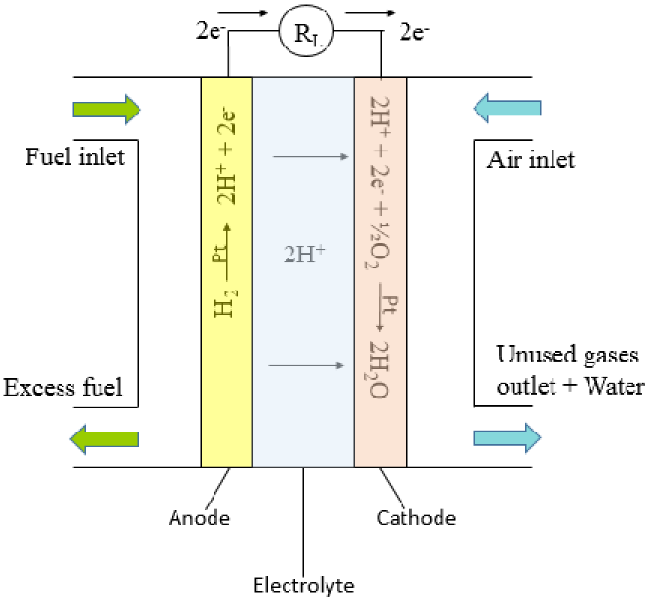
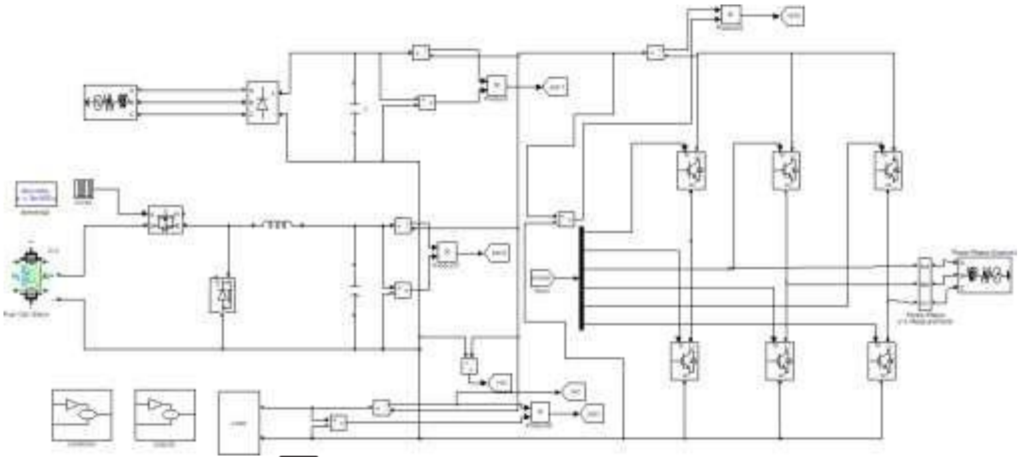


Figure 7. Circuit diagram of fuel cell



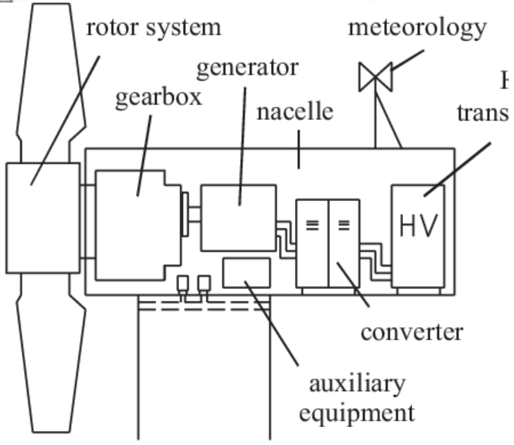


Figure 8. Circuit diagram of Wind turbine

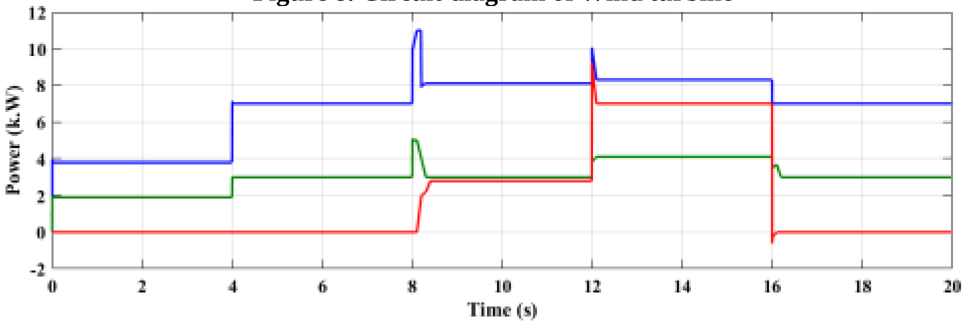


Figure 9. Generators and tie-converter power

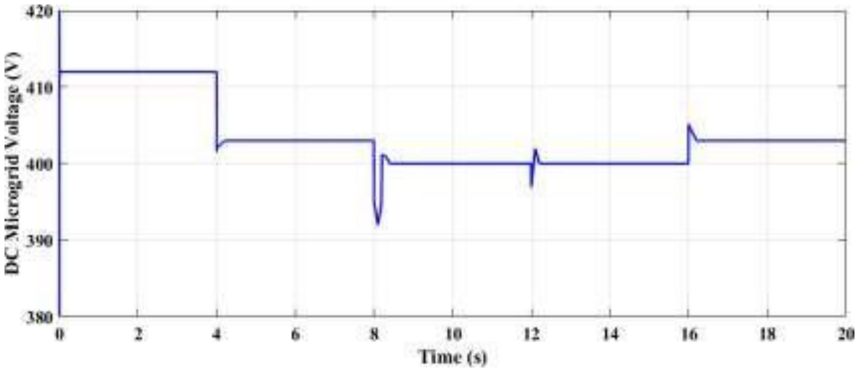


Figure 10. DC microgrid voltage

The DC microgrid's load steadily rises to a high of 24.5 kW, after which it begins to decline. The load on the DC generators grows as the demand for electricity rises. A high-demand load combined with a low solar PV output results in a decline in DC microgrid voltage below the 402.5 V threshold established for Vdc,start,TC1, which is reached at highlight point 1. Tie-converter 1 begins at the highlighted point 1 and imports power from the AC microgrid to solve the power imbalance in the DC microgrid while managing its voltage in accordance with the intended control. Tie-converter 1 regulates the voltage from point 2 to point 3 in 8.5 s and 14.2 s, respectively. DC microgrid load dwindles from point 3 forward, requiring the tie-converter to work in the droop 1 control mode before it can shift the switch to the droop 2 control mode.

16.4 s. off the mark at the marked position 4. The DC microgrid's load demand is smaller than its generation after point 4, therefore the generators on-site can meet the demand. The DC microgrid's tie-converter has been shown to work only when there is a power deficit. Importing electricity from the AC grid also regulates the DC microgrid's voltage. The AC microgrid is shown in grid-connected mode, but with a tie-converter.

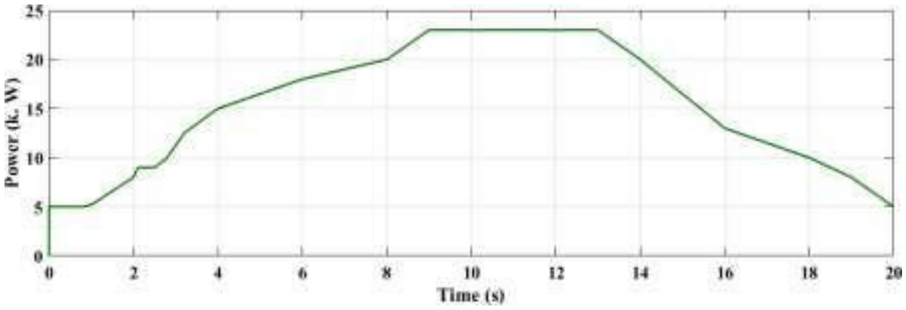


Figure 11. DC microgrid load demand,

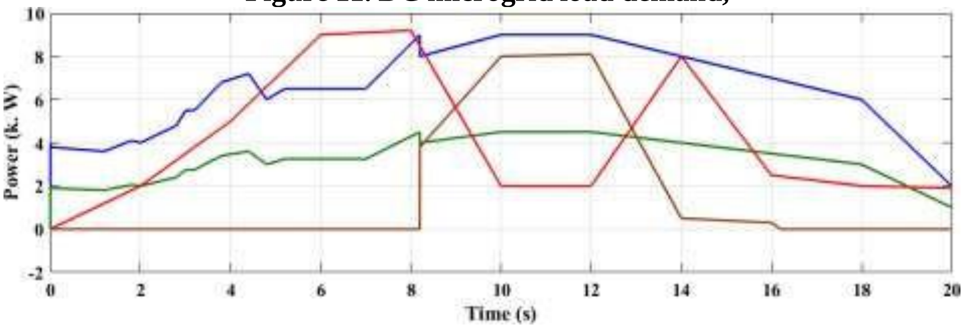


Figure 12. Generators and tie-converter power

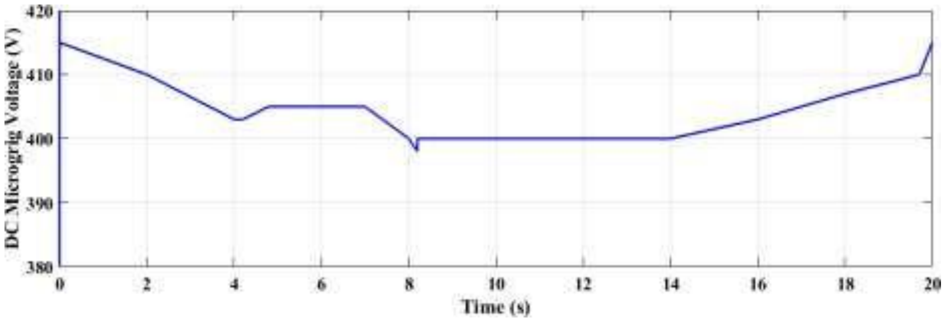


Figure 13. DC micro grid voltage

9. Conclusion

An autonomous power management system has been developed for AC-DC microgrids with a variety of topologies. The suggested system successfully and independently addresses the energy shortfall in the DC microgrid. The intended prioritising has restricted the number of tie-converters in operation in order to save unnecessary running expenditures. The method has beenproved to enhance voltage regulation in aDC microgrid. Both the efficiency anddurability of the proposed system weretested in two different DC microgrid scenarios with varying loads. **References**

AC microgrid power converter control in the IEEETransactions on Power Electronics, Vol. 27, Issue 11,Pages 4734–4749, November 2012.

2] M. Liserre, et al. "Future energy systems: integrating renewable energy sources into the smart power grid via industrial electronics," in IEEEIndustrial Electronics Magazine, Vol. 4, No. 1, March2010.

In "A study of grid code technical requirements for wind farms," M. Tsili and S. Papathanassiou, pp. 308–332, IET Renewable Power Generation, vol 3, no 3.

A study of the architectures and ideas for intelligence in future electric energy systems is presented in IEEE Transactions on Industrial Electronics, 62, no. 4 (Apr. 2015), pp. 2424–2438, in the IEEE Transactions on Industrial Electronics.

As a result of system architecture and converter topology design decisions, "Quantitative assessment" of a dc microgrids' availability is affected, according to Kwasinski's study in IEEE Transactions on Power Electronics.

There are a number of studies that have examined the integration of distributed energy resources into microgrids from the standpoint of control, protection, and stability of microgrids, and these studies are summarised below.

: Drs D. E. Olivares and Mehrizi-Sani, as well as Drs. A. Etemadi, C. A Canizares, R. Iravani, M Kazerani, A. H. Hajimiragha, O. Gomis-Bellmunt, M. Saeedifard and Dr. R. alma-Behnke, G. A. Jimenez- Estevez and N.

IEEE Transactions on Smart Grid, Vol. 5, No. 4, pp. 1905–1919, July 2014.

There is an article by N. Hatziargyriou, H. Asano, R. Iravani, and C. Marnay titled "Microgrids" in IEEE Power and Energy Magazine, volume 5, number 4, in the summer and autumn of 2007.

IEEE Electrification Magazine, vol. 4, no. 2, June 2016, pp. 37–44, L. E. Zubieta, "Are microgrids the future of energy? : DC microgrids from idea to demonstration to implementation."