

New Control Strategy of Interconnected Microgrids for Enhancing Power Sharing Capability

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ABSTRACT

In this study, the AC-DC connected grids are only involved in power sharing or power regulation, but not both, due to operational hurdles to existing power management systems. To overcome these challenges, this paper is offered. In order to import electricity from an interconnected AC micro grid, this suggested autonomous power control system will first analyse the current state of the DC grid. Not only does this approach reduce the amount of active converters required in order to achieve lower energy transfer losses, but it also does so while also creating a DC micro grid. The plug-and-play qualities of generators and tie-converters are adhered to by the proposed system, making it totally self-contained. The suggested control system's efficiency is ensured under a variety of operating circumstances. Researchers were able to validate the suggested system's ability to autonomously manage power shortages in the DC micro grid, while still maintaining better power control and voltage regulations across the DC micro grid. Analysis is carried out in the MATLAB / SIMULINK environment to ensure accuracy.

Key words- Distributed control, autonomous control, droop control, hybrid micro grids, interconnected micro grids, power management.

INTRODUCTION

The advancement of renewable energy technologies plays an important role in the distribution of renewable energy and other energy technologies that have been widely acquired in various forms of network technology. In addition, they have been managed and directed using a variety of control strategies and structures. Their network approaches and control

strategies are adapted primarily to maximize profits while meeting load requirements. Nowadays, renewable technology and other energy are heavily embedded in microgrids. As this new technology has several advantages such as better utilization of resources, improved energy quality and more reliable supply, these new technologies are still being distributed in the form of a small grid. Currently, advanced grid features are

integrated with sin-based grid features. It was a big goal to take advantage of the great benefits of renewable energy sources and so on. For example, if we connect two or more small grids, it will result in saved sharing, support volume and volume, and ultimately strengthen the absolute reliability and flexibility of the connected small grids. Links between two or more small grids have been developed to meet the overall objectives of control and management strategies. Linking to small grids can be done directly or by syncing to turn the tie. Whenever two or more grids are connected with different operating modes and multipliers, compatible tie converters are widely used. If micro grids are to be connected with different control techniques and forces flowing between them, then also tire transformers are needed to control. Similarly, a small DC grid connection to a utility grid or other AC grid, as well as power flow control among other operations, tire converters are required. This was investigated under various circumstances. For connecting tie-converters for AC-DC micro grids, droop demand control has been suggested. On the basis of the standard terminal power and the mass of the controlled group connected between AC-DC grids, the power flow action is determined. This system will make the transfer of power between the connected grids more self-contained due to the relative load status. The connector converter will work continuously if the power flow decision is made with the associated load and thus can lead to inevitable loss of performance. The expansion of the same power-sharing system has been made possible by connecting micro grids to aid the storage system. This system will make the transfer of power between the connected grids more self-contained due to the relative load status. The connector converter will work continuously if the power flow decision is made with the associated load and thus can lead to inevitable loss of performance. The expansion of the same power-sharing system has been made possible by connecting microgrids to aid the storage system.

With automatic development monitoring in an existing scheme, the flow of power through connected converters can be reduced. This proposed automatic tracking system will help determine the way power is transmitted only when one small grid is heavily loaded, and another small grid is loaded. In the various operating conditions of the AC and DC small grid connected, this power sharing is investigated. This power management strategy is introduced by a system of three ports consisting of AC,

DC and the storage network. Decisions regarding power sharing are made on the basis of loading conditions. To a lesser extent, published power-sharing systems for AC-DC-connected microgrids are performed entirely on the basis of droop or voltage regulation rules. Supported power sharing schemes will transfer power because equal load for all converters regardless of the power transfer requirement. Therefore the loss of unnecessary conversion performance is reduced. Typically, power control schemes only control the power of a DC microgrid by ignoring certain loading conditions of the generators, and do not even have a plug-n-play element for tie-converters. These shortcomings and challenges can be addressed in particular through the proposed management plan for this project

The proposed control scheme relies on the details of the final power of the tie converter to determine the overall loading status of the droop-controlled grid. The tie-converter automatically starts and transfers power to the micro DC grid during high loading demands or event status on a small DC grid on the basis of the set loading limit. DC power grid micro grid is controlled at a defined nominal level by the proposed hybrid control mode. In addition, the proposed system allows for the connection of more than one tie-converters, but was opposed to the existing system where all tie converters work simultaneously without the need for power transfer. The next tie converter only works once the original power transformer has been completed. The proposed system is completely independent of the enhanced features.

II. CONTROL STRATEGIES

The considered DC microgrid includes both non-dispatchable generator (solar-PV) and dispatchable generators (microturbine, fuel-cell) and loads, as shown in Fig. 1. The maximum power is extracted by the non-dispatchable -solar PV system at all the times since it is set to run in current control mode. The dispatchable generators are generally used for stabilizing the renewable capacity. These dispatchable generators are controlled through a centralized or decentralized control scheme. Because of its simplicity and reliability, a low-cost drag scheme is the most widely used and popular system. Therefore, the traditional droop system (P-V) has been used for generators sent to a DC microgrid (see Fig. 1), provided by

$$V_{dc,ref,i} = V_{dc,max} - \partial_{dc,i} P_{dc,i}$$

$$\partial_{dc,i} = \frac{V_{dc,max} - V_{dc,min}}{P_{dc,max,i}} = \frac{\Delta V_{dc}}{P_{dc,max,i}} \quad (1)$$

where, i is the DC generator number ($i = 1, 2, 3, \dots$); $V_{dc,ref,i}$ is the reference voltage of i th generator; $P_{dc,i}$ is the output power of i th generator; $V_{dc,max}$ and ($V_{dc,min} = V_{dc,nom,TC1}$) are the defined maximum and minimum voltage; $P_{dc,max,i}$ is the maximum or rated power of i th generator; and $\partial_{dc,i}$ is the droop gain of i th

generator. Based on (1), the voltage reference for the droop controlled generators 1 and 2 can be calculated by (2) and (3). As generators 1 and 2 share common DC bus voltage (i.e., $V_{dc,ref,1} = V_{dc,ref,2}$), (2) and (3) can be equated and rewritten by (4), which demonstrates that the power sharing of droop controlled generator will be proportional, according to their rated capacity.

The generator terminals is the same. Practically, all the generators are connected through feeders and cables of different lengths and hence the voltage at all the generator terminals is not equal. This voltage mismatch at the generator terminals needs to be compensated by using any of the appropriate compensation methods as it affects the power sharing. The droop equation with compensation of the feeder voltage drop can be rewritten by

$$V_{dc,ref,i} = V_{dc,max} - \partial_{dc,i} P_{dc,i} + i_{dc,i} X_i \quad (5)$$

With the load change, the droop voltage controlled by the DC microgrid will change but the specified distance is allowed. For DC microgrid targeted, range of electrical power with the magnified integrated magnification shown in Fig. 1 (bottom left). For water-generating generators, power range

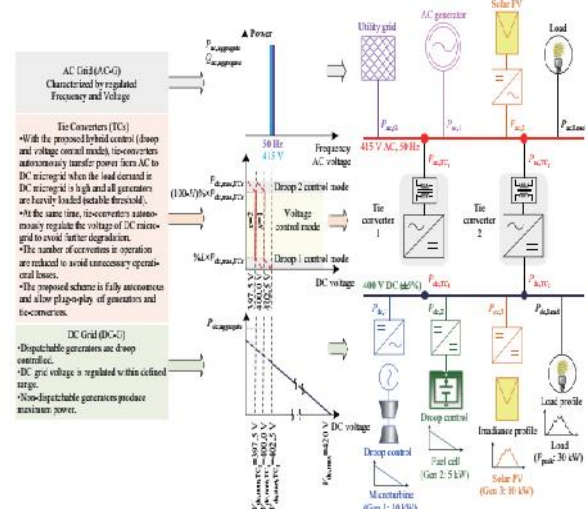


Fig. 2.1. Interlinked AC-DC microgrids and their control strategy.

is set between 395 V and 420 V, indicating that the generators will deliver power to 420 V and 100% power to 395 V. As soon as the DC generators are fully loaded (e.g., 402.5 V at 80% loading generators), tie-converters will start importing power from the AC microgrid to meet the maximum load requirement in the DC system. Therefore, by using tie converters we can also control the power of the DC microgrid. For example the connected microgrids are shown in Fig. 1, the power and frequency of AC microgrid are considered to be stable. The AC microgrid can be controlled by notes with

secondary voltage and frequency regulation, or operates in a grid-connected mode. 1 (e.g. 50 Hz and 415 V).

In addition, the AC microgrid has sufficient production capacity to meet its local demand and is also able to export residual energy to the DC microgrid which has been exposed by independent control of the tie-converters. Details of the control of tie-converters are provided in the section

III. PROPOSED HYBRID CONTROL OF TIE-CONVERTERS

The variability of a renewable source and loads on a micro grid will determine the amount of renewable energy or storage system to stabilize renewable capacity. Generators or high-capacity storage systems are needed for maximum recovery and loads, which may be a viable solution. Alternatively, a microgrid with insufficient production capacity can be linked to another microgrid grid or utility, directly or by synchronizing converters. A tie converter is the only way to connect a small DC grid to a small AC grid as shown in Fig. 1. In the proposed interlinked system, the AC microgrid is defined as a controlled voltage, power and frequency system with sufficient power generation capacity, while the DC microgrid is defined as a notably controlled system of nodes due to high variability of renewable and loads. In the event of high demand or low renewable energy output, power failure in the DC microgrid is treated by importing power from the AC microgrid. Ideally, with the proposed control of tie transformers, it can be achieved. In summary, the control system of tie-converters was developed based on the following objectives:

- 1) Transmission of power from AC to DC microgrid as there is any occurrence of DC microgrid or high demand requirement;
- 2) To reduce the loss of power transmission, by reducing the number of tie converters operating according to the need for power transmission, for example only during high demand flexible to use a tie converter.
- 3) Control of droop voltage controlled by DC microgrid;
- 4) Achieve completely independent and autonomous control over the communication network
- 5) Enable plug-n-play feature for tie converters and generators

Instead of the existing schemes for the interlinked AC-DC microgrids [18]–[22], a hybrid droop and voltage regulation mode control is proposed for the tie-converters and the mathematical form of the proposed

control scheme is given by

$$V_{dc,ref,TCx} = \begin{cases} \text{Off;} \\ V_{dc,start,TCx} - \delta_{L,TCx} \times P_{dc,TCx}; \\ V_{dc,nom,TCx}; \\ V_{dc,nom,TCx} - \delta_{H,TCx} [P_{dc,TCx} - (100-H)\% \times P_{dc,max,TCx}]; \end{cases}$$

when TCx indicates the value of the tie-converter ($x = 1, 2, 3 \dots$); Vdc is DC microgrid voltage; Vdc, Ref, TCx reference power xth tie-converter; Vdc, start, TCx is the voltage at the threshold start of xth tie-converter; Vdc, nom, TCx power to be controlled by xth tie-converter; Pdc, TCx. DC power output of xth tie-converter; Pdc, max, TCx maximum power limit for xth tie-converter; L% and H% are the percentage of power measured by the tie-converter given in droop1 and 2 mode, respectively; Vdc, nom, TCx + 1 is a DC microgrid voltage where the xth tie-converter transmits high power;

$L, TCx = (V_{dc, start, TCx} - V_{dc, nom, TCx}) / (L\% \times P_{dc, max, TCx})$ is the droop 1 (low power) benefit of xthtieconverter; $H, TCx = (V_{dc, nom, TCx} - V_{dc, nom, TCx + 1}) / (H\% \times P_{dc, max, TCx})$ is the droop 2 (high power) benefit of xthtieconverter. tie-converter 1 starts in droop 1 control mode when the voltage across the DC microgrid drops to a set Vdc set limit, start, TCx. When all generators are in a heavily loaded DC microgrid (e.g. over 80% loaded), the voltage drops to a set level. Start of binding converter in droop control mode with smooth transition to power control mode in default mode i.e., $P_{dc, TCx} > L\% \times P_{dc, max, TCx}$. The tie converter imports power from the AC micro grid to the micro DC grid to meet the high load requirement and also controls its power supply to be set at the lowest Vdc value, nom, TCx hence this is called power management mode. In addition, the work of the translators has been prioritized in contrast to the similar performance of tie transformers in existing systems. The first converter-tie starts only when all the generators in the DC microgrid are heavily loaded. As the initial capacity of the tie converter approaches the auxiliary to $P_{dc, TCx} = (100 - H)\% \times P_{dc, max, TCx}$, its control mode is switched to 2 control mode from power control mode and allows for minimal power outages. The next tie converter will start its operation using a small voltage drop caused by droop control 2. If the first tie-converter fails, the second tie-converter will start operating following a power outage due to high load requirement. Therefore, without the consent of the inherited flexibility of the focus system, the proposed control strategy ensures reliable and reliable performance across all working conditions. The power allocation of tie-converter in the control mode of droop1 and droop 2 depends on the selected L% and H% value defined by the user, and the adjustment should be able to move the switch between different modes while considering voltage and power measurement

tolerance or errors in the targeted microgrid. The efficiency of the DC microgrid voltage regulation can be improved, using the proposed power control mode. Especially during high demand,

$$\begin{aligned}
 &V_{dc} > V_{dc,start,TCx} \\
 &0 \leq P_{dc,TCx} \leq L\% \times P_{dc,max,TCx} \\
 &L\% \times P_{dc,max,TCx} < P_{dc,TCx} < (100-H)\% \times P_{dc,max,TCx} \\
 &(100-H)\% \times P_{dc,max,TCx} \leq P_{dc,TCx} \leq P_{dc,max,TCx}
 \end{aligned} \tag{6}$$

voltage of the DC micro grid is controlled at the nominal value, which is not done with the existing power management schemes for interlinked micro grids. The performance of the proposed scheme has been corroborated for different load operating scenarios, as described.

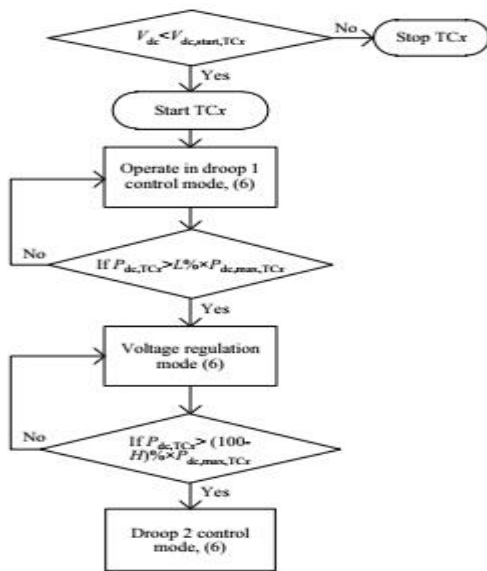


Fig.3. 3 Logic flow diagram showing mode transitions of tie-converter

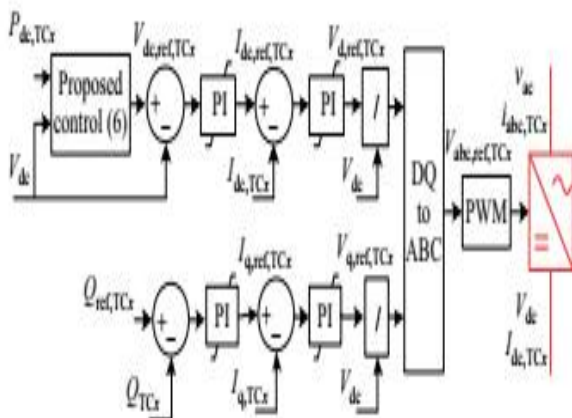


Fig. 3.4. Control block diagram of tie-converter.

IV DG interfacing System description:

The recommended test for island detection reading containing inverter-based DG, the same RLC load and the source-represented grid after impedance is shown in Fig. 4.1. DG mode of operation depends on the location of the circuit assistant whether it is off or not. Inverter based DG such as photovoltaic generation and windpower generation are usually set up with high power point tracking points. Because of the very short time to find islands, output power can be considered as a constant occurrence at the time of acquisition. As, DG is designed as a continuous power source, a permanent dc source is hired after the third phase of the inverter. Figure 5.6 represents the DG interface control block diagram. The three key components are the Phase Locked Loop (PLL), the external power control loop and the current internal control loop. operating independently according to the dual-controlled loop closure structure in the sync index dq..

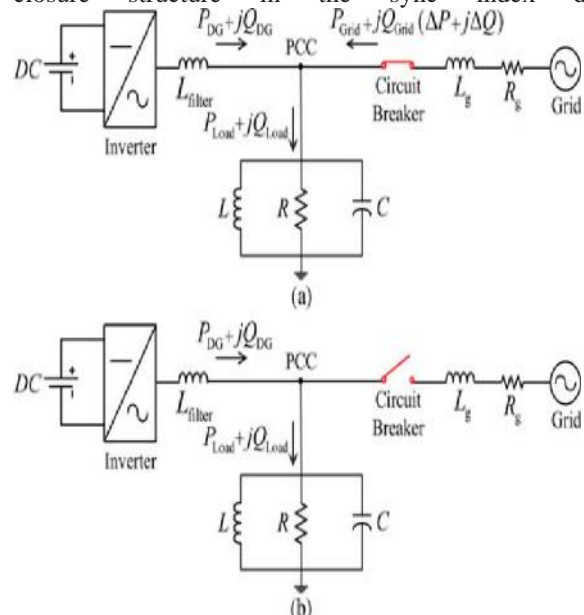


Fig. 4.1 Test system for islanding detection study

- (a) Grid-connected operation mode
- (b) Islanding operation mode.

As shown, when the DG is disconnected to the utility grid, the following equations describe the power flows and the active and reactive power consumed by the load:

$$P_{load} = P_{DG} + P_{Grid} = \frac{3v_{PCC}^2}{R} \tag{1}$$

$$Q_{load} = Q_{DG} + Q_{Grid} = 3V_{PCC}^2 (1/2 fL - 2 fC) \tag{2}$$

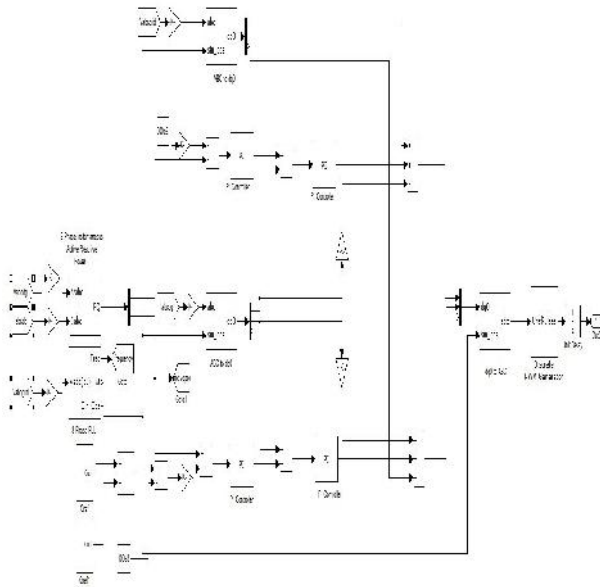


Fig 5.4 The block diagram of the DG interface control

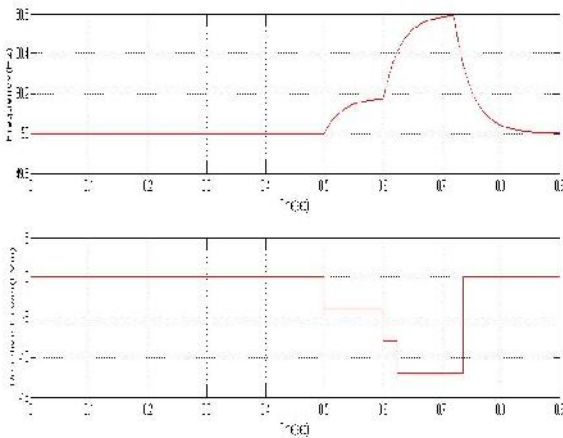


Fig 5.5 shows Reactive power and frequency vs time In sec

CONCLUSION

For interconnected AC-DC micro grids with various designs, an autonomous power management strategy has been provided. The proposed plan efficiently and independently handles the DC micro grid's power shortfall. The suggested prioritising of tie-converters has resulted in a reduction in the number of tie-converters in operation. To evaluate the stability of the system, a DG interfacing network and its control must be simulated. In a DC micro grid, the system has shown improved voltage regulation. Two separate DC micro grid scenarios with

varying load levels were used to test the proposed scheme's performance and robustness.

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