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Research article

Power control of parallel inverters in microgrid

Xuan Hoa Thi Pham*

ABSTRACT

Microgrids can operate in grid-connected mode or standalone mode. Inverters in a microgrid are considered as AC power generation sources, they are often connected in parallel to improve power transmission efficiency. When the microgrid operates in standalone mode, it must stabilize its voltage and frequency. The voltage and frequency of the microgrid depend on the output power of the inverters. Therefore, to avoid the occurrence of balanced currents circulating between inverters, the inverters must be controlled to share their output power. This paper proposes a control method to share output power for inverters connected in parallel in the Microgrid, while improving the reliability of the proposed controller in case the communication bus is interrupted or delayed, the proposed controller still gives better control results than the conventional control method. In addition, the proposed controller is simple to implement and is not affected by line impedance parameters. The focus of this paper is to improve the accuracy of power sharing of parallel-connected inverters in a microgrid to avoid the unbalanced current circulating in the inverters, which will heat the inverters and may lead to inverter damage. In addition, the proposed method is also improved to improve the reliability of the controller. The controller still operates and gives good results even when the communication is interrupted. If during the communication failure the load capacity changes, the proposed controller will give less accurate power sharing results than normal, but this result is still much better when compared with conventional controllers. The proposed controller is simulated for a microgrid with three parallel-connected inverters using Matlab/Simulink software to verify the suitability of the proposed method. The proposed method can be applied to complex microgrids consisting of multiple inverters connected in parallel with multiple power sources.

Key words: Voltage control, power sharing, microgrid control, parallel inverter, frequency control

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INTRODUCTION

Distributed generation (DG) sources are increasingly widely used. Currently, DGs are interested in many industrial fields and become one of the most interesting research directions in the energy field [1–7]. Although distributed generation using wind energy, solar or diesel energy, ... are energy sources that can produce small-scale electricity, in the future, it can be seen as an alternative or complementary source for traditional electricity sources such as thermoelectricity or hydroelectricity. DGs help address the increase in global warming caused by fossil fuels.

Microgrid consists of DGs (DG1,.. DGn). Each DG includes small power generation sources (micro source): solar energy, wind, diesel,...; energy storage system and inverters.

When there is a need for grid expansion, it is difficult for conventional power systems to meet the reliability requirements and diverse needs of electricity users. Furthermore, DGs have the advantage of reducing pollution, flexible installation placement, and reducing power transmission loss. DGs can be controlled easily and are more reliable than traditional power generation sources, so microgrids play an even more important role in maintaining grid stability [1–9]. Microgrid is increasingly providing stronger and more effective support for the traditional power grid [10].

Microgrid and the small power generators are connected on the DC bus, this type of configuration reduces the number of inverters. The energy storage battery helps to stabilize the input voltage of the inverter. Because Microgrid has a common feature that often supplies electricity to remote areas where there is no public power grid, so Microgrid often includes local loads located near areas of energy source (close to the output of the inverter) and concentrated loads (public loads) located in the center of the load and a few hundred meters away from energy sources, usually located at the common AC bus, as can be shown in Figure 1.

Microgrid consists of DGs that are communicated with the grid through inverters, Microgrid is designed so that it can work flexibly in two modes: islanded and grid connection [1–6].

In stand-alone mode, the Microgrid has two important tasks: power sharing between inverters con-

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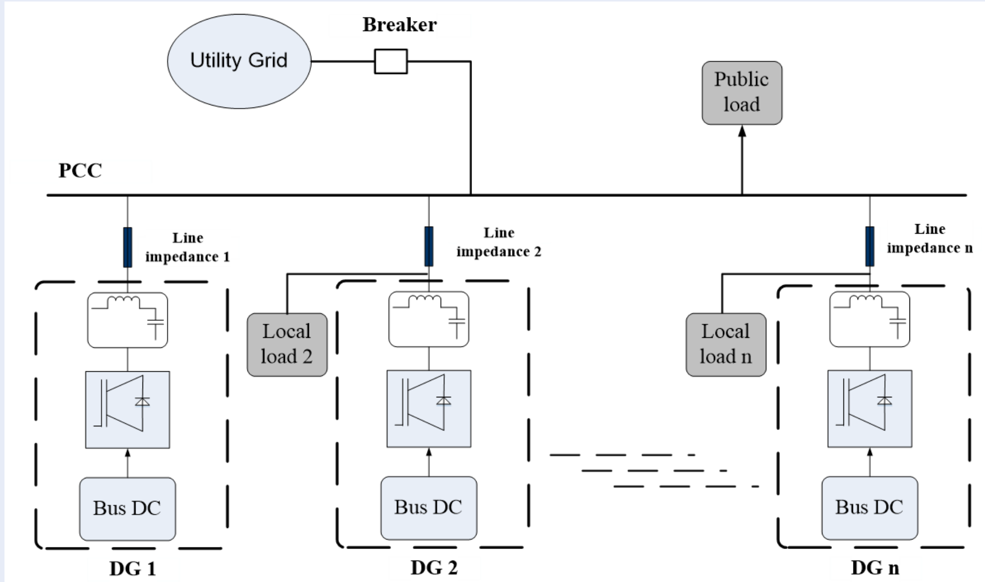

Figure 1: Configuration of Microgrid in DC style

nected in parallel and to maintain voltage and frequency stability.

The inverters in the microgrid can have the same or different rated capacity, and the impedance of the line connecting the inverter to the point of common coupling (PCC) can also be the same or different. Furthermore, in the microgrid there are also nonlinear and unbalanced loads. This fact will cause balanced currents to flow between the inverters, which can damage the inverters [3–13]. The circulating current flowing between the inverters can be illustrated as shown in Figure 2.

In recent years, some researchers have proposed power sharing control techniques by compensating for line voltage drop [6–8]. The purpose of the method is to eliminate impedance deviations of the lines. Power sharing between inverters becomes better. However, this method needs to know the line impedance parameter in advance, which is usually not available.

Besides, some researchers have proposed improved droop power sharing technique using communication. However, the use of communication will reduce the reliability of control, but this proposed method still has no measures to improve the reliability of the controller [9].

In addition, there are also some studies using master/slave control method, this method does not need to know the line impedance parameters in advance. However, this method requires a central controller and high bandwidth communication, which affects the cost of the controller. Even more important is the need to consider the reliability of the controller in the event of a communication bus interruption.

In this paper, a method to improve the traditional droop controller is proposed based on the idea of voltage drop compensation, the purpose of the proposed method is to eliminate the deviation of impedance parameters. Besides, the paper also presents the method to improve the reliability of the proposed controller. As a result, the proposed controller has the following contributions:

• The proposed controller gives accurate power sharing results.

• The controller is easy to use, no need to know the line parameters in advance.

• The controller can divide power well in case the communication bus is interrupted.

PROPOSED CONTROL METHOD

Typically, an independent microgrid has the structure shown in Figure 3. The inverters are connected to a common bus at the point of common coupling (PCC) through the lines. Renewable energy sources, small generators, etc. are concentrated on the DC bus of the inverters. Microgrids typically include local loads and public loads.

Each inverter is considered a power source, the output power of each inverter will supply local loads in that area. The remaining power of the inverter will be transmitted on the line to the common PCC bus to

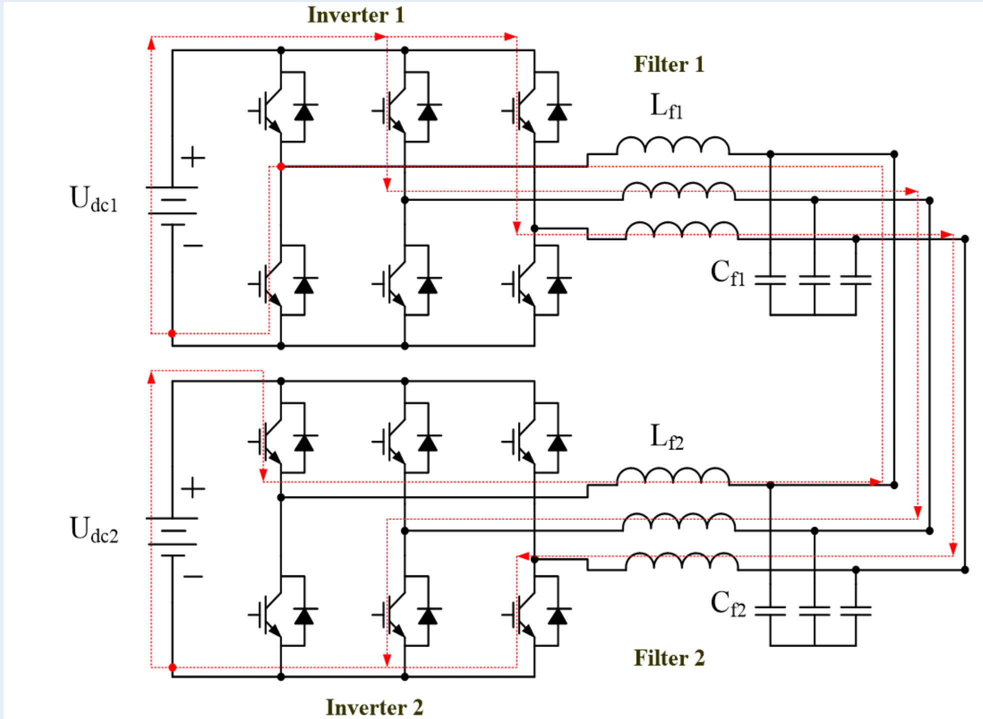

Figure 2: Illustration of the balanced current flowing between two inverters

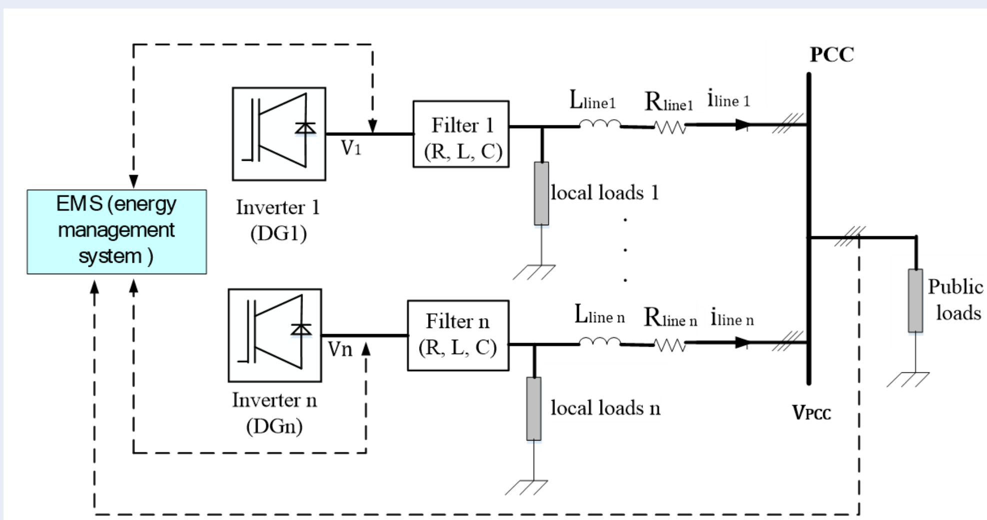

Figure 3: Equivalent diagram of inverters connected in parallel in an independent microgrid

supply public loads or connect to the grid. Because the impedance of the lines can be different and the inverters can also be different. Therefore, control is needed to divide the power between the inverters. The proposed controller needs to use an energy management system (EMS) to regulate the voltage at the output of the inverters, the controller only needs to use low bandwidth communication.

Theoretical basis of the proposed control method

According to research [1–12], the power running on the line is calculated according to the expression :

$$\begin{aligned} \widetilde{S} &= \dot{V}.I^* = \dot{V}.\left(\frac{\dot{V}-\dot{V}_{PCC}}{\dot{Z}}\right) \\ &= Ve^{j\delta_1}\left(\frac{Ve^{j\delta_1}-V_{PCC}e^{j\delta_2}}{Ze^{j\theta}}\right)^* \\ &= \frac{V^2}{2}e^{j\theta} - \frac{VV_{PCC}}{Z}e^{j(\delta_1-\delta_2+\theta)} = P + jQ \end{aligned} \quad (1)$$

From formula (1), we have the expression to calculate real power and reactive power running on the line:

$$\begin{cases} P = \frac{V^2}{Z}\cos\theta - \frac{VV_{PCC}}{Z}\cos(\theta+\delta) & (2) \\ q = \frac{V^2}{Z}\sin\theta - \frac{VV_{PCC}}{Z}\sin(\theta+\delta) & (3) \end{cases}$$

In there:
R(Ω) and X(Ω) are impedance parameters of the line.
V(voltage) is the voltage at the beginning of the line.
P(W) and Q(Var) are the powers running on the line.
V_{PCC}(voltage) is the voltage at the PCC.
δ is the phase difference angle of the voltage V anh V_{PCC}: $\delta = \delta_1 - \delta_2$
$\dot{Z} = Ze^{j\theta}$ = R + jX
Substitute the following expressions into (2) and (3): $cos\theta = \frac{R}{Z}$, $sin\theta = \frac{X}{Z}$
Combining equations (2) and (3), we have:

$$P = \frac{V}{R^2+X^2}\times [R(V - V_{PCC}\cos\delta) + XV_{PCC}\sin\delta] \quad (4)$$

$$Q = \frac{V}{R^2+X^2}\times [-RV_{PCC}\sin\delta + X(V - V_{PCC}\cos\delta)] \quad (5)$$

Combining equations (4) and (5), we have:

$$\sin\delta = \frac{XP-RQ}{VV_{PCC}} \quad (6)$$

$$V - V_{PCC}\cos\delta = \frac{RP+XQ}{V} \quad (7)$$

The actual angle between the output voltage of inverters and PCC bus voltage d is a small value, so sind≈d and cosd=1, X>>R, from equation (6) and (7) we have:

$$\delta = \frac{XP}{VV_{PCC}} \quad (8)$$

$$V - V_{PCC} = \frac{XQ}{V} \quad (9)$$

Equations (8) and (9) show that: P depends on frequency f, Q depends on voltage V. From there, we can establish P/f and Q/V droop controller to control the power of the inverters as follows:

$$\begin{cases} \omega = \omega_0 - m_pP & (10) \\ V = V_0 - m_qQ & (11) \end{cases}$$

Where:
V_0 is the nominal amplitude voltage.
ω_0 is the nominal frequency.
V is the measured amplitude voltage of the inverter
ω is the measured frequency of the inverter
P_0 is the nominal active power of the inverter.
Q_0 is the nominal reactive power of the inverter.
m_p and m_q are the droop coefficients, which are calculated as follows:

$$m_p = \frac{\omega_0 - \omega_{min}}{P_{max}}\ ;\ m_q = \frac{V_0 - V_{min}}{Q_{max}} \quad (12)$$

From the above equations, it is shown that a very small change in line impedance will have a large effect on the transmit power of the inverters. Analysis and simulation results in the study [11–20] show that the impedance of the cable line or the impedance of the overhead line has little effect on the transmit power of a separate inverter, but it has a great impact on many parallel connected inverters in the Microgrid. In practice, the Microgrid consists of inverters connected in parallel, which are connected to the load via a long line, and it is clear that the line impedance significantly affects the control quality of the system and can lead to system instability, a drop in voltage by the impedances causes a bias in the output power control of the inverters.

When the microgrid is in a stable state, the inverters in the microgrid will operate at the same frequency, so the power P of the inverters is almost not affected by the line impedance parameter. However, the power Q of the inverters depends on the voltage drop of the line, so the power Q is significantly affected by the line impedance parameter.

The presence of local loads stuck at the output of inverters is also the cause of deviations in reactive power sharing between inverters in an islanded microgrid.

Deviations in line impedance parameters cause deviations in reactive power division. This problem can be explained by the following equation and figure:

$$V = V_{PCC} + \frac{Q.X}{V} \tag{13}$$

Combining expressions (11) and (13) we get Figure 4. Consider two inverters with the same rated capacity, connected to the PCC point through two lines with different impedances.

Because the two inverters are the same, the Q/V droop controllers for these two inverters are also the same, they are determined according to (11) and (12). The curve droop Q/V (11) and (12) are also shown in Figure 4.

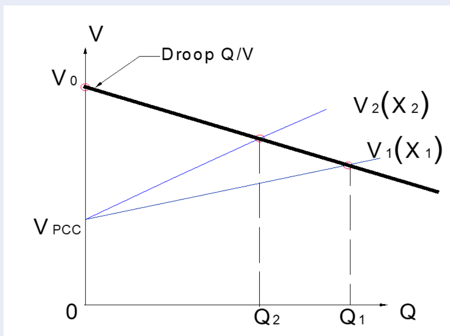

Figure 4: The curve shows the change of reactive power according to line impedance

Figure 4 shows that, assuming there are two inverters with the same rated power so the droop Q/V characteristic curve is the same, they are connected to the PCC point by two different lines so the voltage characteristic curve of The two inverters are also different. As a result, the power Q generated at the output of the two inverters is also different.

The proposed controller

The graph of droop Q/V in (11) has a slope that depends on (12). When the slope (12) changes, the shared reactive power will change.

Therefore, in this paper, a control method is proposed to change the slope of the droop Q/V characteristic curve to reduce the error in dividing reactive power between inverters.

For the conventional Droop controller, the slope m_q is fixed according to (12), and the slope m_q in the proposed controller is adjustable.

The proposed controller has a diagram in Figure 5.

The proposed controller includes the following blocks:

- Power calculation block and low pass filter: This block measures the voltage at the output of the inverter and the current on the line, then calculates the power and low-pass filters, the output of this block is the power P and Q.
- The proposed droop control block is implemented according to equations (10), (16) and (17). This block is presented in detail in section (b). The output of this block will generate a reference voltage for the voltage at the output of the inverter.
- Voltage and current controller to control the voltage and current at the inverter output according to the reference value.

Power calculation and low pass filtering

The instantaneous power p and q are calculated according to the instantaneous value of the current flowing on the line (i_2) and the voltage at the beginning of the line (v_c) in a stationary dq0 frame:

$$p = \frac{3}{2}\left(i_{2d}v_{cd} + i_{2q}v_{cq}\right) \tag{14}$$

$$q = \frac{3}{2}\left(i_{2d}v_{cq} - i_{2q}v_{cd}\right) \tag{15}$$

The proposed controller

In this paper, the proposed controller is presented in detail in Figure 6, this is an improvement from the traditional Droop controller. For the traditional Droop controller, the slope m_q is fixed, while the slope m_q in the proposed controller is adjustable. The slope m_q is adjusted for load changes through the energy management system (EMS). This is shown in formulas (16) and (17).

At the same time, to improve the reliability of the proposed controller in case the communication link is lost, the proposed controller is equipped with additional logic gates as shown in Figure 6.

The power P of the inverters is almost not affected by the line impedance parameter. However, the power Q of the inverters is significantly affected by the line impedance parameter. Therefore, sharing power P to the inverters is still done according to expression (10). However, the Droop Q/V equation (11) for reactive power sharing is improved as follows:

$$V = V_0 - \left(m_q + \triangle m_q\right) Q \tag{16}$$

The equation (16) shows that the slope m_q in (11) is adjusted by an amount Δm_q.

Where:

$$\triangle m_q = k_p \int \left(Q - Q^*\right) dt \tag{17}$$

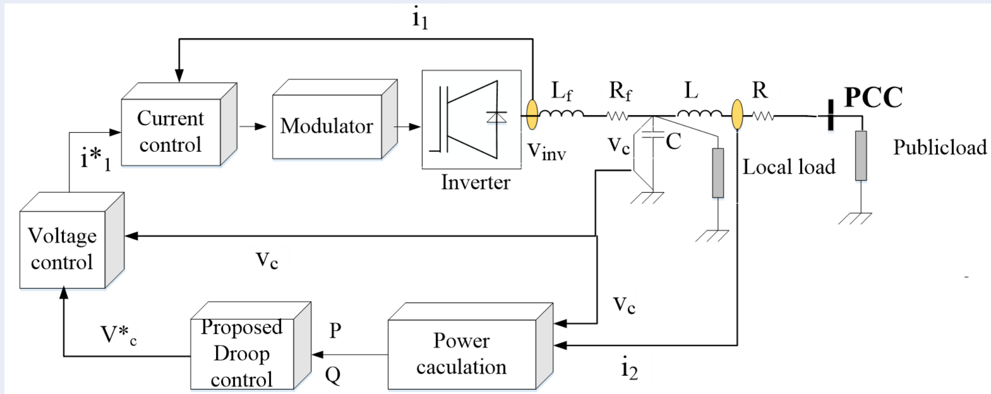

Figure 5: Schematic diagram of the proposed controller

The Δm_q in equation (16) is corrected by adjusting the Q value through the energy management system (EMS).

The EMS collects information about the reactive power Q of each incoming inverter.

On the other hand, the EMS also relies on the load power consumption to calculate the reference Q^* power value for each inverter. After that, the EMS will send the reference power value Q^*back to each inverter, this reference power Q^* is fed into the controller in equation (17) to adjust the slope of the Q/V droop curve. This helps divide power between inverters more accurately.

Depending on the technical specifications of the communication network, we choose the speed of information collection from the inverters sent to EMS or the reference power calculation results from EMS sent back to the inverter.

The reference reactive power value Qi* is also adjusted to vary according to the load. Therefore, each inverter also adjusts its reference value according to changes in load. This means that the slope adjustment of the droop Q/V characteristic curve is also changed according to the load. So the accuracy of power sharing is better.

In case of communication disconnection, the controller still operates with the last adjusted value, due to the use of the integration step in expression (17) and the logic gates in Figure 6, this process is still maintained until communication is reconnected. Therefore, if during the time the communication connection is lost but the load does not change, the power sharing is still guaranteed to be accurate. In case the load changes while communication is disconnected, the sharing error is still acceptable, the power sharing result is still better than the traditional droop controller.

The receiver has the ability to detect communication timeouts. In case of communication loss, the logic gate block will disable the control loop and the reference voltage at the controller output is kept constant. change until communication is restored. In case of communication delay, EMS detects communication timeout from inverters, it will block further data updates to all inverters until communication is restored.

The proposed controller for exact power sharing and improved reliability is shown in Figure 6, it consists of formulas (10), (16), (17), and logic gates.

Design a current and voltage controller

Based on the equivalent circuit shown in Figure 7, we set up these controllers.

Where:

R (Ω) And L (H) are resistor and inductance of the line

R_f (Ω) and L_f (H) are resistor and inductance of the filter (H).

Applying Kirchhoff's laws to the circuit of Figure 7, we have the following equations:

$$\begin{cases} i_1 = i_2 + C\frac{dv_c}{dt} + i' & (18) \\ v_{inv} = L_f\frac{di_1}{dt} + R_f i_1 + v_c & (19) \end{cases}$$

Equations (18) and (19) can be written as:

$$\begin{cases} i_{1d} = i_{2d} + C\frac{dv_{cd}}{dt} - \omega C_{cq} + i'_d & (20) \\ i_{1q} = i_{2q} + C\frac{dv_{cq}}{dt} + \omega C_{cd} + i'_q & (21) \end{cases}$$

$$\begin{cases} v_{invd} = L_f\frac{di_{1d}}{dt} + R_f i_{1d} - \omega L_f i_{1q} + v_{cd} & (22) \\ v_{invq} = L_f\frac{di_{1q}}{dt} + R_f i_{1q} - \omega L_f i_{1d} + v_{cq} & (23) \end{cases}$$

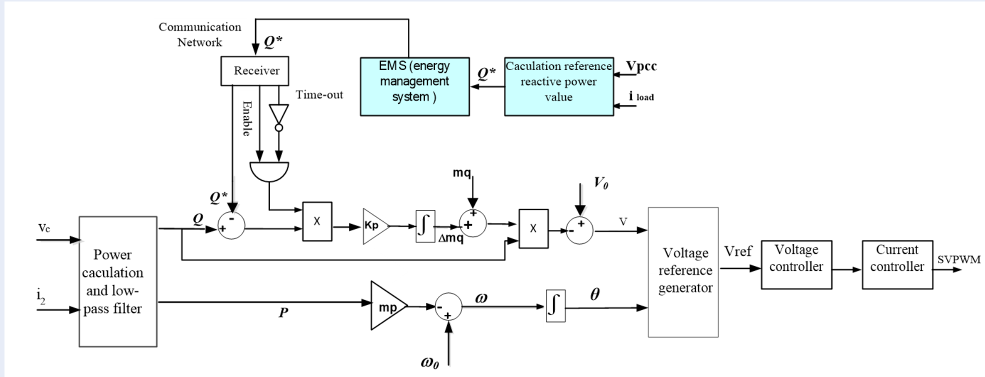

Figure 6: Block diagram of proposed Droop control for an inverter

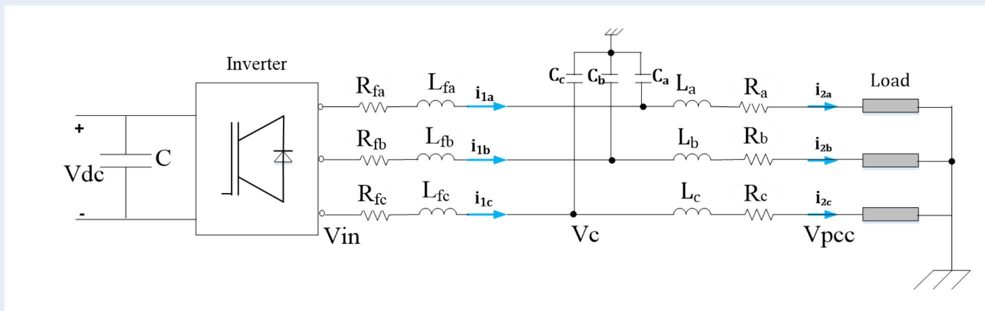

Figure 7: Equivalent schematic of inverters connected to a load.

Based on expressions (20) and (21) we can set up the voltage controller:

$$\begin{cases} i_{1d} = i_{2d} + C\frac{dv_{cd}}{dt} - \omega C v_{cq} + i_d^{'} \quad (24) \\ \quad\quad = \triangle i_d + i_{2d} - \omega C v_{cq} + i_d^{'} \\ i_{1q} = i_{2q} + C\frac{dv_{cq}}{dt} - \omega C v_{cd} + i_q^{'} \quad (25) \\ \quad\quad = \triangle i_q + i_{2q} - \omega C v_{cd} + i_q^{'} \end{cases}$$

Where:

$$\begin{cases} \triangle i_d = k_{pv}\left(v_{cd}^{*} - v_{cd}\right) + k_{iv}\int\left(v_{cd}^{*} - v_{cd}\right)dt \ (26) \\ \triangle i_q = k_{pv}\left(v_{cq}^{*} - v_{cq}\right) + k_{iv}\int\left(v_{cq}^{*} - v_{cq}\right)dt \ (27) \end{cases}$$

Equations (24) to (27) are for the voltage controller. Based on expressions (22) and (23) we can set up the current controller:

$$\begin{cases} v_{invd} = L_f\frac{di_{1d}}{dt} + R_f i_{1d} - \omega L_f i_{1q} + v_{cd} \\ \quad\quad = \triangle v_d - \omega L_f i_{1q} + v_{cd} \quad\quad (28) \\ v_{invq} = L_f\frac{di_{1q}}{dt} + R_f i_{1q} - \omega L_f i_{1d} + v_{cq} \\ \quad\quad = \triangle v_q - \omega L_f i_{1d} + v_{cq} \quad\quad (29) \end{cases}$$

Where:

$$\begin{cases} \triangle v_d = k_{pi}\left(i_{1d}^{*} - i_{1d}\right) + k_{ii}\int\left(i_{1d}^{*} - i_{1d}\right)dt \ (30) \\ \triangle v_q = k_{pi}\left(i_{1q}^{*} - i_{1q}\right) + k_{ii}\int\left(i_{1q}^{*} - i_{1q}\right)dt \ (31) \end{cases}$$

Equations (28) to (31) are for the current controller.

SIMULATION RESULTS AND DISCUSSION

Simulate power control for a microgrid consisting of three inverters connected in parallel using Matlab/simulink software. Simulations are performed by the conventional controller and the proposed controller to compare the results. Simulation parameters are given in Table 1.

Case 1:

Perform power sharing simulation for three inverters in an independent microgrid. To show the effectiveness of the proposed controller, we perform simulations using two controllers (traditional Droop controller and proposed Droop controller) and compare their results.

Rated power ratio 1:1:1

Figure 8a shows that the active power sharing has negligible error, because the active power is not affected by the line impedance, the active power sharing result is exactly according to the ratio of rated power 1:1:1 of

Table 1: Simulation Parameters

Parameters	Values	Parameters	Values
DC link voltage V_{cd} (V)	600	Nominal frequency f_0 (Hz)	50
Filter L_f (mH)	4.2	Nominal power (kVA)	4
Filter R_f (Ω)	0.1	Nominal voltage $V_{AC,p}$ (V)	310
Filter C (μF)	2.2	m_q (V/Var)	1.05e-4
f_z(kHz)	10	m_p (rad/s /W)	1e-4
k_{pv}	0.1	k_{pi}	10
K_{iv}	0.05	k_{ii}	1
Line impedances			
L_1(mH)	1	R_1(Ω)	1.2
L_2(mH)	0.8	R_2(Ω)	0.9
L_3(mH)	0.5	R_3(Ω)	0.7

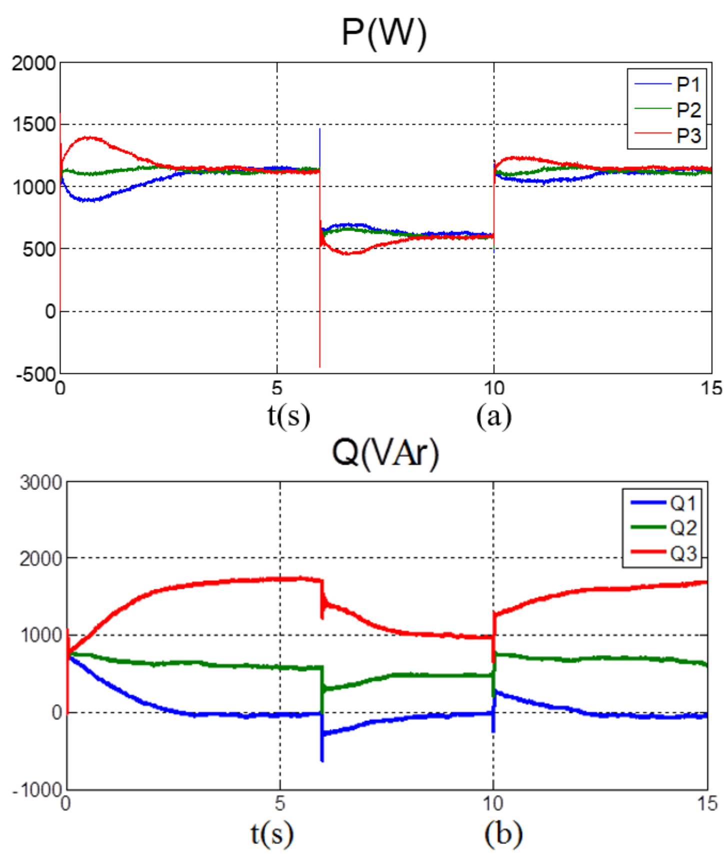

Figure 8: Simulation of power sharing using traditional Ddrop control (a) the active power sharing among three inverters; (b) the reactive power sharing among three inverters

them. Figure 8b shows that the reactive power sharing has a very large error, because the reactive power is affected by the very large line impedance, the result of reactive power sharing is not correct according to the ratio of rated power. of them. Therefore, the traditional drop controller needs to be improved in the case of different transmission line impedances.

Figure 9a and 9b show that the active and reactive power of the three inverters are exactly in the ratio 1:1:1, although there are differences in line impedances and local loads. The deviation in power sharing is negligible and ensures voltage quality in the microgrid (V_{PCCmin} = 307.5V).

Figure 10a shows when we performed with a conventional Droop controller, the current on phase a of the inverters was out of phase and their amplitude was not equal. Figure 10b shows when we performed with the proposed controller, the current on phase a of the inverters is overlapped together and their amplitude was equal. Because the proposed controller adjusts the slope of the droop Q/V characteristic curve, the deviation of line impedances and local loads is eliminated.

Rated power ratio 2:1:

This case performs power-sharing for 2 inverters with a ratio of 2:1 using the proposed controller. Simulation results: power-sharing and voltage at the PCC are presented in Figure 11.

Figure 11a and 11b show that the power of the two inverters is divided exactly according to the rated power ratio of 2:1, even though the line impedance is different and the load changes. At time t=2.5s the load changes but the reactive power is still divided in the correct 2:1 ratio and there is a negligible deviation. The quality of voltage supplied to the load is within allowable limits.

Case 2:

Simulate power sharing for three inverters connected in parallel in the microgrid using the proposed controller, the rated power of the two inverters is in the ratio 1:1:1. Suppose communication is lost at 3s and restored at 8s, the load changes during this period. Simulation results are shown in Figure 12.

Simulate power sharing for 3 inverters with rated power in the ratio 1:1:1 using the proposed controller in case of communication loss.

In 0-3 seconds, the communication bus is connected; within 3-8 seconds, the communication bus is disconnected; After 8 seconds communication is reconnected; The load capacity drops at 5s.

Figure 10a shows that, within a period of 0-3 seconds, the communication is connected and the proposed controller has performed a correct reactive power sharing in the ratio 1:1:1.

The communication bus is interrupted for a period of 3 seconds to 8 seconds. However, during the period from 3s to 5s, the load does not change so the accuracy in power sharing is still maintained. At 5s, the load starts to change and communication fails, so the power sharing result in the time period from 5-8s has errors, although the power sharing has deviations during this time period, the error is share is still lower than the results in Figure 8b.

At 8 seconds, communications are reconnected, and power sharing is now correct. Figure 12b shows that the current in phase a of the lines before and after the communication bus stops working is still well maintained.

CONCLUSION

This paper has proposed an improved power control method, which overcomes the disadvantages of the traditional method. The simulation results show that the proposed method gives accurate power sharing results in situations that often occur in practice, and the quality of voltage supplied to the load is satisfactory. The proposed controller is easy to implement, does not need to know exact line impedance parameters, is highly reliable, and is suitable for practical conditions.

CONFLICT OF INTEREST

There is no conflict of interest regarding this manuscript.

AUTHORS' CONTRIBUTION

Xuan Hoa Thi Pham have writen this entire paper.

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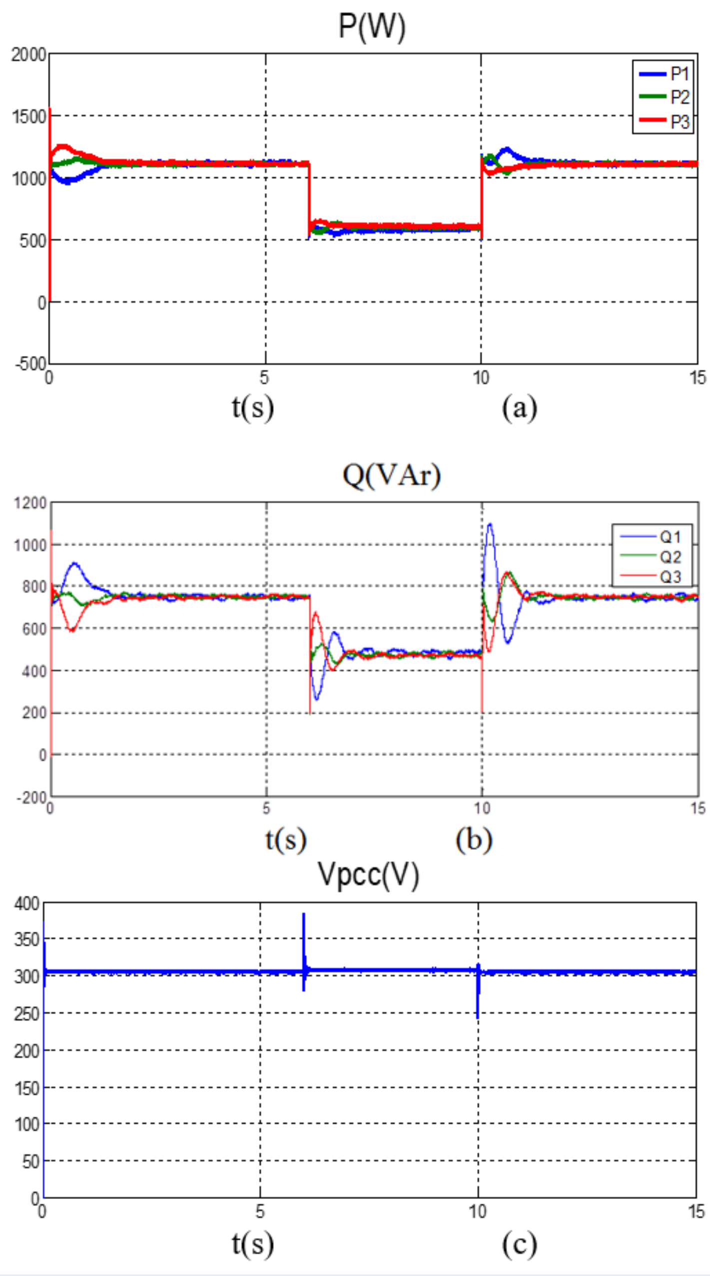

Figure 9: Simulate power sharing using proposed Droop control(a) the active power sharing among three inverters; (b) the reactive power sharing among three inverters; (c) Voltage at the PCC.

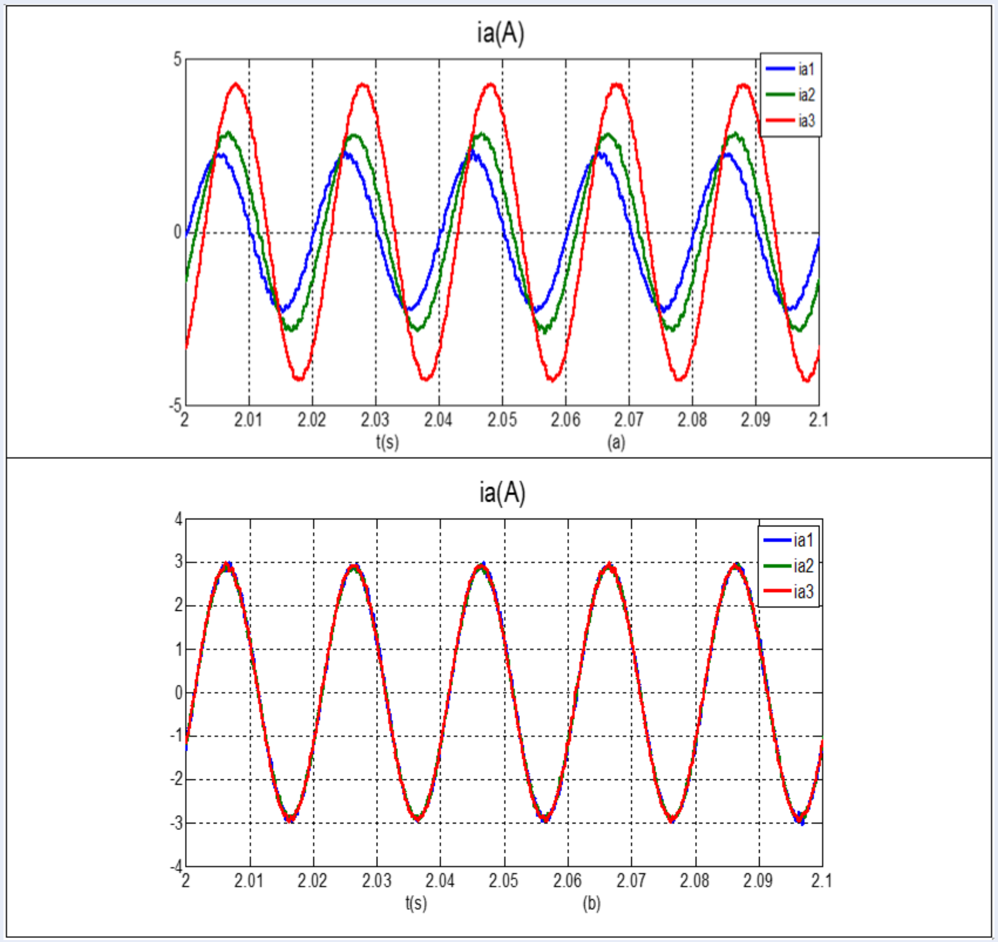

Figure 10: Current on line a of three inverters, (a) Using traditional Droop controller, (b) Using proposed controller

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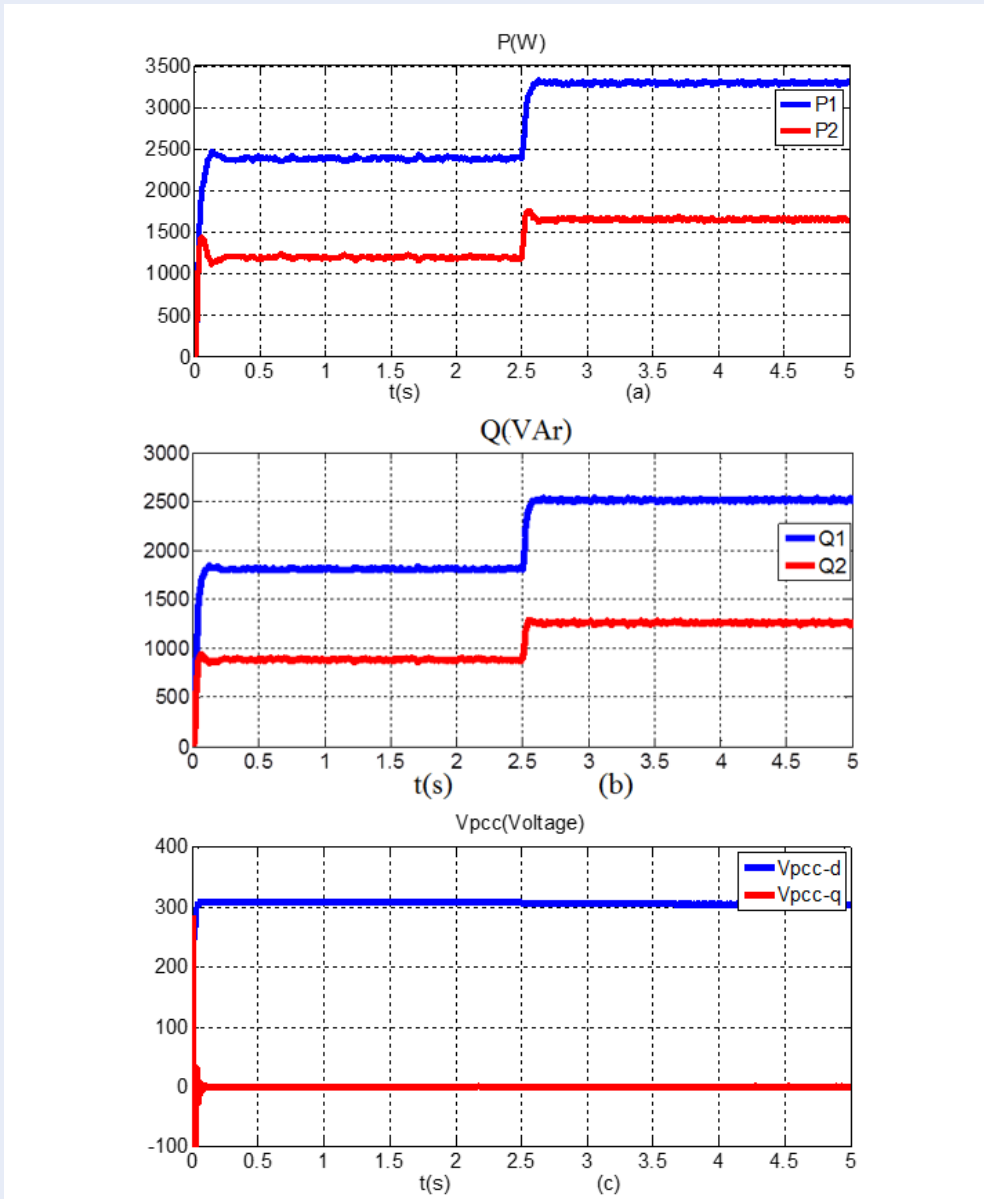

Figure 11: Simulate power sharing usingproposed Droop control(a) the active power sharing among two inverters; (b) thereactive power sharing among two inverters; (c) Voltage at the PCC.

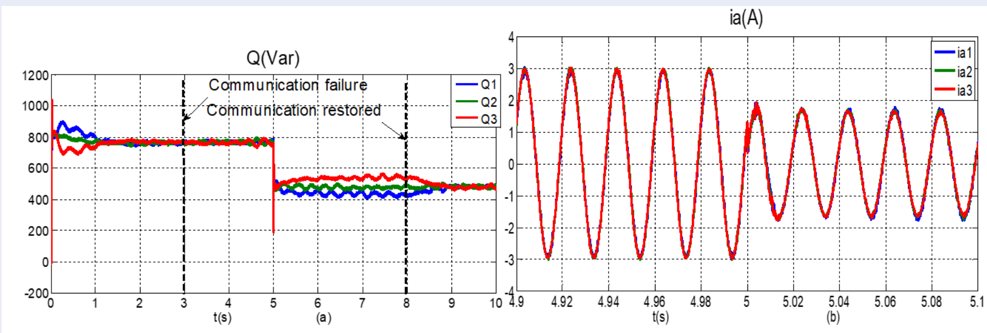

Figure 12: Simulate power sharing using proposed Droop control in case the communication is lost (a) the active power sharing among three inverters; (b) the reactive power sharing among three inverters

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Bài nghiên cứu

Điều khiển công suất của bộ nghịch lưu kết nối song song trong lưới điện siêu nhỏ

Phạm Thị Xuân Hoa*

TÓM TẮT

Microgrid có thể hoạt động ở chế độ kết nối lưới hoặc chế độ độc lập. Các bộ nghịch lưu trong microgrid được coi là nguồn phát điện xoay chiều, chúng thường được kết nối song song để nâng cao hiệu suất truyền tải điện. Khi microgrid hoạt động ở chế độ độc lập, nó phải ổn định điện áp và tần số của mình. Điện áp và tần số của microgrid phụ thuộc vào công suất đầu ra của các bộ nghịch lưu. Do đó, để tránh xảy ra hiện tượng dòng điện cân bằng lưu thông giữa các bộ nghịch lưu, các bộ nghịch lưu phải được điều khiển để chia sẻ công suất đầu ra của chúng. Bài báo này đề xuất một phương pháp điều khiển để chia sẻ công suất đầu ra cho các bộ nghịch lưu được kết nối song song trong Microgrid, đồng thời cải thiện độ tin cậy của bộ điều khiển được đề xuất trong trường hợp bus truyền thông bị gián đoạn hoặc chậm trễ. Ngoài ra, bộ điều khiển được đề xuất dễ triển khai và không bị ảnh hưởng bởi các tham số trở kháng đường dây. Trọng tâm của bài viết này là nâng cao độ chính xác cho việc chia sẻ công suất của các bộ nghịch lưu kết nối song song trong microgrid nhằm tránh dòng điện cân bằng chạy quẩn trong các bộ nghịch lưu, dòng điện này sẽ làm nóng bộ nghịch lưu và có thể dẫn đến hư hỏng bộ nghịch lưu. Bên cạnh đó, phương pháp đề xuất còn cải tiến để nâng cao độ tin cậy cho bộ điều khiển. Bộ điều khiển vẫn hoạt động và cho kết quả tốt ngay khitruy ền thông bị gián đoạn, nếu trong khoảng thời gian sự cố truyền thông mà công suất tải thay đổi thì bộ điều khiển đề xuất sẽ cho kết quả chia công suất kém chính xác hơn so với khi bình thường, nhưng kết quả này vẫn tốt hơn nhiều khi so sánh với các bộ điều khiển thông thường. Bộ điều khiển đề xuất được mô phỏng cho microgrid có ba bộ nghịch lưu kết nối song song bằng phần mềm Matlab/Simulink để kiểm chứng tính phù của phương pháp đề xuất. Phương pháp đề xuất có thể áp dụng cho microgrid phức tạp gồm nhiều bộ nghịch lưu kết nối song song với nhiều nguồn phát công suất.

Từ khoá: Điều khiển điện áp, chia sẻ công suất, điều khiển microgrid, bộ nghịch lưu kết nối song song, điều khiển tần số

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