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GaN Photovoltaic Inverter Used in Solar Grid Connection

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Abstract

This paper presents a solution based on a new GaN device photovoltaic inverter for grid-connected solar power systems. This PV inverter uses the many advantages of GaN semiconductor devices to convert the solar energy in the PV cell set to the grid or to the end-use of the power equipment by using the latest technologies such as maximum power point tracking and detection and grid connection, which greatly improves the conversion efficiency, in addition to the advantages of clean and efficient.

Keywords

Photovoltaic Inverter, Gan, Solar Grid-Connected.

1. Introduction

In recent years, problems such as energy crisis and air pollution have become increasingly prominent. Green and clean energy such as solar energy has received more and more attention from energy experts. Photovoltaic power generation has increasingly become a new type of power generation and comprehensive energy utilization. With the continuous development of solar photovoltaic technology, photovoltaic grid-connected power generation systems have made great progress in terms of high power density, high reliability, and low cost. Photovoltaic power generation advocates the principles of nearby power generation, nearby grid connection, nearby conversion, and nearby use. Effectively solve the problem of power loss in boosting and long-distance transportation.

The grid-connected inverter converts the low DC power output by the photovoltaic cell into a high-frequency alternating current with the same frequency and phase as the grid voltage, fully playing its role in photovoltaic power generation and then integrating it into the grid. It is the entire photovoltaic grid-connected system The core part is also the key to grid-connected power generation, and its performance directly determines the efficiency and cost of the power generation system. Compared with traditional silicon (Si) semiconductor devices, GaN wide-bandgap semiconductor devices have many irreplaceable advantages, including wide band gap width, higher electron migration speed, higher critical breakdown electric field strength and better reliability Performance and so on, so GaN semiconductor devices have a higher conversion speed, and wide band gap semiconductor devices will be more suitable for use in systems with high frequency requirements, high power density and high efficiency. Therefore, this paper proposes a gallium nitride (GaN) photovoltaic inverter applied to solar grids to obtain more superior energy conversion efficiency.

This paper first discusses the classification of traditional inverters, and compares the advantages and disadvantages of centralized, string and micro grid-connected inverters. Secondly, in response to these shortcomings, the proposed emerging GaN devices can significantly reduce the loss of electrical energy conversion and help increase the total energy collected. They can be used to improve photovoltaic systems and have broad application prospects.

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2. Inverter Classification

Photovoltaic inverters can be divided into independent photovoltaic system inverters and grid-connected photovoltaic system inverters according to the isolation mode. Independent photovoltaic system inverters are independent power generation systems with batteries, such as rural electrification, solar user power systems, photovoltaic products, etc. Grid-connected photovoltaic system inverter converts solar radiation energy absorbed by photovoltaic modules into high-voltage direct current, which is converted into alternating current after being inverted by the inverter, and then transmits the same frequency and sinusoidal alternating current to the power grid.

Solar photovoltaic power generation system can be classified into centralized high-power inverter system, group series inverter system and micro grid-connected inverter system according to the different composition of solar photovoltaic cell array and power generation.

Centralized power system is mainly used in large photovoltaic power station and large area roof, ground investment cost is larger, between components and the inverter with high direct current voltage, low energy conversion efficiency and the whole system can produce hot spots, site selection, difficulties, poor flexibility system, build and repair inconvenience, large-scale promotion is difficult.

Table 1. Comparison of advantages and disadvantages of centralized, group series and micro grid-connected inverters

Inverter category	Centralized high power inverter	Group series inverter	Micro grid-connected inverter
Advantages	1. High system power. 2. Suitable for large photovoltaic power stations with uniform illumination. 3. High product and technology maturity. 4. The cost is low.	1. It is not affected by module difference and shading between groups. 2. Compared with the centralized inverter, the design is more flexible and the energy conversion efficiency of the system is improved, but the efficiency is not as good as that of the micro-grid-connected system. 3. Mature products, easy installation and maintenance.	1. Effectively reduce the waste caused by component mismatch and hot spot effect. 2. Each component realizes independent MPPT, with greater power generation. 3. Small size, easy installation and maintenance.
Disadvantages	1. Battery mismatch exists. 2. Hot spot phenomenon. 3. Poor scalability.	1. The power generated by each solar panel module cannot be controlled separately.	1. High price. 2. It has a great impact on power grid harmonics. 3. Reliability needs to be inspected.

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Group series inverter system: The group series inverter system is composed of a group with a grid-connected inverter[2]. Each photovoltaic string passes through an inverter, which has a MPPT at the direct current end and is connected to the grid in parallel at the alternating current end. The system is mainly used in urban distributed generation and household grid-connected generation[3]. Compared with the centralized power generation system, the design of the system is more flexible, and the energy conversion efficiency of the system is also improved, but the efficiency is not as good as the micro grid-connected inverter system.

Micro grid-connected inverter system: the micro grid-connected inverter system is to configure each photovoltaic module into a converter module with independent MPPT function. Through the micro inverter, the output electric energy of the panel is directly converted into alternating current power, which is incorporated into the power grid. In the future, photovoltaic power inverter equipment will tend to develop in the direction of high frequency, small volume, intelligent networking, because of its high power generation efficiency, easy production, convenient installation, flexible networking and many other advantages, will be one of its main development direction.

Centralized high power inverter and micro inverter are two main development directions of photovoltaic grid-connected power generation inverter technology[4]. Centralized high-power inverter system cannot solve the problem of shadow occlusion, so the total power generation is low. The micro inverter has a significant advantage is to solve the problem of shadow occlusion of solar panels, and easy to install, each photovoltaic module to achieve independent MPPT, more power generation. However, it also has some outstanding problems, such as high price, great influence on harmonic of power network and reliability inspection.

3. Gan Inverter in Solar Power Grid Advantages

Photovoltaic power generation is a new energy generation method in China, which mainly uses solar modules to collect solar energy and store it as direct current, grid-connected inverter is used to invert the low DC power output by photovoltaic cells into ac power with the same frequency and phase as the grid voltage. grid-connected inverter is used in related areas to directly supply the power output to users. Solar grid-connected power generation system includes centralized large-scale grid-connected power stations, which are generally national-level power stations. The main characteristic is that the power generated can be directly transferred to the power grid, and the power grid can supply power to users uniformly.

The development and utilization of solar energy resources to build photovoltaic grid-connected power generation system and the development of solar energy technology and industry is an important part of China's development of green energy [5]. In the solar photovoltaic power generation system, the solar panels are stored by direct current through the photoelectric effect, and the dc voltage is converted into the AC voltage that meets the power quality standard by the inverter to connect to the power grid. Power switching device is an important part of photovoltaic inverter system, the efficiency of the product volume and life of the inverter are directly affected by its power loss switching frequency and reliability. Taking photovoltaic grid-connected inverters in the photovoltaic power generation industry as an example, the improvement of photovoltaic product efficiency will have greater competitiveness. Therefore, we consider adopting new devices to reduce losses.

Emerging GaN devices reduce the loss of power conversion and contribute to increasing the total energy collected, which has great potential to be used to improve photovoltaic systems. Power electronics with GaN isolators can increase the efficiency of solar microinverters and series inverters to more than 98%. GaN inverter has obvious advantages in solar energy grid connection, which attracts more and more people's attention. Reference [6] proposed a GAN-based H5 grid-connected photovoltaic inverter. This inverter makes full use of the characteristics of new GaN material, improves energy efficiency while reducing common-mode current, and has potential economic value. Literature [7] analyzes the performance of GaN three-level inverter based on photovoltaic applications. The converter improves energy efficiency while reducing the volume. Reference [8]

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shows that gallium nitride (GaN) transistors applied to microinverters can reduce the thermal management requirements. When the converter is running at 200W, the efficiency is improved by 4%, which means that the heat dissipation in active devices is reduced by 8W. Literature [9] proposed an improved transformerless topology derived from H5 inverter. Compared with Si IGBT based inverter, GaN HEMT based inverter has lower power loss and an efficiency improvement of more than 5%, proving the effectiveness of the proposed inverter for grid-connected photovoltaic applications.

4. Summary and Outlook

Not used in traditional solar photovoltaic power generation systems, power electronic equipment with GaN can significantly improve the efficiency of solar micro-inverters and string inverters, which will provide energy-saving and efficient photovoltaic grid-connected power generation systems in the next few years solution. More than that, in the future, in the automotive industry, gallium nitride is also becoming the preferred technology for power conversion and battery charging in the field of new energy vehicles. GaN-based power products are also increasingly appearing in inverters used in solar power generation devices, as well as in motor drives and other industrial power conversion solutions.

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