A Dual-Buck–Boost AC/DC Converter for DC Nanogrid With Three Terminal Outputs

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Abstract

Due to the widely used dc characterized loads and more distributed power generation sources, the dc nanogrid becomes more and more popular, and it is seen as an alternative to the ac grid. For safety considerations, the dc nanogrid should provide reliable grounding for the residential loads such as the low-voltage ac power system. There are three typical grounding configurations for a dc nanogrid: the united grounding, the unidirectional grounding, and the virtual isolated grounding .Each grounding configuration has its own specifications to ac/dc converters. In this paper, a dual-buck–boost ac/dc converter for use in the united-grounding configuration based dc nanogrid wt three terminal outputs is proposed.The working principle of this converter is presented in detail through analyzing the equivalent circuits. Experiments are carried out to verify the theoretical analysis.

IndexTerms —AC/DCconverter,buck–boost,dcnanogrid, grounding

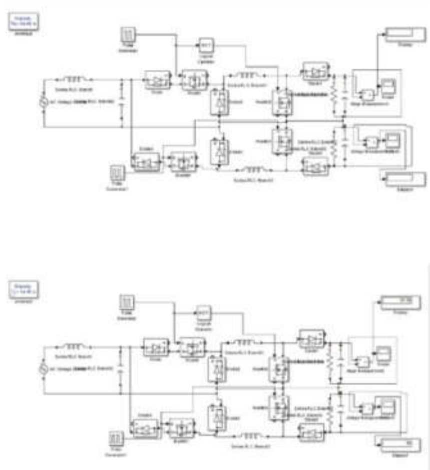
INTRODUCTION

In this paper, THE distributed power generation is becoming more and more attractive due to the long-term lack of energy and the environmental problems caused by the fossil energy. A large number of distributed generation systems, such as photovoltaic systems, are today connected into the ac power system, where they can cause problems such voltage rise and also issues related to protection. Furthermore, more and more loads show dc characteristics, for example, LED lightings, computer power supplies, and variable-frequency-technique-based household electrical appliances. The dc nanogrid may be a good solution to solve the voltage rise and protection problems of the conventional ac power system and can dismiss the traditional ac/dc converters for dc characterized loads, which may result in reduced power losses and material savings. Recently, research on dc nanogrid gets more and more concern, especially for the control of ac/dc topologieswhich are theconnections between the dc nanogridand the traditional ac power system. It should be pointed out that when designing the ac/dc converters for dc nanogrids, the grounding configuration needs to be addressed , since it determines the costs, the flexibility of the installation, and the efficiency of the dc nanogrid system. This paper analyzes first three grounding configurations of the dc nanogrid. Then, a dual-buck–boost ac/dc converter is proposed, which will facilitate the applications of the dc nanogridwith three terminal outputs. Also, theoretical analysis of the proposed converter will be given, as well as experimental verifications are carried out.

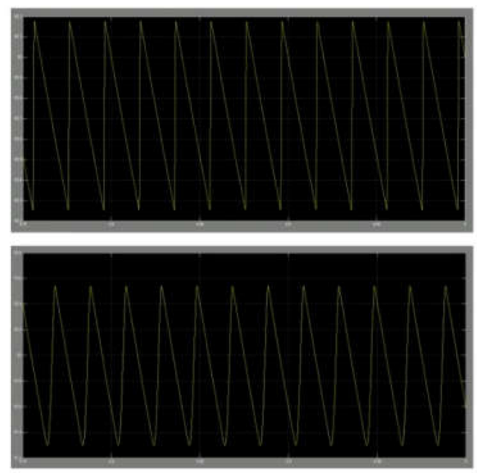
PROPOSEDSYSTEM

Traditionally, the dc nanogrid is connected into the ac power system with bidirectional ac- dc converters, which allows extra dc power to be injected back into the ac power system. In some areas, due to the high population density, the distributed power generally cannot meet the demand of the local loads, so the connection between the ac power system and the dc nanogrid can besimplified to be a power factor correction circuit. In ac/dc converters were reviewed and compared. However, suitable ac/dc converters for the united-grounding-configurationbaseddc nanogridapplicationwere not introduced. In this paper, a new ac/dc converter is proposed.

SIMULATION CIRCUIT DIAGRAM:



SIMULATION OUTPUT:

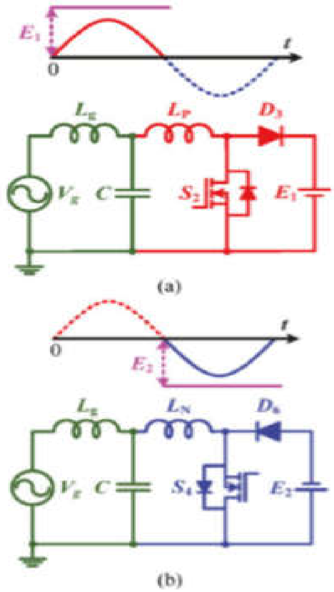


EXISTING SYSTEM

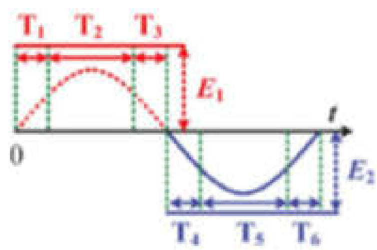
The proposed ac/dc converter as the connecting converter between three-level voltage dc nanogrid and the lowvoltage ac power system. The proposed converter has a vertical symmetry structure. During the positive period of the ac voltage, the devices in red work while the devices in black are OFF. During the negative period of the ac voltage, the devices in black work while the devices in red are OFF. When the proposed ac/dc converter is adopted ,it will be very convenient to connect the dc nanogrid in to most types of current low-voltage ac power systems, for example, the single-phase 220-V ac power grid, the 110-V ac power grid, and three-phase four-line380-Vacpowergridusingthreeofthesameconverters. The dc voltage can also be varied in a wide range.

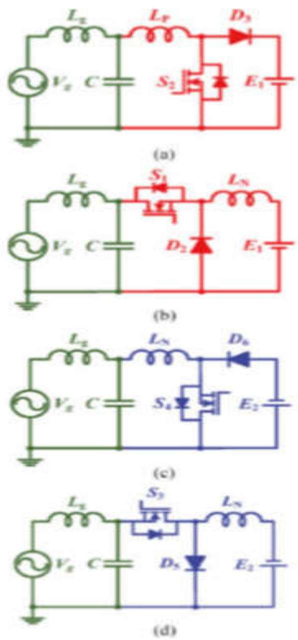
OPERATING MODES OF PROPOSED SYSTEM

1)$|E_1|$or$|E_2| \geq V_{gA}$: When the input dc voltage (E_1, or E_2) is larger than the amplitude value of grid voltage,V_{gA} , the equivalent circuits are as shown in Fig. 5. The inverter works as a pure Boost power factor correction circuit.



2) |E1|and|E2| <VgA : When the input dc voltages (E1,E2) are lower than the amplitude of grid voltage (VgA), the control becomes a little bit more complicated. the working sequence of the proposed ac/dc converter, when the amplitude of the input dc voltage is lower than the ac grid voltage, and the sequence can be separated into six parts during a full line-frequency period. the equivalent circuits in the buck–boost operation. It can be seen that during different working sequences, it works as a pure boost or as a pure buck converter.

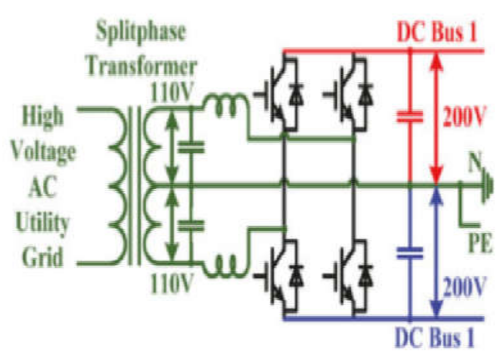




Equivalent circuit of exposed $E_1$and E_2

METHODOLOGY:

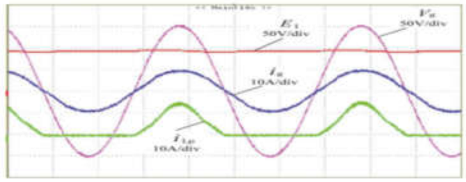
THREE-PHASE ac–dc conversion of electric power is widely employed in speeds drive (ASDs),uninterruptible power supplies (UPSs), HVdc systems, andutility interfaces with nonconventional energy sources such as solar photovoltaic systems (PVs), etc., battery energy storage systems (BESSs), in process technology such as electroplating ,welding units, etc., battery charging for electric vehicles, and power supplies for telecommunication systems Traditionally, ac/dc converters ,which are also known as rectifiers ,are developed using diodes and thyristors to provide controlled and uncontrolled unidirectional and bidirectional dc power. They have the problems of poor and poor powerfactor at input ac mains and slowly varying rippled dc output at load end, low efficiency, and large size of ac and dc filters. In view of the increased applications ,a new breed of rectifiers has been developed using new solid-state self-commutating as MOSFETs, insulated gate bipolar transistors (IGBTs)



DC microgrid system if fault will occurred then isolate the faulty devicessuch section from healthy section and avoid whole shut down of system and increases the reliability of system. The loop type system is used and the supply continuity is maintained through the other buses in the healthy sectionFault current in the faultysection is extinguished through freewheeling diodes and resistance in the freewheeling path provided in the system. This provides additional protection to the system. This scheme is useful for the isolated area supplied through distributed generation and the system where the AC and DC microgrids

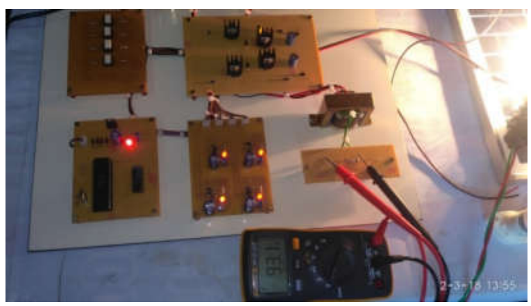
TABLE I
DESIGN PARAMETERS OF A 1-KW AC/DC CONVERTER

Para.	L_g	C	L_P, L_N	f_s	E_1, E_2
Units	200 μH	2 μF	400 μH	60 kHz	90 V



A hybrid ac/dc microgrid is proposed and comprehensively studied in this paper. The models and coordination control schemes are proposed for the all the converters to maintain stable system operation under various load and resource conditions. The coordinated control strategies are verified byMatlab/Simulink. Various control methods have been incorporated to harness the maximum power from dc and ac sources and to coordinate the power exchange between dc and ac grid. Different resource conditions and load capacities are tested to validate the control methods.

KIT OUTPUT



CONCLUSION

Experiments on the proposed ac/dc converter are carried out under the ac grid condition of 110 V/ 50 Hz.

In residential applications, the dc nanogrid should provide ground line for safety. The grounding configuration determines the different requirements on the ac/dc converters. In this paper, three types of the grounding configurations for the dc nanogrid are summarized. The following can be concluded.

1) The united grounding configuration is the most attractive, since the dc nanogrid can be directly connected with the low-ac-power system using the same ground line,which will strongly address the high-efficiency character of the dc nanogrid. This grounding configuration makes it easy to construct a dc nanogrid based on the original low-voltage ac power system and contributes to the application of the dc nanogrid. However, suitable ac/dc converters are currently lacking of this grounding configuration.

2) The unidirectional grounding configuration is widely introduced in current dc nanogrids. It is suitable to construct a new dc nanogrid alone.

3) Compared with the united and unidirectional grounding configurations, the flexibility of the virtual isolated grounding configuration is good, but it results in reduced efficiency, more materials, and thereby higher costs.

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