CANONICAL MODELING OF POWER PROCESSING IN DC DISTRIBUTION SYSTEM USING CASCADED CONVERTORS AND SLIDING MODE CONTROL

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ABSTRACT

Switching dc-dc converters are widely used to interface the dc output of renewable energy resources with power distribution systems in order to facilitate the use of energy at the customer side. In this paper, a system connected to a PV panel, fuel cell ,wind turbine consisting of two cascaded dc-dc boost converters under sliding-mode control and working as loss-free resistors,gyrator,transformer is studied. The modeling, simulation, and design of the system are addressed. First, an ideal reduced-order sliding-mode dynamics model is derived from the full-order switched model taking into account the sliding constraints, the nonlinear characteristic of the PV module, and the dynamics of the MPPT controller. For this model, a design-oriented averaged model is obtained and its dynamic behavior is analyzed showing that the system is asymptotically globally stable. Moreover, the proposed system can achieve a high conversion ratio with an efficiency close to 95% for a wide range of working power. Numerical simulations and experimental results corroborate the theoretical analysis and illustrate the advantages of this architecture in PV systems. The proposed method can be used for the other DC/DC converter. This paper proposes the new cascaded series parallel design for improved dynamic performance of DC-DC buck boost converters by a new Sliding Mode Control (SMC) method. The converter is controlled using Sliding Mode Control method that utilizes the converter's duty ratio to determine the skidding surface. System modeling and simulation results are presented. Microgrid is one of new conceptual power systems for smooth installation of many distributed generations (DGs). While most of the micrograms adopt ac distribution as well as conventional power systems, dc microgrids are proposed and researched for the good connection with dc output type sources such as photovoltaics (PV), fuel cell, and secondary battery. Moreover, if loads in the system are supplied with dc power, the conversion losses from sources to loads are reduced compared with ac microgrid. As one of the dc microgrids, we propose "low voltage bipolar type dc microgrid" which can supply super high quality power with 3-wire dc distribution line. In this paper, one system for a residential complex is presented as an instance of the dc microgrid. In this system, each house has a cogeneration system (CGS) such as gas engine and fuel cell. The output electric power is shared among the houses, and the total power can be controlled by changing the running number of CGSs. Super capacitors are chosen as main energy storage. To confirm the fundamental characteristics and system operations, we experimented with a laboratory scale system. The results showed the proposed system could supply high quality power under several conditions.

1. INTRODUCTION

Clean renewable energy resources have been given increasing interest in recent years, due to concerns about global warming and its related harmful greenhouse effect, air quality, and sustainable development [1]. In the future power grid, not only the utilities, but also the users can produce electric energy by aggregating distributed generation sources [2]. In that context, photovoltaic (PV) arrays, wind turbines, and batteries are used to feed a main (dc or ac) bus connected to its loads, as well as the utility grid, forming the so-called nanogrid system [3] . Nanogrids can then work in the stand-alone mode or they can be connected to the utility grid performing peak shaving and smooth transitions between the different modes of operation.

Modern electronic systems require high-quality, small, lightweight, reliable, and efficient power supplies. So, the DC/DC converters are widely used in many industrial and electrical systems. The most familiar are switching power supplies, DC drives, and photovoltaic systems. The stability is an important aspect in the design of switch mode power supplies; a feedback control is used to achieve the required performance. Ideally the circuit is in steady state, but actually the circuit is affected by line and load variations (disturbances), as well as variation of the circuit component (robustness). These parameters have a severe effect on the behavior of switch mode power supply and may cause instability. Design of controller for these converters is a major concern in power converters design [1–3] Sliding mode control is a well-known discontinuous feedback control technique which has been exhaustively explored in many books and journal articles. The technique is naturally suited for the regulation of switched controlled systems, such as power electronics devices, in general, and DC/DC power converters, in particular [2]. Many sliding mode controllers have been proposed and used for DC/DC converters . These controllers are direct or indirect control method . The direct method is proposed in . In , the output capacitor current of DC/DC converter is used to control the output voltage. The differences of the DC/DC output voltage and the reference voltage enter the proportional-Integrator (PI) type controller, and then the output capacitor current of DC/DC converter is decreased from the output of controller . The output voltage and inductor current are used to control of DC/DC converter in . These references have not completely investigated the load and line as well as reference regulations.

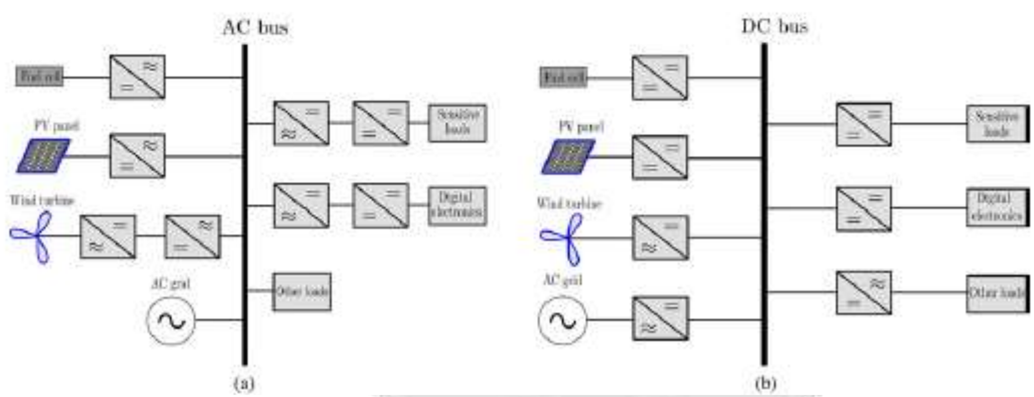

Fig.1 (a) an ac distribution system (b) a dc distribution system

1.1 DC/DC Converters.

The DC-DC converters can be divided into two main types: (1) hard-switching pulse width modulated (PWM) converters and (2) resonant and soft-switching converters [1].

Advantages of PWM converters include low component count, high efficiency, constant frequency operation, relatively simple control and commercial availability of integrated circuit controllers, and ability to achieve high conversion ratios for both step-down and step-up applications. The circuit diagram of the DC/DC converter is shown in Figure 2. In this figure, the circuit schematic is depicted with the transistor-diode symbols. Energy and environmental problems are remarkably concerned in recent years such as greenhouse gas, growth of energy demand, and depletion of energy resources. Against the background of these problems, a large number of distributed generations (DGs) are being installed into power systems. It is well known that if many DGs are installed into a utility grid, they can cause problems such as voltage rise and protection problem. To solve these problems, new conceptual electric power systems were proposed. As one of the concepts, microgrids are especially researched all over the world.

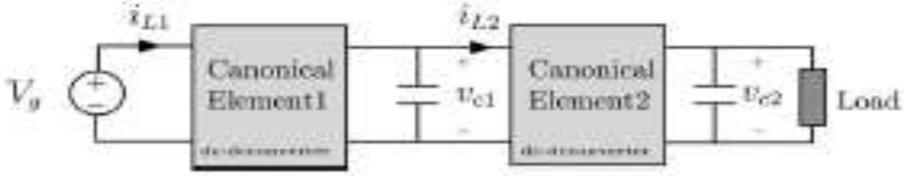

Fig.2 dc – dc converter

2. INDENTATIONS AND EQUATIONS

Stability analysis of the idial sliding mode dynamic model

1. DC transformer
   pj (s) = $s^4 + a_1s^2 + a_2s^2 + a_3s + a_4$ ...(1)

2. g- gyrators

   $S^2 + \beta_4 / g_2L_2 \text{ x } s + \beta_1\beta_3g_2{}^2=0$……(2)

3.LFRs

   $(S+2g_{r2}/C_1) (S+2/RC_2) = 0$ ………..(3)

3. FIGURES

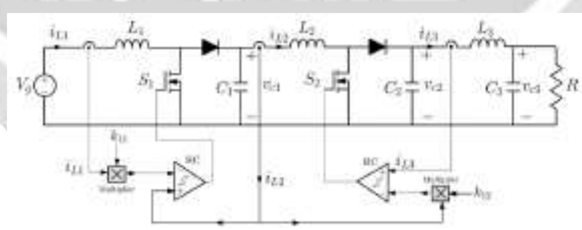

Fig. 3 Two cascaded boost-based dc transformer by using sliding mode controller

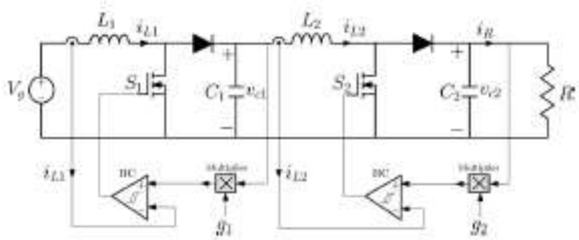

Fig. 4. Two cascaded boost-based g-gyarator by using sliding mode controller

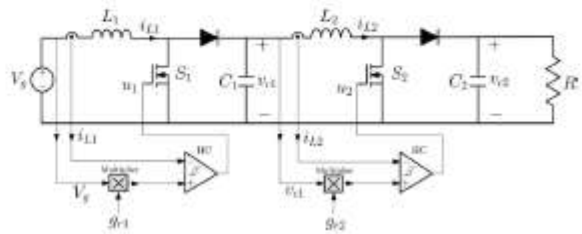

Fig. 5. Two cascaded boost-based LFRs by using sliding mode controller

4. CONCLUSIONS

An approach is proposed to connect in cascade dc–dc switching converters to obtain high voltage conversion ratios by using the concept of canonical elements in power processing. These canonical elements, named dc transformer, power gyrator, and LFR, have been implemented by means of the SMC technique.the dynamic performance is worse than in the case of dc transformer because of the lower damping factor corresponding to the complex conjugate poles Moreover, compared to the dc-transformer case, the cascaded gyrators do not require the presence of an additional inductor at the output port. The introduction of this element yields also to a fourthorder unconditionally stable system but with worse dynamic performance. Finally, the cascade connection of two LFRs results in a second-order unconditionally stable system. In this case, the existence conditions of the sliding-mode regime depend on the load resistance but are less restrictive than in the case of gyrators interconnection Thefact that the disturbances that might occur at the output port are not transferred to the input port would allow the implementation of a fastMPPT of the PVgenerator. Based on this discussion, the cascade connection of boost-based LFRs could be considered as the best option to obtain high voltage conversion ratios with good dynamic performance and good line and load regulation performances. Moreover, as in the case of an individual boostbased LFR, the cascaded connection of LFRs could be used to implement electronic functions in energy processing, like PFC in ac–dc applications and MPPT in PV applications [18], where high voltage conversion ratios are needed and the use of high frequency transformers is not a preferred solution

6. REFERENCES

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