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Power Supply System of Internet of Things (IOT) is Bidirectional DC / DC Converter

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Abstract: This paper studies the bidirectional DC / DC converter of power supply system based on the IOT, and discusses the basic principle and types of DC / DC converter; The buck / boost bidirectional DC / DC converter is proposed, and the inductance parameters are designed. The buck / boost simulation experiment is carried out through the proposed inductance algorithm. The simulation data under boost mode and topology simulation data under buck mode are tested; The results show that when the input voltage is 150V, the steady-state values of the output voltage and the flying capacitor voltage remain unchanged when the circuit is in a stable mode. The proposed topology can achieve a high step-down ratio without limiting the duty cycle, and the flying capacitor voltage is half of the output voltage. Through the analysis of the two modes of topology voltage rise and fall, it can be seen that this topology can achieve a high step-down ratio and two-way flow of energy. Therefore, this topology can realize high-power operation. The above circuit data changes, and the results are well verified in the stability of dynamic response.

1. Introduction

Distributed generation makes up for the shortage of large power grid with its advantage of being free from regional restrictions; With the introduction of AC / DC hybrid microgrid technology, distributed generation has been more widely used. In island mode, AC / DC hybrid microgrid can be applied in areas not covered by large power grid to improve local living conditions. Under the grid connection mode, AC / DC hybrid microgrid can be applied in areas with large load, alleviate the pressure of large power grid, ensure the normal operation of load or cut peak and fill valley. This paper introduces the voltage and current control signals of the converter in Buck and boos circuits, analyzes the signals in detail, and makes simulation. The simulation results are the same as the theoretical values.

Many scholars at home and abroad have studied the research of bidirectional DC / DC converter of power supply system based on IOT. Datta a j introduces a two-way power sharing scheme

between AC power company and DC microgrid. The two are connected by interconnected converters and dual active bridges. The proposed control scheme allows predefined power to be provided from the AC side to the DC side or the opposite direction. The active power bridge is connected to the bi-directional DC converter. These DC / DC converters and dual active bridges are controlled by state feedback and integrated control in the linearized discrete domain [1]. Ortigoza RS modeled and verified a new topology of DC / DC step-down power converter DC motor system. The bidirectional rotation of DC motor shaft is realized by using DC / DC power converter. The experimental results confirm the effectiveness of the mathematical model in general, real-time variable trajectory tracking, not just constant trajectory [2].

This paper studies the bidirectional DC / DC converter of power supply system. This paper makes a detailed analysis on the control link of bidirectional converter, mainly in the compensation link, and makes a reasonable analysis from the perspective of control mode and control method. In each link of bidirectional DC / DC converter circuit, in addition to the research direction in this paper, further research is needed from the control algorithm. Now digital control has become a trend in the research of switching power supply. In terms of its advantages, it has great advantages over analog control in terms of data acquisition, in addition to easy implementation [3, 4].

2. Bidirectional DC / DC Converter of Power Supply System

2.1. Basic Types of DC / DC Converters

2.1.1. Topology of Isolated Bidirectional DC / DC Converter

Isolated bi-directional DC / DC converter is generally evolved from DC-DC converter circuit. It only needs to slightly improve the rectifier circuit on the secondary side. This type of converter can be obtained through different combinations of forward and flyback circuits, half bridge, full bridge circuits and push-pull circuits. Due to the diversity of combination modes, there are many types of this type of converter. However, there are multi-level transformations in the energy transfer process of isolated converter, and there will be energy loss in each stage of transformation process, so the transfer efficiency of the converter is low. Because the structure of multi-level transformation is complex and there are many switching devices, the control is also relatively complex [5].

2.1.2. Topology of Interleaved Parallel Bidirectional DC / DC Converter

Interleaved parallel bi-directional DC / DC converters are obtained by paralleling several identical topologies on the basis of isolated and non isolated converters. Because the output power of the converter with interleaved parallel structure is the superposition of the power of each phase converter, the interleaved parallel structure can improve the power level of the converter [6]. When controlling this type of converter, the driving signals between the phases need to be staggered by a certain phase, which can reduce the voltage and current ripple. The interleaved parallel topology is suitable for occasions requiring high power quality or high power level. Due to the advantages of high power level and small voltage and current ripple, interleaved parallel bidirectional DC / DC converter has been widely used, but there are also inherent deficiencies caused by topology. At present, the research on the converter is mainly to solve the problem of phase to phase current sharing [7, 8].

2.1.3. Topology of Cascaded Bidirectional DC / DC Converter

The cascade mode also reduces the voltage withstand requirements of switching devices. However, like the isolated topology, the cascaded topology also has the problems of complex structure, many switching devices and many energy transfer stages, so it is not suitable for the occasions requiring efficient operation.

2.2. Realization of Each Link of Bidirectional DC / DC Converter System

Voltage sampling link, in the current MATLAB software, in the current simulation, there are generally the following voltage sampling methods: voltage division through resistance: series voltage division between resistors, and the sampling voltage is obtained through series resistance and proportional voltage division principle. The voltage is divided through the VCVS device. While dividing the voltage, the voltage sampling is carried out when the sampling coefficient has been set.

According to the requirements of power level, conversion efficiency and response time, appropriate energy storage methods need to be selected in different occasions [9]. The AC power grid provides electric energy to meet the power demand of the whole microgrid. In islanding mode, if the power generated by the distributed power generation is greater than the power consumption of the load, the battery will store the abundant electric energy. If the distributed power supply and energy storage device cannot meet the demand of the load, it is necessary to cut off some secondary loads to ensure the normal operation of the main load.

2.3. Control Mode of Bidirectional DC / DC Converter

From different angles, the control modes are mainly divided into many kinds. Now, from the perspective of variables, they are mainly divided into voltage control mode and current control mode. The former requires auxiliary communication to realize complete control, while the current mode control mode of the latter is mainly applied in the double closed-loop control strategy, that is, the input voltage outer loop and the output current inner loop. The advantage of this is that it can realize the full-automatic omni-directional detection of energy flow, that is, it can accurately monitor the operation mode of energy by monitoring the different change behavior of input voltage [10].

Voltage control mode: voltage control mode is a very basic control mode used in the earliest switching power supply field. In principle, it belongs to the control system mode of single closed-loop feedback. The specific principle is as follows: on the basis of voltage division, the output voltage of the switching converter is compared with the voltage value given by the system, and applied to the required PWM circuit. At the same time, the analog signal generated by the voltage is used to further transform the pulse signal of the switching tube to achieve the desired purpose.

There are many kinds and types of DC / DC converters. Due to many combinations, many changes and many characteristics of various topologies, the topology suitable for the selection in this paper must be selected according to the characteristics of different topologies, and the following factors should be considered:

(1) Complexity of topology: in order to better ensure the feasibility and reliability of the experiment, on the premise of ensuring the efficiency and stability of the experiment, simplicity, convenience and high reliability are my first choice.

(2) Difficulty of experimental implementation: Despite the performance advantages of different

topologies, the requirements are too high, so the problems we need to consider must be grounded and understand the degree of our implementation.

(3) Cost: when doing different topology research, we must first understand whether we can have the economic level to do such things. However, the requirement of this subject is bidirectional, which must be higher than unidirectional. Due to the high complexity of isolated converter, the cost is also high.

(4) Volume and weight: in more cases, the circuit where the transformer is located to see the difficulty of realization [11, 12].

3. Inductance Parameter Design

Inductance is not only an important energy storage element in bidirectional DC / DC circuit, but also the core device of the whole energy storage link. The rationality of inductance parameters is related to the continuity of current and the magnitude of current peak, which affects the stability and cost of the whole circuit. The expression of inductance is shown in formula (1):

$$U = \frac{V_1}{2\Delta i_U} \bullet \frac{V_2 - V_1}{V_2} \bullet H_r \tag{1}$$

In the critical state, the average value IU of inductive current shall be equal to the current variation Δ IU, and the average value of inductance current can be expressed by power and voltage, as shown in formula (2):

$$\Delta i_U = I_U = \frac{I_1}{2} = \frac{Q_1}{2V_1} \tag{2}$$

To sum up, the expression of critical inductance in Buck mode can be obtained, as shown in formula (3):

$$U_{0.BUCK} = \frac{V_1^2}{Q_1} \bullet \frac{V_2 - V_1}{V_2} \bullet H_r \tag{3}$$

From the above formula, it can be calculated that the critical inductance value is 0.35mh in boost mode and buck mode. In order to avoid current interruption, the value of actual inductance should be less than the critical value, but it should not be too small, so as to avoid pressure on the switch tube caused by excessive current peak. The actual value is 0.25mh.

4. Simulation Test and Analysis

4.1. Matlab Simulation of Bidirectional DC-DC Converter

The simulation model of bidirectional DC / DC converter is carried out in MATLAB software, and different designs are carried out in each module, mainly including the main circuit of the converter, the sampling circuit of output voltage and current, and the circuit of PI regulation control signal. The circuit is generated through the driving signal, and the circuit can be switched through the control circuit. The power of the system simulation parameter is 3KW, which is first described in detail in boost working mode. The input range of the input voltage is about 120 ~ 180V, and the output voltage is 1300 ~ 1600V. In the circuit, the selected load belongs to inductive load, and the selected switching frequency is 30kHz, and the control mode in the circuit belongs to double

closed-loop control strategy, voltage outer loop, current inner loop, and 8 switches conduct complementary conduction.

Simulation verification under boost working mode and simulation data under boost mode are shown in Table 1 and figure 1

Table 1: Simulation data in boost mode

time	input voltage	Flying capacitor voltage	Boost capacitor voltage	output voltage
0.00	150	0	0	0
0.05	150	881	300	500
0.10	150	750	309	500
0.15	150	752	311	500
0.20	150	751	313	500

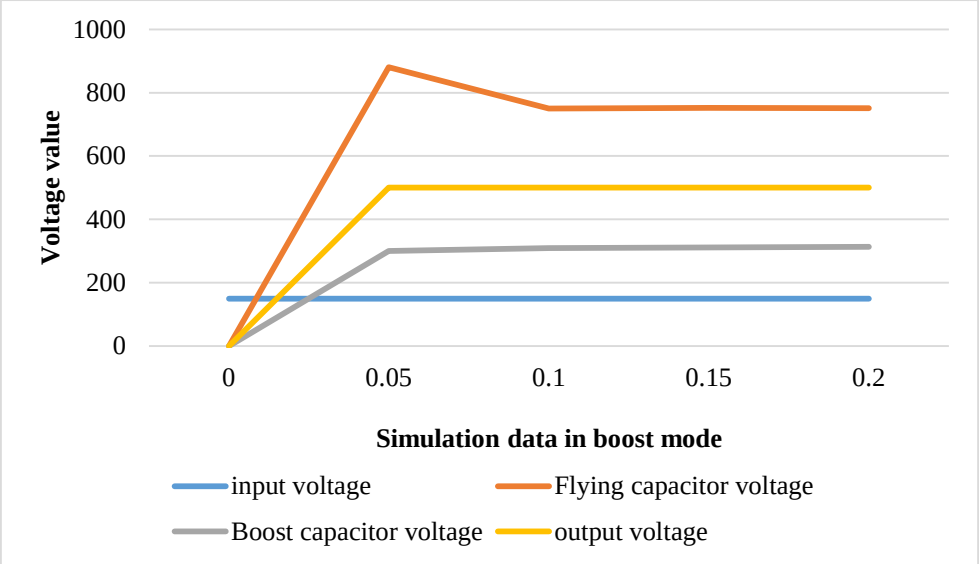

Figure 1: Simulation data in boost mode

It can be seen that the proposed topology can achieve high voltage rise ratio without limiting duty cycle, and the flying capacitor voltage is half of the output voltage. At the same time, interleaved parallel input is adopted at the low-voltage side, which not only reduces the current pulsation, but also reduces the current stress of the switch, so that the topology can realize high-power operation. From the waveform above, it can be seen that the input voltage is 150V, and the output voltage and flying capacitor voltage can be adjusted immediately on the basis of adjustment. When the circuit is in stable mode, its steady-state value remains unchanged, and the above circuit data changes, and the results are well verified in the stability of dynamic response.

In the buck working mode, the load and input disturbance simulation tests are carried out respectively. After the simulation, the control is realized by adjusting the off of different switches. In step-down mode, the high voltage side is 1500V. Topology simulation data under buck working mode is shown in Figure 2.

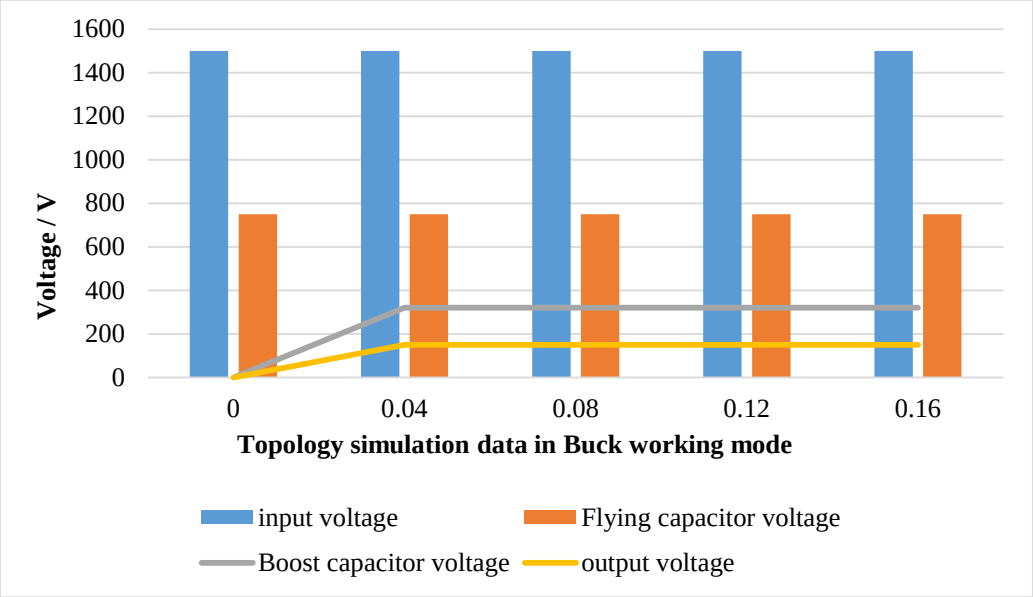

Figure 2: Topology simulation data in Buck working mode

Through the above load and input disturbance simulation test in Buck and boost mode, it can be seen that the system has good anti disturbance ability. It can be seen that the proposed topology can achieve high step-down ratio without limiting duty cycle, and the flying capacitor voltage is half of the output voltage. Through the analysis of the two modes of topology voltage rise and fall, it can be seen that this topology can achieve high step-down ratio and two-way flow of energy.

5. Conclusions

At present, the theoretical analysis is complete and the experiment has been successful. However, limited by time and my level, there are still some deficiencies in the whole experimental platform. The experimental simulation platform is not stable and beautiful, and the wiring process is also very inconvenient. After the control mode is mature, the experimental platform can be improved to make it small, stable structure and neat appearance; The main switch tube in Buck mode is not reliably grounded, so it cannot be reliably turned off in high-frequency operation, resulting in low efficiency of energy transfer during voltage reduction. In subsequent experiments, it is necessary to improve the driving circuit and give negative voltage to the switch tube to make it reliably turn off; At present, only the open-loop control strategy is adopted for the converter control. Although the ideal output waveform can be obtained in the simulation, there will be great errors in the actual circuit, so it is necessary to add PID closed-loop control to the circuit to make the circuit monitor the output signal in real time.

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