Research on Back-to-Back Converter Based on Computer Microgrid and Off-grid Control Theory

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Abstract. Active and reactive power can be controlled by connecting the two ends of back-to-back voltage source converters to AC power grid. In this paper, the back-to-back converter system and computer microgrid and off-grid control theory and methods are described, and the application field and software design of the back-to-back converter are discussed, for readers' reference.

Keywords: Microgrid Concurrent Off-Grid, Back-to-Back Converter, Reactive Power, the Online Power

1. Introduction
With the continuous expansion of power grid scale, centralized power grid is difficult to ensure the security and stability of power supply. At the same time, in order to protect the ecological environment, the development of new energy has become an important topic. Back-to-back voltage source converters can realize the mutual exchange of power in the AC system at both ends, and have been widely used in energy conservation fields such as wind power generation.

2. Back-to-back converter system
2.1. System Structure
Based on the back-to-back voltage source converters, the system studied is a three-phase AC system. The system is fed from the network side through the converter 1 and the converter 2 to the network side [1-3]. The two voltage source converters are connected back-to-back through the DC bus capacitor C, which provides voltage support for the converter and reduces the DC side harmonics. The reactor is used to filter the output current harmonics.

2.2. Working principle
When the back-to-back converter system is connected with the AC system on both sides, the capacitor is connected in the form of an AC-DC-AC topological structure, and the control of the running state of the converter at both ends is used to realize the bidirectional flow of energy. The DC side voltage and AC side voltage are controlled by the switching state of the power electronic switching device [4-6].

Back-to-back converters can be used on one side of the converter with a quasi-maternal secondary
voltage and reactive power output, the other side of the converter control of active power and reactive
power output.

3. Research on the theory and method of computer microgrid and off-grid control

3.1. Control principle of network and off-grid
The parallel operation, the network and the traditional distribution network, obey the dispatch system,
the network system of micro power supply through the converter to the public grid generation, at the
same time if you use the battery energy storage link, such as, also can absorb energy from the power
grid, such as battery energy storage link, and in the case of its electricity supply sending extra
electricity to power grid. When the microgrid system is connected with the public grid, the internal
converter of the microgrid system can switch to the current source mode instead of using the sag
characteristic, or even quit the voltage source operation mode. At this time, the power deficiency in the
microgrid system is balanced by the public grid through PCC, which makes the control difficulty of
the converter greatly reduced. When the public grid fails, the micro grid needs to be able to
automatically interrupt from the public grid, but the internal converter of the micro grid system can
still continue to work to supply power for the internal load of the micro grid system, so as to improve
the power supply reliability of the internal load of the micro grid system. It is of great significance to
improve the reliability of power supply of the whole power system, especially to ensure the continuous
and stable power supply of some important loads. Since the converter is required to automatically
adjust the voltage and frequency during off-grid operation to ensure the power supply quality of the
load, the converter is required to have the ability of primary and secondary frequency and voltage
regulation to ensure the stability of the micro-grid system during off-grid operation. At the same time,
when the public power grid from fault conditions to restore power, should has the ability of public
power grid automatic synchronization of the converter, and finally realize the smooth transition of
off-grid state to the grid during transition in the process of the network system of the internal load
power supply stability, and won't cause big influence to the safety of the public power grid.

3.2. On-line power calculation
It is one of the key points to realize the converter control in microgrid system to calculate the
instantaneous active power and reactive power by detecting the instantaneous value of line voltage and
phase current output by the converter. Through the internal voltage and current sensor of the converter,
the instantaneous value of line voltage and phase current output of the converter can be more
accurately obtained, and in order to simplify the structure of the converter, usually only need to use
two voltage sensors to detect two line voltage, and two current sensors to detect two phase current. At
this point, the third line voltage and the third phase current are calculated according to the sum of the
three-phase voltage instantaneous value is zero, and the sum of the three-phase current instantaneous
value is zero. It is important to note that this conclusion can only be obtained if the three phase voltage
and current are balanced. When the three-phase current is unbalanced, the midline current will not be
zero, and the sum of the instantaneous values of the three-phase current will not be equal to zero.

4. Application field and software design of back-to-back converter

4.1. Application fields of back-to-back converters
Since the voltage source type back-to-back converter was first used in the induction motor AC speed
regulation, because of its ideal performance, a wide range of applications, has been the attention of
many scholars. Here are a few common and promising application areas.

4.1.1. Wind power application field
Wind energy, as an important new energy source, has attracted extensive attention in recent years.
With the development of wind power, also put forward higher technical requirements, to achieve
effective control of voltage and frequency, to be able to flexible for active and reactive power regulation, in order to achieve in certain situations such as puzzled column grid fault condition, low voltage across, back to back voltage source type inverter with its excellent properties has been widely applied in wind power generation technology. Doubly-fed asynchronous wind generator (DFIG), full power conversion permanent magnet synchronous generator (PMSG), winding synchronous generator (WRSG), induction generator (SCIG) adopts voltage source type back-to-back converter as the current converter system (Figure 1 Application of converter elements in wind power generation).

4.1.2. Application fields of motor frequency conversion speed regulation

Variable frequency speed regulation is to adjust the speed by changing the frequency and voltage. Variable frequency speed regulation has the advantages of wide application range, high speed control precision, high efficiency, flexibility, starting, braking performance is excellent, is a kind of speed regulation with broad development prospects. The traditional AC/DC/AC variable frequency speed regulation system has many shortcomings. For example, diode uncontrolled rectifier is usually used on the grid side, which will bring high harmonic to the grid. At the same time, because the diode does not control the one-way transmission characteristics of rectification, limit the energy flow direction of the variable frequency speed regulation system, when the motor braking or deceleration, the load feedback energy can not be transferred to the grid, resulting in a waste of resources; In addition, because the feedback energy can not be discharged, resulting in the DC side voltage rise, which is a great hidden danger to the use of devices, the normal operation of the motor, system safety and so on.

USES the voltage type source back-to-back converter for ac speed regulation control scheme, as the variable frequency speed regulation system of the network side rectifier circuit, not only can improve the performance of speed adjustment, reduce the network side input current harmonic distortion and improve the power factor, and realize the speed control system of four quadrant operation faster adjusting of the sensor element (figure 2).

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4.1.3. Application field of flexible direct current transmission
HVDC-Flexible is mainly used for distributed power grid connection, island power supply, power grid capacity transformation, etc. HVDC transmission has the characteristics of high transmission efficiency, high transmission stability, large transmission capacity and so on, and has high power supply reliability. The traditional HVDC with thyristor converter has many disadvantages, such as injecting large harmonics to the side of the network, which has higher requirements on the performance of AC filter. A large amount of reactive power is absorbed from the side of the network, so a reactive power compensation device is required. The power network is required to have a large short circuit capacity. These disadvantages limit the application of traditional HVDC in medium and small capacity and short distance power transmission. In recent years, HVDC-Flexible based on voltage source converter can make up for the above bad feet, and has the following characteristics: harmonic content is small, and easy to filter; No need for reactive power support, can be used as reactive power supply; DC voltage pulsation is small; Additional AC power quality control function.

4.2. Back-to-back control software design
The stable operation of the control system depends not only on the correct control algorithm, but also on the reasonable structure of the software and the fault-tolerant and fault-correcting ability of the software design. With TMS320F28335 as the main controller and back-to-back converter connected to the grid as the application background, the design of system control software is discussed.

In order to easy to debug management system software, based on the program implementation function as the basis, the system software is divided into module, all modules with independent C source file exists in engineering, and set a variable H header file and a function declaration H header file, respectively used to declare all C program for external use of global variables and its definition for external call subroutine.

Table 1 shows the control algorithm modules related to the controller and the experimental hardware, as well as the function description. The modules work together to calculate the voltage, current, phase and other parameters needed by the algorithm, and send them to the actuator. Reasonable division of system resources and modular design of control algorithm software structure can maximize the coordination of resources and achieve stable and reliable operation of the system.

| Module name | Function description |
|-------------|----------------------|
| Interrupt   | Responsible for generating the execution flag of each module |
| ADC         | Responsible for 16 channel AD sampling, including three-phase AC voltage, current and DC voltage at grid side and Microgrid side |
| DAC         | Responsible for the input of some variables concerned in the intermediate process of the algorithm, a total of 4 channels |
| SCI         | It is responsible for communication with upper computer, and can realize manual control of start / stop / reset and real-time adjustment of PI parameters |

4.2.1. The main program
After power on, MCU initialization is completed, including system clock, interrupt vector entry address, peripheral clock needed for enabling, relevant registers, sampling module and other initializations. After initialization, make the program interrupt at all levels, set the interrupt entry address and open the total interrupt. When the interrupt flag position is a bit, the program immediately
responds, determines the flag bit and executes the corresponding interrupt subroutine.

4.2.2. Interrupt subroutine
Timer cycle interrupt subroutine is the core part of back-to-back system control, mainly to complete the voltage, current signal data sampling and processing, instruction current/voltage calculation, protection logic configuration, etc.

4.2.3. Phase-locked subroutine
The phase-locked program is the key step to realize the parallel connection between VSC2 and microgrid. The program mainly involves the following parts: A/D sampling of input voltage, Clark transforms, Park transform, and the operation of PI regulator. Among them, the PI regulator parameters are based on the simulation model, using the positional PI regulator formula to achieve.

4.2.4. Protection logic configuration subroutine
Protective logic configuration subroutine is one of the core subroutines in all programs. The main completion of the fault signal identification, processing, display, the realization of the device starts, reset and other functions, to achieve the coordination of each function.

5. Conclusion
To sum up, through the research of computer micro-grid and off-grid control theory and method, the back-to-back converter is optimized, so that the back-to-back converter has been widely used in wind power generation, motor frequency conversion speed regulation and flexible direct current transmission and other application fields. Therefore, we should increase the research on the back-to-back converter, so that the advantages of the back-to-back converter have been given full play.

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