Research on improvement of power quality of Micro-grid based on SVG pulse load

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Abstract. Pulse load will make the micro-grid public bus power to produce a high peak pulse due to its cyclical pulsation characteristics, and make the micro-grid voltage fluctuations, frequency fluctuations, voltage and current distortion, power factor reduction and other adverse effects. In order to suppress the adverse effects of the pulse load on the microgrid and improve the power quality of the microgrid, this paper established the SVG simulation model in Matlab/Simulink environment, the superiority of SVG is verified by comparing the improvement of power quality before and after adding the SVG to microgrid system. The results show that the SVG model can suppress the adverse effects effectively of the pulse load on the microgrid, which is of great value and significance to the reactive power compensation and harmonic suppression of the microgrid.

1. Introduction
Military micro-grid is based on photovoltaic, diesel generator, energy storage systems in one of the power supply system. As a weapon and equipment of the military micro-grid, energy protection, it is essential to our military field conditions and protect the power quality power of the supply equipment. With the development of power electronics technology, some special loads, especially pulsed loads, such as phased array radar, electromagnetic track launch weapons, pulse generators, have been widely used in various fields. The Pulse load’s pulse cycle is usually tens or hundreds of milliseconds, power consumption is not stable and present typically pulse characteristics, with the average power is low and the peak power of the characteristics of large. The pulse load is divided into AC pulse load and DC pulse load. This paper focuses on the DC pulse load. In literature [1] three kinds of AC pulse load models are established and their influence on diesel generator sets is studied. Impulsive load can cause military micro-grid voltage fluctuations, frequency fluctuations and harmonic distortion and cause serious power quality problems. The existence of reactive power and harmonics poses a serious threat to the stability and safe operation of the power supply system. Therefore, it is really important to realize the real-time fast and accurate compensation of reactive power.

As a new type of reactive power compensation device, the static reactive power generator (SVG) has the advantages of fast response speed, good compensation ability and good reliability, and has become the development trend of reactive power compensation.

At home and abroad in the micro-grid system compensation control research, In the literature [2] proposed the use of active filter as a limited capacity system filtering means to suppress the pulse-type harmonics on the power supply system and the literature [3] proposed a power factor correction technique based on single cycle control to improve the power factor of the system and to suppress the
pollution of the harmonics;[4] designed an improved power allocation method based on the traditional hybrid capacitor system composed of supercapacitor and battery to improve the effectiveness of the fluctuation power compensation; In [5], the droop controller in the microgrid is improved to ensure that the amplitude and frequency of the microgrid voltage fluctuate within the allowable range; and [6] through the introduction of virtual synchronous generator technology to suppress the frequency of fluctuations. However, the above documents are for a micro-grid power quality problems in a certain aspect of the solution, not through a compensation device or control strategy to solve the power quality of multiple aspects of the problem; and the load for the load is mostly stable power of the conventional load but not on the pulse load of this power repeatedly mutated load to do in-depth study.

This paper in the microgrid system with pulse load as the research background. According to the problem of voltage quality, frequency fluctuation and voltage and current distortion caused by pulsed load, by adding the SVG compensation device to microgrid system, the reactive power current detection method based on dq transform and the hysteresis comparison control strategy are used to suppress the power quality problem caused by pulse load on microgrid. Finally, the model is validated sexuality and superiority by simulation.

2. Microgrid system structure and working principle

2.1. Microgrid system architecture

![SVG military micro-grid system structure](image)

Figure 1. Joined the SVG military micro-grid system structure

Figure 1 is the military micro-grid system structure which join the SVG. In the power supply system, the solar photovoltaic power generation as a new energy, lithium iron phosphate battery as a system of energy storage units, diesel generators as emergency power supply equipment, the three common in parallel with an exchange bus to form a military micro-grid power supply system. The pulse load is connected to the DC bus via AC-DC. The duty cycle can be adjusted by adjusting the opening and closing time and the ratio of the entire switching period. The switching period is adjusted by simulating the periodic load on the pulse load. By adjusting the pulse load resistance to adjust the peak power. SVG connected to the AC bus by adjusting the bridge circuit AC side of the output voltage phase and amplitude, so that SVG absorption or issued to meet the requirements of the reactive current to achieve the purpose of dynamic reactive power compensation.

2.2. Pulse load simulation structure

The pulse load simulation structure is mainly composed of a controllable rectifier unit, a filter unit, a DC switch unit and a load cell. The pulse load simulation model shown in Figure 2, Where in the DC switch is provided with an action command from the pulse control unit, and the control part of the controllable rectifier unit utilizes the synchronous 6 pulse generator to generate a pulse trigger signal to drive the thyristors of the three-phase bridge rectifier circuit.
Figure 2. Pulse load simulation structure

In order to obtain an intuitive output DC voltage, the control circuit with output voltage feedback is added to the model. The input signal is the ideal DC voltage, and then compared with the circuit output value, the PID control is adopted to obtain the phase shift control angle input signal, and then directly output DC bus voltage. This model can set the filter capacitor, duty cycle, duty cycle, peak power, different parameters under the pulse load to show the different operating characteristics.

2.3. SVG simulation structure

SVG simulation model mainly includes reactive current detection part and control part. The key to establish SVG model lies in the selection of reactive current detection method and its control strategy. P-q detection method and ip-iq detection method in the synchronous rotation coordinate transformation need to know the phase of the three-phase power grid, and pulse load will produce a large number of micro-grid harmonic, when the power grid distortion, positive and negative sequence voltage and current Harmonic voltage and current interaction will make the reactive power fluctuations caused by the test results are not accurate. The dq detection method is a further optimization design of the first two detection methods, which reduces the computational complexity and can be combined with the control strategy mentioned later. The pulse load can achieve accurate and fast reactive power compensation. Dq detection method simulation structure shown in Figure 3. In this paper, we use the tracking hysteresis comparison method to control the SVG, the simulation structure shown in Figure 4. Hysteresis comparison method is real-time control mode, the current response is really fast; does not need the carrier and the output voltage does not contain the specific frequency harmonic component; if the hysteresis width is fixed, the current tracking error range is fixed. So we choose this method as the SVG control strategy.

Figure 3. dq detection method simulation structure
3. Simulation results and analysis
In order to verify the correctness and validity of the proposed algorithm, this paper built the SVG simulation model in Matlab / Simulink environment and carried on the simulation experiment. The microgrid mainly consists of 5kW photovoltaic power generation system, 30kWh energy storage system and 50kW diesel generator system. The pulse load is connected to the DC bus via AC / DC, and set the pulse load switch cycle is 56ms, duty cycle is 0.4, the peak power is 50kw, the filter inductance is 0.125mH, the filter capacitance is 4000μF. The simulation results are shown in the following figure:
Figure 5. DC voltage before and after Join SVG

Figure 5 is the compensation before and after the DC bus voltage waveform, it can be seen from the figure that the DC bus voltage fluctuations strongly before the compensation, and the DC bus voltage fluctuation significantly reduced after adding SVG, the DC side voltage reach the set value after about 0.1s, and after a small overshoot, the stability of the set value of 500 V. We can see the SVG with a fast compensation speed and the system can work safely, improve the quality of power supply.

Figure 6. AC current before and after Join SVG
Figure 6 and Figure 7 respectively before and after compensation for AC current and THD$_i$ waveform, it can be clearly seen before the compensation AC current distortion is serious, when the pulse load peak power comes, the current change is most obvious, before adding the SVG, the compensation current is provided by the filter capacitor, the compensation effect is not significant; and after adding SVG, the net current is quickly compensated, basically reached with the AC voltage in phase. After 0.05 s, the network side phase current quickly stabilized, making the system to be fully compensated reactive power. Before the compensation of the total harmonic current distortion rate of about 30%, seriously affected the system power supply quality. After compensation, the total harmonic distortion of the current is reduced to about 2%, the current distortion is significantly reduced and reached the national standard. Greatly improving the quality of power supply.
Figure 8 is to compensate before and after the system power factor waveform, from the figure can be clearly seen the system power factor is about 83% before the compensation pulse load peak power comes, and after adding SVG compensation system power factor significantly increased, after a slight fluctuation power factor reached 99%, it achieved a complete compensation for reactive power and basically reached the ideal expected value.

4. Conclusion
In this paper, SVG is introduced into the military microgrid with pulse load. By using the reactive power current detection method based on dq transform and the control strategy of hysteresis comparison, it can meet the instantaneous pulsation performance of the load and improve the power supply of the microgrid. The feasibility and superiority of the SVG model are verified by constructing the MATLAB simulation model. The simulation results show that the reactive current of the system can be compensated rapidly after the SVG compensation is added. The DC voltage fluctuation of the DC bus is slowed down, the current distortion is suppressed, the system power factor is improved, and the power quality of the military microgrid is improved, the compensation effect is expected.

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