Large Chemical Companies' Measures For Anti-voltage Sag

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Abstract. Power grid volatility is inevitable due to its wide coverage, complex properties of users and influence of environment, equipment and human activities. Modern coal chemical industry operates on specific conditions characterized by high temperature and pressure, strong corrosion, inflammability, explosibility, and poisoning, which raises demands for electric energy of high quality and reliable power supply system. When the voltage of grid reduces to a certain level, the output of equipment units derates. This results in medium interruption, which poses a serious threat to the safety of equipment or even human beings. Thus, equipment units' functioning properly or safe parking is significant under voltage sags or interruptions. Based on these facts, higher requirement to the reliability of the chemical power supply system is raised. In this paper, we discuss several measures for anti-voltage sag including DC-BANK support system, Dynamic Voltage Restorer and high-speed bus transfer device.

Introduction

The term voltage sag refers to temporary power voltage fluctuation or temporary power outages caused by lightning, short circuit or other reasons. The power grid consists of all levels of substations including 6(10) kV circuits, the user localities of which are wide spread, thus raising the risk of short circuit and over current fault, which is the chief reason of voltage sag. When failure occurs, the relay protection of the circuit acts to cut this fault circuit off the power system. It costs 20-700 ms to clear the fault. In the meantime, voltages of other normal circuits drop, which leads to voltage fluctuation.[1]

Voltage Sags are defined as a sudden decrease in the root-mean-square (rms) value of an AC voltage between 0.1 p.u. and 0.9 p.u. at the power frequency for the duration of 0.5 cycles to one minute.[2]

Voltage fluctuations are classified into three types: (1) Voltage swell or dip, meaning that the grid voltage suddenly rises to 110% - 180% of the rated voltage or drops to 10%-90% of the rated voltage in a short period of time, the duration of which ranges from 0.5 cycle to a few seconds. (2) Voltage flicker, namely voltage waveform varies randomly or in a certain pattern in a short time. (3) Short-term voltage interruption, meaning power outage caused by standby power auto-switching or reclosing, lasting 0.5 cycles to 3s.

Anti-voltage sag technology does not prevent the supply voltage from temporary drop or interruption, but take measures during supply voltage fluctuations, maintain electricity load functioning properly until voltage returns to normal, and continue working normally after the voltage is back to normal.

The specific measures for anti-voltage sag

DC-BANK support system

1)the aim of DC-BANK support system

In recent years, the frequency converter with its excellent performance of speed regulation and energy saving characteristics has been widely applicated in coal chemical industry and brings good ecocomic benefits to the enterprise. However, the coal chemical production enterprise characterizes

itself as large scale , continuous production, complicated process and material for flammable and explosive, toxic and harmful substances, production environment of high temperature and high pressure, thus it poses strict requirements on safety and stability of power supply and distribution system of enterprises. Therefore, research on frequency converter is of great importance for the coal chemical enterprises.[3]

The DC - BANK system can ensure the frequency converter rotating at constant speed and torque keeping stable under voltage sag, so as to avoid changing of the motor's output torque caused by the system voltage fluctuation and ensure the process parameters do not vary, thus achieving the goal of the anti-voltage sag.

2)DC-BANK support system's operating principle

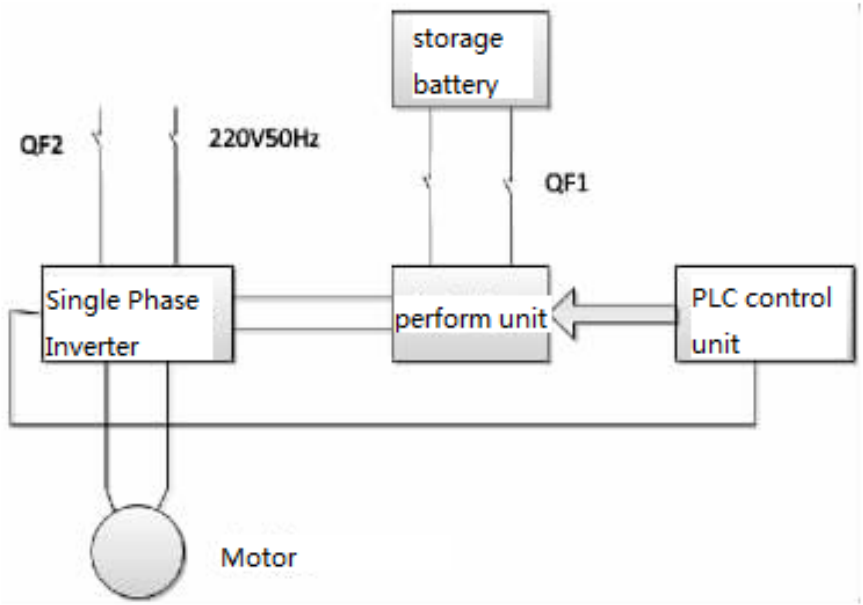

Fig.1.DC-BANKstructure diagram

(1) when the grid voltage is standard, DC-BANK support system come into use. After the frequency converter taking charge, machine processor sends out frequency converter operating instruction, the frequency converter operates and the motor gets start according to the analog quantity current. When frequency inverter operates normally, the state nodes close, if the air switch QF1of battery circuit is closed, DC-BANK support system officially put into anti-voltage sag protection.

(2) when voltage fluctuation appears in the grid and the DC bus voltage is less than 180V, PLC(Programmable Logic Controller) sends the static transfer switch action instructions, it will switch on quickly. So it disconnects rectifier bridge and DC bus, battery supplies power to inverter directly, to ensure motor operating uninterruptedly.

(3) when the power supply is restored, DC bus voltage is up to 180V, the PLC knows that the bus voltage is restored, sends out the instruction to the static transfer switch. The static transfer switch act fast to get the battery out of DC bus. Power system begins to supply the inverter power after restoration. Motor maintains operating uninterruptedly in this process.

Dynamic Voltage Restorer (DVR)

1) Basic theory of DVR

Dynamic voltage restorer is a device which appeared in recent years. It is in series connection with the power supply and load. When the load voltage is normal, the DVR is bypassed, the system provides power direct to the load, and when the voltage sag appears, DVR can compensate for the load voltage in milliseconds effectively. DVR is composed of four parts: an energy storage device, three-phase bridge inverter, filter circuit and the series transformer. DVR is a controlled voltage source, the output voltage isU_2, the power supply bus voltage isU_L, when the power supply circuit is in the emergence of voltage sag, in order to ensure the load voltage of U_1 maintained at the normal

level, DVR can control the output voltage of U_2, to satisfy the equation $U_1 = U_L + U_2$.

When the voltage detecting unit detects the voltage sag appearing at the load side of power supply lines, standard signal generation module generates a standard sine signal synchronized with the grid voltage according to detected actual voltage from the power supply line, and generates a compensation signal through the control circuit after compared with the actual voltage in the bus and determined by the compensation strategy.[4] Once getting the signal of compensation voltage, using controlling unit to generate SP-WM signal and through the drive circuit to control the inverter power switch on and off. The output voltage of the inverter filters the high harmonics through LC filter and injects into the power system through a series transformer, generates a compensation voltageU_2, used to offset the power supply line voltage fluctuations, so as to ensure the stability of the load side voltage, improve voltage quality of the power grid.

2)Structure of DVR

The typical structure of the main circuit of DVR as shown in figure 2. As can be seen from the graph, the main circuit of DVR typically includes energy storage device, inverter, filter and series transformer. As with the UPS（Uninterrupted Power Supply）power supply, when the deviation of voltage appears in the system, the energy exchange between the DVR and the system with absolute certainty. The energy storage device part is to provide energy for DVR, mainly using a large capacitor energy storage, uncontrollable or controllable rectifier which energy is provided by grid, superconducting magnetic energy storage and some other way to store energy. Inverter produces the required compensation voltage to the grid by inverting DC voltage provided by energy storage device. Experiments have proved that the inverter with different structures have their respective advantages and disadvantages, such as bridge inverter has a universal problem of shoot-through phenomenon, and the inverter of push-pull type does not exist this shoot-through phenomenon problems, in the low input voltage, the switching loss is much less under the condition of the same output power, and is suitable for the high-power converter with low voltage input.

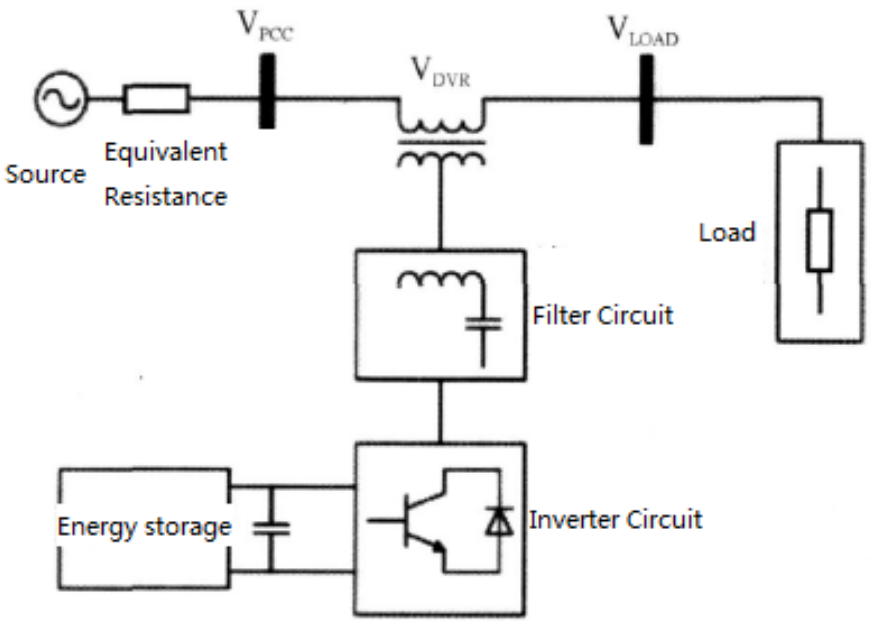

Fig.2. structure of DVR

In addition, one of the hotspot researches is three-phase four-bridge inverter. It is on the basis of three-phase bridge type inverter, added a bridge to form the output neutral point, reducing the asymmetric of three-phase output with unbalanced loads. However, the control of the inverter is relatively complex. Filter is used to eliminate higher harmonic produced by inverter, make the system offset voltage as pure as possible. Thus, the location of filter should be taken into account while deciding the performance of filter. Different location can show different effects, such as on the output side of the inverter is the closest position to the harmonic source, it can solve the

harmonic problems more effectively. Also it can save the components through putting inductance coil of series transformer and filter capacitor together to form filter. However, it increases the capacity of series transformer at the same time. Therefore, when the system voltage distortion (mainly the voltage sag and voltage rise) is detected by the detection control circuit of DVR, it will control energy storage device to compensate dc voltage. The required compensation voltage run through the inverter and series transformer to make load in stable operation.

High-speed bus transfer device

1) Basic theory of high-speed bus transfer device

Industrial substations require existing power rapid switching related criterion to be improved, when the working power is in voltage fluctuation, the standby power supply should be put into use in hundreds of milliseconds to make the production load continuous operation before the bus voltage is reduced to influence production.

After the power supply is removed, the working bus loses the power, the motor will continue to rotate in a short period of time due to magnetic energy storage and the inertia, and the magnetic field energy can change into electric energy. There will be an exchange between electromagnetic energy and kinetic energy because of difference among each motor’s capacity and parameters. As part of asynchronous motor has in actually turned into the asynchronous generator running condition, the voltage on the working bus is a synthetic of feedback voltage came from multiple asynchronous generators, it is called the bus residual voltage. Because there is original power and excitation, the amplitude and frequency of the residual voltage will gradually decrease and phase of voltage between residual voltage and standby power supply voltage will gradually increase over time. The change of residual voltage phasor diagram is shown in the figure 3, $U_s$is thestandby power supply voltage, $U_d$is the bus residual voltage.

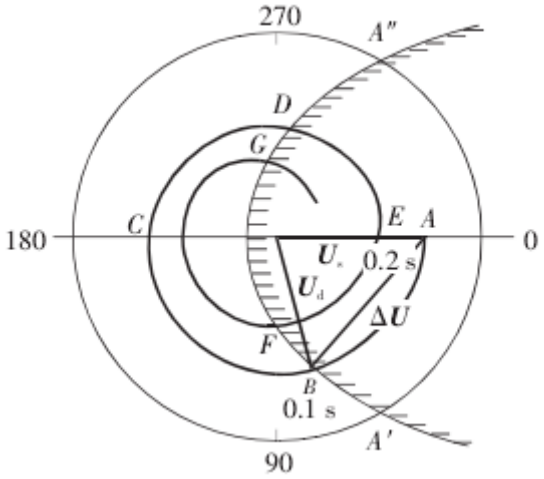

Fig.3.Phasor diagram of residual voltage

In figure 3, section AB is the range which allows to switch the power. Assuming that the working power and the standby power is in the same phase during normal operation. the voltage phasor endpoint is A, bus residual voltage phasor will move along the curve from A to B endpoint after the bus is loss its voltage, it is called a "rapid switch" when the standby power is on during this period.

After point B is the unsafe area, it’s not allowed to switch the power. After the point C to section CD, it will use rapid transfer equipment to track the difference between residual voltage and standby power voltage of the frequency and phase angle in real-time. According to real time calculation, analysis of bus phase changes, and the time needed for closing, catching the closing time to make the phase difference between standby power supply voltage and bus voltage phase is close to zero when switch-on. That is called "synch capture switch".

When the synch capture switch condition is not satisfied and bus voltage does not return to normal level situation in time, bus voltage decreases to the 20%~40% of rated value, rapid transfer equipment switch the power, known as the "residual voltage switch".

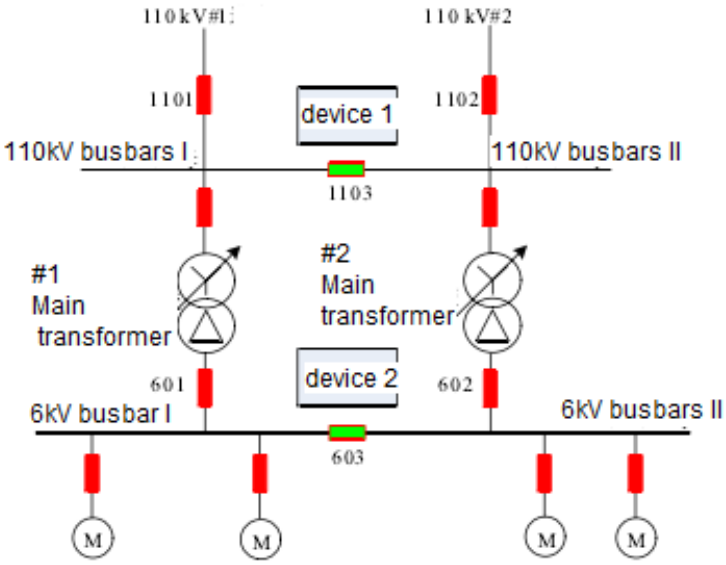

Fig.4. Application drawing of switch-over

2) use of high-speed bus transfer device

The transfer device 1 and 2 are respectively in charge of two voltage grade. When fault occurs on110 kV bus, the transfer device 1 works to cut off the faulty line and put on the standby power supply; When two main transformers have problems, the transfer device 2cut off the faulty transformer, the another transformer will carry the two 6 kV busbars.

According to the working principle of high-speed bus transfer device, there are some following main technical difficulties:

1) According to the electrical main connection, analysing various kinds of closed loop operation under different modes of connection;

2) Research on criterion of each single operation's action condition during the closed loop operation;

3) Research on criterion of whether the closed loop operations success or not;

4) Research on taking remedial measures after fails on automatic closed loop operation,

Conclusion

With the rapid development of chemical enterprise, the power grid expands correspondingly, and its structure is becoming more and more complicated. The process of production in modern chemical industry is continuous. Voltage sag or momentary loss of power in the grid system result in motor outage and disruption of production in chemical enterprise. In some large enterprises of continuous production, recovery of the production process is complex and the enterprises suffer from great loss. In addition, some enterprises may also cause environmental pollution. Therefore, in order to ensure that the unit is able to function properly or park safely under voltage fluctuation, it is of great significance to promote the anti-voltage sag among chemical enterprises.

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