

ZBSVR Single Phase Line Automatic Voltage Regulator

32 level voltage regulation with higher precision

1.1 Analysis of domestic line voltage



Reactance switch has no arcing and is maintenance free for life

According to the provisions of our national standard GB /T-12325-2008, the voltage drop of transmission lines in China needs to be within $\pm 5\%$, in order to ensure the actual voltage level of the distribution line is within the allowable range of electrical equipment, and the line length is generally maintained at a reasonable distance (18KM ~ 25KM), moreover, it will not carry too much load according to the actual use. Figure 1 shows the ideal situation of transmission line with load.

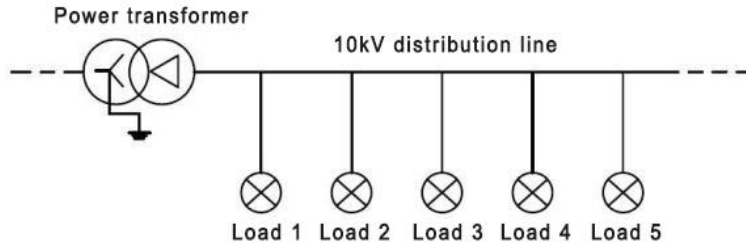


Figure 1: normal condition (red indicates voltage fluctuation)

In fact, with the increase of power load, many lines can only be extended due to various conditions, increasing the impedance of the line and increasing the electrical load will lead to the actual voltage level of the terminal voltage exceeding the working voltage range of the electrical equipment, figure 2 shows the actual use of power grid in China and its voltage reduction.

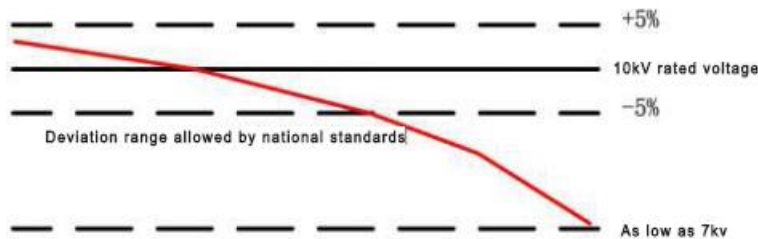


Figure 2: actual situation (red indicates voltage fluctuation)

Because the line voltage cannot be kept constant, when the actual voltage level exceeds the allowable fluctuation range of normal voltage, it is bound to seriously affect the power supply normal use of power system and electrical equipment.

Power system: Low voltage will affect the output of power generation and power supply equipment, reduce the reliability of power supply, and also affect the economic efficiency of power enterprises, when the voltage drop is particularly serious, accidents such as voltage collapse, frequency drop and large-area power failure may even occur.

Electrical equipment: Voltage quality has a direct impact on the safe and economic operation of all kinds of equipment. Taking asynchronous motor as an example, if the voltage decreases, the power will be reduced, the voltage torque will decrease, so that the slip will increase, so that the stator and rotor current will increase significantly, resulting in the rise of motor temperature, and even can burn the motor; On the contrary, when the voltage is too high, the excitation current and iron loss increase greatly, so that the motor overheats and the efficiency decreases.

Low voltage will also affect the use of incandescent lamps. When the voltage is 10% lower than the rated voltage, the flux of incandescent lamp is reduced by 30%, and the voltage is higher than the rated voltage when it is 10%, the life of the bulb is reduced by half.

Low voltage will also affect a series of problems such as air conditioning operation, mobile phone charging, TV signal receiving capacity and so on.

System loss: when the transmission power is certain, the system loss is inversely proportional to the square of the operating voltage. If the voltage decreases, the current and

loss increase, and the system loss increases.

1.2 Comparison of five common ways to improve line voltage

In order to ensure voltage quality, the main voltage regulation measures in medium and low voltage distribution network include the following five aspects:

1) Change the transformation ratio of transformer:

The method of adjusting the output voltage of the main transformer has poor flexibility and pertinence;

2) Improve the reactive power of the line:

Reactive power compensation is mainly used to improve the power factor of the line. The voltage regulation effect is very limited, and only 2% - 3% of the voltage can be regulated;

3) Change line parameters:

Change the circuit parameters, increase the conductor section and reasonably reduce the impedance of the system, only when the load power factor is high and the original conductor section is small, it is more effective in the distribution line, which is generally not suitable for use, and the cost is high, so it is necessary to cut off the power supply for construction;

4) New substation: In places where the voltage is low or high, the project cost of new substation is high and can not get good economic benefits. According to the current situation in China, it is necessary to build a new substation, it is impractical to set up a large number of substations;

5) Install line automatic voltage regulator:

The voltage regulating transformer has the advantages of low cost, good voltage regulating effect, short transformation period and no later manual maintenance. After comparison, this solution is the most suitable to improve the quality of lines in remote areas in China.

1.3 Working principle of single-phase voltage regulator

The main body of ZBSVR feeder voltage regulator is a single-phase autotransformer. It cooperates with the 32 gear change-over switch and American SEL intelligent controller to complete the voltage regulation function of 32 gears, and the voltage regulation accuracy of each gear is 0.625%. The change-over switch is connected with a specially designed reactor. When the gear is changed, the reactance provides current to offset the arcing current generated by switch shift. Therefore, the switching action will not have any impact on the internal insulating oil, in a real sense, the equipment is maintenance free. The switch has 8 contacts in total. For example, when the tap contacts are at 1 and 2 and both are at 1 or 2 contacts, they are counted as the first gear. In addition, the positive and negative regulation function of the switch realizes the 32 gear high-precision voltage regulation function, which is much ahead of the domestic three-phase voltage regulator.

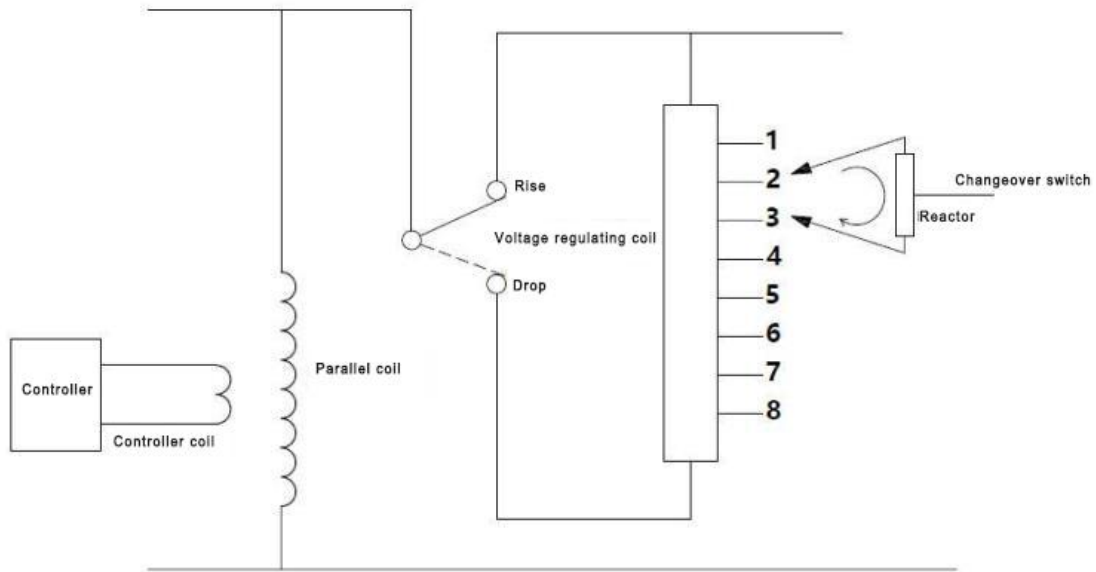


Figure 4: working principle diagram

Taking Figure 5 as an example, when the line voltage drop exceeds the power grid quality standard required by the state. After installing the single-phase voltage regulator, the fluctuation range of the line will not exceed 0.625%. Taking 10kV as an example, the voltage range of the line will be stable between 10062V -9937V. After passing through the distribution transformer to the user, the voltage fluctuation at the secondary side will be stable between 402.5V and 397.5V, which greatly improves the power grid quality and ensures the power consumption of the user and equipment.

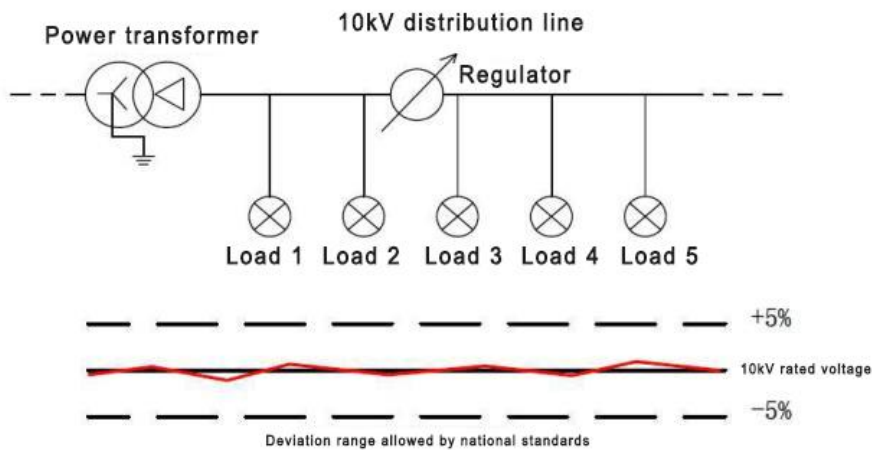


Fig. 5 used circuit of single-phase voltage regulator

1.4 Comparison with conventional three-phase voltage regulator (treatment of three-phase imbalance)

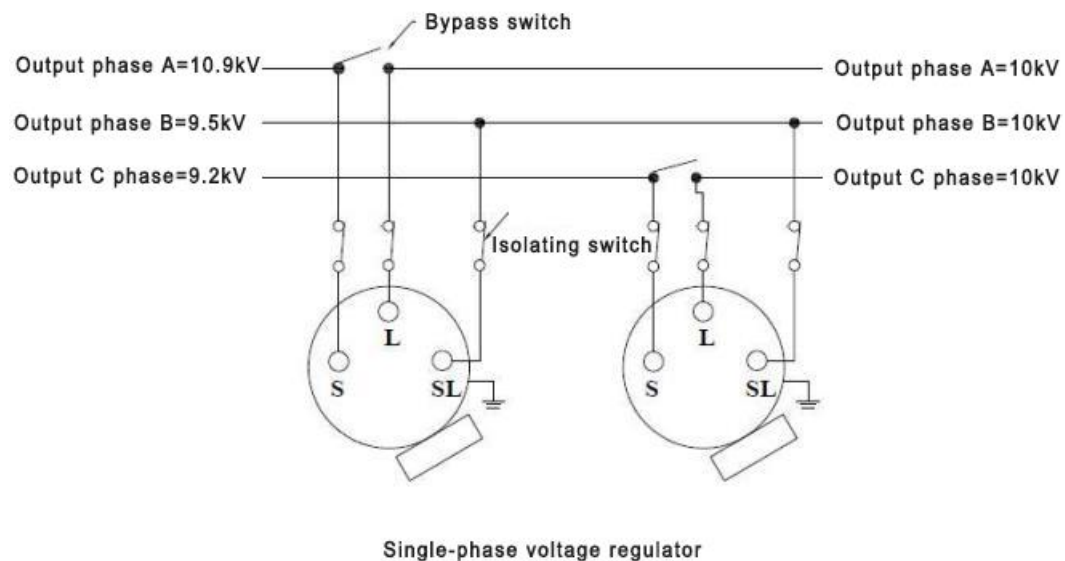
In China, although the use of three-phase voltage regulator is more common, in the treatment of three-phase imbalance, the three-phase voltage regulator can only use one phase voltage for voltage judgment and voltage regulation because it adopts a coaxial on load tap changer for voltage regulation, so it can not solve the problem of three-phase imbalance.

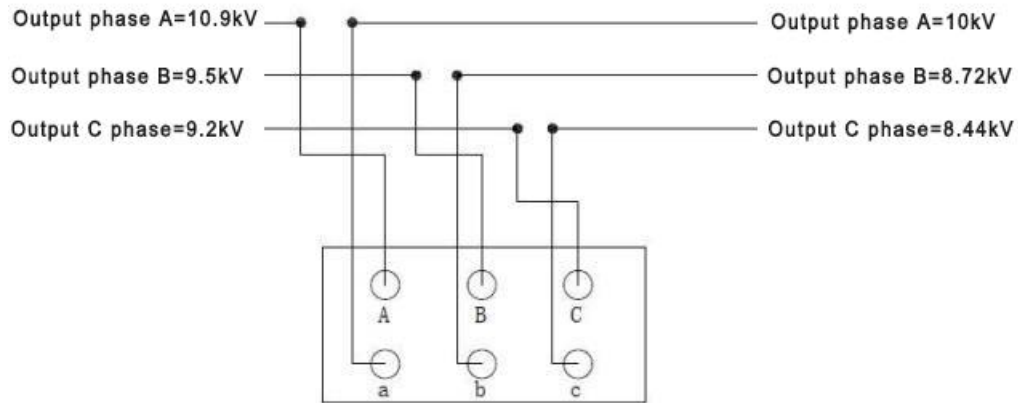
Since the transformation of the national rural power grid, the economy has developed rapidly, and the power load has exceeded the expectation. Rural economy is also developing rapidly, and farmers' life is improving rapidly. Especially after the completion of rural power network transformation and the implementation of "the same network and the same price", in addition to the increase of lighting appliances in rural households, a large number of medium, high-grade and high-power household appliances enter ordinary people's homes. They all use single-phase (220V) power supply, and the single-phase load surges; On the other hand, with the development of industry, rural single-phase load has become the main aspect of power load. It is understood that the general rural single-phase load has accounted for more than 70% of the total load, more than 90% in rich areas, and 50 ~ 60% in rural areas with poor economy.

To sum up, in the case of great increase in power consumption of single-phase load, if you do not pay attention to three-phase balance, the following hazards will be caused:

1. Increase line loss;
2. Increase power loss of distribution transformer;
3. The service life of distribution transformer is reduced due to three-phase imbalance;
4. Affect the safety of electrical equipment and reduce equipment efficiency.

Please see the effect of two voltage regulation methods when the three phases are unbalanced:





Three-phase voltage regulator

When the three-phase imbalance occurs, the single-phase voltage regulator can stabilize the three-phase line voltage at the rated voltage; However, the three-phase voltage regulator can only judge according to the imbalance of one phase and regulate the voltage in the same direction. There is nothing to do about the voltage imbalance of two phases. See the figure above for detailed data.

1.5 Structure of voltage regulator



1.6 Functions and characteristics of voltage regulator

- 1.6.1 high precision: 32-stage voltage regulation can be realized within the setting range;
- 1.6.2 long service life: the unique voltage regulating tap design can avoid arc during voltage regulation and ensure the service life of 2 million operations;
- 1.6.3 maintenance free: fully sealed design, high protection grade, excellent weather resistance, and maintenance free for a long time;
- 1.6.4 flexibility: it can be flexibly installed in the line and substation, and can exit the function of operation and switching post when necessary;
- 1.6.5 strong function: realize SCADA power distribution automation through RS232 interface of controller;
- 1.6.6 low loss: designed to minimize iron loss and no-load loss;
- 1.6.7 Economy: it can economically and effectively adjust the line voltage, greatly reduce the line loss and prolong the service life of the equipment.

1.7 SEL control function features

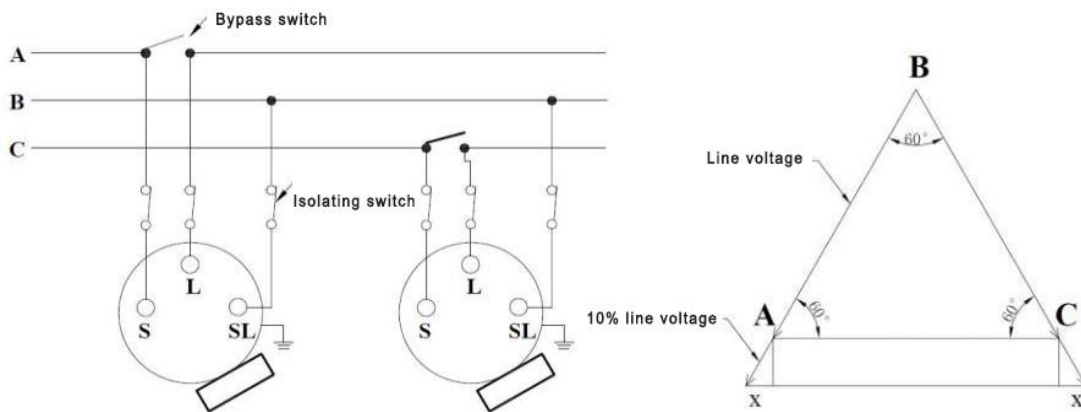


- 1.7.1 the operation interface is friendly, and you can modify settings and browse online data at will;
- 1.7.2 voltage, bandwidth, time delay and compensation voltage can be set;
- 1.7.3 various data can be measured: load voltage, load current, apparent power, reactive power, power factor, etc.
- 1.7.4 it can realize automatic forward and reverse voltage regulation (for loop network power supply) according to the power flow direction of the power grid, and complete all functions;
- 1.7.5 provide RS232 and RS485 data interfaces for remote control and telemetry to realize distribution network automation;
- 1.7.6 cooperate with various communication protocols to directly communicate with the master station without adding RTU (FTU) device;

1.8 ZBSVR installation method

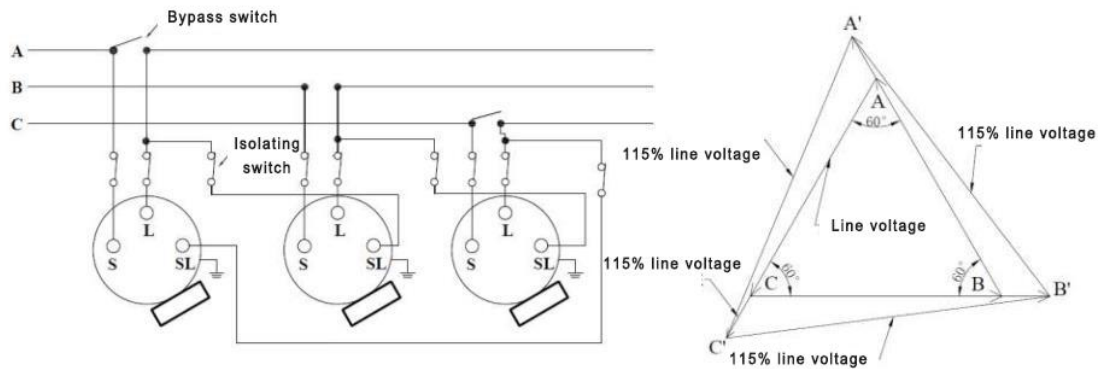
According to the basic situation in China, ZBSVR-8 voltage regulator can be installed in two ways:

1. Open triangle connection mode



When the three lines are connected by two single-phase voltage regulators into an open triangular connection, the regulation range of line voltage is $\pm 10\%$,

2. Closed triangular connection



Ordering instructions: according to the application scheme, provide the line voltage fluctuation range and line current at the installation and voltage regulation position, provide the length of the whole line, and determine the cause of voltage fluctuation.

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