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# *Analysis and discussion of practice based on knowledge of electrical engineering*

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***Abstract:*** As a student majoring in electrical engineering and automation, theoretical knowledge is required in the learning process and practical opportunities to better apply professional knowledge. If only armed with theory and emphasizing theory over practice, it is highly unfavourable for students to go to work in the future. Therefore, while learning professional course knowledge, we must pay attention to improving practical ability and consolidating the foundation.

## 1. Substation

### 1.1 Introduction of Substation

In layman's terms, a substation is a place where voltage is changed, current and voltage are concentrated, converted and distributed, and a device is used to convert voltage, power and distribute electrical energy. In some places, to ensure the power supply's safety, voltage adjustment, power flow distribution control, and protection of transmission lines and electrical equipment are also carried out.

According to the geographical environment, there are many ways to classify substations: (1) According to the geographical environment: above-ground substations, underground substations, and sometimes semi-open-air substations. (2) According to the function: hub substation, step-up substation and step-down substation. The choice of substation type varies according to functional requirements and environmental conditions. Generally speaking, according to the national standard, the AC power of 10 kV and below is transformed to supply power to the equipment. This requirement can be called a substation.

### 1.2 The composition of the substation

The essential components include power distribution devices, transformers, communication facilities, control facilities, protection devices, measurement facilities, and secondary power supplies. Some substations also connect capacitors and reactors in parallel for reactive power compensation. The following is an introduction to the two core parts of the substation.

A power distribution device refers to a combined facility for distributing electric energy and converting power. It consists of voltage transformers, arresters, current transformers, circuit breakers, busbars, isolation switches, etc. Generally speaking, the power distribution system should be arranged according to the main wiring requirements of the substation, and there are two layout methods: indoor and outdoor. For those less than 10KV, an indoor layout is adopted; for those with 30KV or so, indoor and outdoor layouts can be selected, and the choice is made according to the actual situation; for more than 110KV, an outdoor layout is usually used. But there are also exceptional cases, such as in narrow and remote areas, the indoor layout is used for no more than 200KV.

Power transformer: a device that exchanges voltage (current) by using the primary side and secondary side transformation ratio, and the frequency does not change before and after the transformation. Rated capacity is its standard parameter, usually used to represent the amount of electric energy transmitted. The one that reduces the primary voltage and then supplies power to the user is called a step-down transformer; the one that increases the primary voltage and transmits power to the grid is called a step-up transformer. Power transformers generally have two or more windings, and the choice of several windings often depends on the generator's capacity. When its capacity exceeds 200WM, a double-winding transformer is usually selected; double-winding and three-winding transformers can be used when their capacity is lower than 100WM. There is also a tie transformer for power exchange.

### 1.3 Construction requirements and maintenance points of substations

Basic requirements: (1) The electrical equipment meets the requirements for safe operation, and the facilities prone to safety accidents are blocked to ensure the safety of the staff and facilities. (2) Make rational use of land resources, occupy as little land as possible, and make more use of wasteland. (3) Reasonably arrange the lines to improve work efficiency and save human and material resources. (4) Clarify the role and type of the substation, and plan reasonably according to the construction needs and construction scale, so that the substation can better meet the power supply needs.

## 2. Electric motor experiment based on electrical control

### 2.1 Motor jog control circuit

Circuit composition: The jog control circuit uses buttons and contactors to realize a simple forward rotation experiment of the motor. Simply put, when the button is pressed, the three-phase asynchronous motor is powered and rotated; when the button is released, power is lost and the motor stops rotating. The schematic diagram of the circuit is shown in Figure 1 below.

QS is the air switch, SB is the start button, FU is the fuse for short-circuit protection, KM is the contactor, and the three-phase motor is represented by M. The button controls the power-on and power-off of the coil of the KM, and the main contact of the contactor controls the start and stop of the three-phase motor.

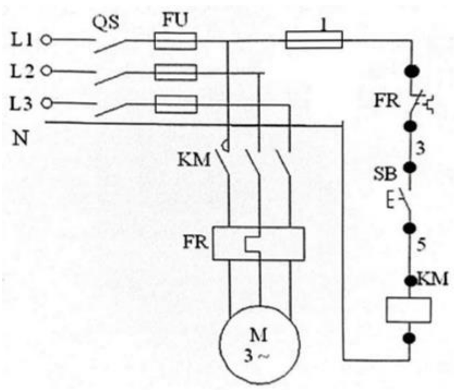


Figure 1 Motor jog control circuit

working principle:

1) Start-up process: close the air switch SB → contactor coil energized → Coil main contacts closed → the motor starts to rotate

2) Stopping process: close the air switch SB → contactor coil de-energized coil → main contact is disconnected → The motor stops turning

## 2.2 The continuous operation control circuit of the motor

Circuit composition: The continuous operation control is based on the jog control. The start button SB2 is connected in parallel with the normally open auxiliary contact, and a normally closed button SB1 is connected in series at the same time. The schematic diagram of the circuit is shown in Figure 2 below.

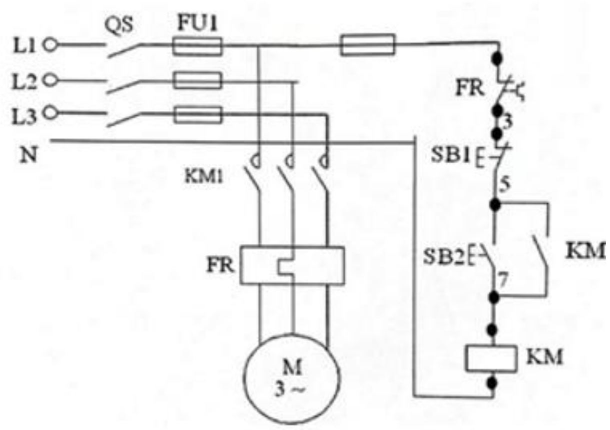


Figure 2 The continuous operation control circuit of the motor

working principle:

(1) Start: close the air switch QS → Pressing the button SB2 →

coil energizes → the main contact closure → The motor is powered to rotate, and the KM normally open contact connected in parallel with SB2 is closed at the same time. Make sure that even if the SB2 is released, the KM is still in the power-on state and the motor will not stop rotating.

(2) Stop: close the air switch QS → press the stop button SB1 → the coil loses power → the main contact is disconnected → the motor stops rotating

## 2.3 The control circuit of the forward and reverse operation of the motor

Contactor KM1 corresponds to forward transmission, and contactor KM2 corresponds to reverse rotation. When the main contact of KM1 is closed, the positive phase sequence of the three-phase power supply is connected. When the main contact of KM2 is closed, the three-phase power supply is connected in reverse phase sequence. The two contactors cannot be turned on at the same time, otherwise it will cause a short circuit. Therefore, the auxiliary contacts of each other are connected in series in the respective branches of the two coils to prevent the two coils from being powered on at the same time, forming an interlocking effect. The inconvenience of this connection is that the stop button must be pressed first to change the direction of the motor. The schematic diagram of the circuit is shown in Figure 3.

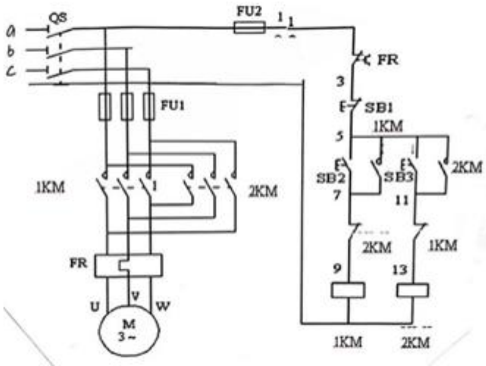

Figure 3 Control circuit for forward and reverse operation of the motor

working principle:

1) Forward rotation: close the air switch QS → press the button SB2 → KM1 get power → the self-locking contact is closed and the interlocking contact is disconnected,the main contact is closed (all of the coil KM1) → the Motor loses power

2) Reverse: close the air switch QS → press the button SB1 → KM1 gets power → the self-locking contact is disconnected, the main contact is disconnected, and the interlocking contact is closed at the same time (both of the coil KM1) → the motor is de-energized → Press the button SB3 → KM2 to energize → the self-locking contact to close, the main contact to close, and the interlocking contact to open (both of the coil KM2) → the motor rotates in the opposite direction

Summary: (1) The fuse can achieve short-circuit protection. (2) Thermal relays are used for overload protection. (3) The AC contactor itself can realize under-voltage protection.

## 3. New energy laboratory visit

With the continuous advancement of the concept of sustainable development, the application of electrochemical energy storage has gradually expanded from electric vehicles to power systems. The batteries of the energy storage system are often composed of battery clusters, and the cells in the battery clusters are connected in series, and these battery clusters are generally connected in parallel. The reason why the energy storage battery is environmentally friendly is that it mainly uses solar energy and wind energy to generate electricity. Because battery energy storage is easily affected by environmental factors, in practical applications, the energy storage system will be used in conjunction with the management system, and there is a battery energy storage and management system cabinet as shown in Figure 4.

Figure 4 Battery energy storage and management system cabinet


Figure 5 Control system of double-fed wind turbines

The most widely used wind turbine is the doubly-fed wind turbine, which consists of a generator whose stator winding is directly connected to the three-phase power grid and a bidirectional voltage source converter on the rotor winding, as shown in Figure 5. Double-fed wind turbines include asynchronous and induction types, only the types of generators are different, and the connection methods are the same. "Double-fed" means that both the stator and the rotor can exchange power with the grid, but the asynchronous generator cannot realize the power exchange between the rotor and the grid, only the stator and the grid can exchange power. Whether power is taken from the rotor or fed back to the rotor depends on the operating state: in the under-synchronized state the power is supplied to the rotor from the grid, in the over-synchronized state the power transfer direction is reversed. But whether it is under-synchronized state or super-synchronized state, the stator is fed back to the grid power.

The converter consists of a grid converter and a rotor-side converter that are independent of each other. The grid converter is mainly responsible for controlling the bus voltage, while ensuring that the reactive power is zero when the converter is running; while the rotor-side converter controls the active and reactive components.


Figure 6 Microgrid energy storage bidirectional converter cabinet

The energy storage bidirectional converter cabinet is also a significant application of new energy, as shown in Figure 6. Its main features: (1) The integration of charging and discharging is realized so that energy can flow in both directions between the DC system and the AC system. (2) Active and reactive power can be efficiently controlled. (3) Adjust the power factor at will to realize reactive power compensation. (4) It can operate both in an isolated network and connected with the network, and the two can be automatically switched.

In addition to controlling the charging and discharging of the battery, the energy storage converter can convert DC to AC and supply power to AC loads in the particular case of no power grid. It generally consists of a bidirectional converter and some control units. The circuit structure is divided into two types: one is a one-level topology structure with only three full-bridge circuits, and the other is a two-level transformation topology. The former stage uses a three-phase full-bridge circuit, and the latter uses a chopper circuit. In contrast, the cost of the one-level transformation topology is lower, the operation efficiency is higher, and the grid-connected operation is better realized.

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