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3 Phase Motor Running on Single Phase Power Supply

Friday, March 17, 2017

Three phase asynchronous AC motor is widely used in industrial and agricultural production due to its simple structure, low cost, easy maintenance and easy operation. 3-phase AC motor uses 3 phase power supply (3 ph 220v, 380v, 400v, 415v, 480v etc.), but in some actual applications, we have single phase power supplies only (1 ph 110v, 220v, 230v, 240v etc.), especially in household appliances. In the case to run the three phase machines on single phase power supplies, there are 3 ways to do it:

1. Rewinding the motor
2. Buy a GoHz VFD
3. Buy a frequency/phase converter

I: Rewinding the motor

It has some works to do to convert 3 phase motor work on 1 phase power supply. Here will show you how to convert 3 phase 380v motor to run on single phase 220v power supply.



Rewinding Principle

Three phase asynchronous motor uses three mutually separated 120° angle of the balanced current through the stator winding to produce a time-varying rotating magnetic field to drive the motor. Before talking about the usage of three phase asynchronous motor being converted to work on single phase power supply, we should explain the issue of establishing single phase asynchronous motor rotating magnetic field, because single phase motor can be started only after the establishment of rotating magnetic field. The reason why it has no initial starting torque is because single phase winding in the magnetic field is not rotating but pulsating. In other words, it is fixed in terms of the stator. In this case, the pulsating magnetic field of the stator interacts with the current in the rotor conductor cannot generate torque because there is no rotating magnetic field, so that the motor cannot be started. However, the position of the two windings inside the motor has a different angle of space. If it tries to produce a different phase current, the two phase current has a certain phase difference in time to produce a rotating magnetic field. So the single phase motor stator should not only have a working winding, but also must have a starting winding. According to this principle, we can use the three phase winding of the three phase asynchronous motor, and shift one of the winding coils with a capacitor or inductance, so that the two phase can go through a different current to establish a rotating magnetic field to operate the motor. When the three phase asynchronous motor uses single phase power supply, the power is only 2/3 of the original.

Rewinding Method

To use 3 phase motor on 1 phase power supply, we can connect any 2 phase winding coils in series, and then connected to the other phase. At this time, the magnetic flux in the two windings have a phase difference, but the working winding and starting windings are connected to the same power supply, so the current is the same. Therefore, connect a capacitor, inductance coil or resistor to the starting winding in series make the current have a phase difference. In order to increase the starting torque on the connection, an autotransformer can be used to increase the single phase power supply voltage from 220v to 380V, shown in Figure 1.

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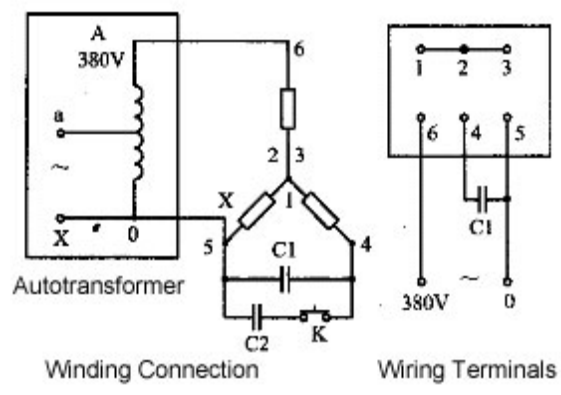


Fig.1

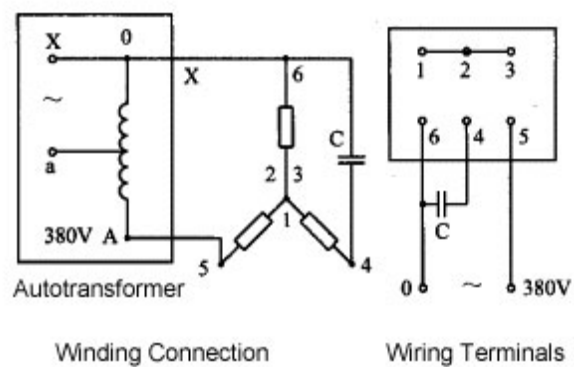


Fig.2

General small motors are Y connection. For the Y-type three phase asynchronous motor, the capacitor C winding terminal connects to the autotransformer starting terminal. If you want to change the shaft rotation direction, wire it as Figure 2.

If you do not want to increase the voltage, the 220V power supply can use this too. Because the original three phase 380V power supply voltage winding is now used for 220V power supply, the voltage is too low, so the torque is too low.

Figure 3 wiring torque is too low. If you want to increase the torque, you can connect the phase-lock capacitor to the two-phase winding together in the coil and use this as the starting winding. A single coil directly connected to the 220V power supply, see Figure 4.

In Figure 3 and 4, if you need to change the shaft rotation direction, you can simply change the end-to-end direction of starting winding or working winding.

The magnetic moment after the two windings are connected in series (one of which is a reverse string) is composed by two angles of 60° magnetic moment (Figure 5). The magnetic moment is much higher than those of 120° magnetic moment (shown in Figure 6), so Figure 5 wiring starting torque is bigger than Figure 6 wiring.

The value of the access resistor R (Figure 7) on the starter winding should be closed to the stator winding phase resistance and should be able to withstand the starting current, which is 0.1-0.12 times of the starting torque.

Selection of Phase Shift capacitor

Working capacitor $c = 1950 \times I_e / U_e \times \cos\phi$ (micro-law), I_e , U_e , $\cos\phi$ is the original motor rated current, rated voltage and power laps.

General working capacitor used in single phase power supply on the three phase asynchronous motor (220V): each 100W use 4 to 6 micro-law capacitor. The starting capacitor can be selected according to the starting load, usually 1 to 4 times of the working capacitor. When the motor reaches 75%~80% of rated speed, the starting capacitor should be disconnected, otherwise the motor will burn out.

The capacity of the capacitor should be correctly chosen to make the currents I_1 , I_2 of the two phase windings are equal and equal to the rated current I_e , means $I_1 = I_2 = I_e$. If require high starting torque, you can add a starting capacitor, and connected to the working capacitor. When the starting is normal, disconnect the starting capacitor.

There are many benefits in running three phase motor on single phase power supply, the rewinding work is easy. However, the general capacity of single phase power supply is too low, it has to withstand high starting current, so this method can be applied to 1kw motor or less only.

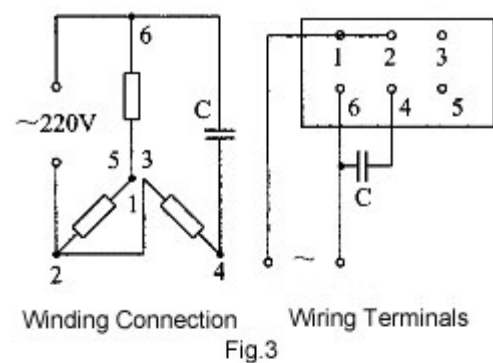


Fig.3

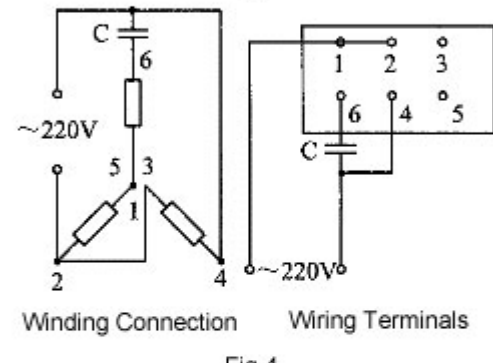


Fig.4

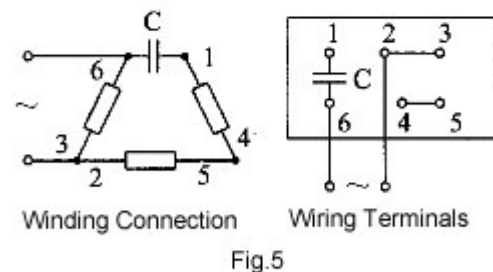


Fig.5

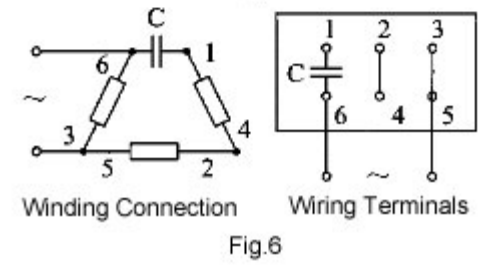


Fig.6

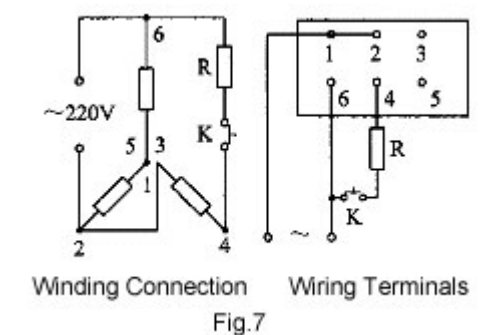


Fig.7

II: Buy a GoHz VFD (<https://www.gohz.com/vfd>)

VFD, short for Variable Frequency Drive, it's a device to control motor running in adjustable speeds. The single phase to 3 phase VFD is the best option for a 3 phase motor running on single phase power supply (1ph 220v, 230v, 240v), it will eliminate the inrush current during motor starting, make the motor run from zero speed to full speed smoothly, plus, the price is absolutely affordable. GoHz VFDs are available from 1/2hp (<https://www.gohz.com/1-2-hp-vfd>) to 7.5hp (<https://www.gohz.com/7-5-hp-vfd-single-phase-to-three-phase>), higher capacity VFDs can be customized according to actual motors.

GoHz Single Phase to Three Phase VFD Wiring Video

Benefits of using GoHz VFD for 3-phase motor:

1. Soft start can be achieved by adjusting the VFD's parameters, the starting time can be set to a few seconds or even tens.
2. Stepless speed regulation function to make the motor work at its best status.
3. Make the inductive load motor to capacitive load which can increase the power factor.
4. VFD has self-diagnosis function, and overload, overvoltage, low pressure, overheating and more than 10 protection functions.
5. Can be easily programmed through the keypad to achieve automatic control.

III: Buy a frequency/phase converter

A GoHz frequency converter (<https://www.gohz.com/frequency-converter>) or phase converter also can be used for such situations, it can convert single phase (110v, 120v, 220v, 230v, 240v) to three phase (0-520v adjustable) with pure sine wave output which is better for the motor performance rather than VFD's PWM waveform, they are designed for lab testing, aircrafts, military and other applications which require high quality power supplies, it's extreme expensive.

Related article: Impact of 60Hz (50Hz) motor being used on 50Hz (60Hz) power supply (<https://www.gohz.com/impact-of-60hz-50hz-motor-being-used-on-50hz-60hz-power-supply>)

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