

# Motor start-up

The purpose of the starter is to:

- Ensure that motors start reliably.
- Limit starting stresses of a mechanical, electrical and thermal nature.
- Regulate speed, torque and power to the desired values.
- Protect against overloading.
- Prevent accidental start-up.

The choice of starting method is dependent on:

- Motor type
- Load characteristic
- Stresses on the system
- Operating conditions
- Mechanical stresses
- Maintenance
- Weight/volume
- Price

## Autotransformer start-up

This method is often used for starting up large motor loads. The autotransformer has a main winding designed for the rated voltage with a terminal which is connected to the motor. Noratel supplies both single and three-phase transformers.

The combination of large electric motors and relatively low generator power is very common in some ship systems. A direct-on-line start-up in such cases would lead to a voltage drop which would exceed the requirements of the classification society and regulations. When it comes to dimensioning starting transformers there are two important parameters which work against each other to some extent.

1. The smallest possible reduction in generator voltage at start-up of the motor(s). This is achieved by the lowest possible voltage at the terminal for the motor.
2. The voltage at the terminal for the motor must not be so low that the motor's torque curve is not reached. Normally the terminals are between 50% and 80% of system voltage.

The great advantages of starting transformers are great freedom of choice with regard to voltage and a small number of components, i.e. few fault sources. The disadvantages are size and weight. (Since autostarter transformers have large voltage drops, this has to be compensated for. Otherwise there is a risk that the motor will not start satisfactorily.)

## Alternative starting methods

The characteristics of common starting methods for electrical machines:

### ▪ Direct-on-line start-up:

Direct-on-line start-up is a reasonable and fast starting method. It is simple and robust, but gives high currents in the supply conductors. It is not unusual to have an effective start-up current value that is 5 to 8 times the current at full load. Another disadvantage is that a voltage drop can occur in the transfer link to the motor, so other equipment may be supplied with a reduced voltage. In the case of a hard start-up the current could be high and long-lasting, resulting in thermal stresses on both the system and the motor. This limits the size of motor which can be started on the system. This method has a low power factor, high mechanical stresses and no regulation possibilities.

### ▪ Star-delta start-up

A common starting method. It is based in principle on the stator windings on the electrical machine being started in star connection (Y) and switched to delta (D) when the rotor has gained speed. The advantage of this method is that the current in the supply conductors is only a third of the current for direct-on-line start-up, and this gives a "soft" start-up. The disadvantages of this starting method are a pre-set starting torque (1/3), long starting time and transients caused by switching from Y to D.

### ▪ Changing rotor resistance:

A controlled converter is used in the rotor circuit to change the rotor resistance and so limit the starting current. This method is only suitable for wound-rotor induction motors. It can also be used for speed regulation. This method is expensive and gives increased heat loss.

### ▪ Soft starter:

A voltage regulator - gives, as the name suggests, a "soft start". The disadvantages of this starting method include harmonic influences and a restricted starting current.

### ▪ Changing the number of poles:

This method can only be used for special motors and in a limited speed interval.

### ▪ Frequency converter:

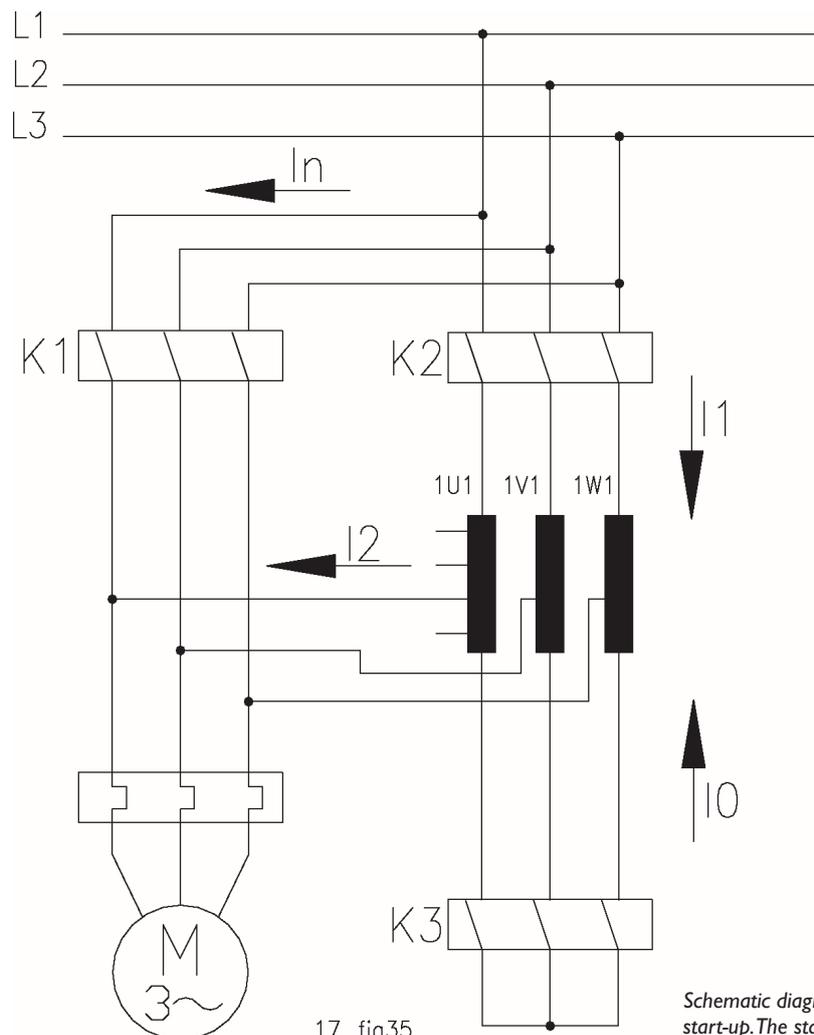
This method has good regulation possibilities and converters are available in different versions in a wide power range. There are two main types: with and without intermediate circuit.

### Autotransformer start-up

At start-up contactor "K3" should be connected first. Then contactor "K2" should be connected. The transformer will then work with a reduced operating voltage to the motor. At the right speed contactor "K3" will then open and part of the transformer winding will be in series, something which gives a certain reactor effect and a soft continuation of the start-up without voltage spikes. Contactor "K1" close and the motor being supplied with operating voltage. Finally contactor "K2" should open.



Three-phase autotransformer for motor start-up from Noratel. It is equipped with, among other things, thermistors for monitoring and disconnection in the event of a fault. The transformer can be supplied with a large number of tapings/adjustments for several stages if desired. Small overall dimensions versus high motor powers.



Schematic diagram of autotransformer start-up. The starting transformer is normally connected for what is known as closed circuit transition autotransformer starting.