Motor Starting

STUDY FOR FE

Induction Motor Starting

An induction motor starts when a 3-phase power supply activates the stator windings, creating a rotating magnetic field. This field induces voltage and current in the rotor windings, enabling the motor to start automatically. However, starting schemes are crucial to manage high inrush currents that lead to voltage drops, prevent motor overheating, and ensure system safety through overload and voltage protection. Methods such as star-delta and soft starters help enhance the motor's efficiency and system reliability

Direct On-Line Starting : Direct On-Line starting powers motors at full voltage, triggering a starting current 6 to 8 times the rated current and a torque between 0.5 to 1.5 times full-load, causing substantial voltage drops.

- **Advantages:** Simple, cost-effective, provides high starting torque, and ensures a quick start.
- **Disadvantages:** Not suitable for motors over 5 kW due to high inrush currents and voltage drops, which can compromise electrical system stability.

Star-Delta Starting:

- **Initial Connection:** Stator winding starts in star configuration, reducing start current to $\frac{V_L}{\sqrt{3}}$
- **Reduced Torque:** Induced torque is one-third of that in direct on-line starting due to $\tau_{ind} \propto V^2$
- **Changeover:** Switch from star to delta at 75%-85% of synchronous speed.
- **Contactors:** Transition involves opening star contactors and closing delta contactors.
- **Timing:** Changeover is managed by a timer set between 30ms and 50ms.
- **Transient Current:** Peak current occurs during changeover.
- **Common Use:** Ideal for applications that require low initial torque

Part Winding Starting:

- **Stator Configuration:** Stator winding is split into two parallel windings, essentially creating two half motors of equal power.
- **Terminal Outputs:** Typically configured with 6 or 12 terminal outputs.
- **Initial Connection:** Initially, only one half of the motor is connected directly to the full mains voltage.
- **Reduced Current and Torque:** The starting current and torque are about 50% of what is experienced with Direct On-Line (DOL) starting.
- **Sequential Connection:** After an initial period, the second winding is connected to the mains to complete the start sequence.

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Resistance Stator Starting:

- **Configuration:** Resistors are added in series with motor windings to reduce initial voltage.
- **Reduced Current:** Starting current is about 4.5 times the rated current, lower than DOL.
- **Higher Torque:** Starting torque is approximately 0.75 of the rated torque, surpassing Star-Delta.
- **Elimination of Resistors:** Resistors are removed post-start, connecting the motor directly to mains.
- **Smooth Current Transition:** Avoids the transient peaks seen in Star-Delta starts.

Autotransformer Starting

- **Reduced Voltage Start:** Uses an autotransformer to start the motor at a lower voltage.
- **Starting Current:** Typically ranges from 1.7 to 4 times the rated current.
- **Starting Torque:** Between 0.5 and 0.85 times the rated torque.
- **Voltage Adjustment:** Autotransformer taps allow for the adjustment of starting current and torque.
- **Current Formula:** Starting current is calculated as (%tap)2×IDOL(\%tap)^2 \times I_{DOL}(%tap)2×IDOL, providing a controlled start.

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Synchronous motor starting

Synchronous motors are not self-starting because the stationary rotor's constant magnetic field creates a pulsating torque when interacting with the rotating stator field, which doesn't produce rotation. To start, the motor is first accelerated to near synchronous speed, and then DC field current is applied as it reaches this speed, allowing it to sync and rotate properly.

Pony Motor

- **Motor Type:** The pony motor is an induction motor directly coupled to the synchronous motor.
- **Pole Configuration:** It has fewer poles than the synchronous motor to ensure efficient speed escalation.
- **Function:** Brings the synchronous motor's rotor up to synchronous speed.
- **Activation:** Once synchronous speed is reached, the DC supply to the rotor is switched on.
- **Magnetic Lock-in:** This action causes the rotor's and stator's magnetic fields to synchronize.
- **Operation:** The synchronous motor then operates at synchronous speed.
- **Decoupling:** After synchronization, the pony motor is decoupled from the synchronous motor.

DC Machine

- **Coupling:** A DC machine is directly coupled to the synchronous motor, similar to a pony motor.
- **Initial Function:** Initially functions as a motor to accelerate the synchronous motor's rotor to synchronous speed.
- **Transition to Generator:** Upon reaching synchronous speed, the DC machine transitions to act as a generator.
- **Field Current Supply:** As a generator, it supplies the field current to the rotor.
- **Magnetic Lock-in:** This enables the rotor’s magnetic field to lock in with the stator’s magnetic field.
- **Continuous Operation:** The synchronous motor then continues to operate at synchronous speed.
- **Dual Role:** The DC machine serves both as a motor to start the synchronous motor and as a generator to supply field current.

Damper Windings

- **Structure:** Synchronous motors are equipped with squirrel cage windings on the rotor, known as 'damper windings.'
- **Purpose:** Damper windings are not designed to carry load current but assist in starting the motor.
- **Starting as Induction Motor:** The synchronous motor starts as a squirrel cage induction motor using methods like DOL, Star-Delta, or Autotransformer.
- **Activation of DC Supply:** Once the rotor nears synchronous speed (around 95%), the DC supply to the rotor is switched on.
- **Synchronization:** The rotor then synchronizes at 100% synchronous speed.
- **Magnetic Lock-in:** The rotor's magnetic field locks in with the stator’s magnetic field, allowing stable operation.
- **Continuous Operation:** Post lock-in, the synchronous motor operates continuously at synchronous speed.
- **Commonality:** Damper windings are a prevalent method for starting synchronous motors.