



Basic of Low Voltage Soft Starter

 บริษัท ไทนามิกส์ จำกัด
Tinamics Co., Ltd.

Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical
Comparison

Engineering

FAQs

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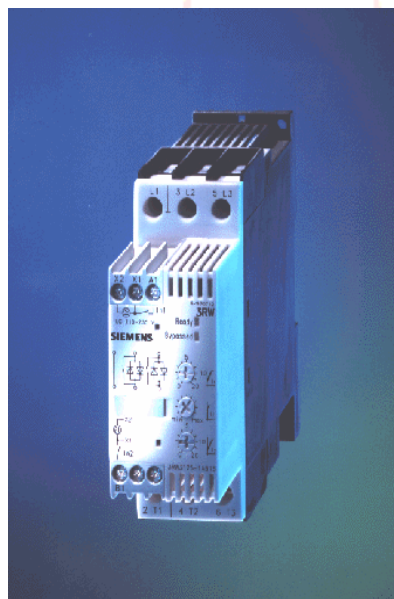
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Starting Methods for AC Motor

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Soft Starter

Technical
Comparison

Engineering

FAQs

- **Direct-on-line starting (DOL.)**
- **Star-Delta starting (Y- Δ)**
- **Reactor starting or
Auto-transformer starting**
- **Part-winding starting**
- **Rotor resistance starting (slip ring)**
- **Variable speed drive**
- **Soft Starting by Electronic Controller
So Call Soft Starter**

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Ways to start a motor Direct On Line Start (DOL)

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Part winding

Reactor Start

Rotor Resistance

Inverter Starting

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Technical
Comparison

Engineering

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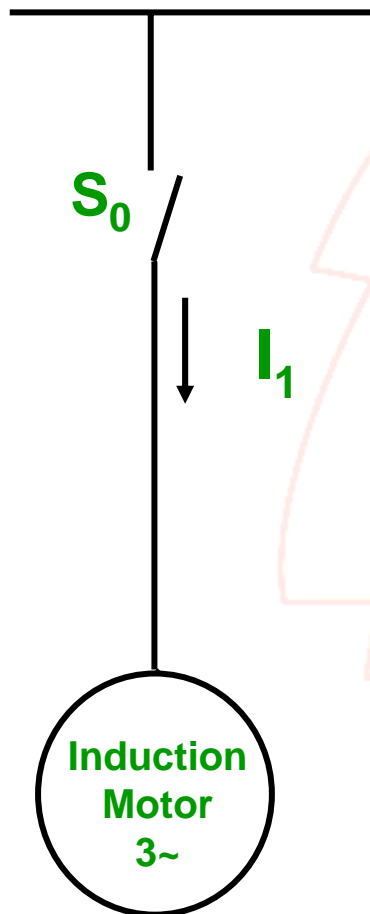
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Advantages:

- ✓ Lowest costs for breakers and auxiliaries; simple installation, hence low capital costs.
- ✓ Develop maximum starting torque.
- ✓ System conditions permitting, direct-on-line starting should therefore always be preferred.

Disadvantages:

- ✗ Starting current is about 4 to 7 times the motor rated current, depending on motor power rating and speed.
- ✗ Voltage drop when motor is switched on. Lower the line power and/or the higher the multiple of the motor rated current, the larger will be voltage drop.



Ways to start a motor Direct online Start (DOL)



Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical

Comparison

Engineering

FAQs

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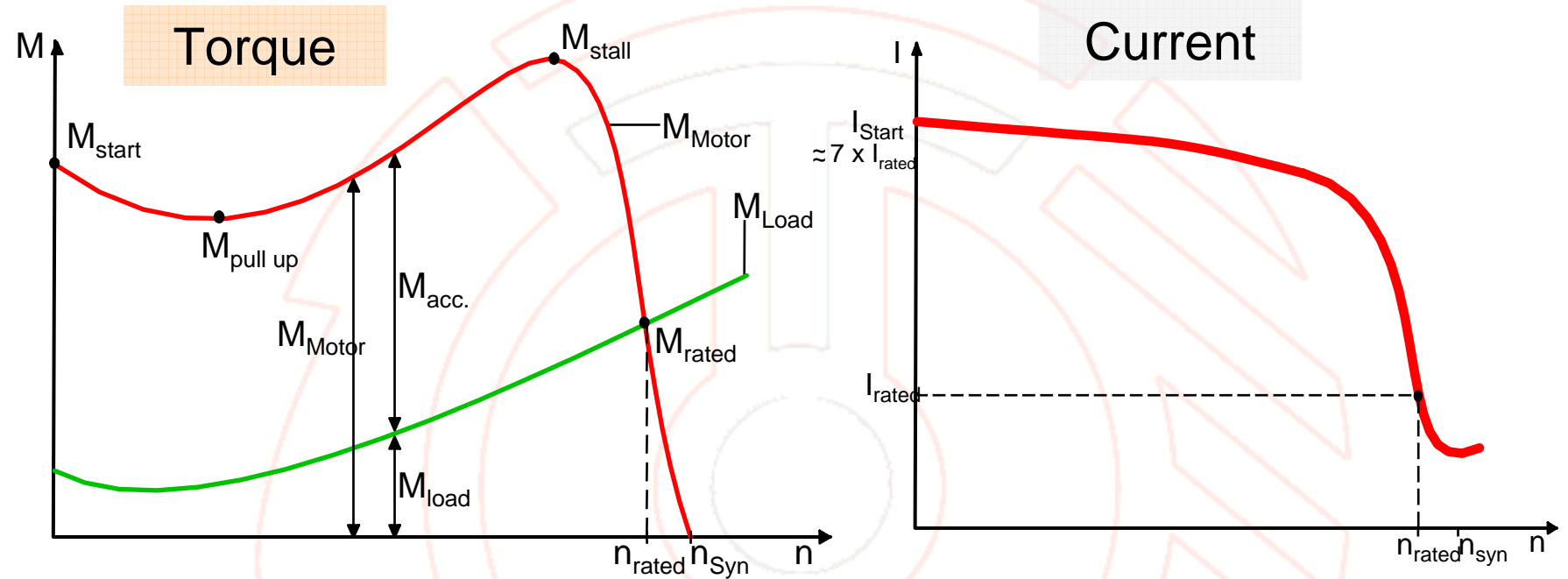
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- DOL-Torque causes **stress** to the motor and to the **load**

- increasing maintenance costs
- shorter maintenance periods

- DOL-current causes **stress** to the motor and to the **line**

- take effect to the dimensioning of the line
- take effect to the dimensioning of the switchgears



Ways to start a motor Star-Delta starting

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Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical
Comparison

Engineering

FAQs

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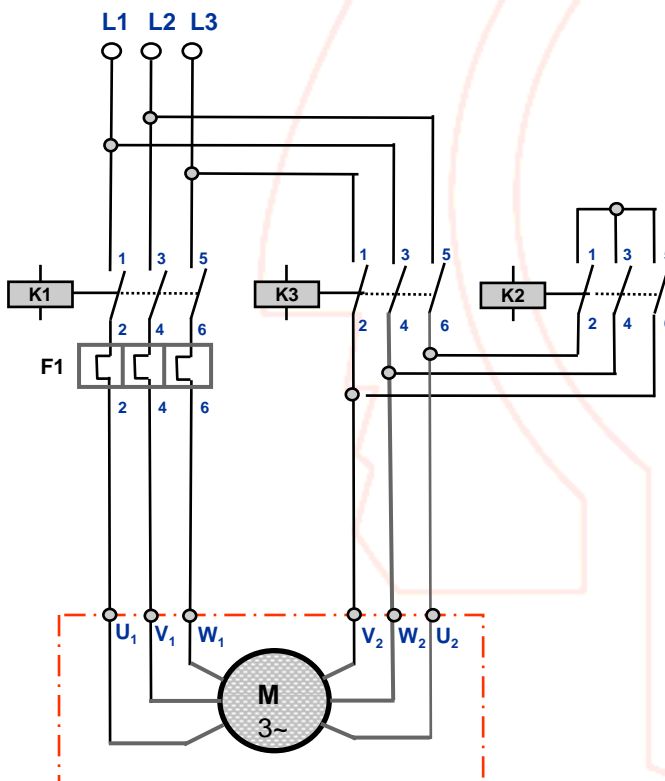
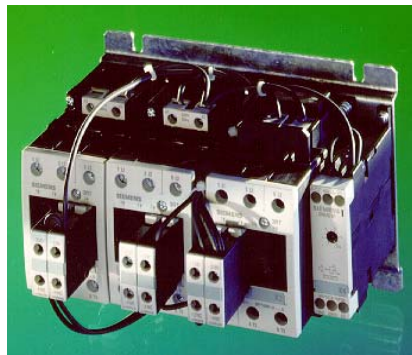
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Advantages:

- ✓ Starting current is reduced to approx. 33% of the values encountered if the motor was started across the line.

Disadvantages:

- ✗ Torque ($\propto V^2$) is also reduced to 1/3.

Remark:

Mainly use in low voltage motor.



Ways to start a motor Star-Delta starting



Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical

Comparison

Engineering

FAQs

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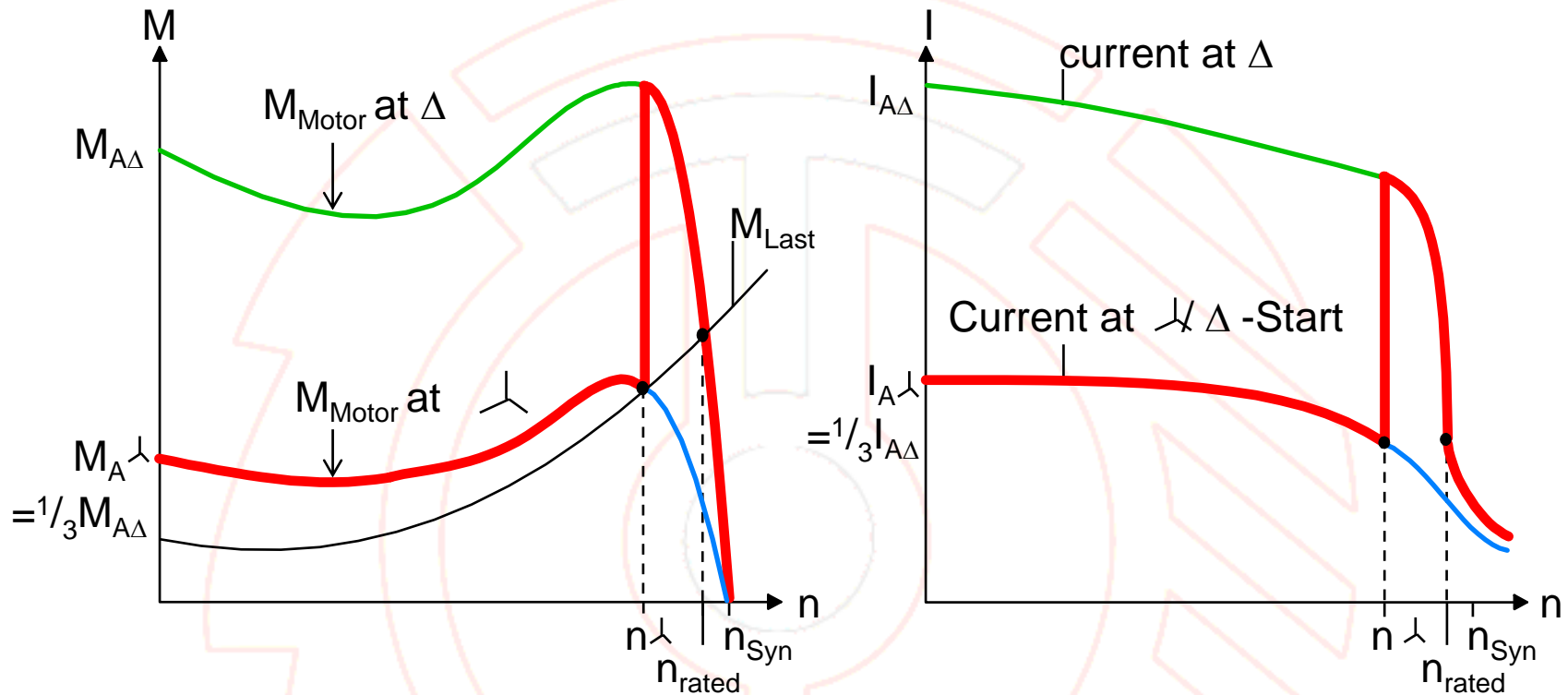
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Basic of Low Voltage Soft Starter



- torque-peek causes stress to the motor and to the load

- increasing maintenance costs

- shorter maintenance periods

- current peek causes stress to the motor and to the line

- take effect to the dimensioning of the line

- take effect to the dimensioning of the switchgears



Part winding starting



Starting Methods

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Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical
Comparison

Engineering

FAQs

Some squirrel cage motors have two or more stator windings which are connected in parallel during normal operation. During starting, only one winding is connected.

This increases stator impedance and reduces starting current. Such a starting scheme is called *part winding starting*.

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Page : 7/25



Reactor Starting Methods

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Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Starting

Rotor Resistance

Inverter Starting

Soft Starter

Technical
Comparison

Engineering

FAQs

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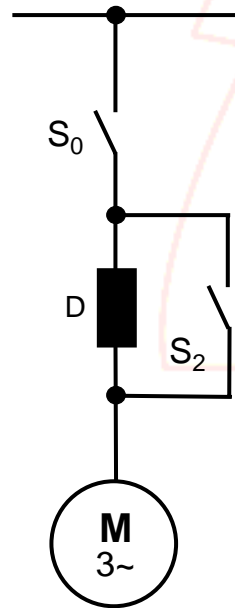
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Starting by Reactor or Auto-Transformer



$$I \sim M^2$$

When the current is linearly reduced, the torque is reduced according to a square law

Switching sequence:

- 1) Breaker S_0 is closed, the motor starts via the reactor.
- 2) After starting, the reactor coil is by-passed by breaker S_2 .



Compared to conventional solutions

Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Starting

Rotor Resistance

Inverter Starting

Soft Starter

Technical

Comparison

Engineering

FAQs

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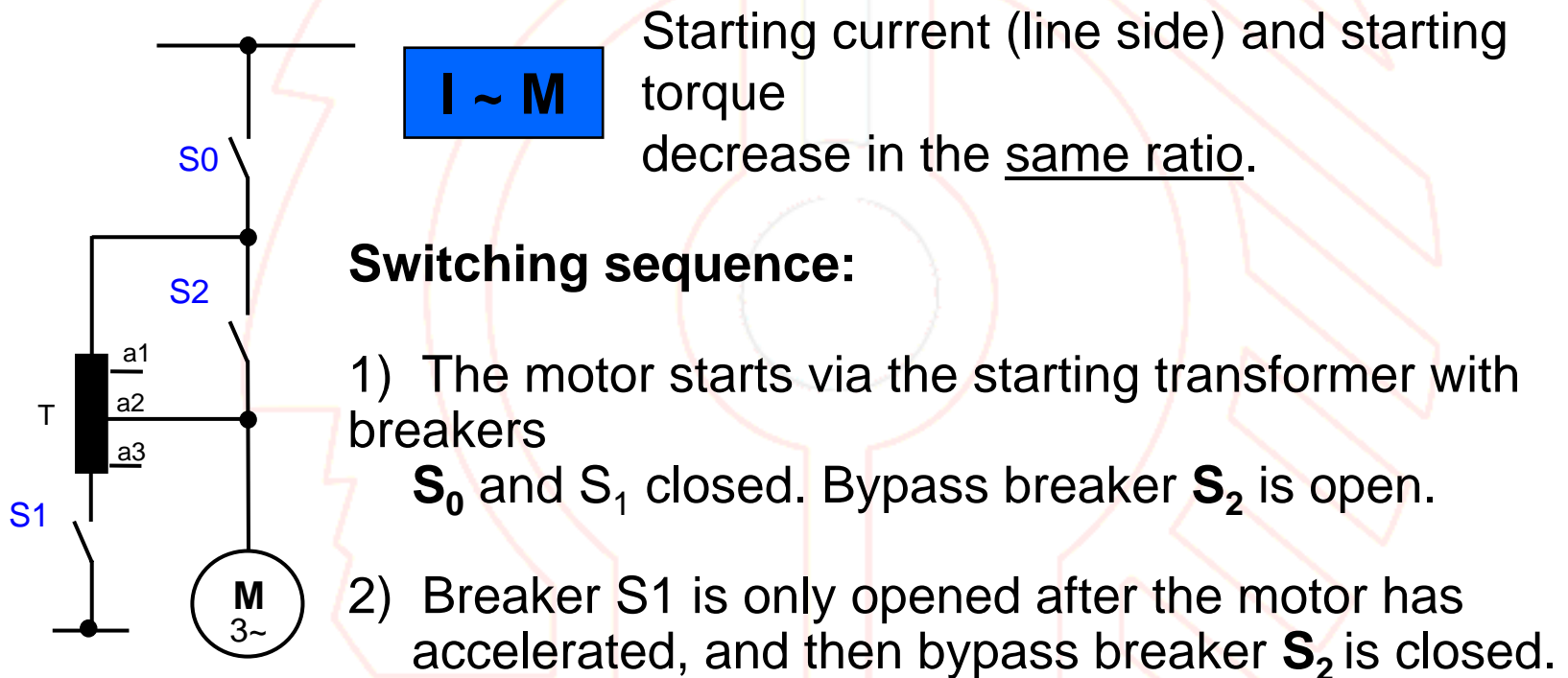
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Starting by Reactor or Auto-Transformer



The costs involved are significant which makes it more expensive than reactor starting.



Rotor Resistance starting Methods

Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical
Comparison

Engineering

FAQs

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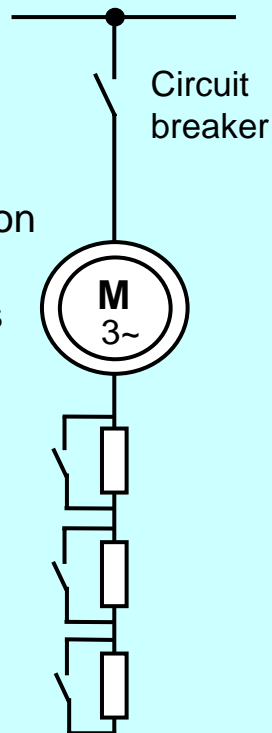
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- + Circuit breaker
- + Engineering costs
- + Mounting/installation
- + Service/ maintenance costs

+ **Series resistors**



Advantages:

- Important feature is that the starting torque and torque-to-current ratio are high. It is, therefore, suitable for applications requiring starting with heavy load and starting with high inertia load.
- While maximum torque is independent of rotor resistance value, speed at which maximum torque is produced can be controlled by changing the value of external resistors.

Disadvantages:

- ✗ Higher maintenance of slip ring motor is required.



Ways to start a motor Inverter starting

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Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter starting

Soft Starter

Technical
Comparison

Engineering

FAQs

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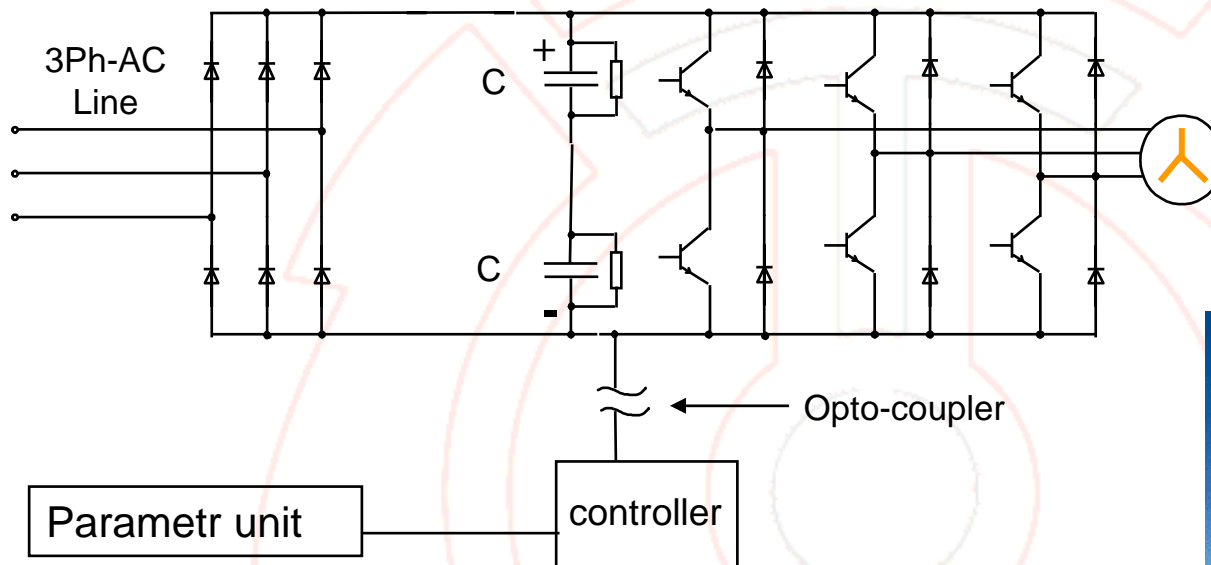
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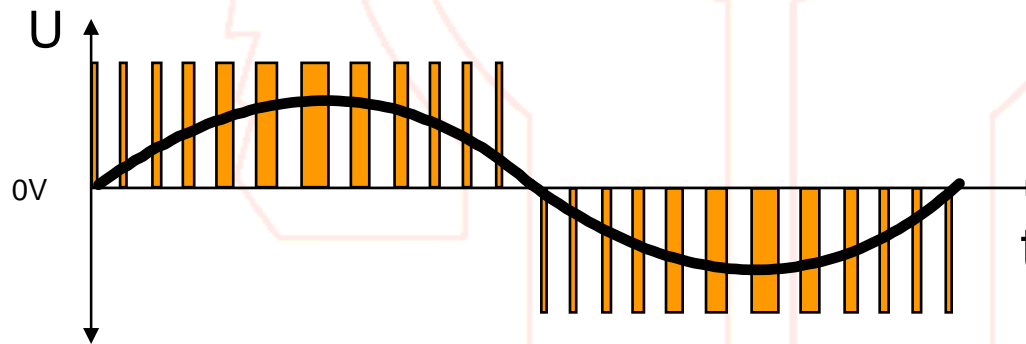
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DC-Converter

AC-Converter



Complicated Electronics
and Expensive way



Inverter can produce Voltage with changed amplitude and frequency



Ways to start a motor Inverter starting

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Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

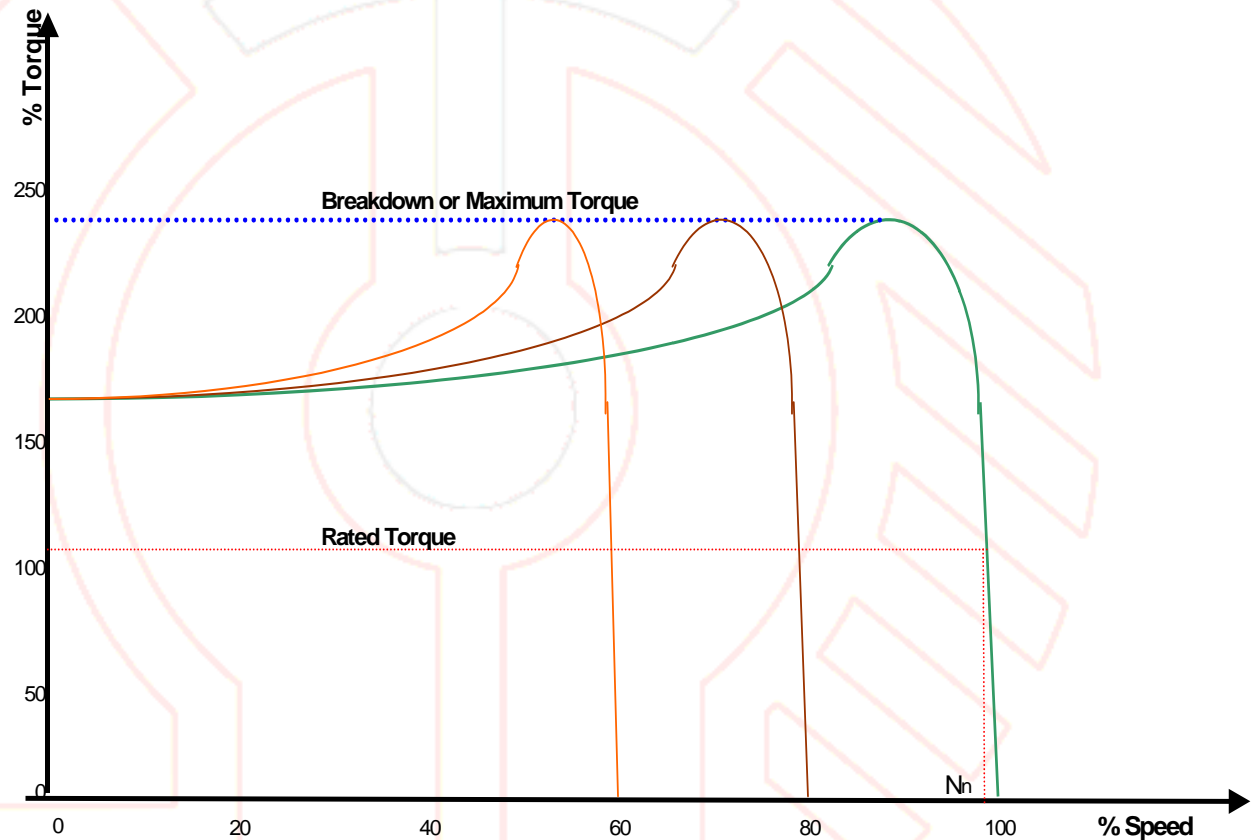
Inverter starting

Soft Starter

Technical
Comparison

Engineering

FAQs



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Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft starter

Technical
Comparison

Engineering

FAQs

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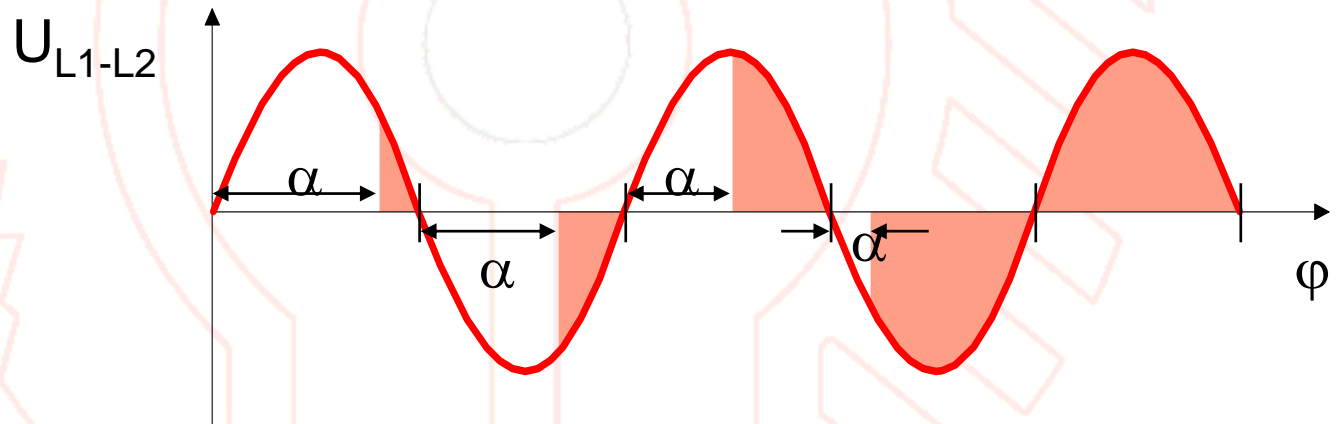
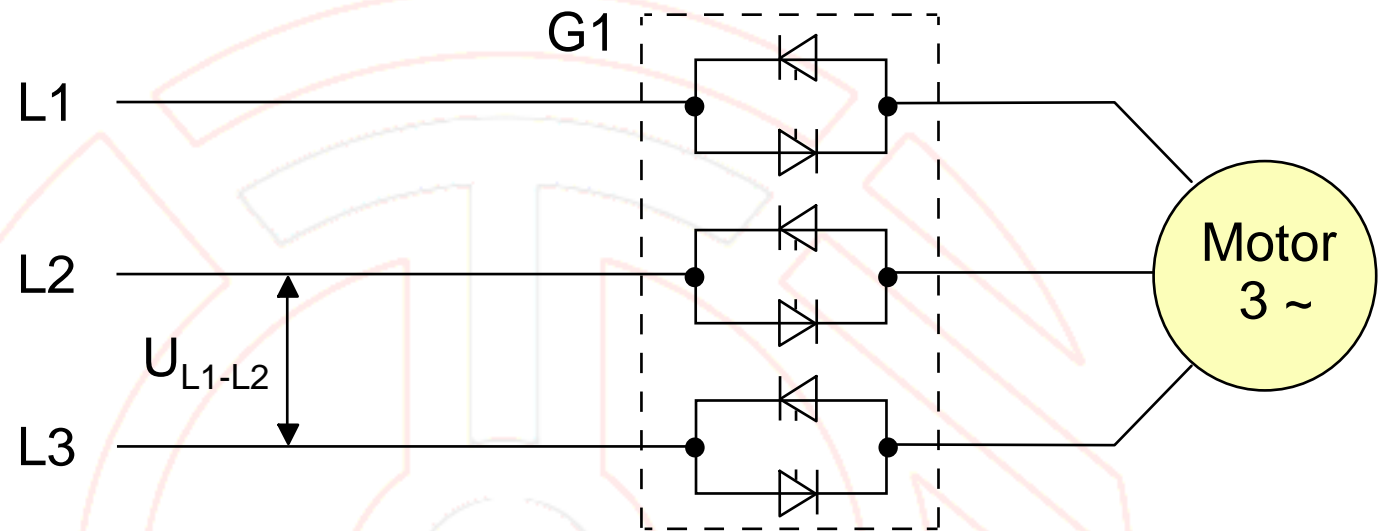
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Power electronics in 1, 2 or 3 controlled phases

Reduction of the voltage via phase-angle-control



Compared to conventional solutions

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Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Starting

Rotor Resistance

Inverter Starting

Soft Starter

Technical Comparison

Engineering

FAQs

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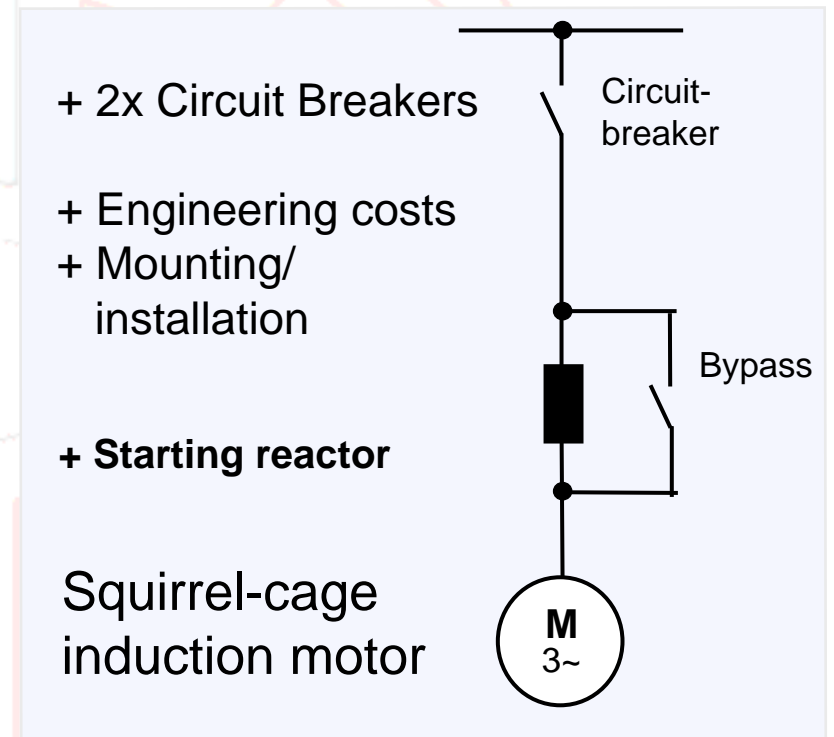
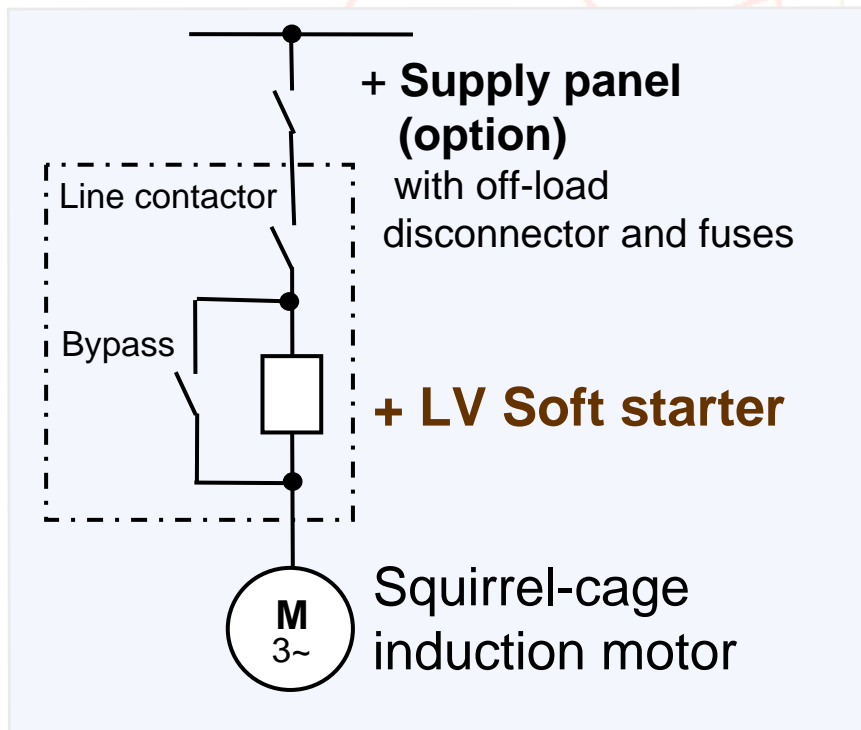
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System comparison, LV SST to reactor starting





Compared to conventional solutions

Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Starting

Rotor Resistance

Inverter Starting

Soft Starter

Technical Comparison

Engineering

FAQs

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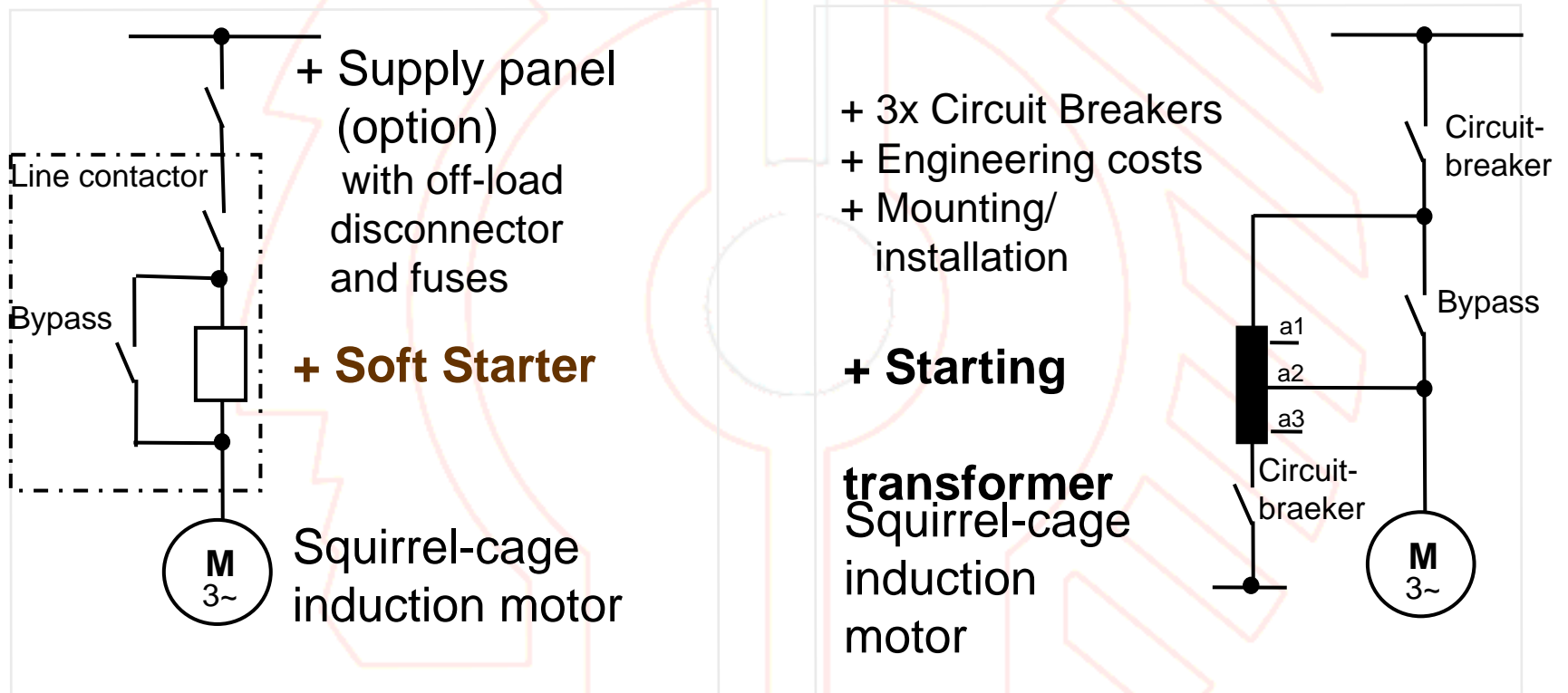
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System comparison, Soft Starter to transformer starting





Ways to start a motor Soft Starter



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Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft starter

Technical
Comparison

Engineering

FAQs

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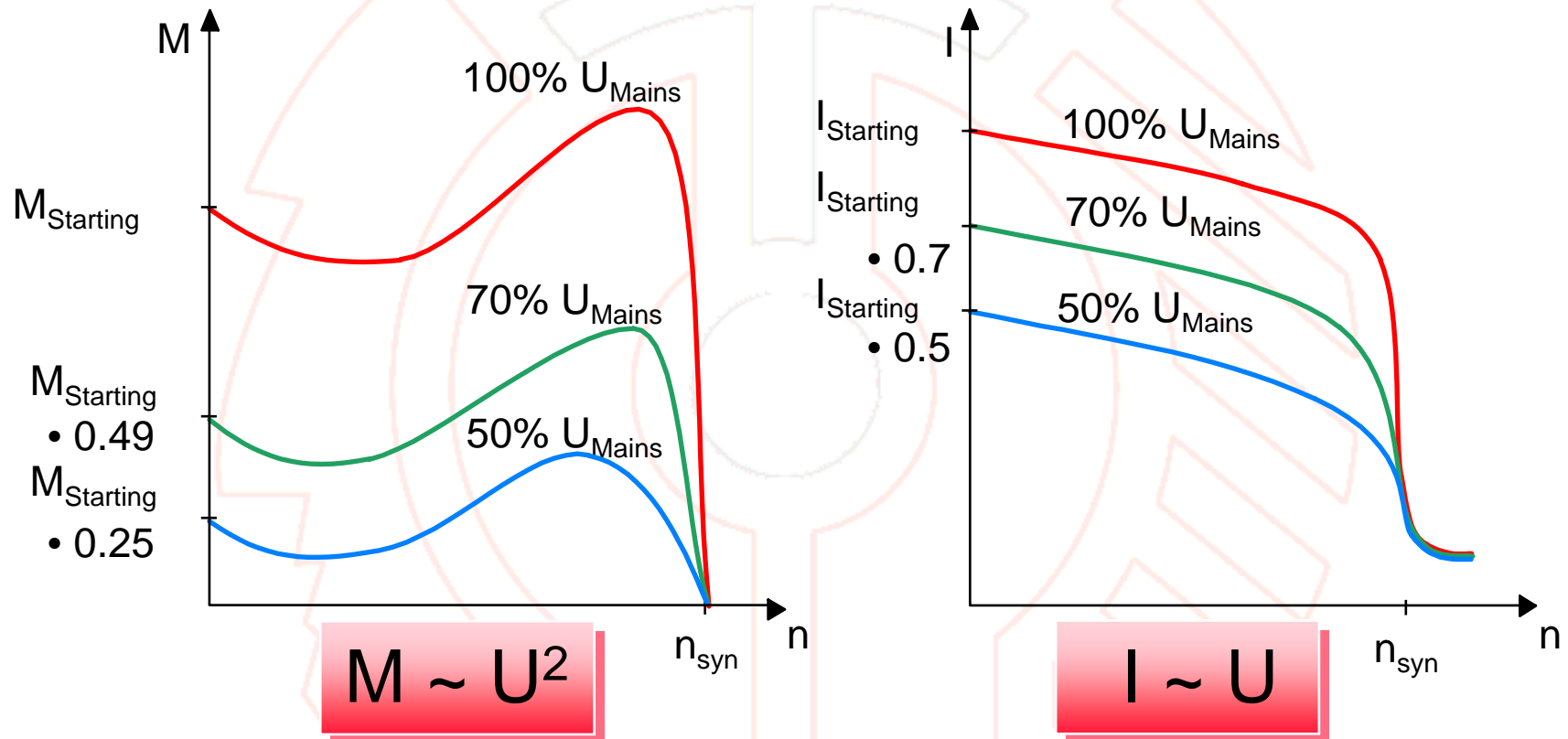
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Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Starting

Rotor Resistance

Inverter Starting

Technical Comparison

Comparison

Engineering

FAQs

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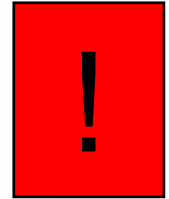
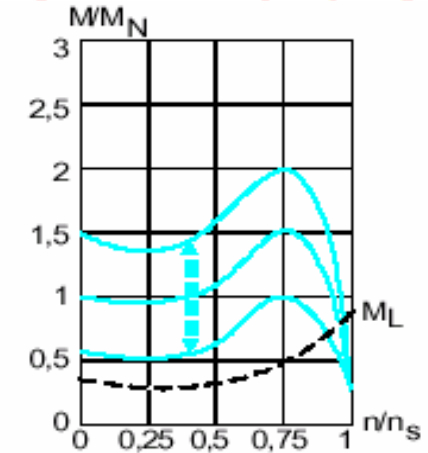
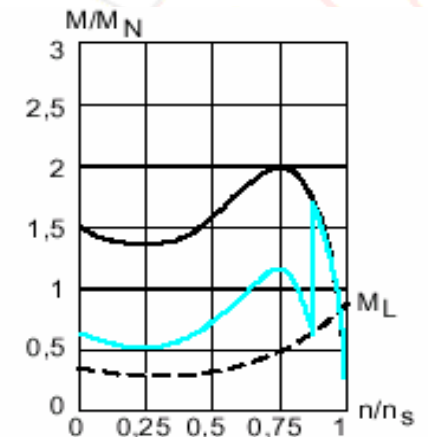
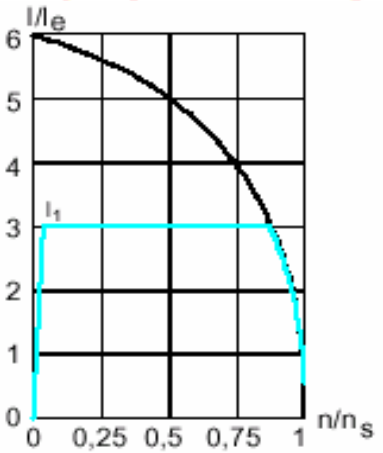
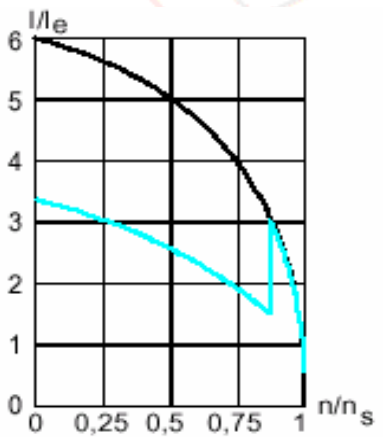
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The current and torque characteristics

Starting transformer

Soft starting



High current peaks can still be identified for starting transformers.



Compared to conventional solutions



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Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical Comparison

Engineering

FAQs

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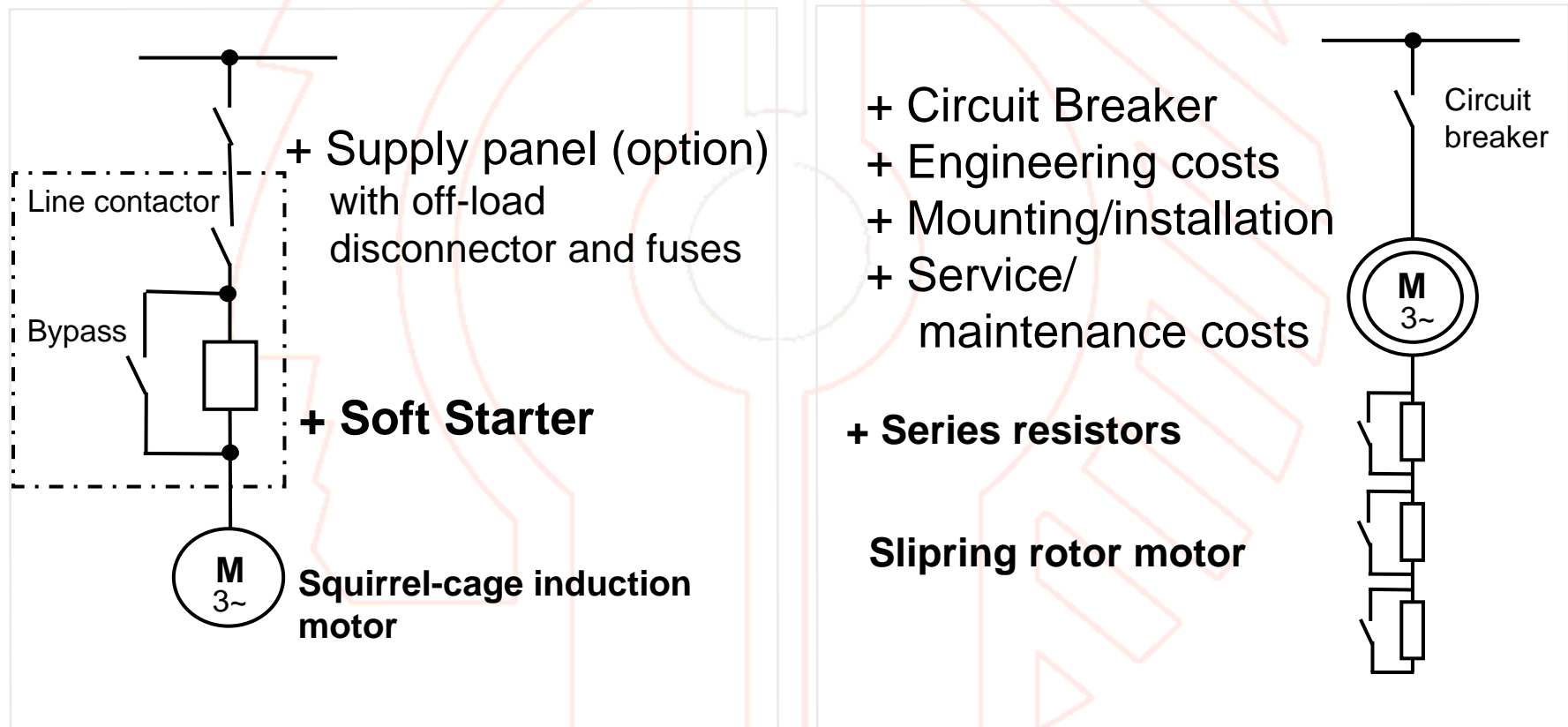
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System comparison, MV SST squirrel-cage induction motor with slipring rotor motor with starter





Compared with conventional starting Equipment Slipping motor with starter



Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical Comparison

Engineering

FAQs

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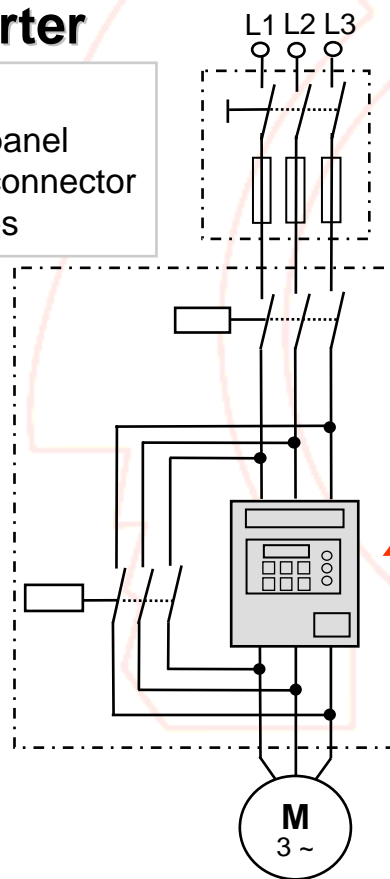
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Squirrel-cage induction motor

Slipping rotor

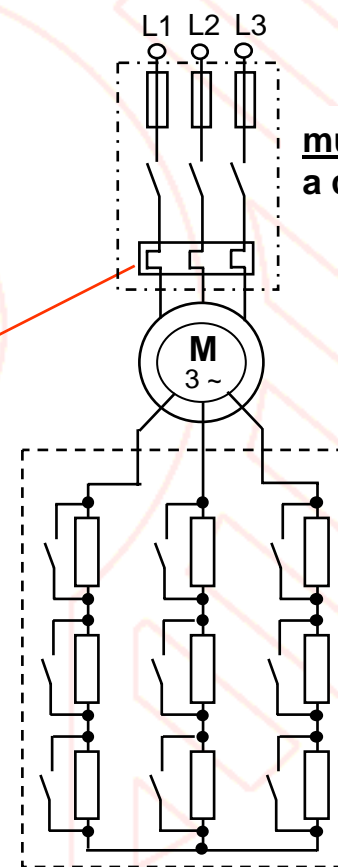
Softstarter

Option:
Supply panel with disconnecter and fuses



Starter

must be
a circuit-breaker!





Compared with conventional starting Equipment Slipping motor with starter

Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

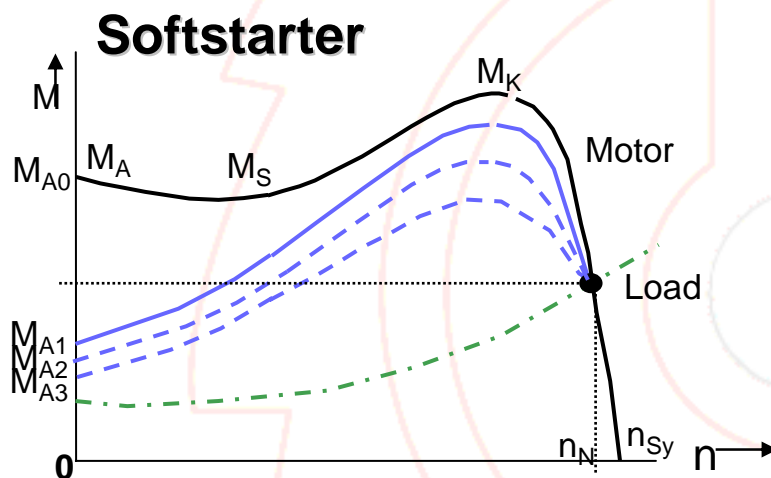
Technical Comparison

Engineering

FAQs

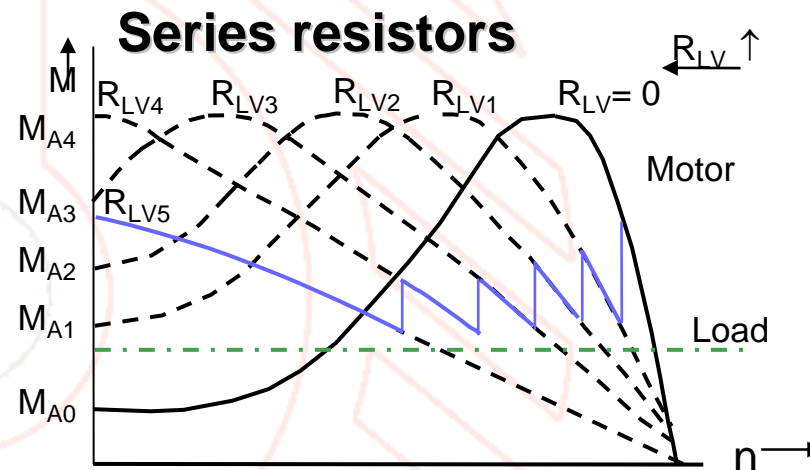
Squirrel-cage induction motor

Slipping motor



Soft starter reduces the starting torque

$$\frac{M_A}{M_N} = 0,25 \text{ to } 1$$



The starting torque is adjusted by matching the starting resistance to the rotor resistance.

$$\frac{M_A}{M_N} = 0,25 \text{ bis } \frac{M_K}{M_N} \text{ (approx. 2,5-3,5)}$$

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Compared with conventional starting Equipment Slipping motor with starter



Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical Comparison

Engineering

FAQs

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25/285

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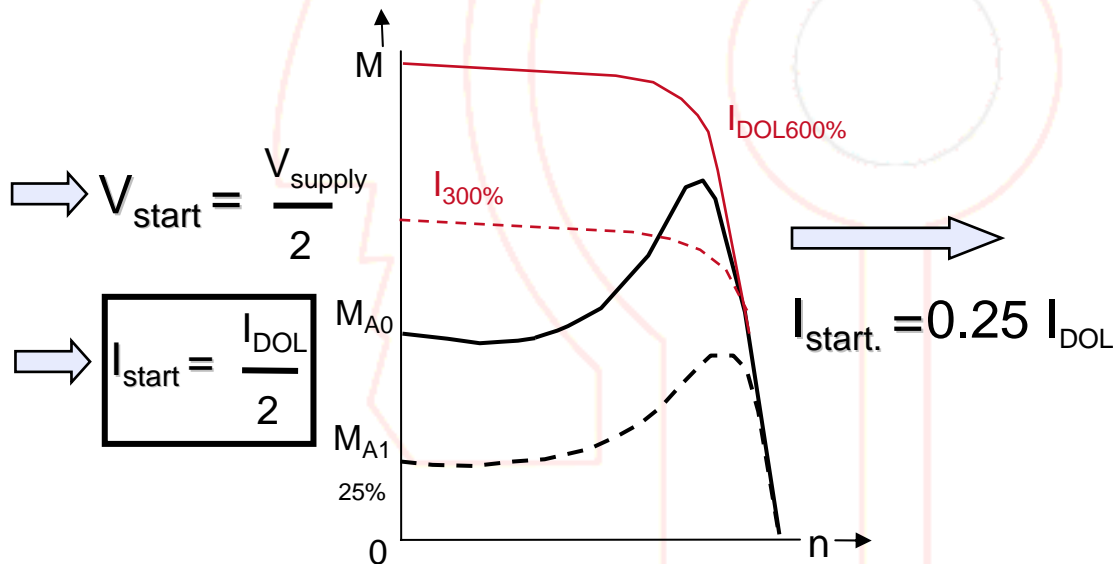
Squirrel-cage induction motor

Softstarter

$$I_{\text{start}} \sim V_{\text{start}}$$

$$M_{\text{start}} \sim V_{\text{start}}^2$$

Starting torque 25% M_N

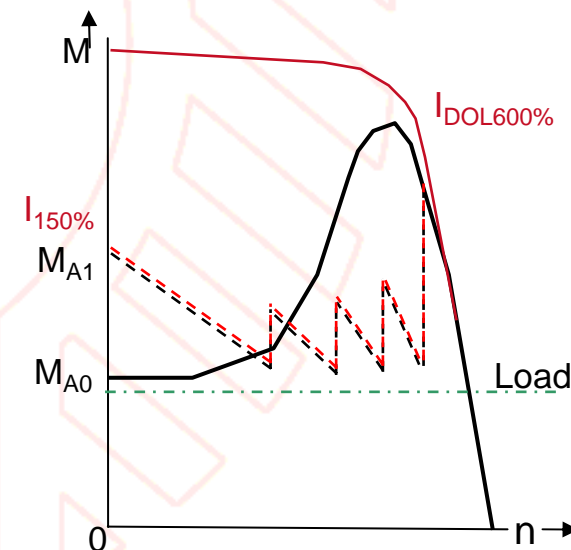


Slipping motor

Series resistors

$$I_{\text{start}} \sim M$$

Starting torque 25% M_N





Load characteristics



Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical
Comparison

Engineering

FAQs

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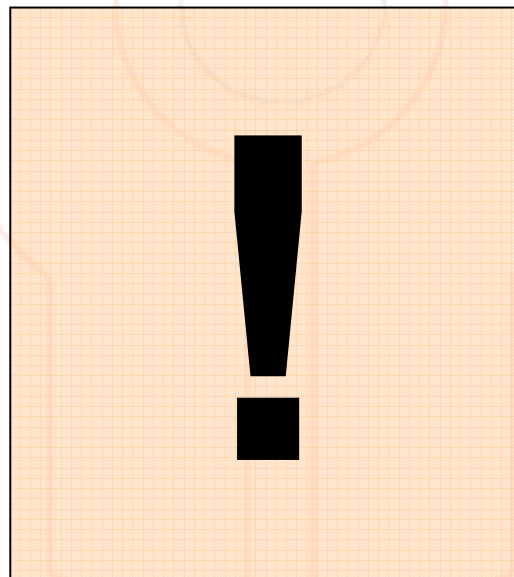
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Different loads

have

Different load-characteristics.

To know this different characteristics is very **important** to select the right soft starter !!!!!





Load characteristics

Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical Comparison

Engineering

FAQs

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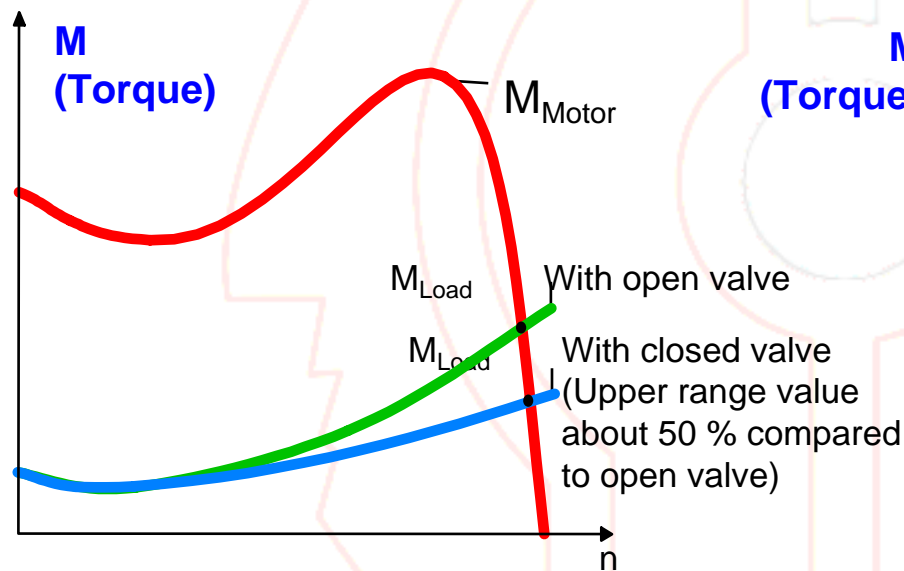
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Example:
Pumps, ventilators



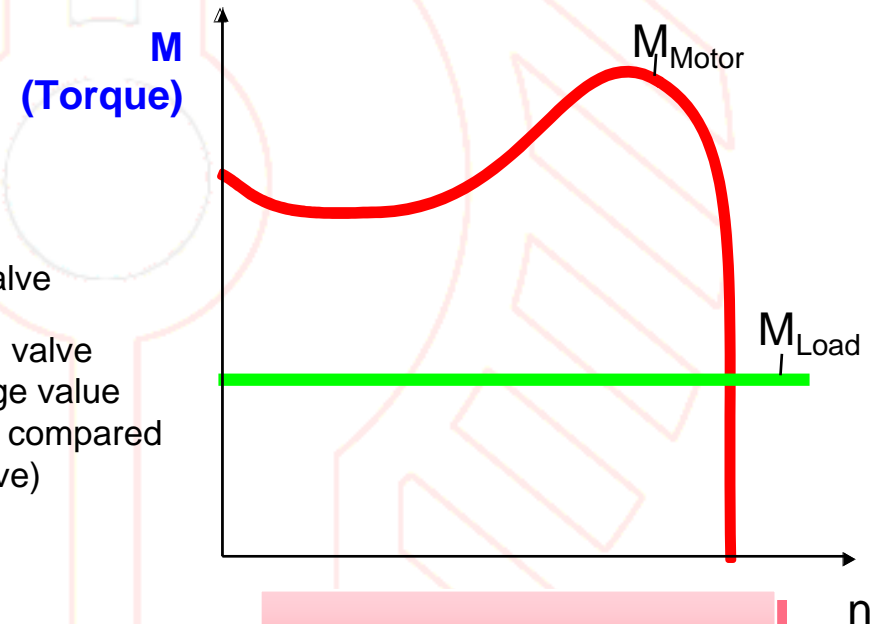
Example:
Hoists, conveyor- belts

Square-law load torque:



$$M_{Load} \sim n^2$$

Constant load torque:



$$M_{Load} = \text{const.}$$



Load characteristics

Starting Methods

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Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical
Comparison

Engineering

FAQs

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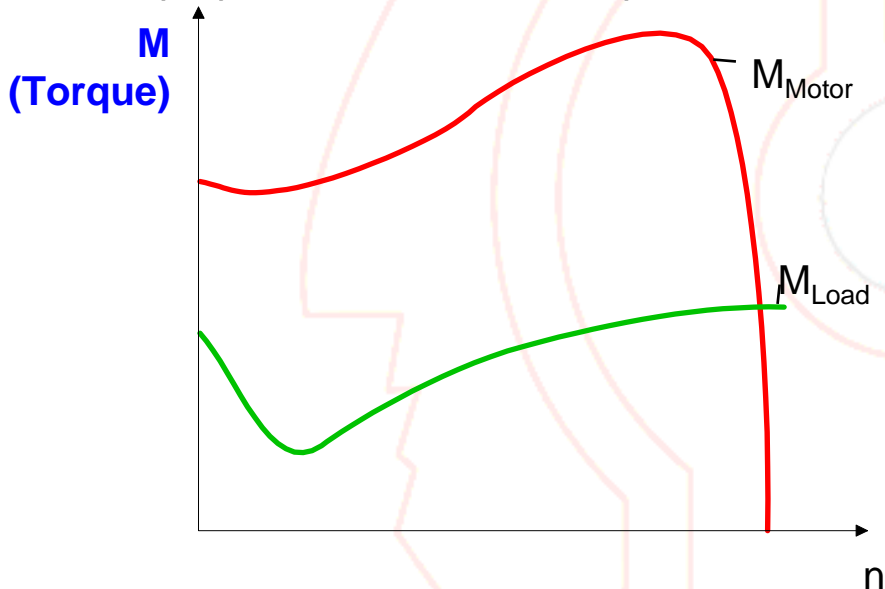
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Example:
Mills, crushers

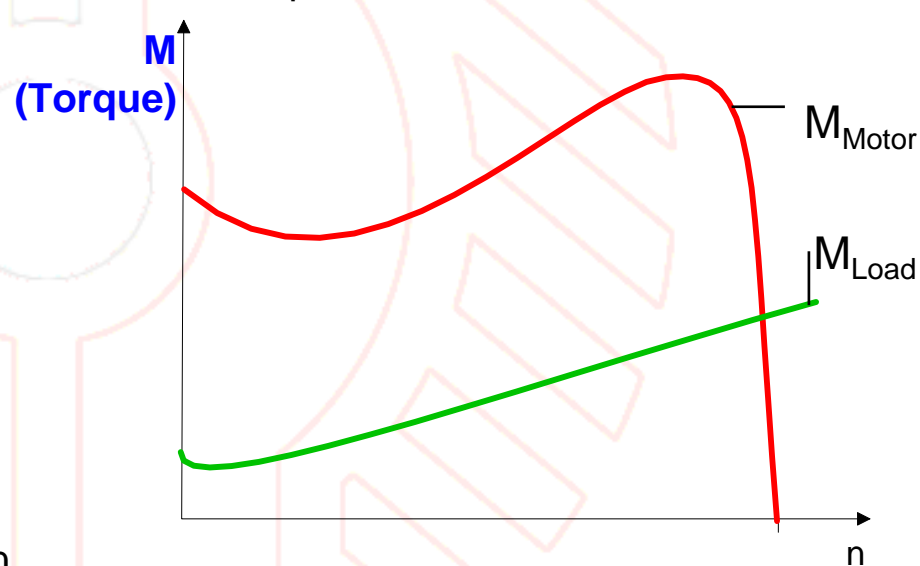
Example:
Rotary irons, calenders

Load torque inversely proportional to rotational speed:



$$M_{Load} \sim 1/n$$

Load torque with linear rise:



$$M_{Load} \sim n$$



Problems faced by customers using conventional starters



Starting Methods

Direct On Line

Star-Delta

Part winding

Reactor Start

Rotor Resistance

Inverter Starting

Soft Starter

Technical
Comparison

Engineering

FAQs

> 35% - over current (surge)

> 20% - under current

> 40% - water hammering

Starting time too long - O/L

Mechanical breakage - Belts

Stopping time too long

Cost of inverters too high

Solved by TiNAMiCS Soft Starters

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Page : 25/25