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MAINTENANCE
RELIABILITY
OPERATIONS

## TECHNICAL CONFERENCE & WORKSHOPS

# Starting Methods for Large Electrical Motors

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VOITH

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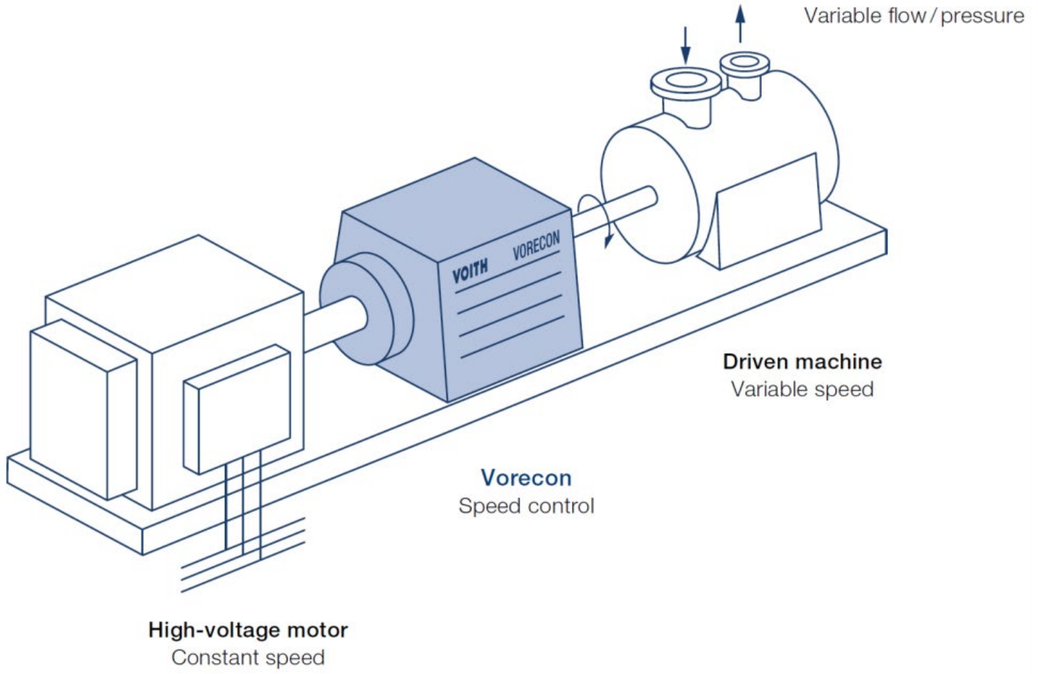
DOW Centennial Centre - Fort Saskatchewan

# Abstract


Electric Motor Drives for turbomachinery applications  have two topics of consideration:

- Motor start-up has to be managed without exceeding the maximum permissible voltage dip.
- The choice of drive impacts the train's torsional characteristics, shaft endurance limits and operational flexibility.




This tutorial shows an overview of proven start-up methods for direct online operating electric motor drives. Furthermore this tutorial outlines a methodology used to ensure torsional integrity in standardized Electric-motor-driven gas compressor packages.

# Starting methods for large electrical motors

# Voltage sequence - Parameters

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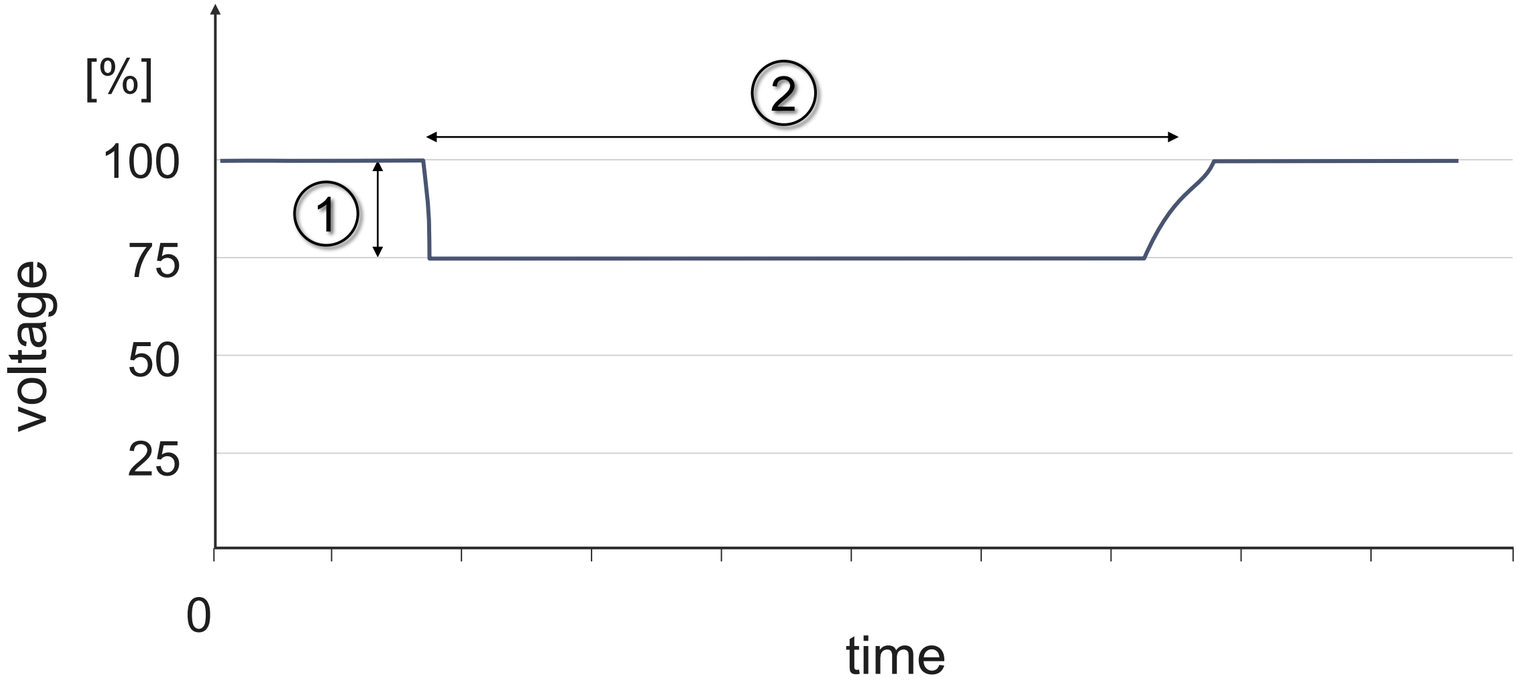
① **Dip:**

② **Duration:**



# Voltage sequence - Parameters

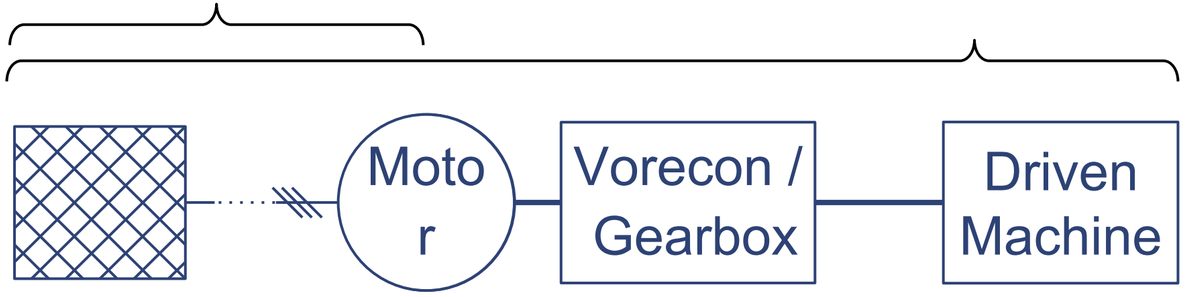
VOITH

**1 Dip: Electrics**

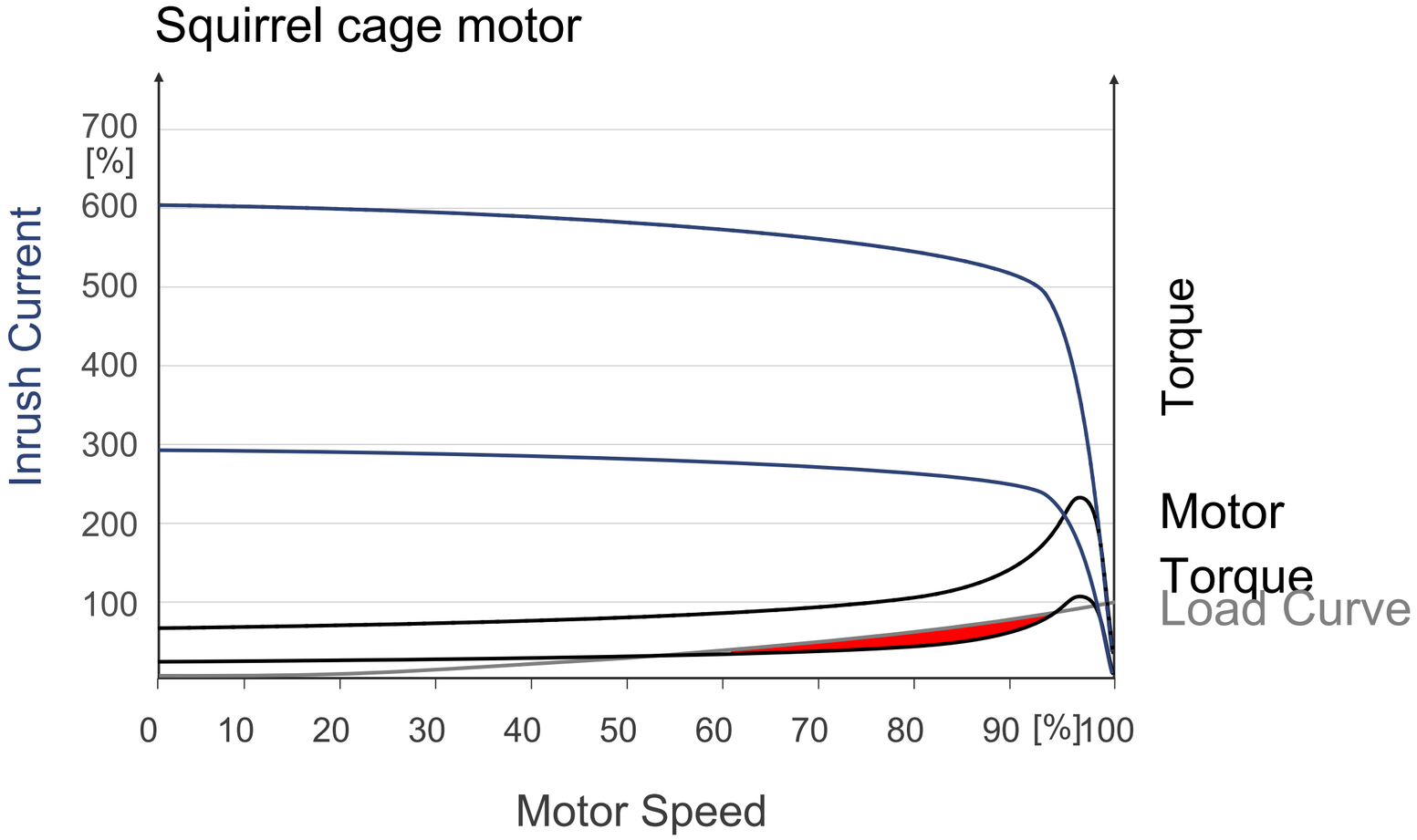
grid .. motor

**2 Duration: Electrics - Mechanics**

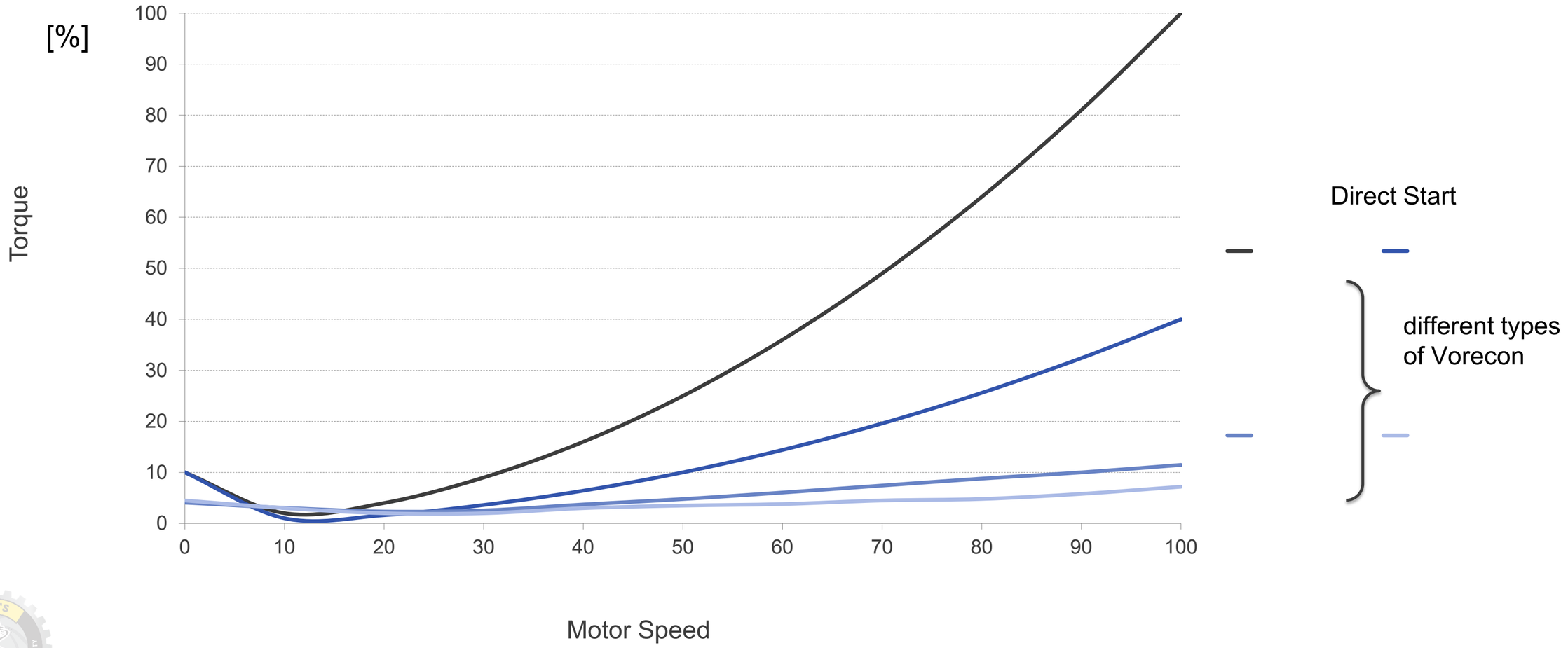
grid .. motor
mechanic / hydrodynamic drive train



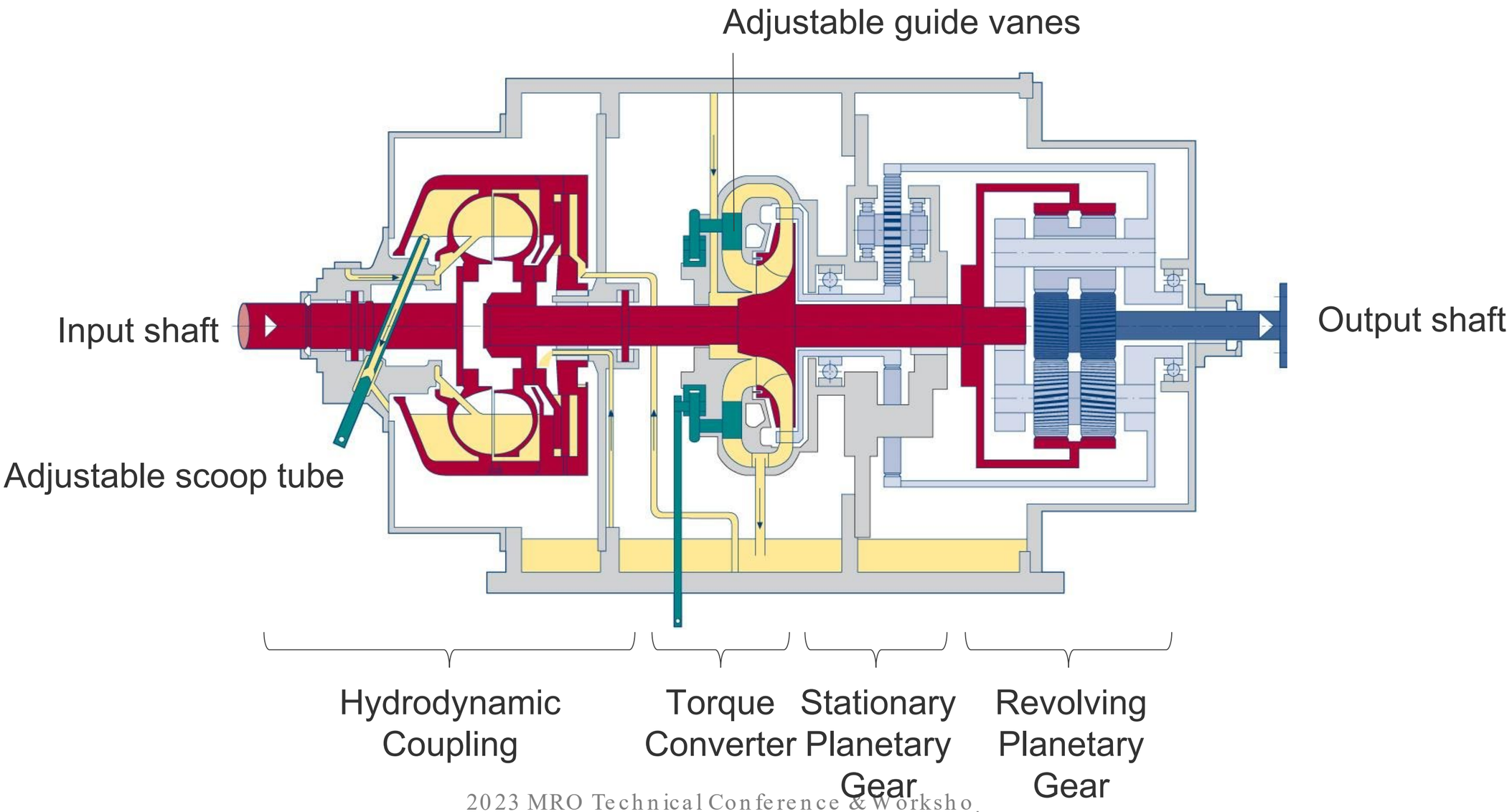
# Voltage sequence - Dependence of inrush current ↔ motor torque



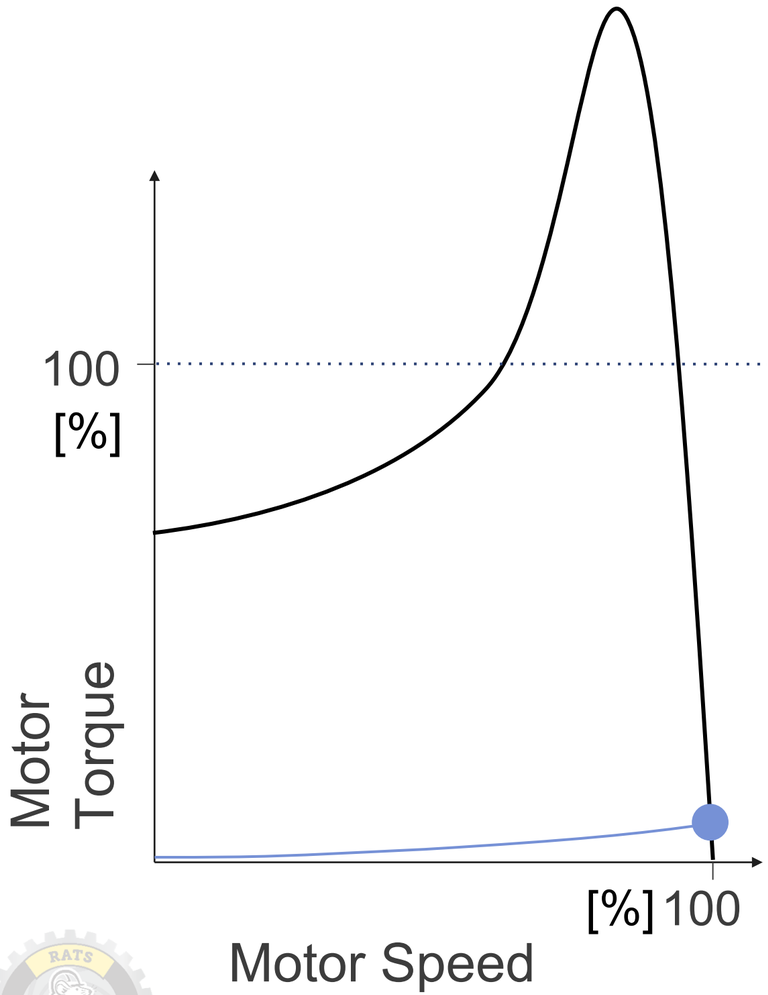
# Load curve

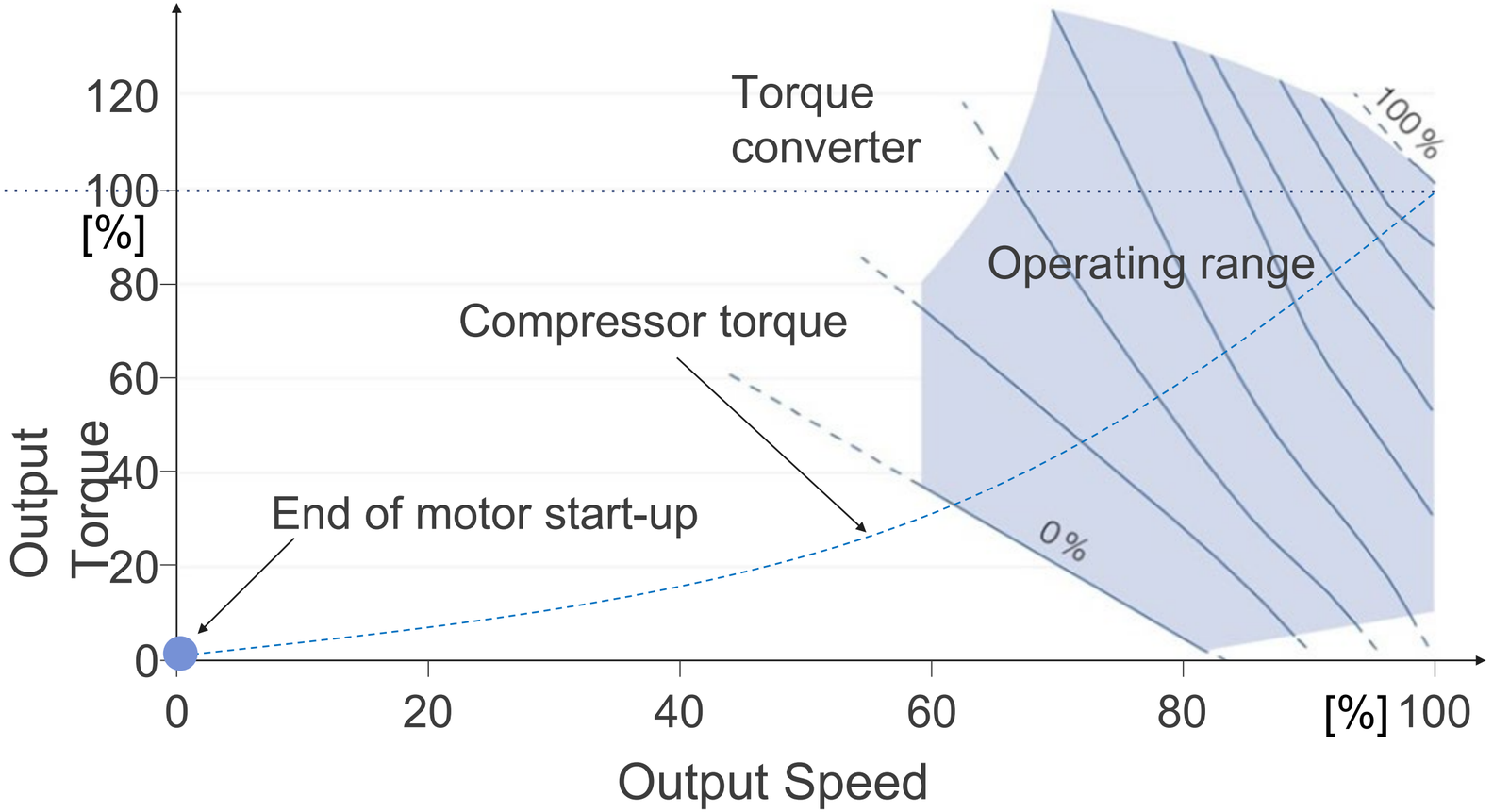

[%]
Torque
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Motor Speed
Direct Start
different types
of Vorecon

# Vorecon RWC

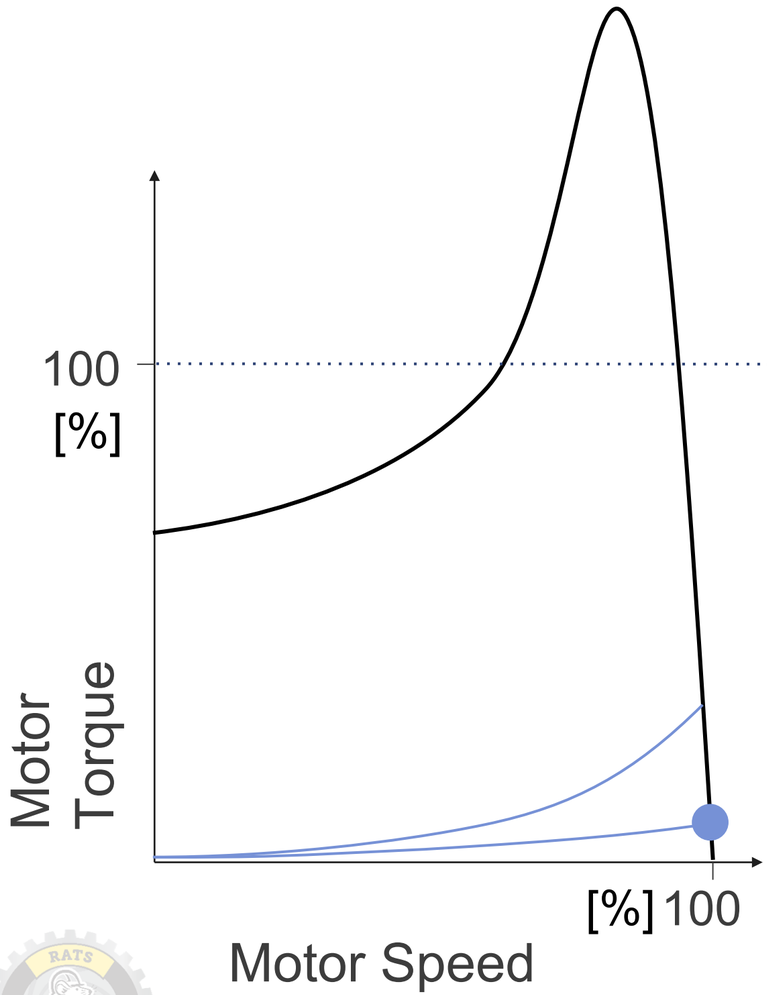

Adjustable guide vanes
Input shaft
Output shaft
Adjustable scoop tube
Hydrodynamic Coupling
Torque Converter
Stationary Planetary Gear
Revolving Planetary Gear

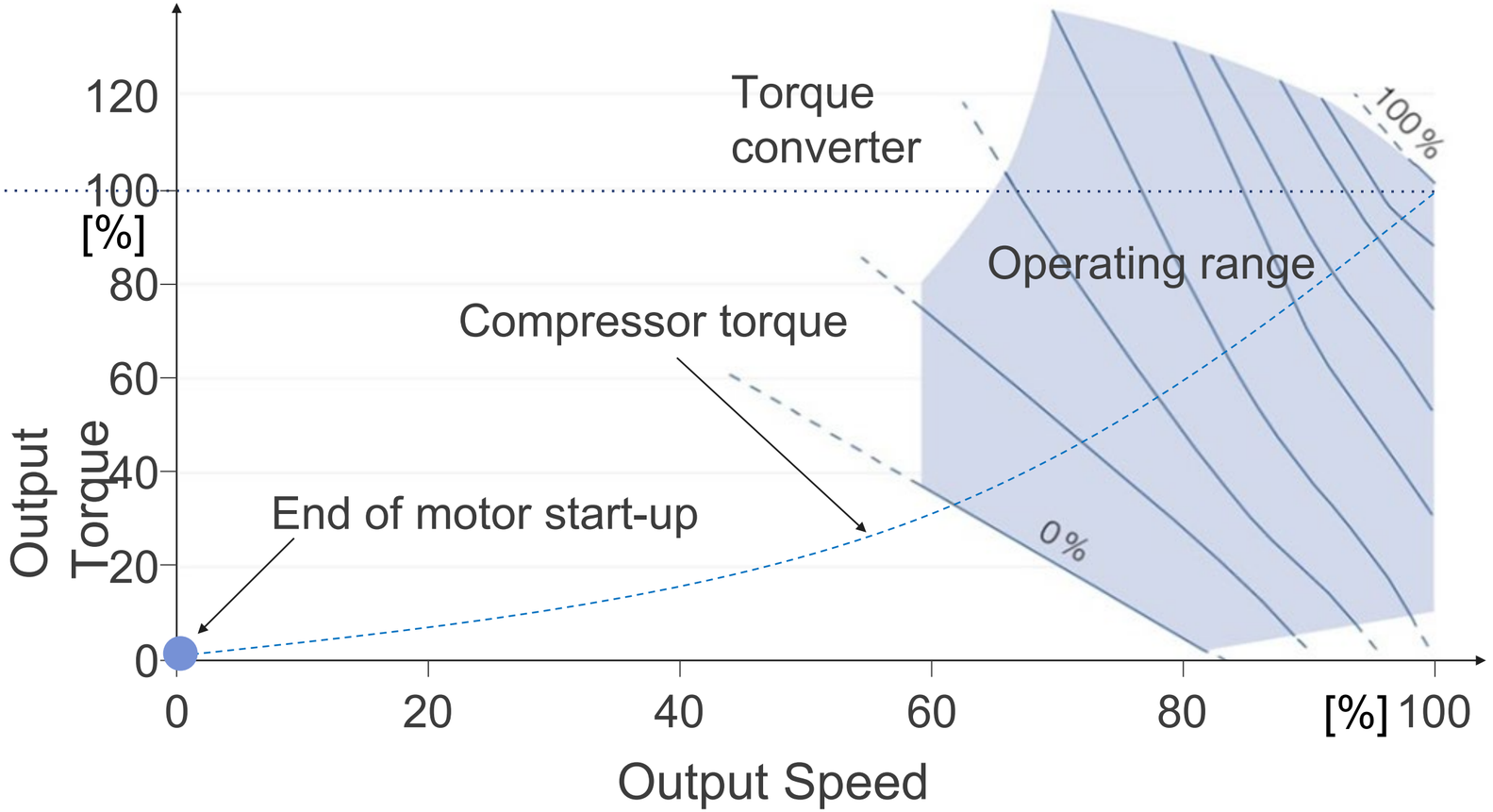
# RWC: Unloaded start-up



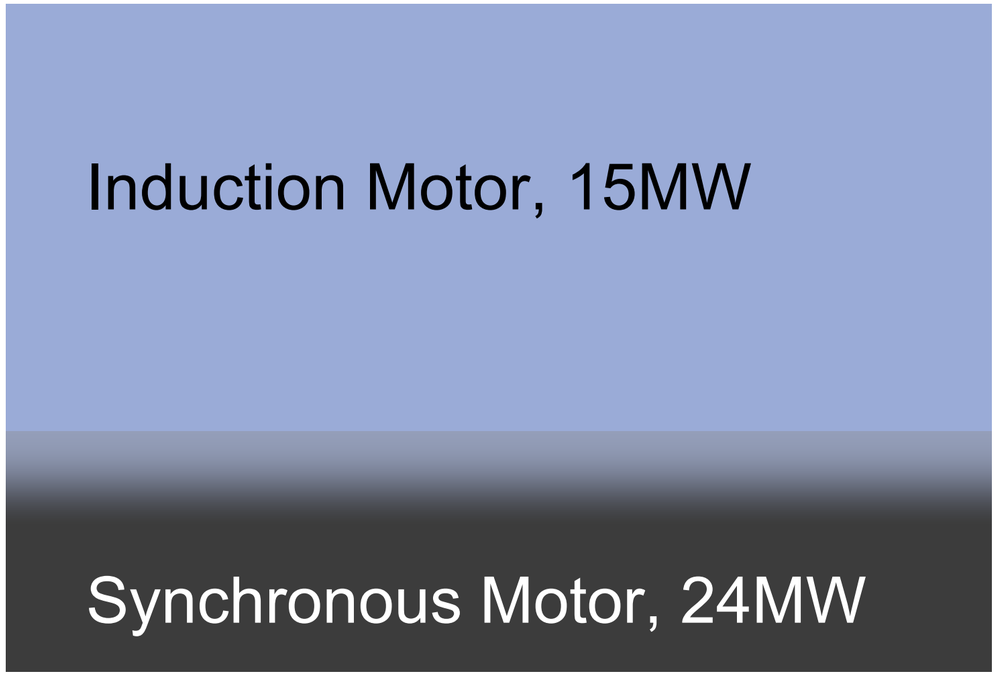
# RWC: Unloaded start-up



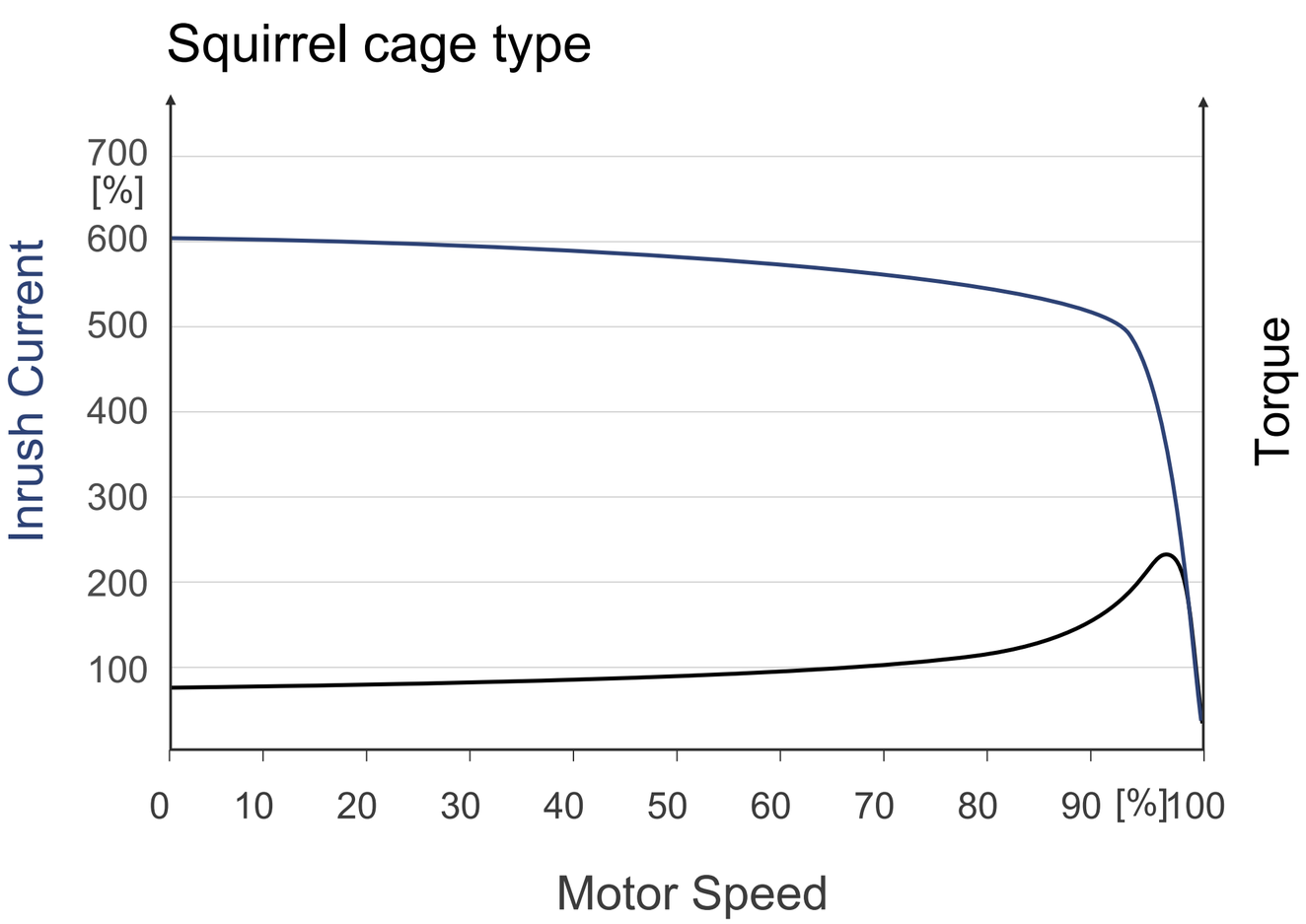



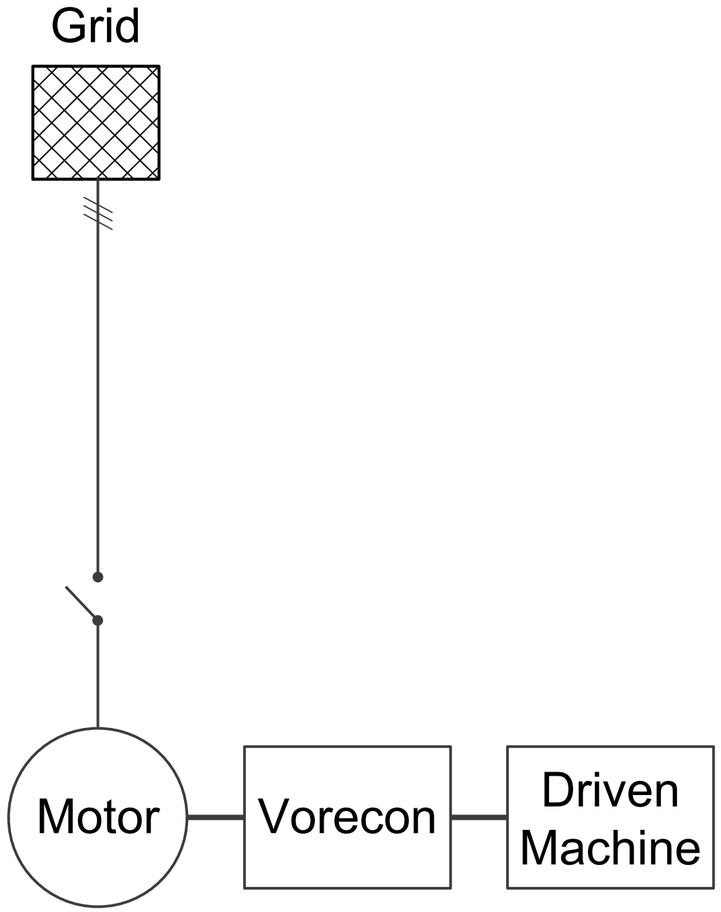
# Starting Methods

- Direct online (DOL)
- Low inrush current (LIC) motor
- Autotransformer
- Soft Starter
- Rotor-Resistance Starter
- VFD-Starter
- Pony Motor Starter



# Direct online (DOL) start-up

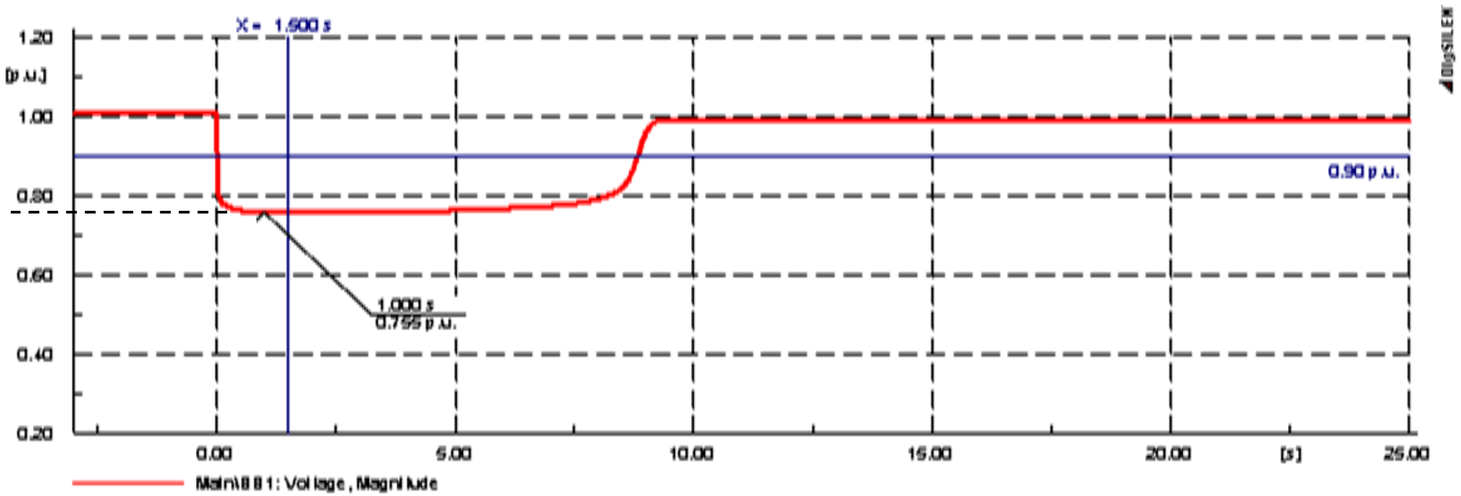


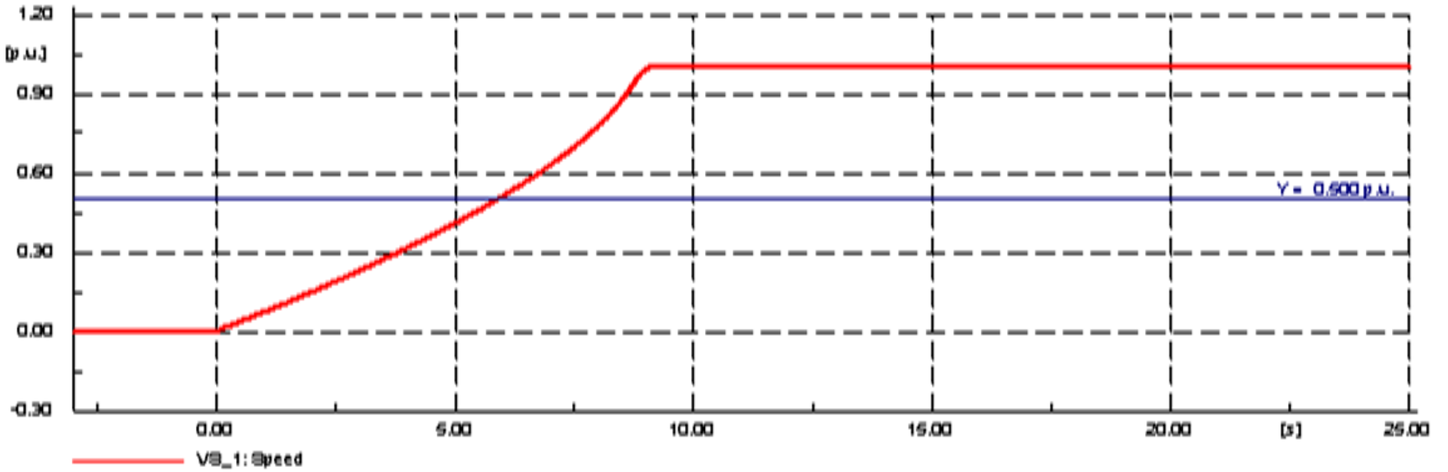
# Direct online (DOL) start-up

Voltage

76%

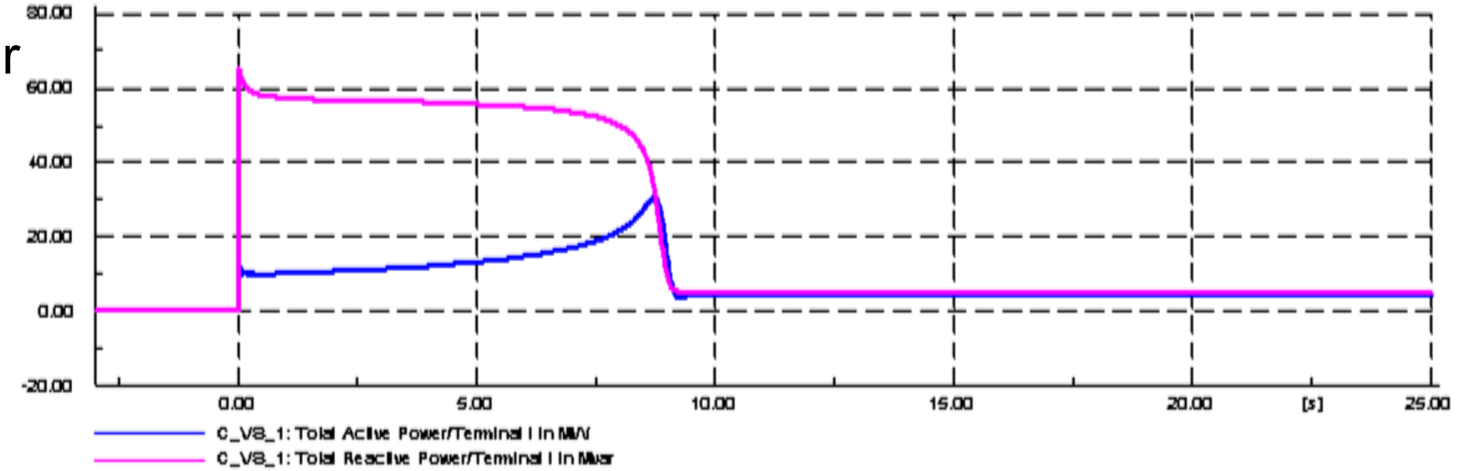



Speed

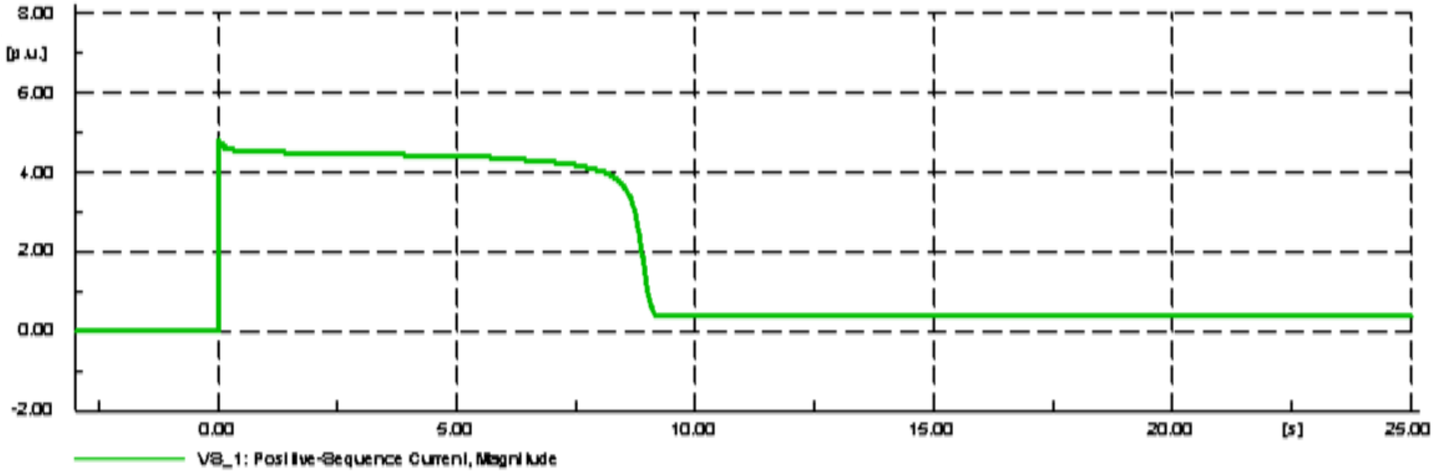


# Direct online (DOL) start-up

Power




Current



# Direct online (DOL) start-up

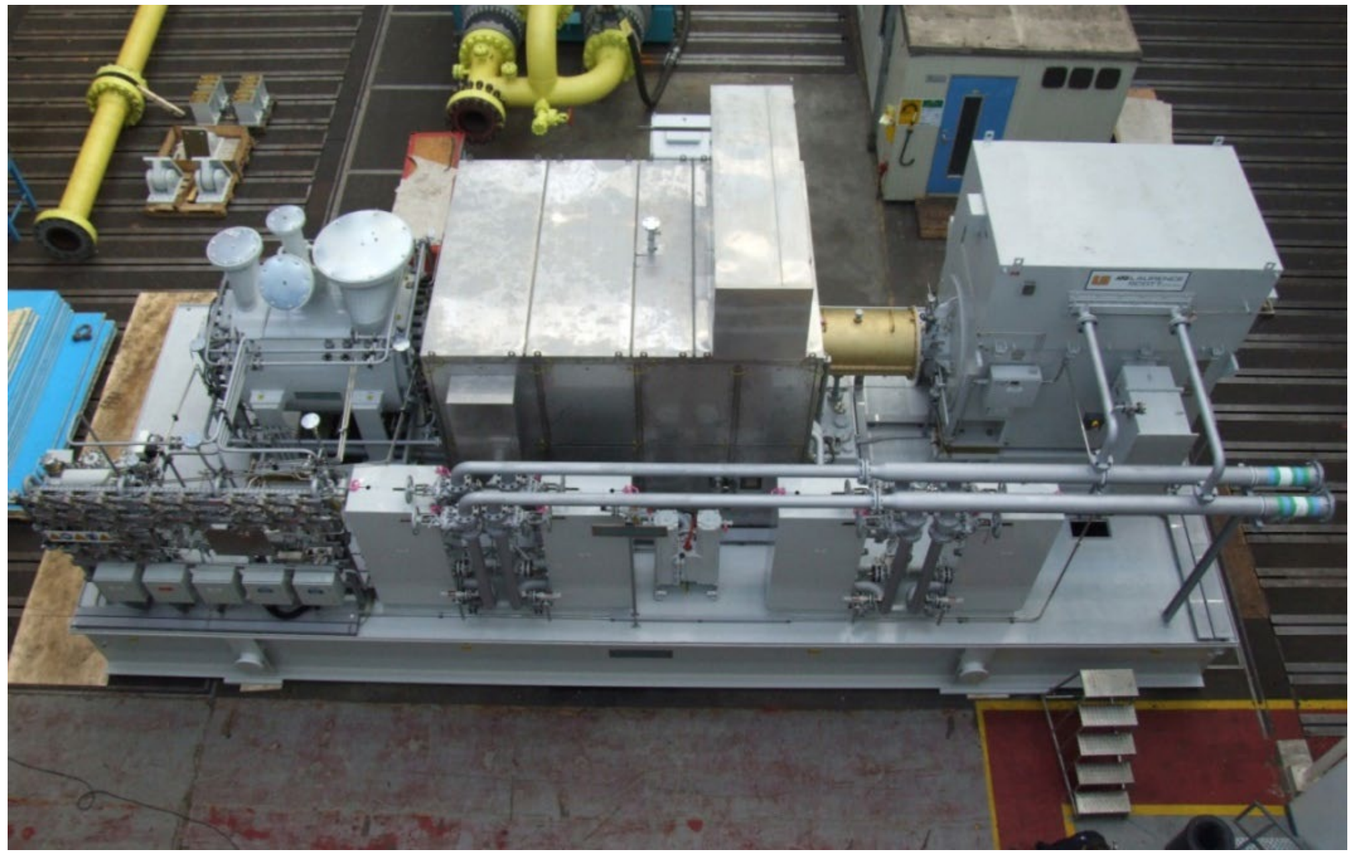
VOITH

Pros

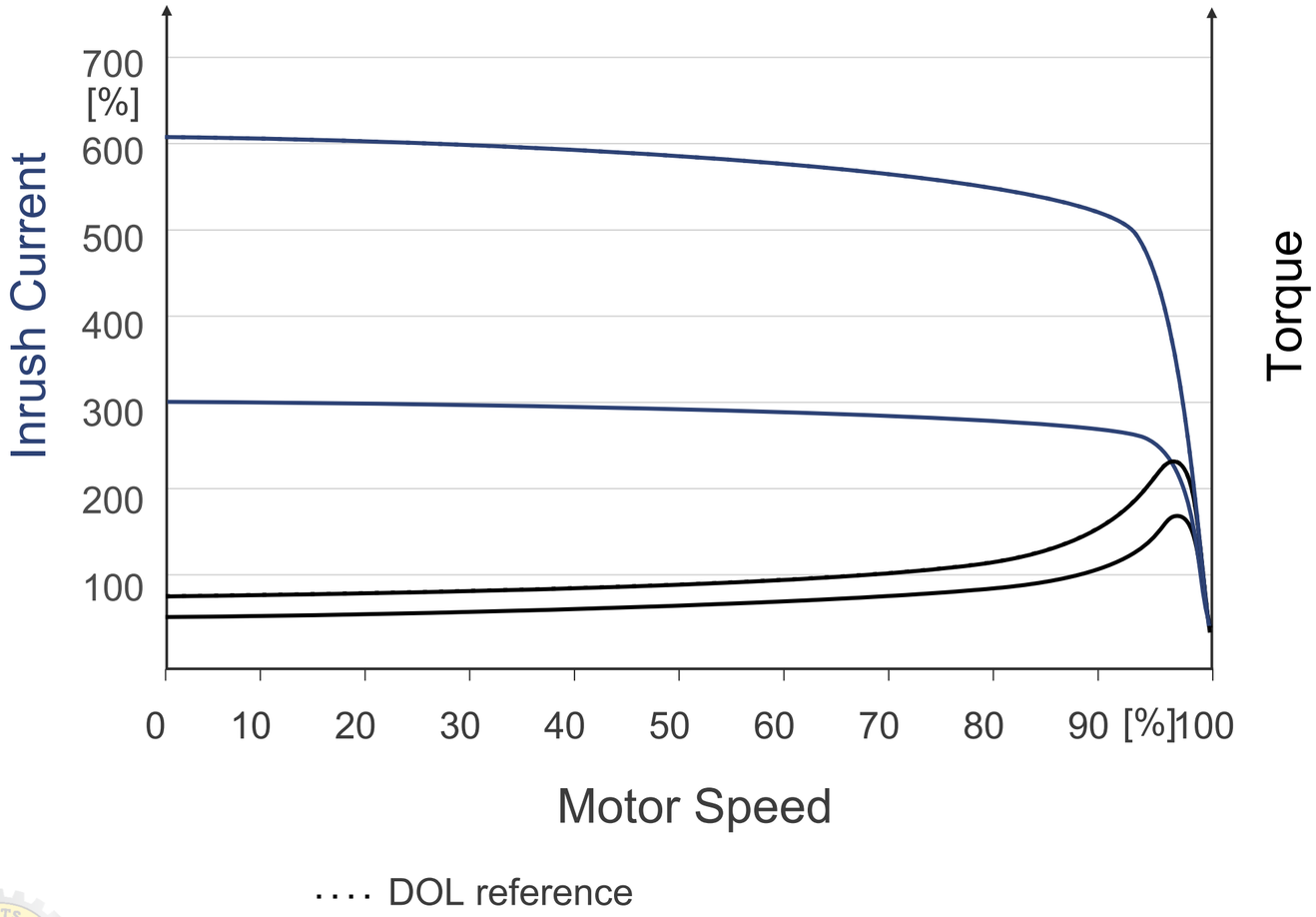
- Most used starting method

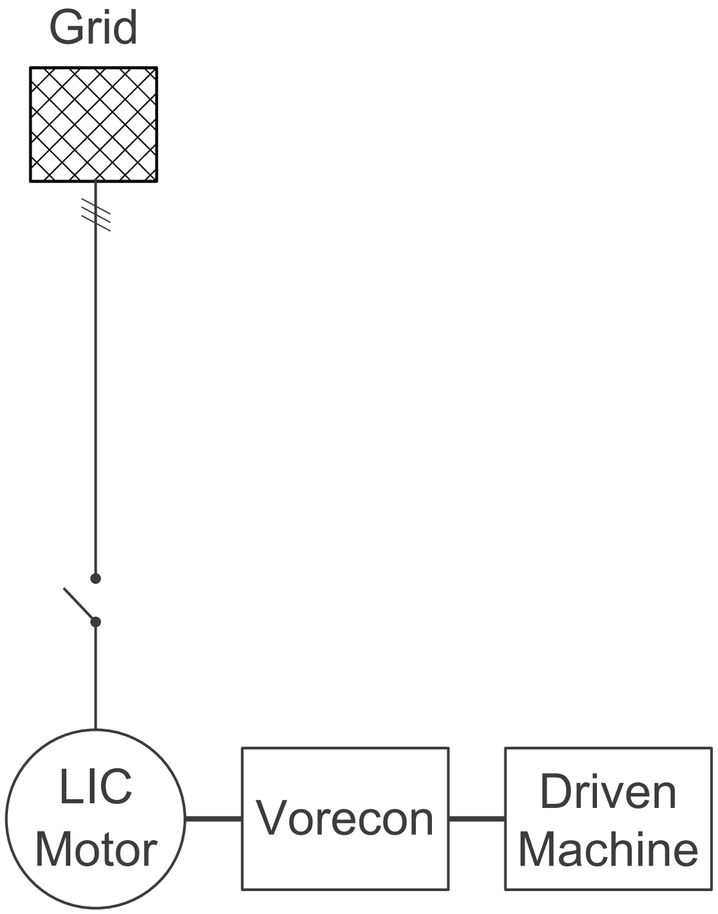
Cons

- High starting current 5 .. 7 pu
- Challenge for high power and weak grid



# LIC motor


Inrush Current
700
[%]
600
500
400
300
200
100
0
10
20
30
40
50
60
70
80
90
[%]100
Motor Speed
Torque
DOL reference

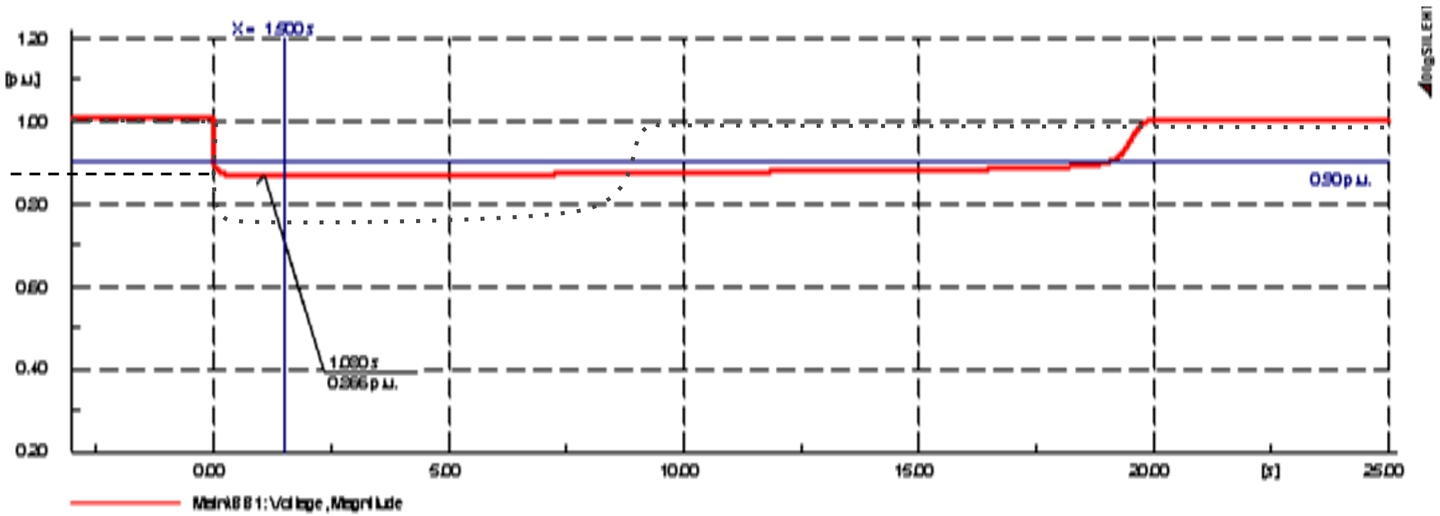

Grid
LIC
Motor
Vorecon
Driven
Machine

# LIC motor

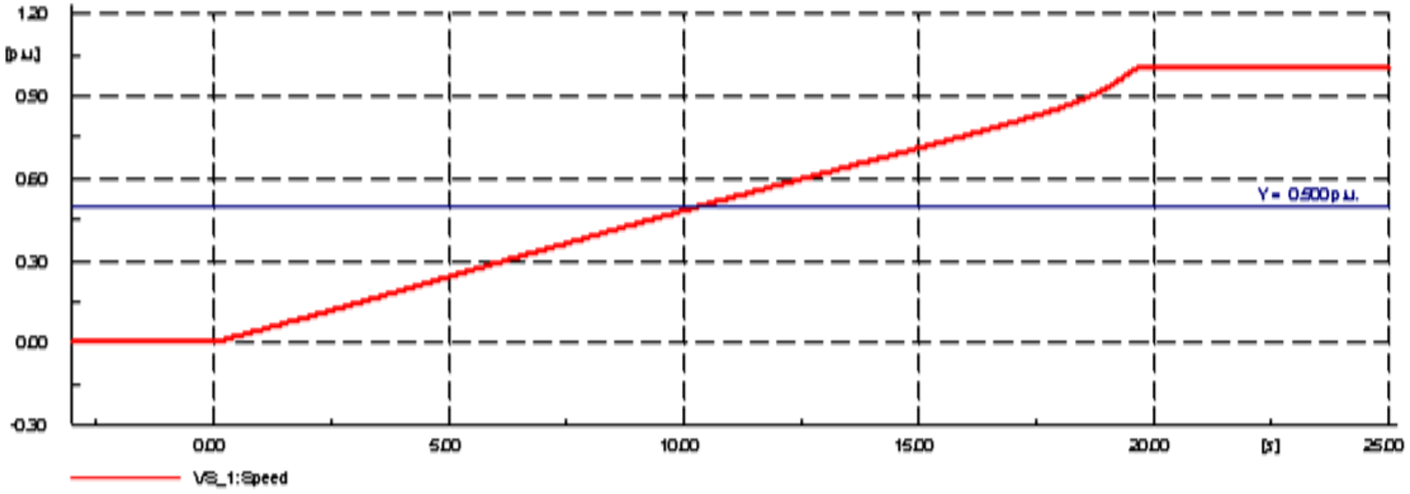
Voltage

87%

···· DOL reference




Speed



# LIC motor

VOITH

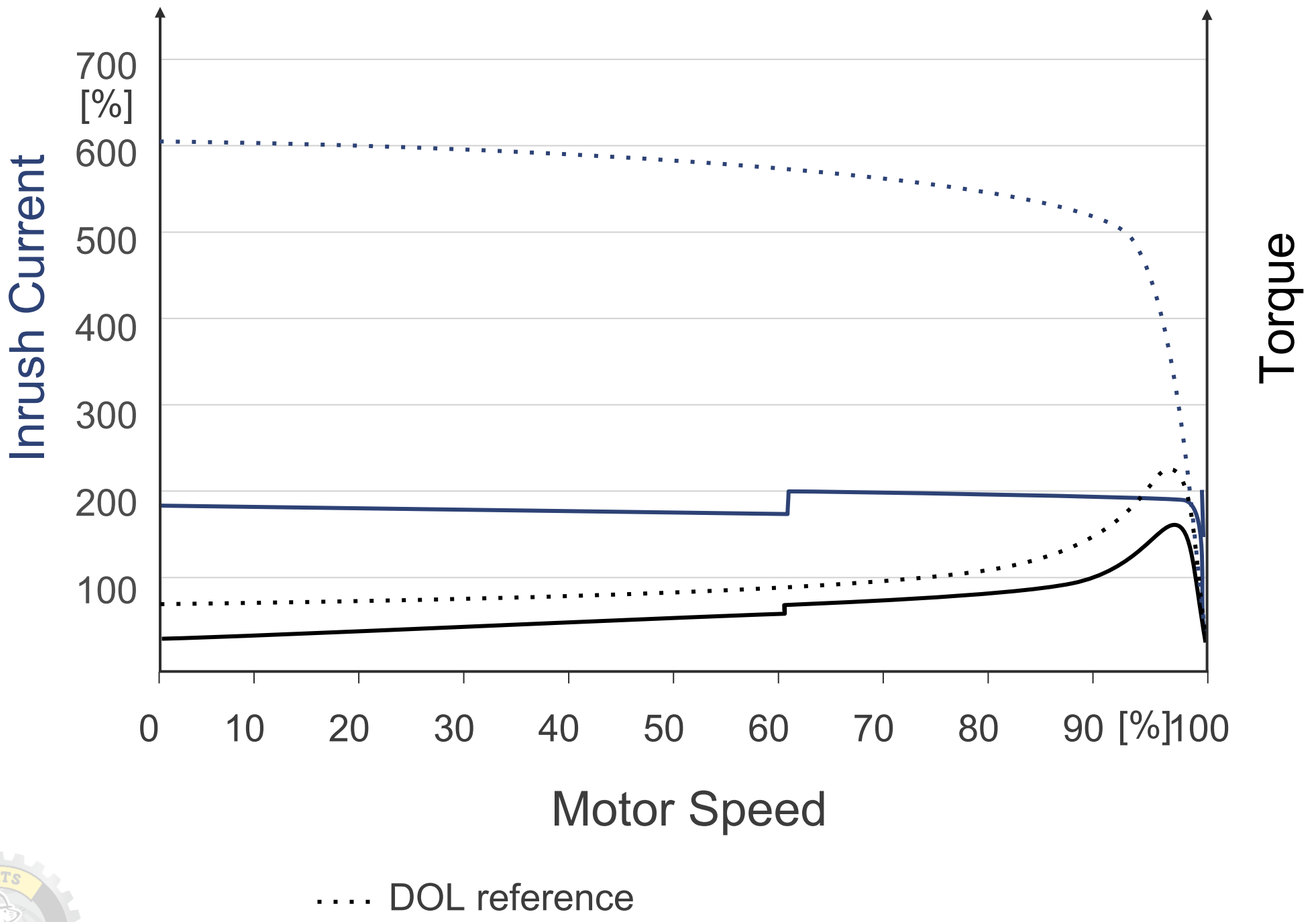
Pros

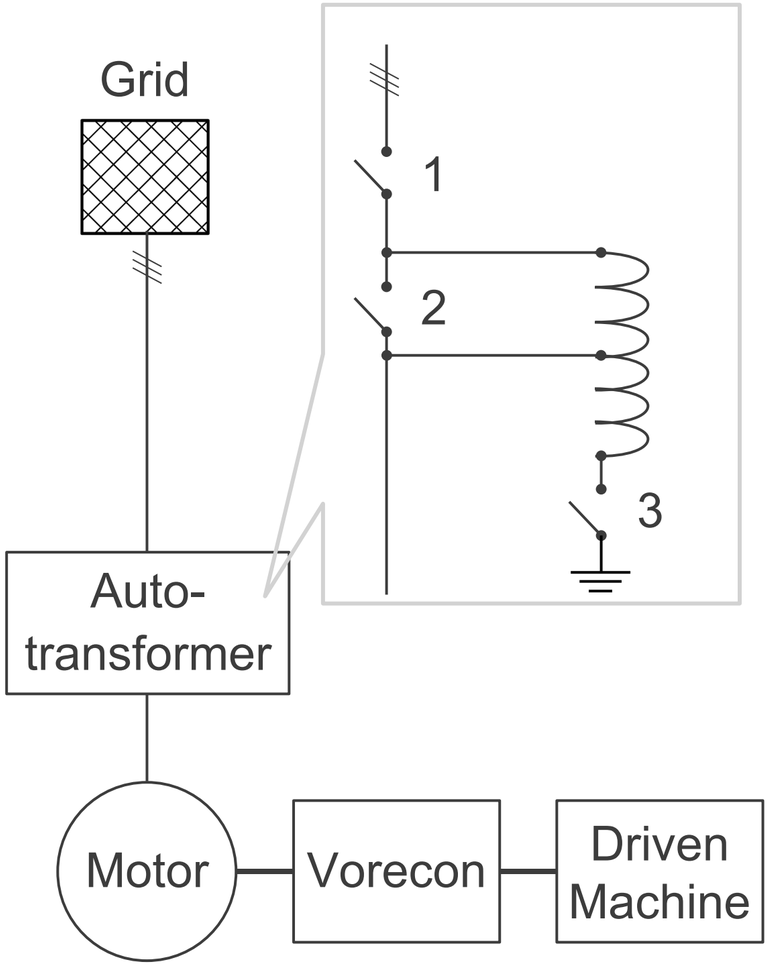
- Simple solution
- Footprint quite similar compared to standard motor
- General applicable for weak grid and offshore application
- Cost increase is quite minor

Cons

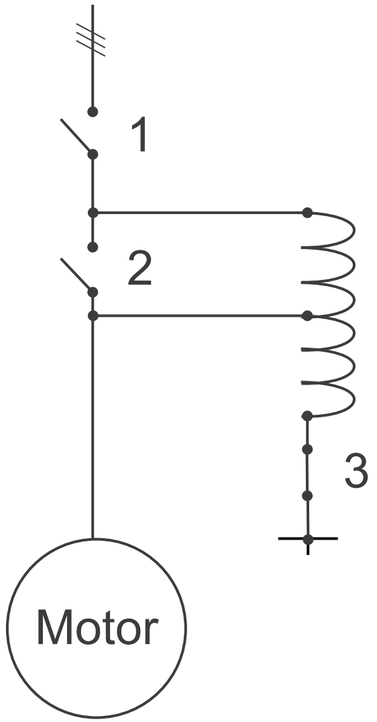
- Current limitation below 3 pu is not practicable due to higher motor mass and additional losses

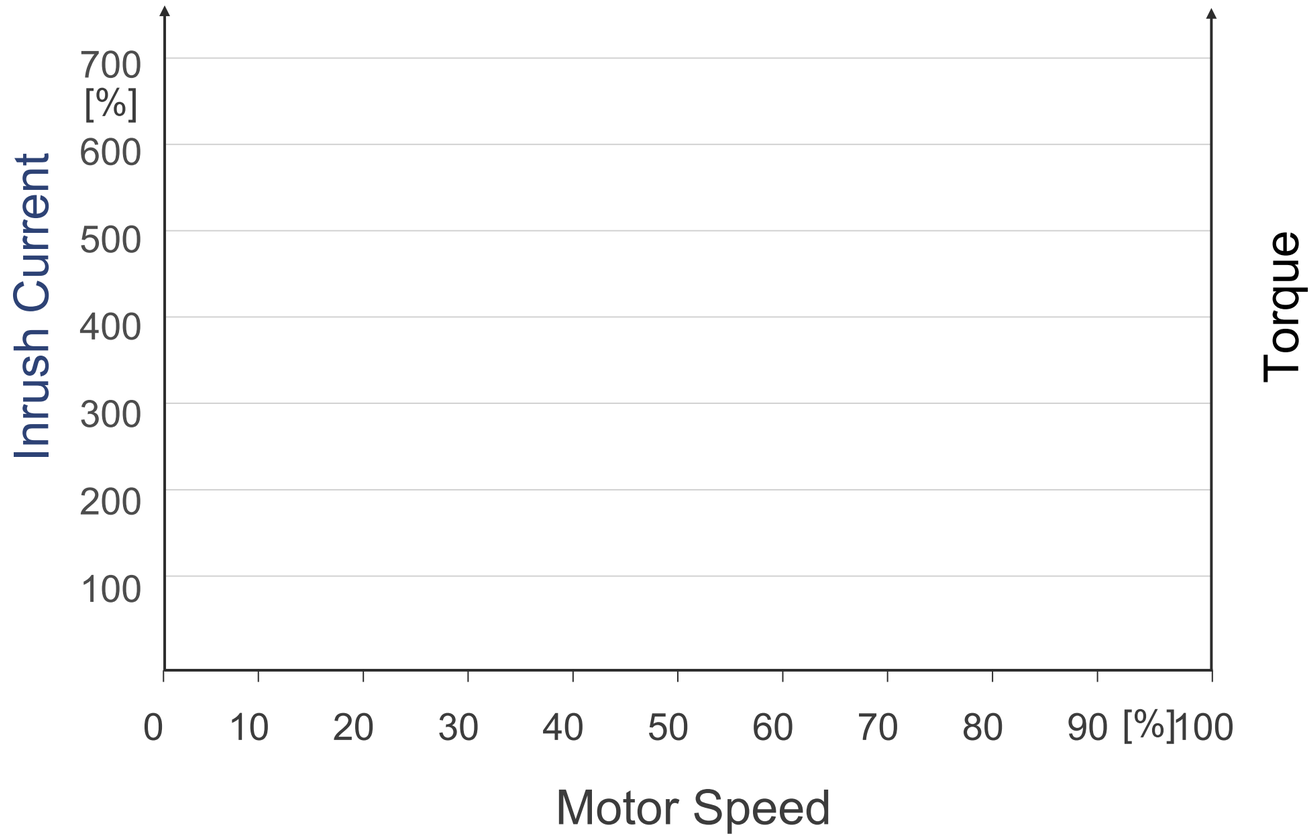
# Autotransformer



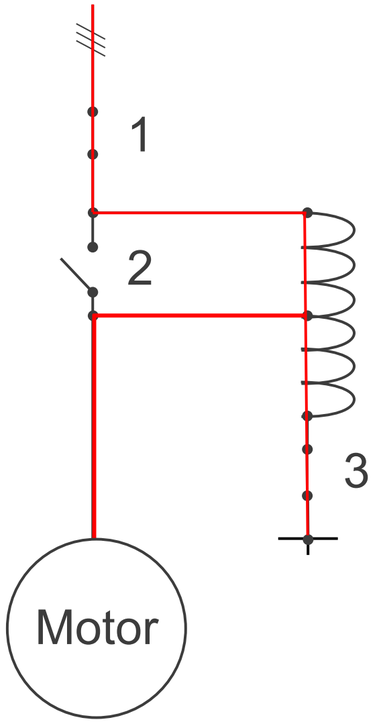



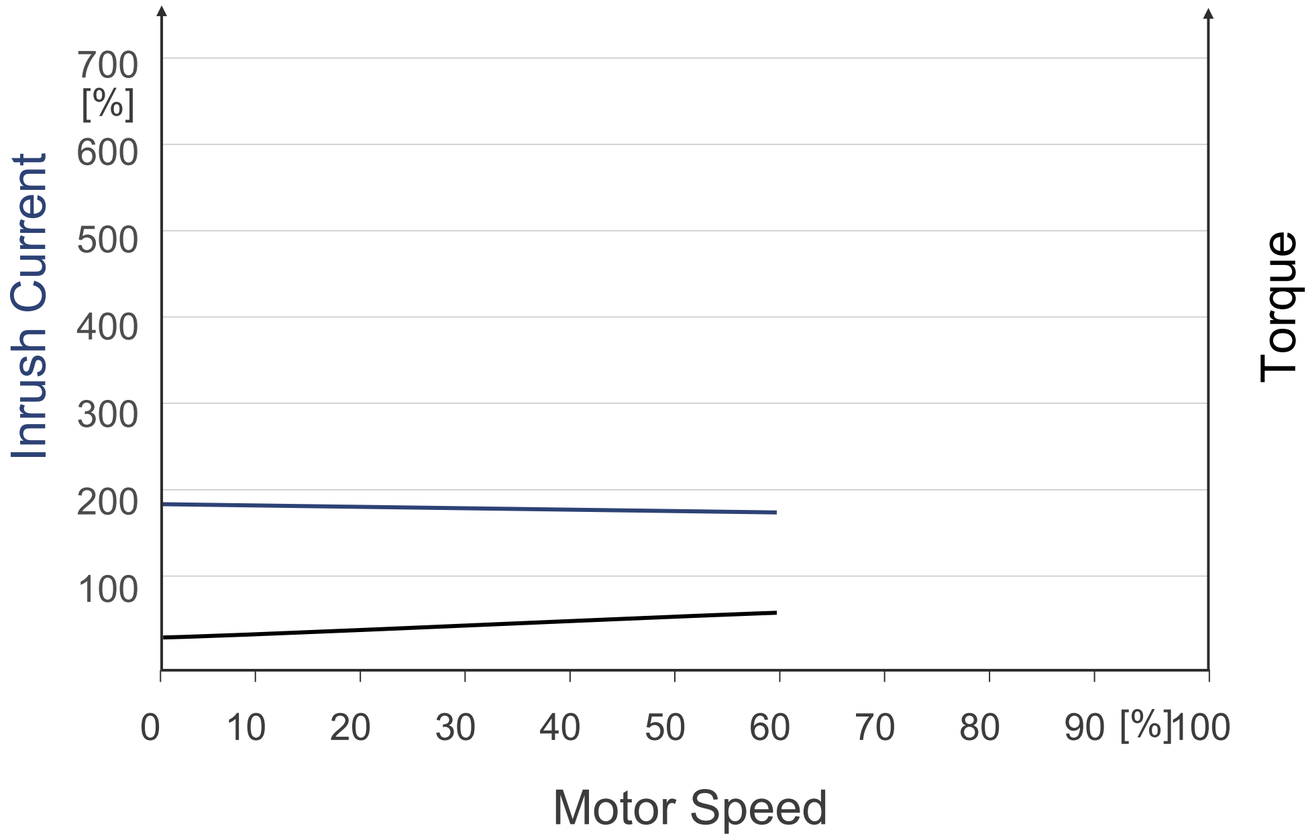
# Autotransformer - standstill



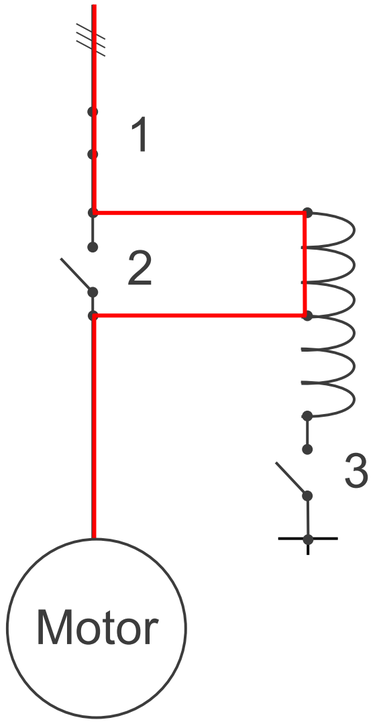



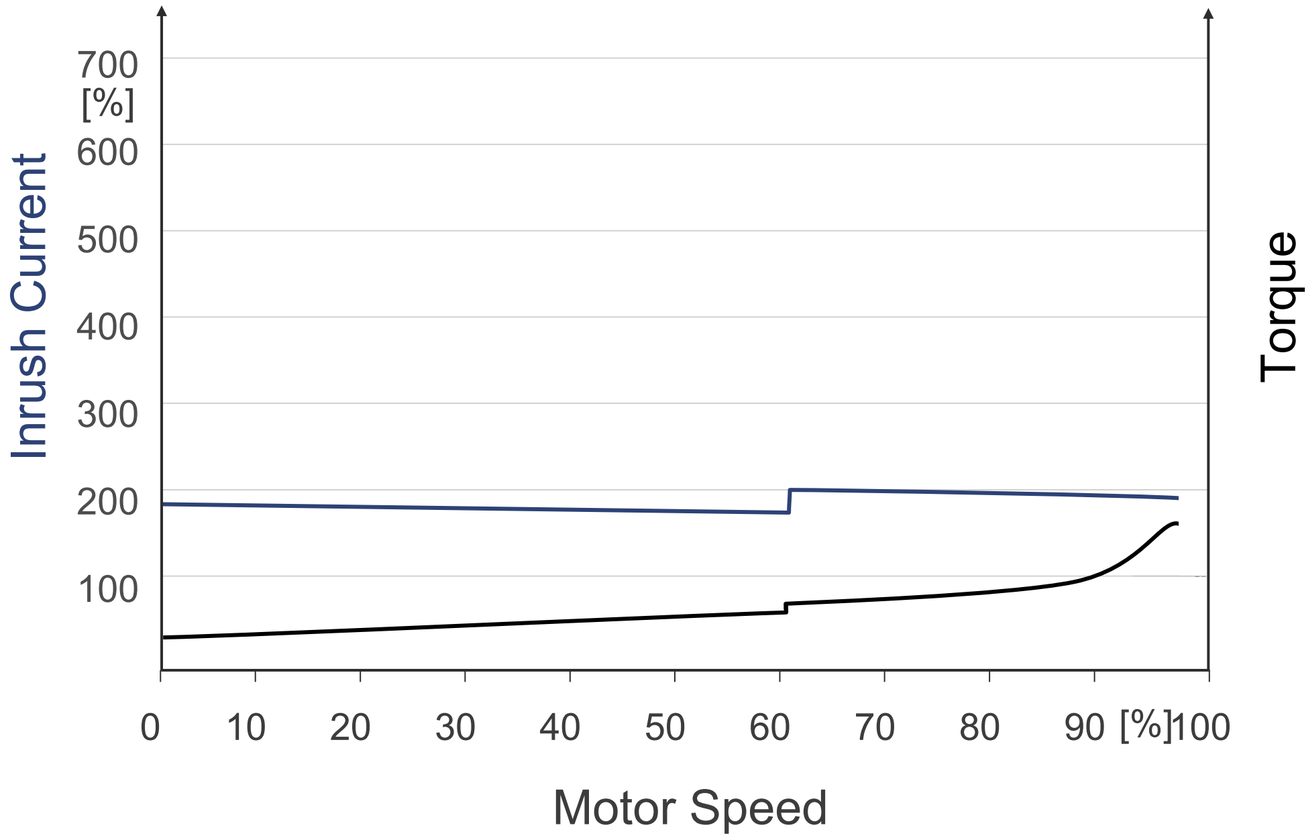
# Autotransformer - 1. stage



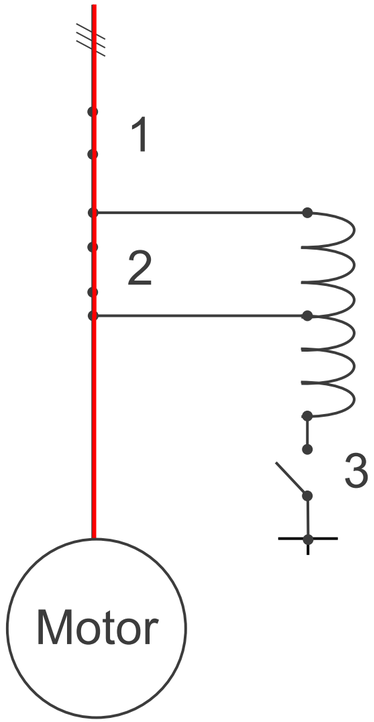



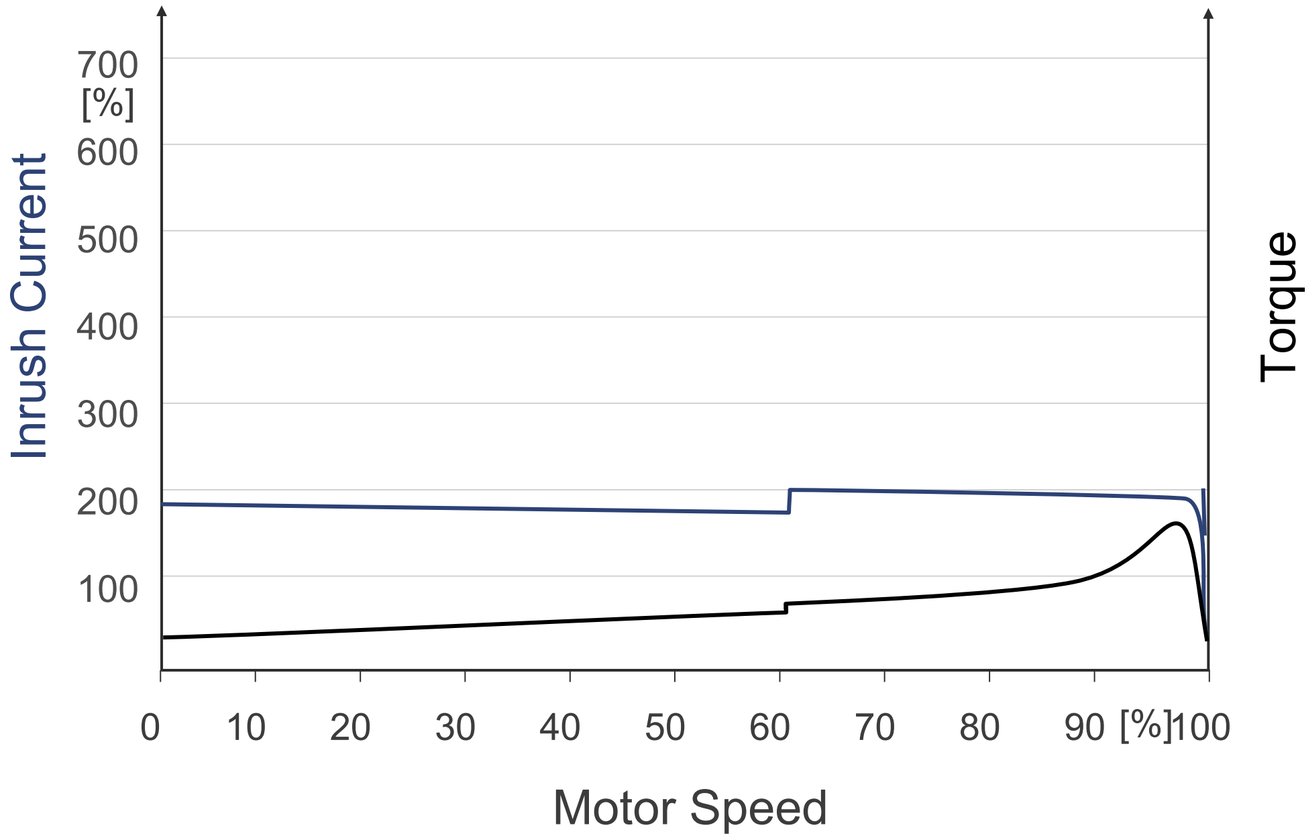
# Autotransformer - 2. stage



# Autotransformer - 3. stage start-up finished



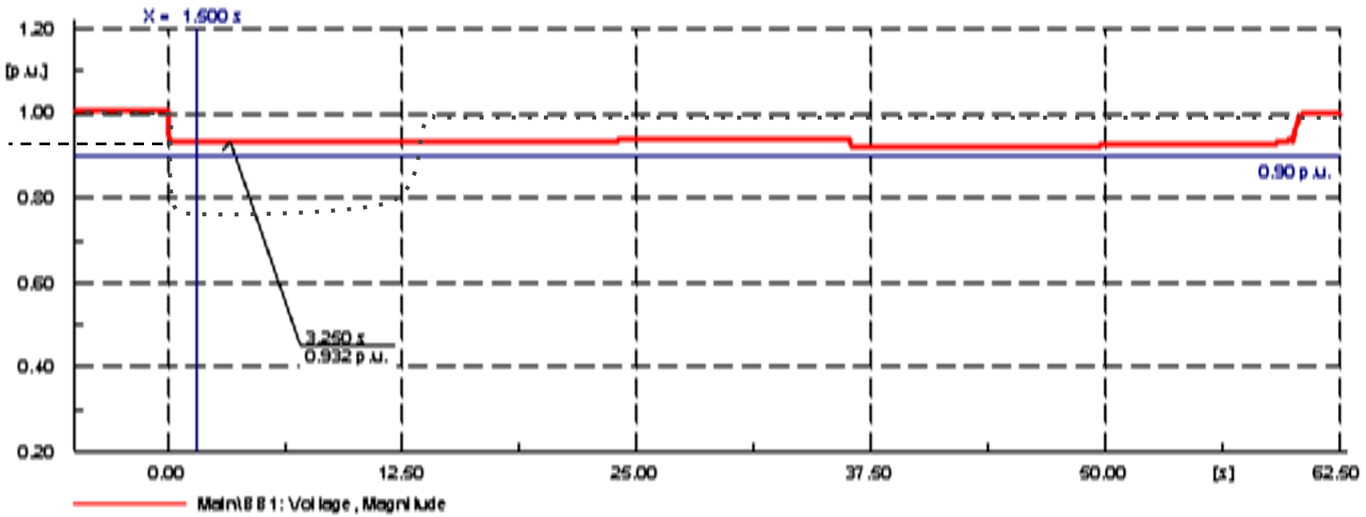
# Autotransformer

VOITH

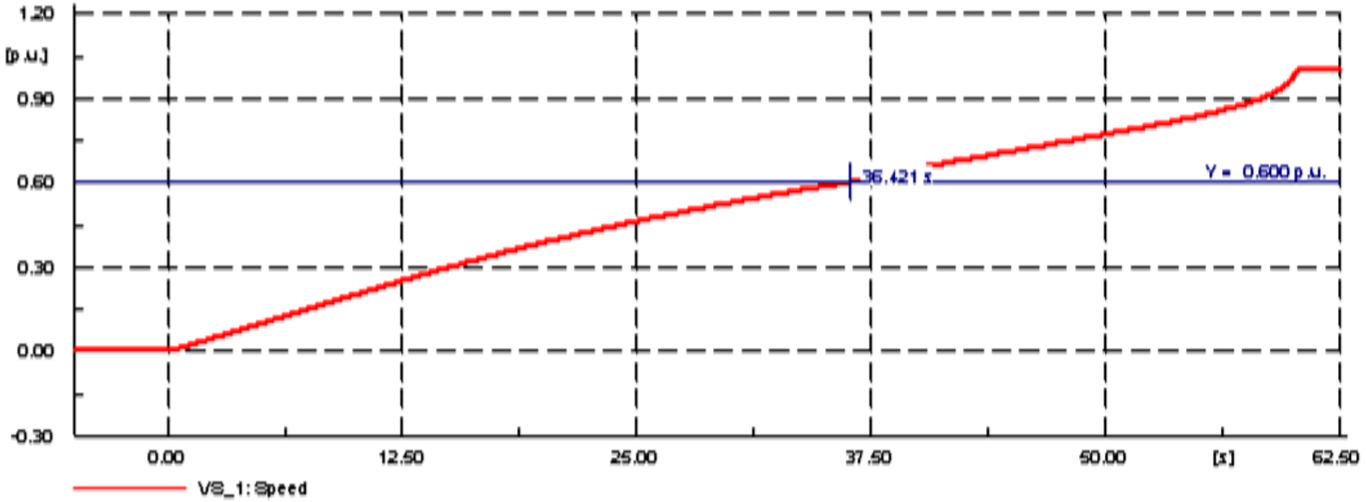
Voltage

93%

···· DOL reference




Speed



# Autotransformer

VOITH

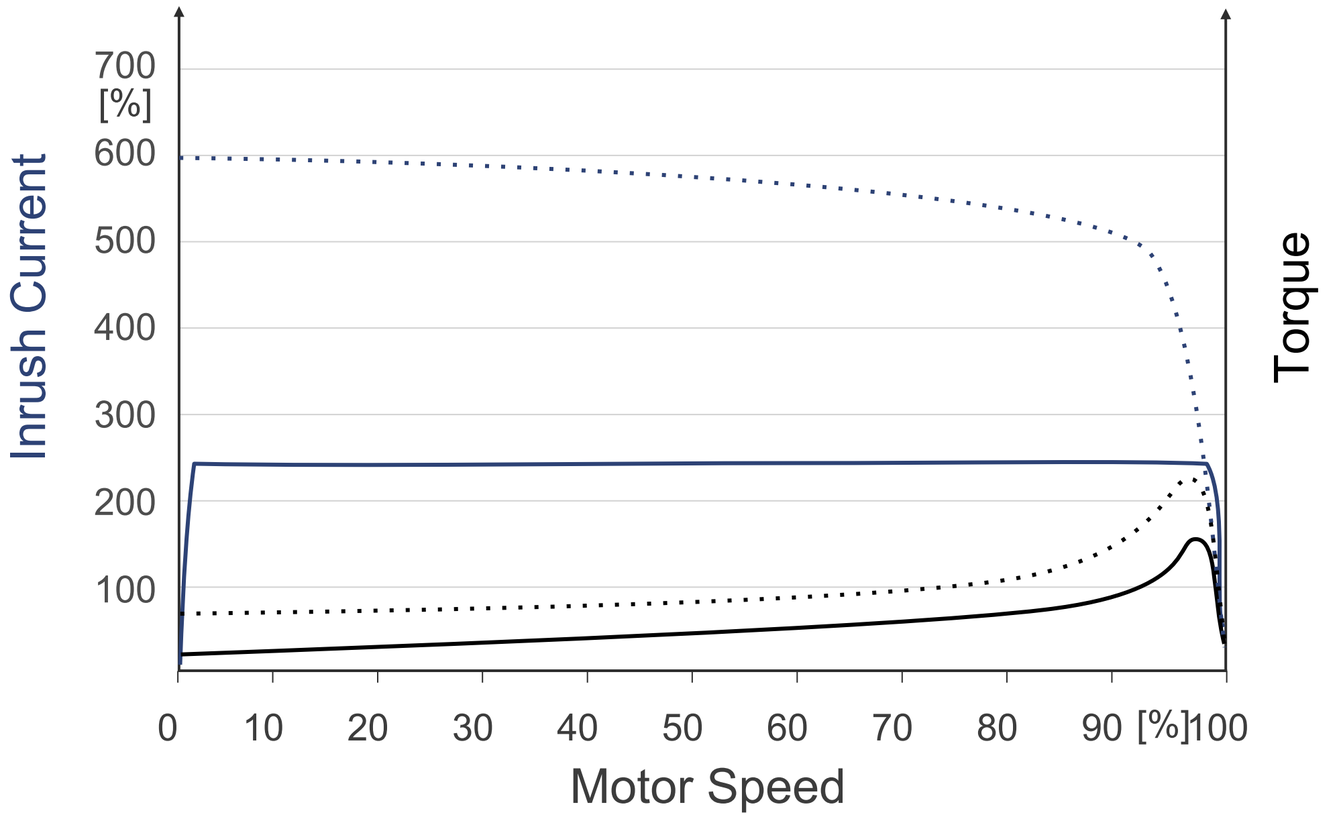
Pros

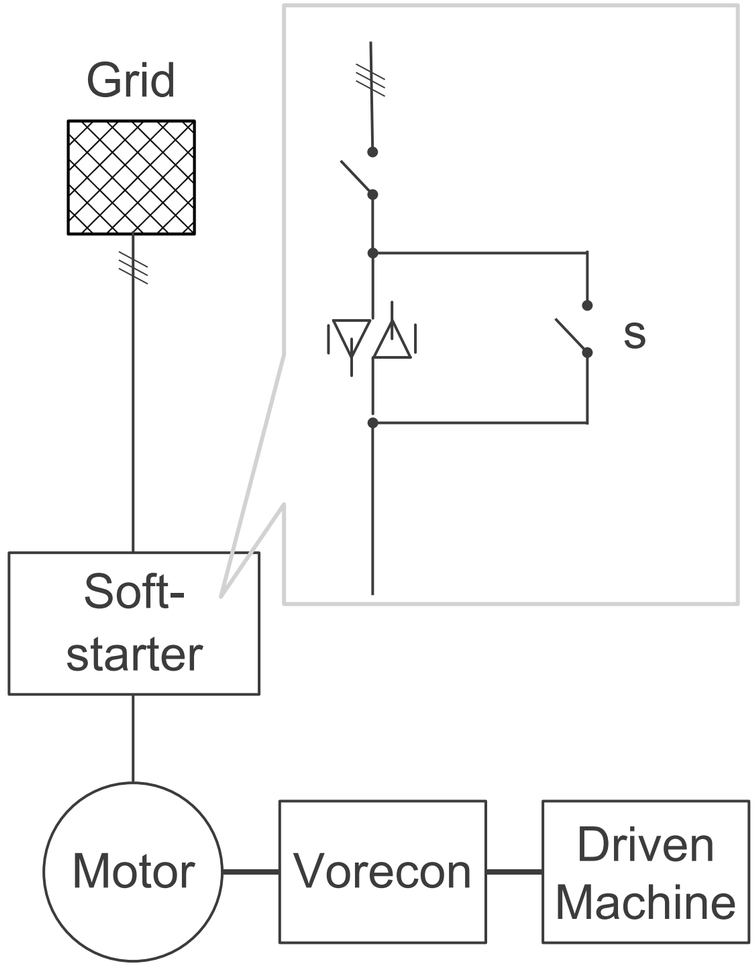
- Multiple proven technology
- Most torque per incoming line amps of any reduced voltage starting method
- Voltage adjustment by using of additional taps

Cons

- 3 contactors are required

# Soft Starter



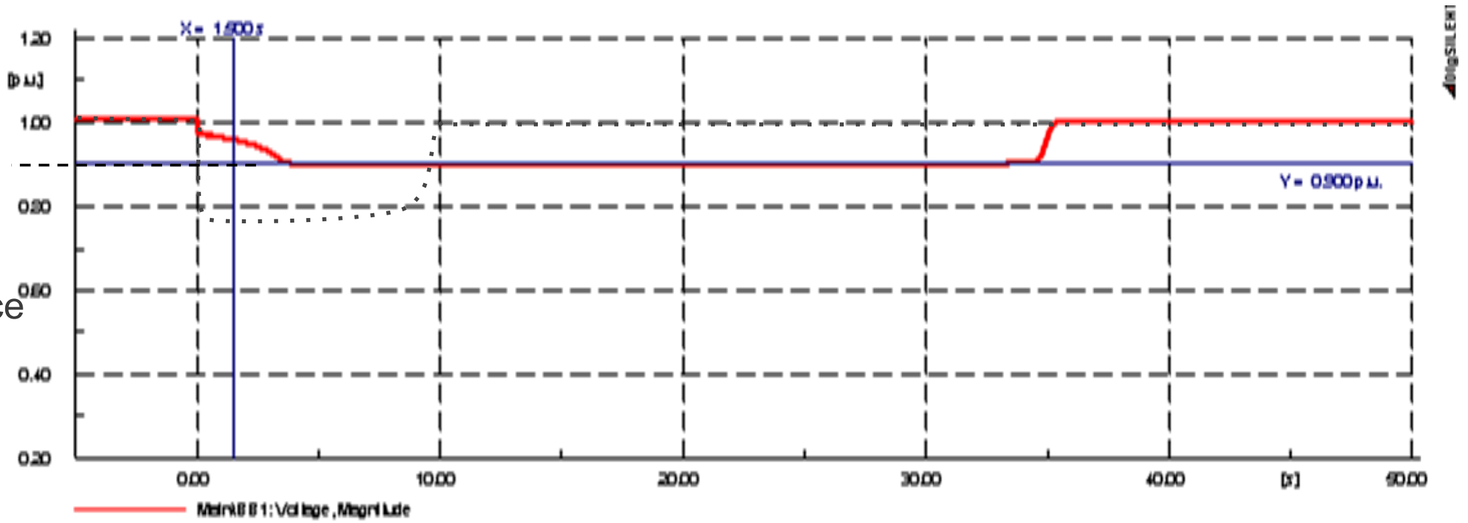
# Soft Starter

VOITH

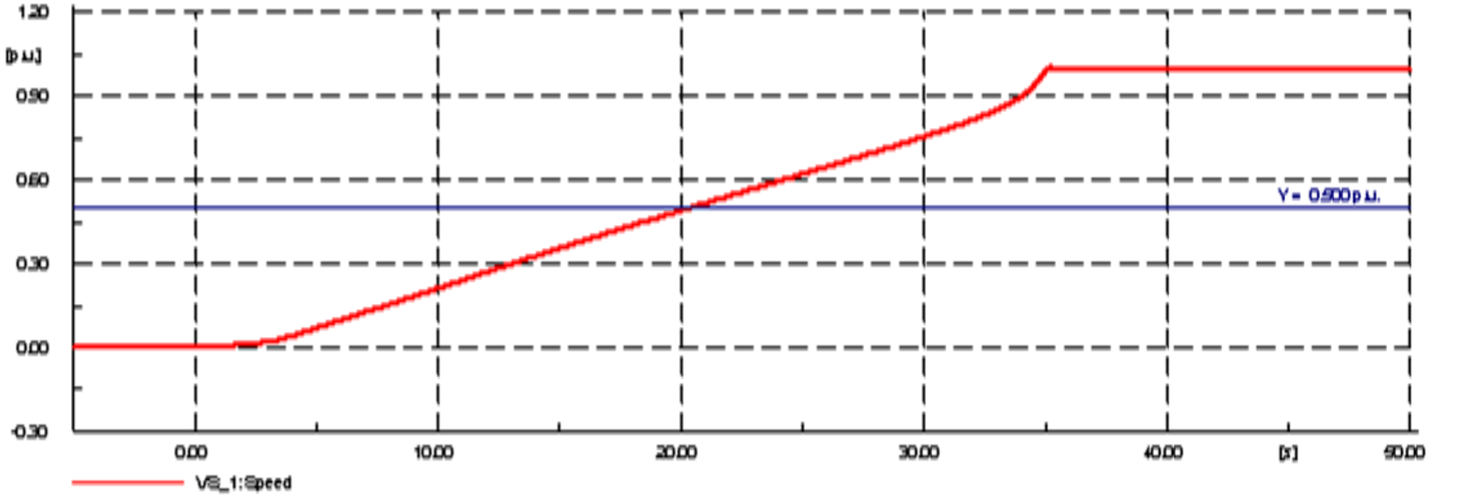
Voltage

90%

···· DOL reference




Speed



# Soft Starter

VOITH

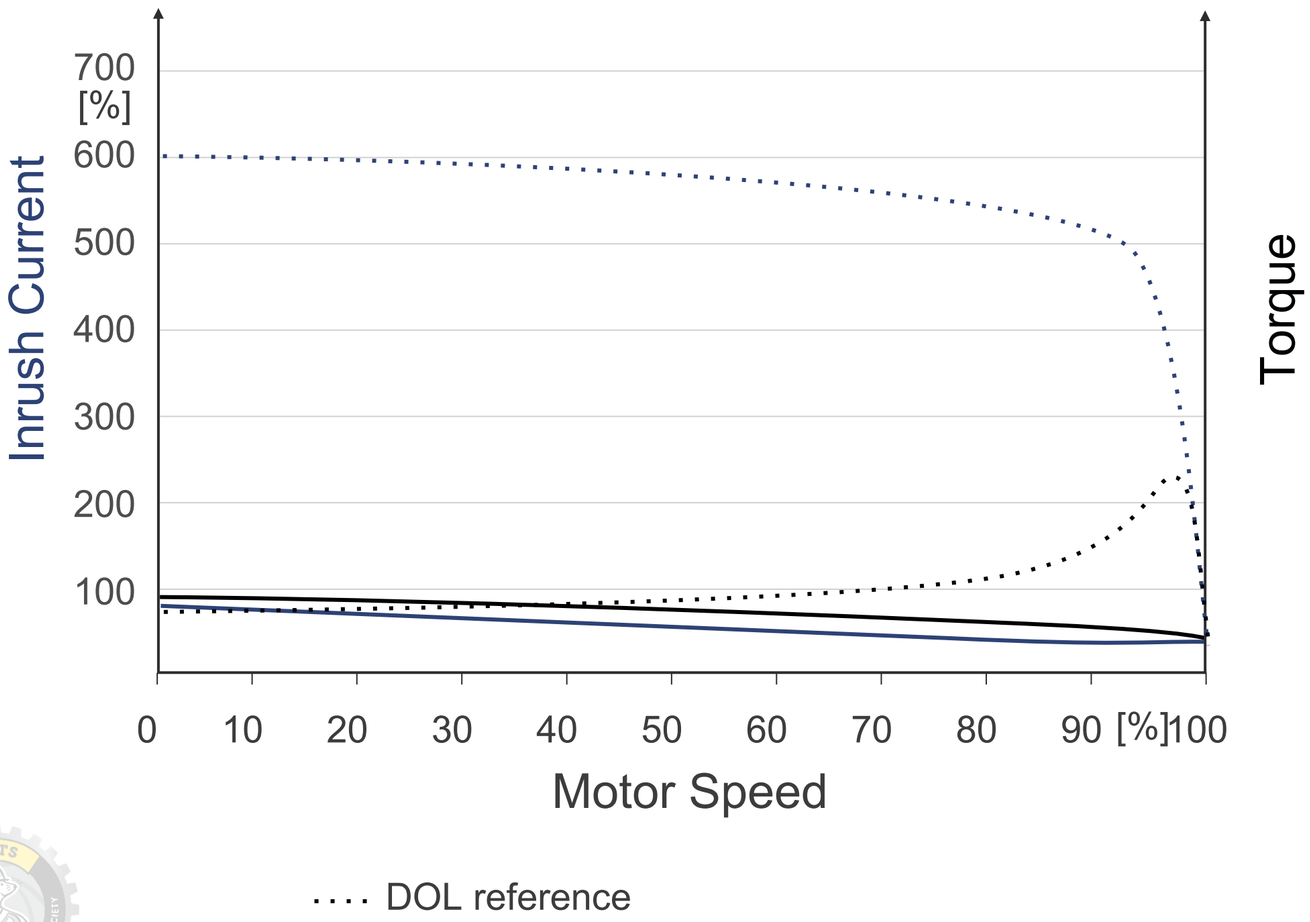
Pros

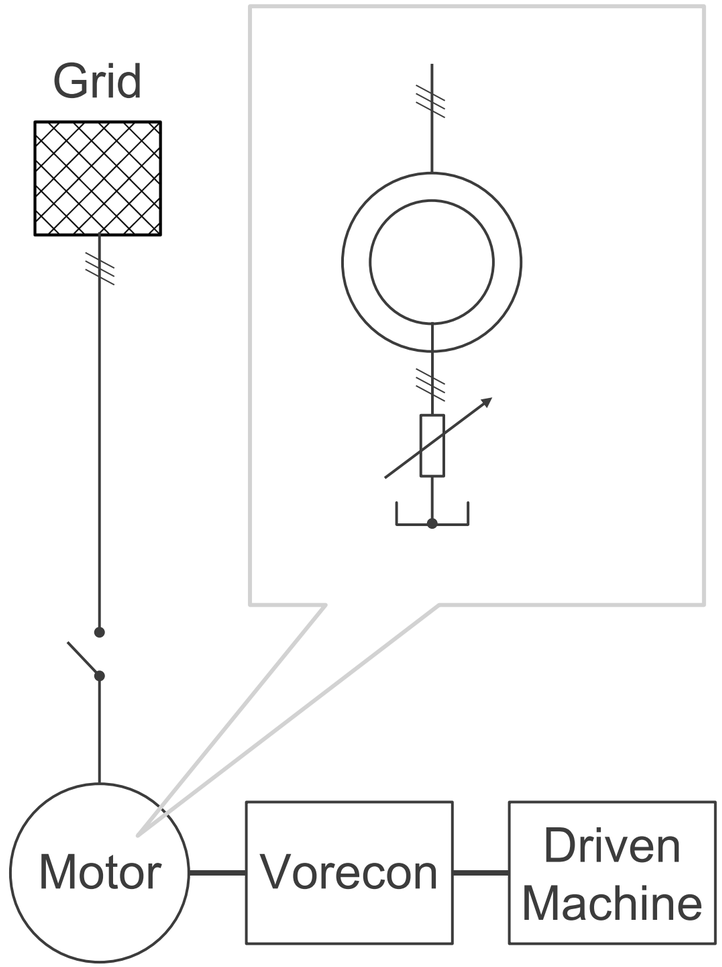
- Multiple proven technology
- Starting current adjustable on-site

Cons

- For weak grid, unloaded start-up with low breakaway torque favorable
- Generation of harmonic distortions during motor runs up

# Rotor Resistance Starter



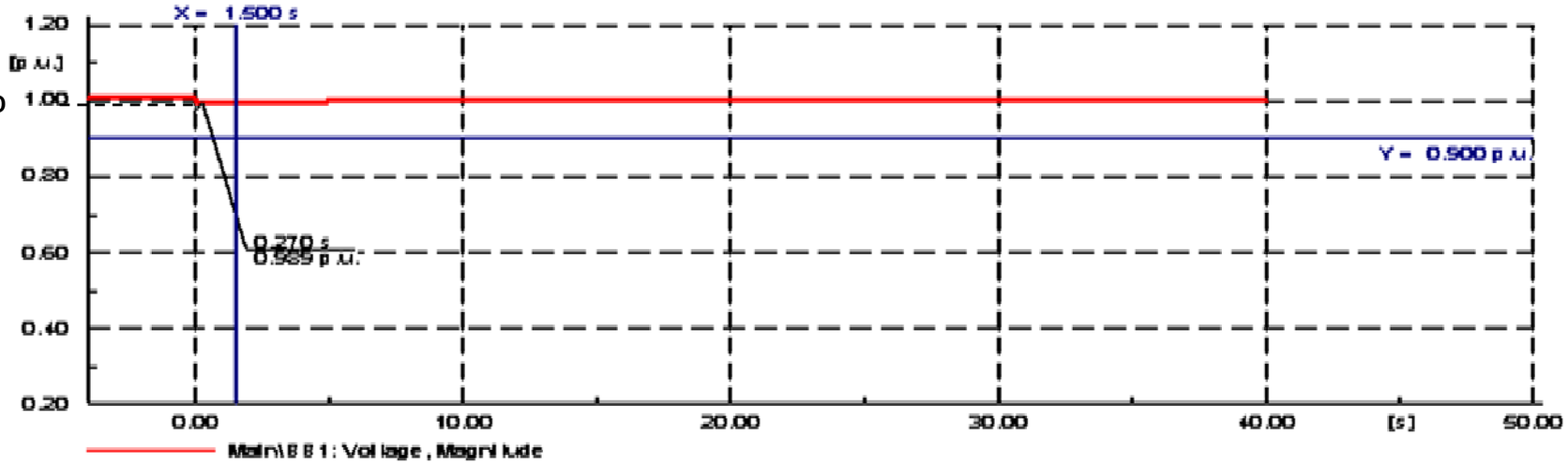



# Rotor Resistance Starter

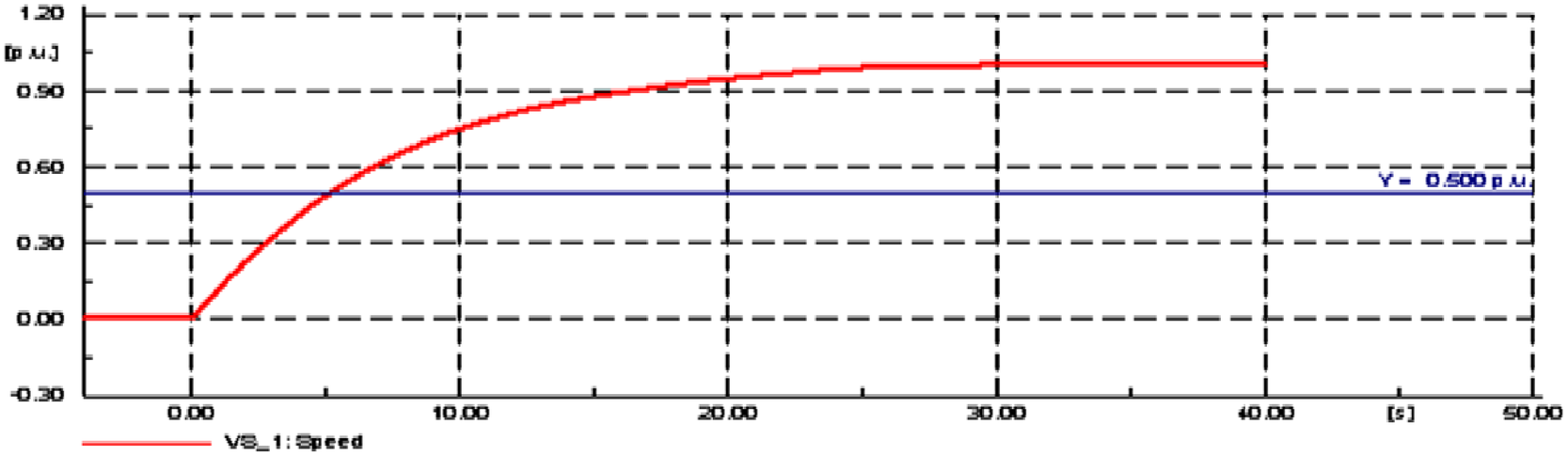
VOITH

Voltage

99%

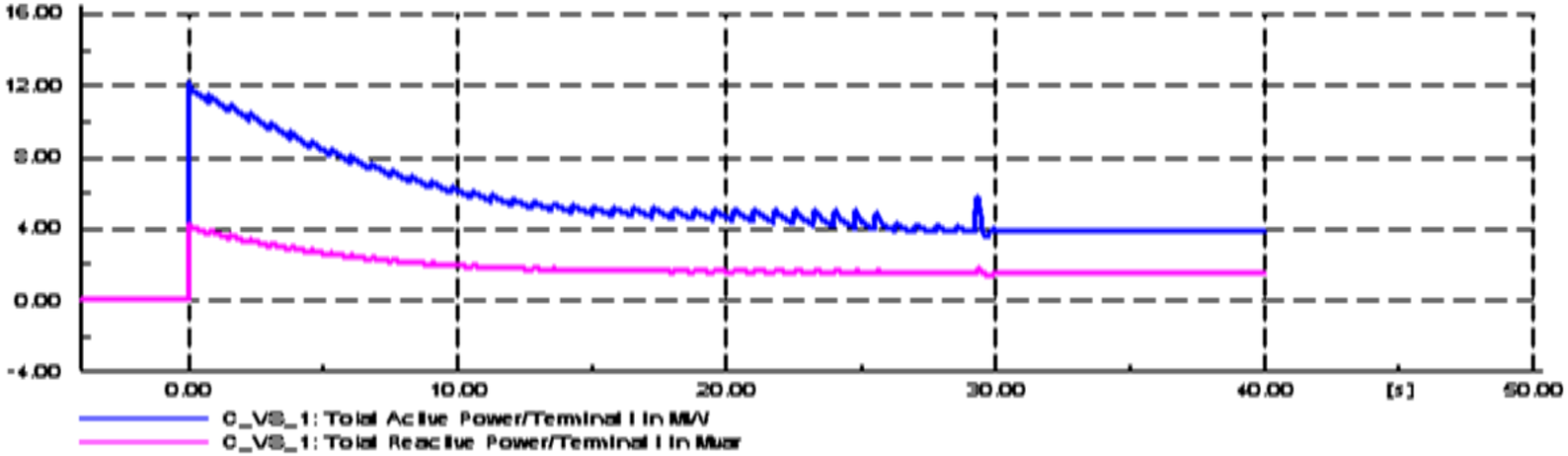



Speed

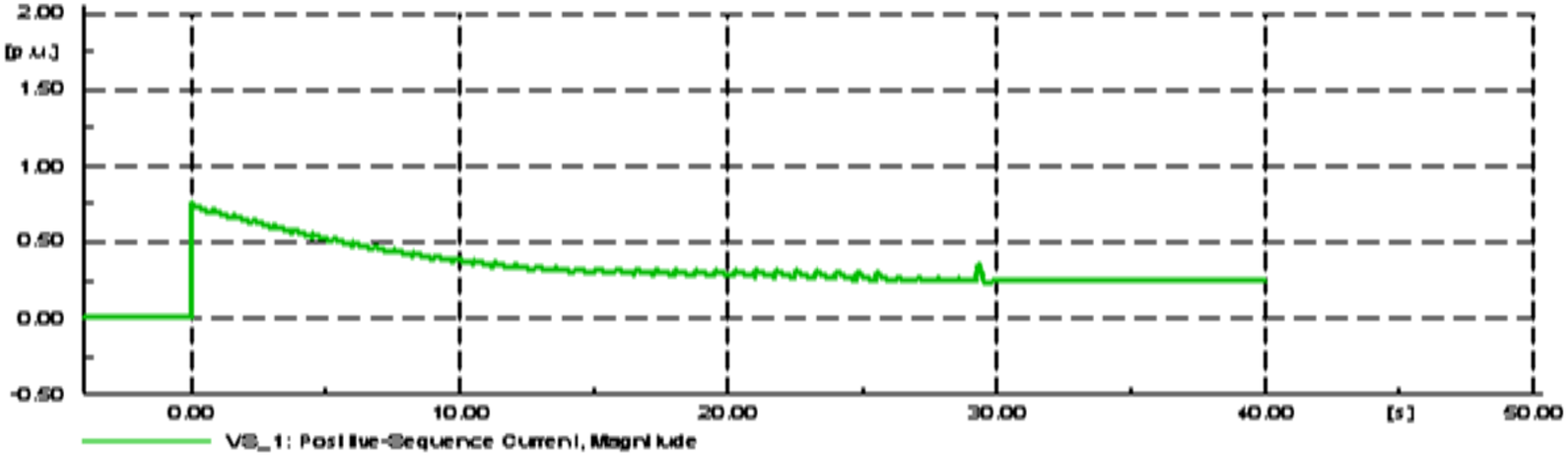


# Rotor Resistance Starter

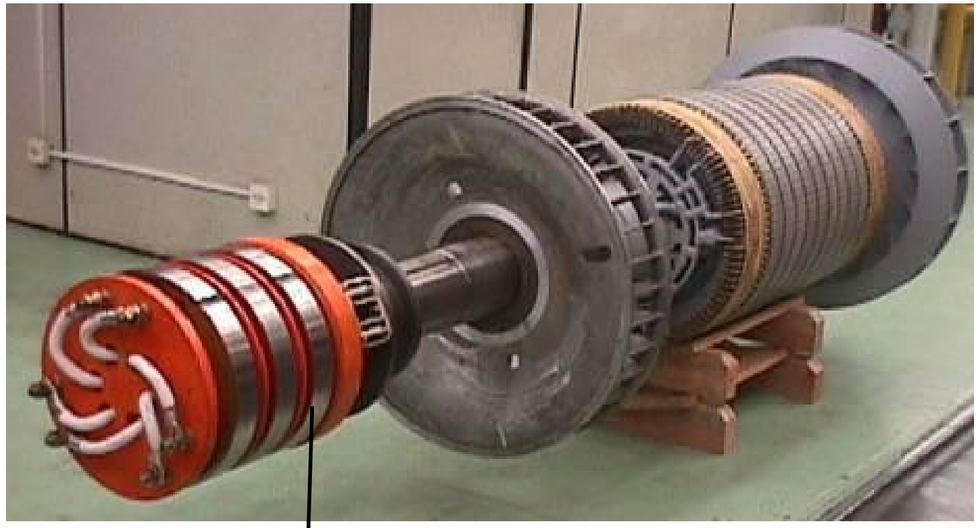
Power




Current

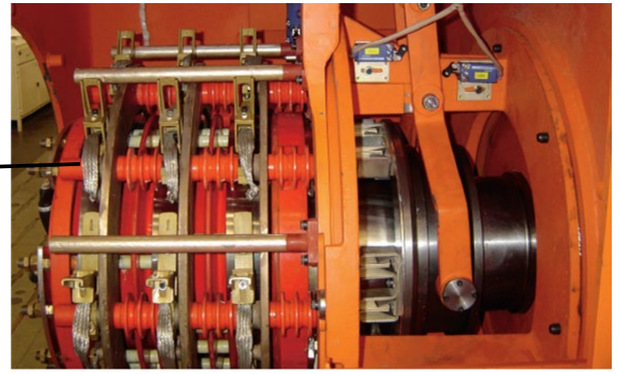


# Rotor Resistance Starter



Slip rings

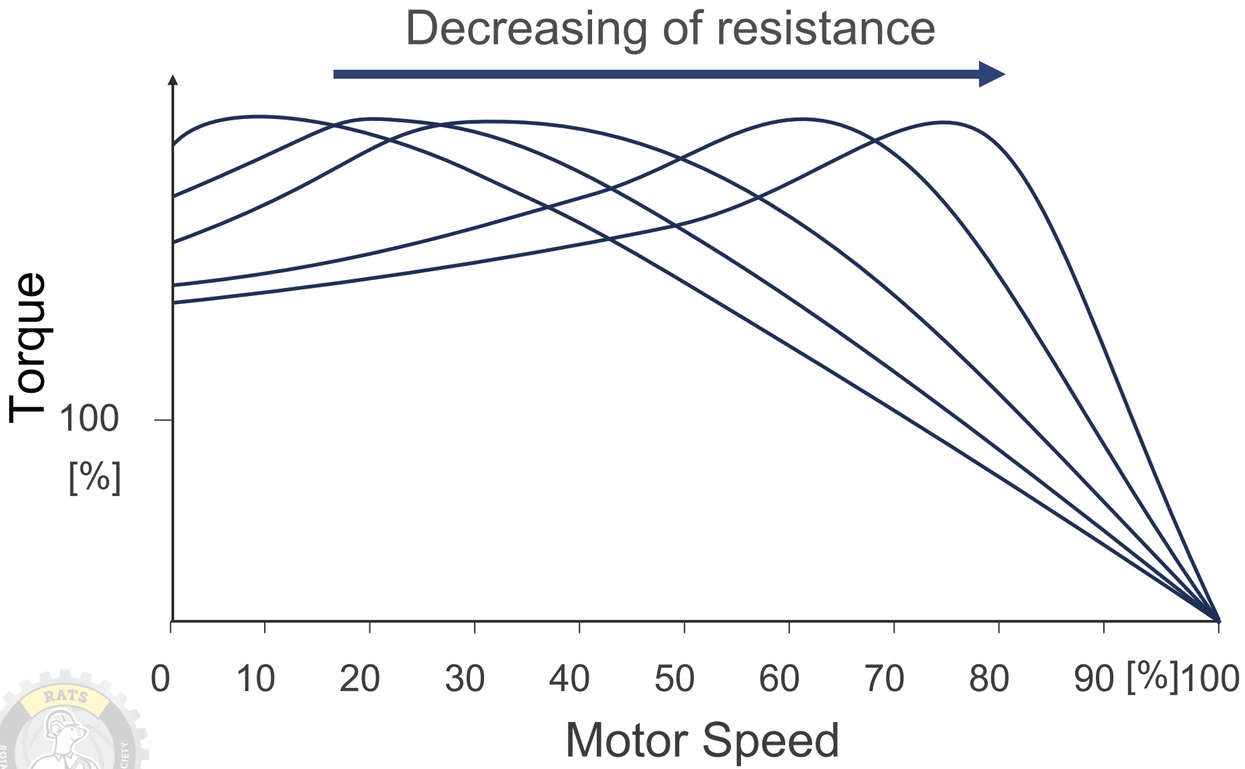
Brush lifting device



# Rotor Resistance Starter

**Resistance starter** The drive train is accelerated by reducing of switched resistances depending on the motor slip.

**Liquid starter** Continuously adjustable resistance with an electrode system and an electrolyte for changing the resistance.




# Rotor Resistance Starter

VOITH

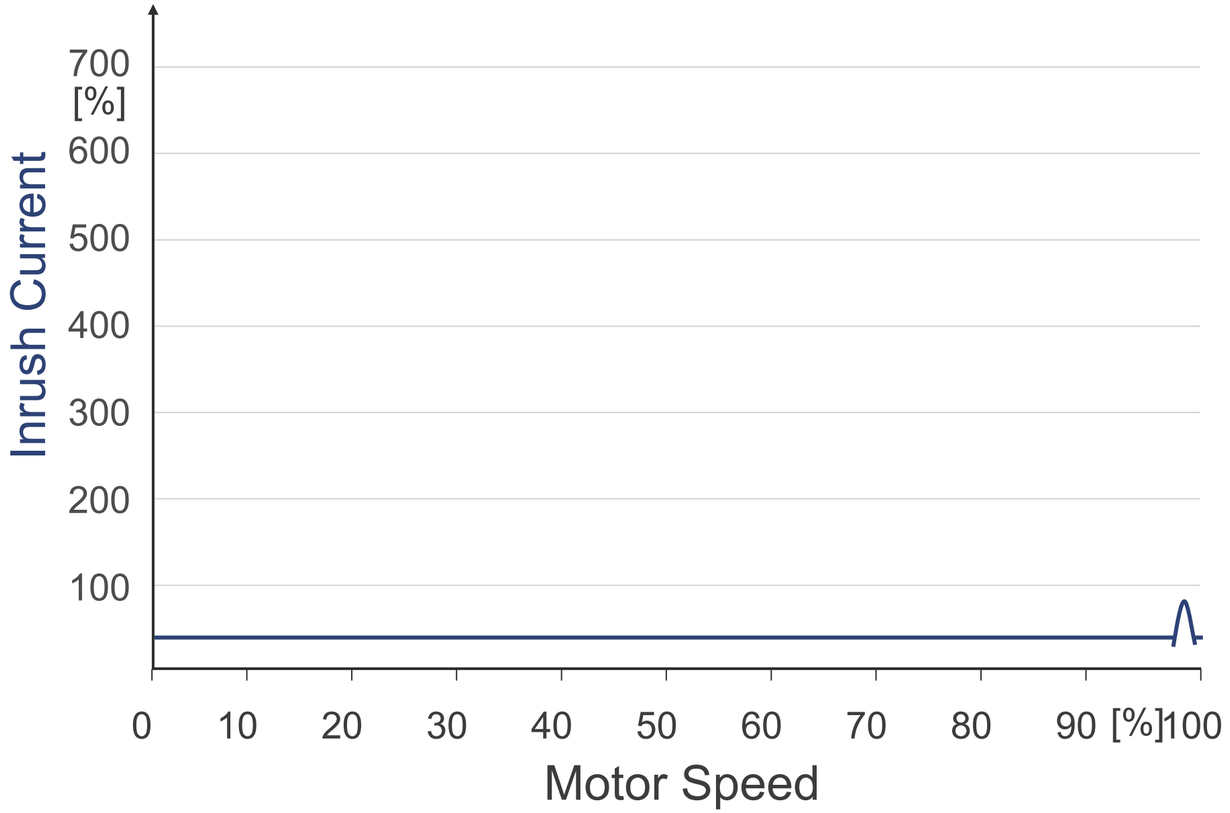
Pros

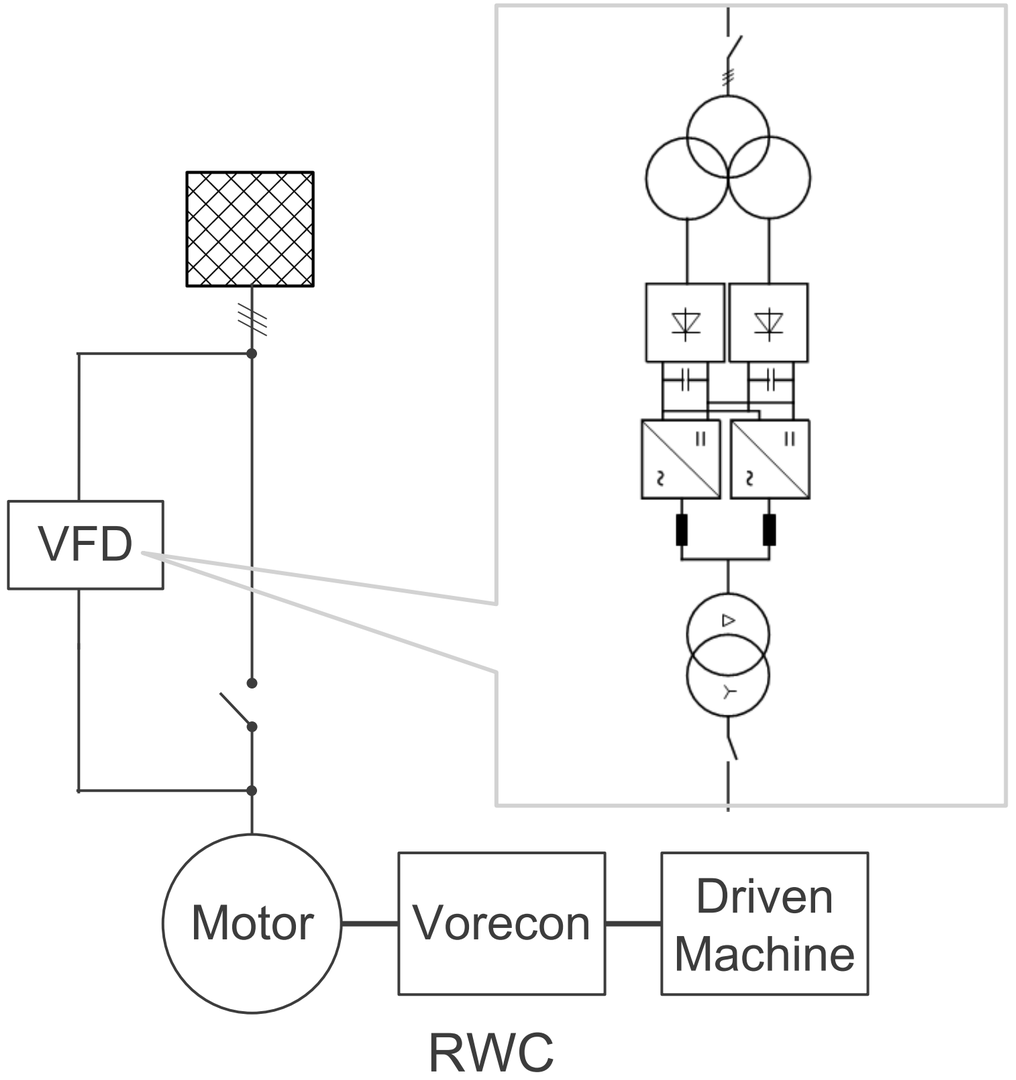
- Rated torque at motor standstill
  - heavy starting application
- Negligible circuit feedback
- Suitable for all grids, especially for very weak grids

Cons

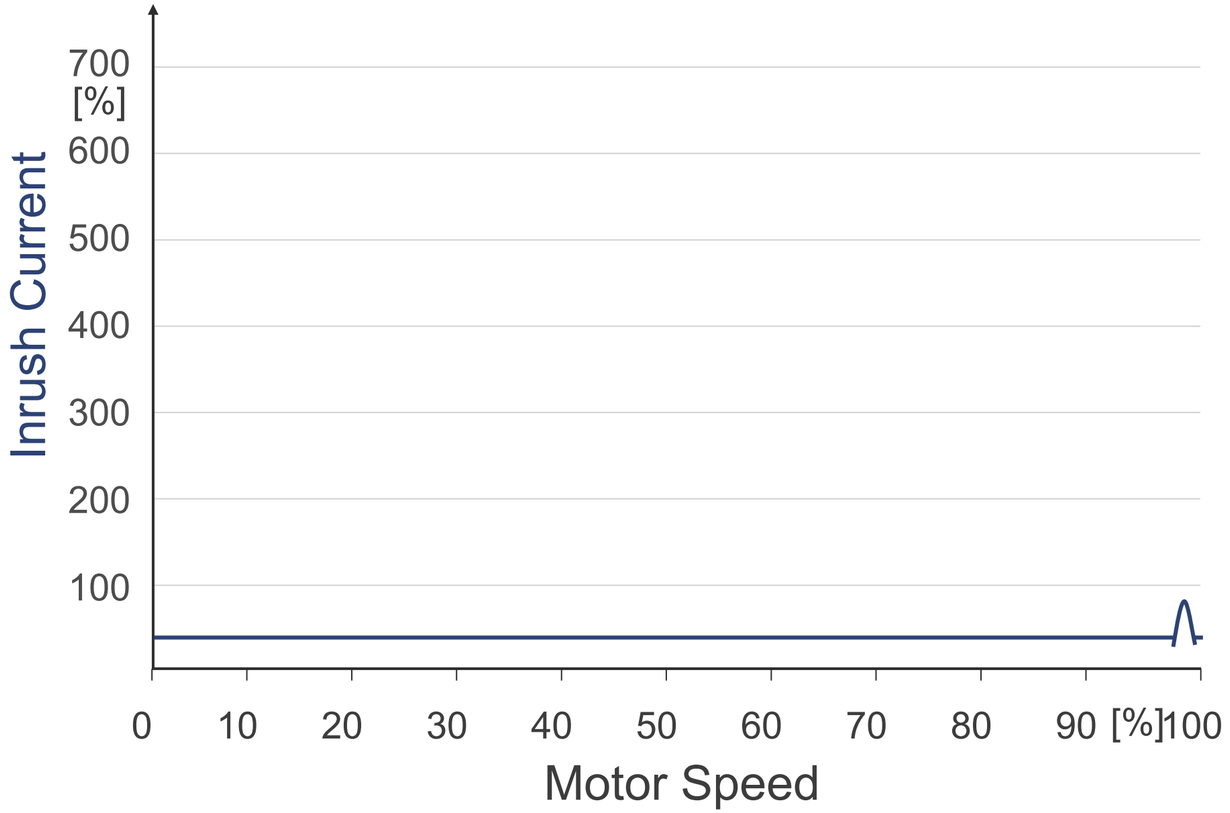
- 50% motor length increasing
- Not advisable for frequently start-ups (increased friction of the brush lifting device)

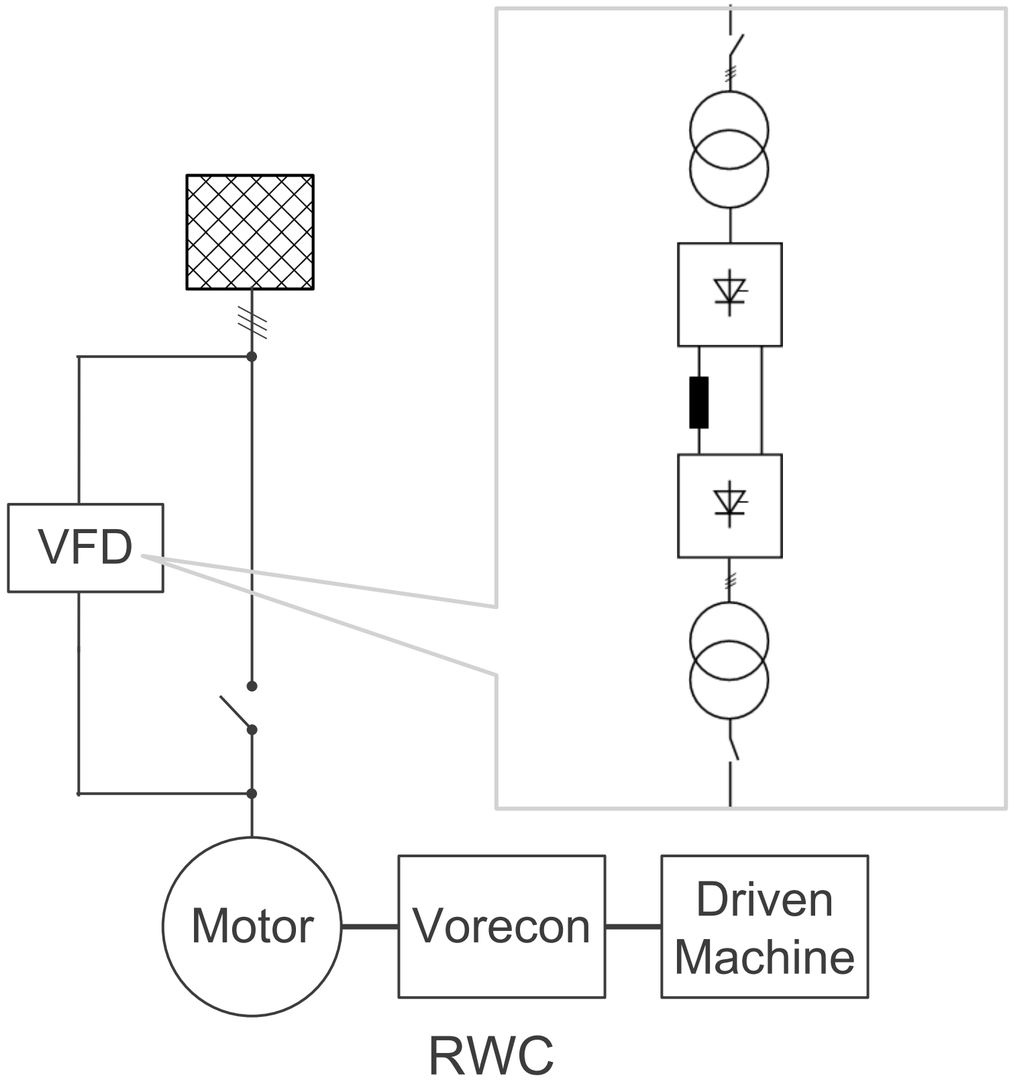

# VFD-Starter


Inrush Current
700
[%]
600
500
400
300
200
100
0
10
20
30
40
50
60
70
80
90
[%]100
Motor Speed

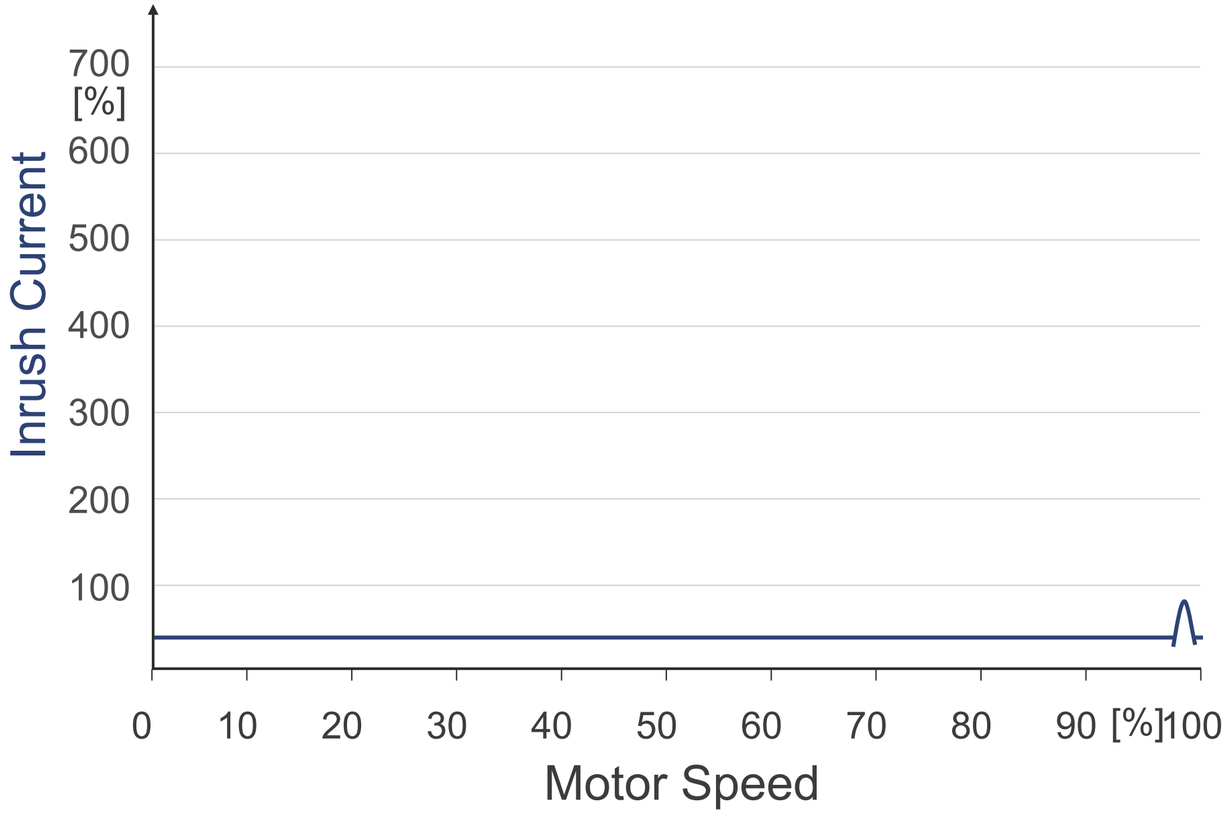

VFD
Motor
Vorecon
Driven Machine
RWC

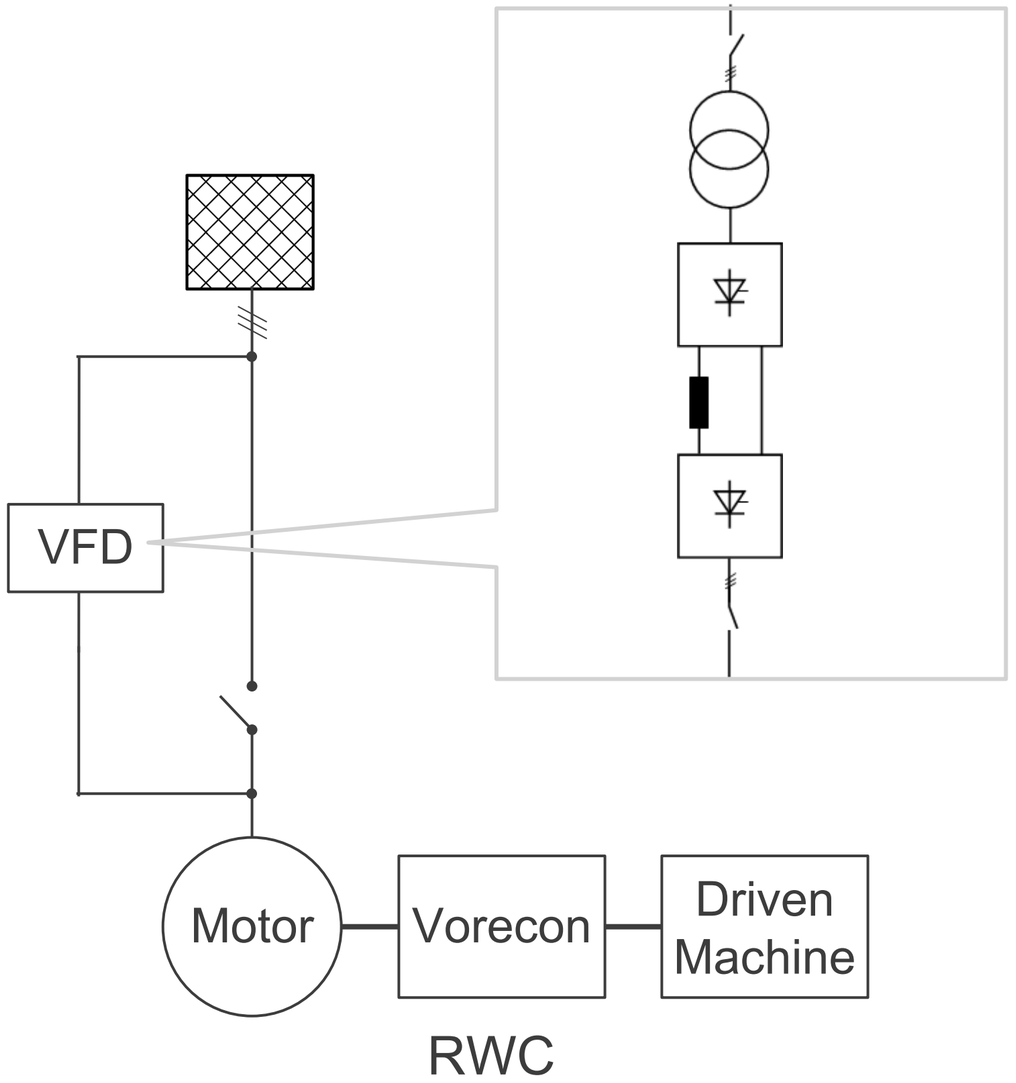
# VFD-Starter


Inrush Current
700
[%]
600
500
400
300
200
100
0
10
20
30
40
50
60
70
80
90
[%]100
Motor Speed


VFD
Motor
Vorecon
Driven Machine
RWC

# VFD-Starter

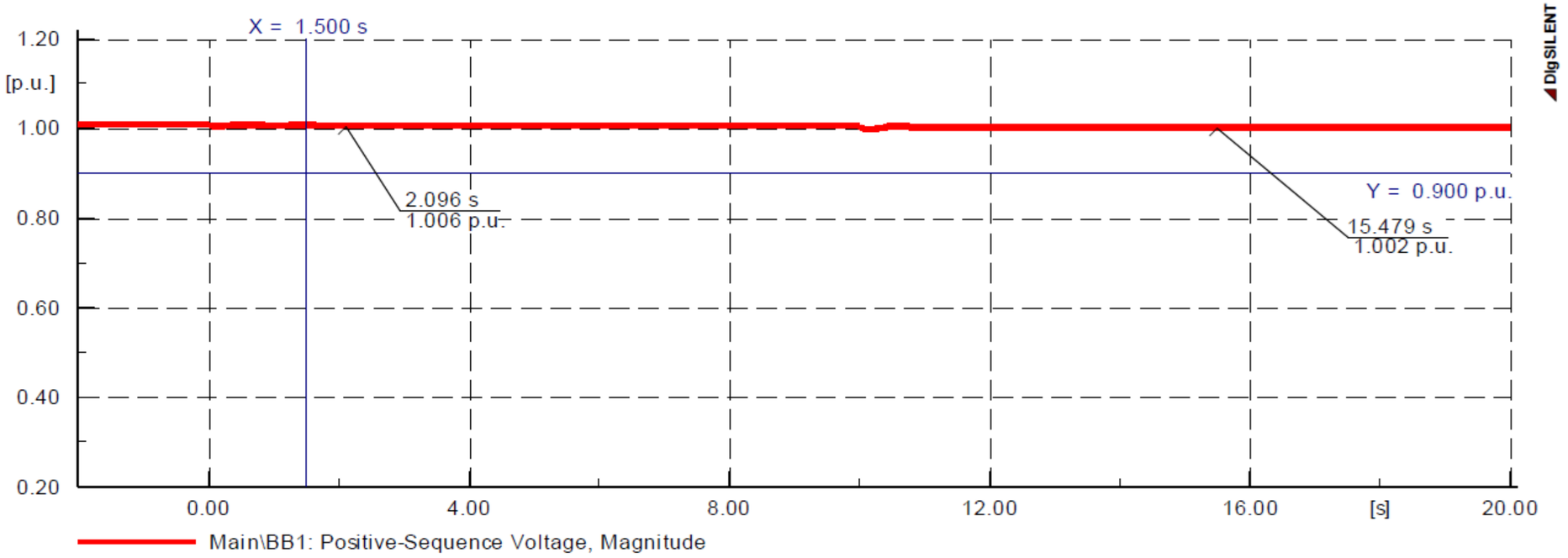

Inrush Current
700
[%]
600
500
400
300
200
100
0
10
20
30
40
50
60
70
80
90
[%]100
Motor Speed


VFD
Motor
Vorecon
Driven Machine
RWC

# VFD-Starter

VOITH

Voltage



# VFD-Starter

VOITH

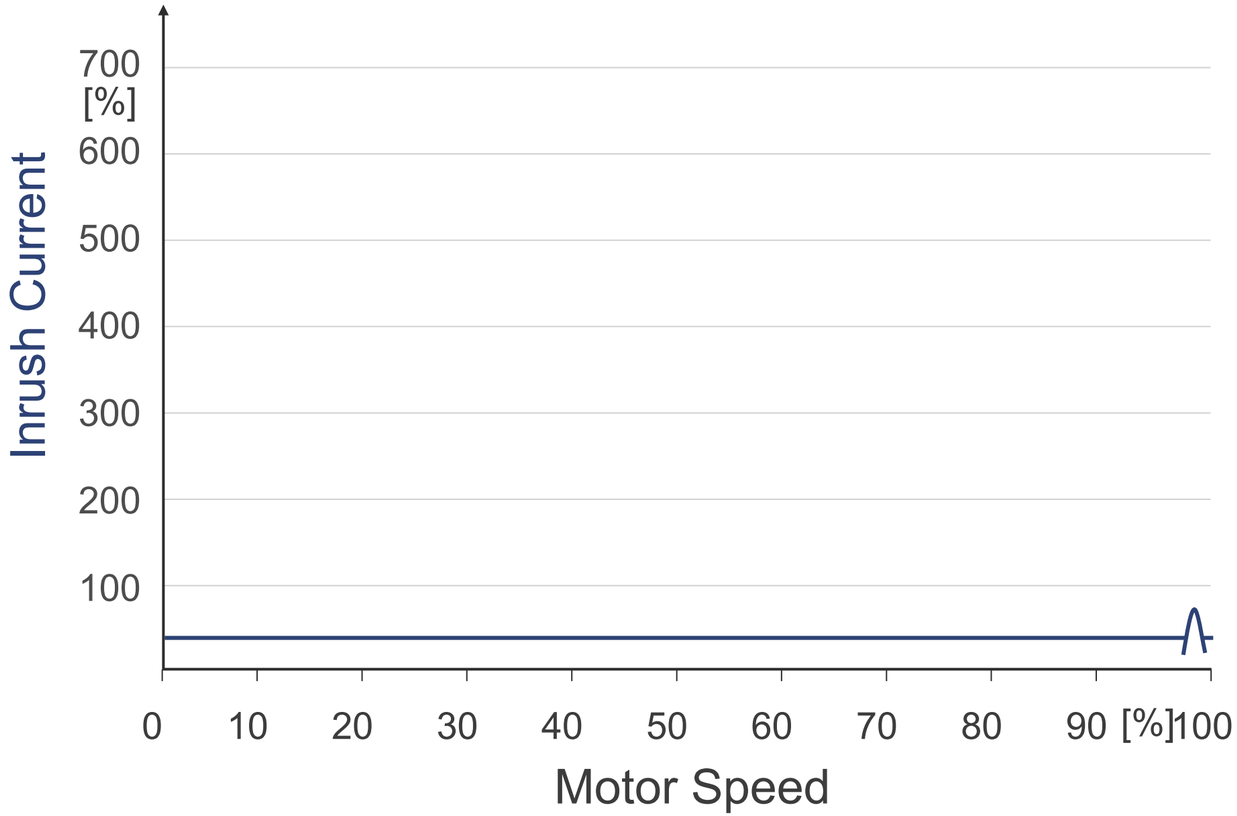
Pros

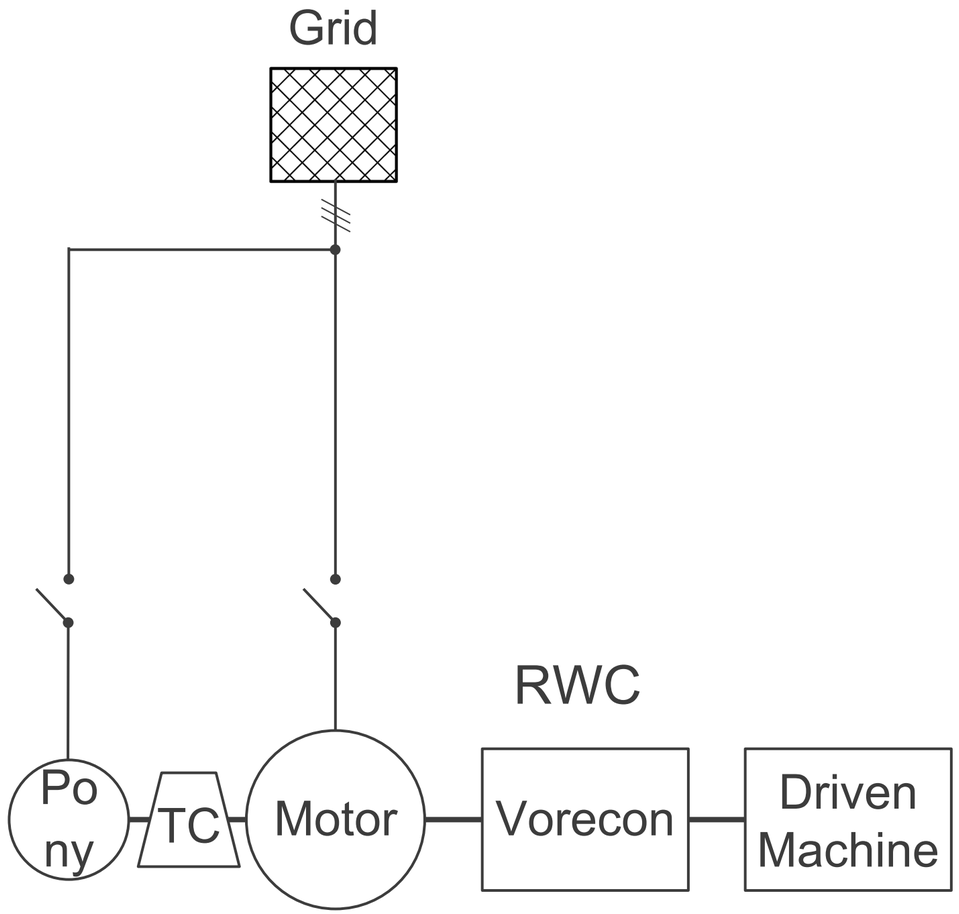
- No circuit feedback in case of motor is run at rated voltage before synchronization.
- Suitable for all grids, especially for very weak grids
- For induction and synchronous motor
- Smooth run-up of main motor

Cons

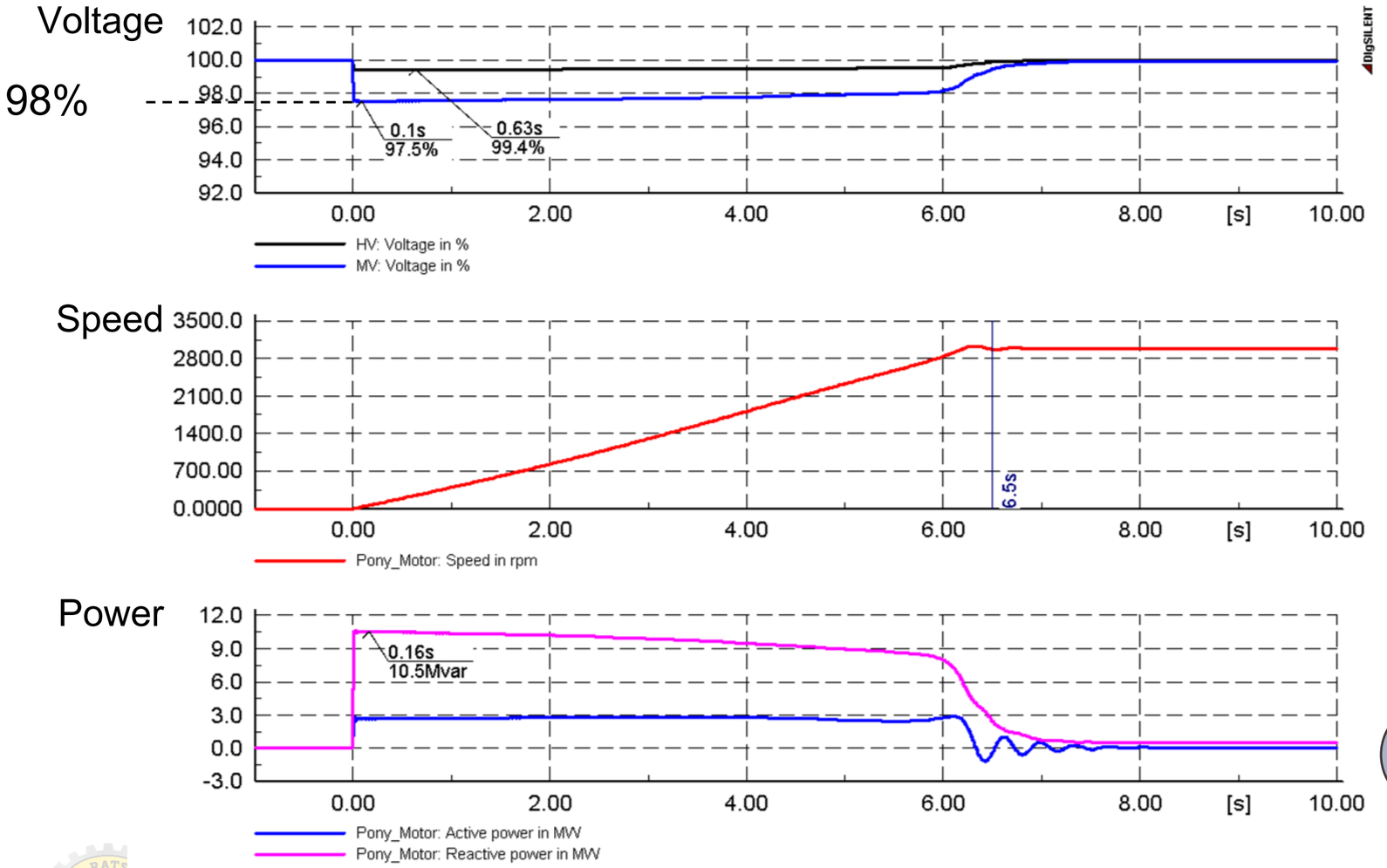
- -

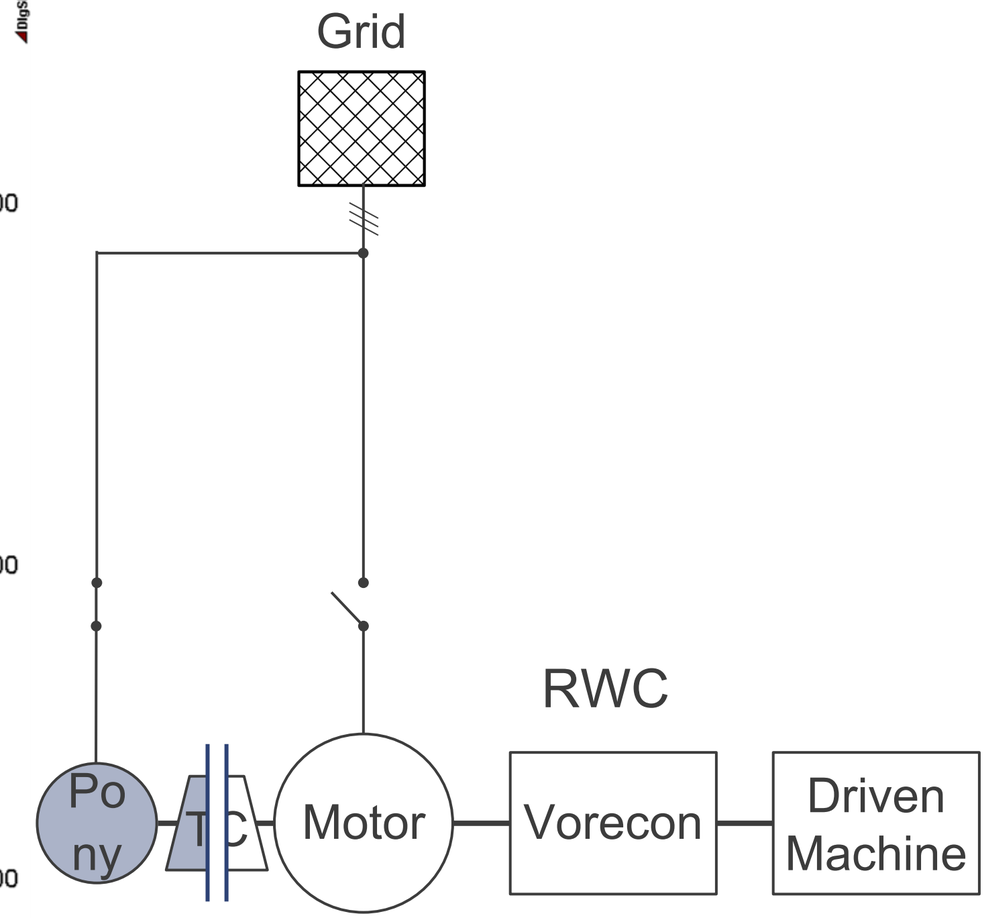
# Pony Motor Starter



# Pony Motor Starting

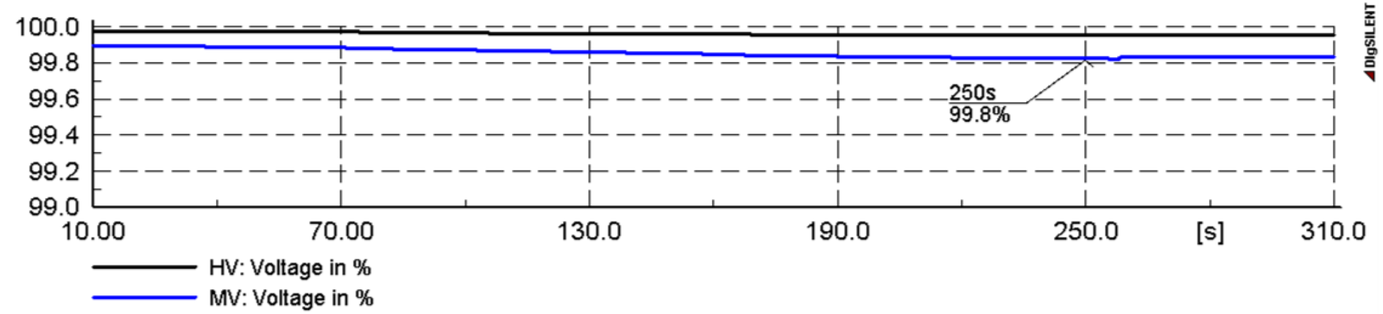


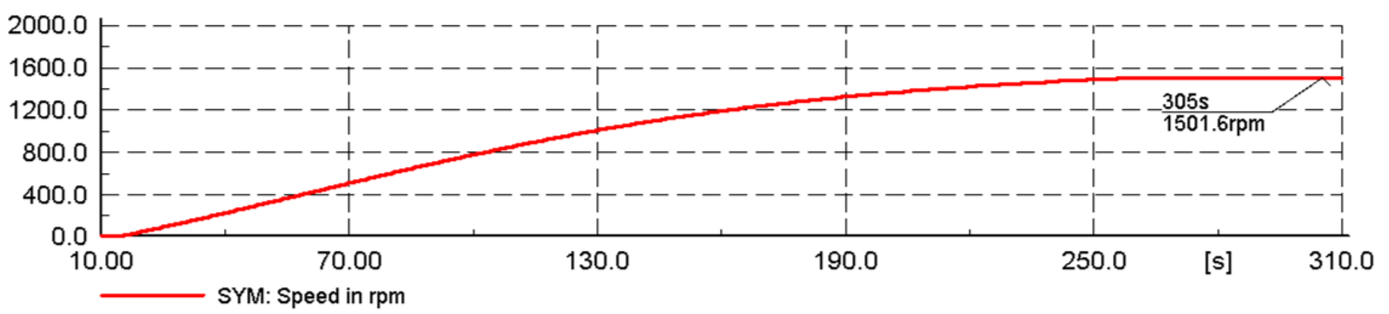
# Synchronous Motor run-up

VOITH

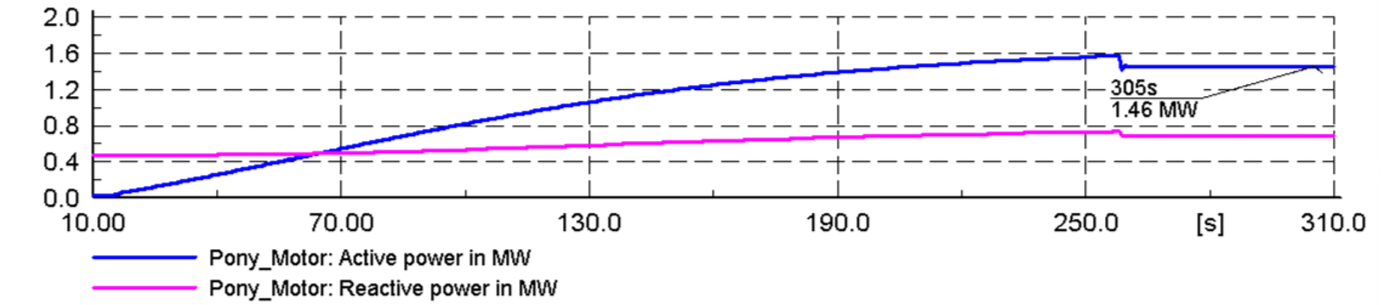
Voltage

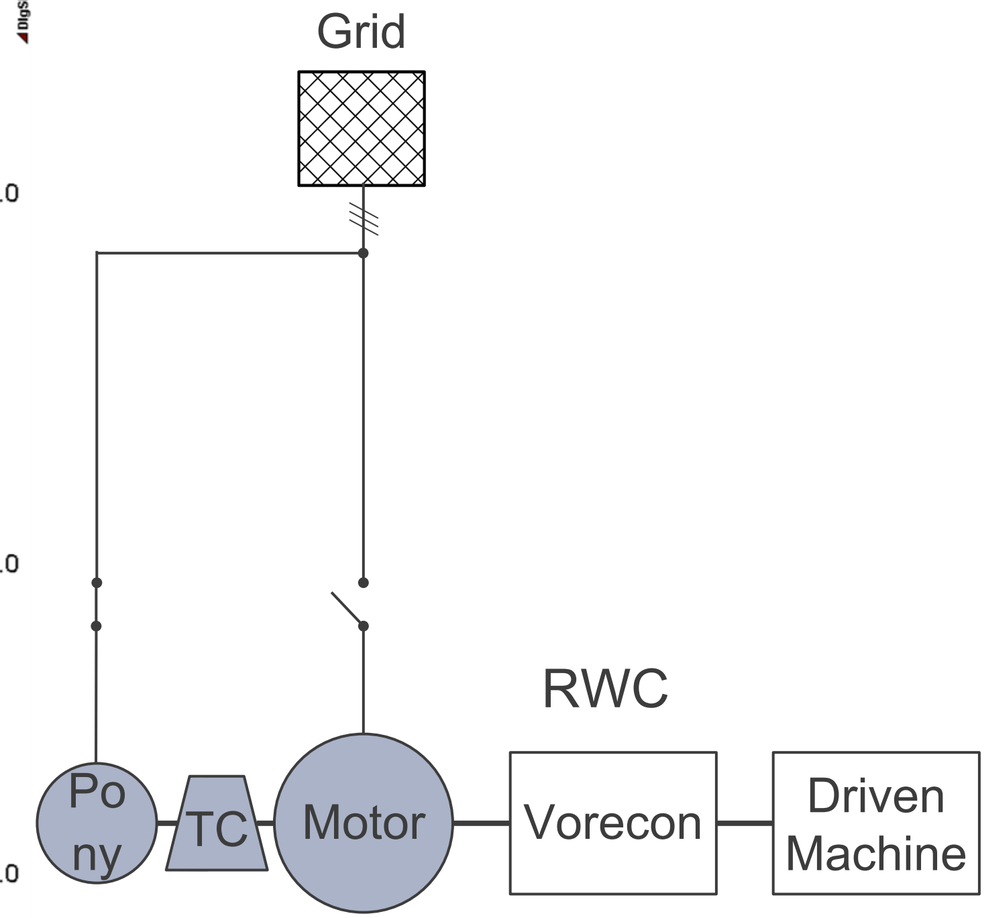



Speed

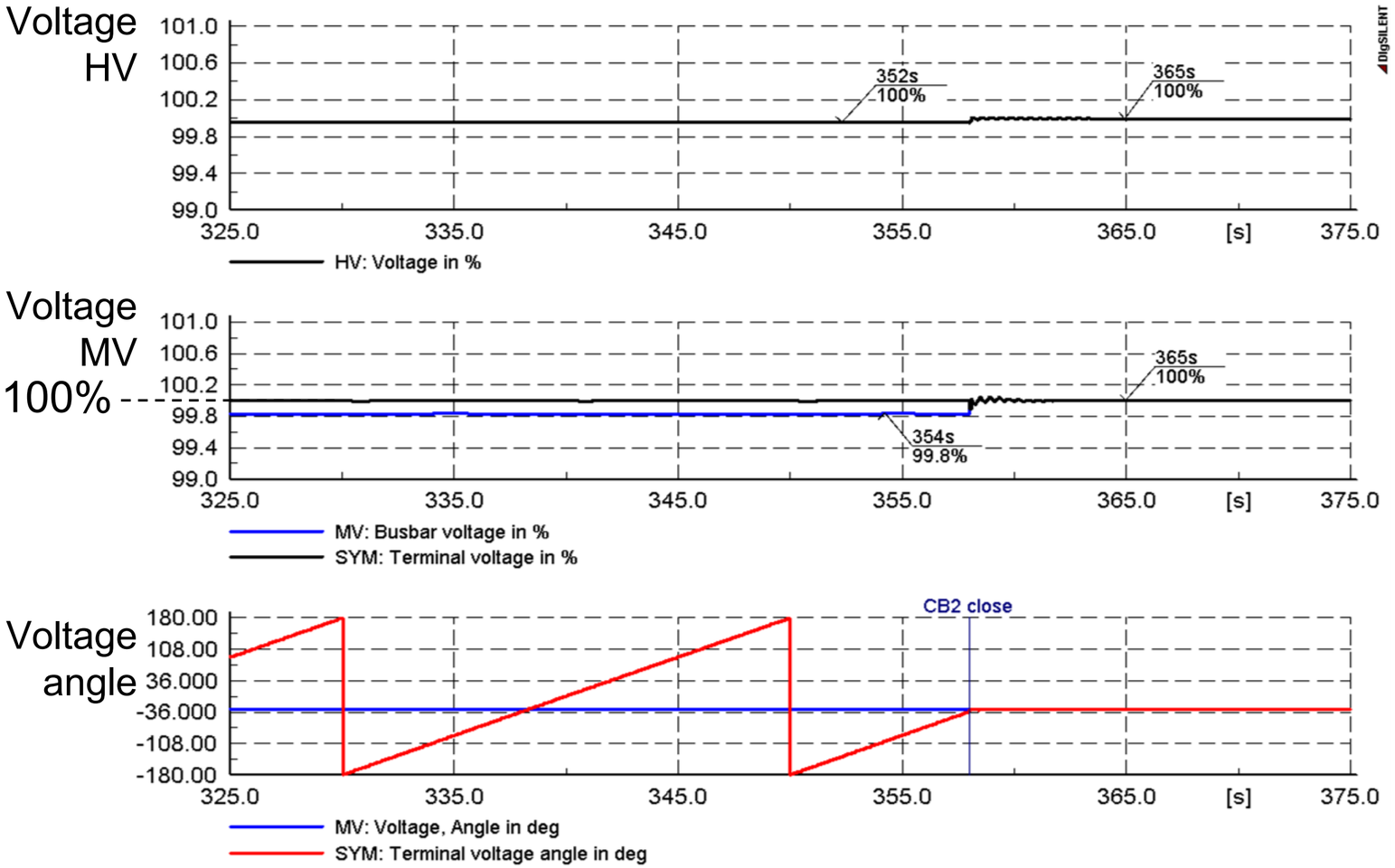


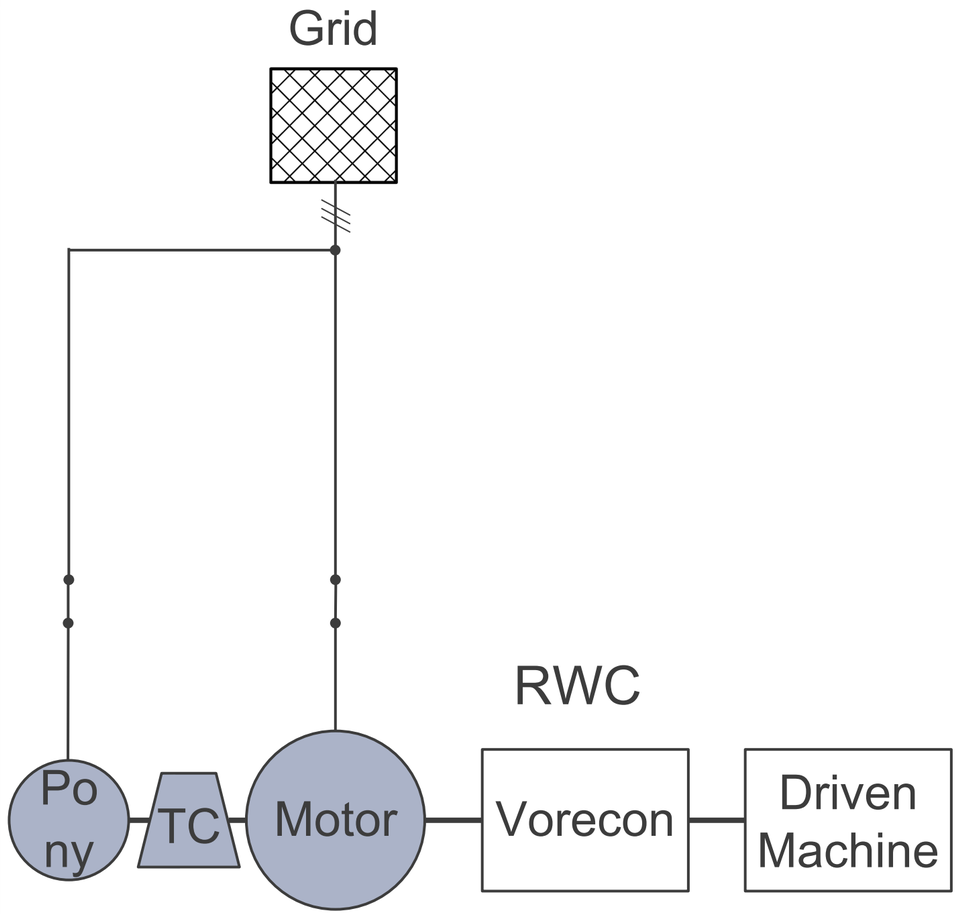

Power



# Motor Synchronization



# Pony Motor Starter

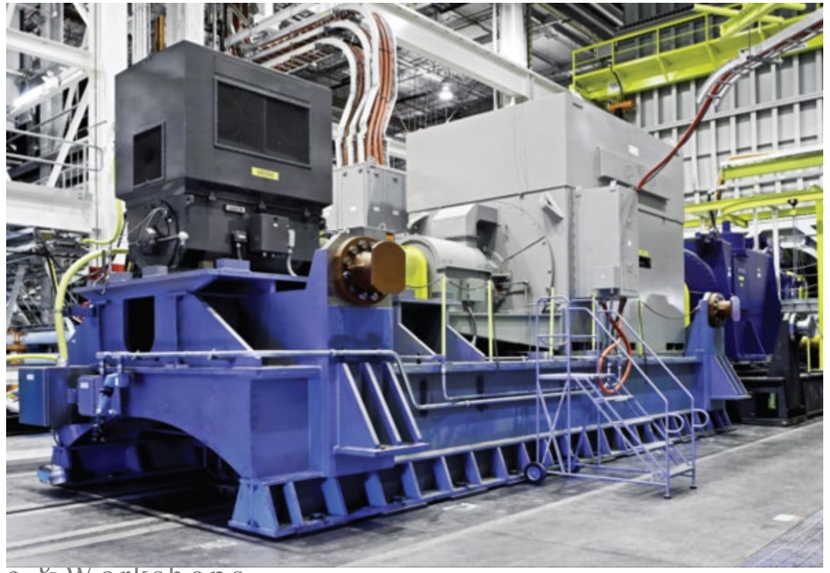
VOITH

Pros

- Pony motor grid disturbance is negligible
- Smooth run-up and synchronization of main motor
- Suitable for all grids, especially for very weak grids

Cons

- Increased installation length
- Enlarged electrical installation efforts



# Conclusion

- 6 starting methods are shown
- 6 different ways to limit the voltage / current
- Electrics & Mechanics predetermine possible starting methods
  - no possibility to influence the grid strength
  - Mechanics can be influenced by reducing the load curve
- The optimal starting method depends on the application and the objectives.
  - Simple: Low Inrush motor
  - Popular: Autotransformer or Softstarter
  - Weak grid: Pony Motor or VFD-Starter
  - No circuit feedback: Rotor Resistance Starter

  Starting methods can be utilized best in combination with a relieved or unloaded load curve.

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