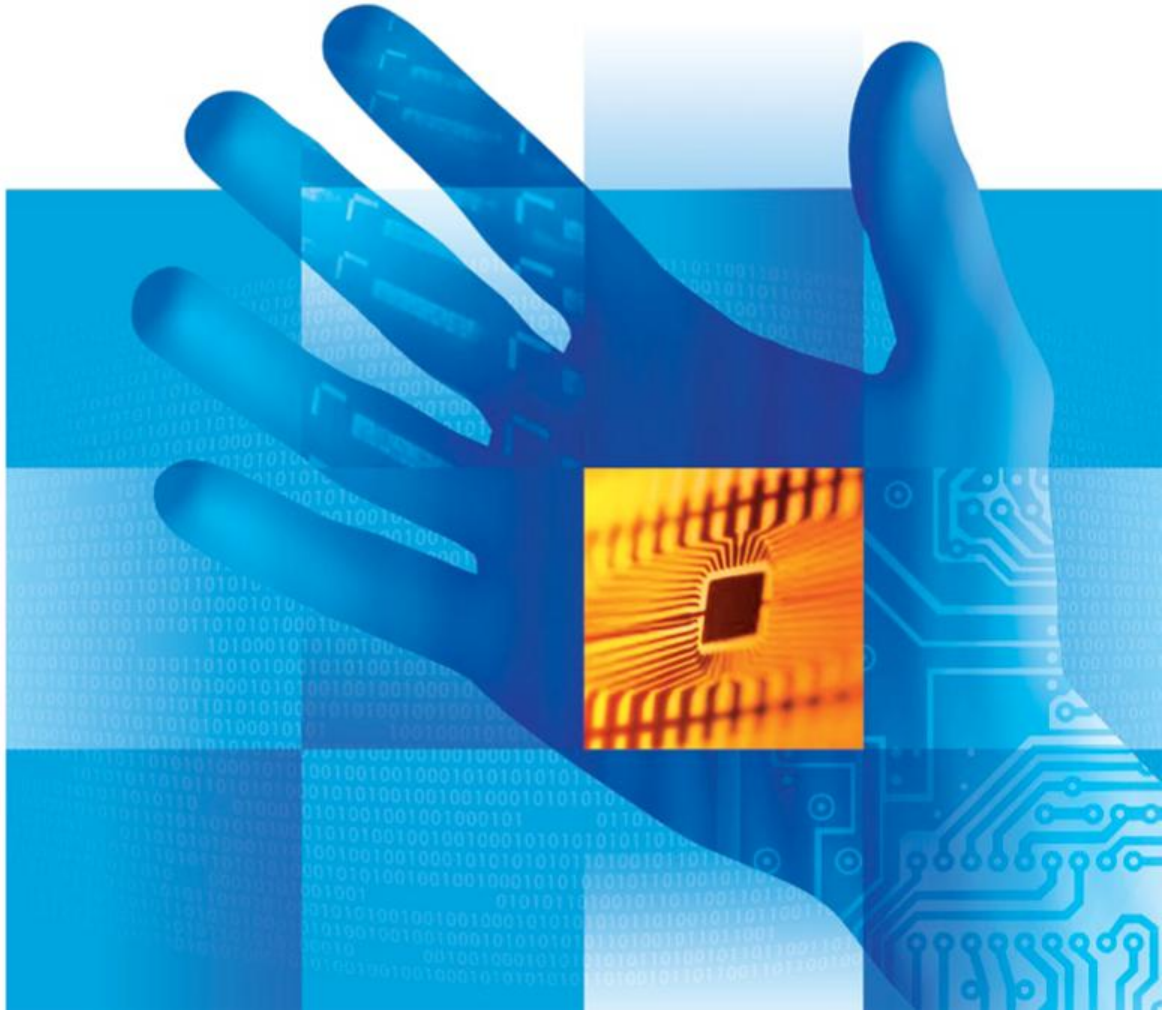
EVROPSKÁ UNIE
Evropské strukturální a investiční fondy
Operační program Výzkum, vývoj a vzdělávání

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

11. INDUCTION MOTORS



Doc. Ing. Stanislav Kocman, Ph.D.

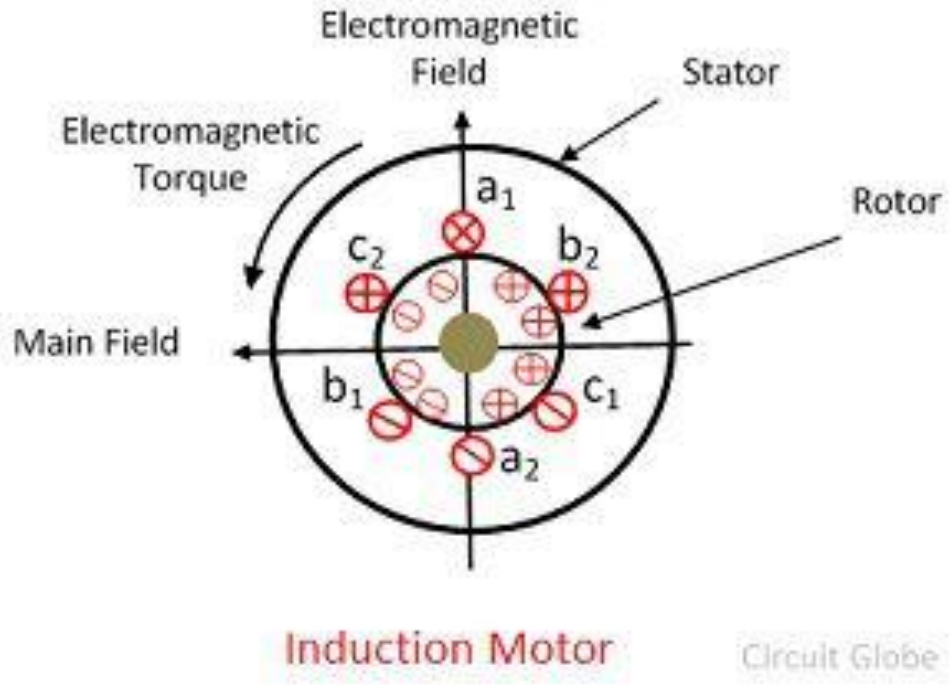
20. 4. 2018, Ostrava

LECTURE PLAN

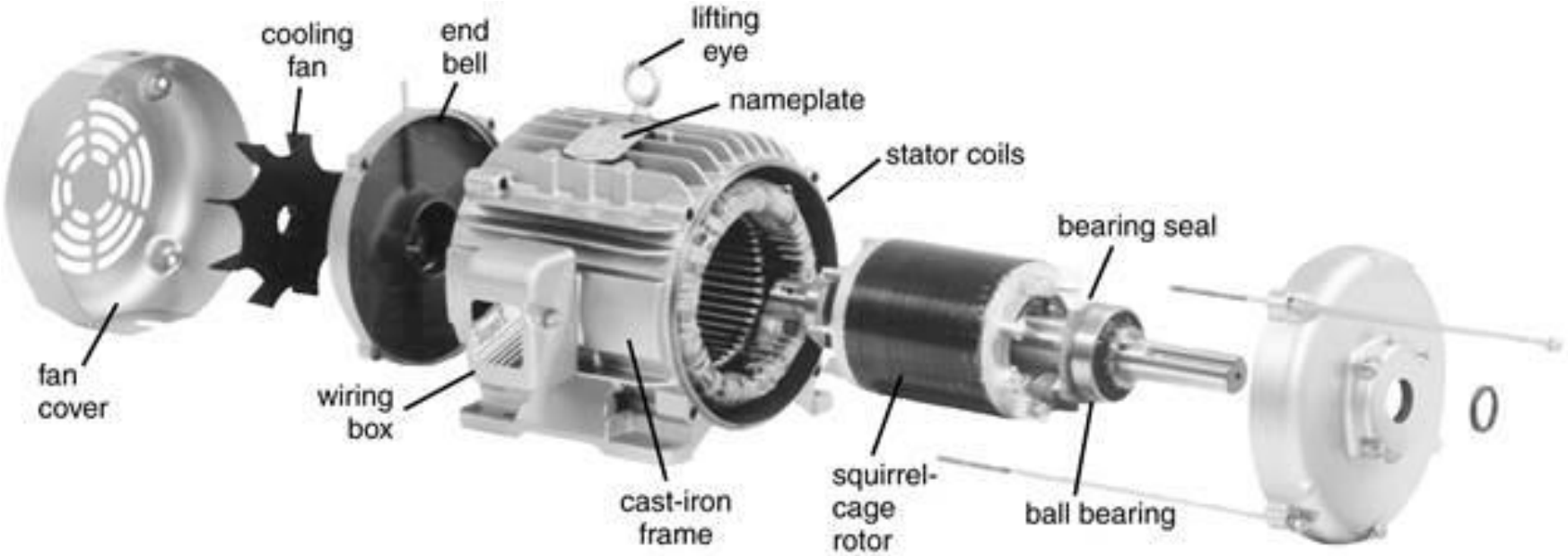
- principle and design of induction motor
- characteristics and parameters of three-phase induction motors
- starting three-phase induction motors
- speed control of induction motors

Principle and design of induction motor

Principle of operation



Design of induction motor





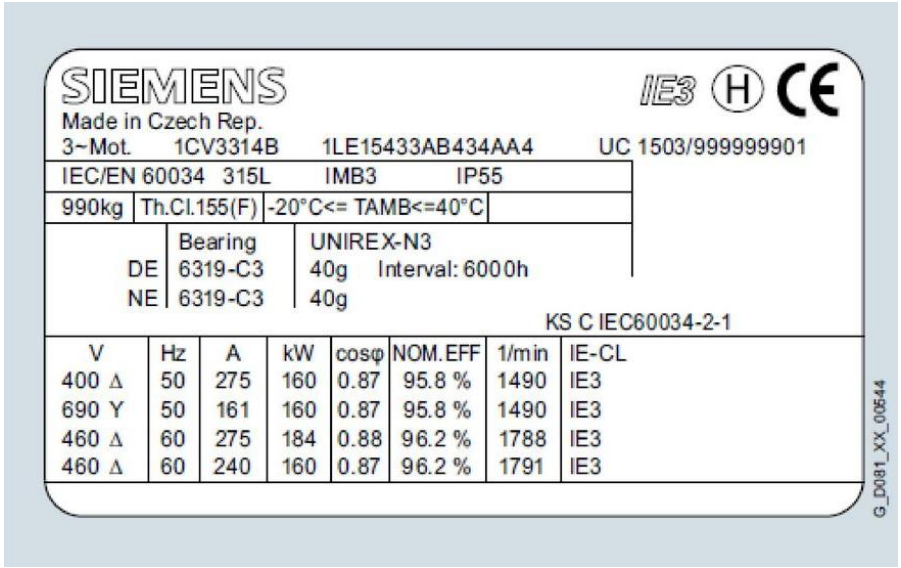




Parameters of three-phase induction motors

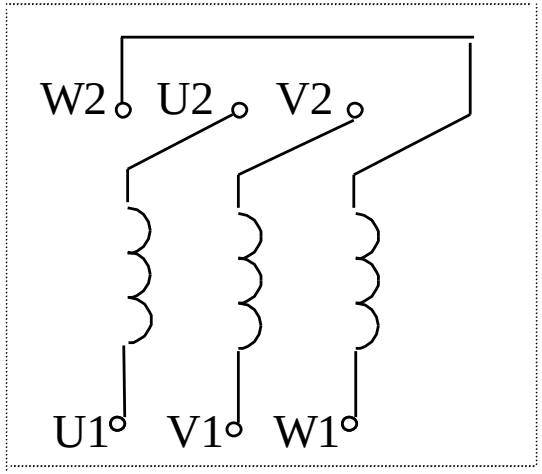
Motor nameplate



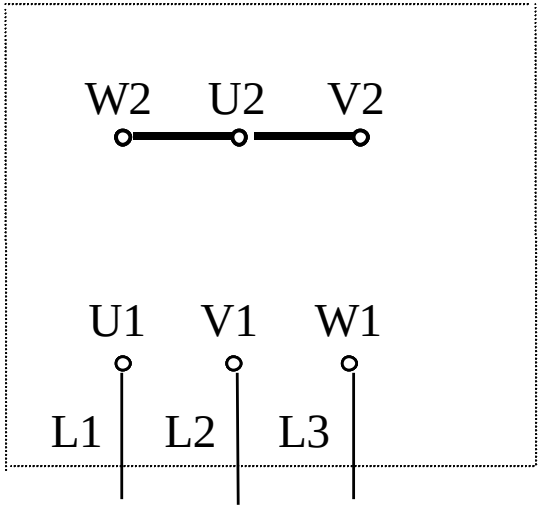


Connection of three-phase stator winding

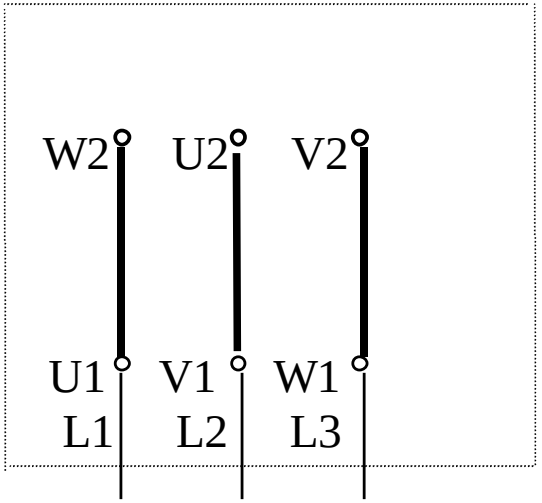
Motor wiring box



Connection of phase windings



Connection windings into star



Connection windings into delta

Parameters of three-phase induction motor

Synchronous speed (of rotating magnetic field)

$$n_{S1} = \frac{60 \cdot f}{p} \quad \left(\text{min}^{-1}, \text{Hz}, -\right)$$

Slip

$$s = \frac{n_{S1} - n}{n_{S1}} \cdot 100 \quad (\%)$$

Mechanical speed (of rotor)

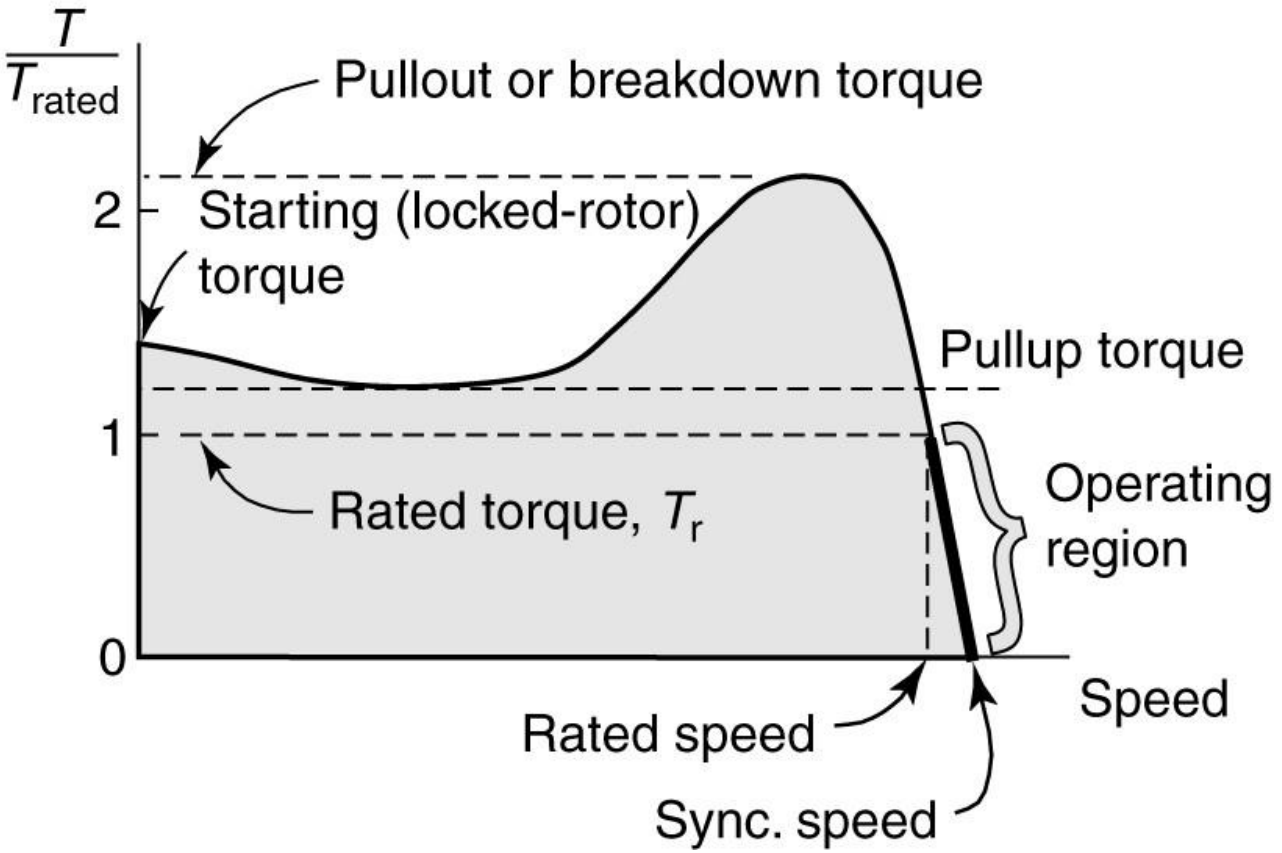
$$n = n_{S1} \cdot (1 - s) = \frac{60 \cdot f}{p} \cdot (1 - s)$$

Torque on the shaft

$$M_N = \frac{P_N}{\Omega_N} = \frac{P_N}{\frac{2\pi \cdot n_N}{60}} = 9{,}55 \cdot \frac{P_N}{n_N} \quad \left(\text{N} \cdot \text{m}, \text{W}, \text{min}^{-1}\right)$$

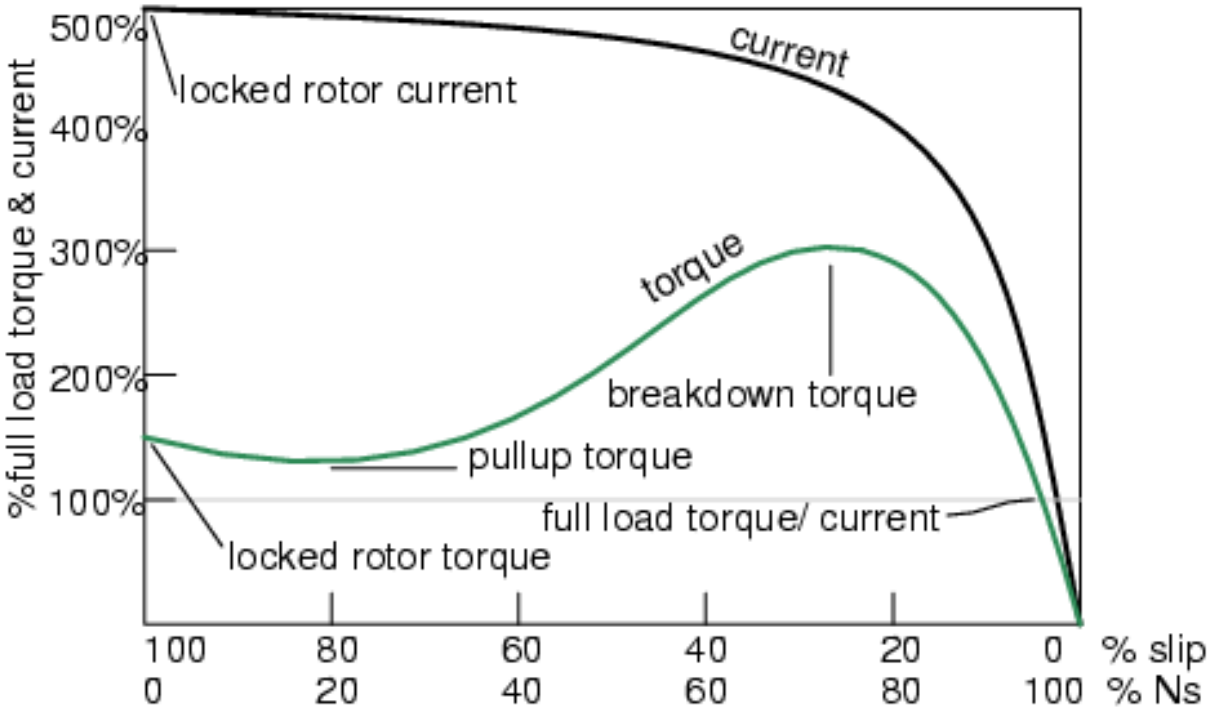
Characteristics of three-phase induction motors

Torque-speed curve



Characteristics of three-phase induction motors

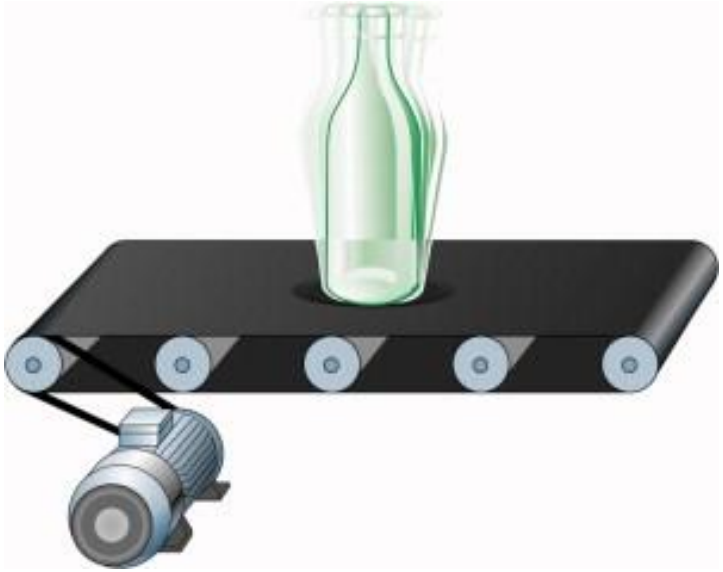
Torque and current-speed curve



Starting three-phase induction motors

Requirements for motor starting

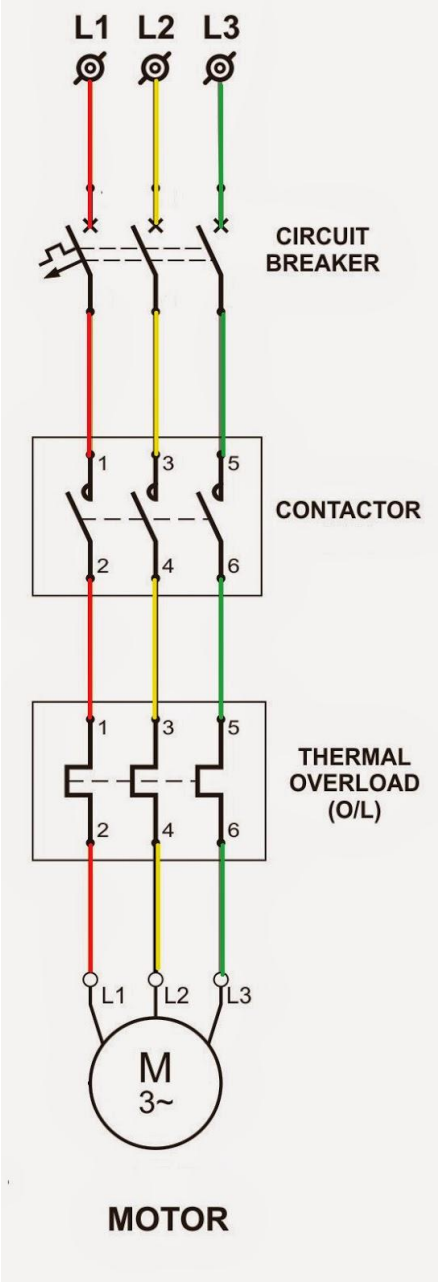
- Biggish starting torque to break the motor load at the standstill and during starting
- Small starting current to avoid a voltage drop and negative impacts on the induction motor

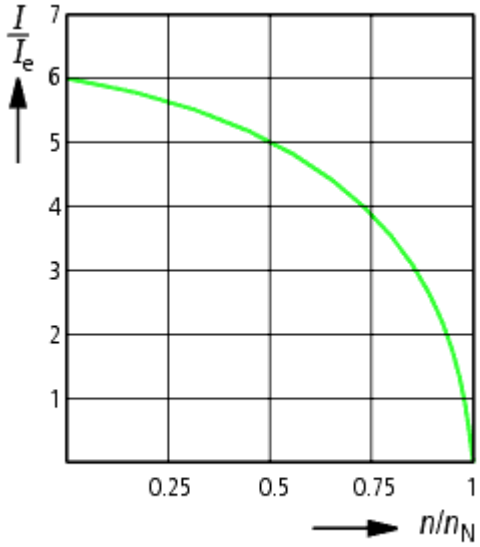


Starting methods

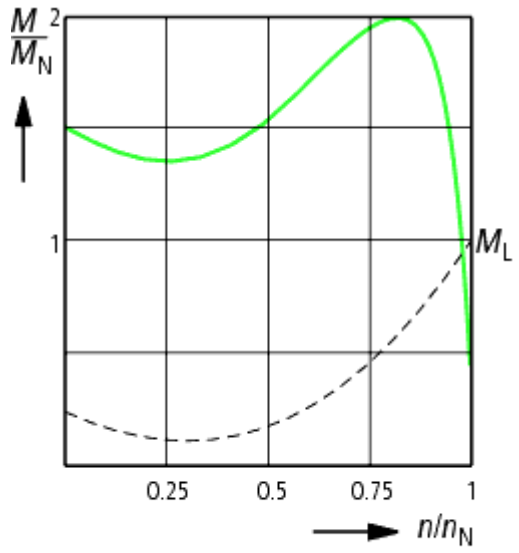
- Direct on-line start-up
- Reduce voltage resistor/reactor starter
- Autotransformer starter
- Star/Delta starter
- Soft starter
- Variable frequency drive starting

Direct on-line start-up



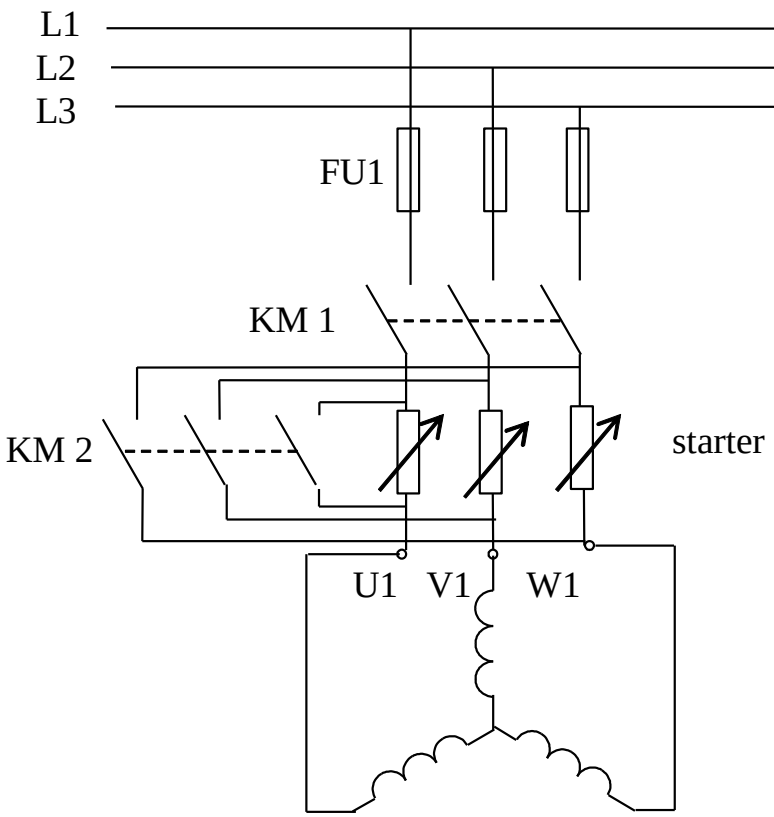


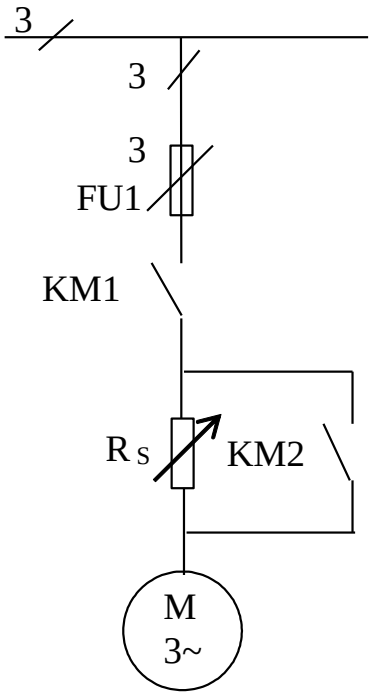
I/I_e: 6...10



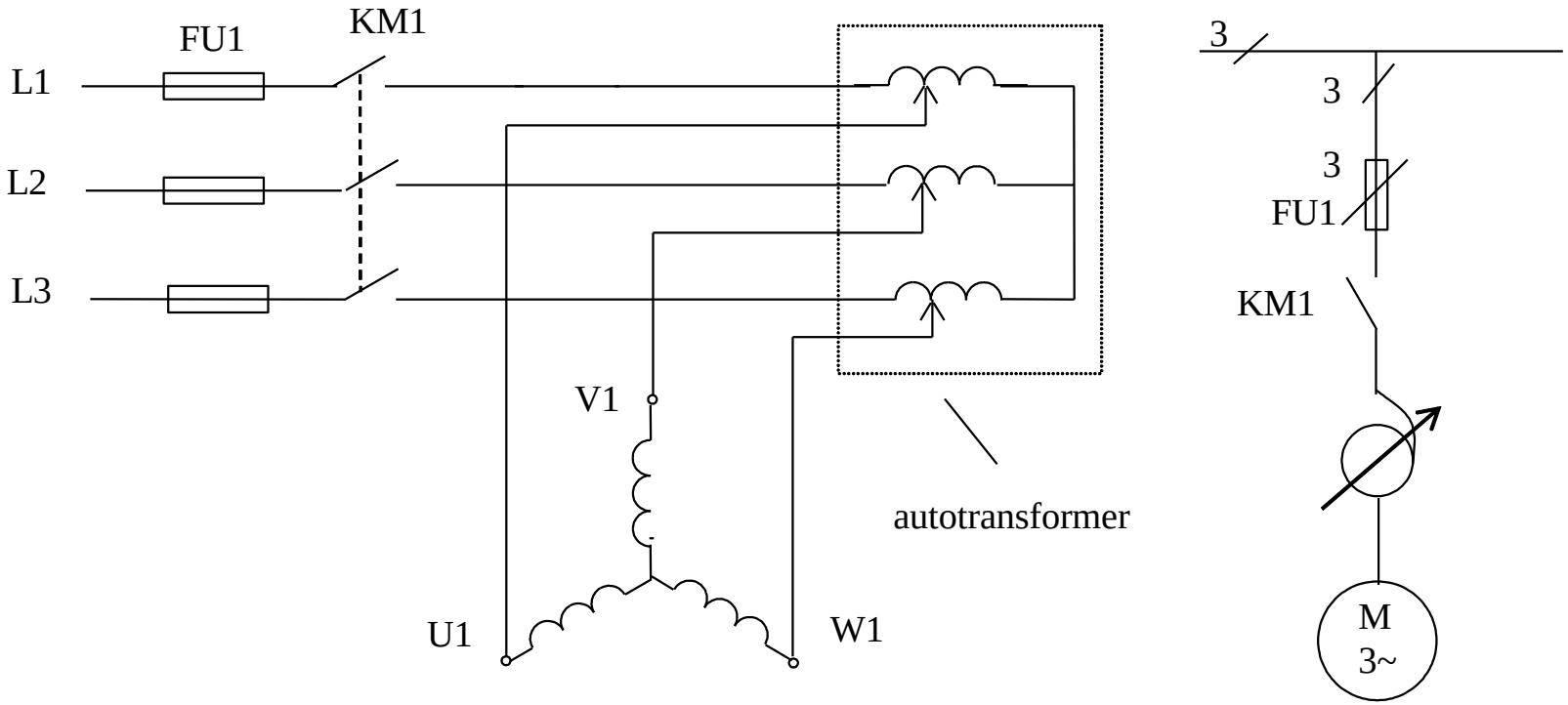
M/M_N: 0.25...2.5

Reduce voltage resistor/reactor starter

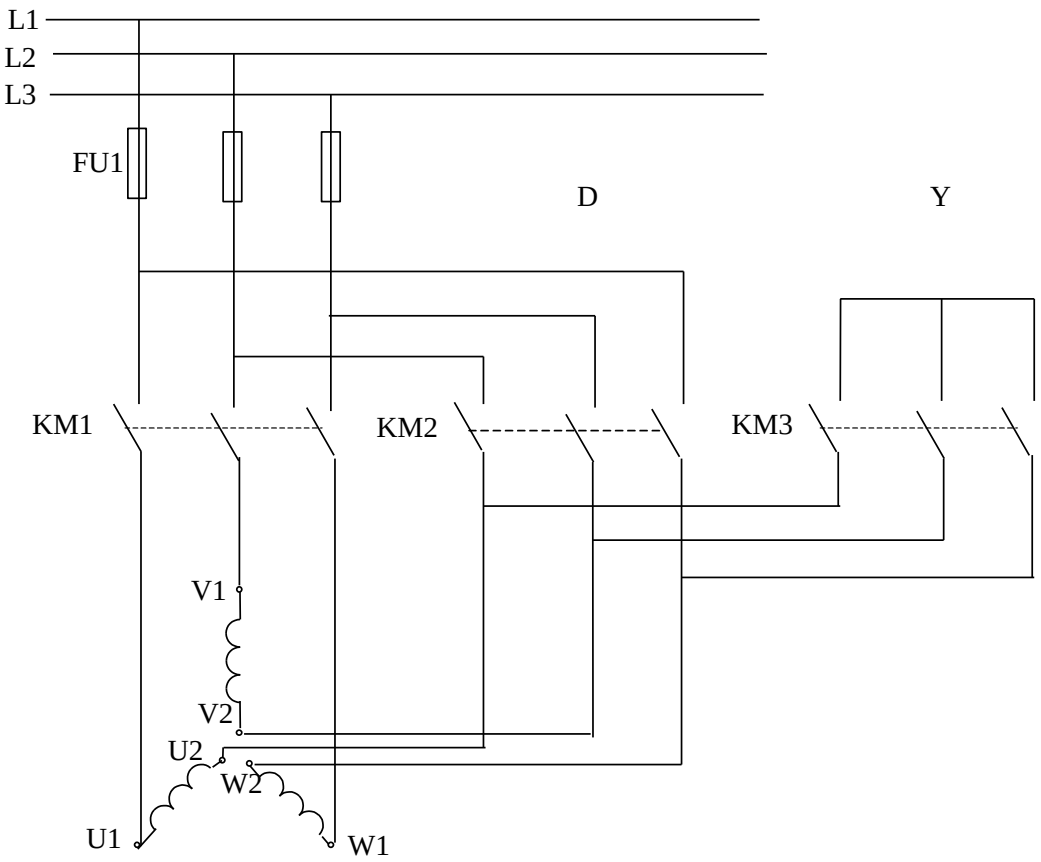


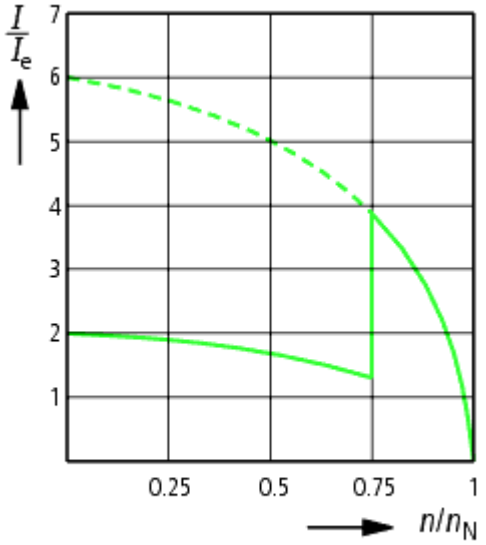


Autotransformer starter

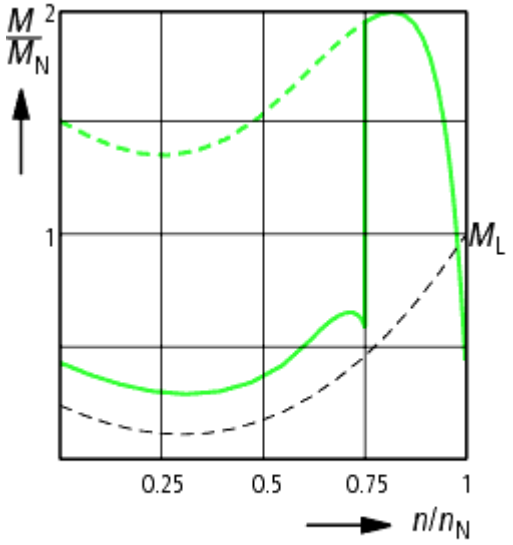


Star/Delta starter



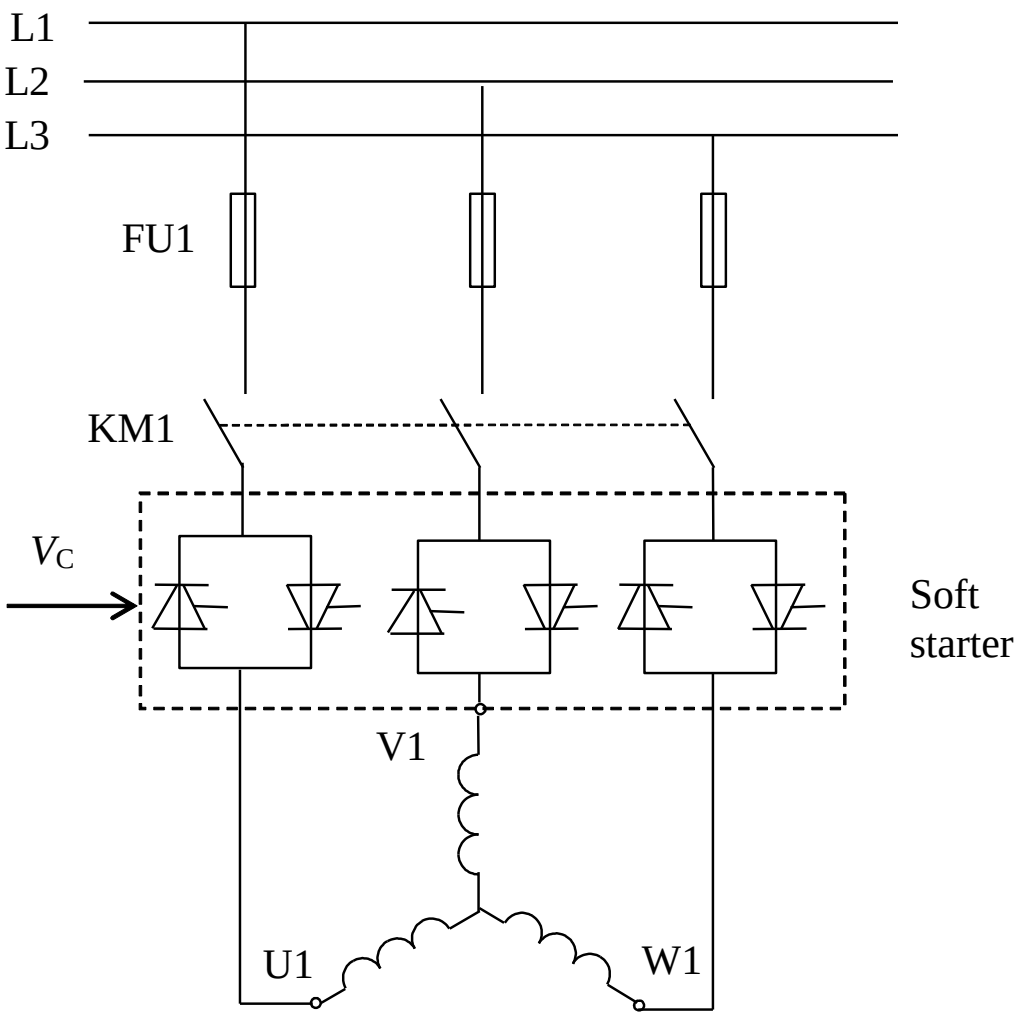


I/I_e: 1.5...2.5

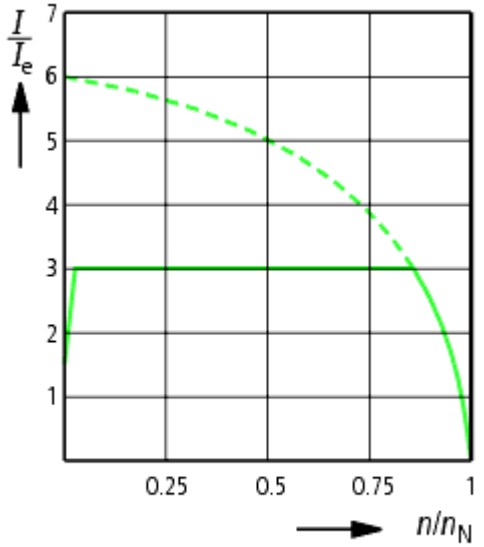


M/M_N: 0.5

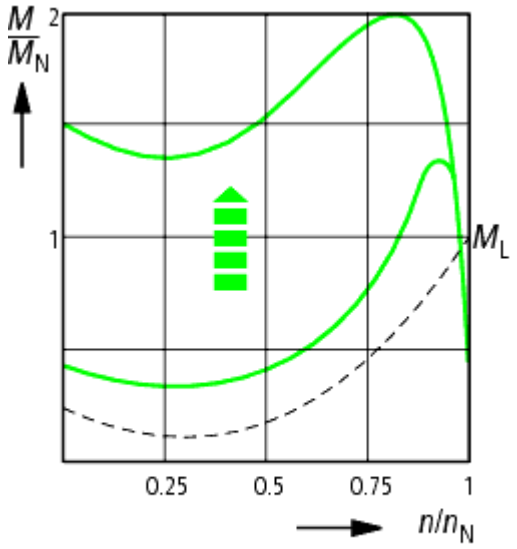
Soft starter



Soft starter

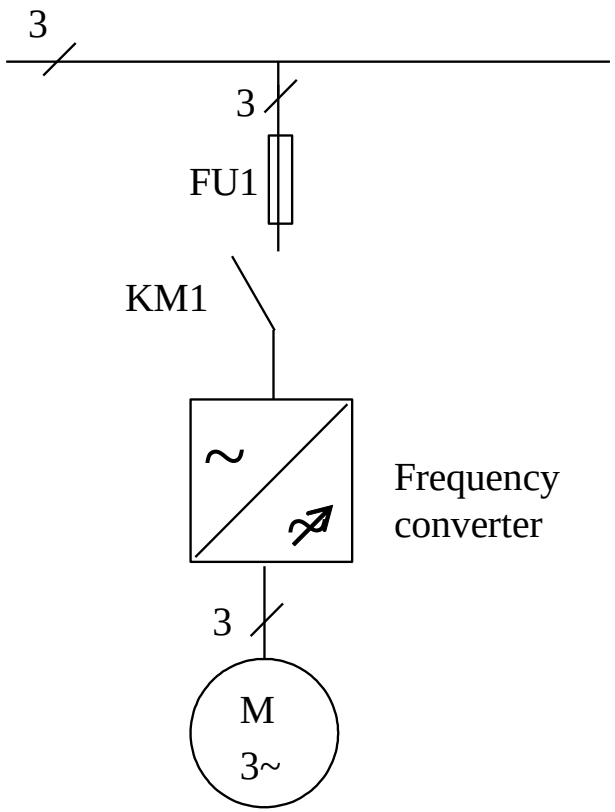


I/I_e: 1...5



M/M_N: 0.15...1

Variable frequency drive starting



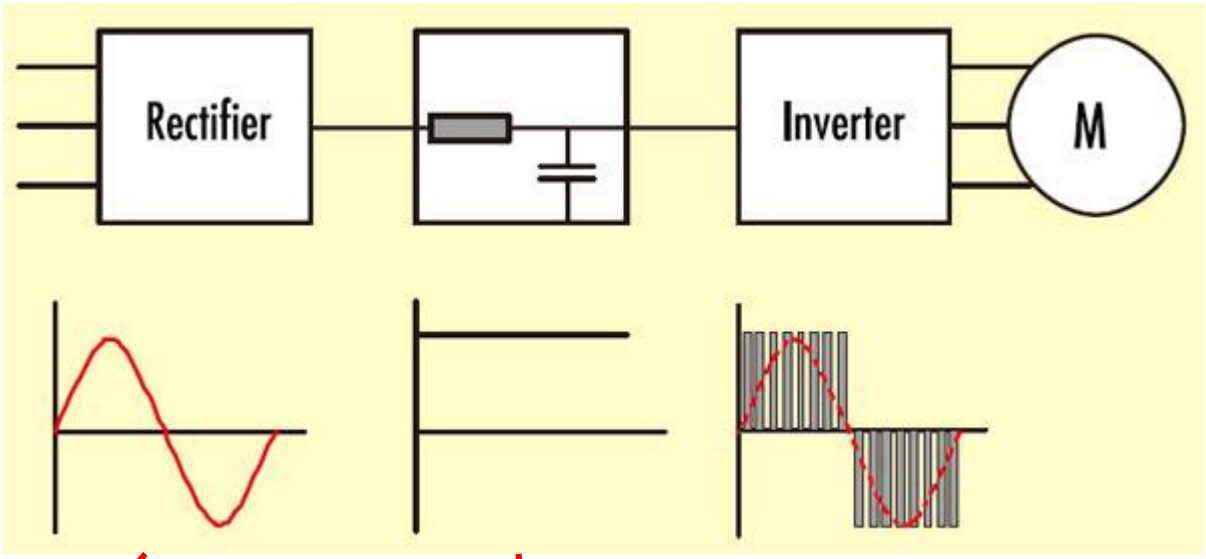
Speed control of induction motors

$$n = n_{S1} \cdot (1 - s) = \frac{60 \cdot f}{p} \cdot (1 - s)$$

- to alter the slip *s*
- to alter the number of pole pairs *p*
- to alter the supply frequency *f*
  - the most efficient

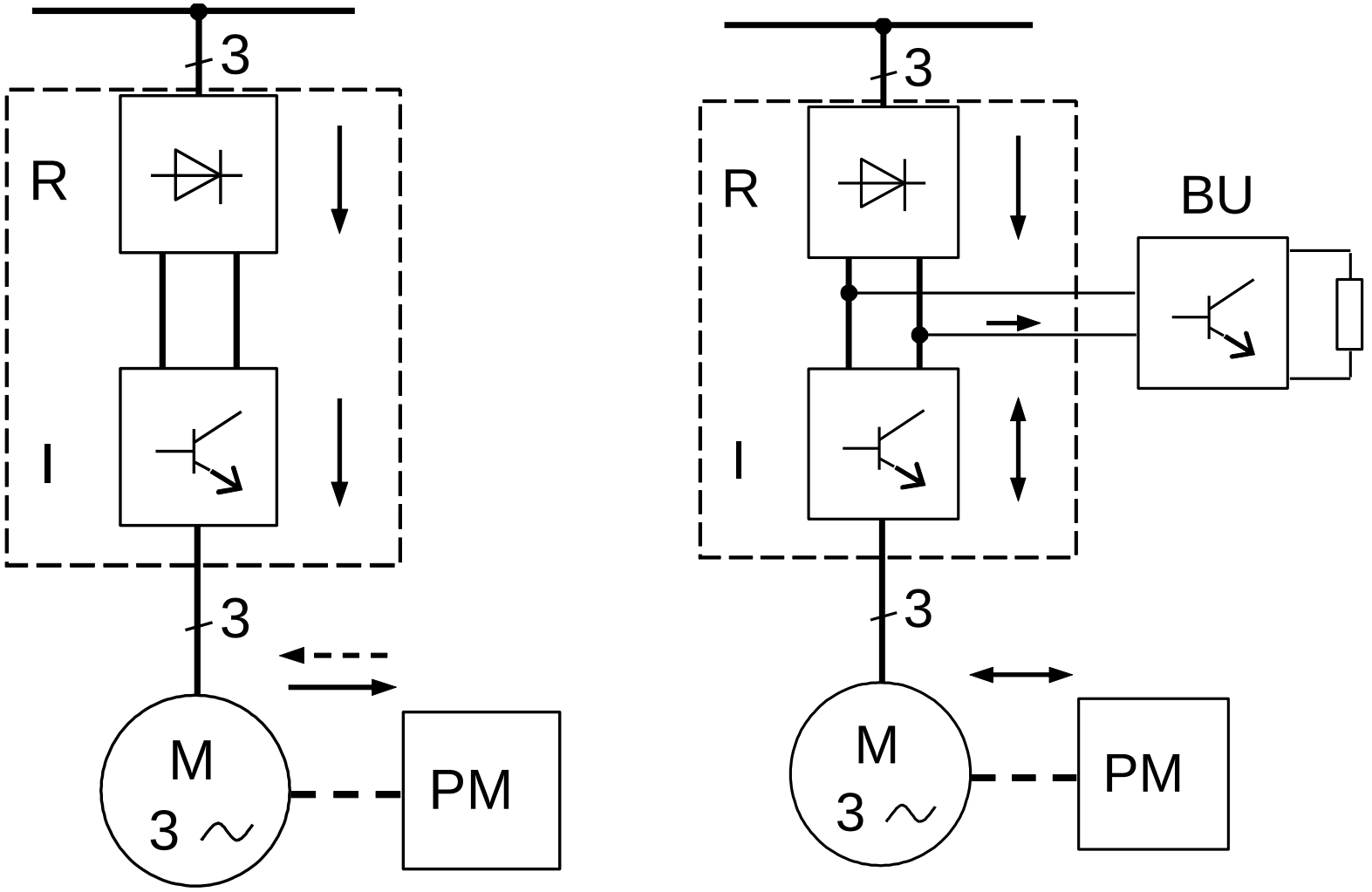
To alter the supply frequency – frequency converter

Frequency converter with voltage inverter



input voltage smoothed DC voltage output voltage

To alter the supply frequency – frequency converter



To alter the supply frequency – frequency converter

Torque - speed curve

