

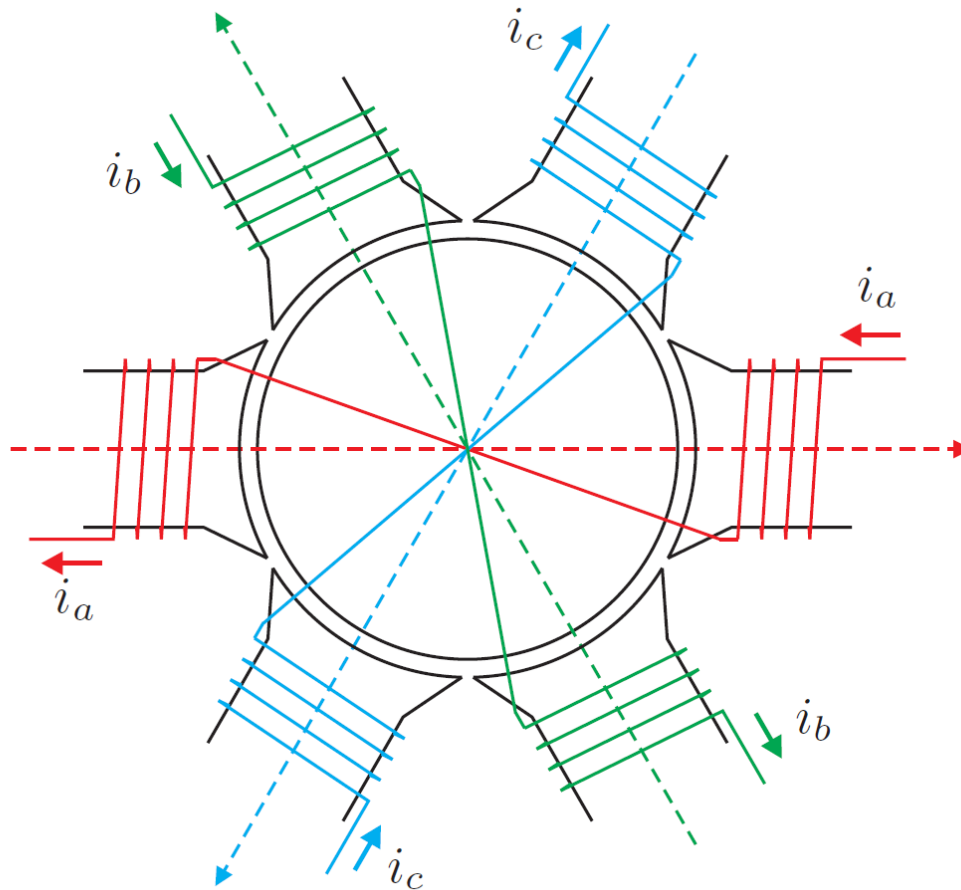
# Mechatronic Actuators

Lecture 5b

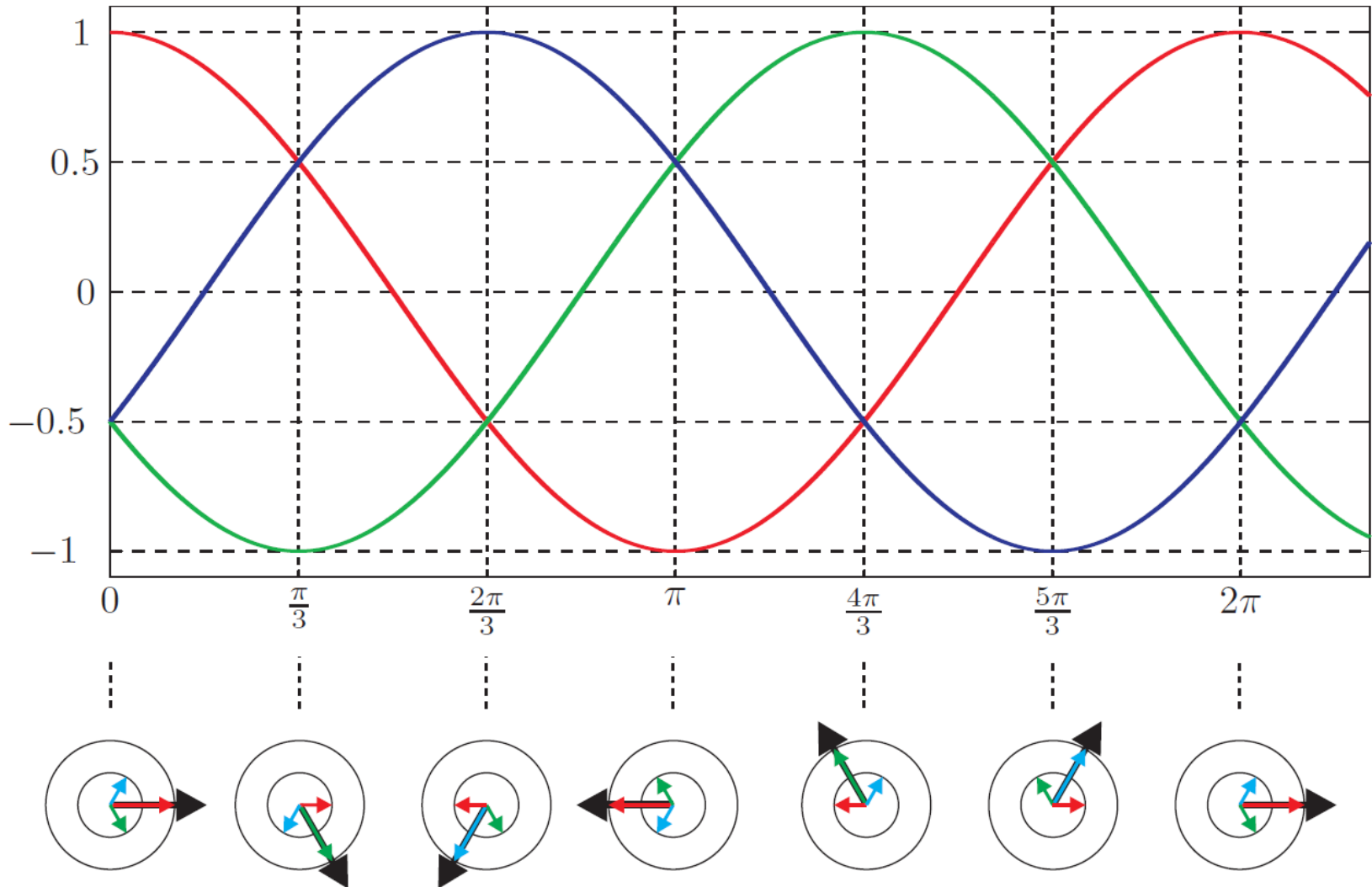
# Asynchronous motors

# Asynchronous electric motor

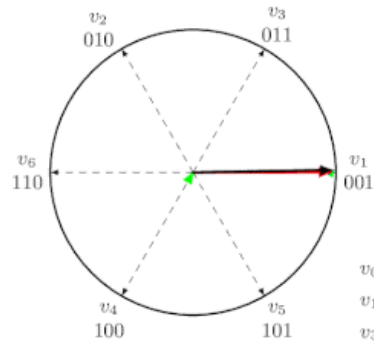
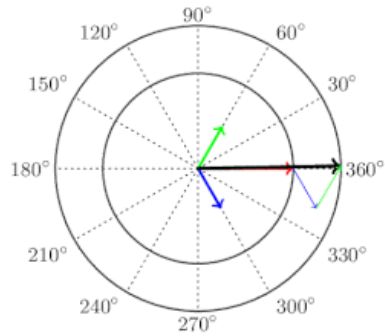
## Rotating magnetic field 1



# Rotating magnetic field 2

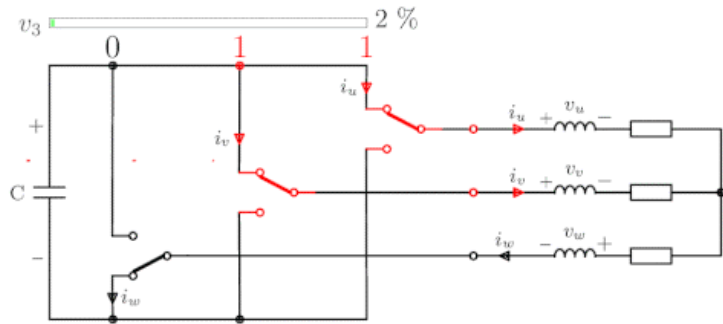
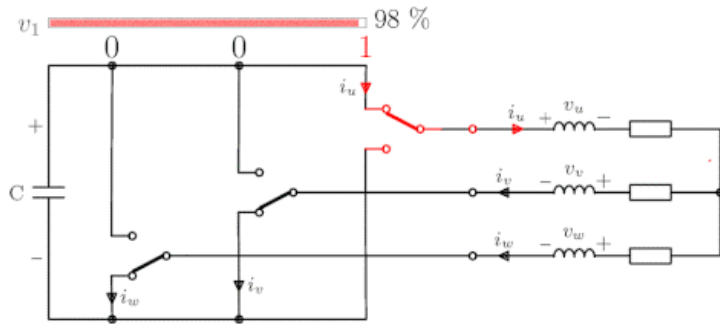
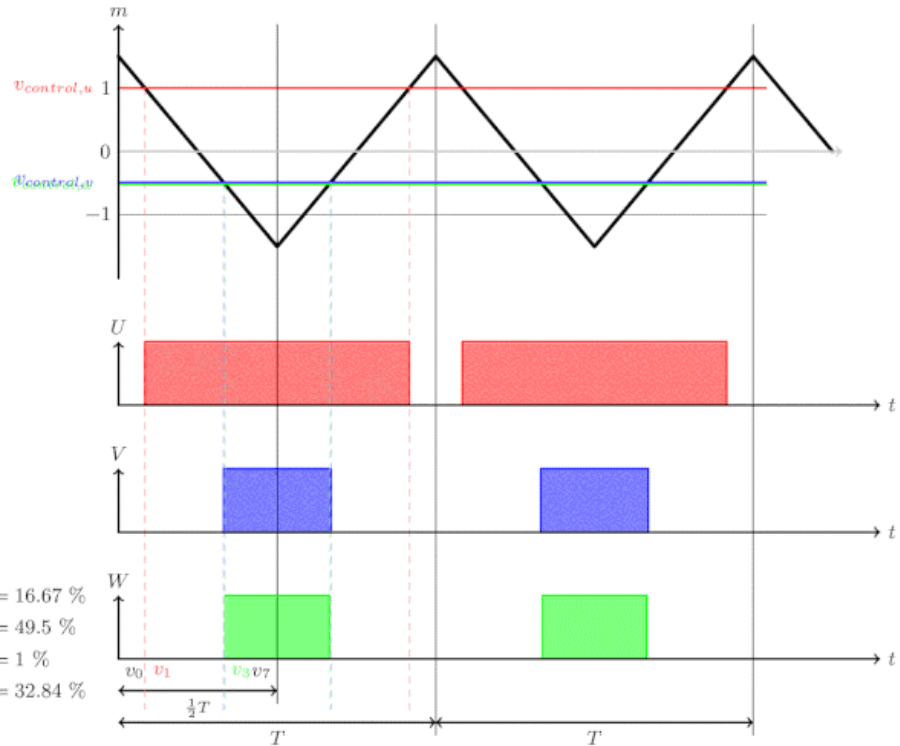


# Operation

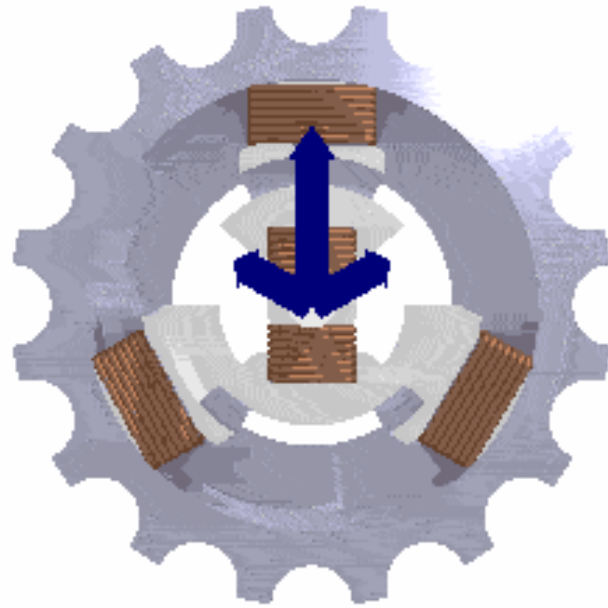


$s = 1$   
 $\phi = 1^\circ$   
 $x = 0.98007$   
 $y = 0.01993$

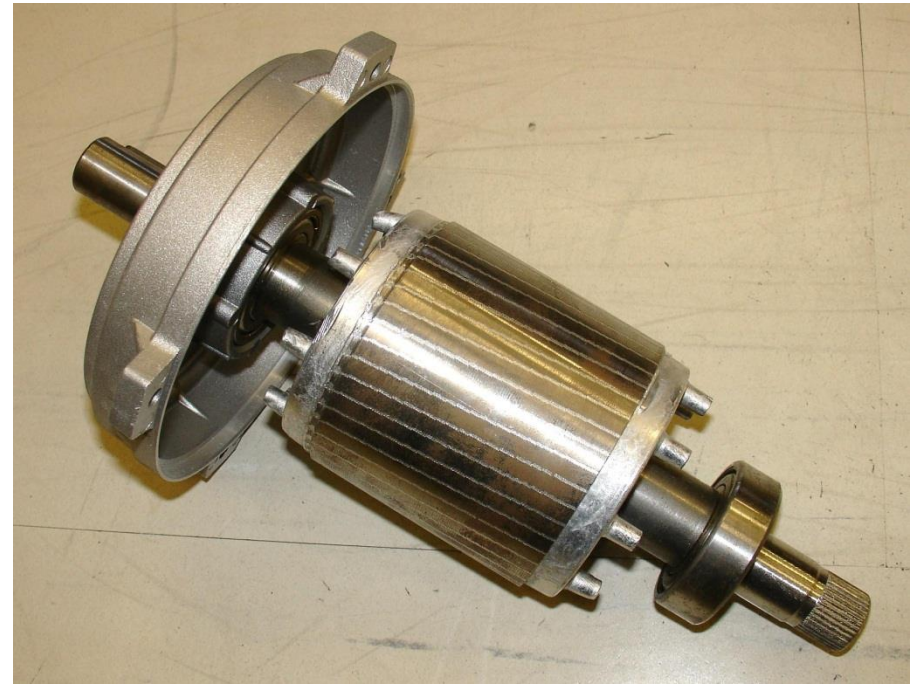
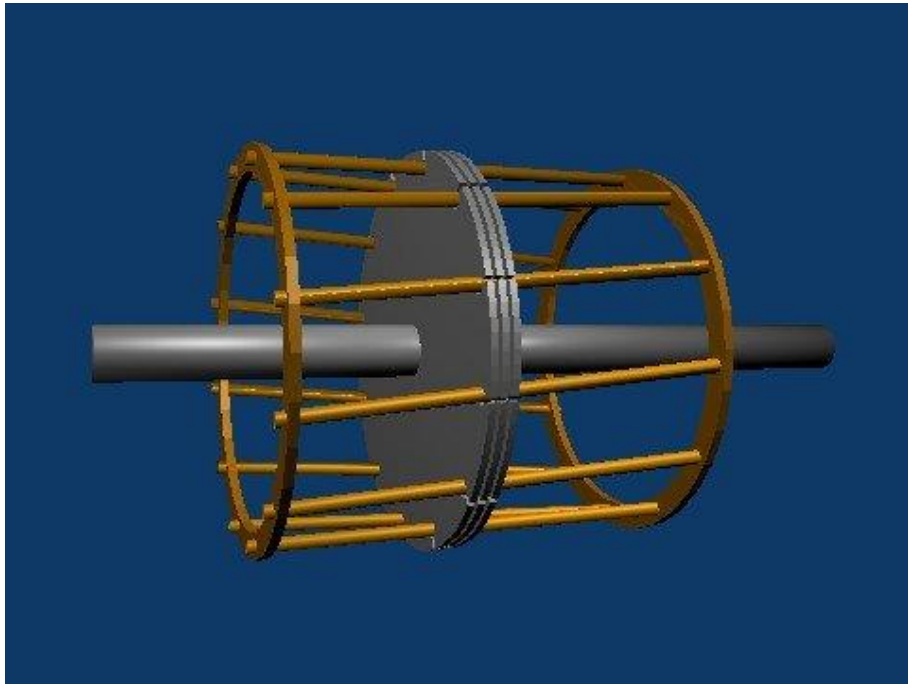
$v_0 = 16.67\%$   
 $v_1 = 49.5\%$   
 $v_3 = 1\%$   
 $v_7 = 32.84\%$



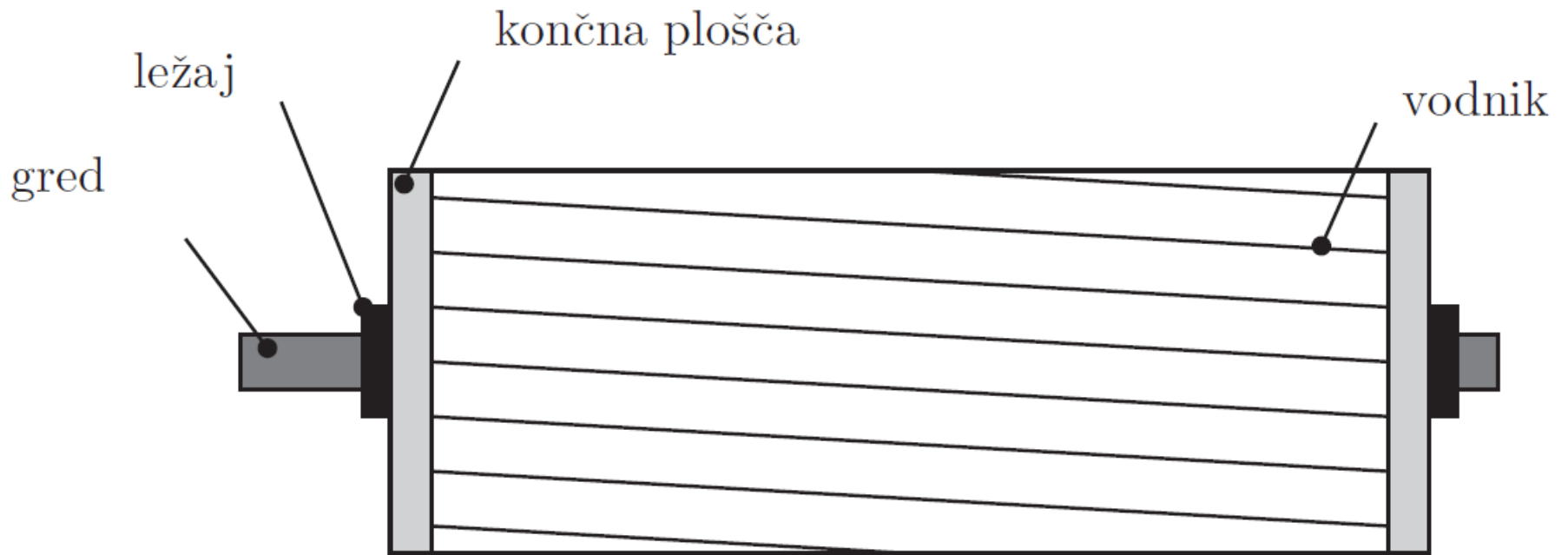
# Operation



# Squirrel cage

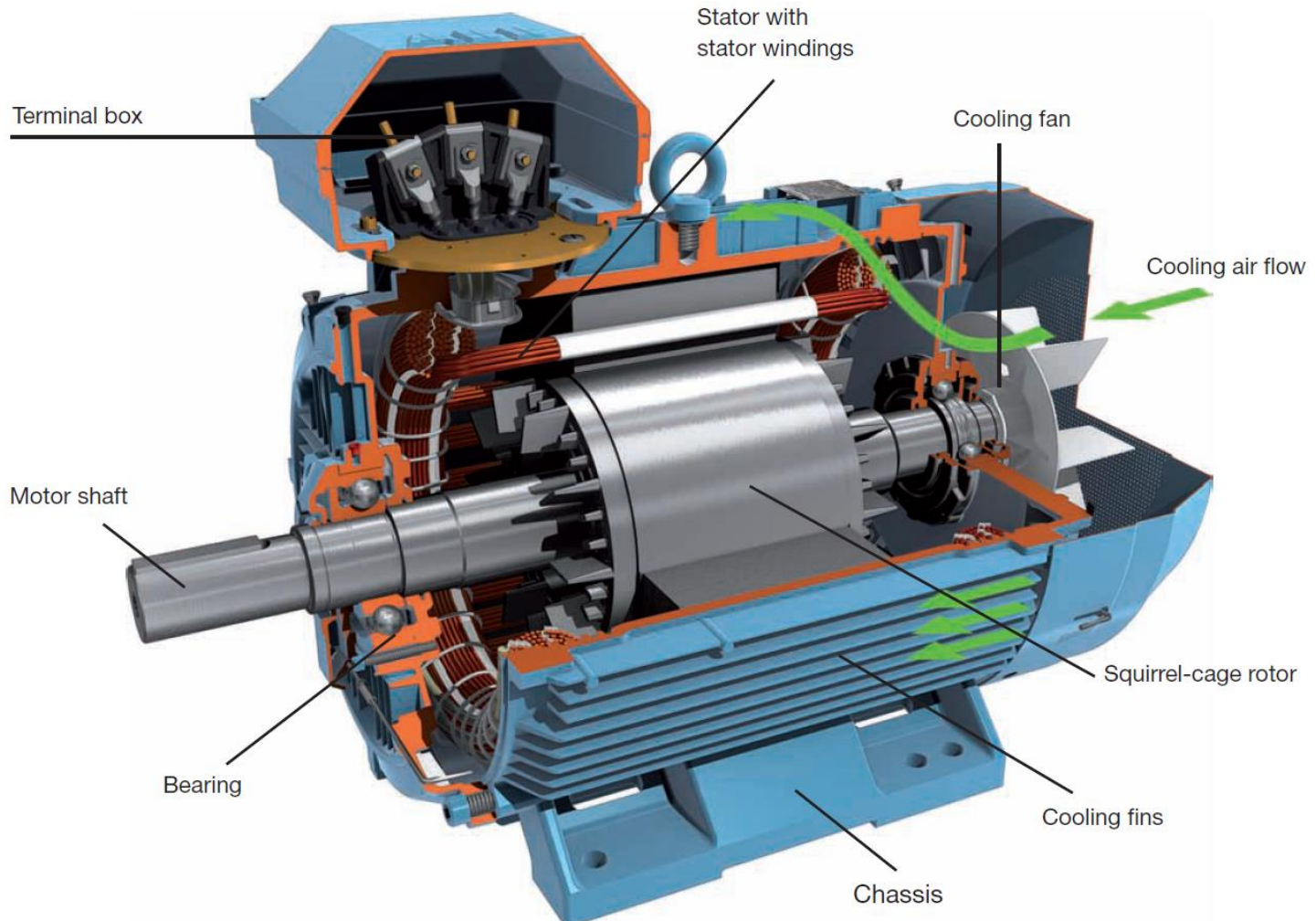


# Squirrel cage (schematic)

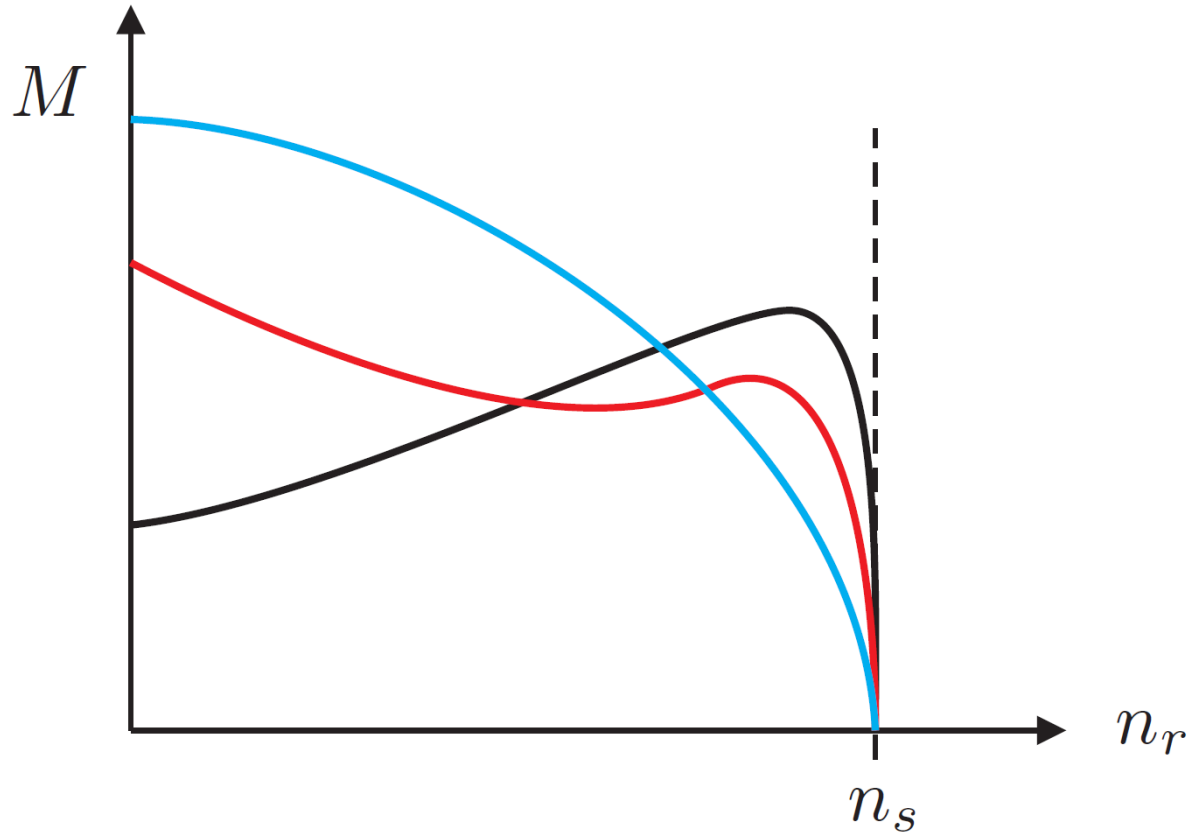




# Detailed composition

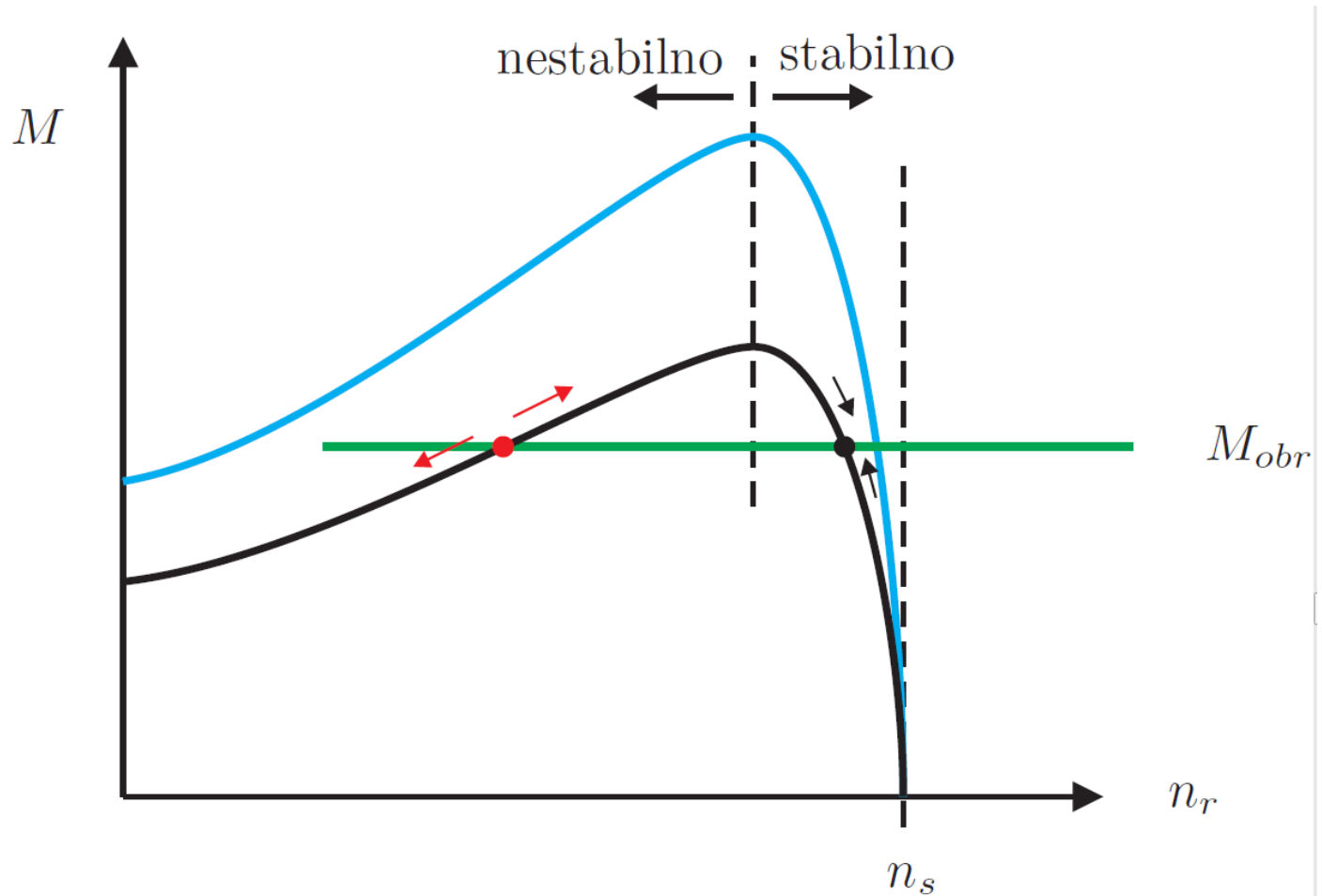


# Moment characteristic

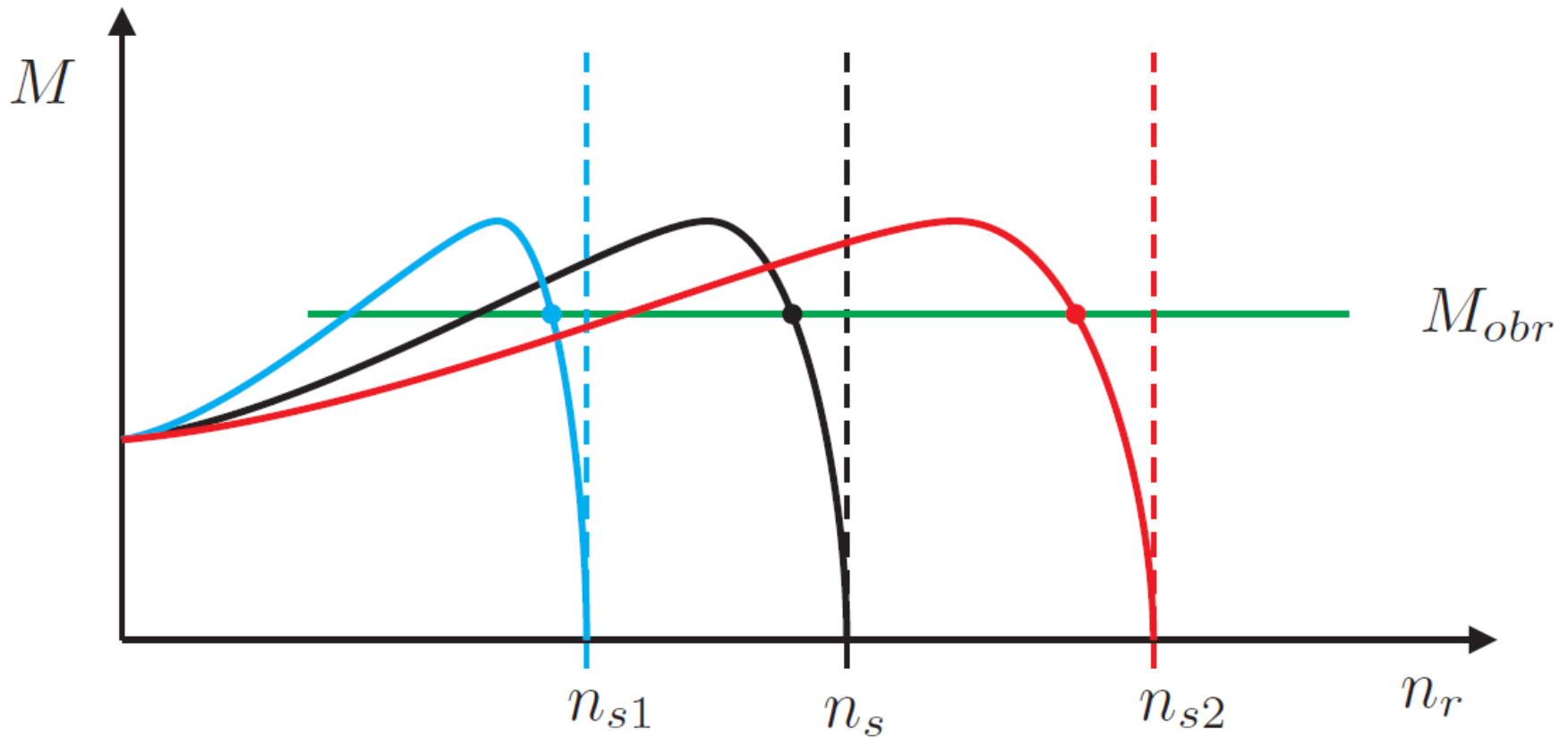


$$s = \frac{n_s - n_r}{n_s} \cdot 100\%$$

# Control options (1)

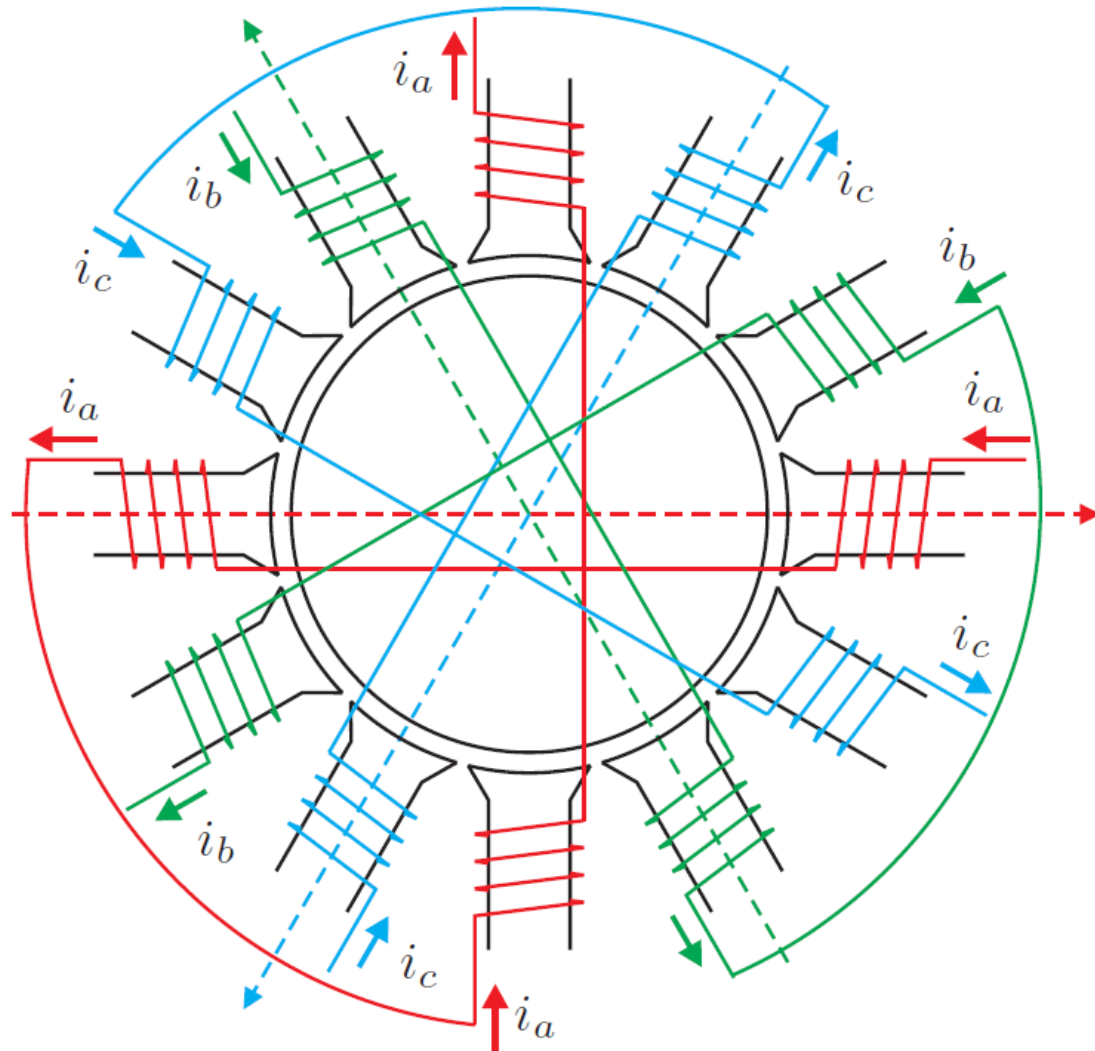


# Control options (2)

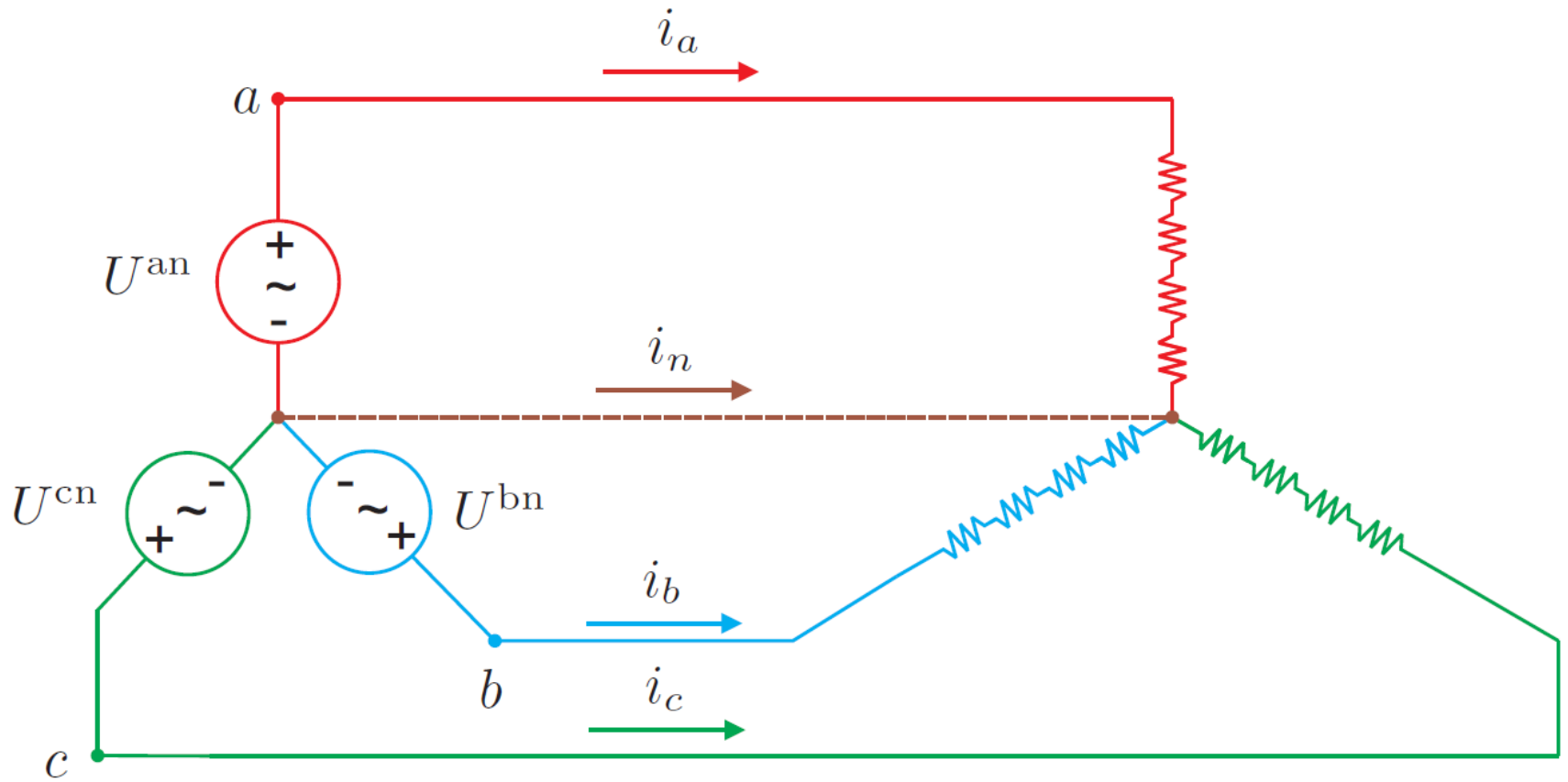


$$n_s = 50 \frac{60 \text{ vrt. na min.}}{1\text{Hz}} = 3000 \text{ vrt. na min.}$$

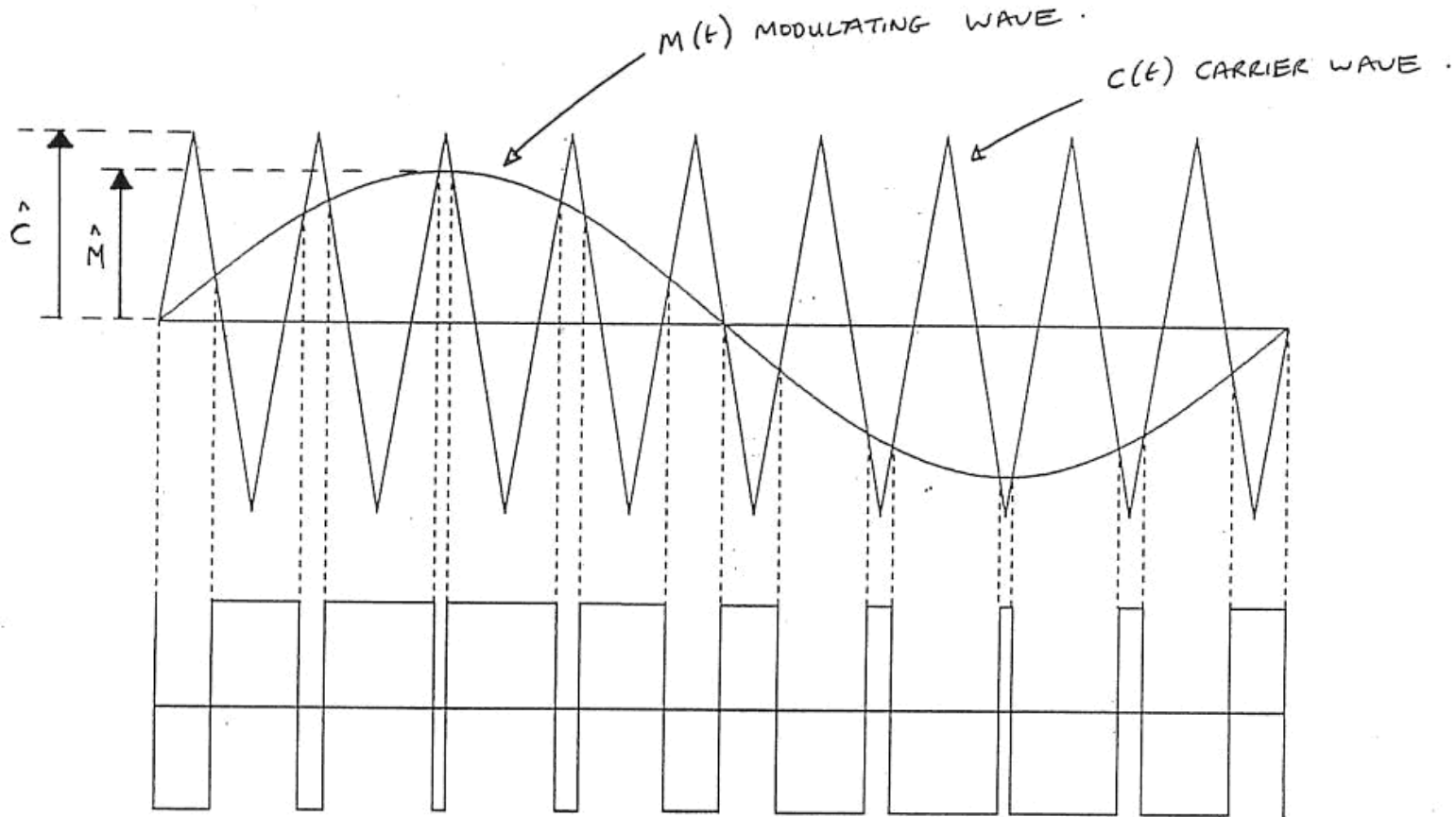
# Control options (3)



# Control options (4)



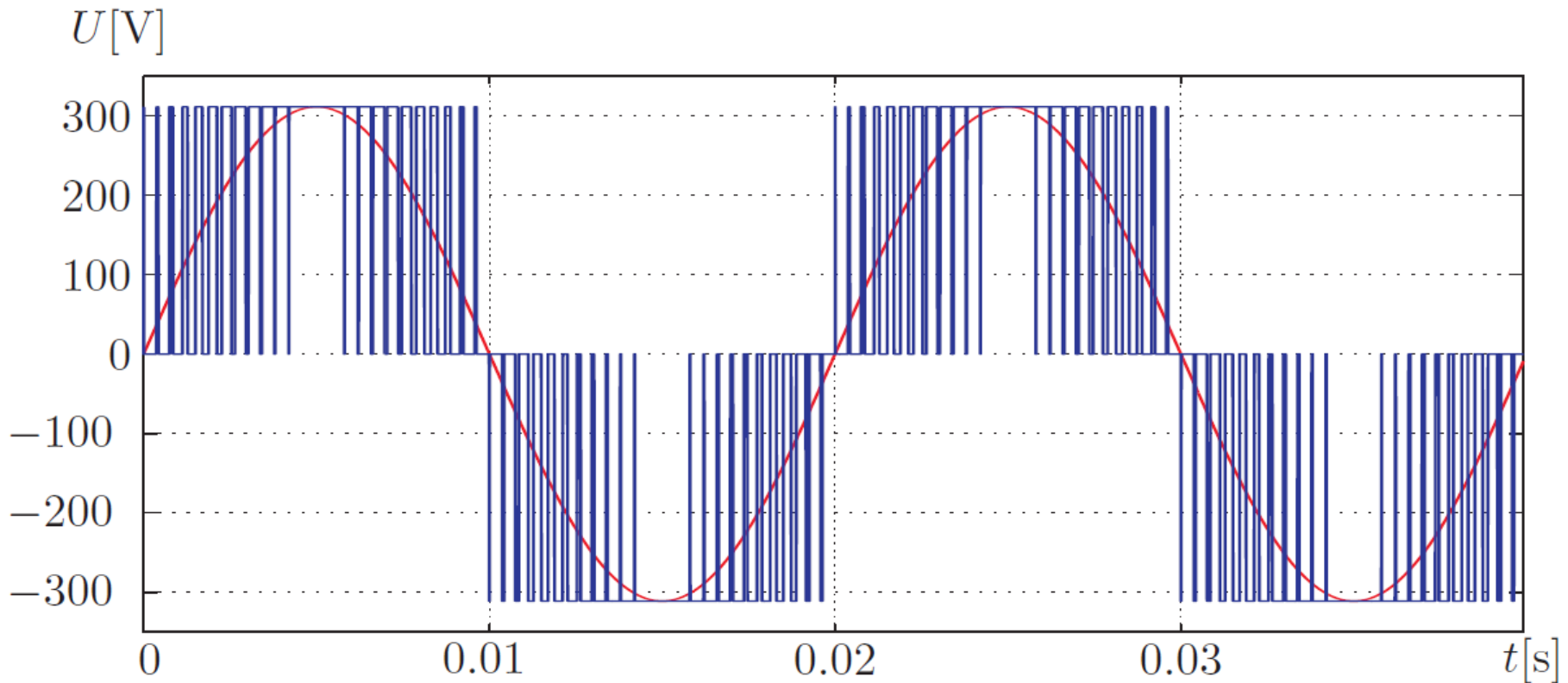
# Principle of pulse width modulation



Generation of Pulse Width Modulation using natural sampling  
Frequency ratio = 9, Modulation depth = 0.8 ( $M/C$ )

# Pulse width modulation (1)

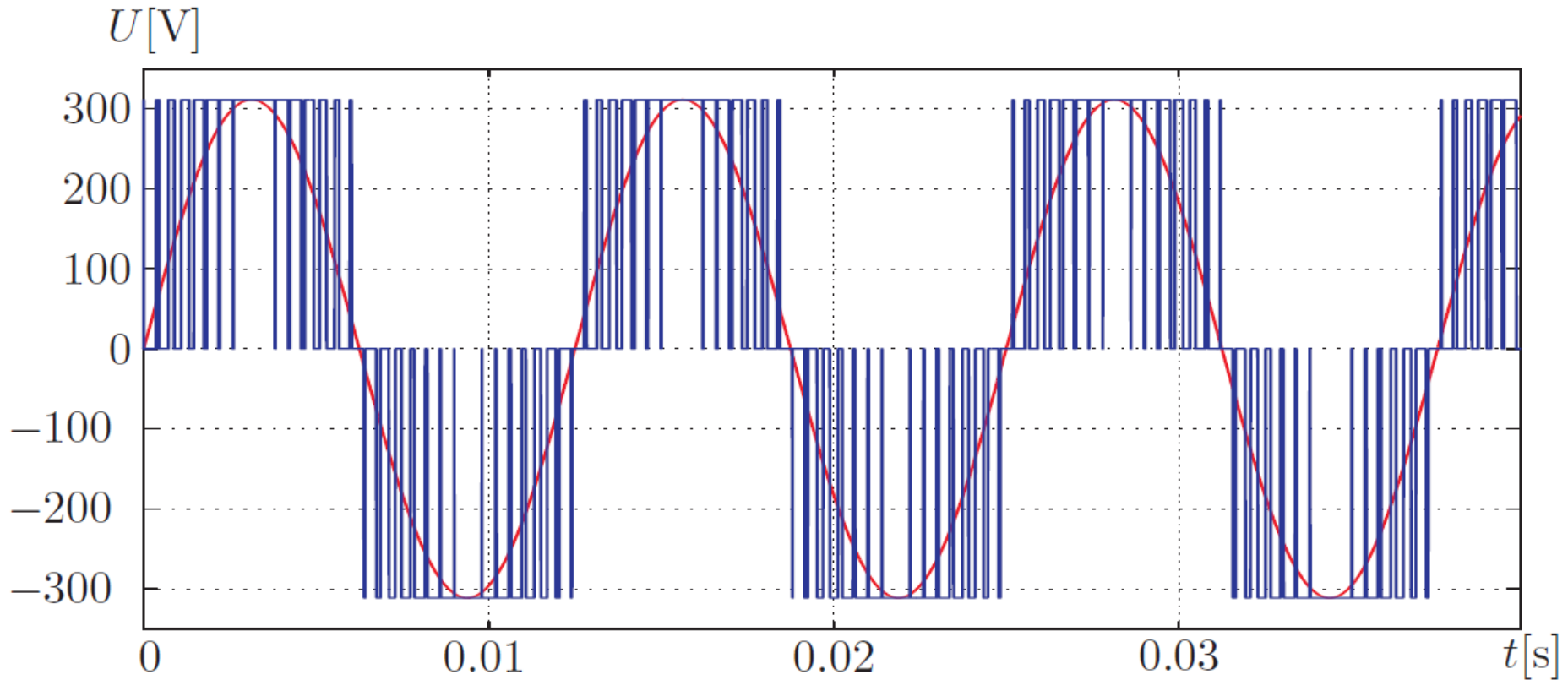
## 220V, 50Hz





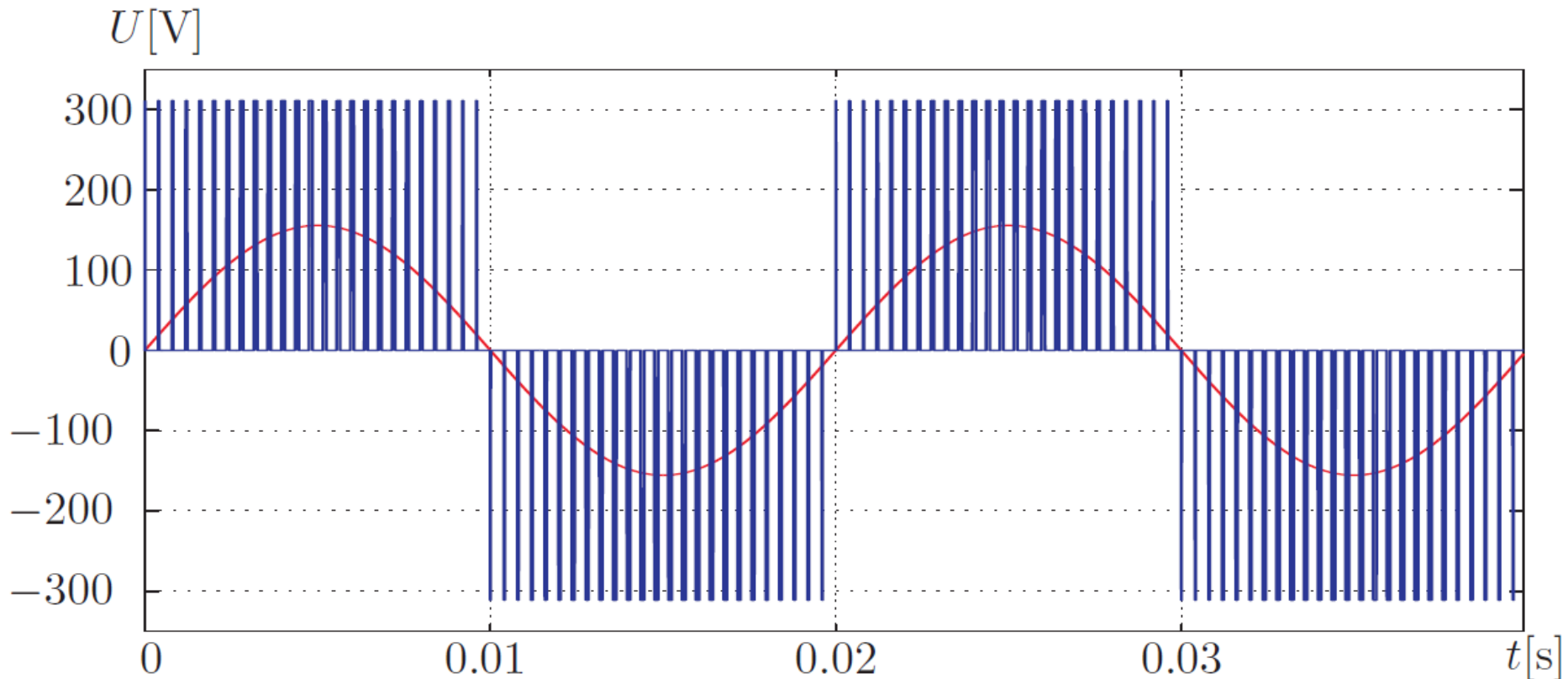
# Pulse width modulation (2)

## 220V, 80Hz

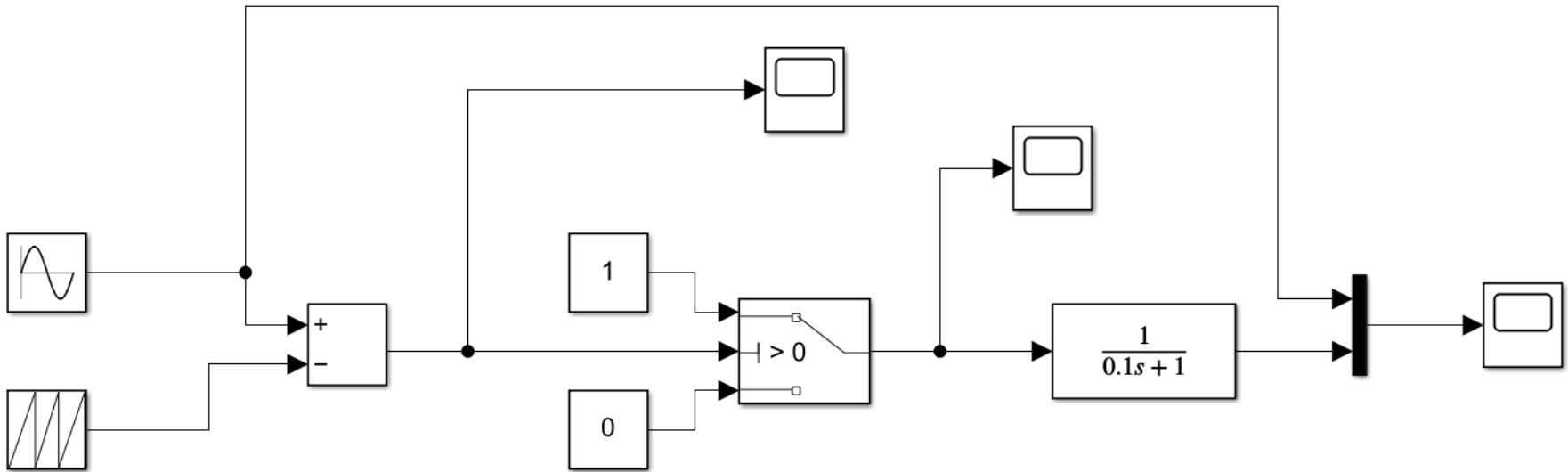


# Pulse width modulation (3)

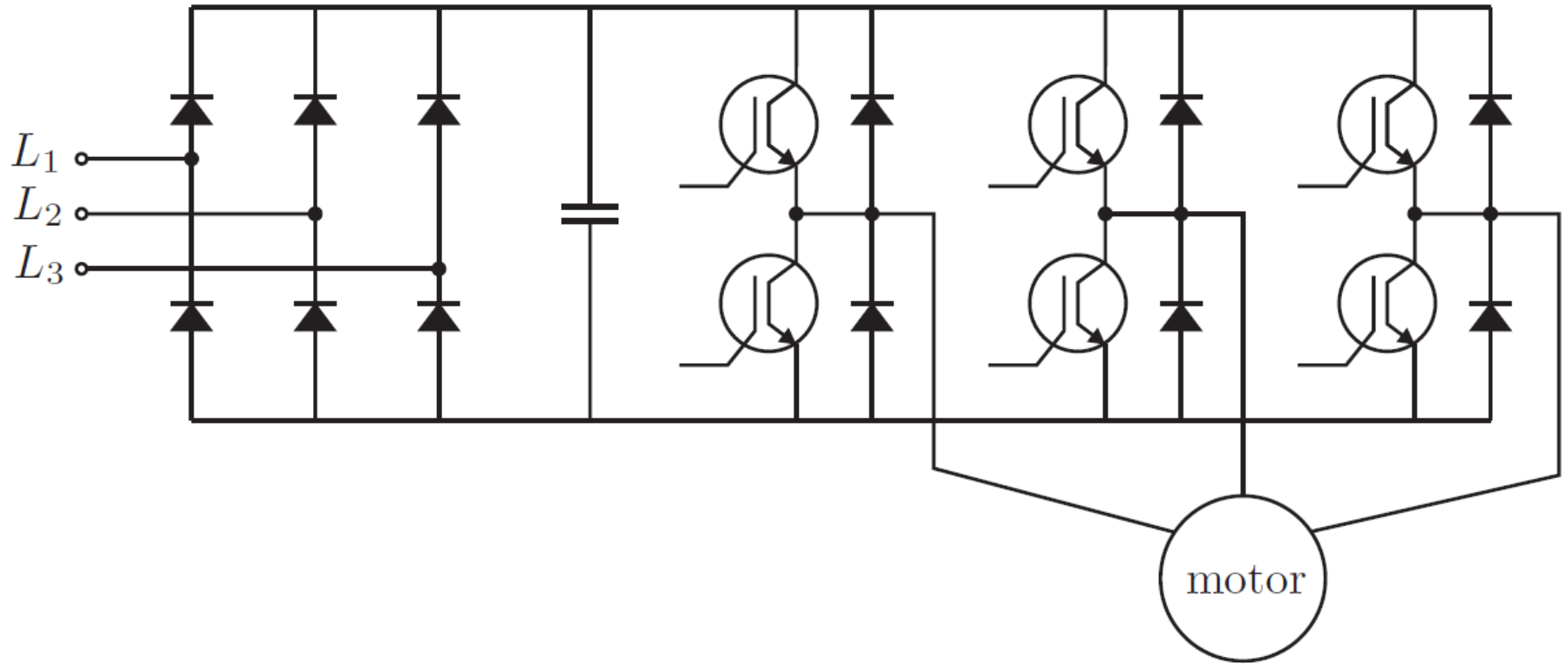
## 110V, 50Hz



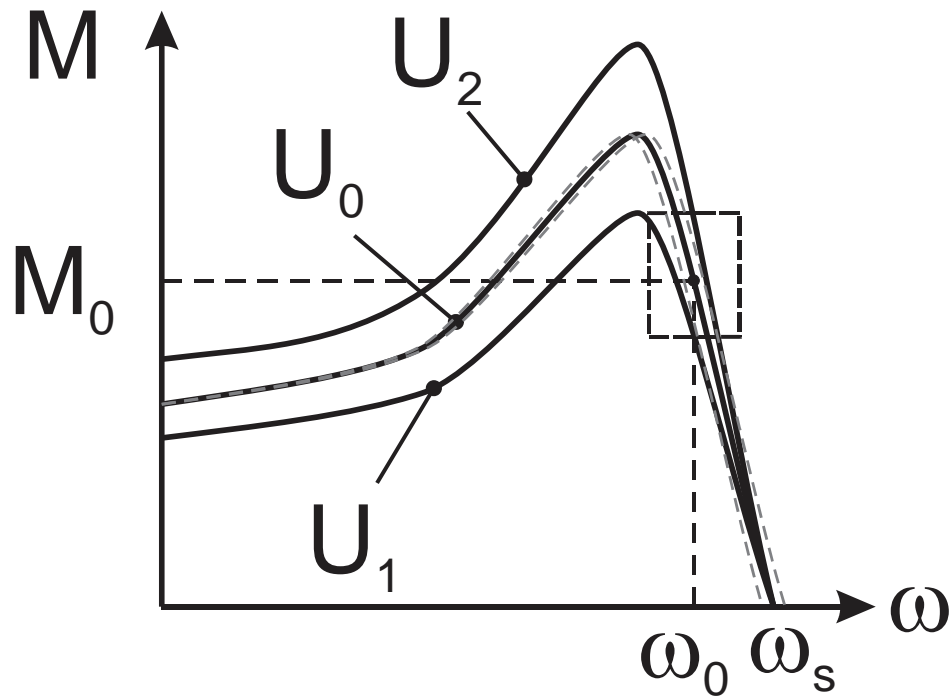
# Realization in Simulink



# Frequency regulator

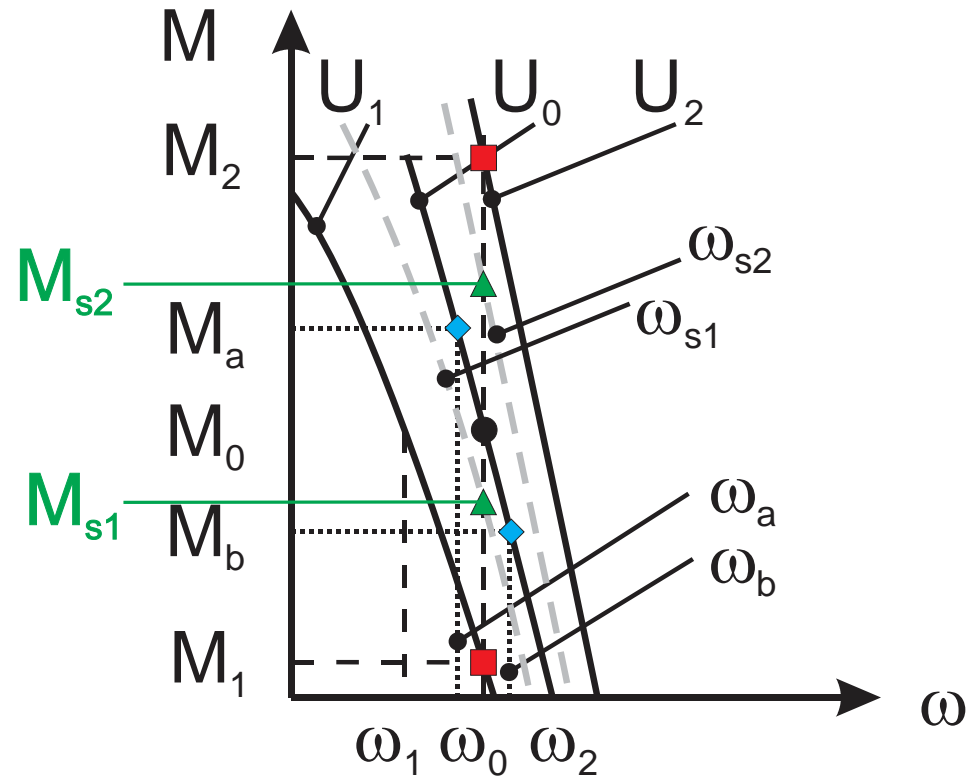


# A model of an asynchronous electric motor



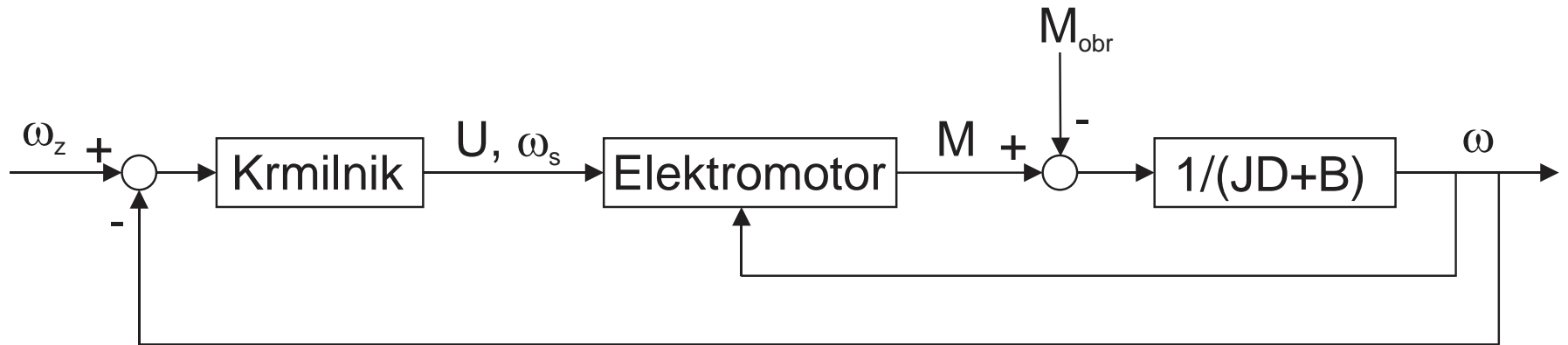
# Linearization

$$M = F(\omega, U, \omega_s)$$

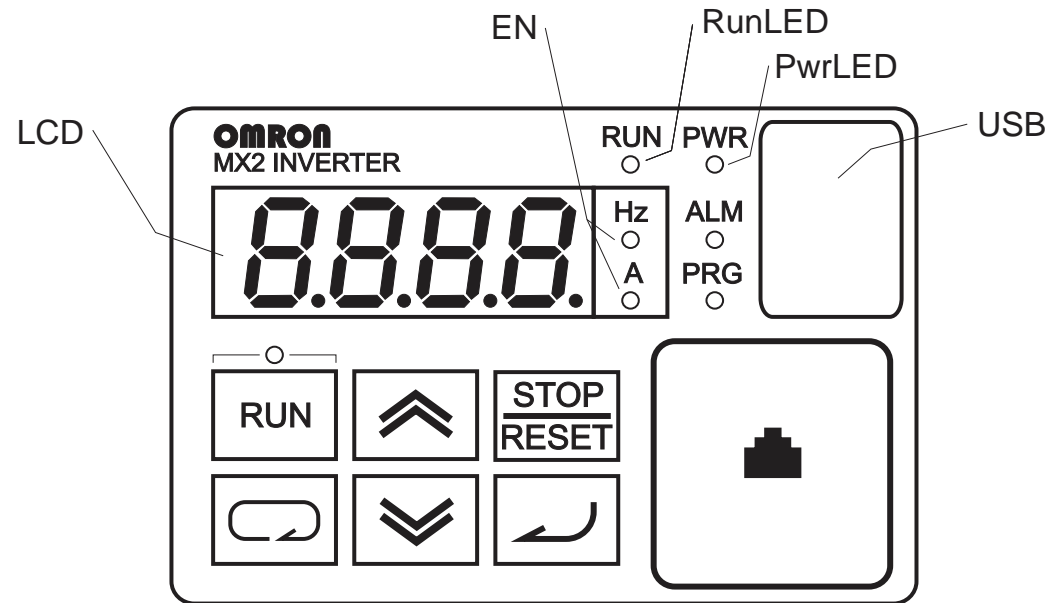


$$\Delta M = \frac{\partial f}{\partial \omega} \cdot \Delta \omega + \frac{\partial f}{\partial U} \cdot \Delta U + \frac{\partial f}{\partial \omega_s} \cdot \Delta \omega_s$$

# Asynchronous motor as an element in the control system



# Frequency controller





# Frequency controller

Workspace1 - CX-Drive - Drive1 - [Drive1 - [MX2-A4004-PRG43234413 Parameter Editor \*]]

File Edit View Drive Tools Window Help

Drive 1 (Online) \*

- Parameter Editor
- Graphs
- Status
- Monitor
- Tuning
- Settings
- Drive Programming

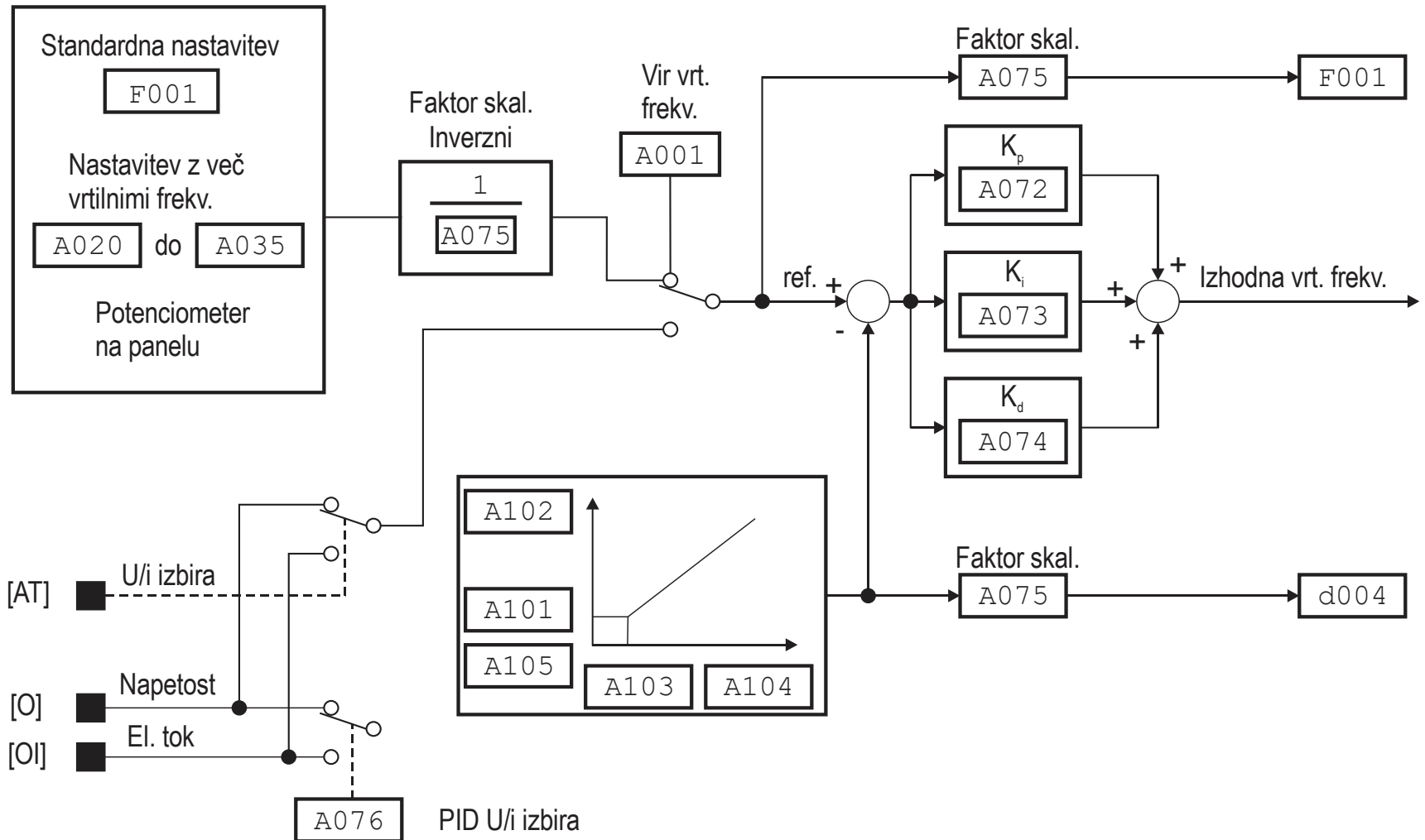
## A001 - Frequency Reference Selection 1

Eight options, select codes:

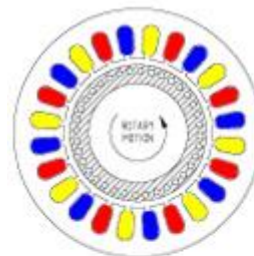
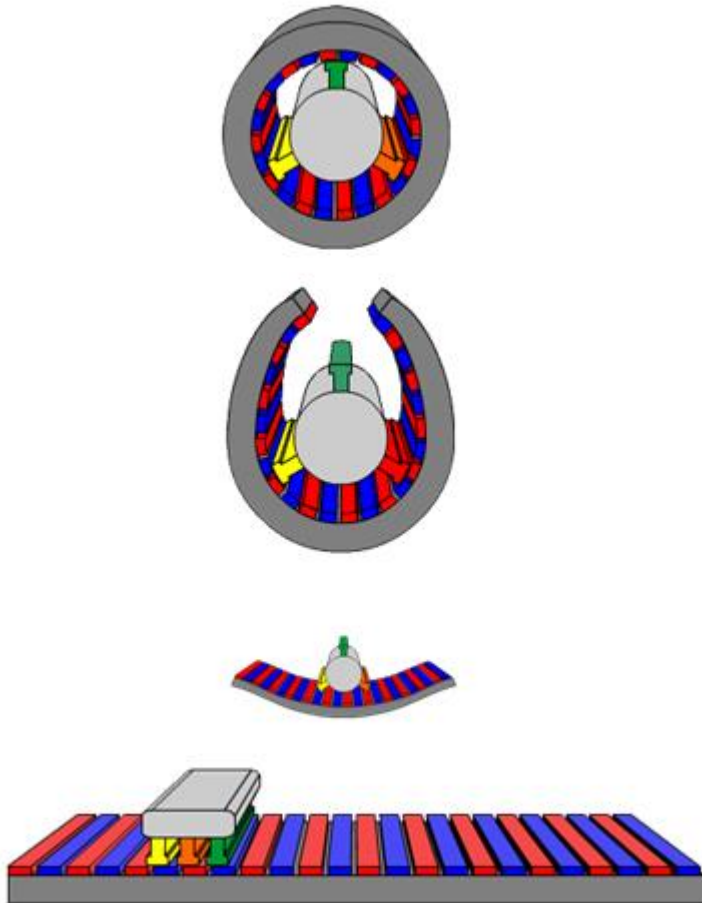
- 0: Keypad potentiometer
- 1: Control circuit terminal block
- 2: Digital operator
- 3: Modbus
- 4: Option Card
- 6: Pulse train input
- 7: Drive Programming
- 10: Operation function result

...	...	Index	Description	Value	Drive Value	Default	Range	Units	Hex Address	Rest...
		A001	Frequency Reference Selection 1	1: Control circuit terminal block	---	1	0 to 10		1200	<input type="checkbox"/>
		A002	RUN Command Selection 1	1: Control circuit terminal block	---	1	1 to 4		1201	<input type="checkbox"/>
		A003	Base Frequency 1	50.0	---	50.0	30.0 to 50.0	Hz	1202	<input type="checkbox"/>
		A004	Maximum Frequency 1	50.0	50.0	50.0	50.0 to 400.0	Hz	1203	<input type="checkbox"/>
		A005	FV/FI Selection	0: Switching between O and OI ter...	---	0	0 to 3		1204	<input type="checkbox"/>
		A011	FV Start Frequency	0.00	---	0.00	0.00 to 400.00	Hz	120A	<input type="checkbox"/>
		A012	FV End Frequency	0.00	---	0.00	0.00 to 400.00	Hz	120C	<input type="checkbox"/>
		A013	FV Start Ratio	0	---	0	0 to 100	%	120E	<input type="checkbox"/>
		A014	FV End Ratio	100	---	100	0 to 100	%	120F	<input type="checkbox"/>
		A015	FV Start Selection	1: Use 0 Hz	---	1	0 to 1		1210	<input type="checkbox"/>
		A016	Analog Input Filter (FV, FI Sampling)	8	---	8	1 to 31		1211	<input type="checkbox"/>
		A017	Drive Programming Selection	0: Disabling	---	0	0 to 2		1212	<input type="checkbox"/>
		A019	Multi-step Speed Selection	0: Binary mode	---	0	0 to 1		1214	<input type="checkbox"/>
		A020	Multi-step Speed 1 Reference 0	6.00	---	6.00	0.00 to 50.00	Hz	1215	<input type="checkbox"/>
		A021	Multi-step Speed Reference 1	0.00	---	0.00	0.00 to 50.00	Hz	1217	<input type="checkbox"/>
		A022	Multi-step Speed Reference 2	0.00	---	0.00	0.00 to 50.00	Hz	1219	<input type="checkbox"/>
		A023	Multi-step Speed Reference 3	0.00	---	0.00	0.00 to 50.00	Hz	121B	<input type="checkbox"/>
		A024	Multi-step Speed Reference 4	0.00	---	0.00	0.00 to 50.00	Hz	121D	<input type="checkbox"/>

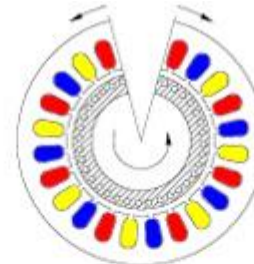
# Frequency controller



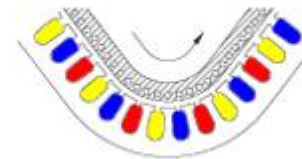
# Linear motor



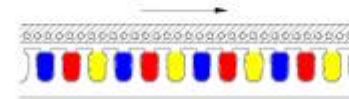
3 PHASE 'SQUIRREL CAGE' INDUCTION MOTOR



MAKE A CUT

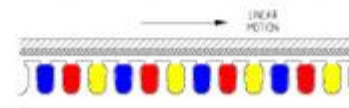


OPEN OUT FLAT



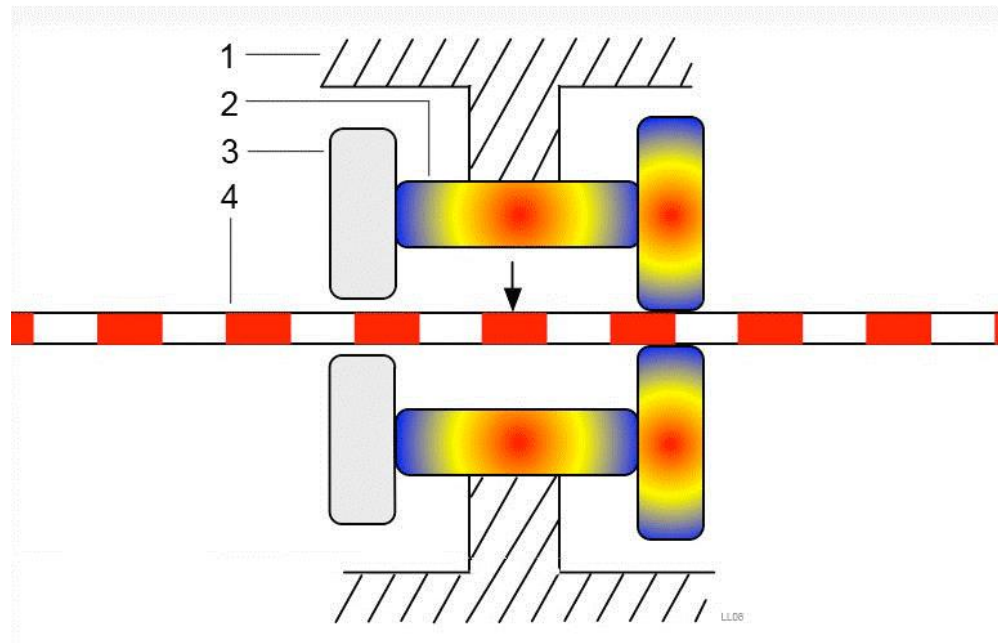
3 PHASE LINEAR INDUCTION MOTOR

3 PHASE POWER SUPPLY



SMOOTH THE ROTOR INTO SEPARATE SHEETS

# Piezoelectric motor (USM)



# Synchronous motor

