Fan academy

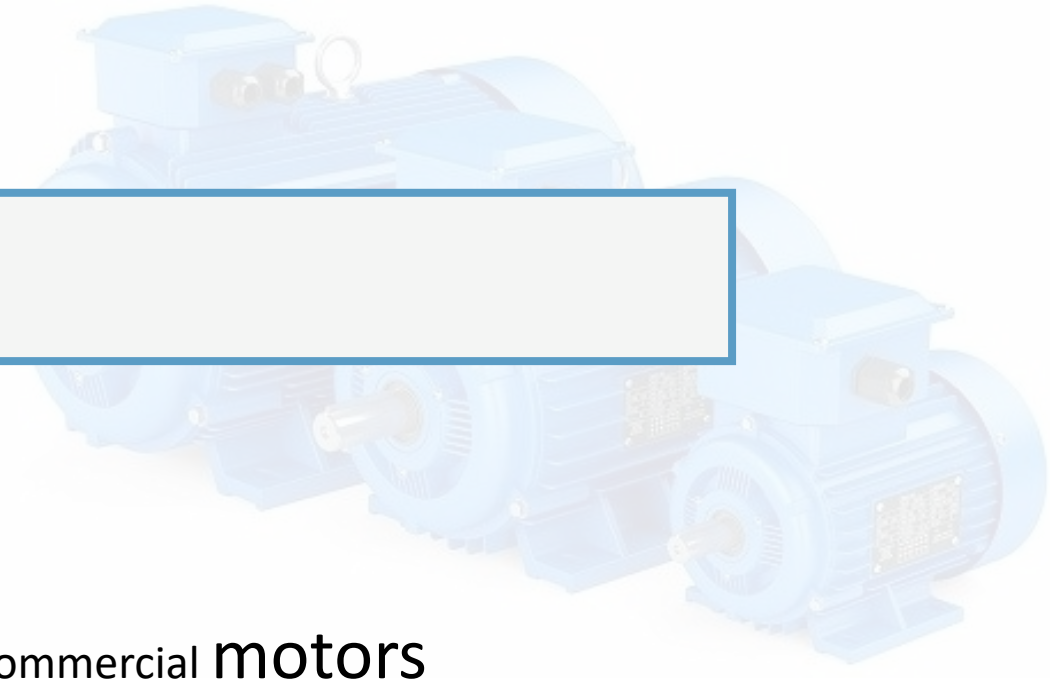
Introduction to Electric Motors

Alex Haertel
Electrical/Controls Engineer

Basic principles and physical considerations

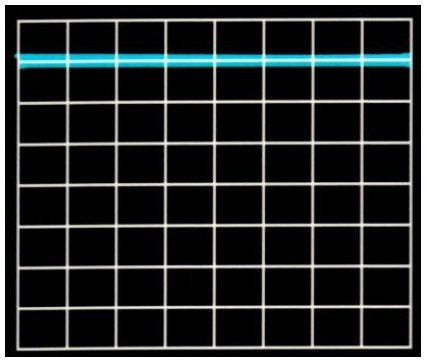
At the end of this session, you will be able to

1. Explain the basics of electric power
2. Explain the basic principles of electric motors
3. Explain the construction and operation of commercial motors
4. Understand motor features to consider while making a selection

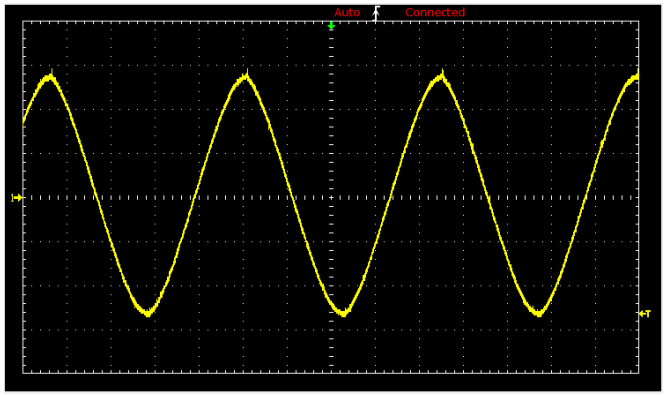


Electricity

Direct current
(DC)

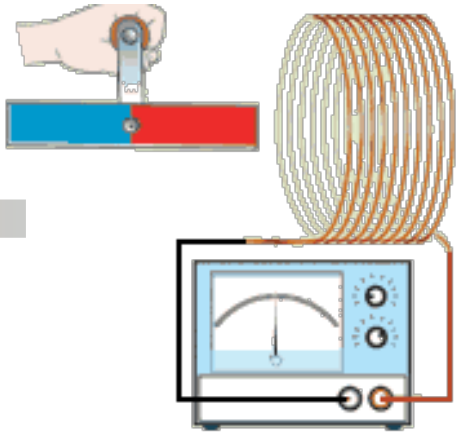


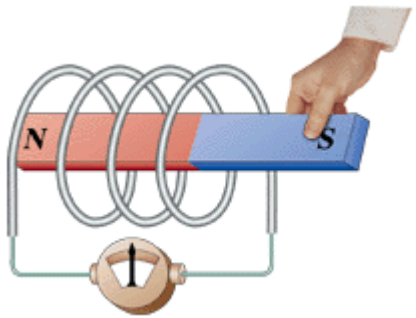
Alternating current
(AC)



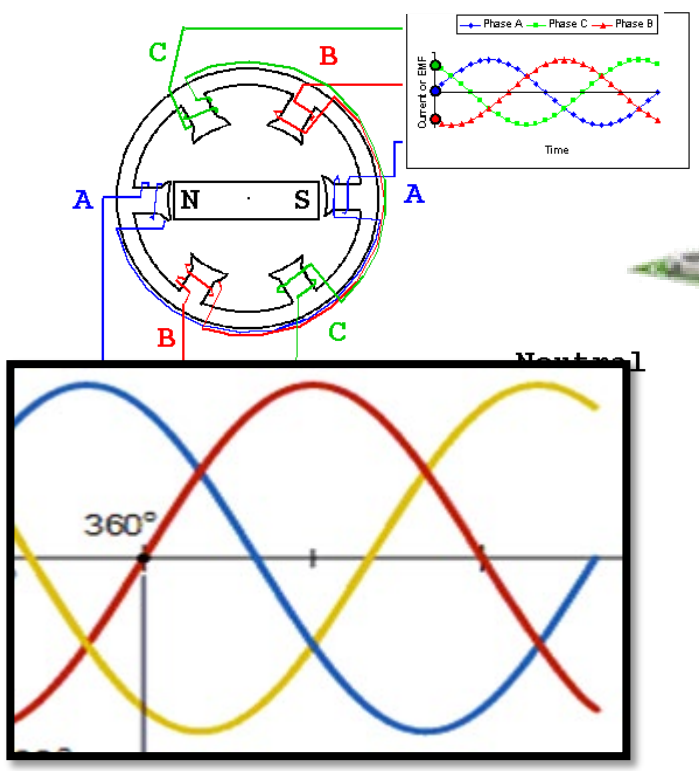
Where do we get DC power from?

Where do we get AC power from?



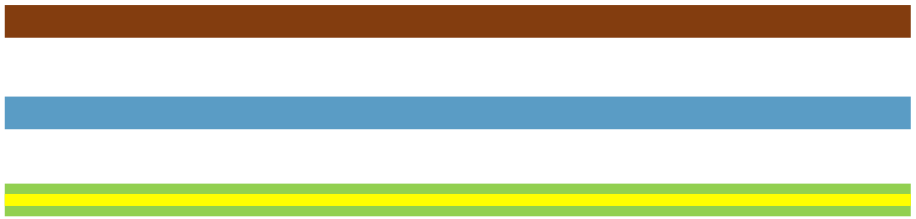


AC power conventions in the UK



Phase 1 - Brown
Phase 2 - Black
Phase 3 - Grey
Neutral - Blue
Green & Yellow - Ground

* These could be different outside UK



Phase - Brown
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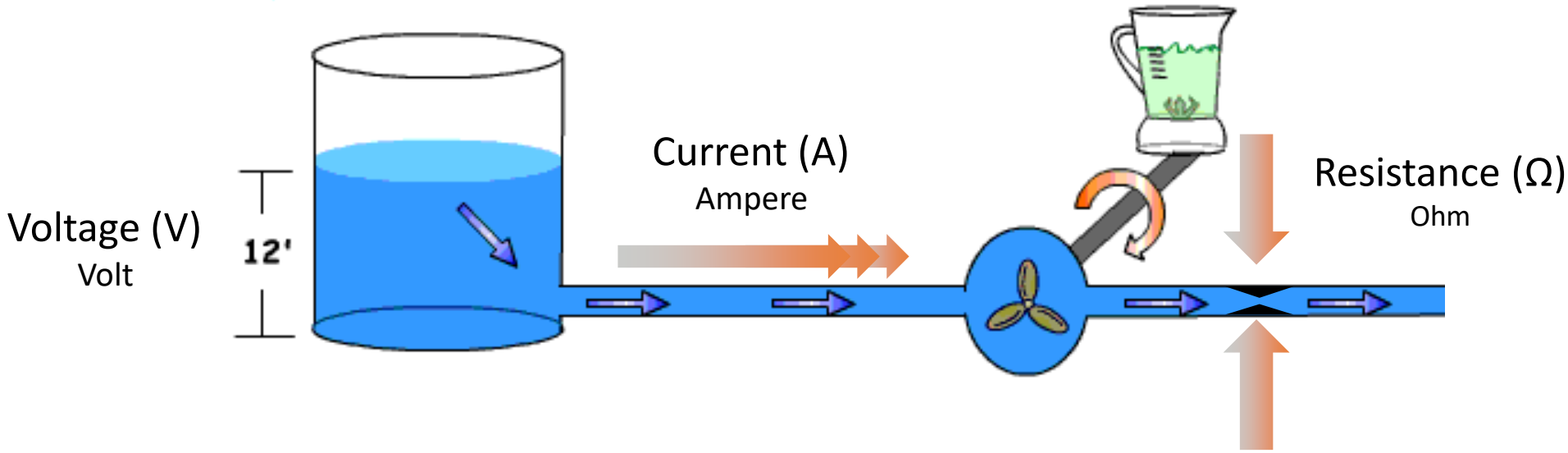

Voltage = Current x Resistance

Power (Watts) = Voltage x Current

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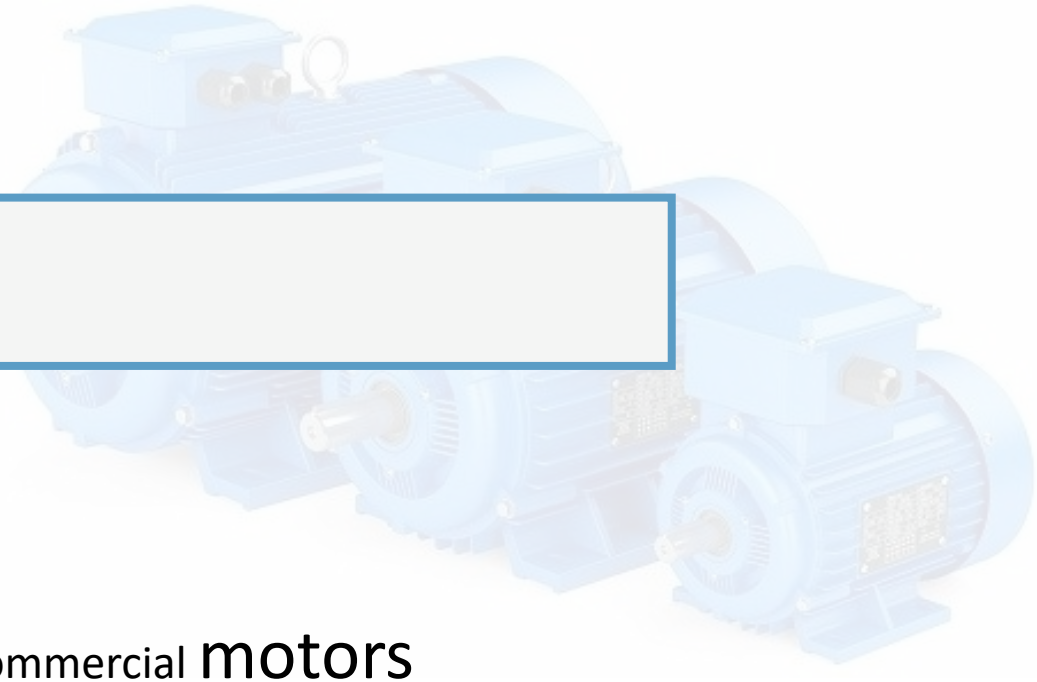
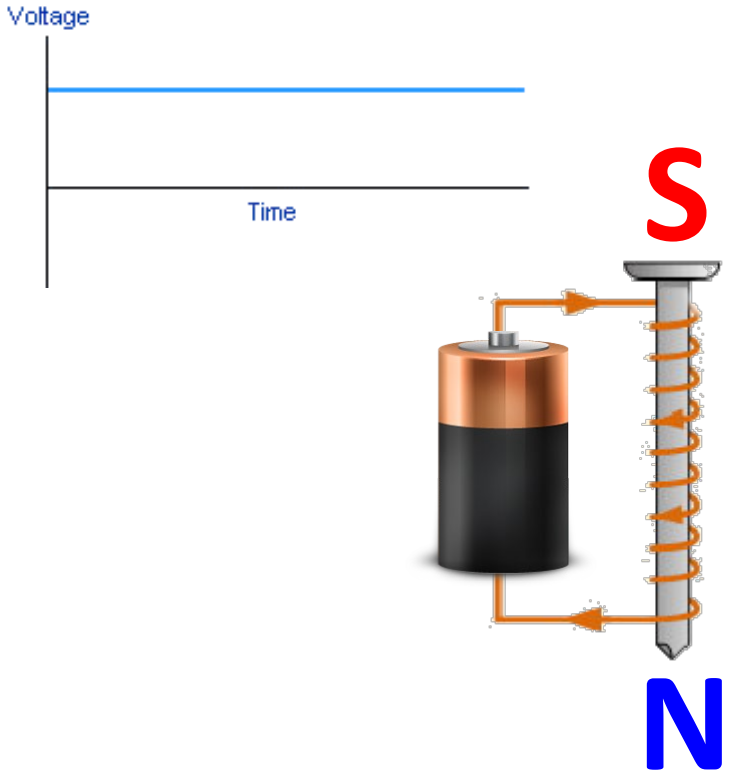
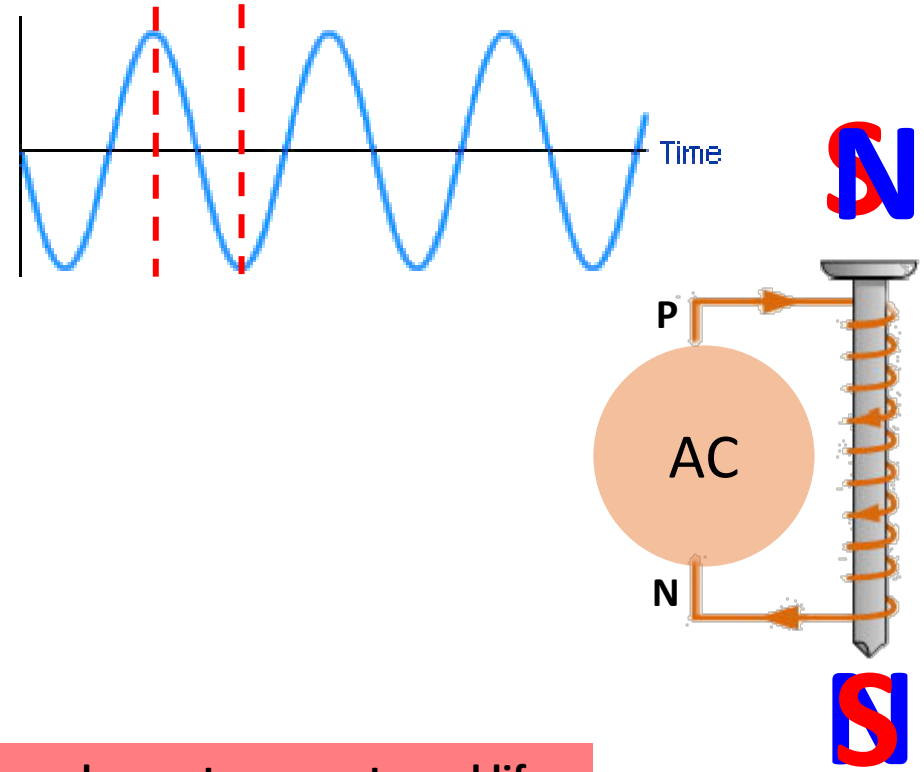
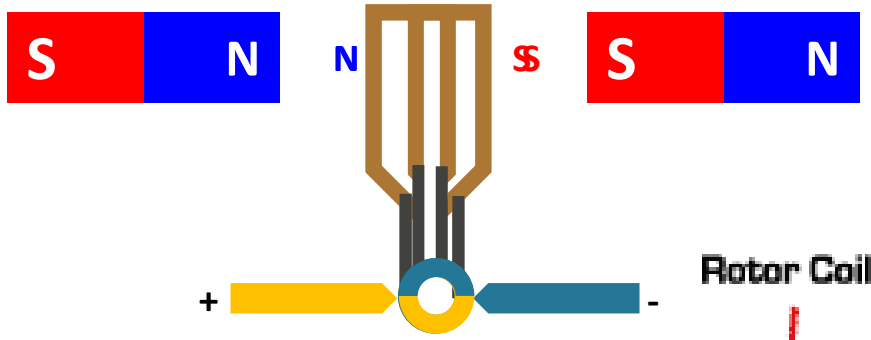
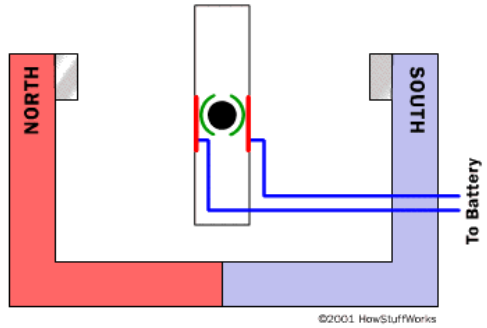


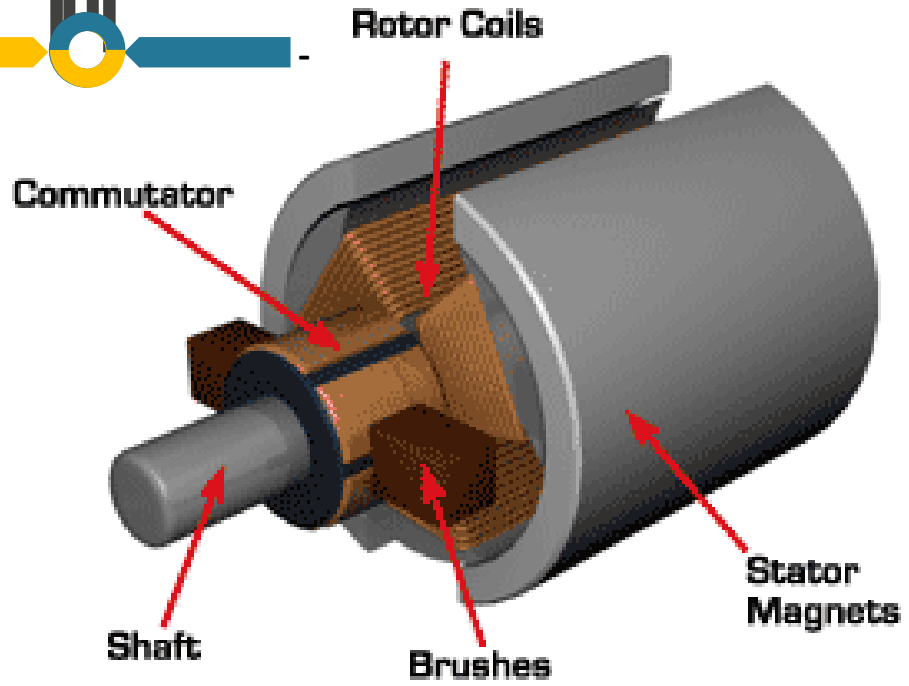




Caution: Please do not attempt to do this as it could pose extreme danger to property and life.



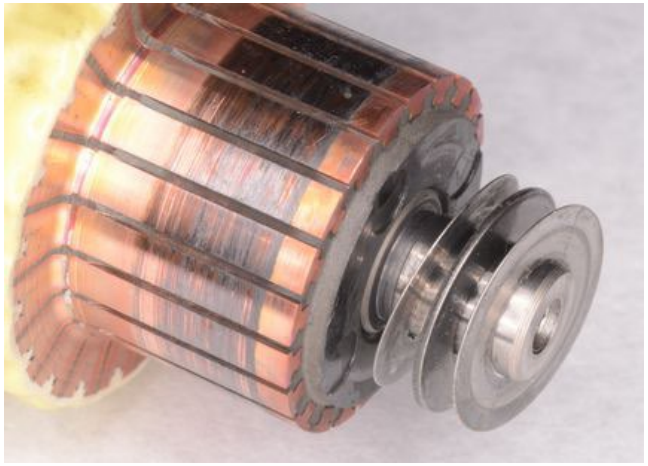


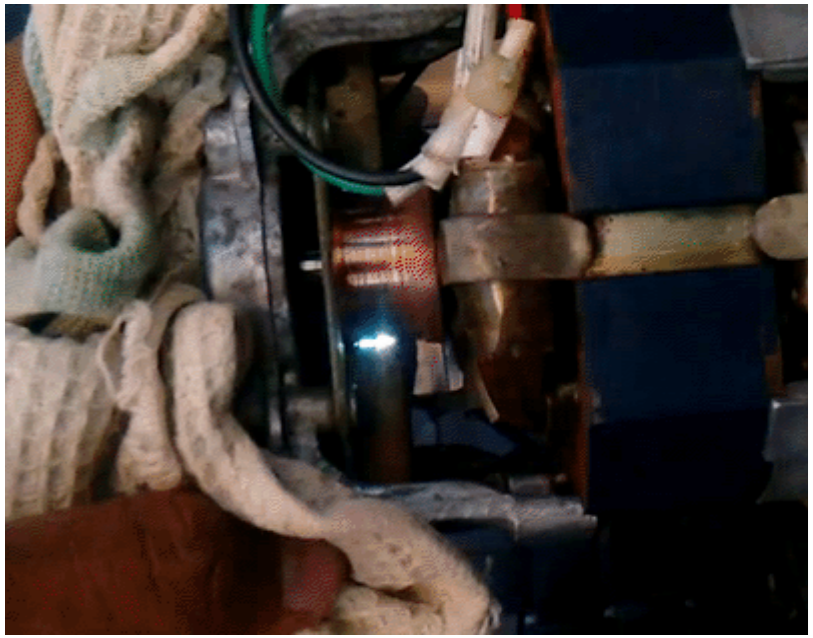


What are the benefits?

What are the drawbacks?

Drawbacks of brushed motors



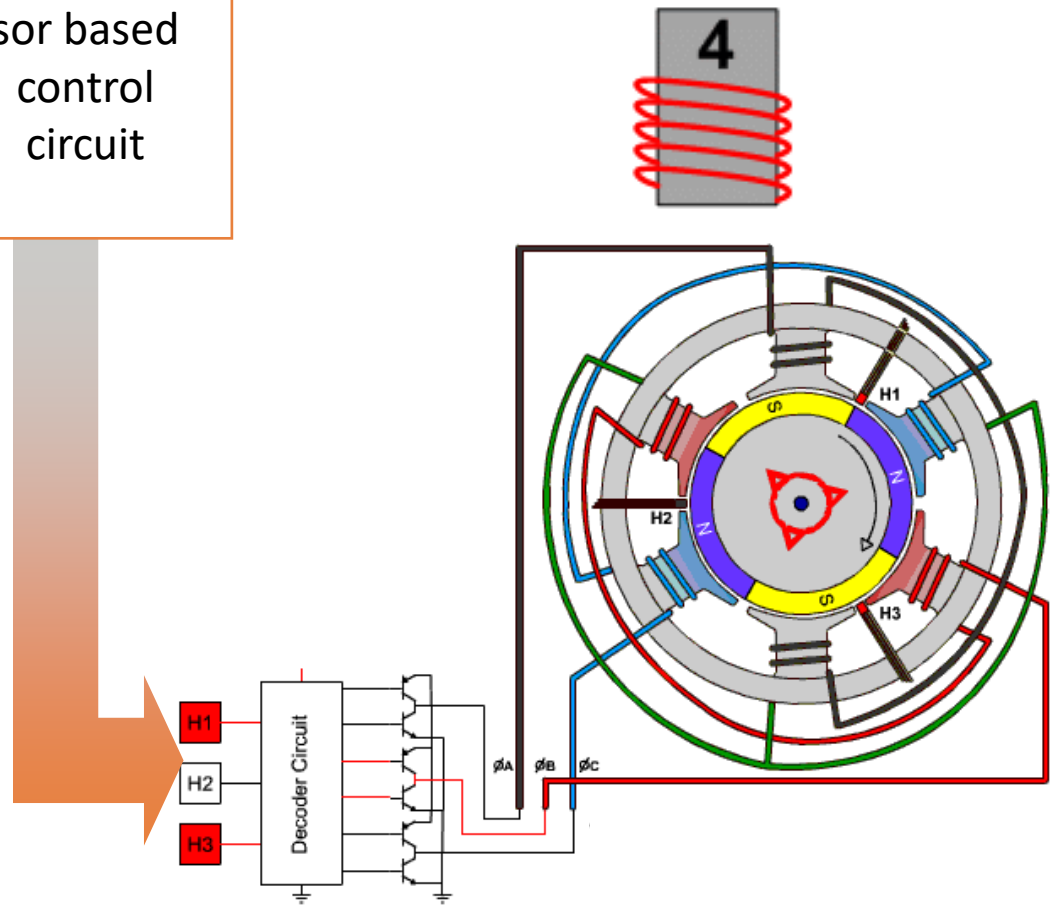


Electronically commutated (EC) motor

Phase 1 - Brown
Phase 2 - Black
Phase 3 - Grey

AC to DC converter

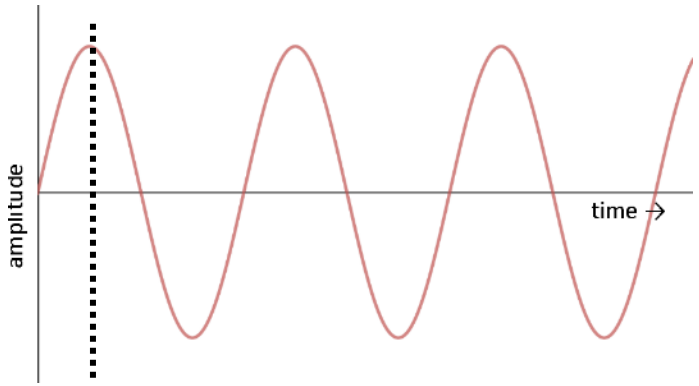
Microprocessor based control circuit

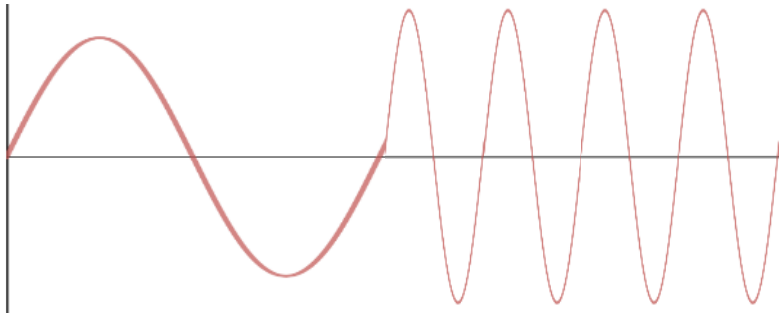


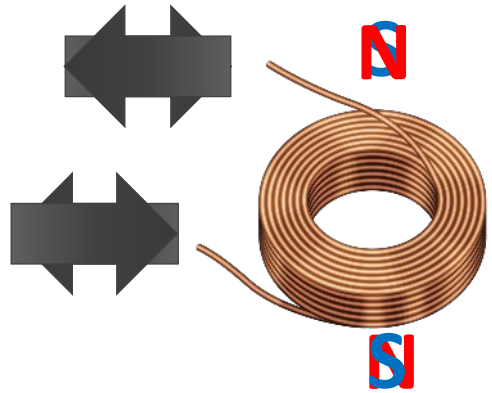
What are the benefits?

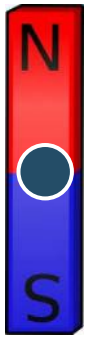
What are the drawbacks?

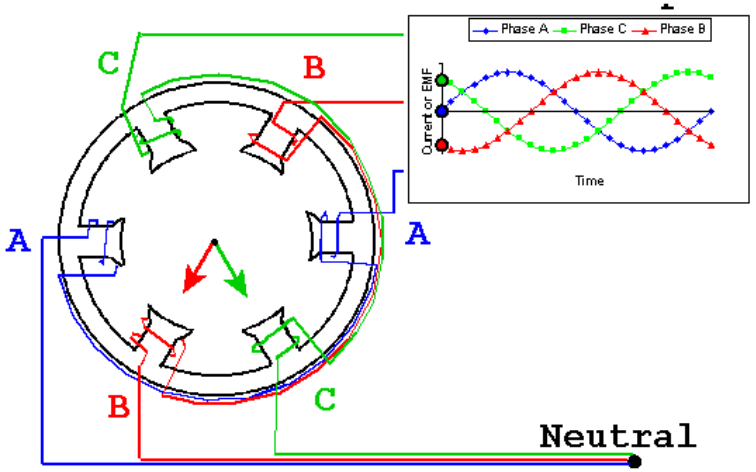
AC motor











$$\textbf{Synchronous Speed (rpm)} = \mathbf{120} \times \frac{\textbf{Supply frequency (Hz)}}{\textbf{Number of poles}}$$

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Speed of 2 pole motor ? $= 120 \times \frac{50}{2} = 3000\ RPM$

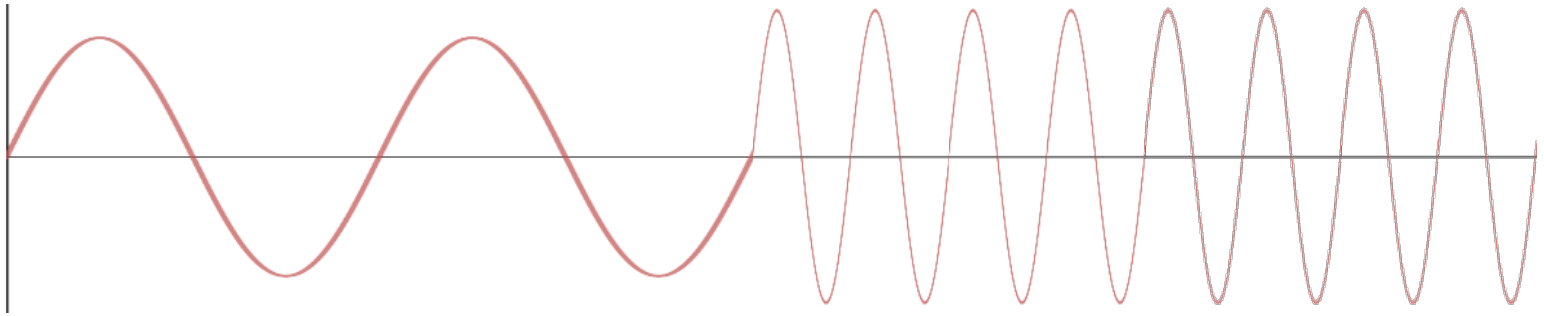
Speed of 4 pole motor ? $= 120 \times \frac{50}{4} = 1500\ RPM$

No. of poles	Sync. speed (at 60 Hz)	Sync. speed (at 50 Hz)
2	3600	3000
4	1800	1500
6	1200	1000
8	900	750
10	720	600
12	600	500

$0 \times \frac{60}{4} = 1800\ RPM$

Only possible if the motor is designed for it

$$\textbf{Synchronous Speed (rpm)} = \mathbf{120} \times \frac{\textbf{Supply frequency (Hz)}}{\textbf{Number of poles}}$$



Speed control with voltage

- ME controllers

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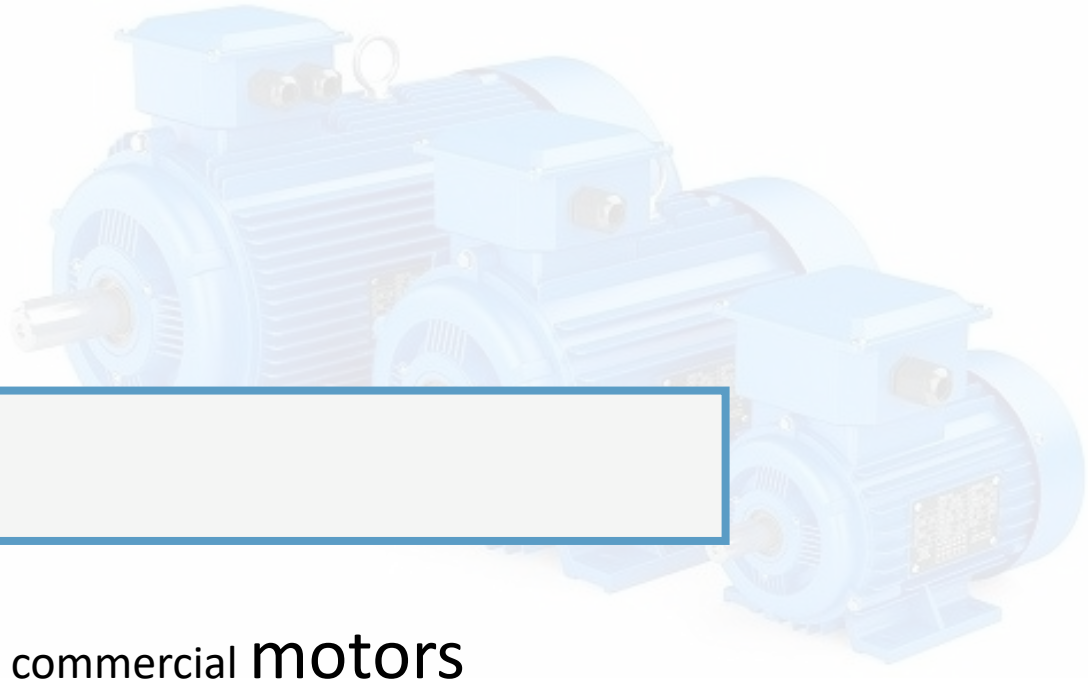
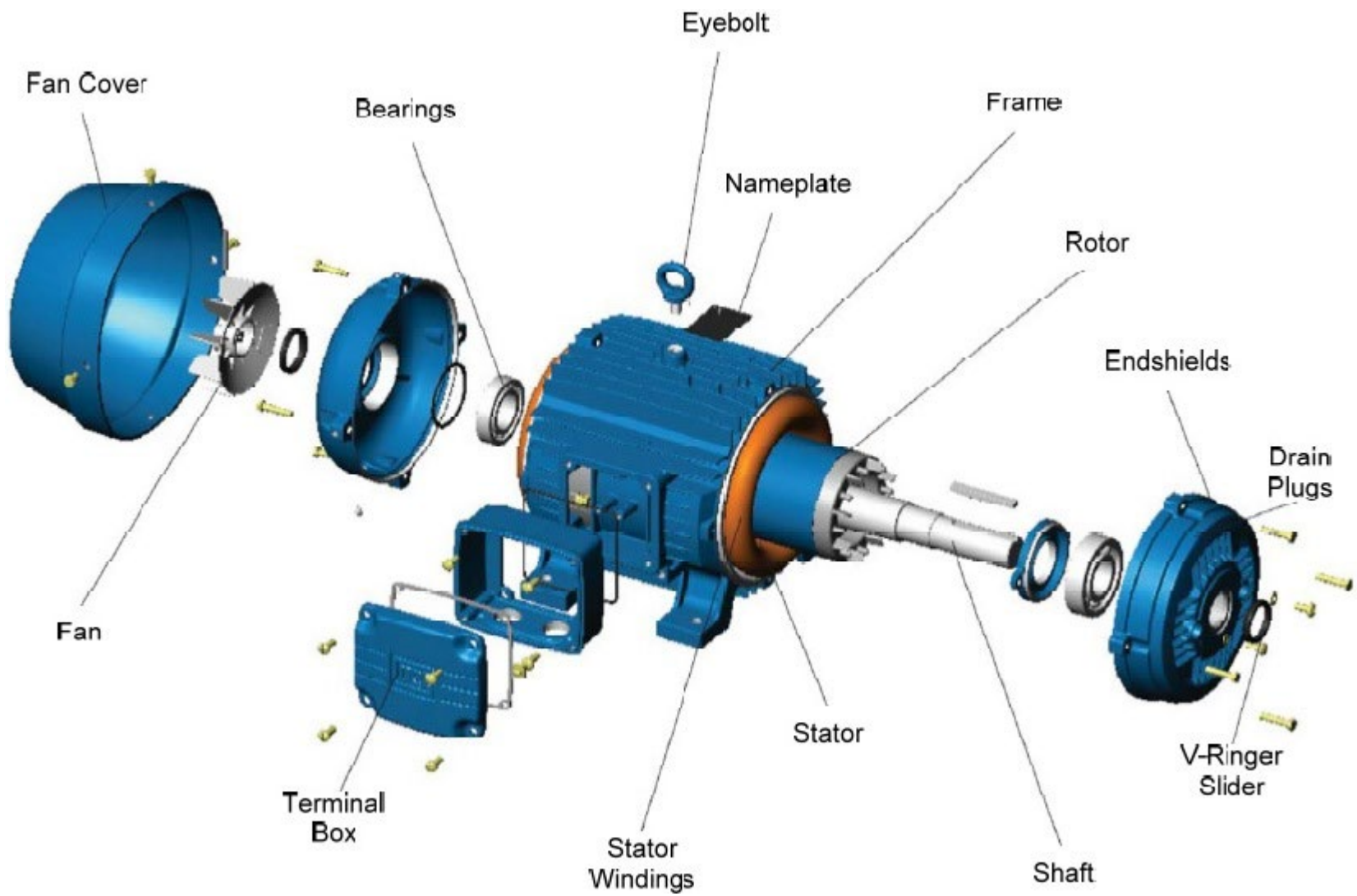
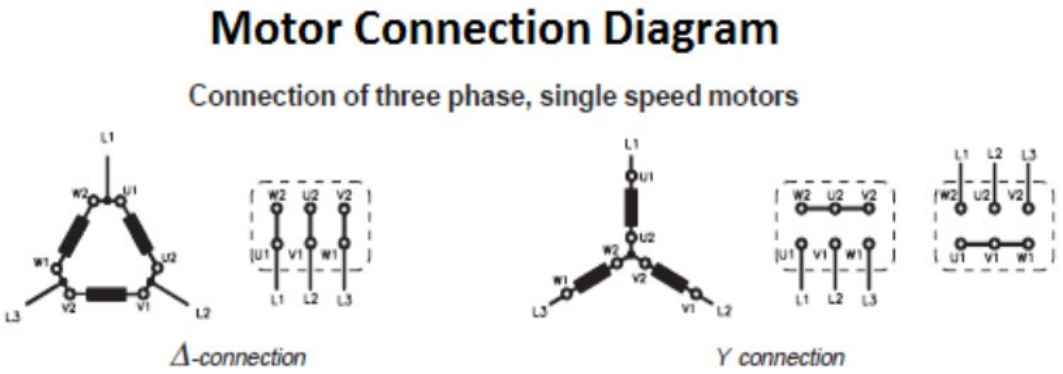
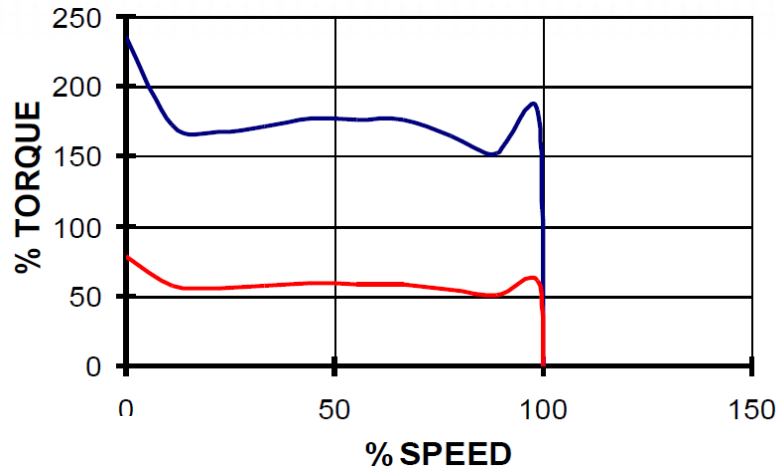
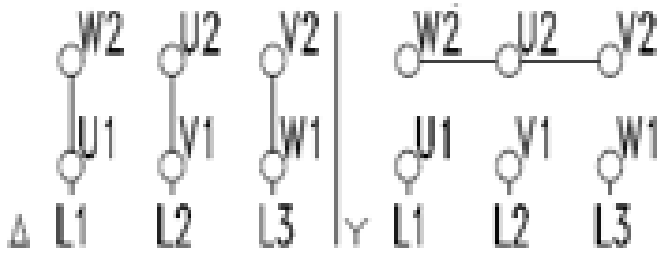


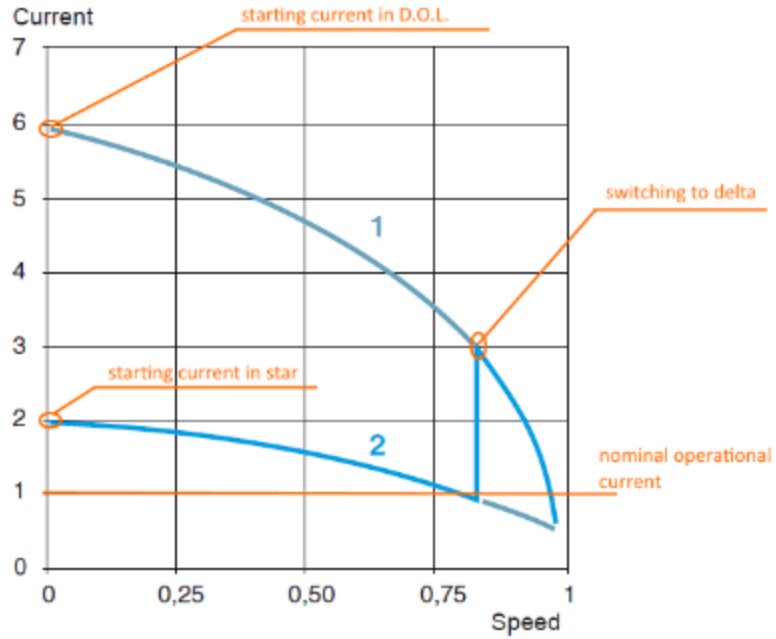
Squirrel Cage Induction Motor Construction



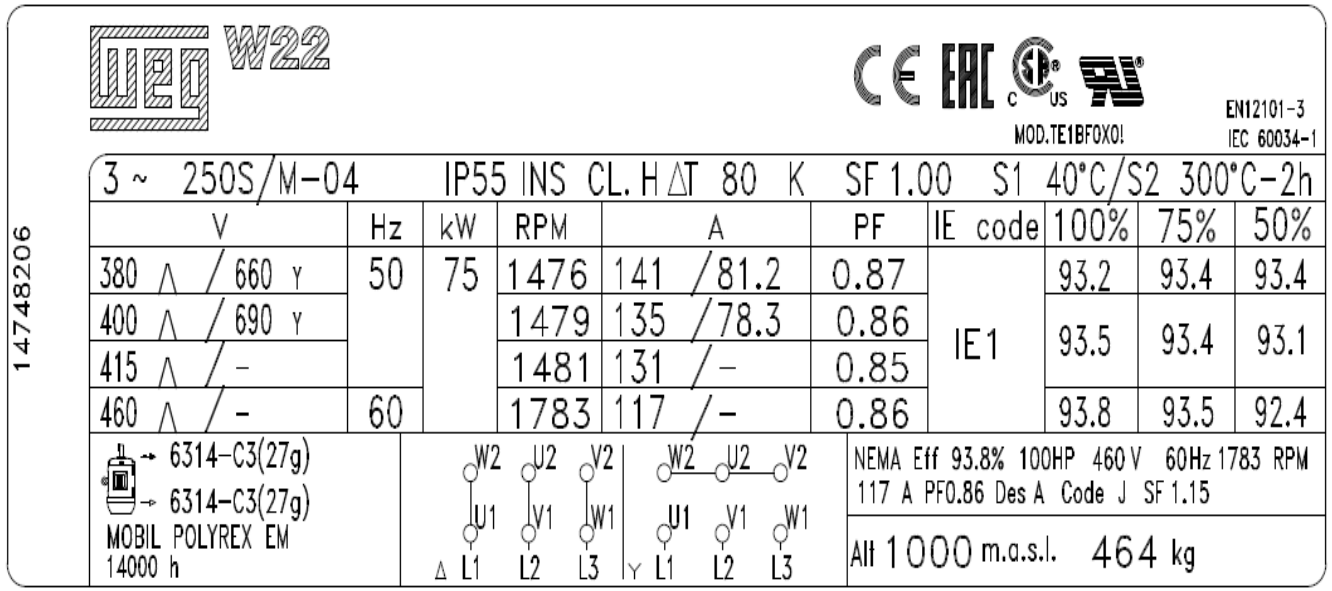

Motor Connection Diagram
Connection of three phase, single speed motors
Δ-connection
Y connection


% TORQUE
250
200
150
100
50
0
0
50
100
150
% SPEED


W2 U2 V2
U1 V1 W1
Δ L1 L2 L3
Y L1 L2 L3


Current
starting current in D.O.L.
switching to delta
starting current in star
nominal operational current
1
2
7
6
5
4
3
2
1
0
0
0,25
0,50
0,75
1
Speed

Motor nameplate



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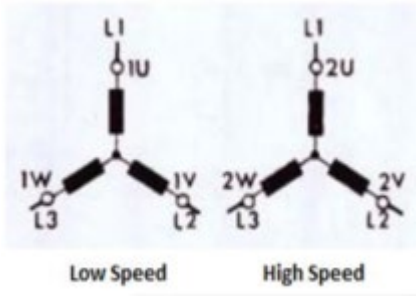
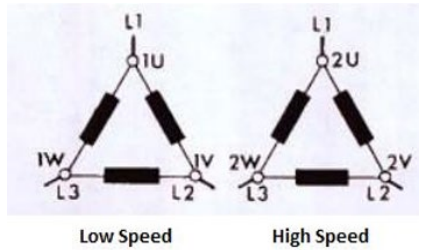
Two Speeds Motor





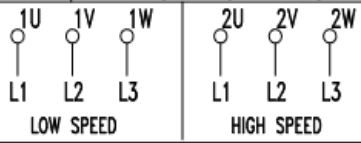
WEG W22 13889195

3 ~ 100L-06/04

IP55 INS CL.F △T 80 K SF 1.00 S1 40°C/S2 200°C-2h

V	Hz	kW	RPM	A	PF
400 Y /-	50	0.70	970	2.48 /-	0.60
400 Y /-		2.2	1430	4.91 /-	0.84
- /-				- /-	
- /-				- /-	
- /-					

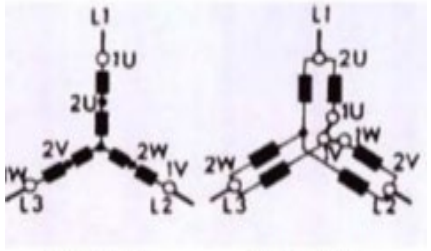
400	-	68.0	(100%)	64.0	(75%)	57.0 (50%)
400 /-		77.0	(100%)	77.0	(75%)	76.0 (50%)
-		-	(100%)	-	(75%)	- (50%)

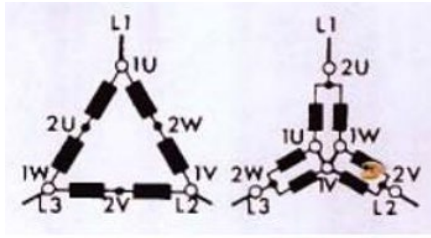


NEMA Eff -% -HP - V - Hz - RPM
- A PF - DES - CODE - SF -

6206-ZZ
6205-ZZ
MOBIL POLYREX EM
31 kg

MOD.TE1BF0%0X
EN12101-3
IEC 60034-1





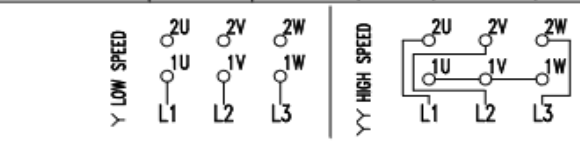
WEG W22 12574257

3 ~ 90S-04/02

IP55 INS CL.F △T 80 K SF 1.00 S1 40°C/S2 200°C-2h

V	Hz	kW	RPM	A	PF
400 Y /-	50	0.37	1430	1.19 /-	0.63
400 YY /-		1.5	2875	3.45 /-	0.82
- /-				- /-	
- /-				- /-	
- /-					

400	-	71.0	(100%)	70.0	(75%)	65.0 (50%)
400 /-		76.5	(100%)	76.0	(75%)	73.0 (50%)
-		-	(100%)	-	(75%)	- (50%)



NEMA Eff -% -HP - V - Hz - RPM
- A PF - DES - CODE - SF -

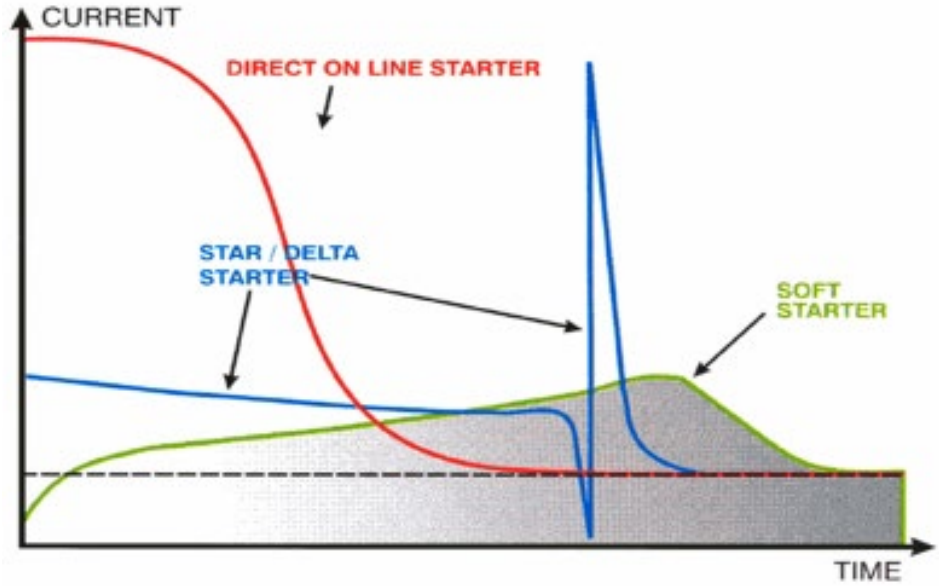
6205-ZZ
6204-ZZ
MOBIL POLYREX EM
19 kg

MOD.TE1BF0%0X
EN12101-3
IEC 60034-1

Methods of Starts

Starting Method	SC / FLC
Direct On Line (DOL)	5 - 7
Star / Delta	3 – 4
Soft Starter	3 – 4
Variable Frequency Drive (VFD or Inverter)	2 – 3

Recommended on larger powered motors.



The inverter Drive provides the means to vary the frequency and therefore motor speed.

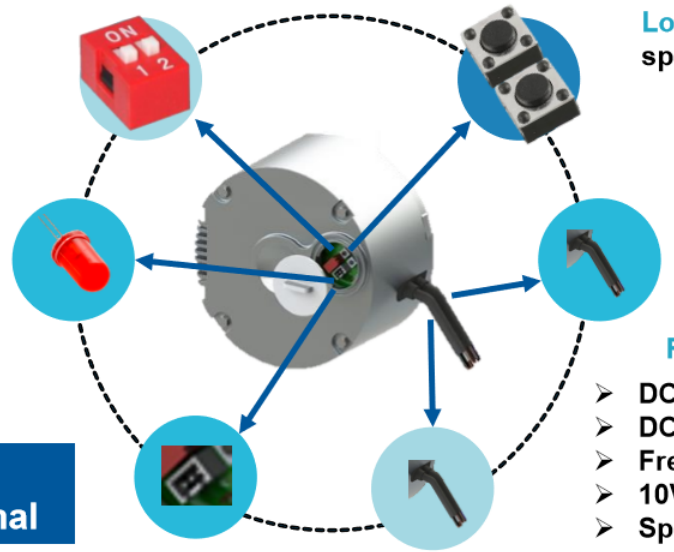
Two way dip-switch

- Local / Remote speed adjust reference
- CW / CCW rotation direction selection

Diagnosis led

Fault identification

External speed controller terminal



Tact buttons

Local Instant / Maximum speed adjust

- Increase speed (turn on)
- Decrease speed (turn off)

Control Cable

Remote speed adjust

- DC voltage: 2 to 10V DC
- DC current: 4 to 20mA DC
- Frequency: 10 to 95%
- 10VDC power source
- Speed feedback

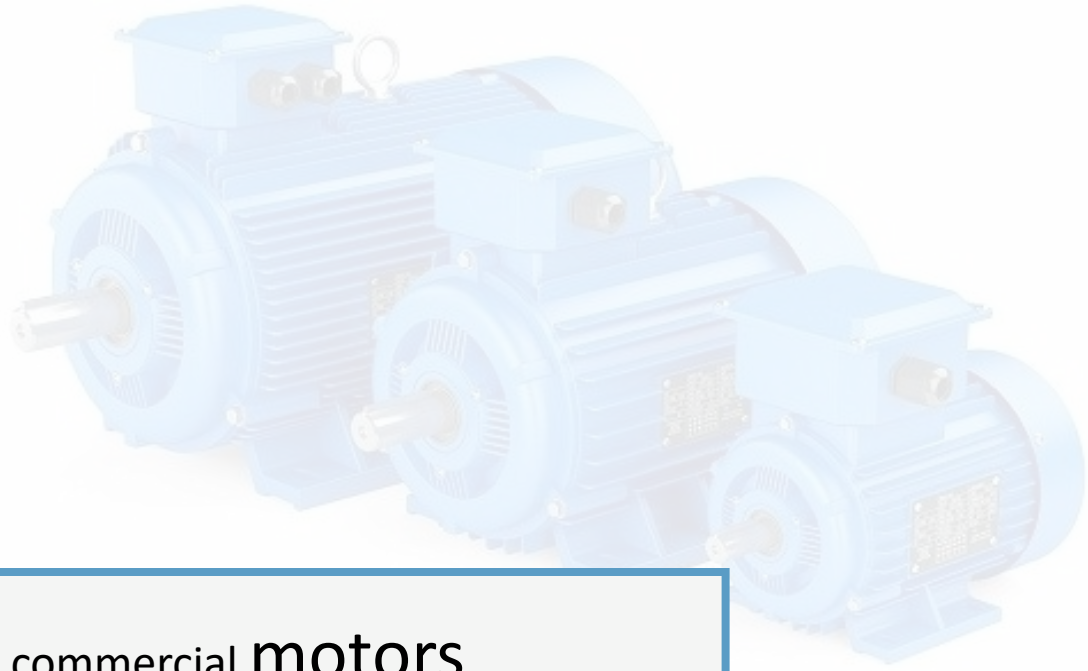
Power Cable

Other features:

- Maximum speed limitation
- Speed memory

Session aim

At the end of this session, you will be able to



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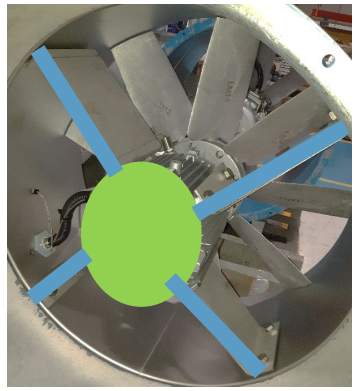
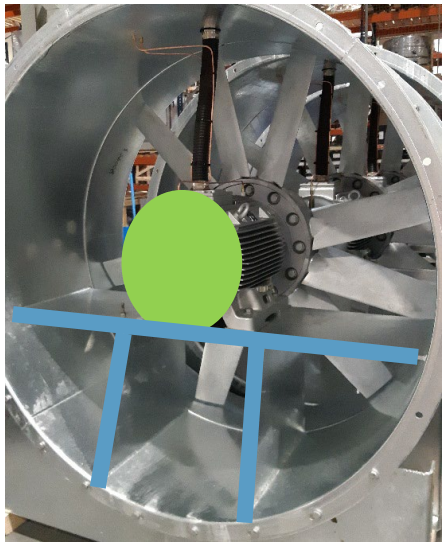
PAD Mounted:
Code B30 (3 or 4 pads on end-shield or frame)
IM 9201



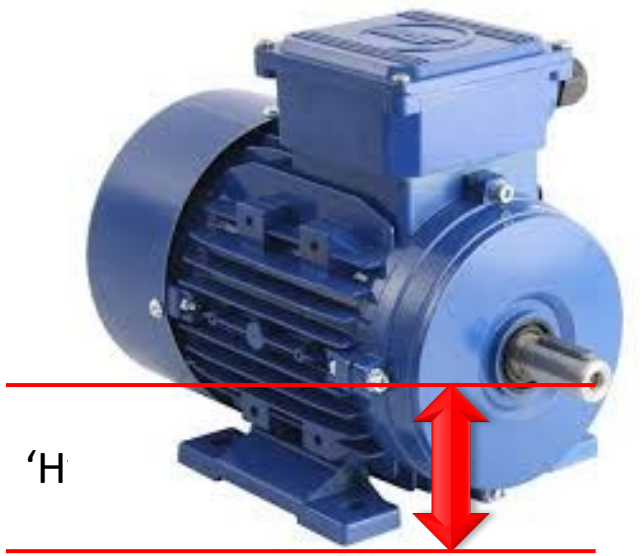
Foot Mounted:
Code B3 (Horizontal, foot)
IM 1001



C Flange Mounted:
Code B14 (Horizontal or Vertical, “C” flange or face)
IM 3601

D Flange Mounted:
Code B5 (Horizontal or Vertical, “D” flange) IM 3001

Frame Size



Examples:

71

80

90

100

112 etc…

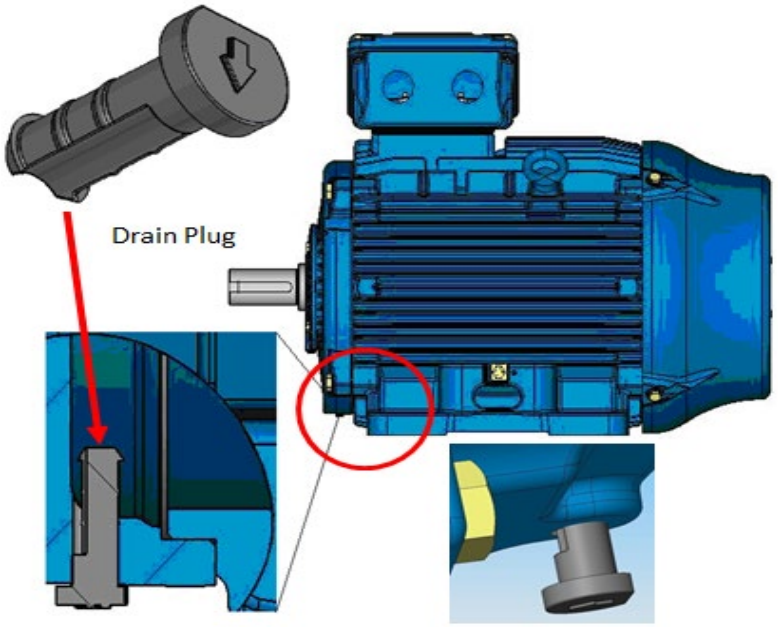
- The Motor frame size is determined by the Shaft centre height (known as Dimension ‘H’)
- This is the distance in mm between the centre of the Shaft and the base of the Motor foot

Motor Ingress Protection

First Numeral	Protection
0	None
1	Solid objects over 50mm
2	Solid objects over 12mm
3	Solid objects over 2.5mm
4	Solid object over 1mm
5	Dust (no harmful deposits)
6	Dust (total protection)

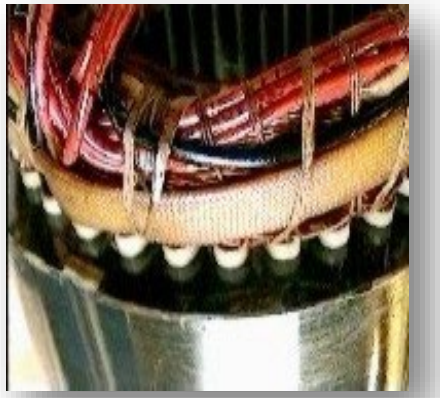
Second Numeral	Protection
0	None
1	Vertically dripping water
2	75° to 90° dripping water
3	Sprayed water
4	Splashed water
5	Water jets
6	Heavy sea
7	Effects of temporary immersion
8	Indefinite immersion

Dealing with Internal Condensation



Detail of the closed drain plug in the drive end end-shield.

Note: Drain plugs are not permitted in ATEX and Hazardous area motors

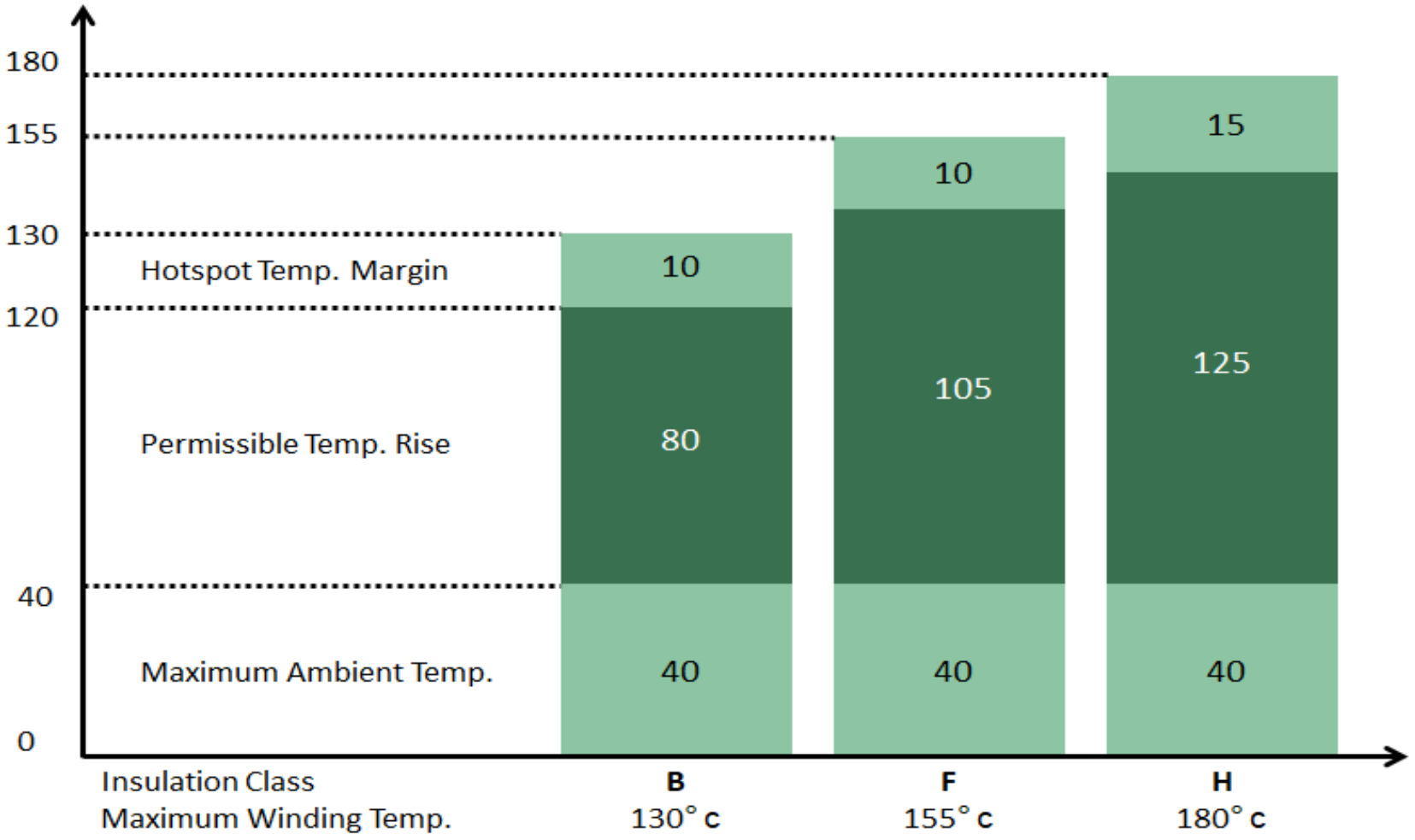


Frame Size	Wattage	No. of Heaters
63-90	8	1
100-112	16	2
132	24	1
160-200	48	2
225-250	80	1
280-355	160	2

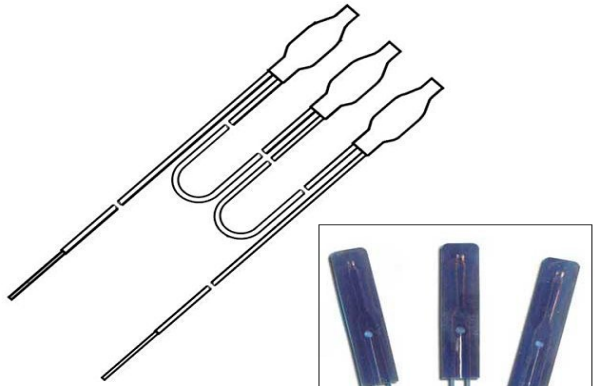
Anti-Condensation Heaters: These are necessary in order to prevent failure or corrosion to equipment, cause by water condensing inside the enclosure.

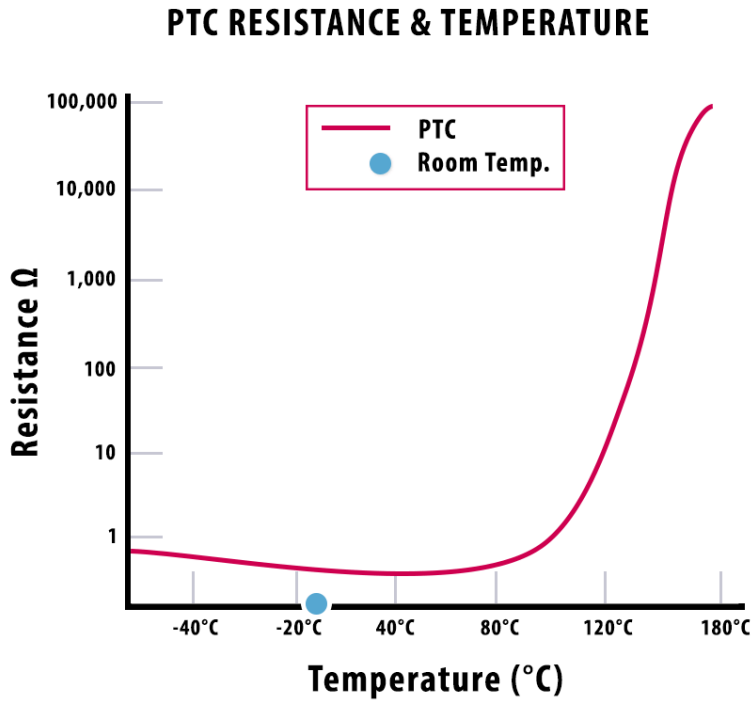
Tropicalisation: Additionally it is also possible to treat the Rotor and winding with special varnishes which help to prevent corrosion build up inside the motor enclosure.

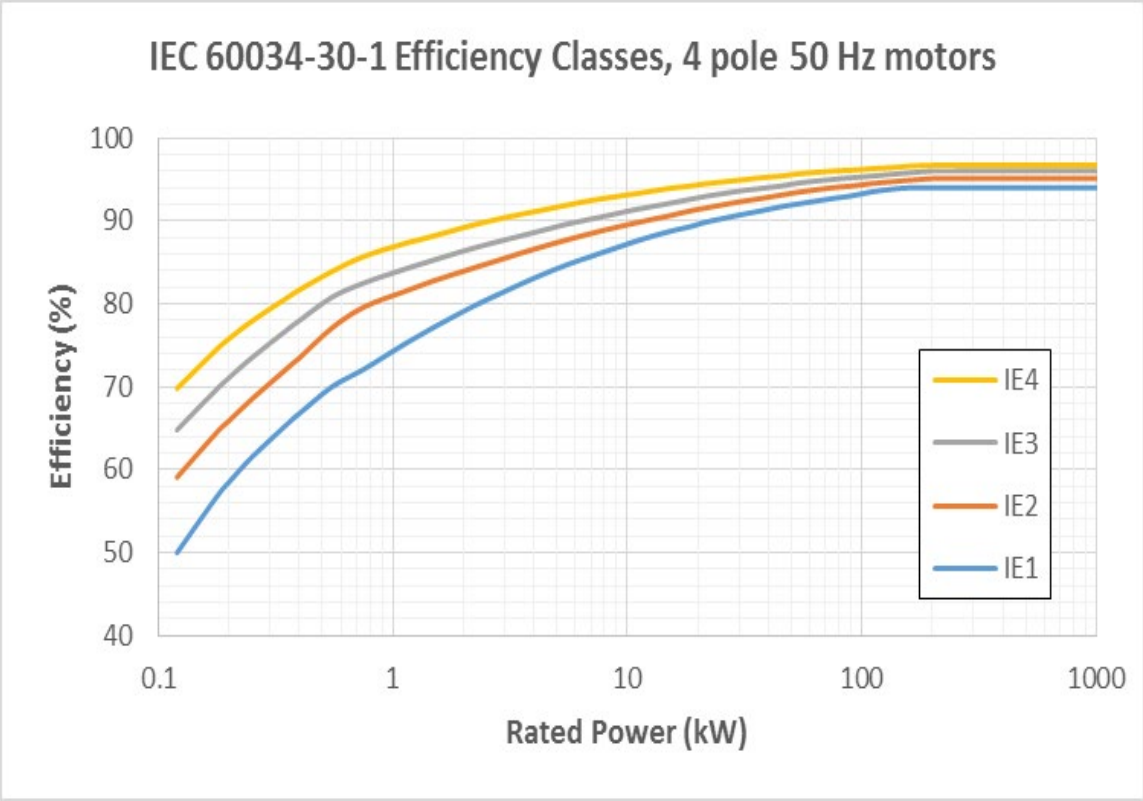
Winding Insulation



Thermal Protection







Example of target levels across the range of ratings covered by IEC 60034-30-1.

IE = International Efficiency :
IE1 (Standard Efficiency)
IE2 (High Efficiency)
IE3 (Premium Efficiency)
IE4 (Super Premium Efficiency)

Summary – covered:

- Basics of electrical power:
  - Difference between AC & DC.
  - Difference between single and three phase.
- Basics of electric motors:
  - Pros and cons of AC & DC motors.
  - Basics of running Induction & EC motors.
  - How to work out/or find out a motors synchronous speed.
- Basic construction and operation of electric motors:
  - How to read nameplates
  - Different ways to operate induction motors
  - Different starting methods of induction motors.
  - Generic control/operation of EC motors
- Basic features of electric motors:
  - Mounting
  - IP rating
  - Condensation prevention
  - Insulation class
  - Thermal protection
  - Efficiency rating

Thank you… Questions?