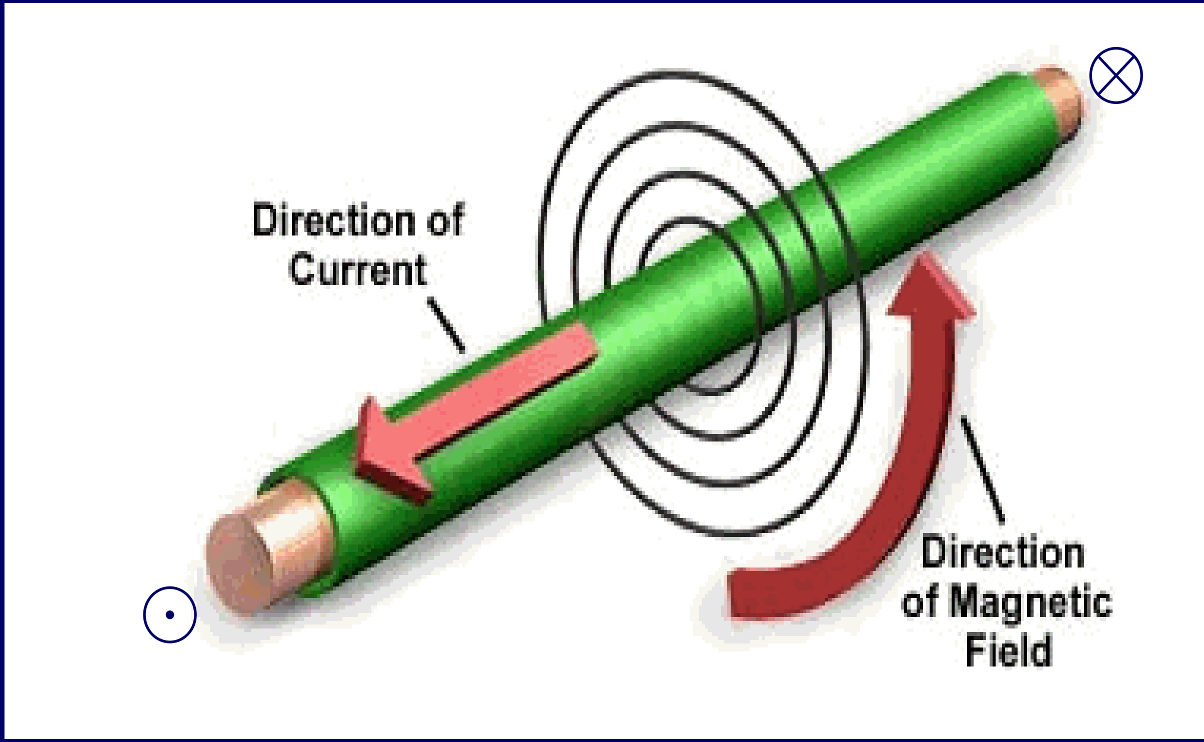
Three Phase AC Induction Motors

Motors

Motors convert Electrical energy into Mechanical energy

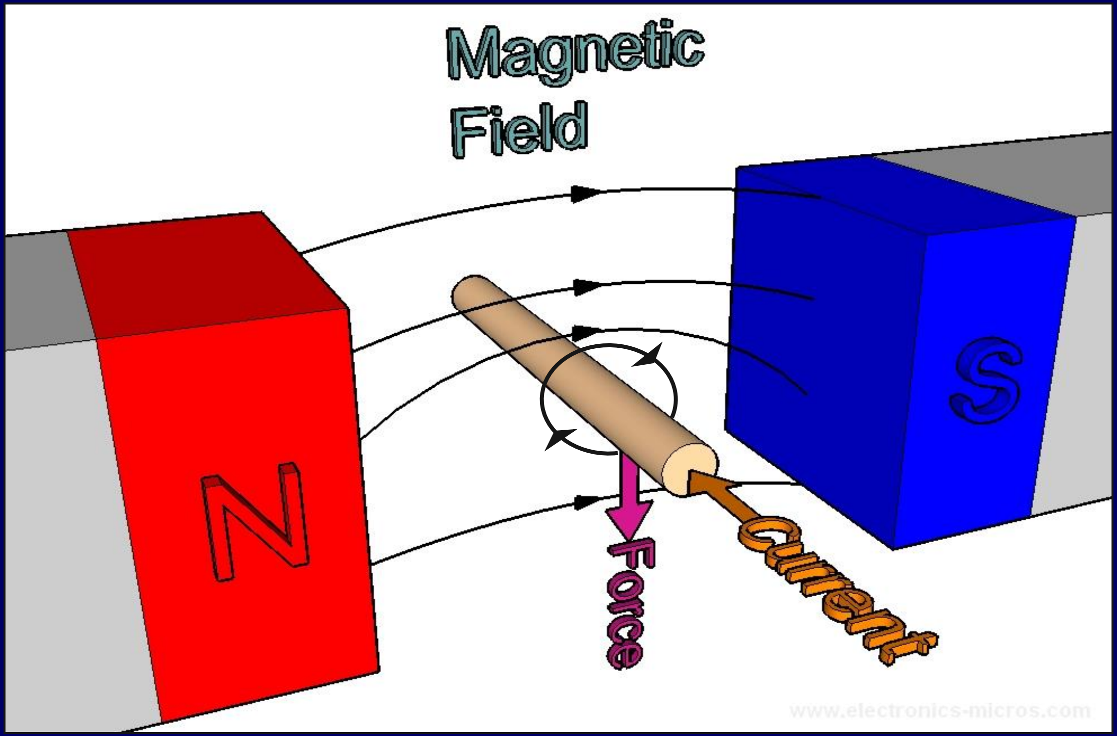
Magnetic Fields

When current flows in a conductor it produces a magnetic field about it - as shown below



Motion

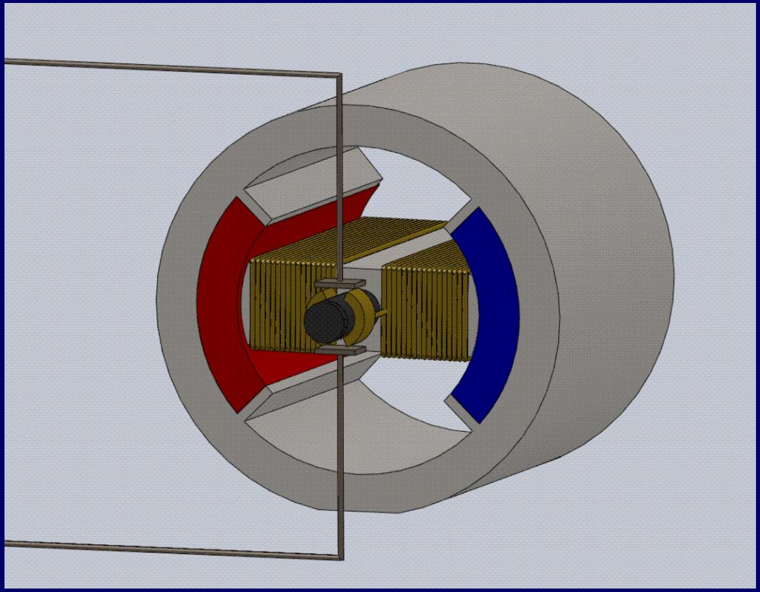
When the current-carrying conductor is placed within an external magnetic field, the two fields interact, and a force is exerted on the conductor



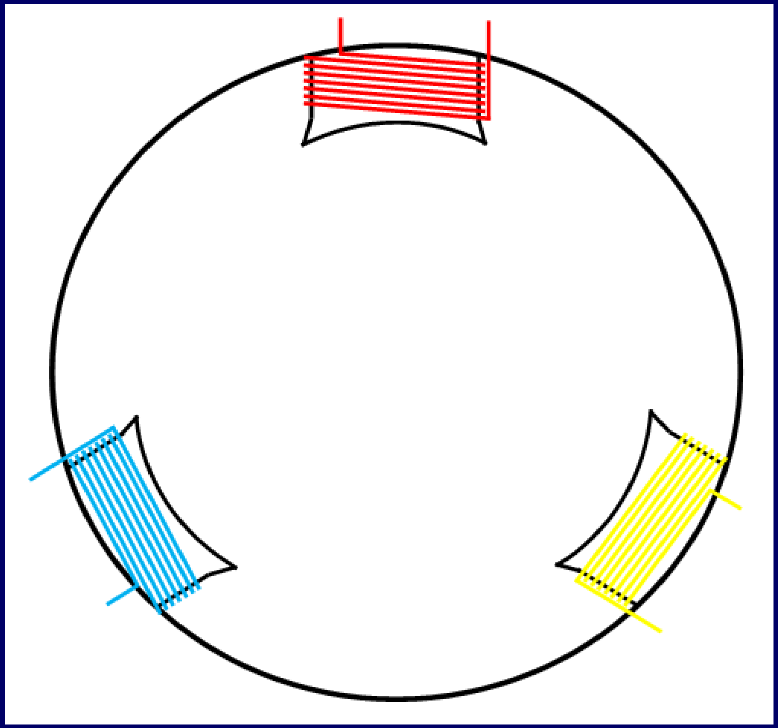
Basic DC Motor

If the current-carrying conductor is placed within an external magnetic field and coiled in a loop the conductor field can be increased in strength, the fields interact on both sides of the loop, and a force is exerted on the conductors to make them rotate

+

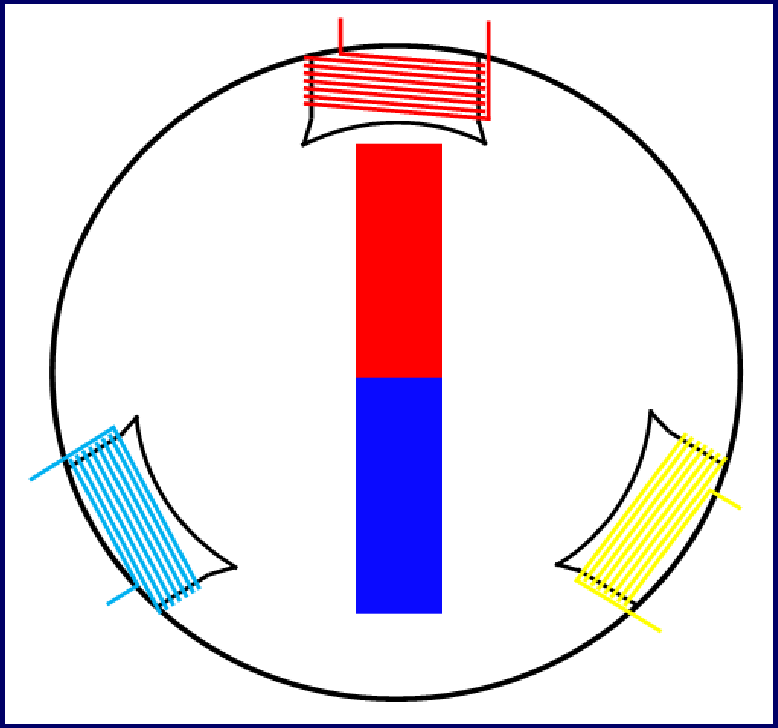


Three Phase AC Winding



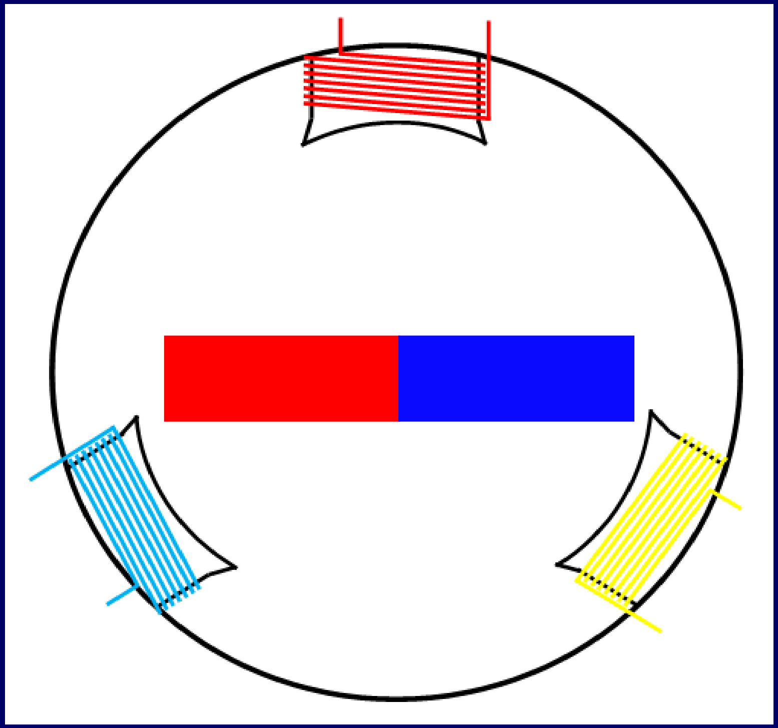
With three windings we can position them 120^0 apart to give us 3 pole faces

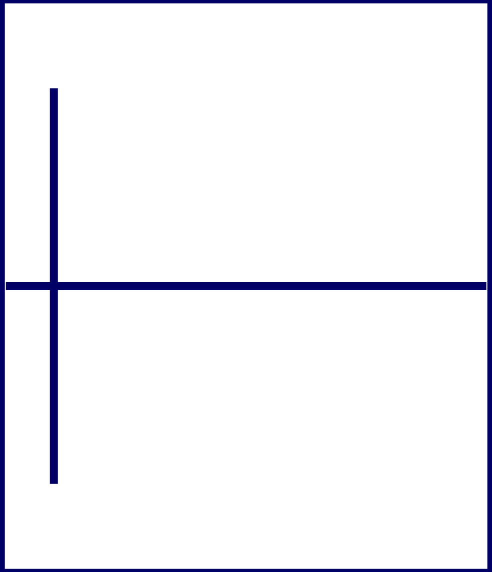
Three Phase AC Generator Winding



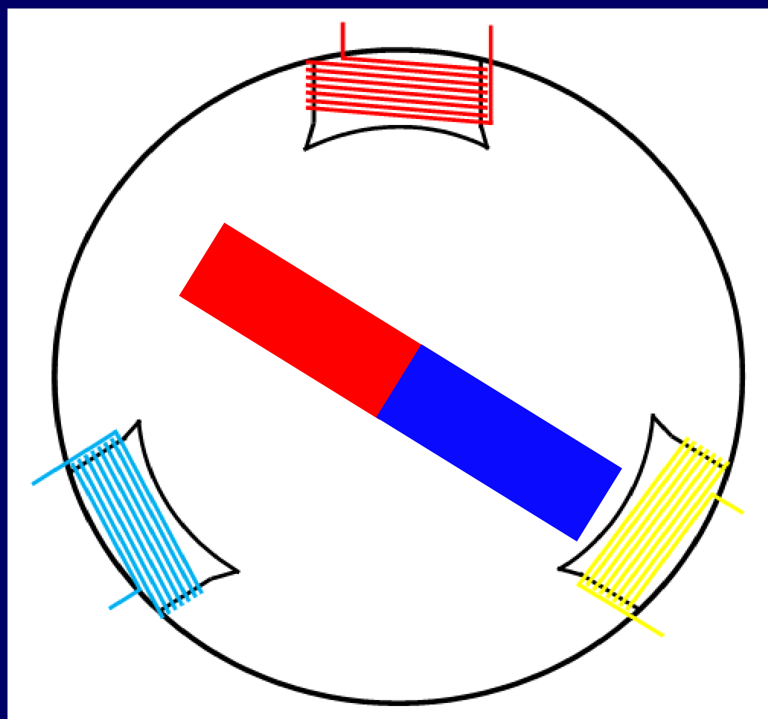
This is how a Generator would be configured

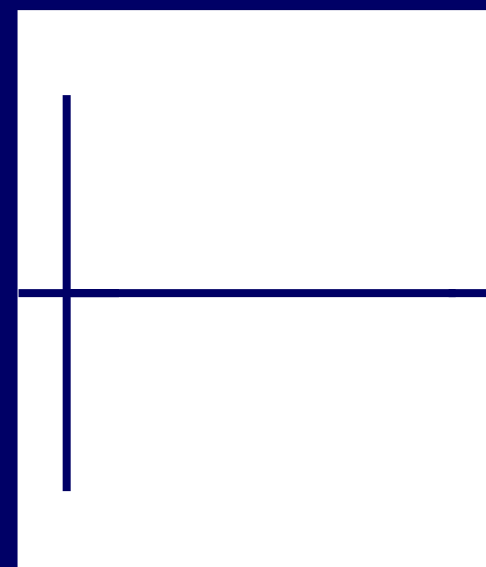
Three Phase AC Generator Winding



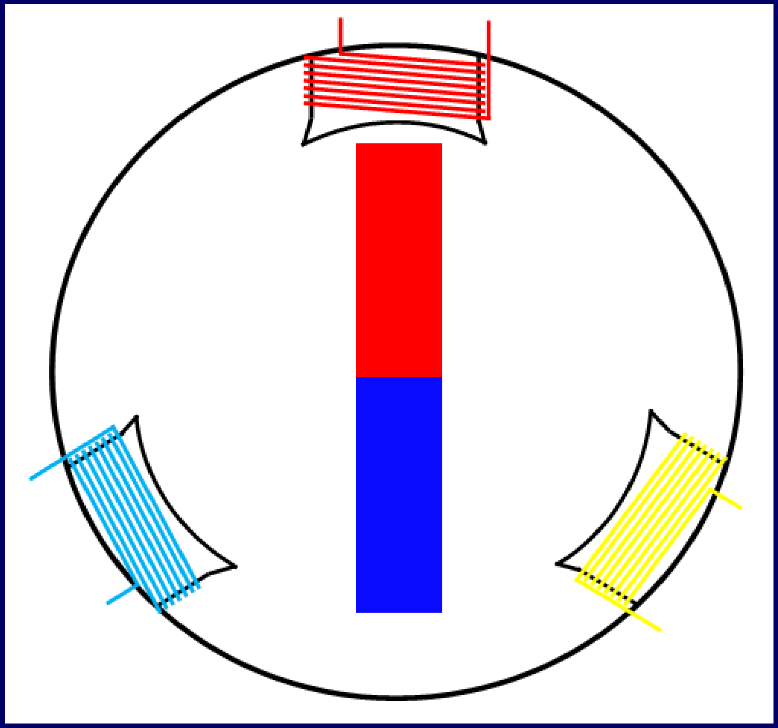


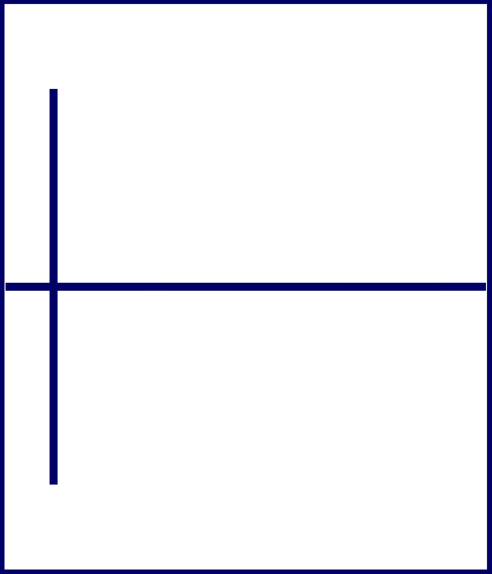
Three Phase AC Generator Winding



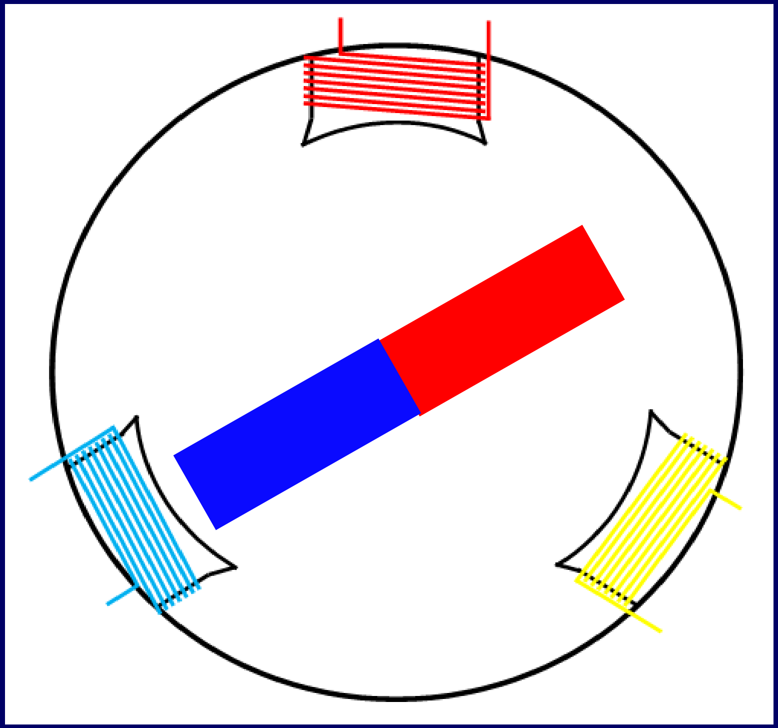


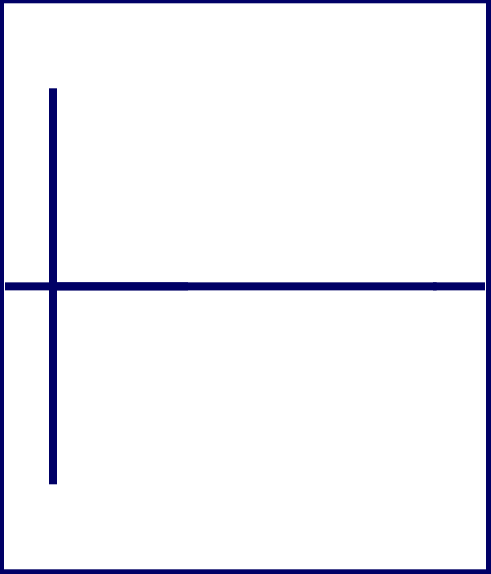
Three Phase AC Generator Winding



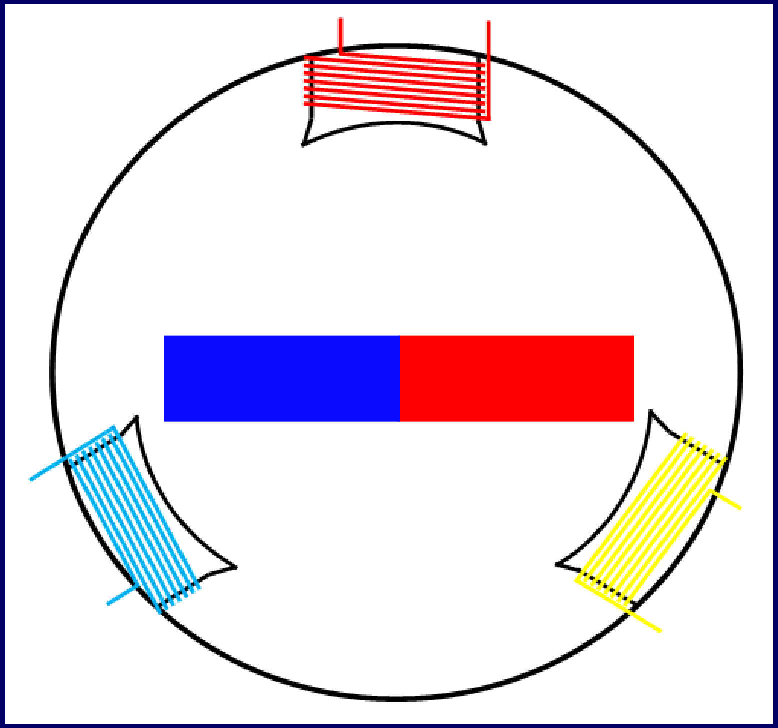


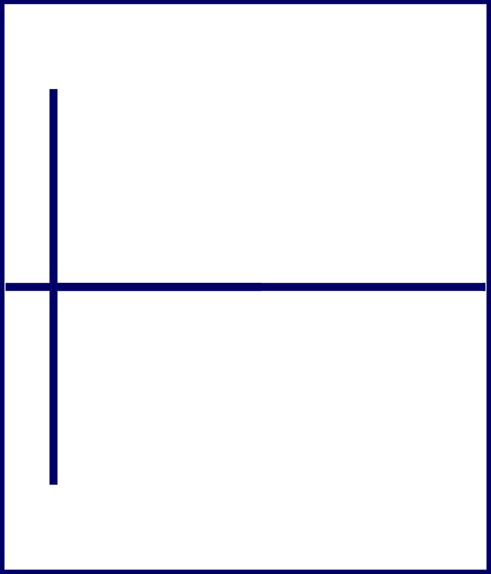
Three Phase AC Generator Winding



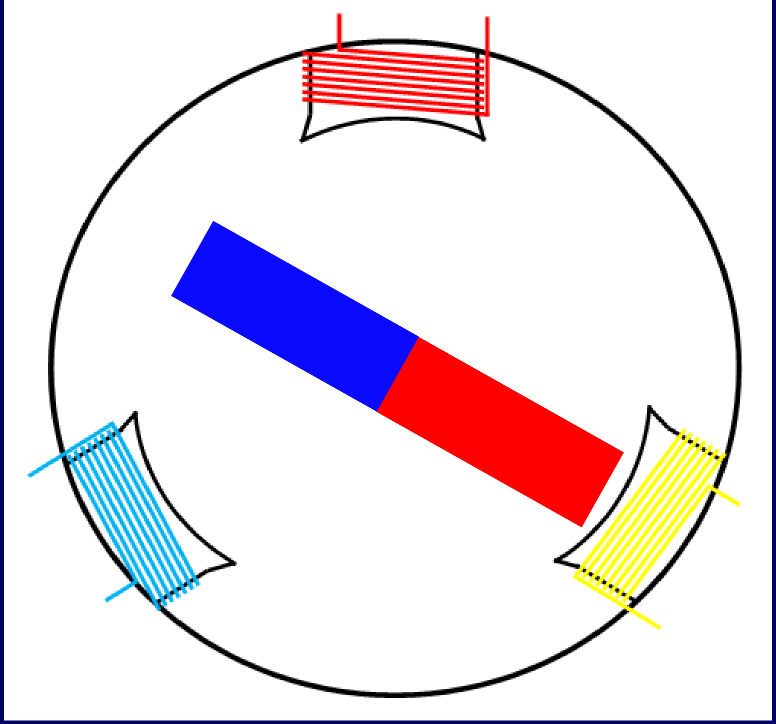


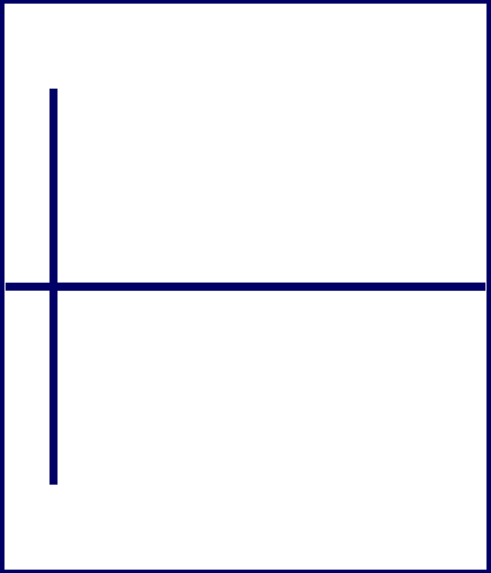
Three Phase AC Generator Winding



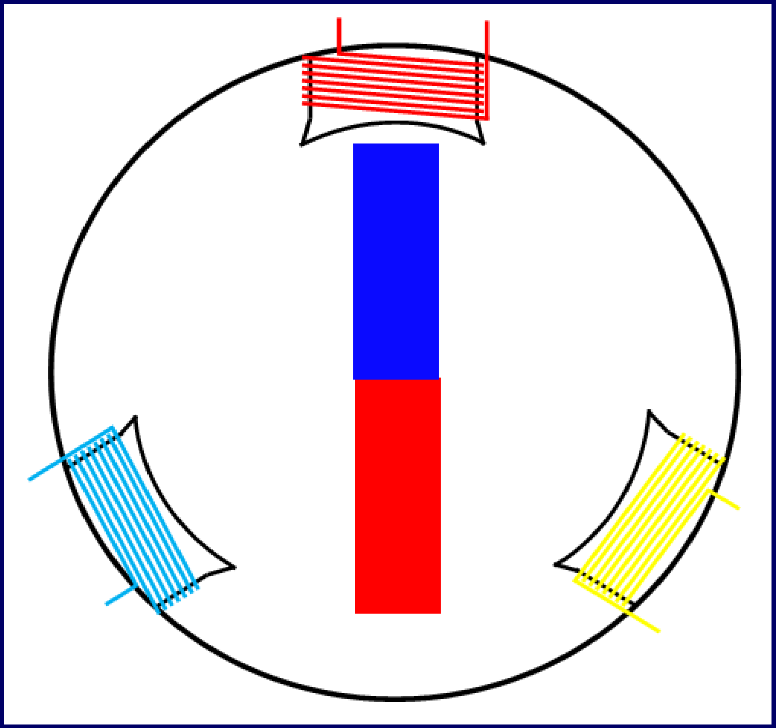


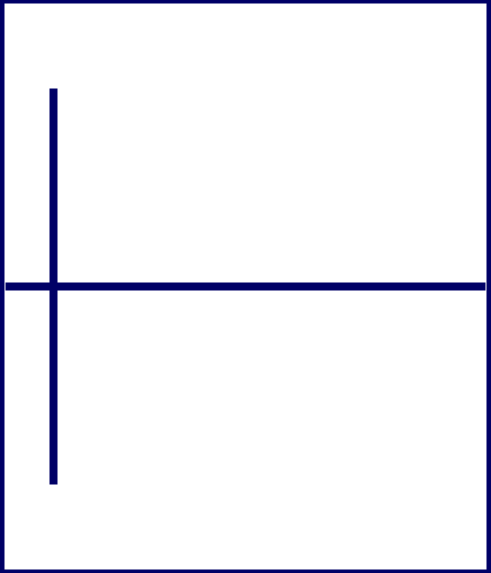
Three Phase AC Generator Winding



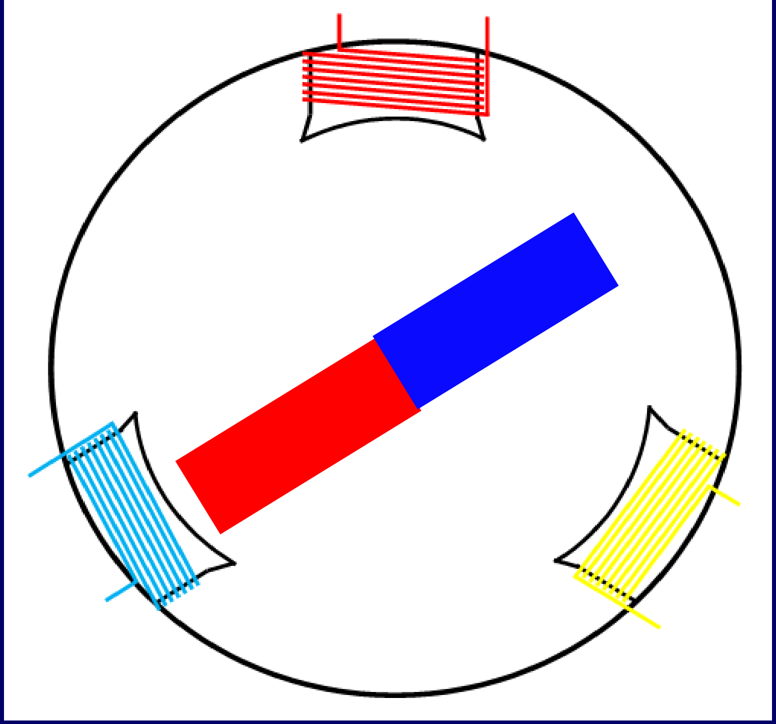


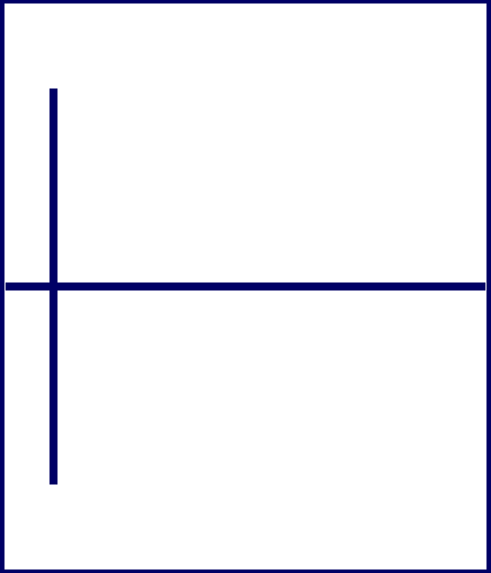
Three Phase AC Generator Winding



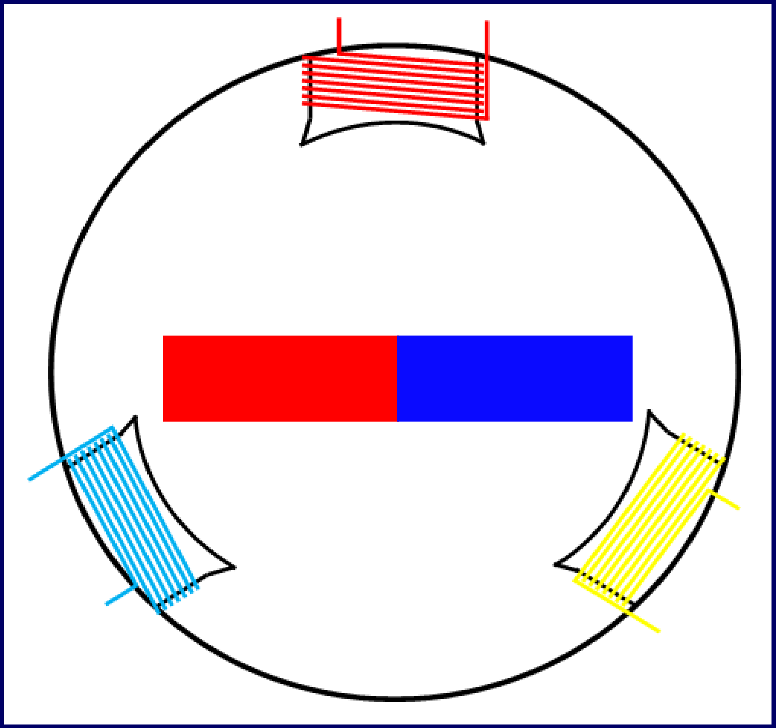


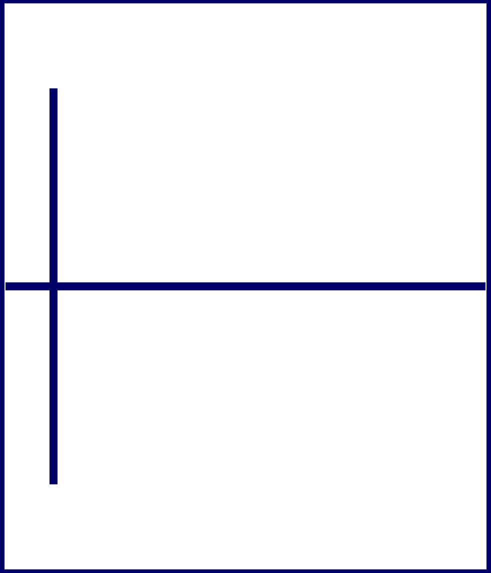
Three Phase AC Generator Winding



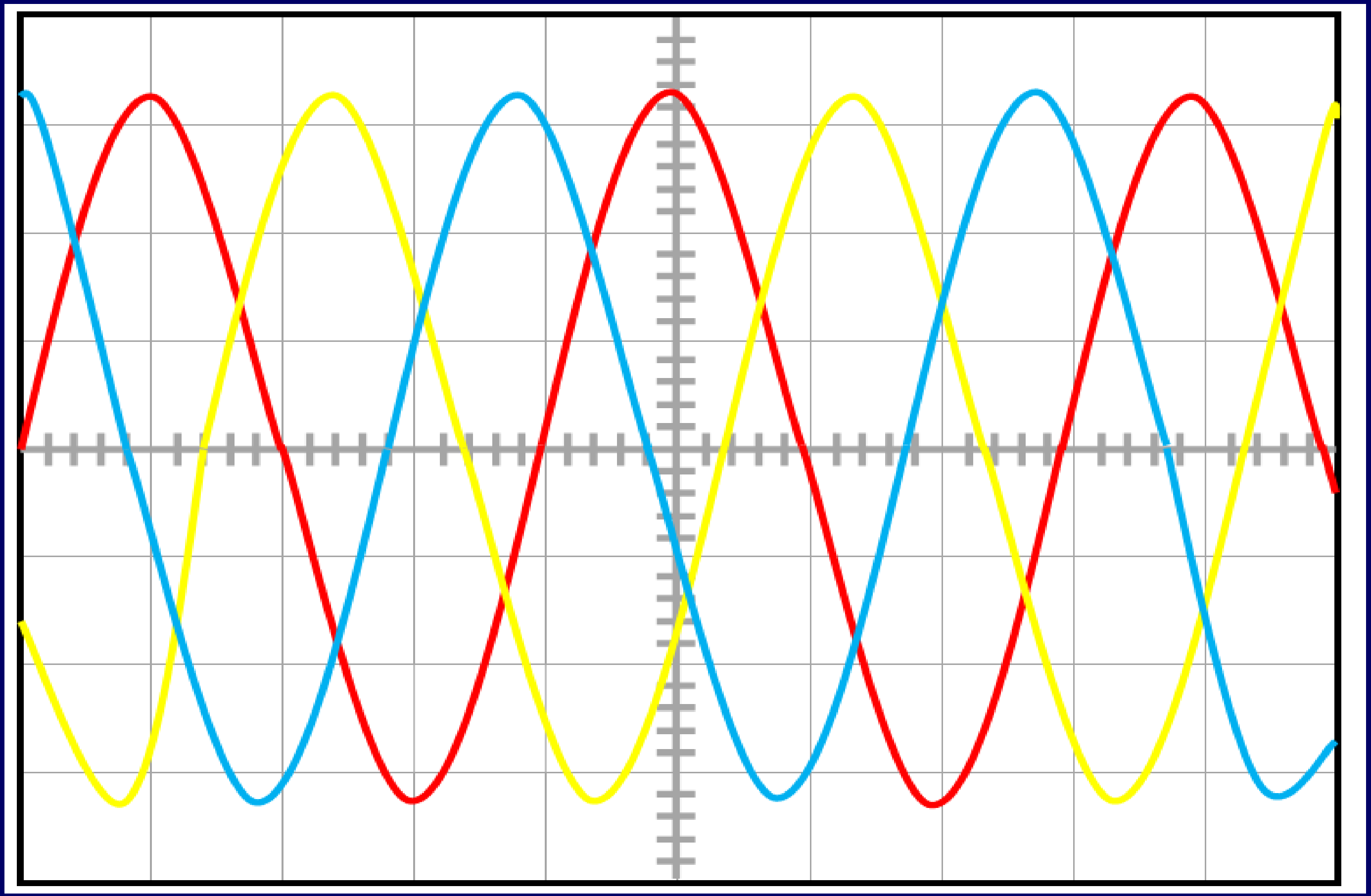


Three Phase AC Generator Winding

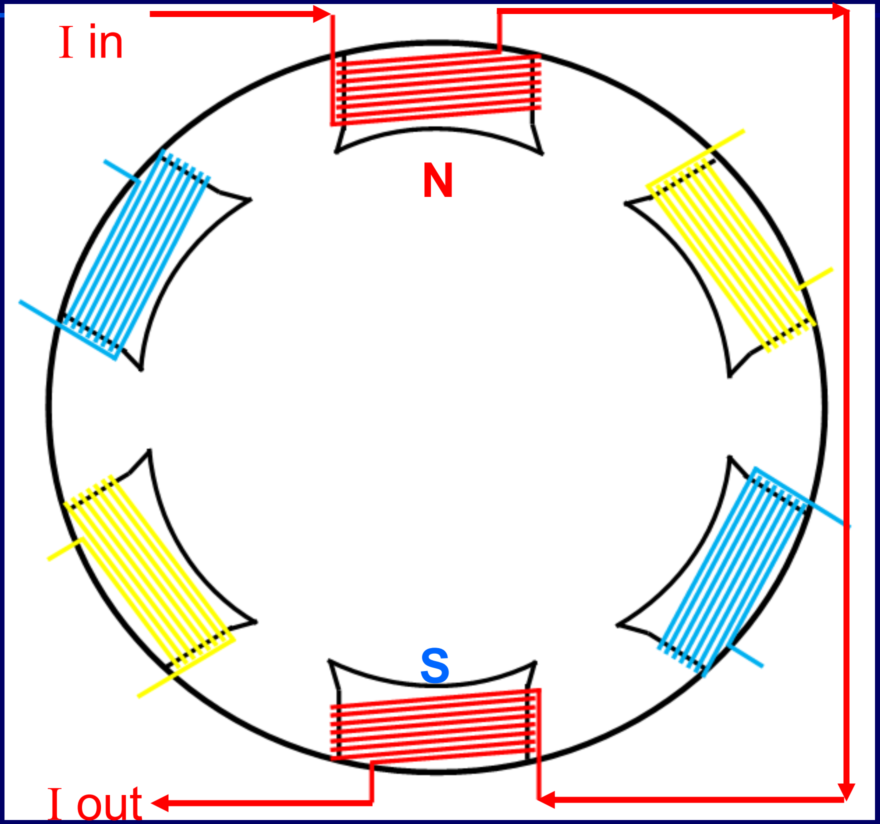




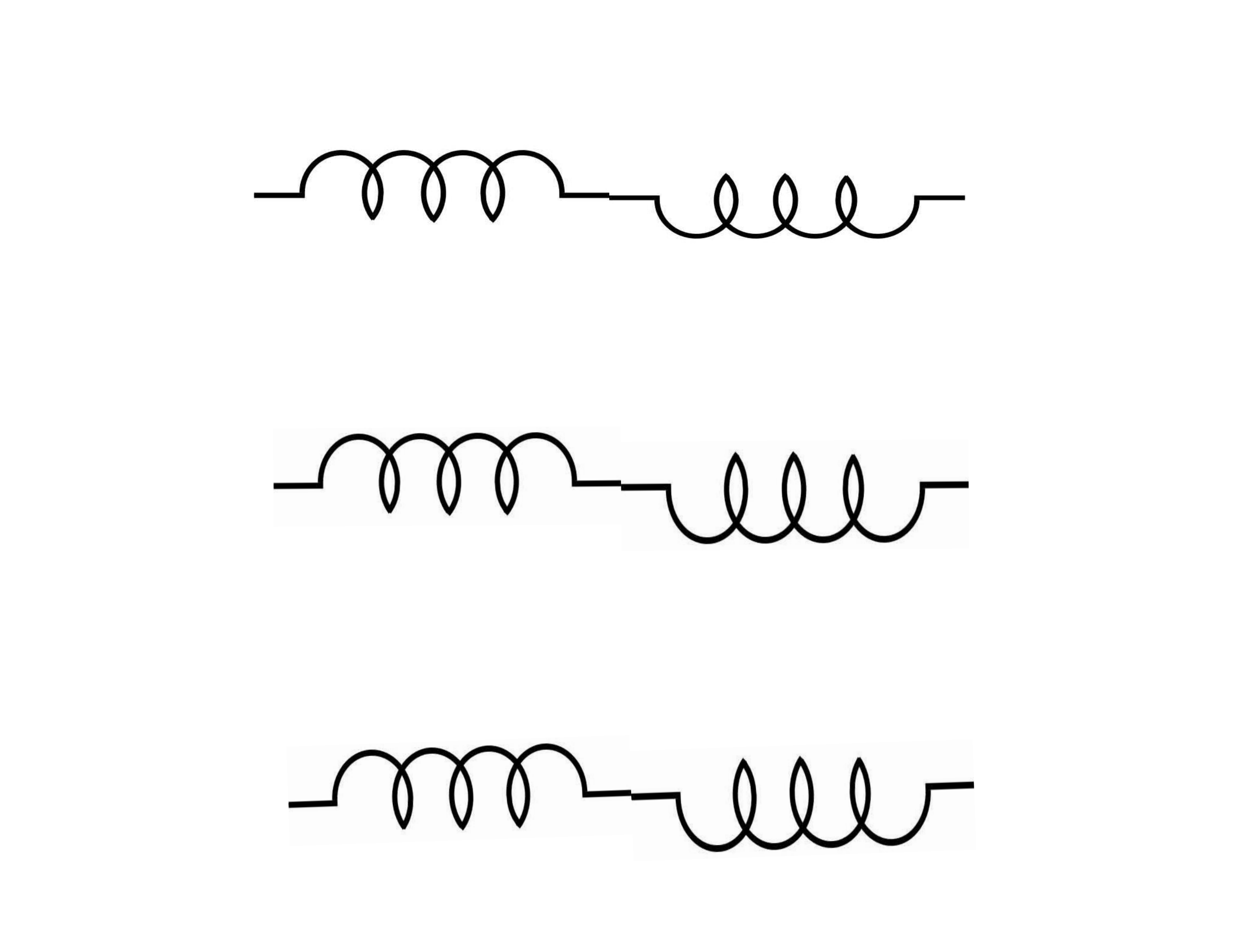
Three Phase Supply Rotation



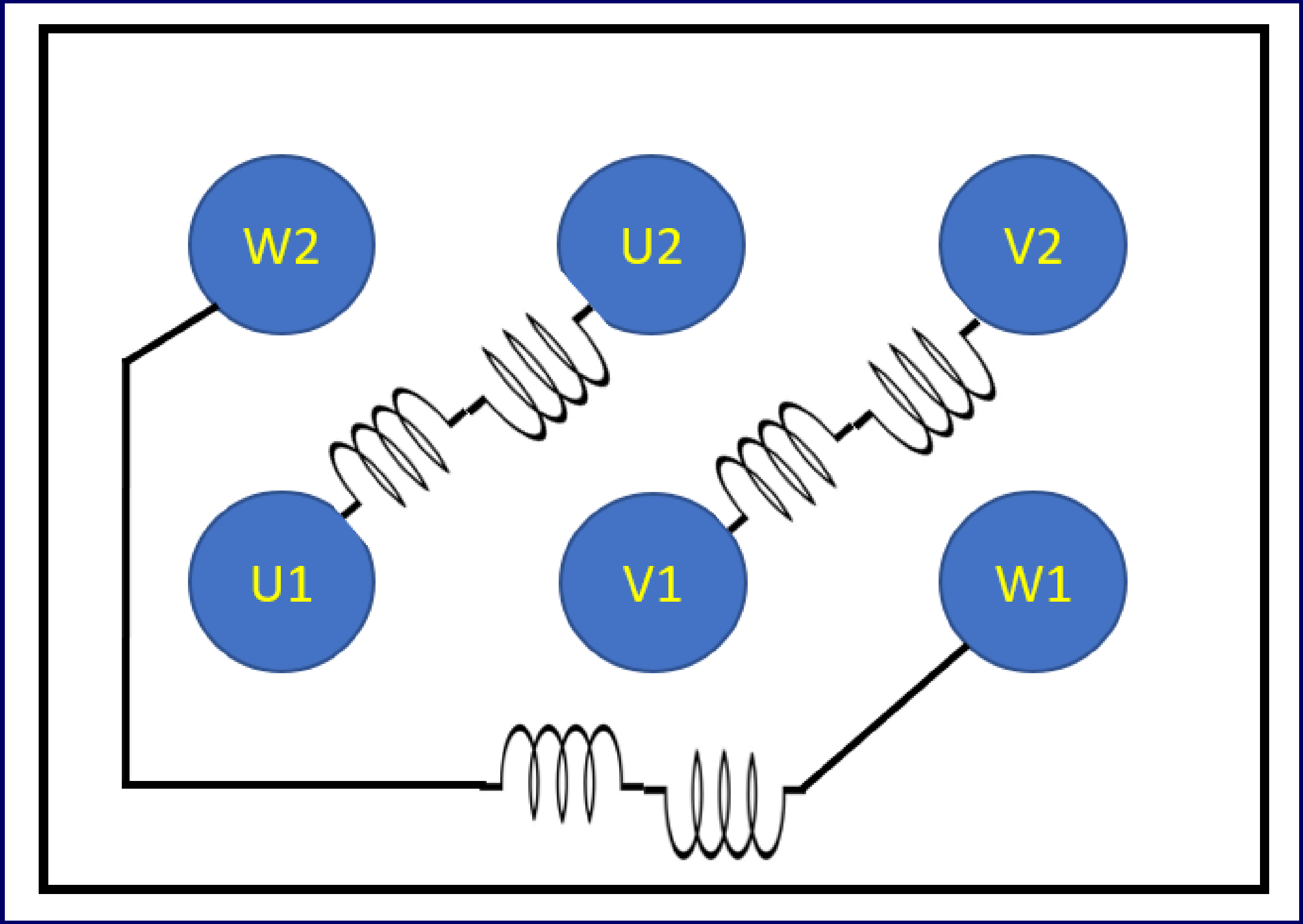
Stator Windings

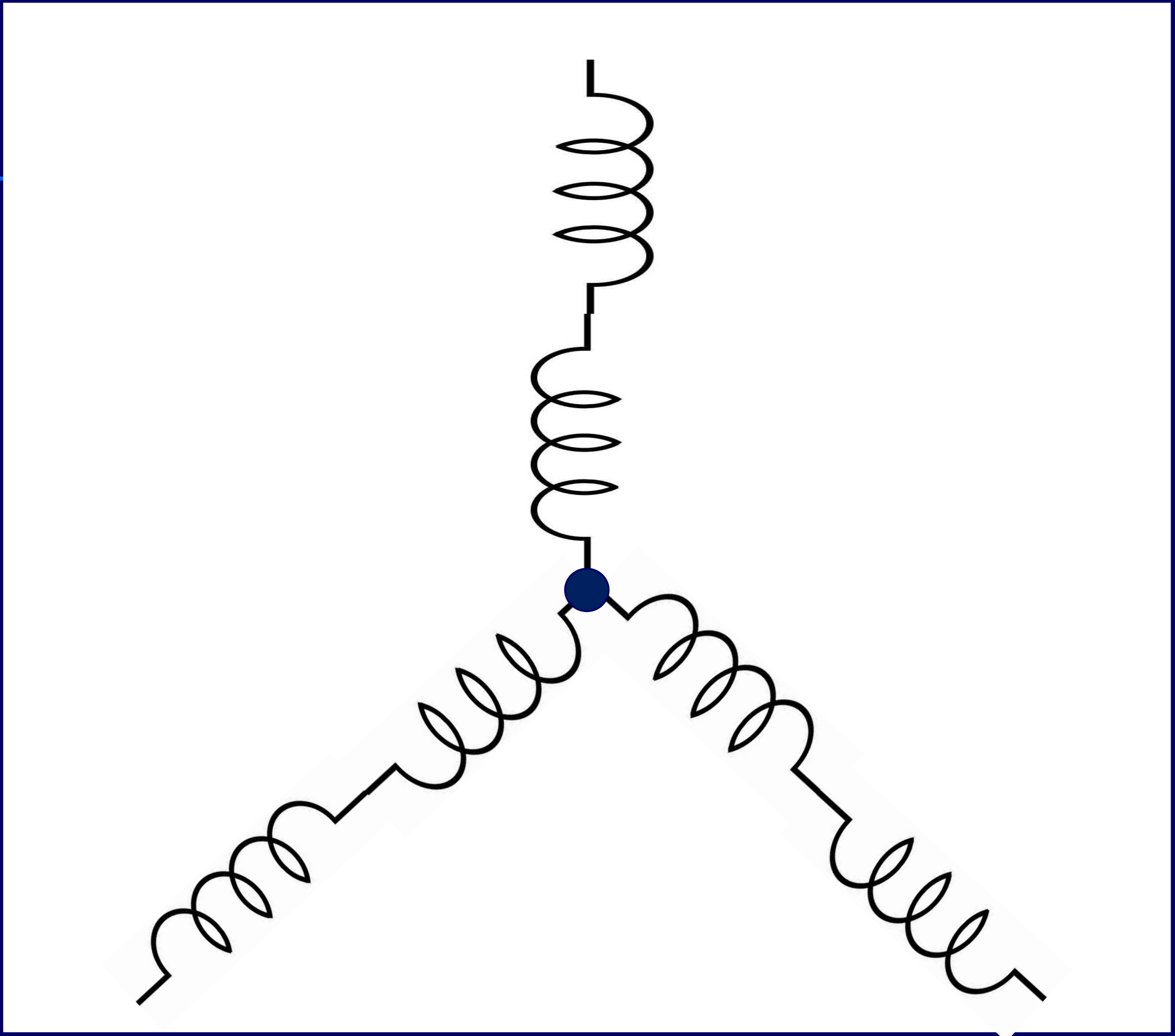


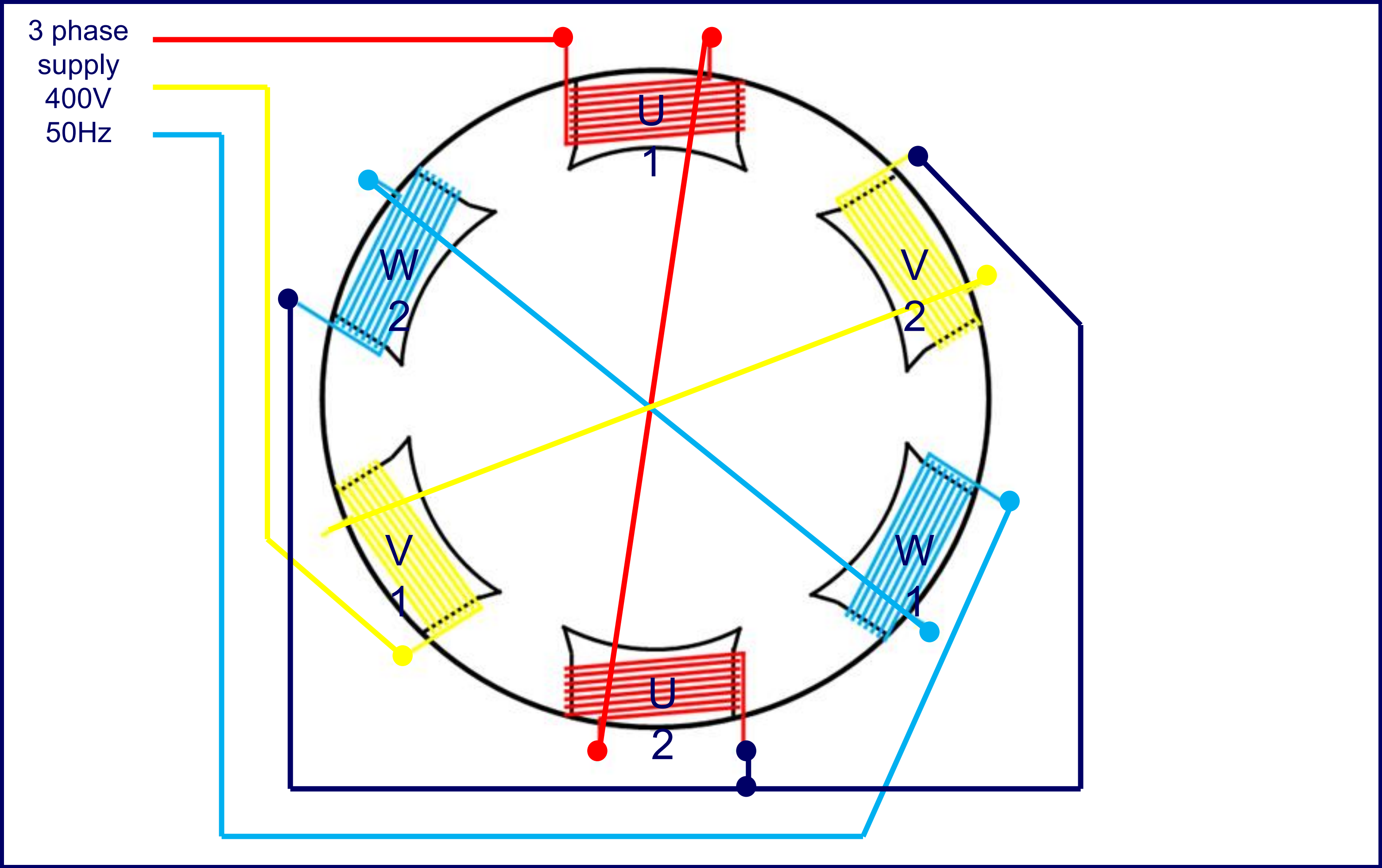
3Φ AC induction motors are wound to give us pole pairs, Norths & Souths for opposite pole faces. Here we have a 2-pole motor i.e., 2 poles per phase or 1 pole pair per phase



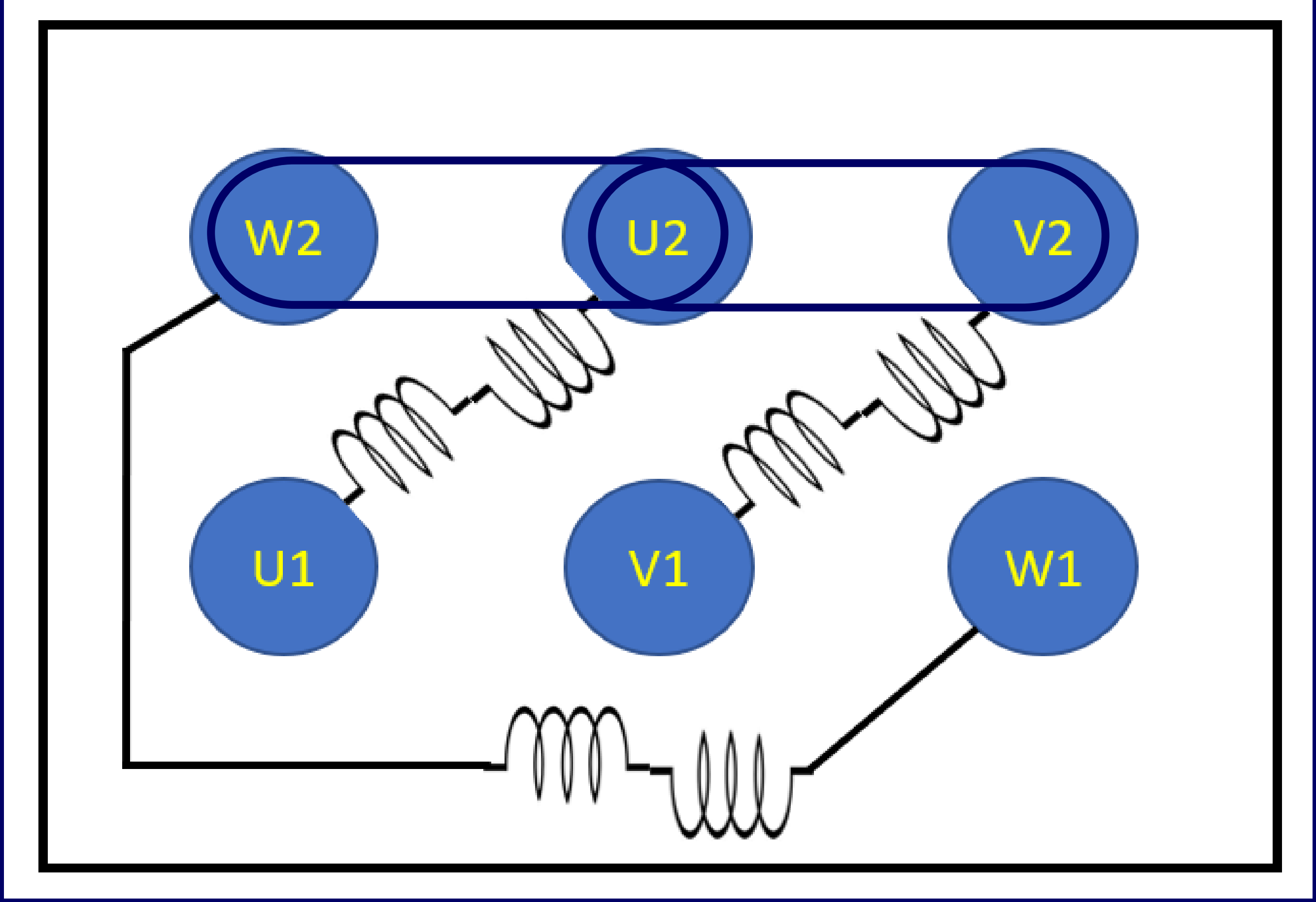
Terminal Box Configuration



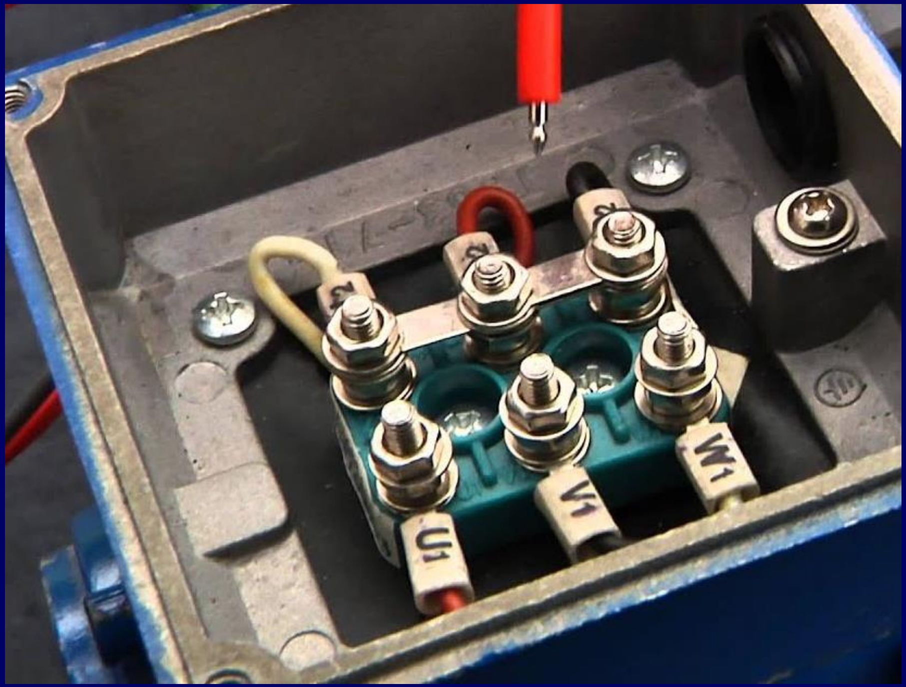



3 phase
supply
400V
50Hz
U
1
V
2
W
2
V
1
W
1
U
2

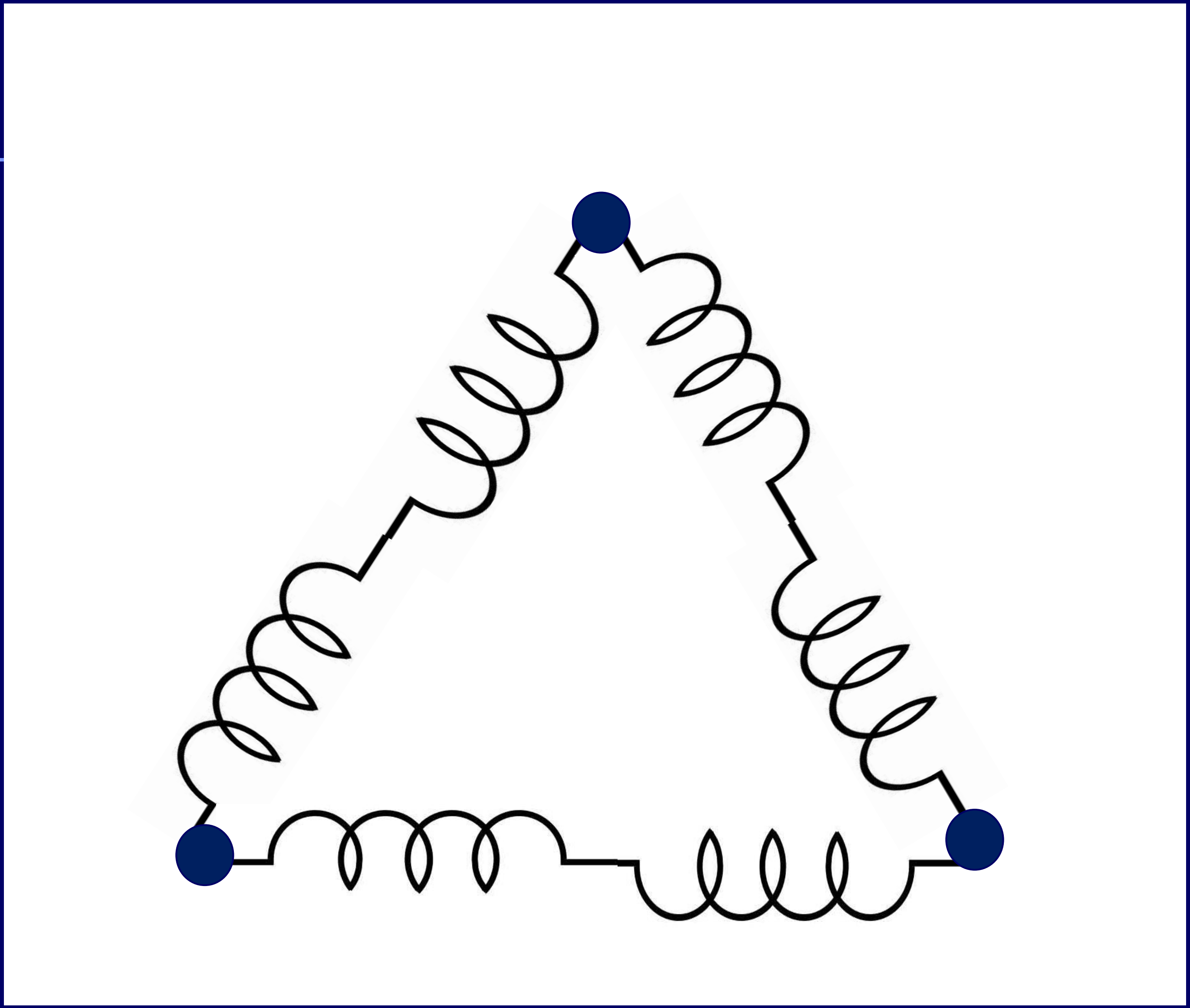
Terminal box linked for Star

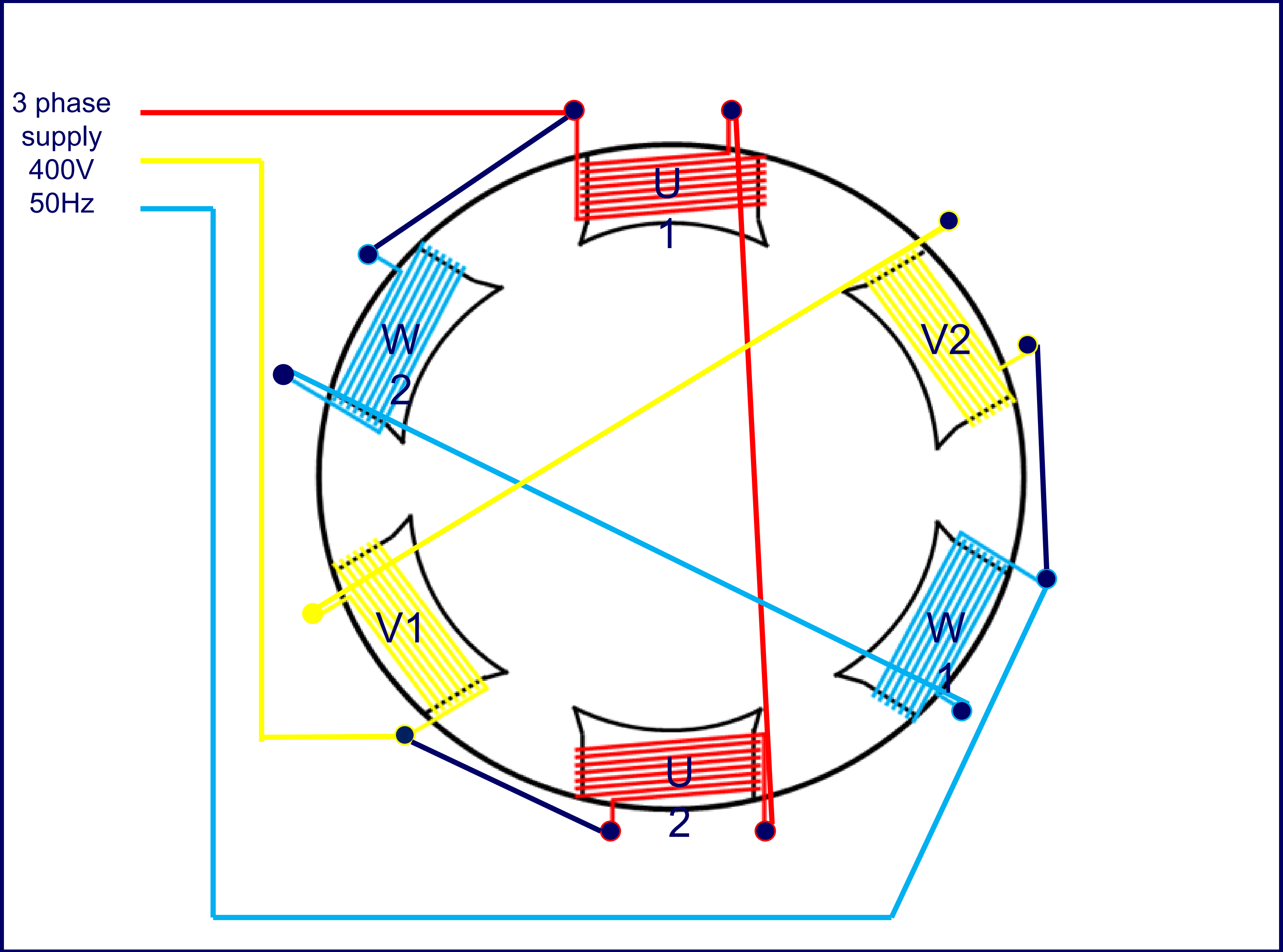


Motor Links

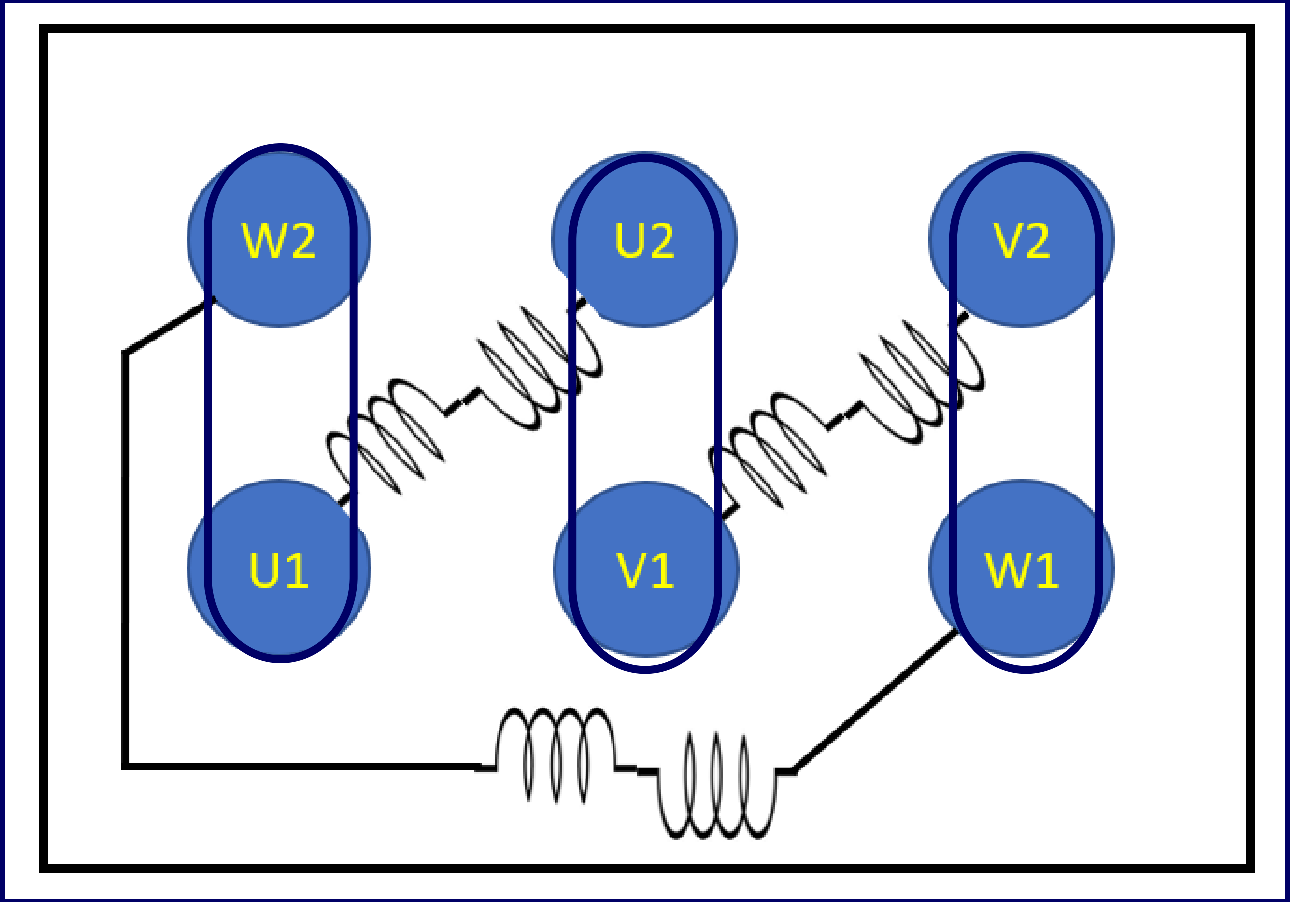


STAR
CONNECTED

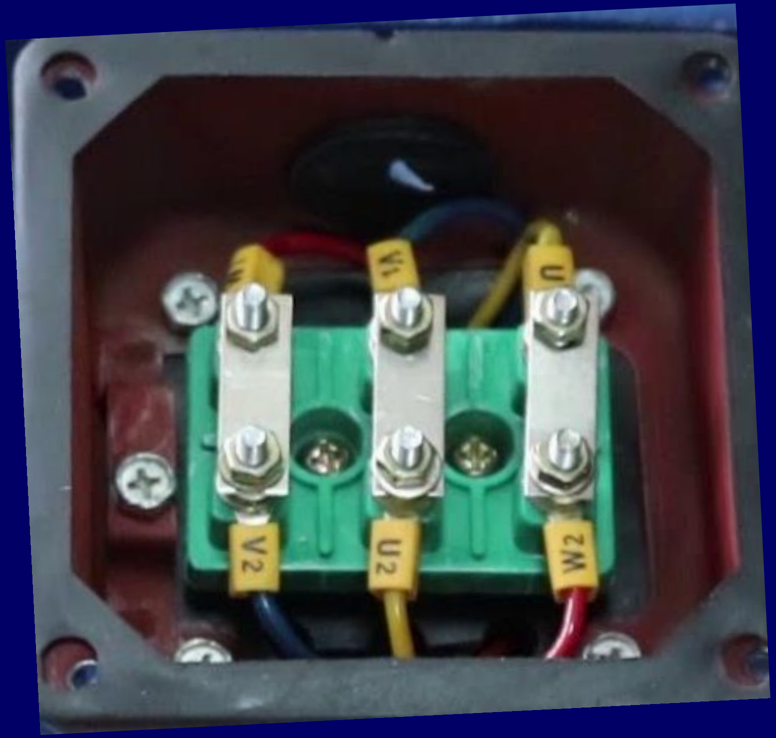



3 phase
supply
400V
50Hz
U
1
W
2
V2
V1
W
1
U
2

Terminal box linked for Delta

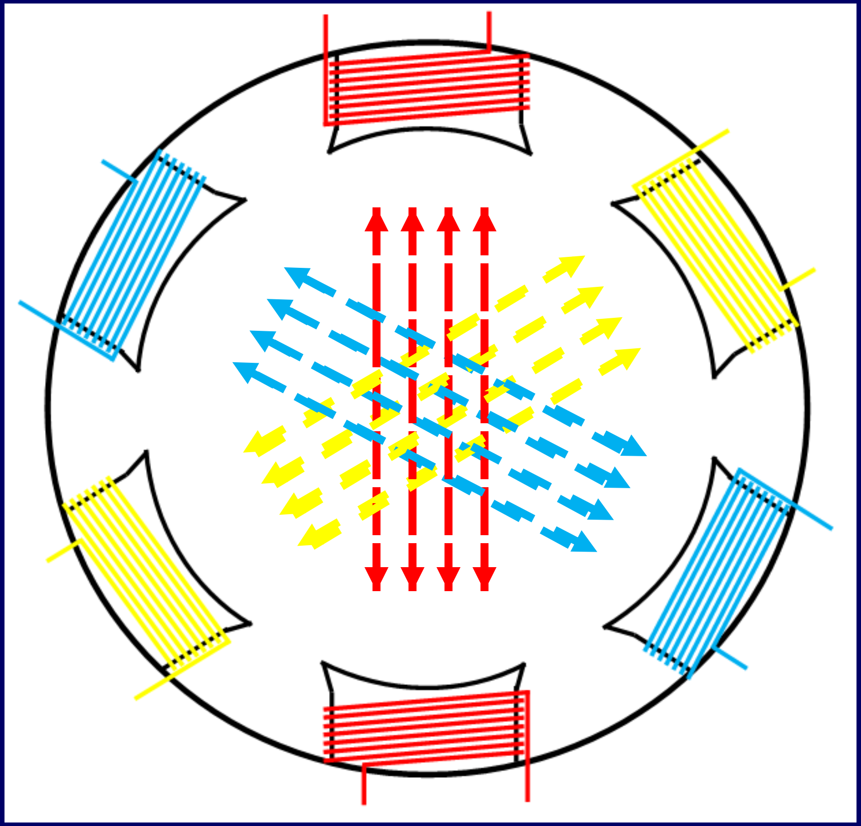


Motor Links



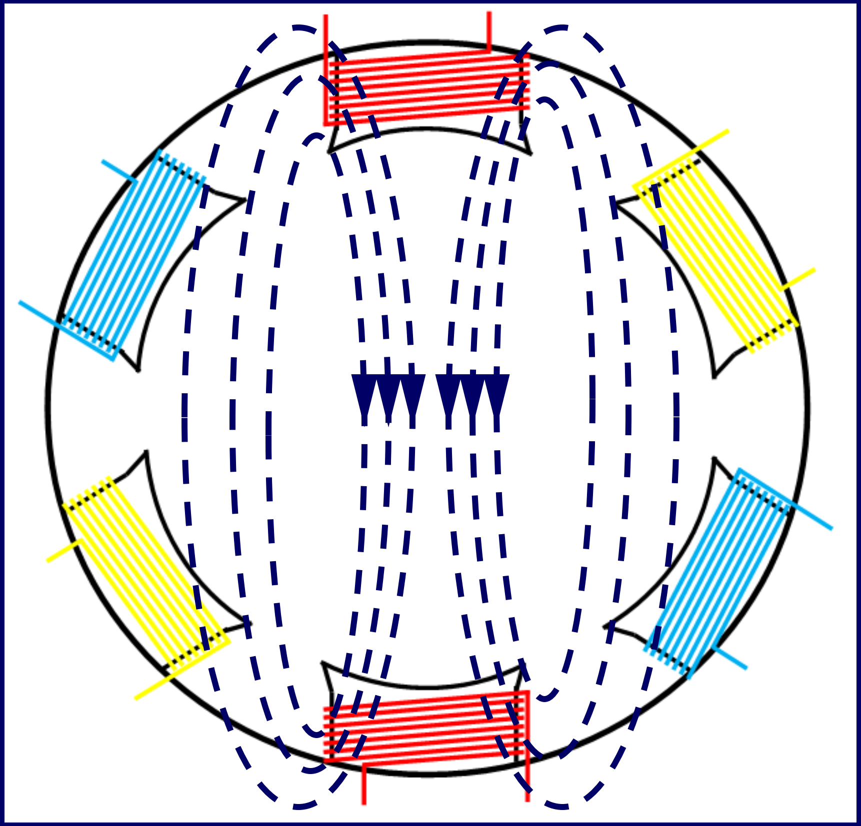
DELTA
CONNECTED

Three Phase Stator Windings



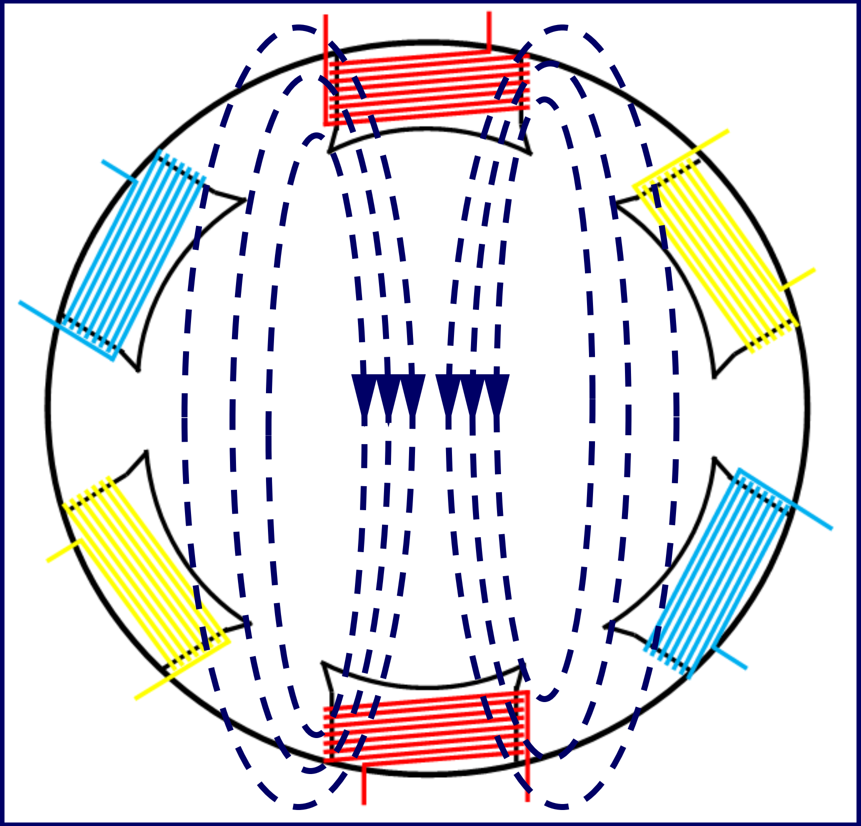
With the three windings now configured for STAR or DELTA we can create pole faces that concentrate the magnetic fields as each phase peaks

Three Phase Stator Windings



The magnetic field will adopt the standard pattern created by a solenoid and due to phase rotation, it will appear to rotate

Three Phase Stator Windings

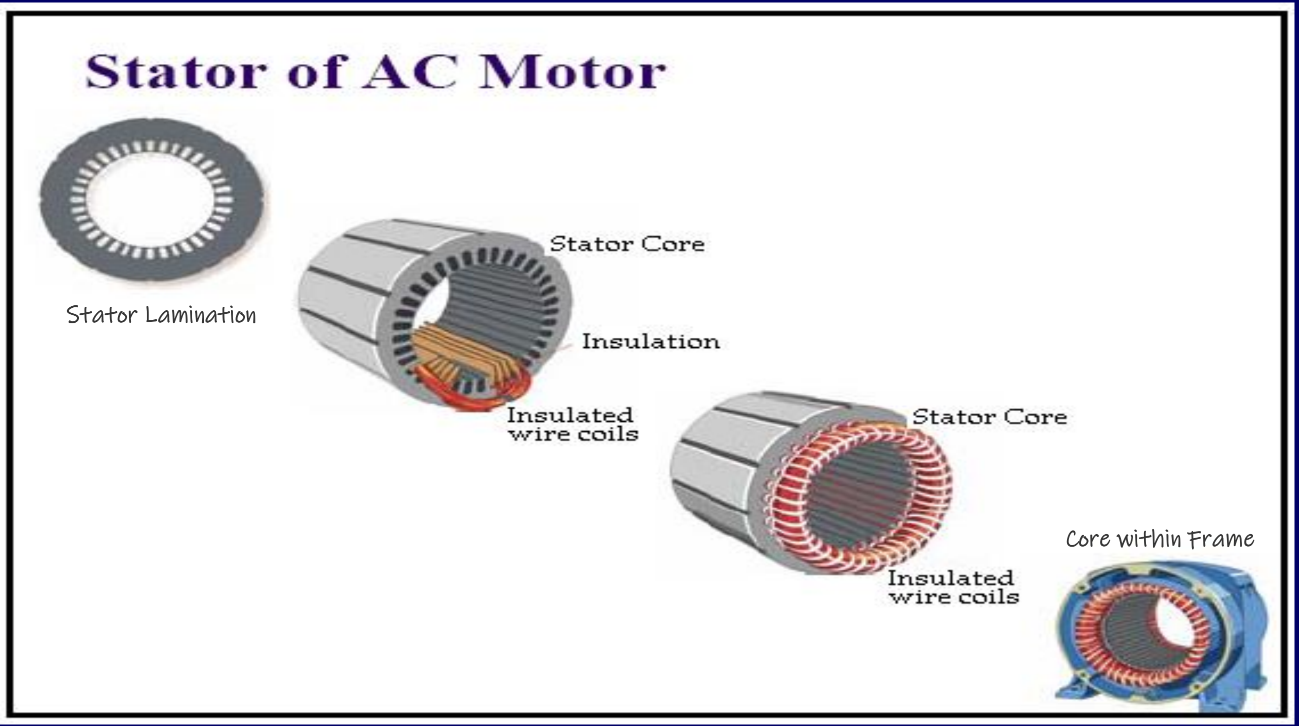


The magnetic field will adopt the standard pattern created by a solenoid and due to phase rotation, it will appear to rotate

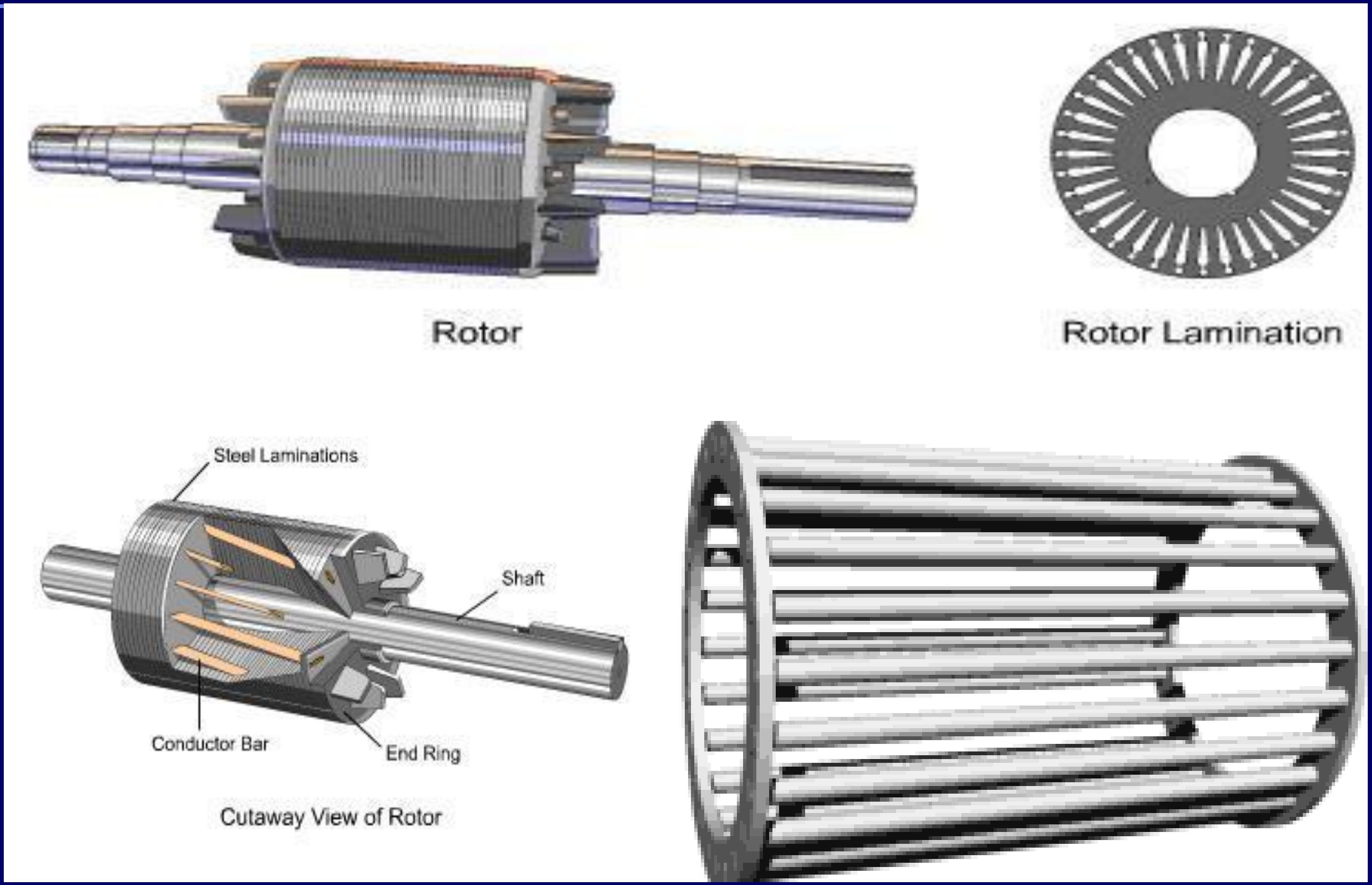
UK once every 20 milliseconds (50Hz)

AC Cage Induction Motor

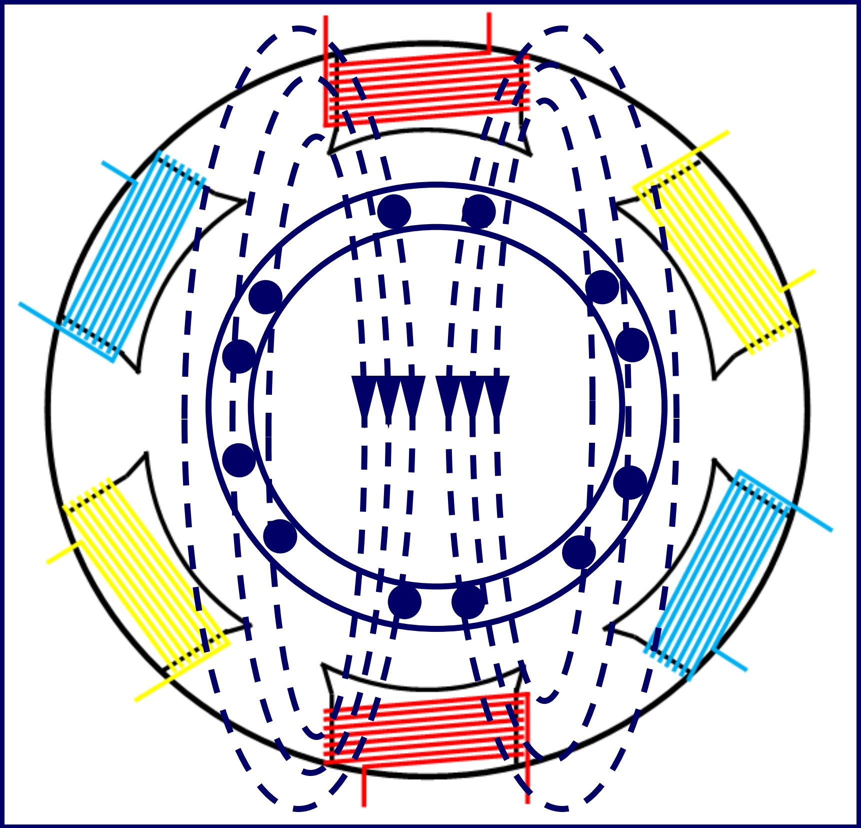
This machine uses the same basic principles of motors but also utilises some of the technology of generators and is essentially consisting of two main parts.



AC Cage Induction Motor

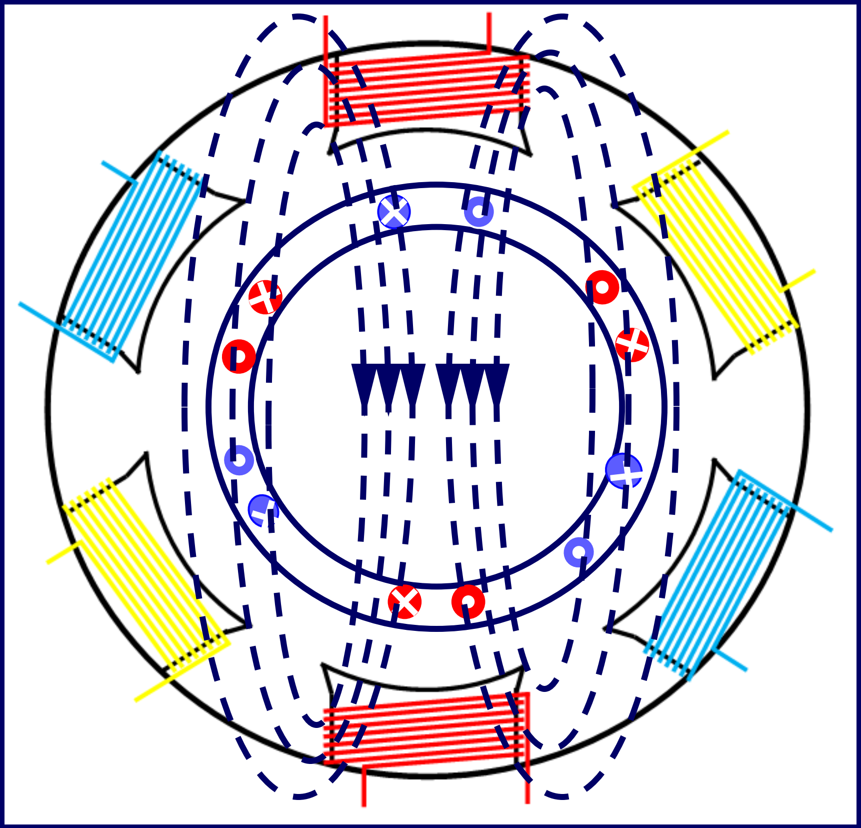


Induction into Rotor



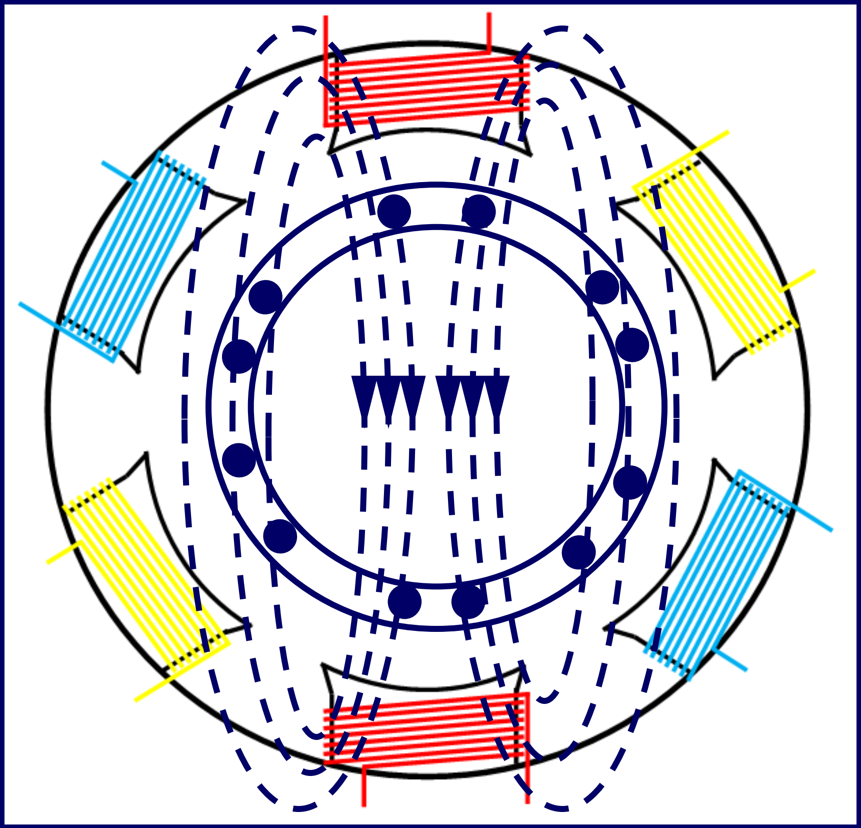
If we now place the cage rotor inside the rotating field of the stator that rotating field will induce a current into the bars of the cage as they are closed loops

Induction into Rotor



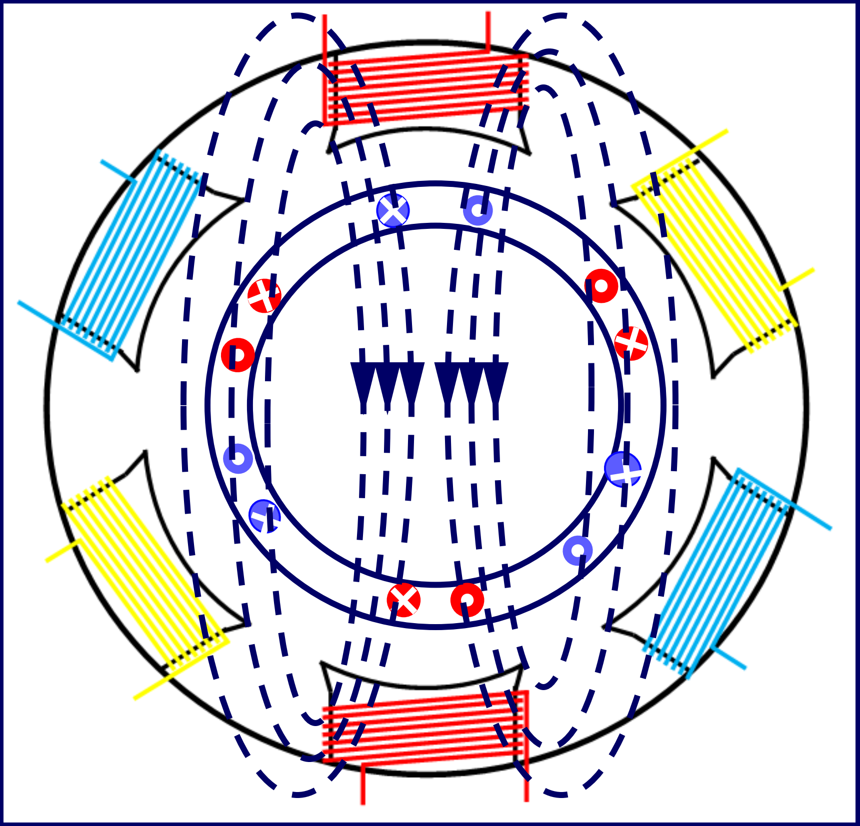
These individual loop currents will create their own fields which will try to lock on to the rotating stator field therefore the rotor will rotate in the direction of the rotating field

Induction into Rotor



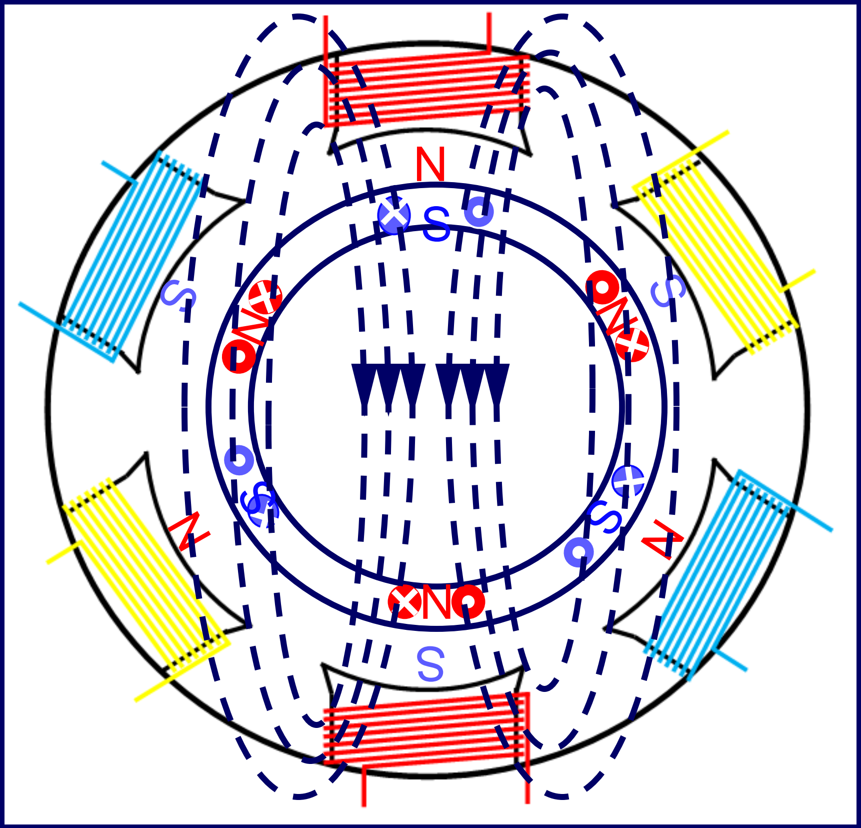
If the rotor catches up to the stator, they will become **synchronous**, and no current will be induced into the rotor bars, and it will slow down

Induction into Rotor



The slowing down of the Rotor speed to less than the Stator field speed re induces current into the Rotor bars and the motor would speed up again

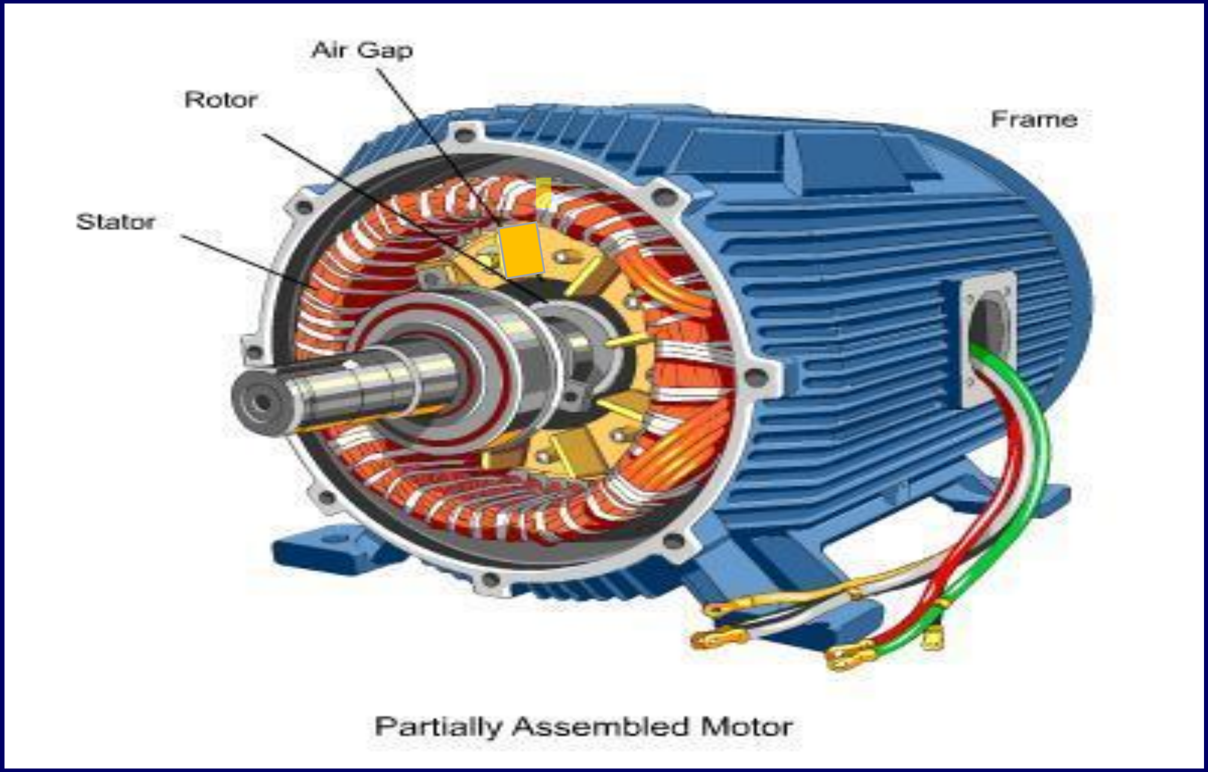
Induction into Rotor



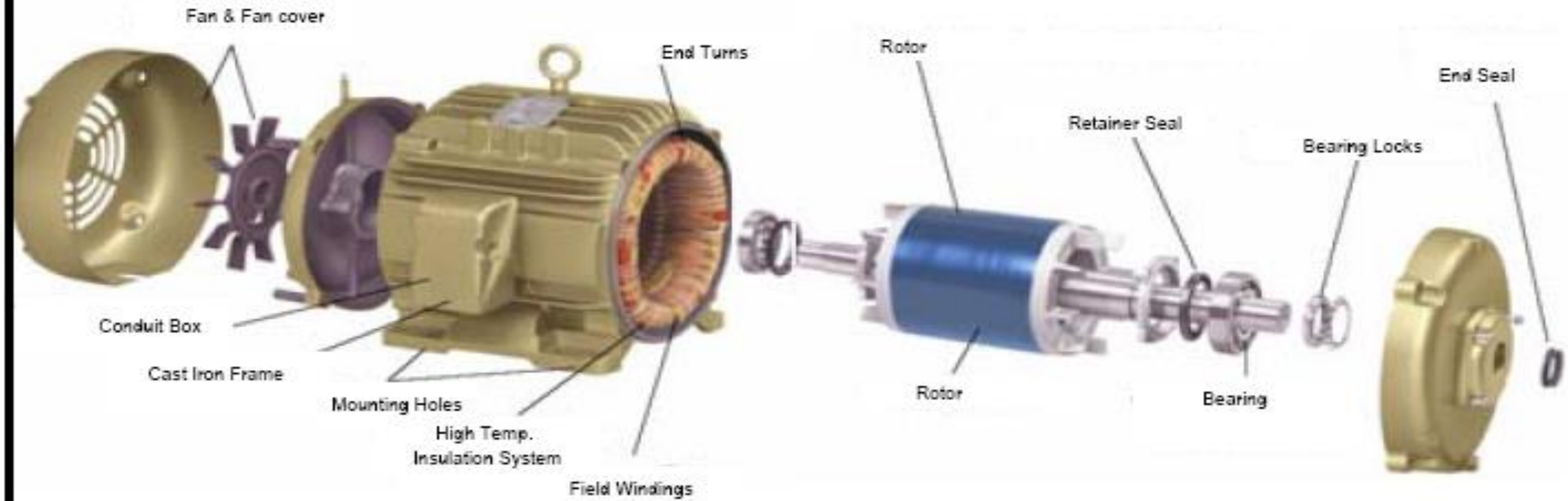
We clearly don't want the motor speeding up and slowing down so the Rotor is designed to run at slip speed (*asynchronous*) so, there is always interaction between the Rotor and the Stator

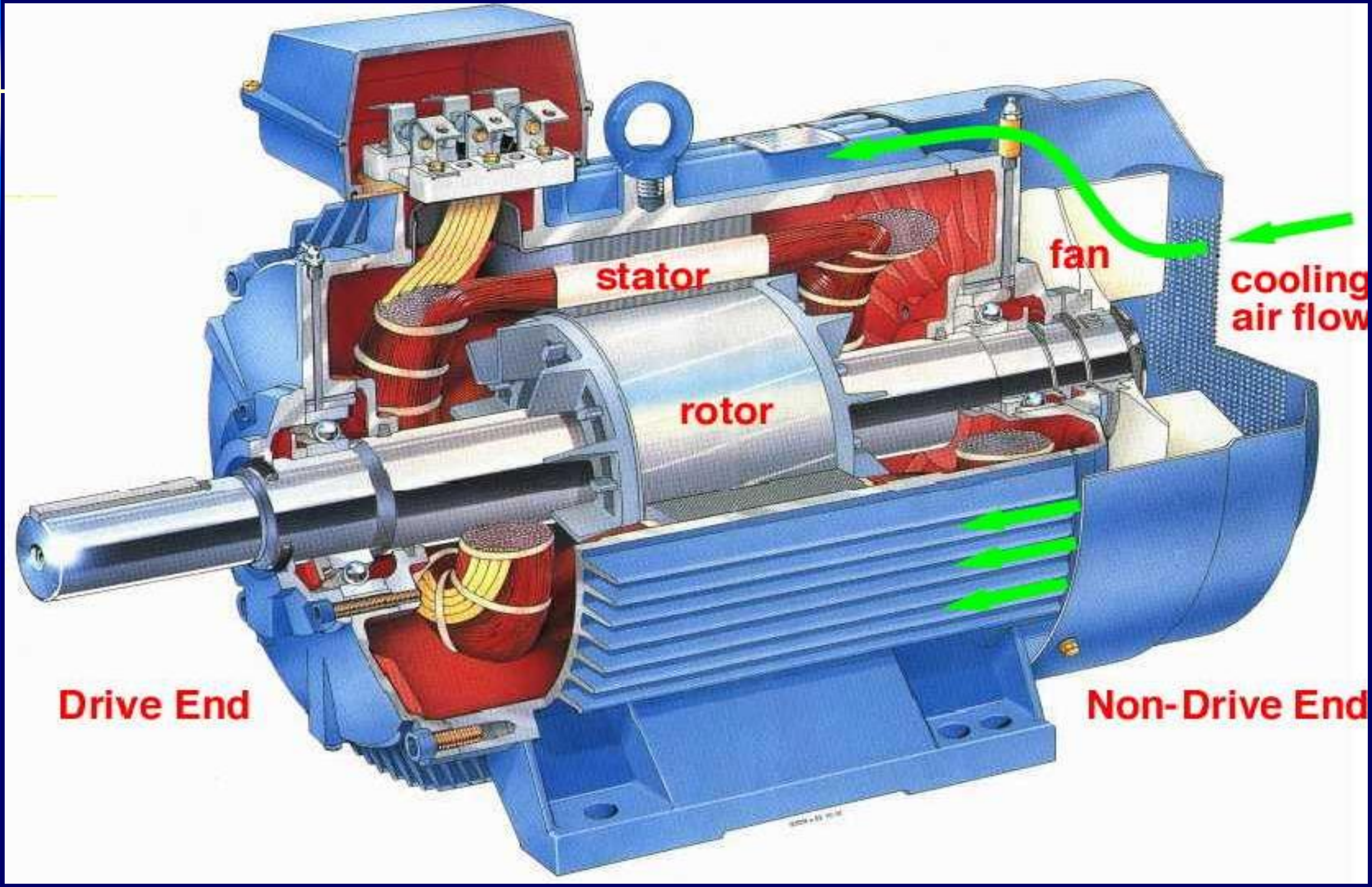
Three Phase AC Motor

- It has three pairs of electromagnets, connected to each of the three phases of the power supply.
- It provides a lot higher power that a single-phase motor can deliver.

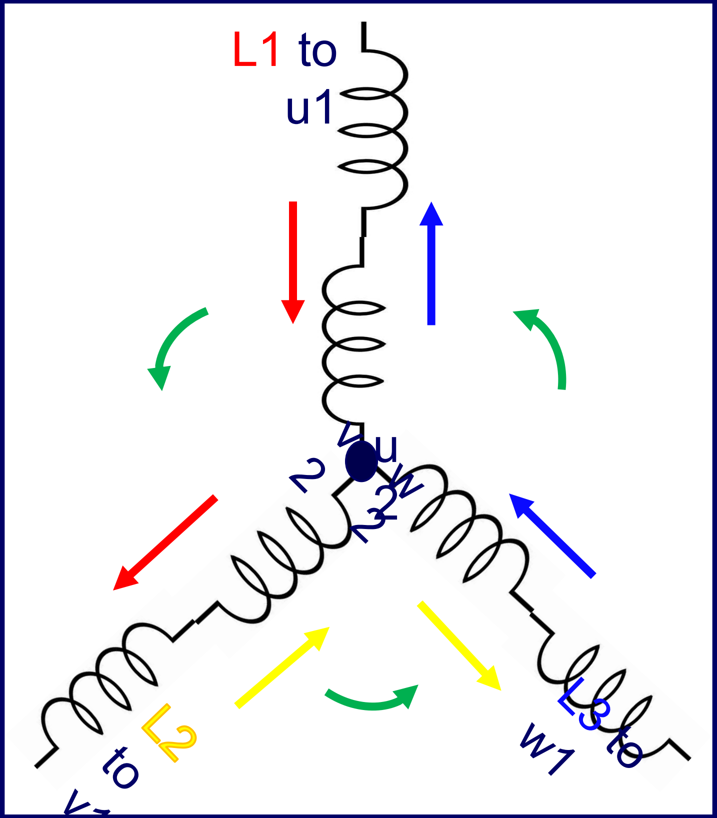


Parts of AC Motor

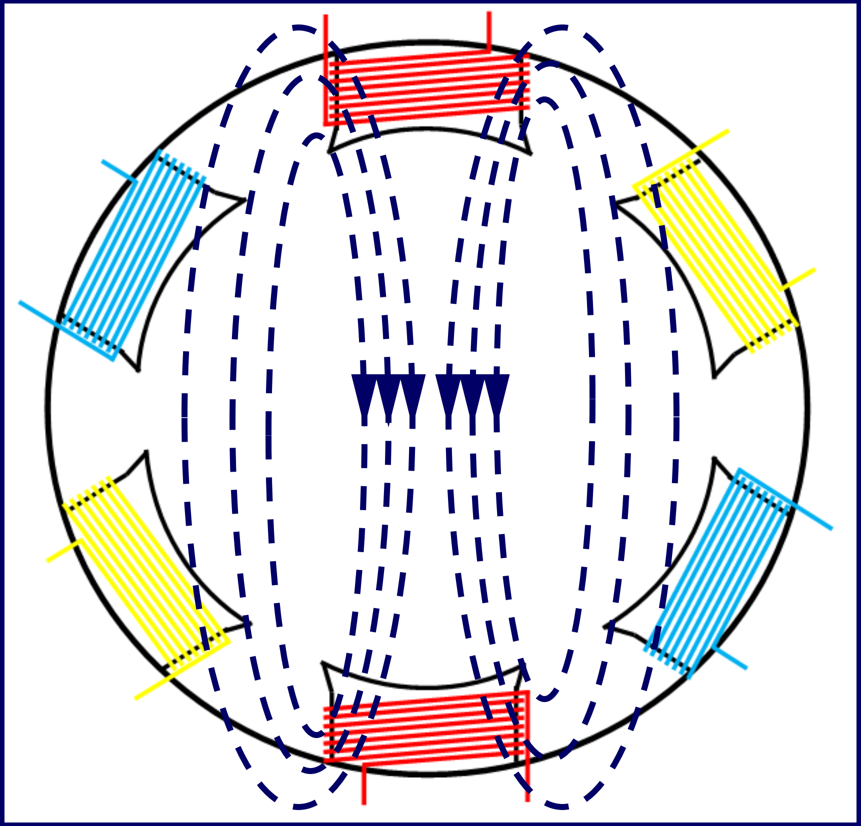



stator
fan
cooling
air flow
rotor
Drive End
Non-Drive End

Phase Rotation

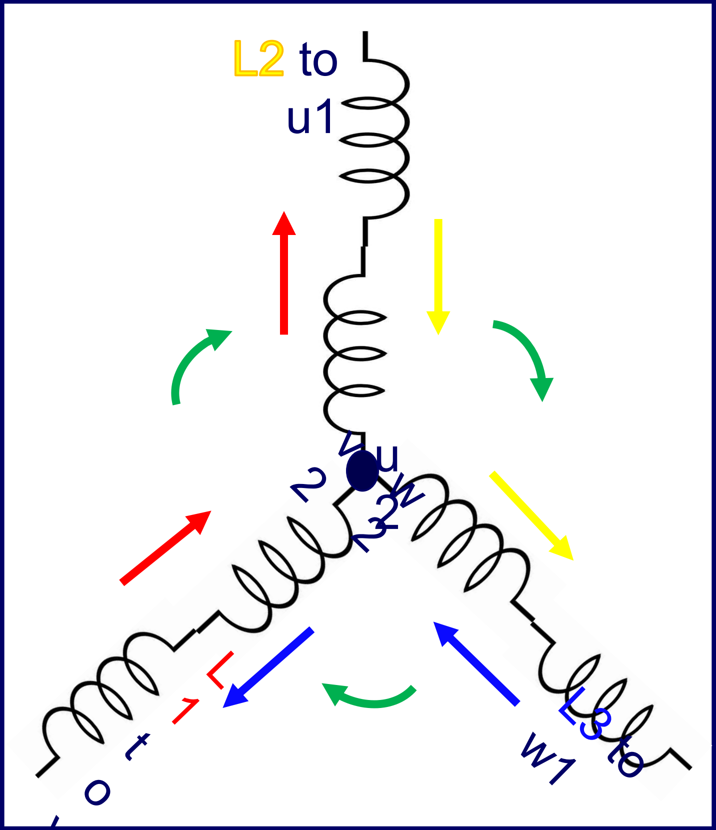


Phase Rotation

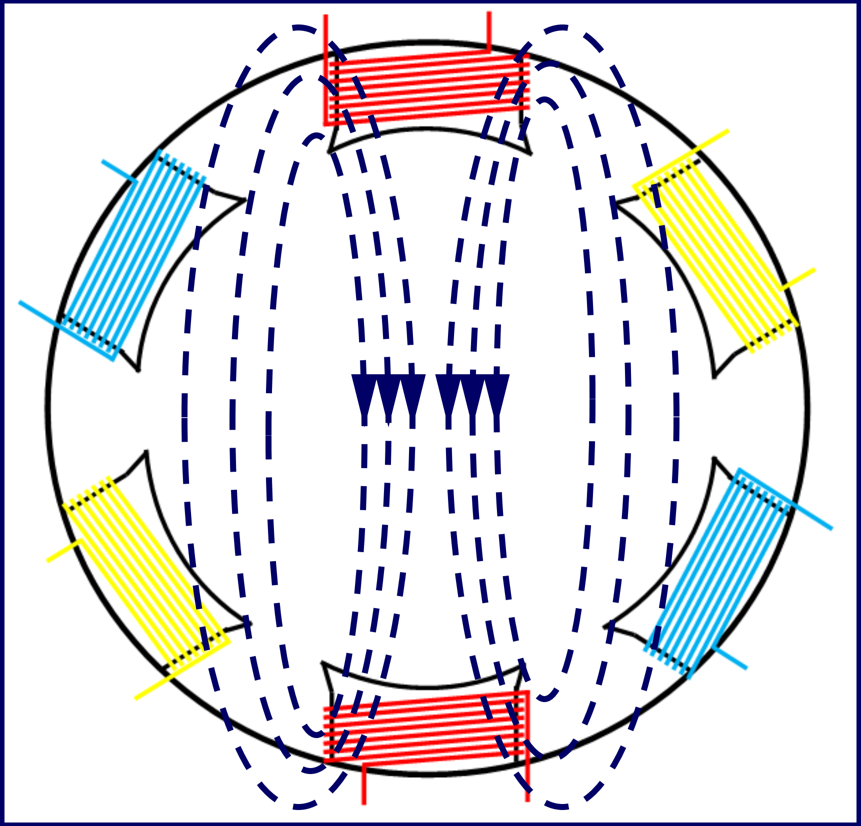


In this configuration the stator field will rotate in an Anticlockwise direction

Phase Rotation reversal



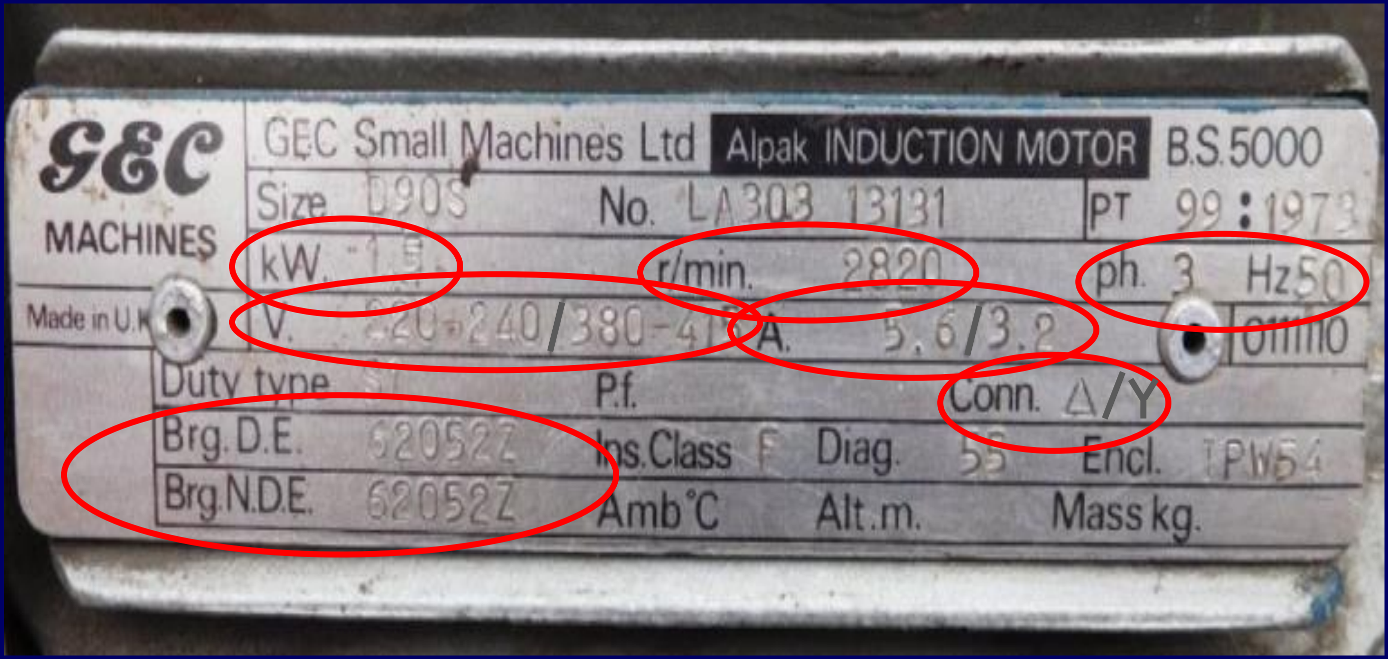
Phase Rotation reversal



With any two input phases swapped, the Stator field will now rotate in a Clockwise direction

AC Motor Data Plate

Each motor has a plate mounted on its frame, with electrical mechanical and thermal information.

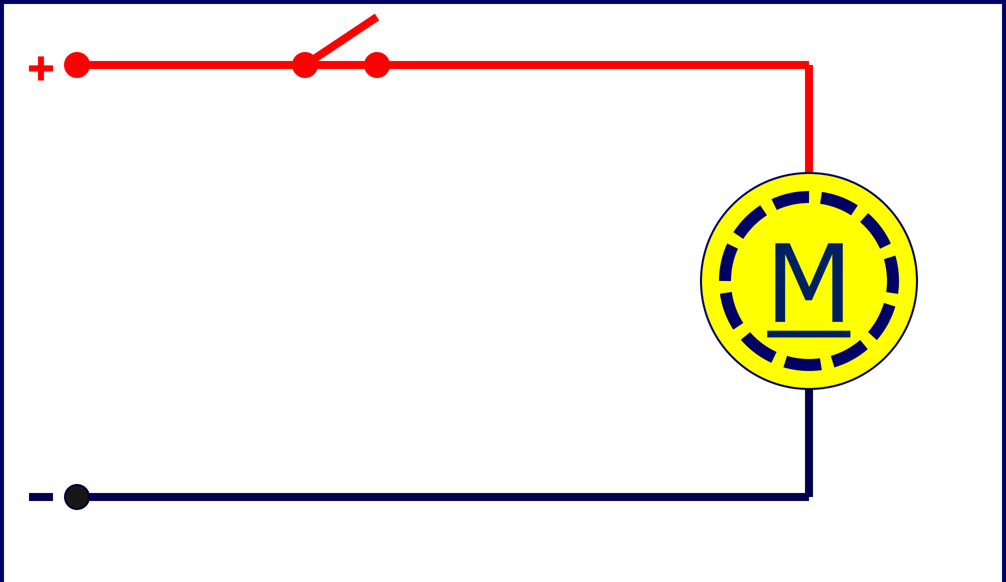


Motor Control
Direct Online

DOL

Motor Control

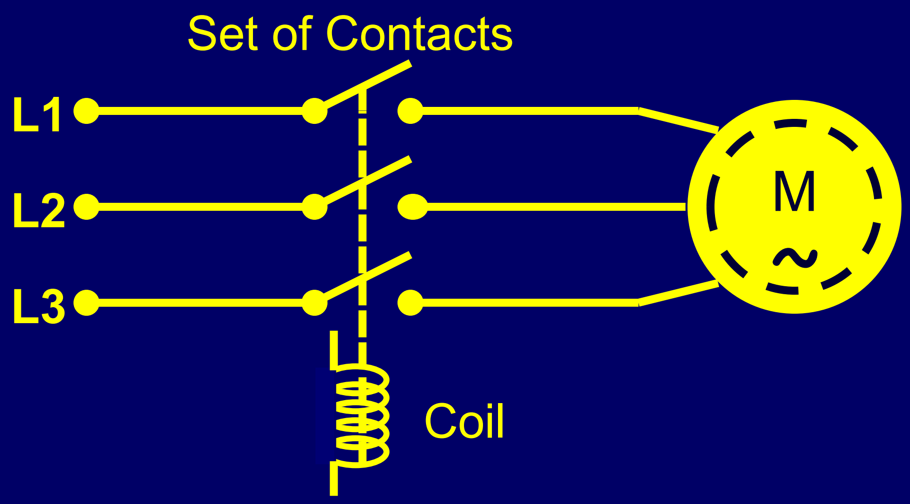
All electric motors require some form of starting method



In this DC case a simple switch would suffice

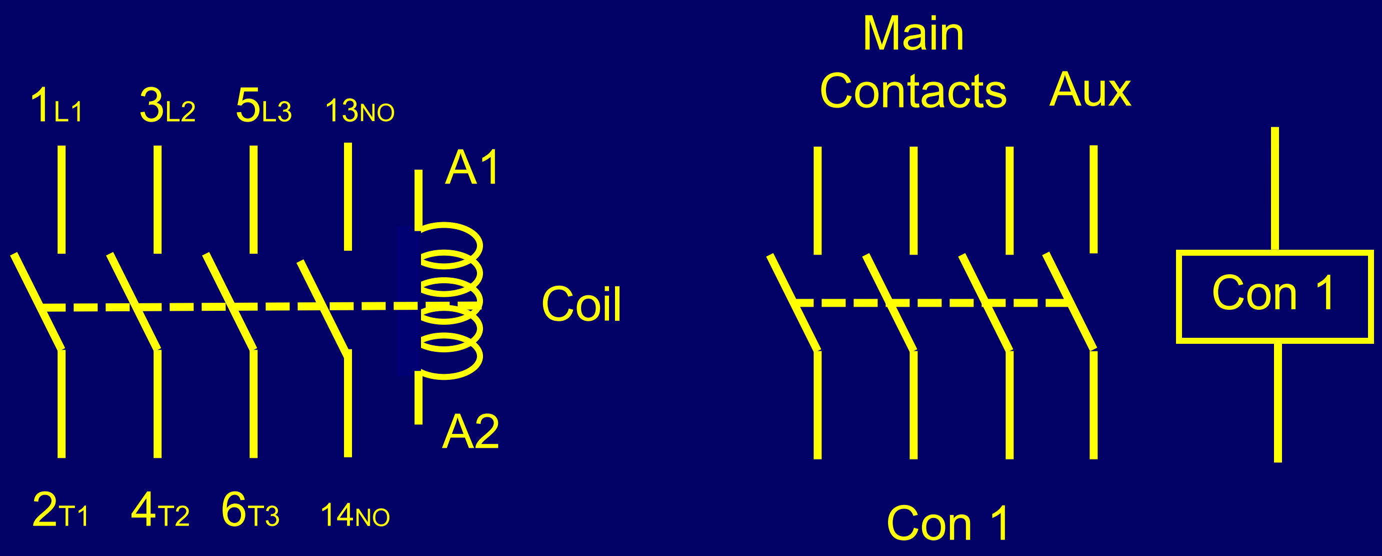
Three Phase AC Motor

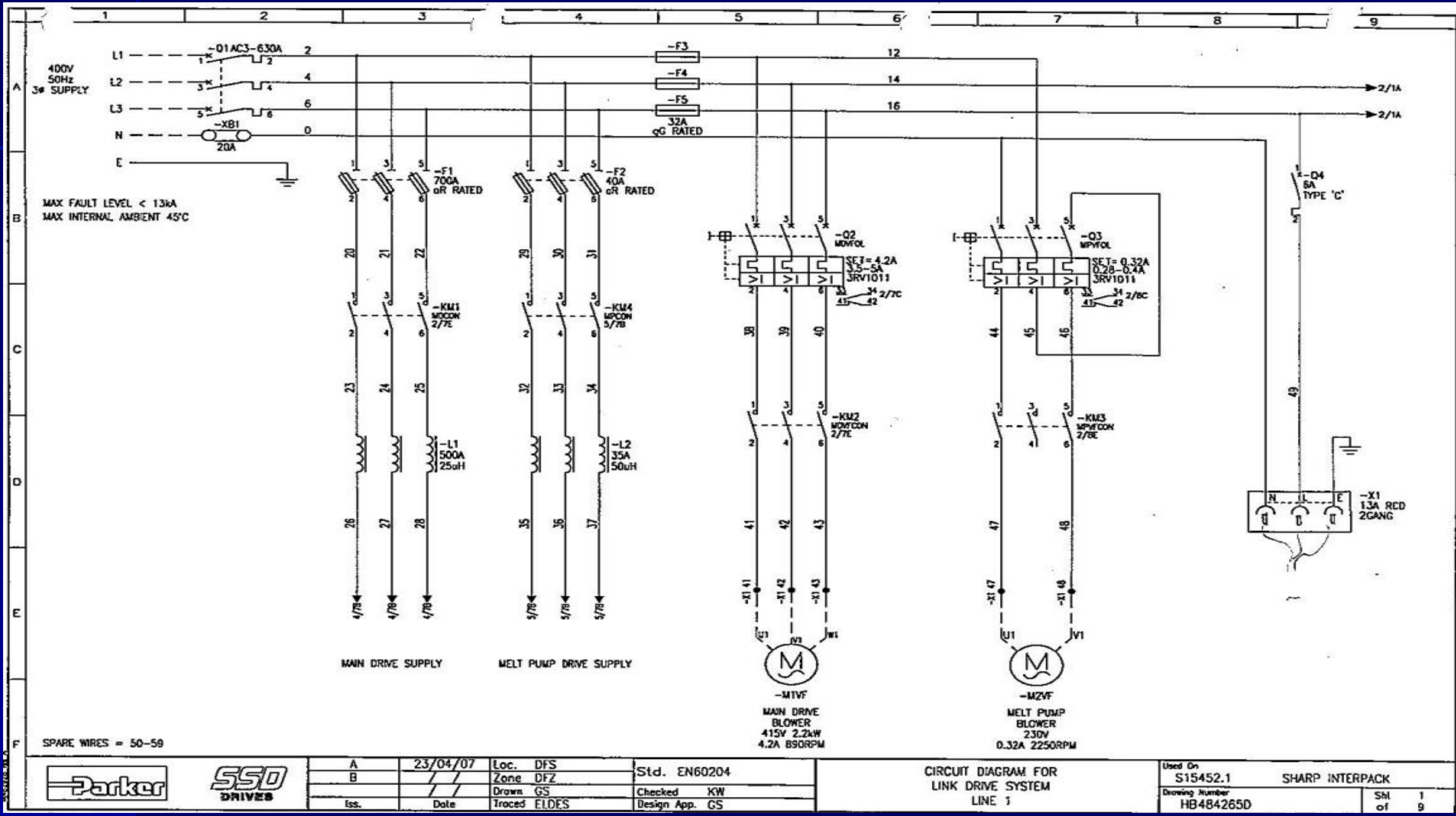
With a three-phase motor we need to switch all three live Lines on at the same time

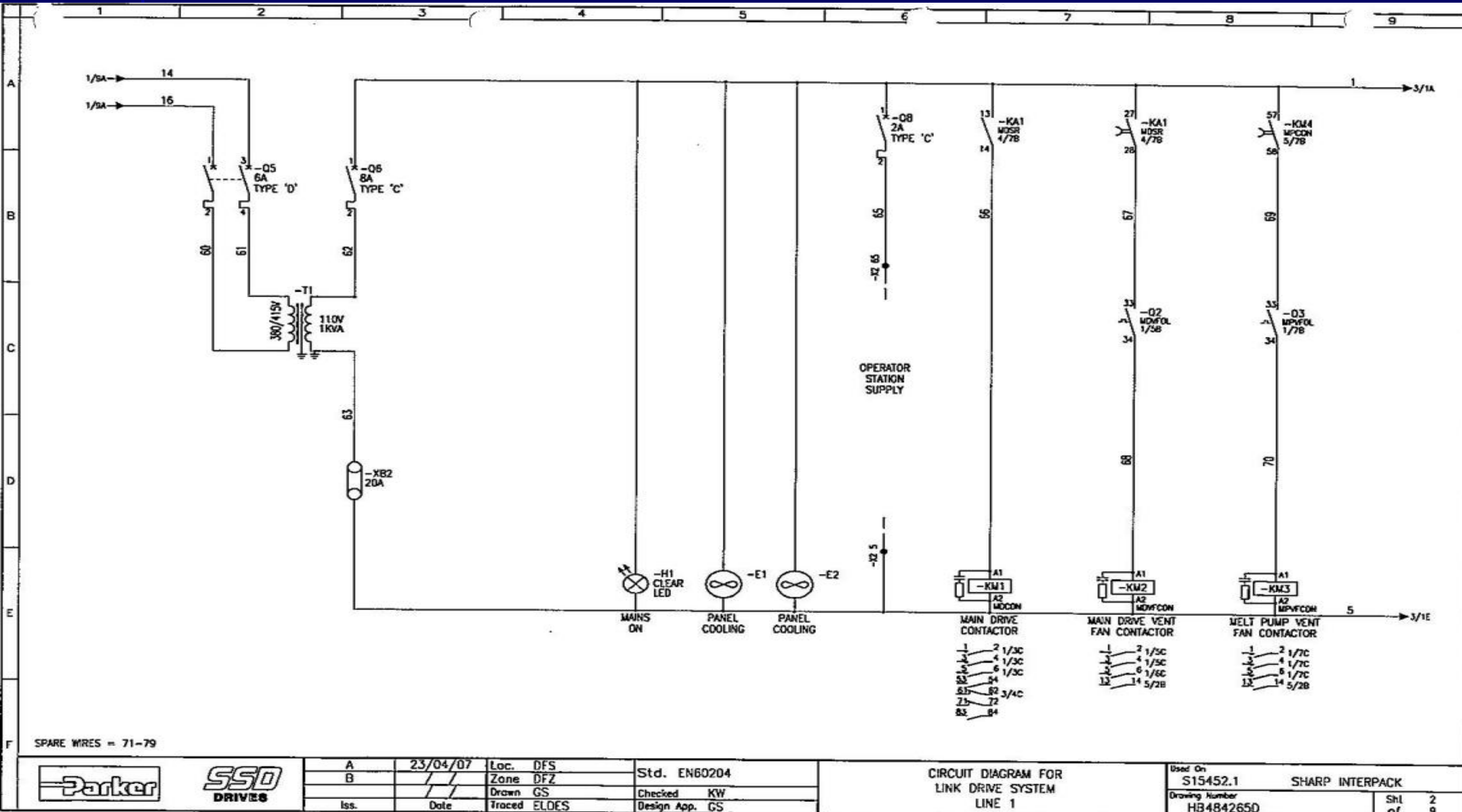


For this we can use a component called a CONTACTOR , this is an electrically controlled switch and consists of two main parts

Contactor Circuit Symbols

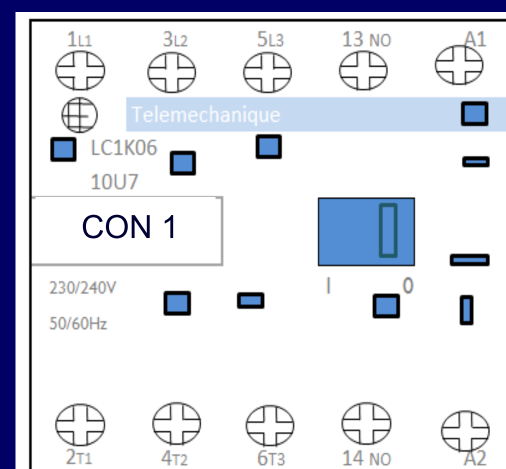



400V
50Hz
3ø SUPPLY
-Q1 AC3-630A
-XB1
20A
-F3
-F4
-F5
32A
gG RATED
MAX FAULT LEVEL < 13kA
MAX INTERNAL AMBIENT 45°C
-F1
700A
aR RATED
-F2
40A
aR RATED
-Q2
-Q3
-Q4
6A
TYPE 'C'
-KM1
-KM4
-KM2
-KM3
-L1
500A
25uH
-L2
35A
50uH
-X1
13A RCD
2GANG
MAIN DRIVE SUPPLY
MELT PUMP DRIVE SUPPLY
-M1VF
MAIN DRIVE
BLOWER
415V 2.2kW
4.2A 890RPM
-M2VF
MELT PUMP
BLOWER
230V
0.32A 2250RPM
SPARE WIRES = 50-59
Parker
SSD DRIVES
23/04/07
Loc. DFS
Zone DFZ
Drawn GS
Traced ELDES
Std. EN60204
Checked KW
Design App. GS
CIRCUIT DIAGRAM FOR
LINK DRIVE SYSTEM
LINE 1
S15452.1
SHARP INTERPACK
HB484265D


-Q5
6A
TYPE 'D'
-Q6
8A
TYPE 'C'
-T1
380/415V
110V
1KVA
-XB2
20A
-Q8
2A
TYPE 'C'
-KA1
MDSR
4/7B
-KM4
MPCON
5/7B
-Q2
MDVFOL
1/5B
-Q3
MPVFOL
1/7B
OPERATOR
STATION
SUPPLY
-H1
CLEAR
LED
MAINS
ON
-E1
-E2
PANEL
COOLING
PANEL
COOLING
-KM1
MDCON
MAIN DRIVE
CONTACTOR
-KM2
MDVFCON
MAIN DRIVE VENT
FAN CONTACTOR
-KM3
MPVFCON
MELT PUMP VENT
FAN CONTACTOR
SPARE WIRES = 71-79
Parker
SSD
DRIVES
23/04/07
Iss.
Date
Loc. DFS
Zone DFZ
Drawn GS
Traced ELDES
Std. EN60204
Checked KW
Design App. GS
CIRCUIT DIAGRAM FOR
LINK DRIVE SYSTEM
LINE 1
Used On
S15452.1
SHARP INTERPACK
Drawing Number
HB4842650
Sht 2
of 9

Contactor

The modern contactor has an internal operating coil and a set of spring-loaded main contacts. Some versions have extra contacts integral to the design or as an add on component. These can be either normally open or normally closed, or a combination of both, called Auxiliary contacts.



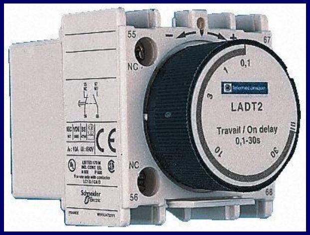
AC Motor Starting Methods

This type of starter configuration is called **Direct Online** and is the simplest most common method of starting motors.

It consists of a contactor to supply the voltage directly through to the motor and some form of overload protection relay to protect the motor from excesses of current during overload situations.

This configuration can be incorporated into one single device or by building modular starters using manufactured , type specific components.

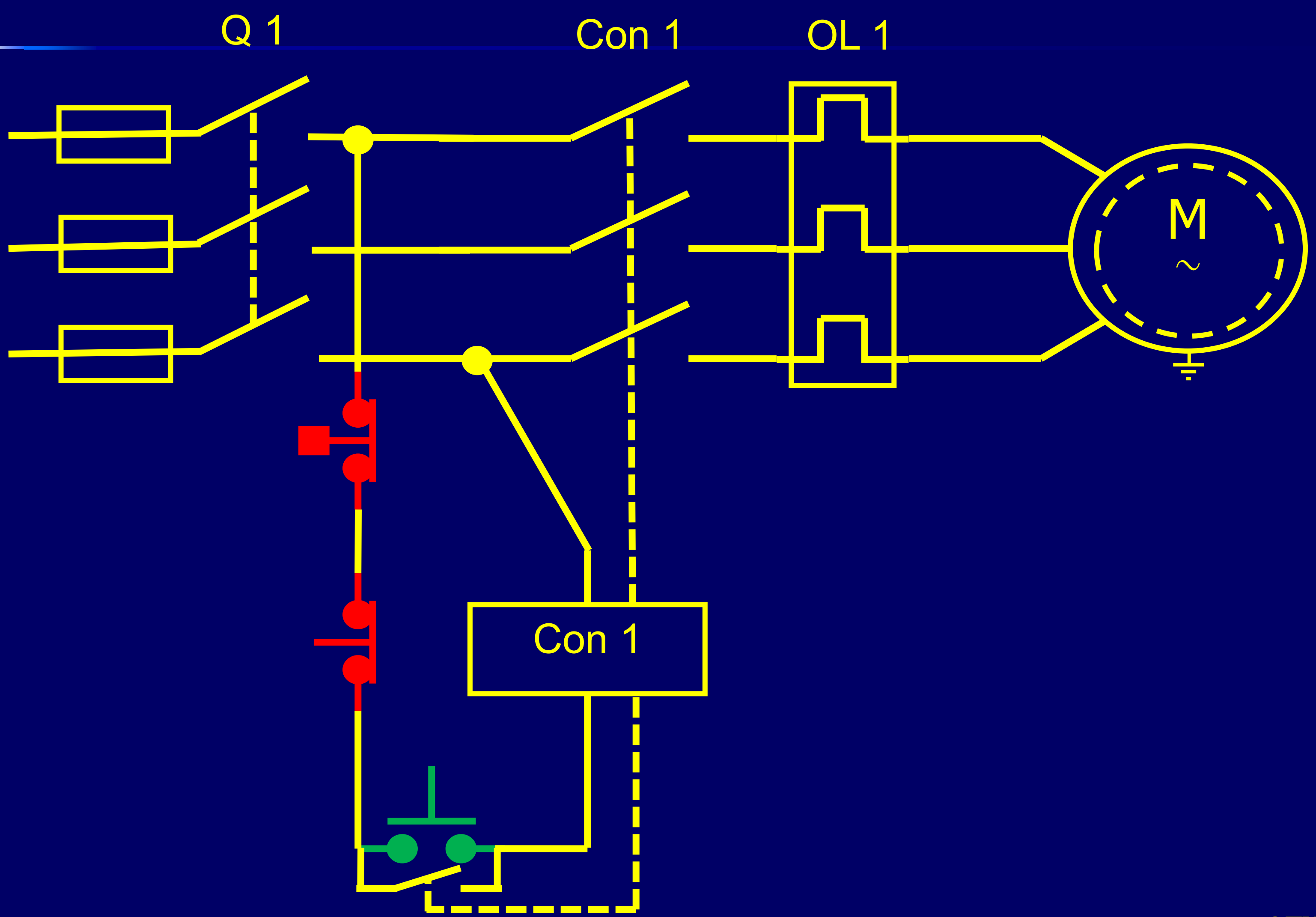


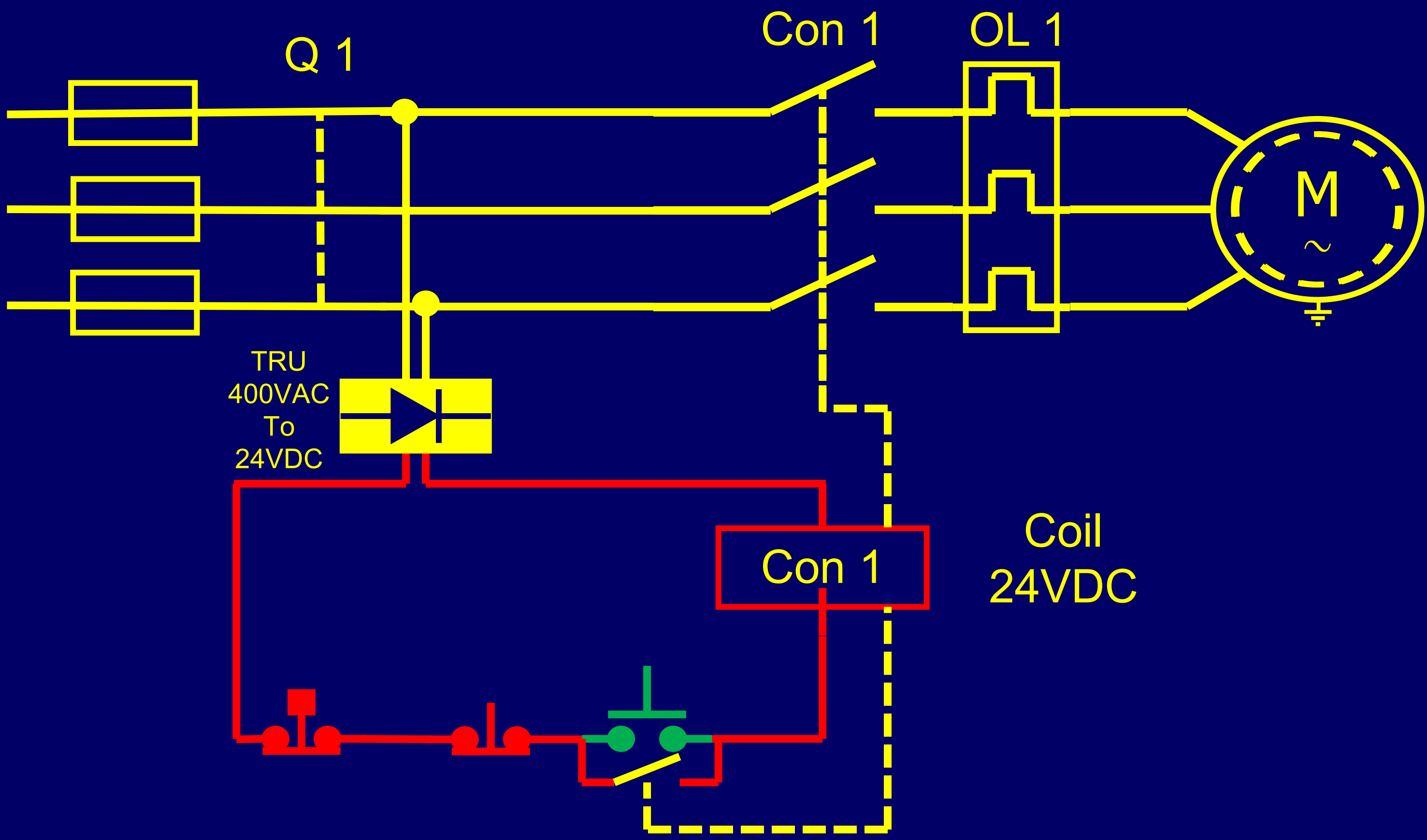
Thermal Overload Relay

The overload is a thermal device and operates in much the same way as the thermal device in an MCB. It connects directly to the Contactor

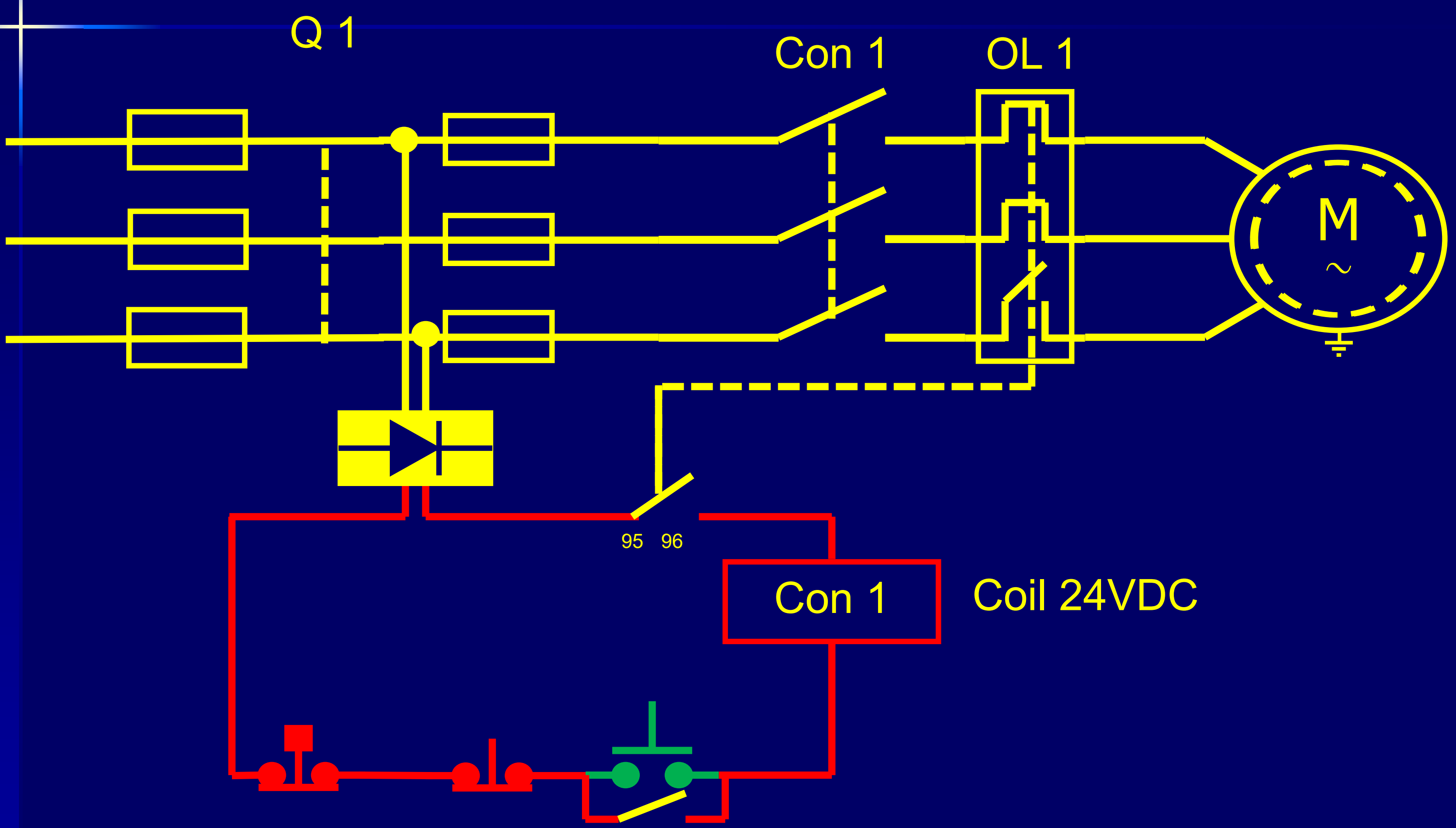
Configuration 400VAC Coil



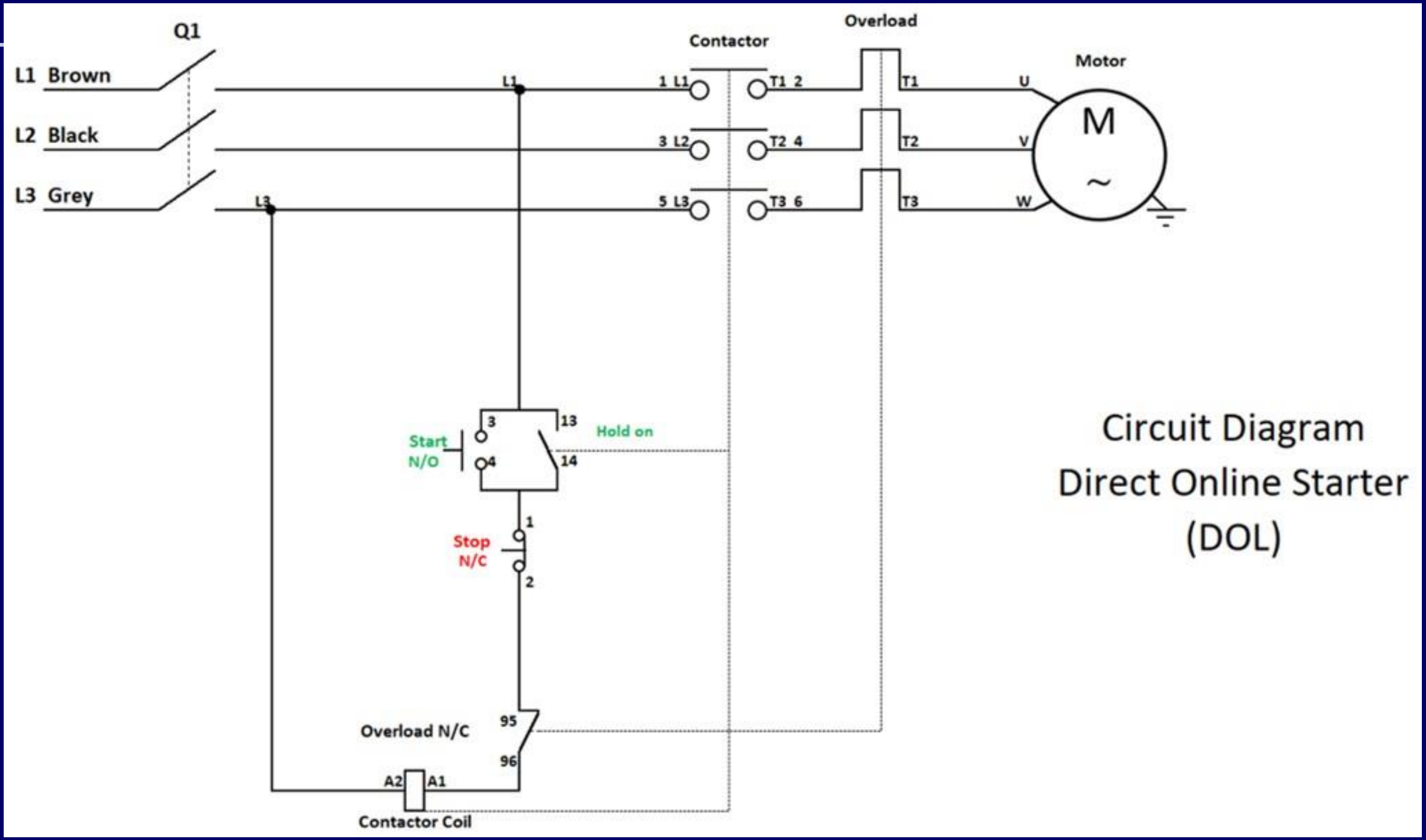
Configuration 24VDC Coil



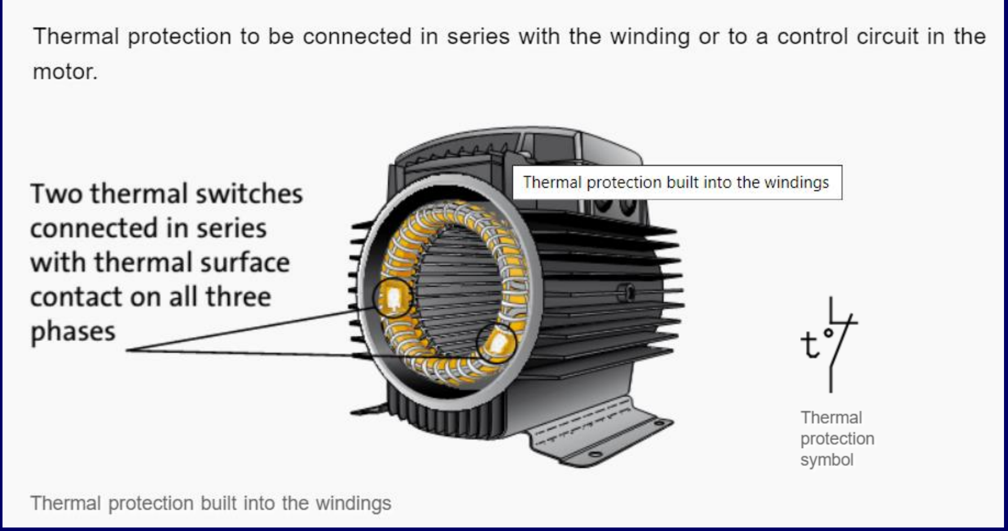
Overload



DOL Circuit Diagram
400V Control



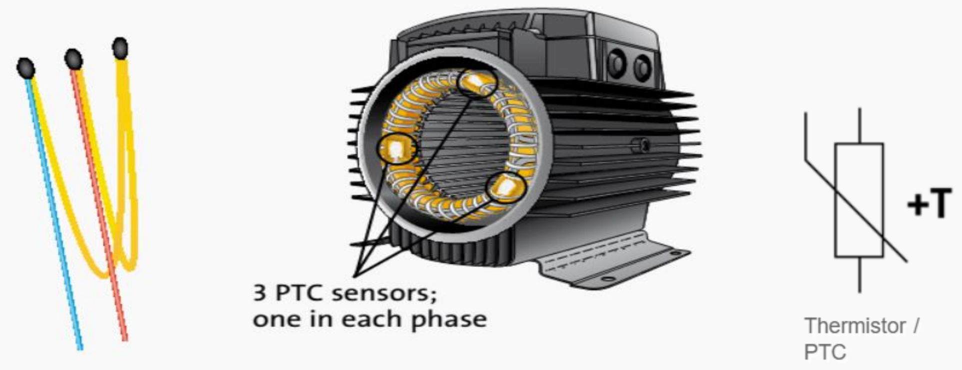
Additional Thermal Protection



Thermal protection built into the windings

Additional Thermal Protection

The thermistor temperature sensing system consists of **positive temperature coefficient sensors (PTC) embedded in series of three** – one between each phase – and a matched solid-state electronic switch in an enclosed control module. A set of sensors consists of three sensors, one per phase.



PTC sensors

PTC protection built into windings

Only temperature sensitive. The thermistor has to be connected to a control circuit, which can convert the resistance signal, which again has to disconnect the motor. Used in three-phase motors.