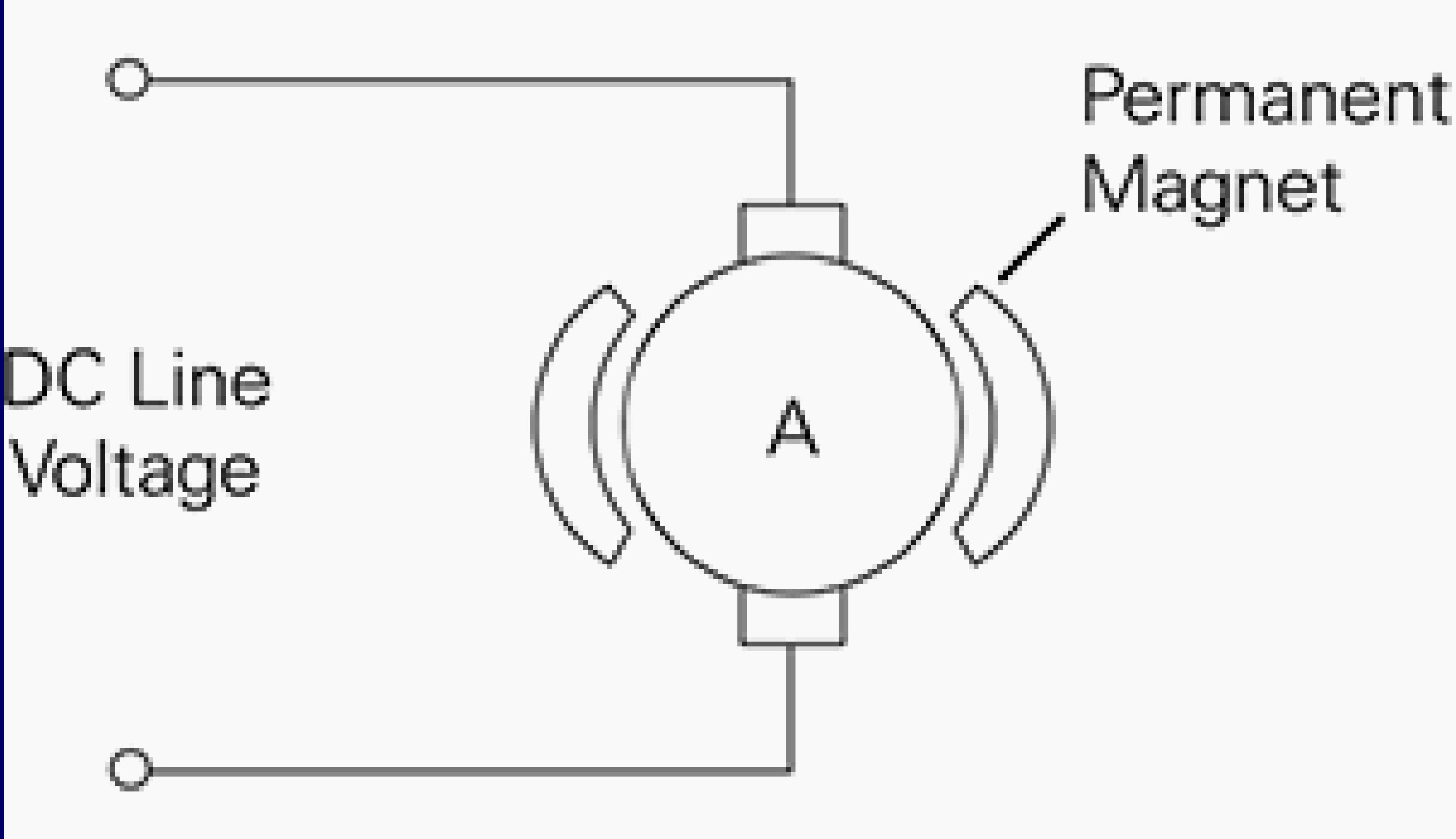
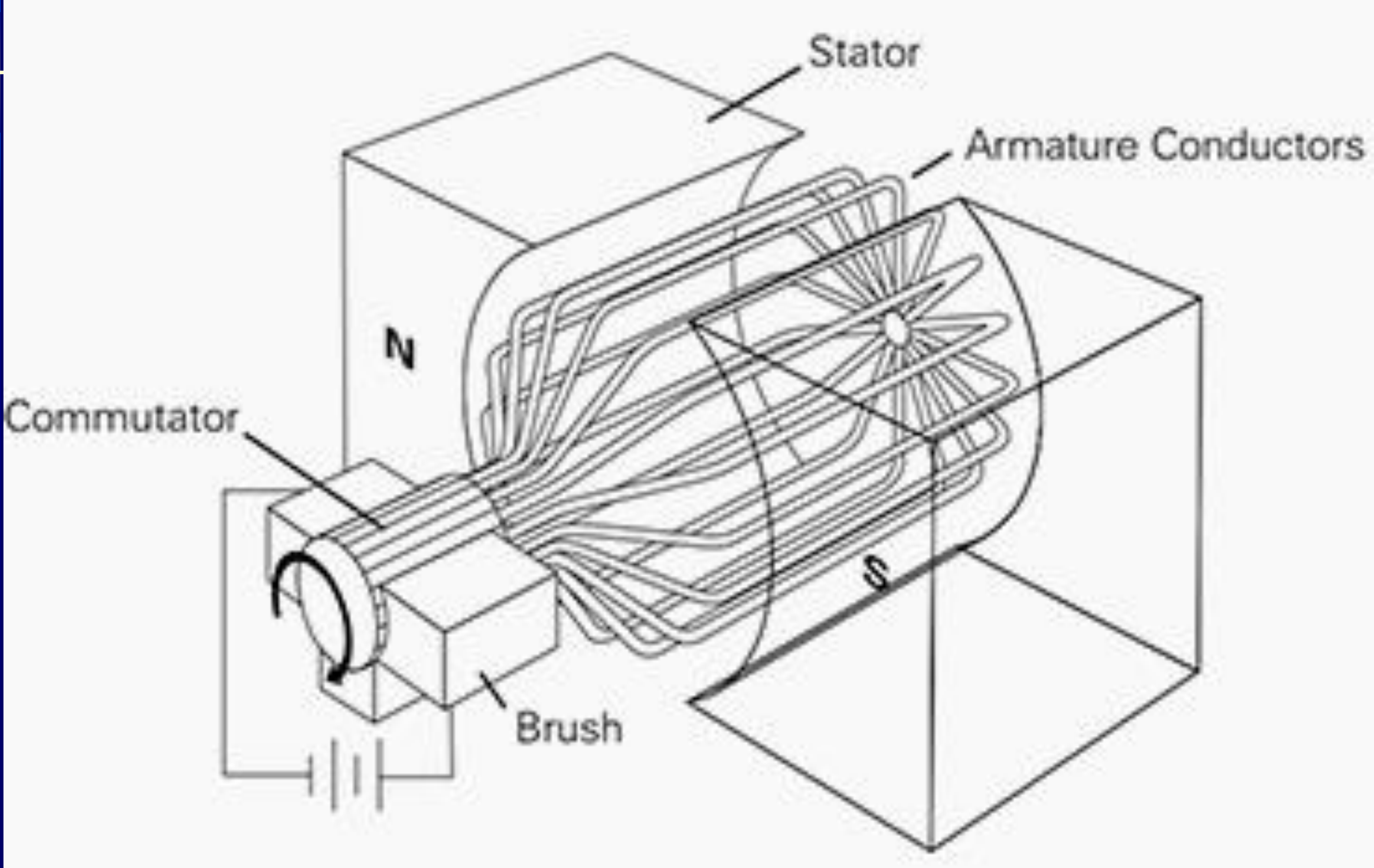
DC Motors

Industrial Electronics
DC Motors
Speed & Torque Control
Utilising 3 Term Closed Loop PID Control

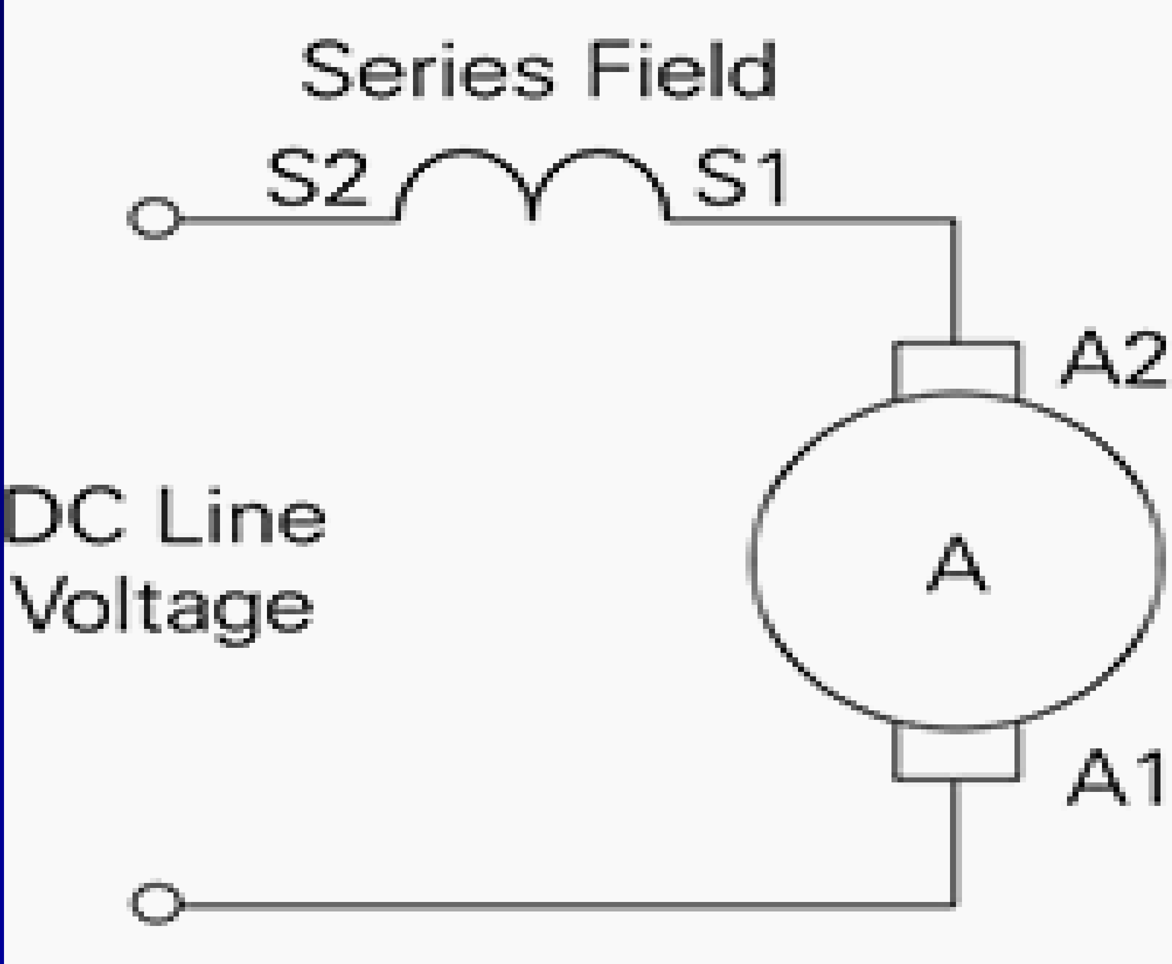
Basic DC Motors



Basic DC Motors



Series Motor

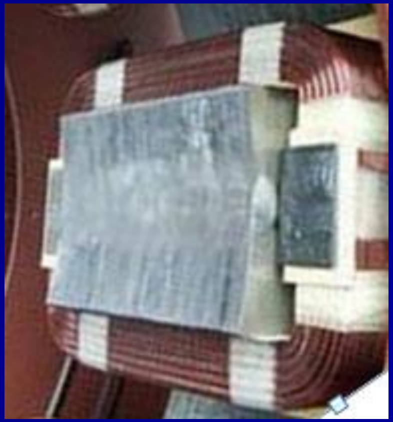


BACK EMF (E)

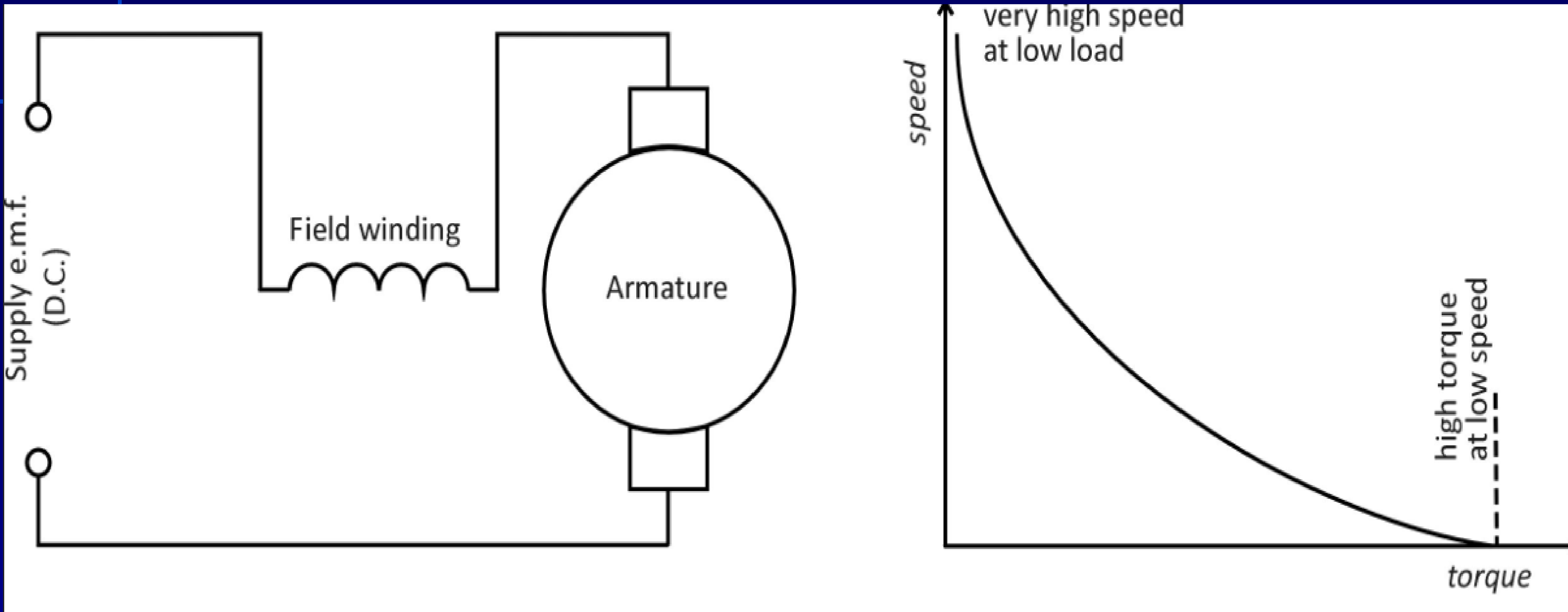
As the Armature windings begin to rotate within the magnetic field of the series winding, a back emf will be produced in opposition to supply voltage

$$V = E_b + I_aR_a$$

Series Motor Windings



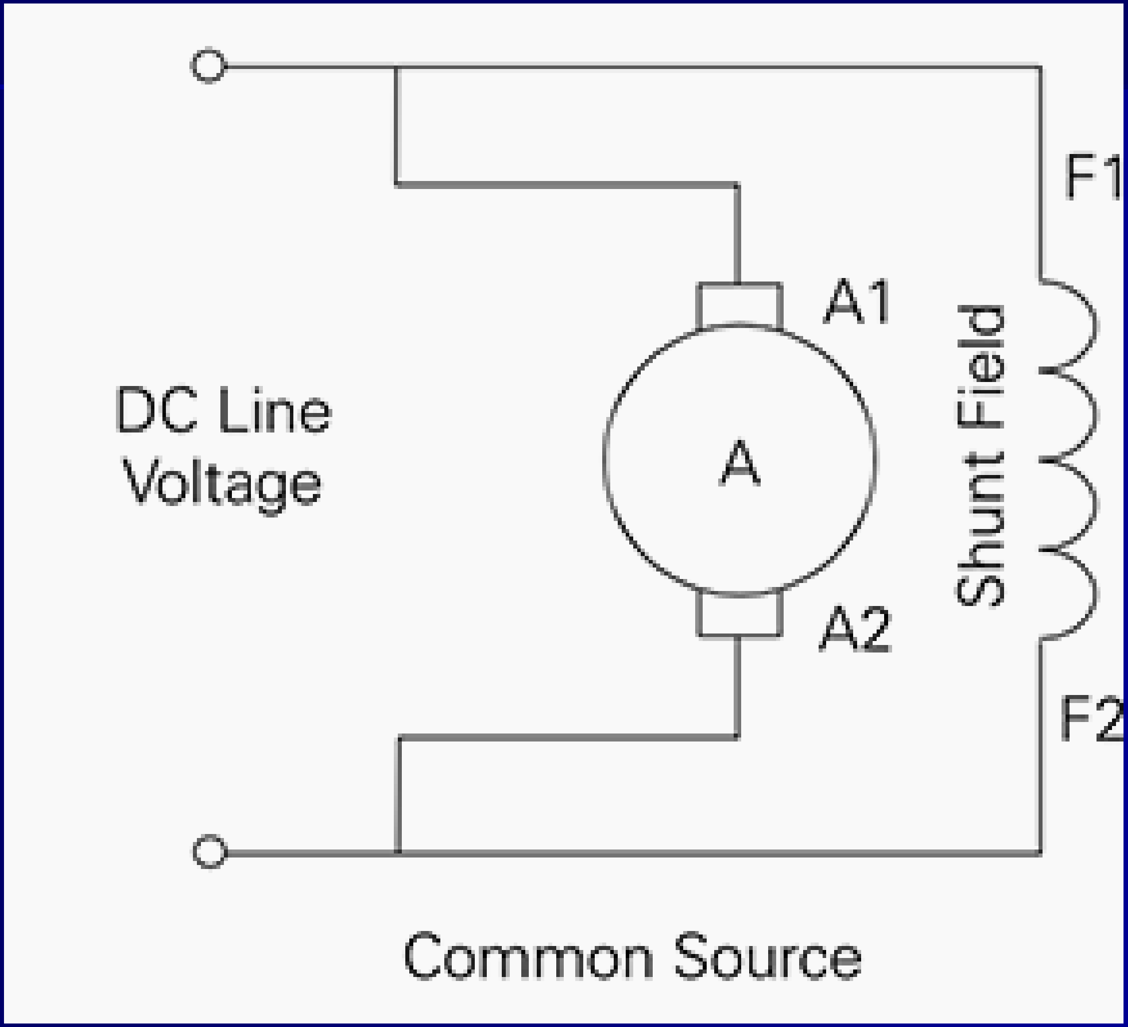
Series Motor Speed/Torque Curve



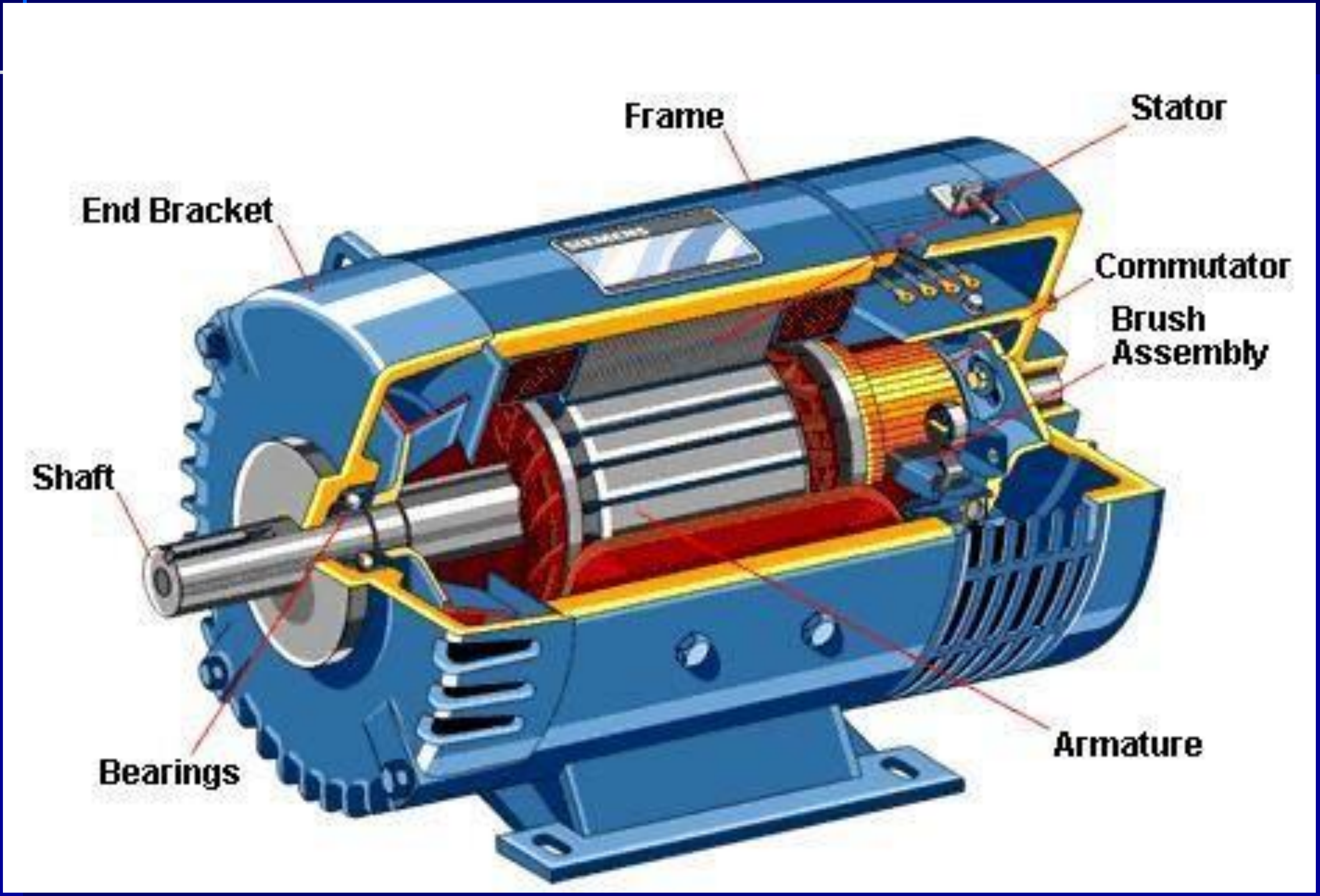
(a): D.C. Series Motor Connection (b): D.C. Series Motor Speed vs Torque

At low speed, the back-e.m.f developed in the armature is very low. This means that the armature (and field) current is very high, limited only by the resistance of the field and armature windings, so at low speeds, the torque is very high. This is an advantage for traction applications. At low loads, the speed can be very high – high enough for the rotor to fly apart. So this type of motor must never be used without some load connected. There is no effective means of speed control of this motor

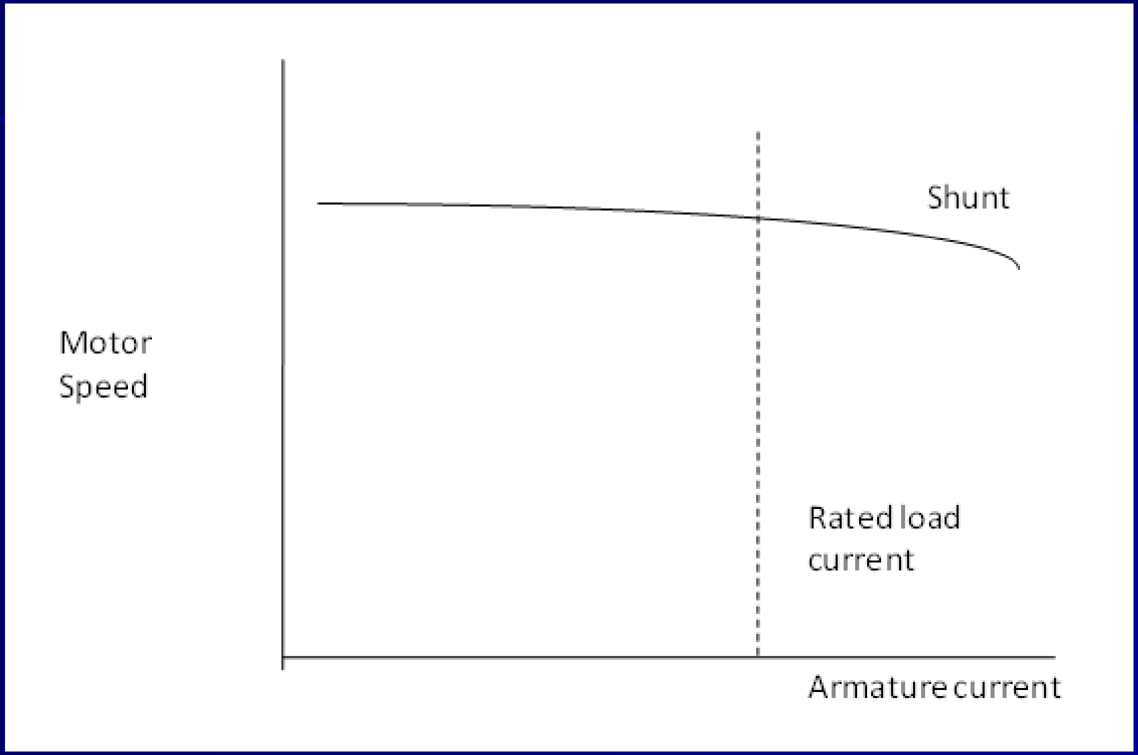
Shunt Motor



Shunt Motor Windings

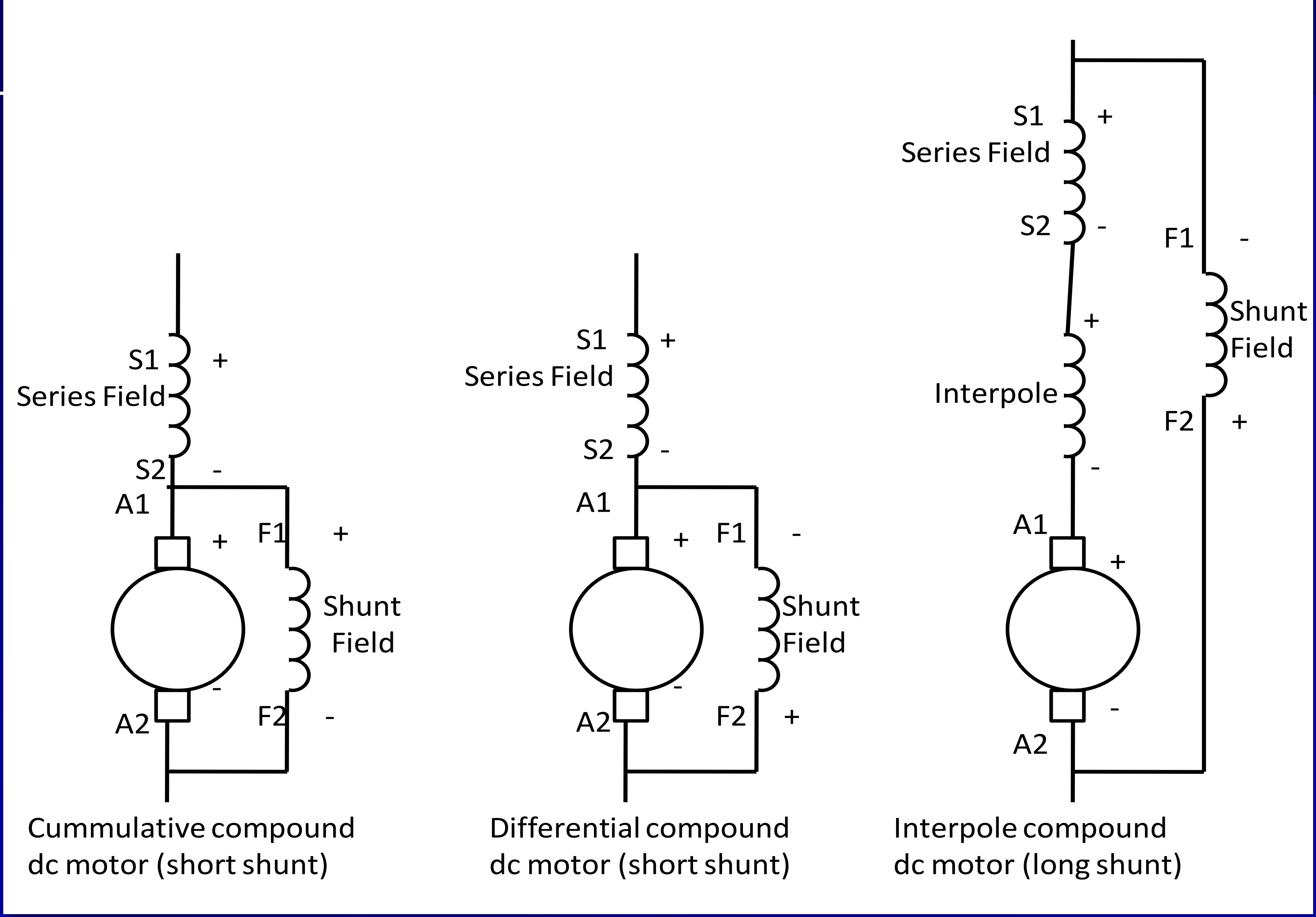


Shunt Motor Curves

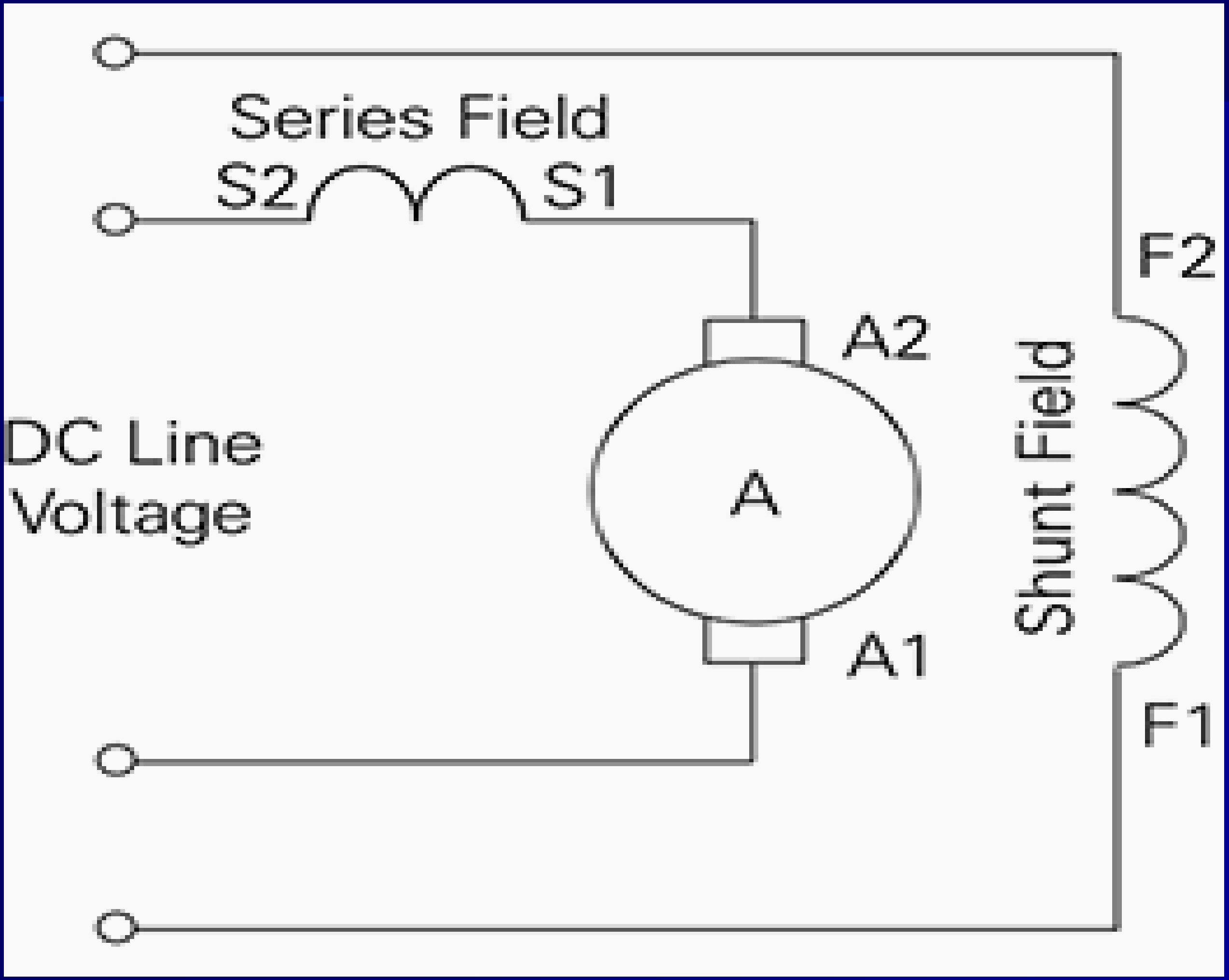


Like the AC induction motor the DC Shunt motor is pretty much self regulating for constant speed, e.g. mechanical loading will initially cause the speed to fall. To change the speed we can directly increase/decrease Armature current (Armature Control) or indirectly Field Current (Field Control). Both methods effectively adjust the Armature current.

Compound Motors

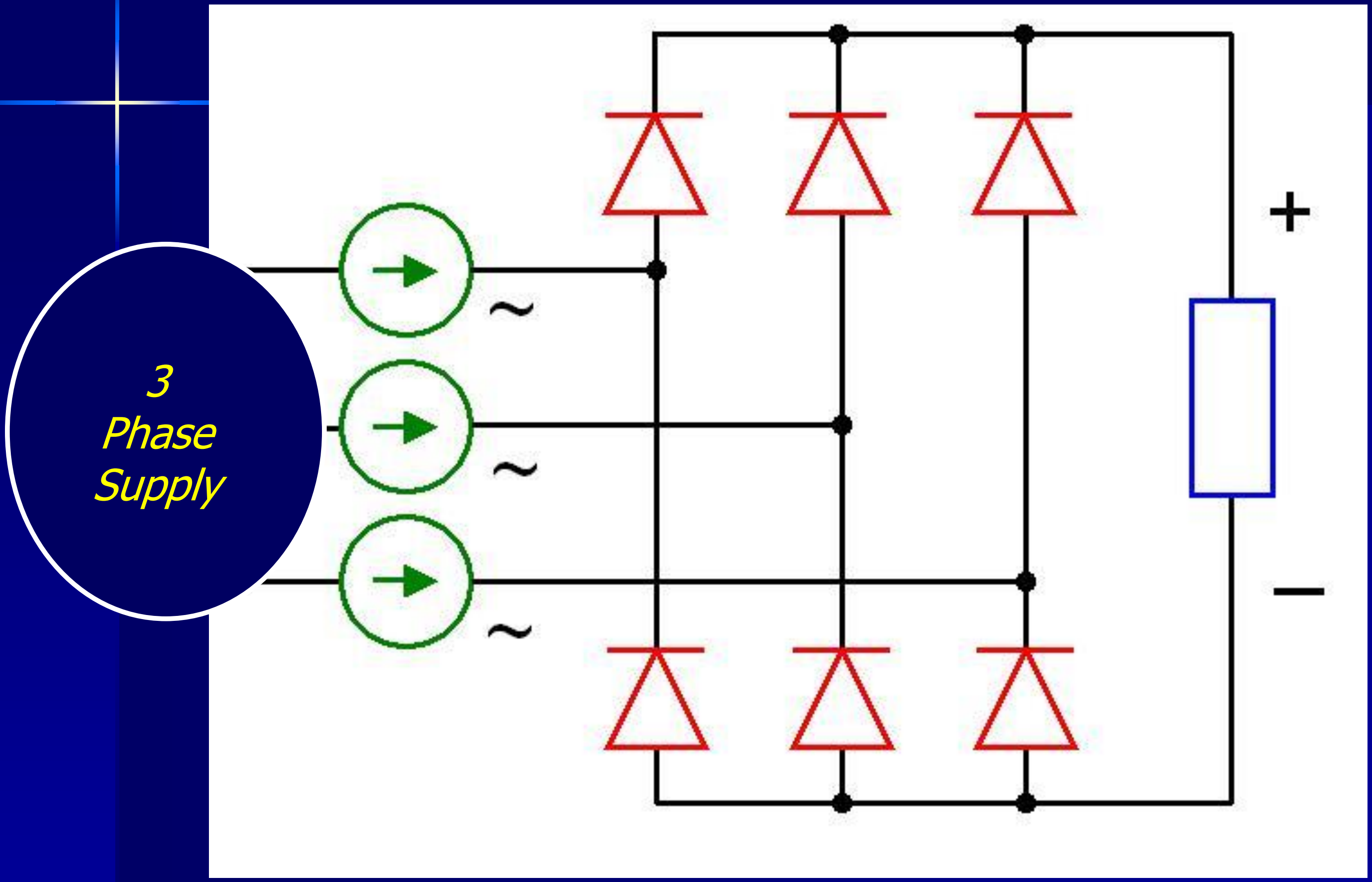


Separately Excited Motor



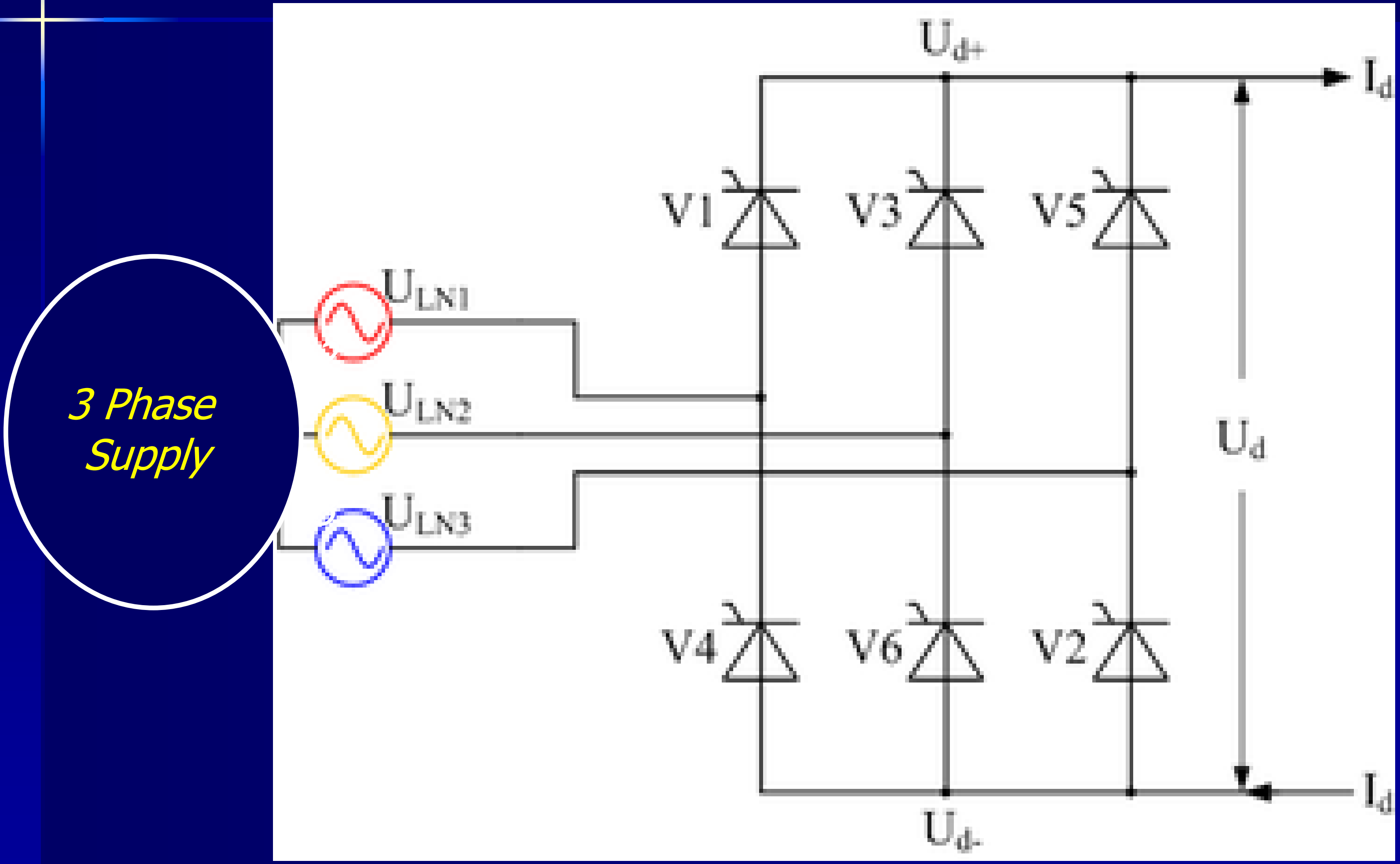
DC Drives

Full Wave Rectification

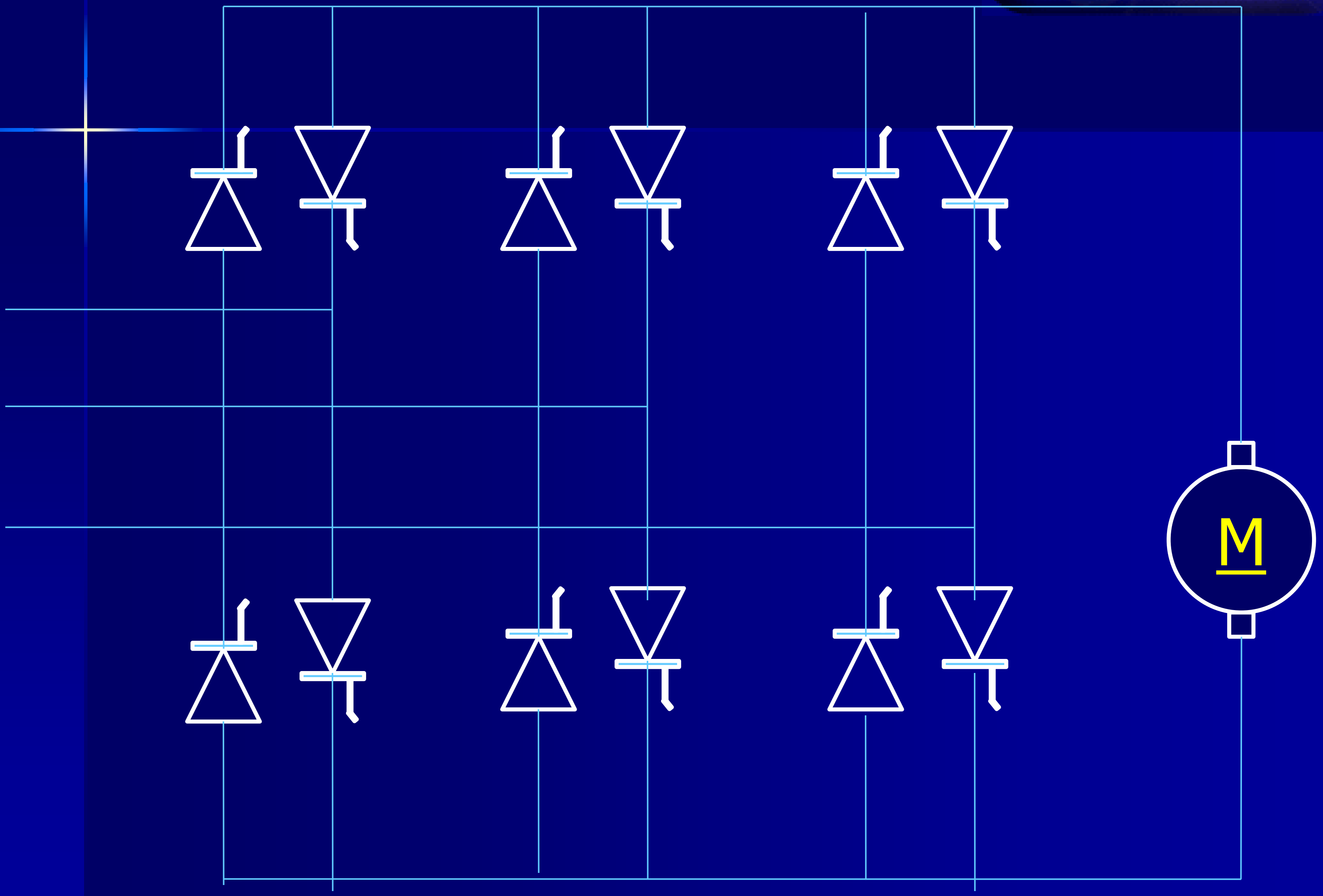


Full wave rectification of a 3 phase supply to direct current (DC)

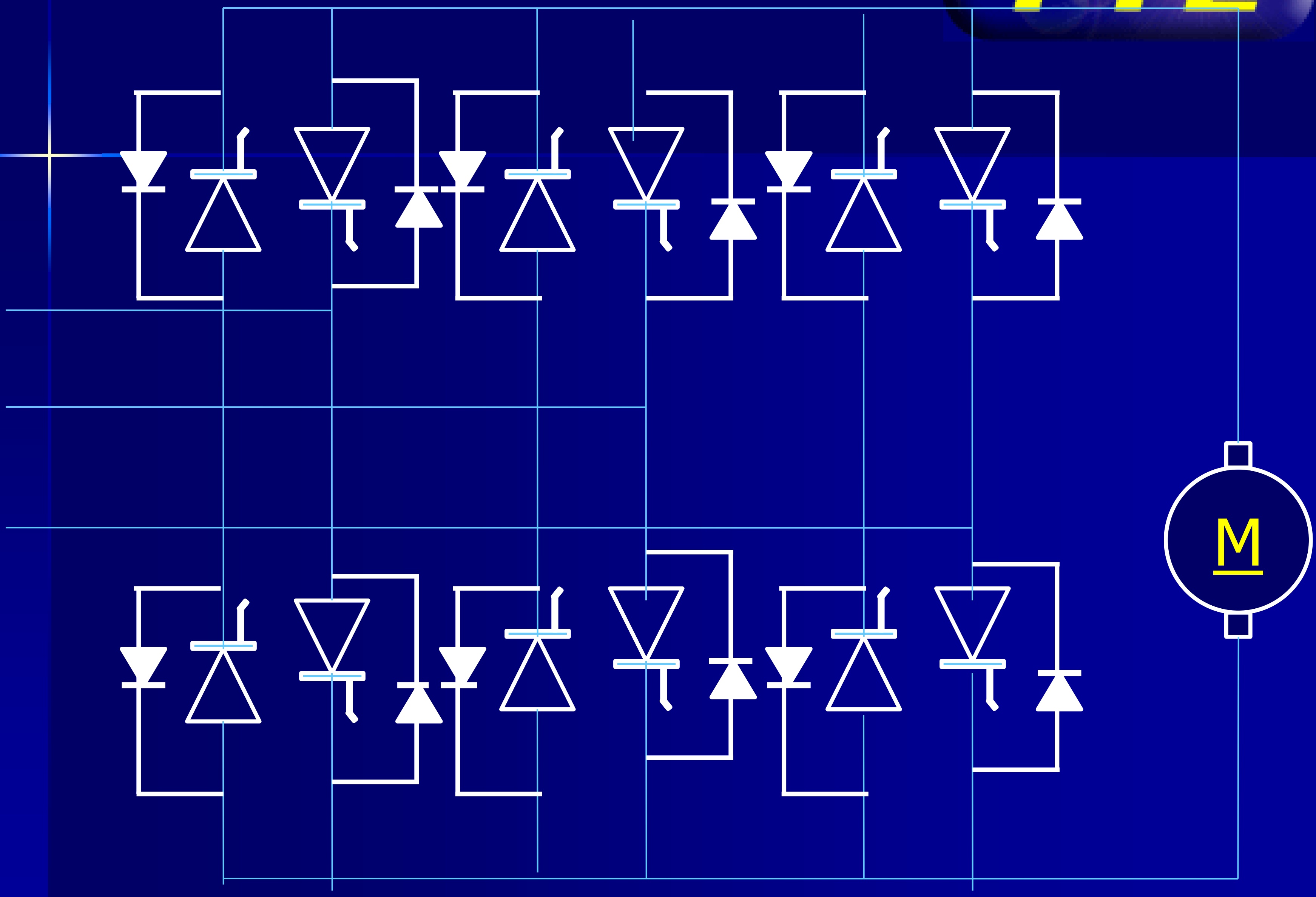
Full Wave Rectification With speed control

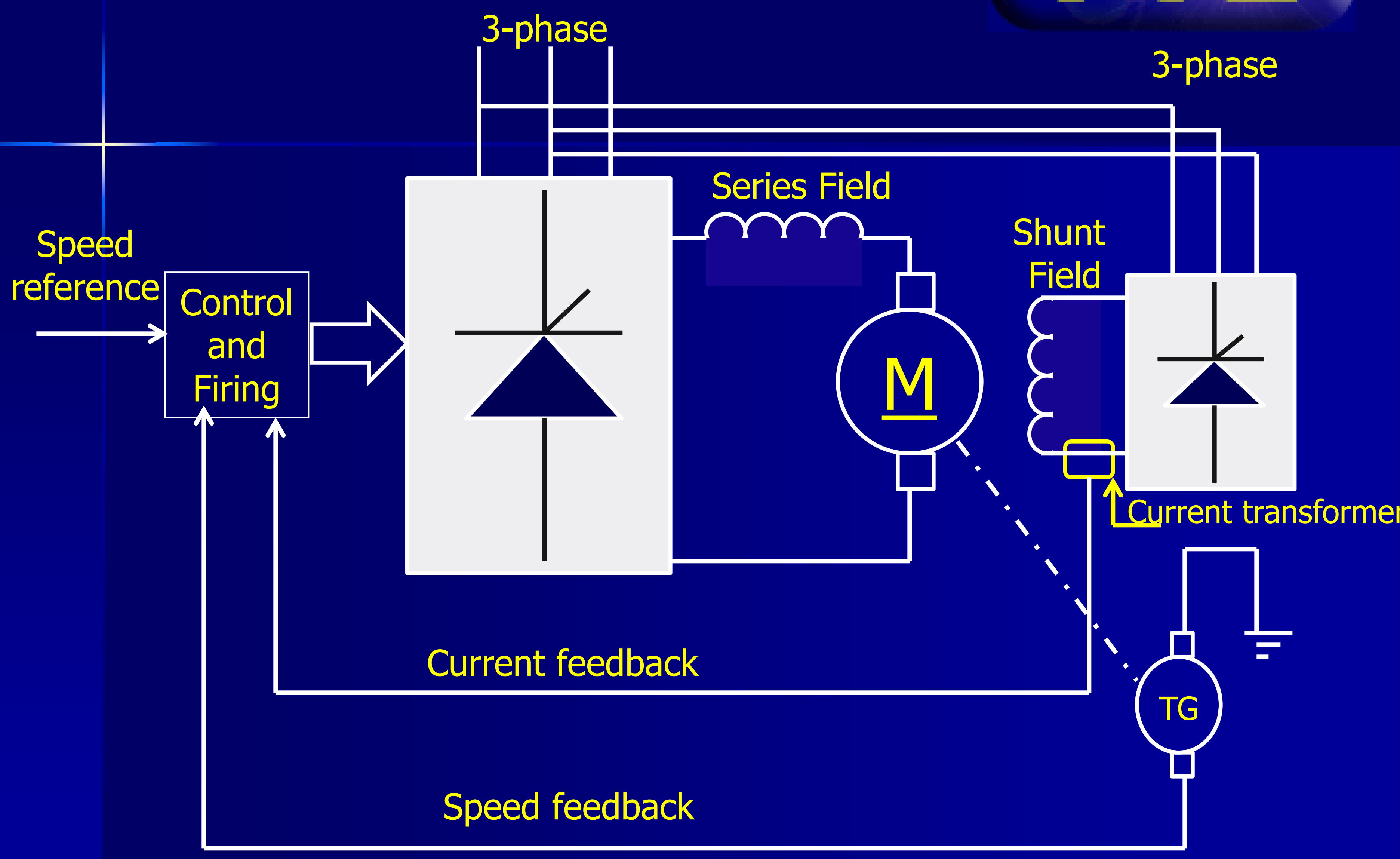


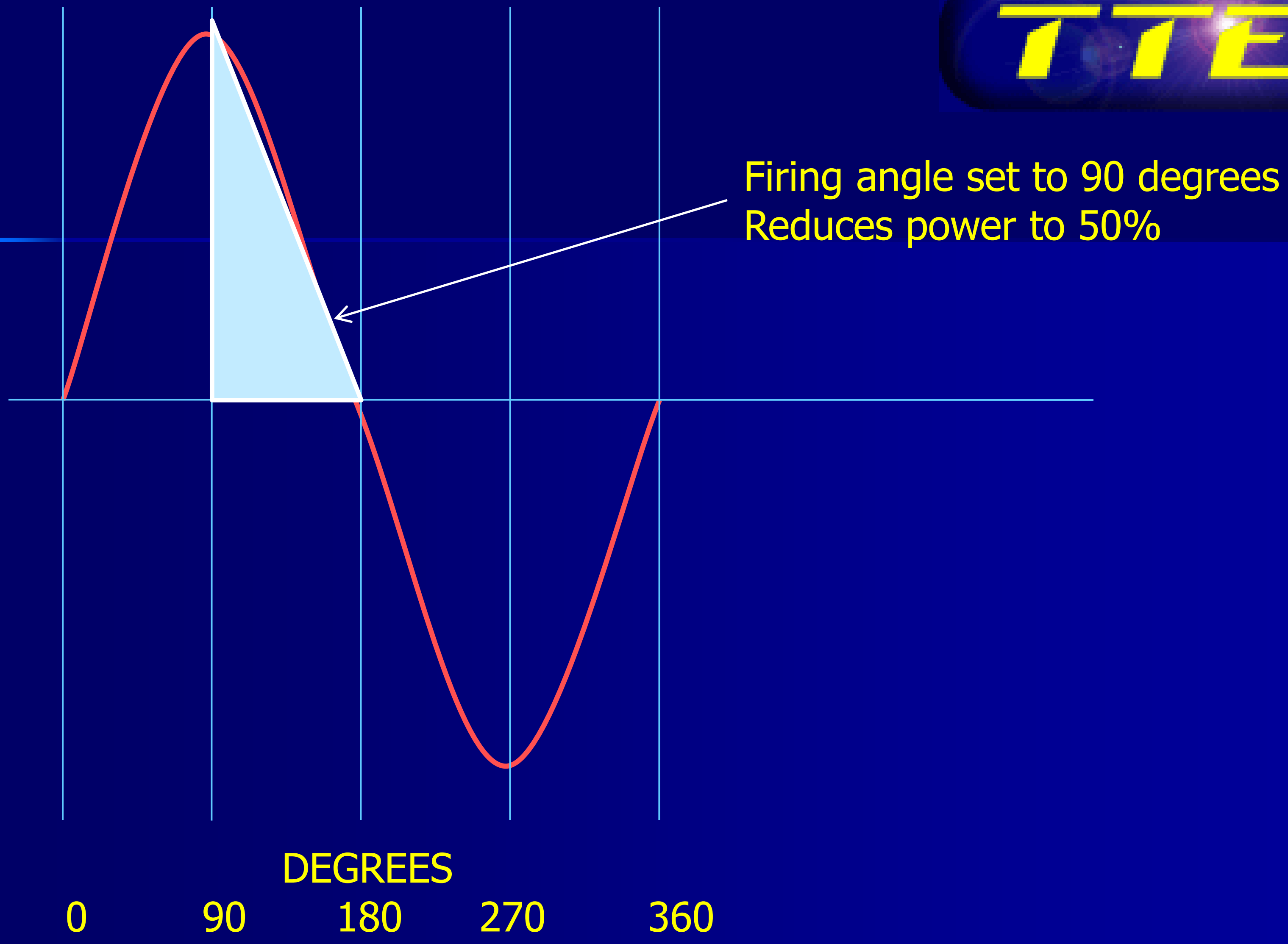
Full Control

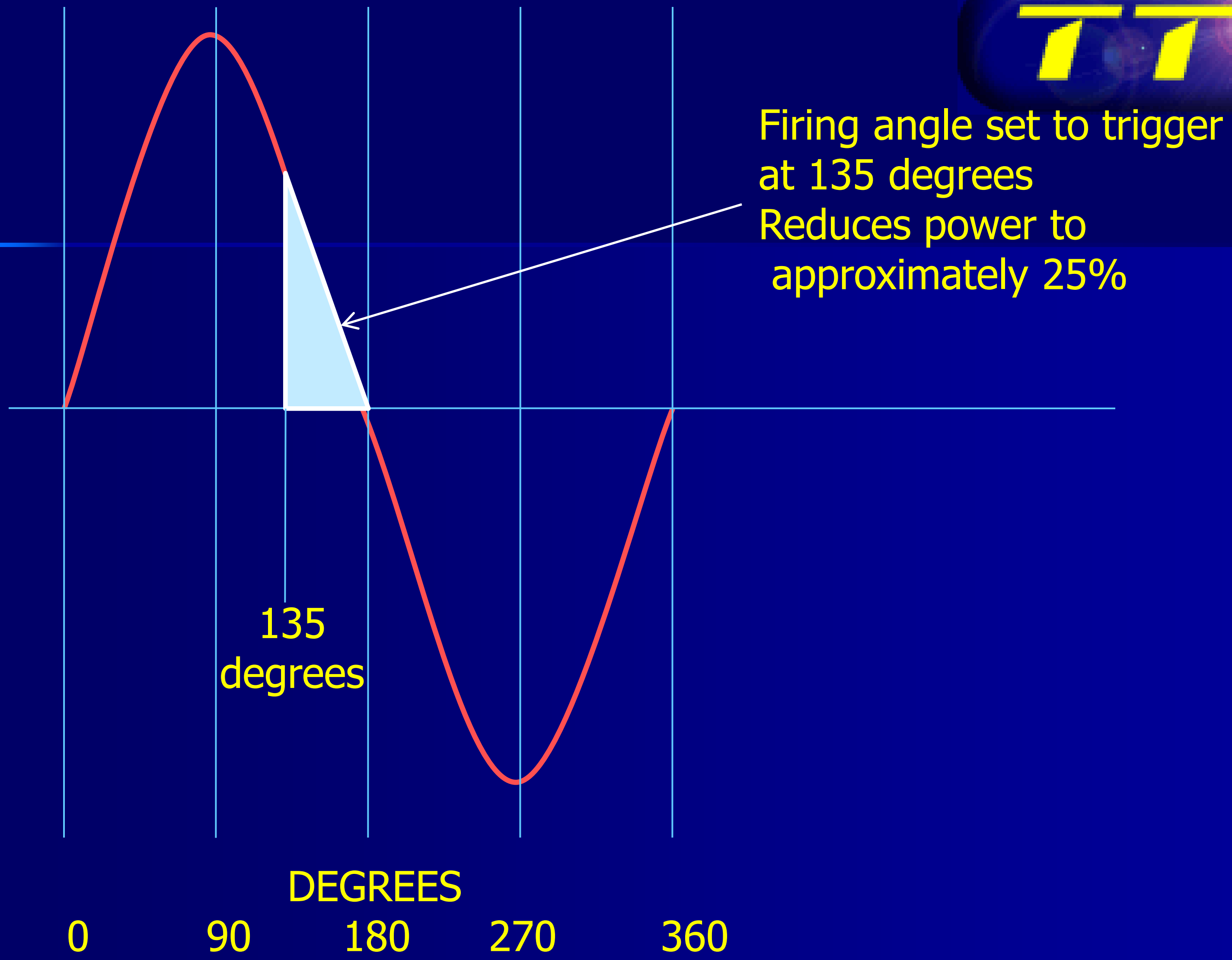


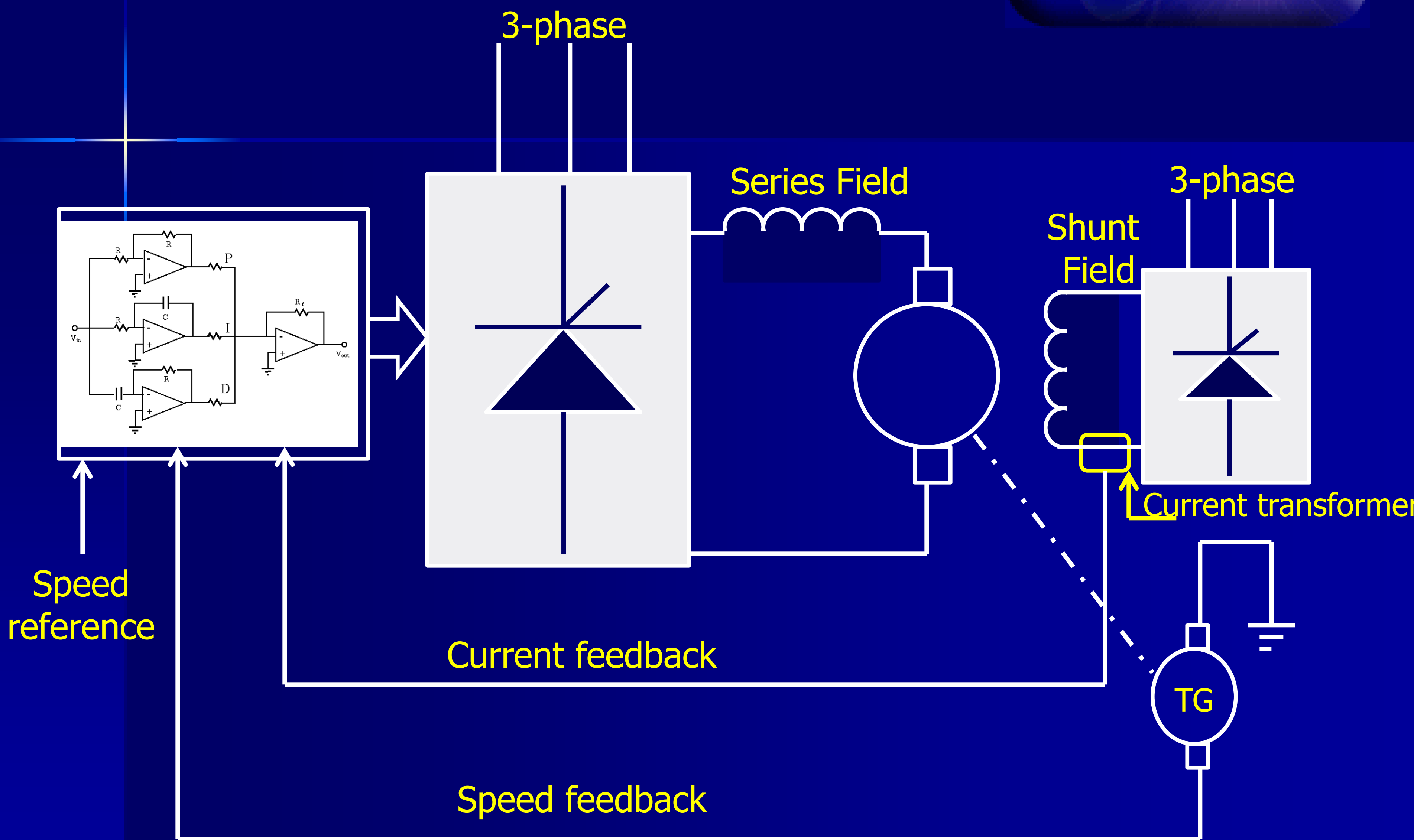
Freewheel Diodes



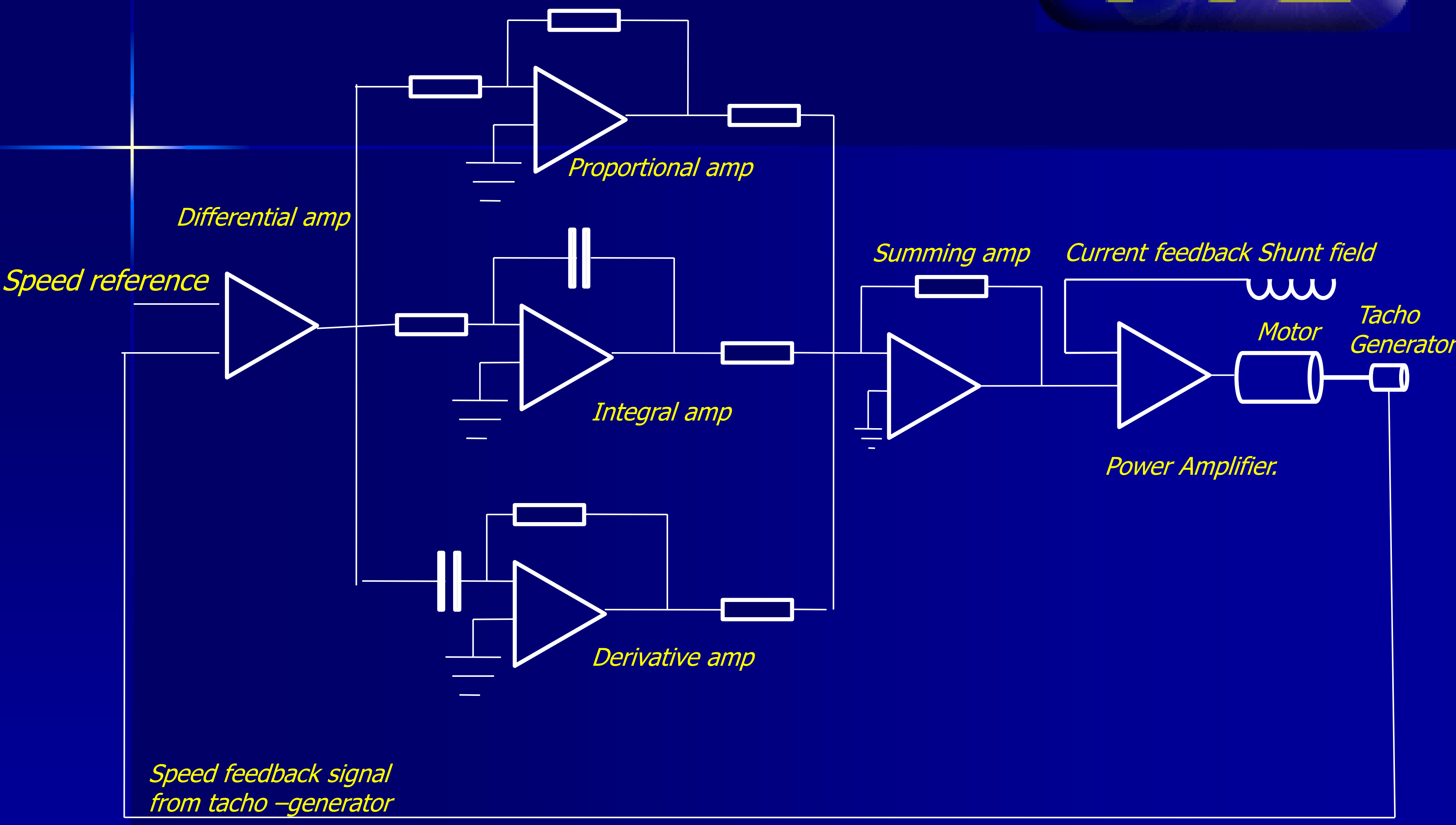

3-phase
3-phase
Series Field
Shunt
Field
Speed
reference
Control
and
Firing
M
Current transformer
TG
Current feedback
Speed feedback


Firing angle set to 90 degrees
Reduces power to 50%
DEGREES
0
90
180
270
360

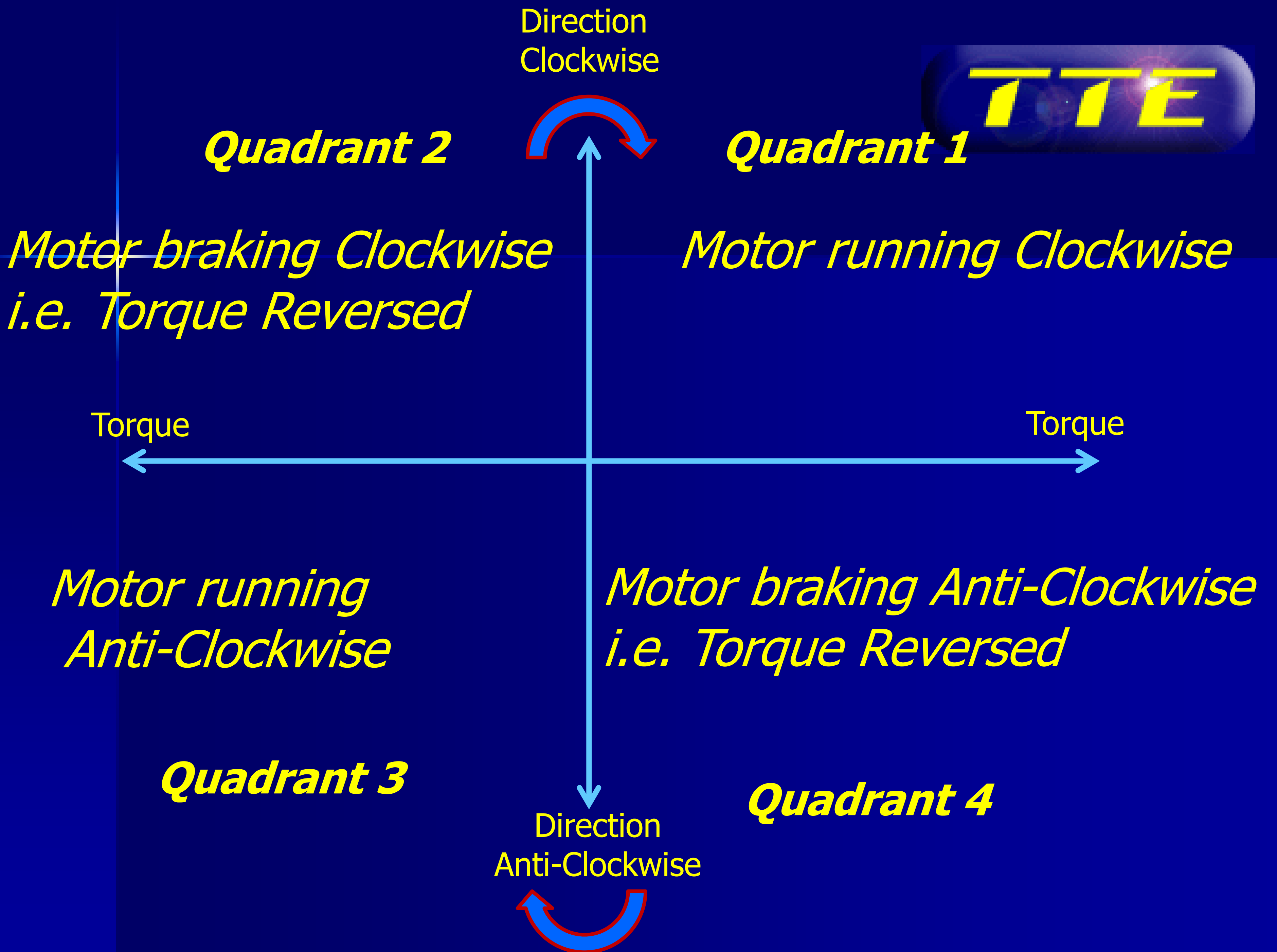

Firing angle set to trigger
at 135 degrees
Reduces power to
approximately 25%
135
degrees
DEGREES
0
90
180
270
360


3-phase
Series Field
3-phase
Shunt
Field
P
I
D
Current transformer
Speed
reference
Current feedback
TG
Speed feedback

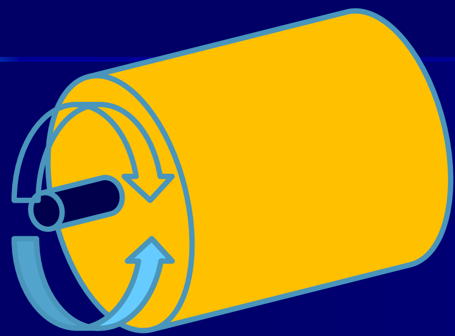
Three Term (PID) Control



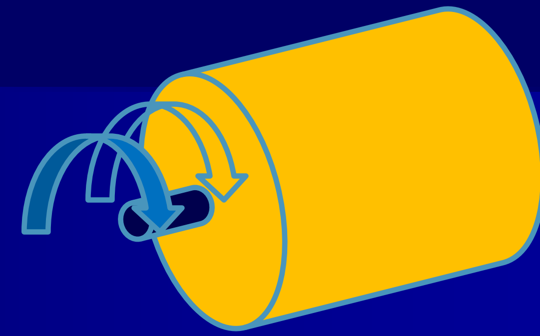
DC compound Motor with separately excited Shunt Winding

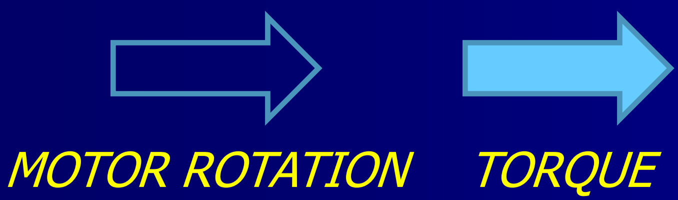

Direction
Clockwise
Quadrant 2
Quadrant 1
Motor braking Clockwise
i.e. Torque Reversed
Motor running Clockwise
Torque
Torque
Motor running
Anti-Clockwise
Motor braking Anti-Clockwise
i.e. Torque Reversed
Quadrant 3
Quadrant 4
Direction
Anti-Clockwise

Quadrant 2 motor braking clockwise



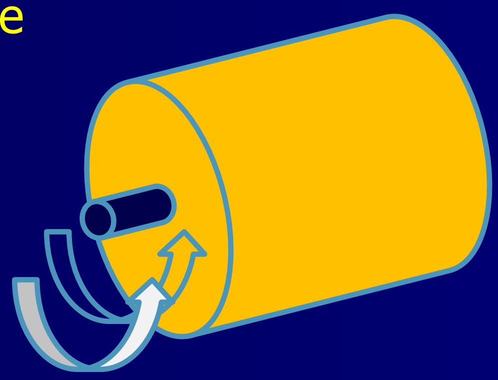
Quadrant 1 motor running clockwise



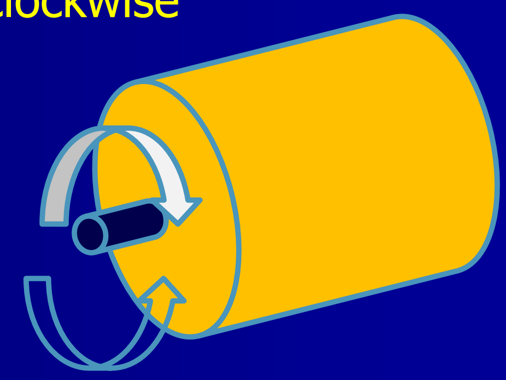


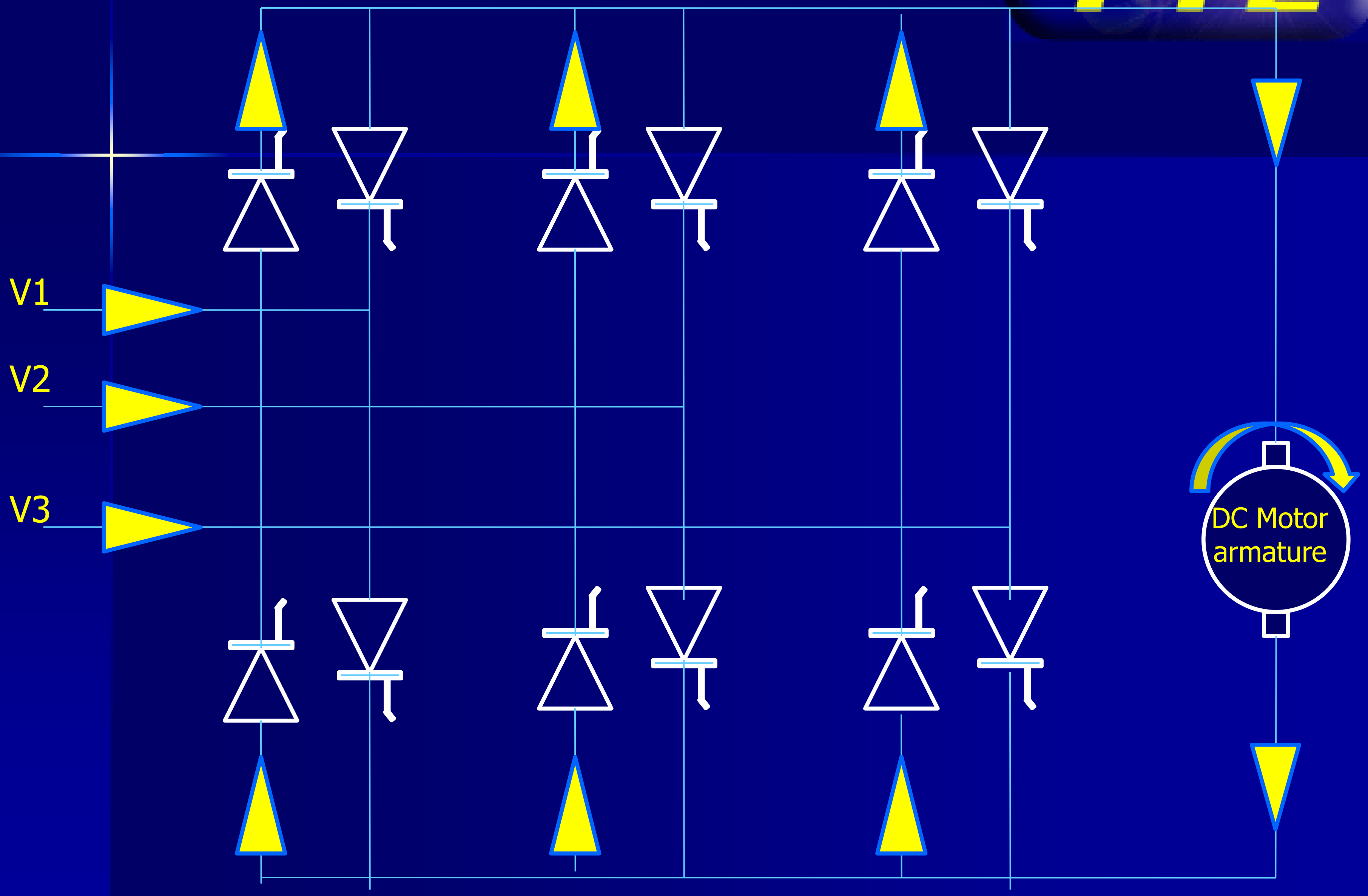
Torque ∞ Magnetic Flux & Armature Current

Quadrant 3 motor running anti-clockwise

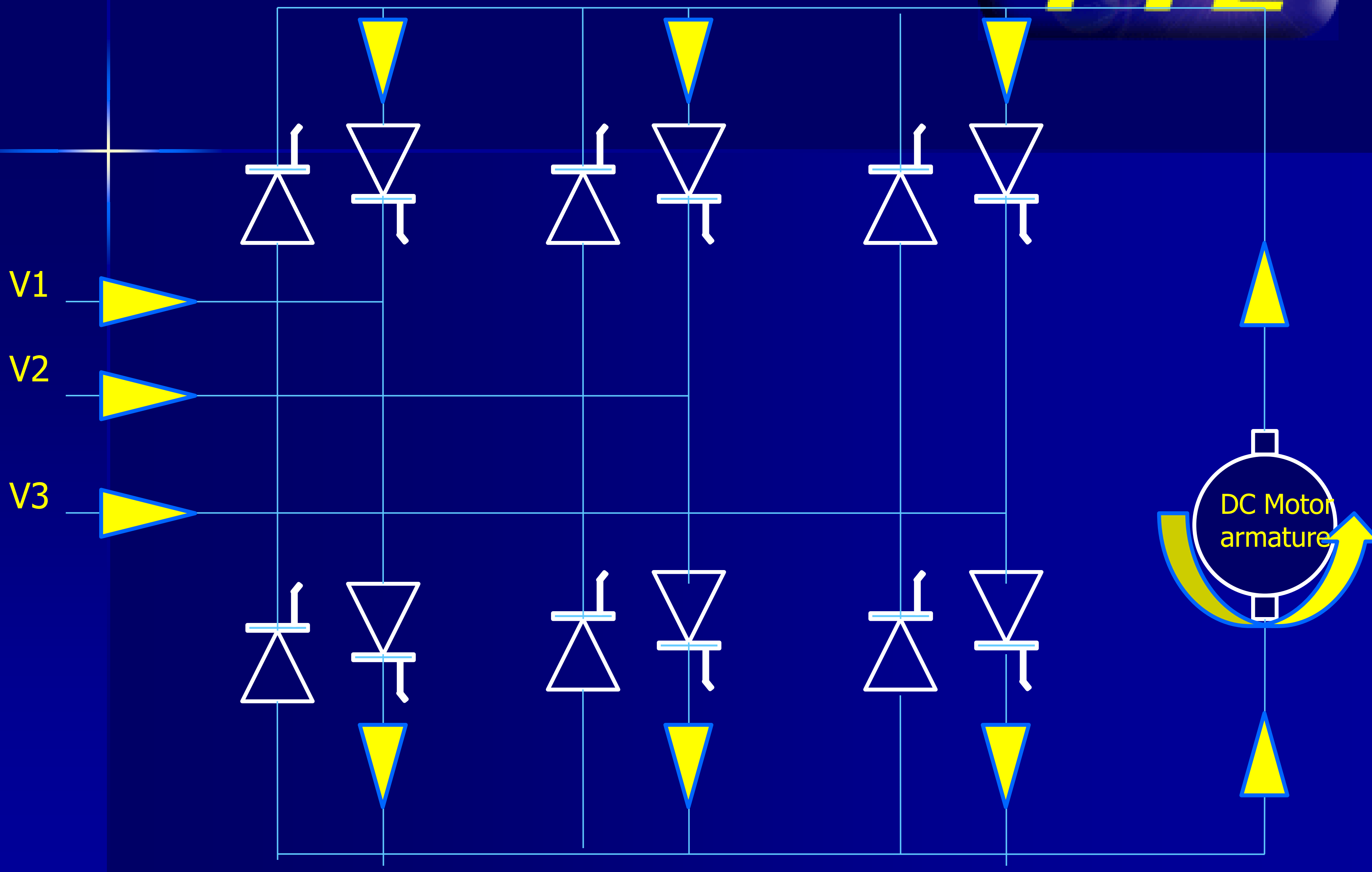


Quadrant 4 motor braking anti-clockwise

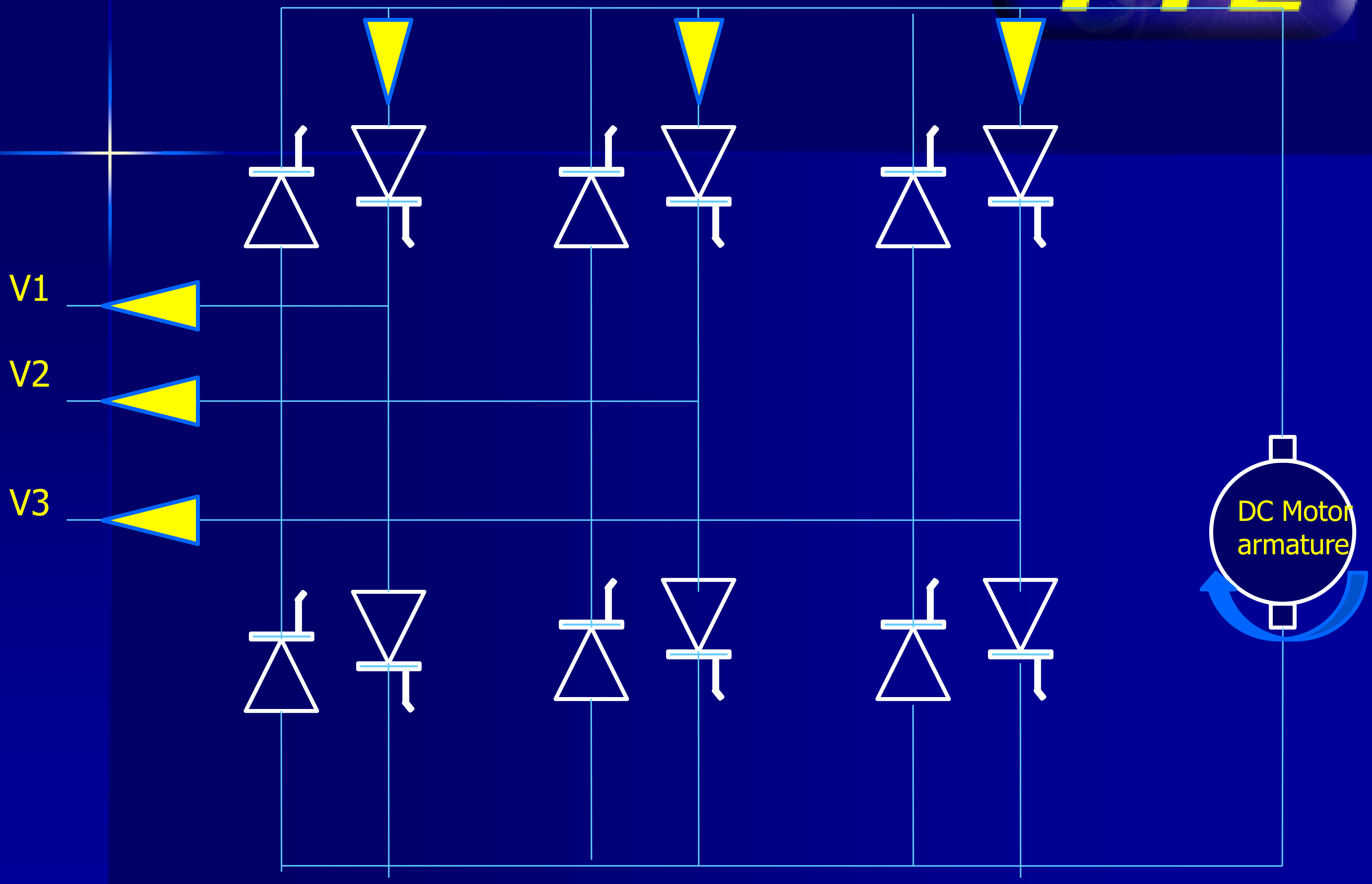




Thyristor switching for Clockwise rotation



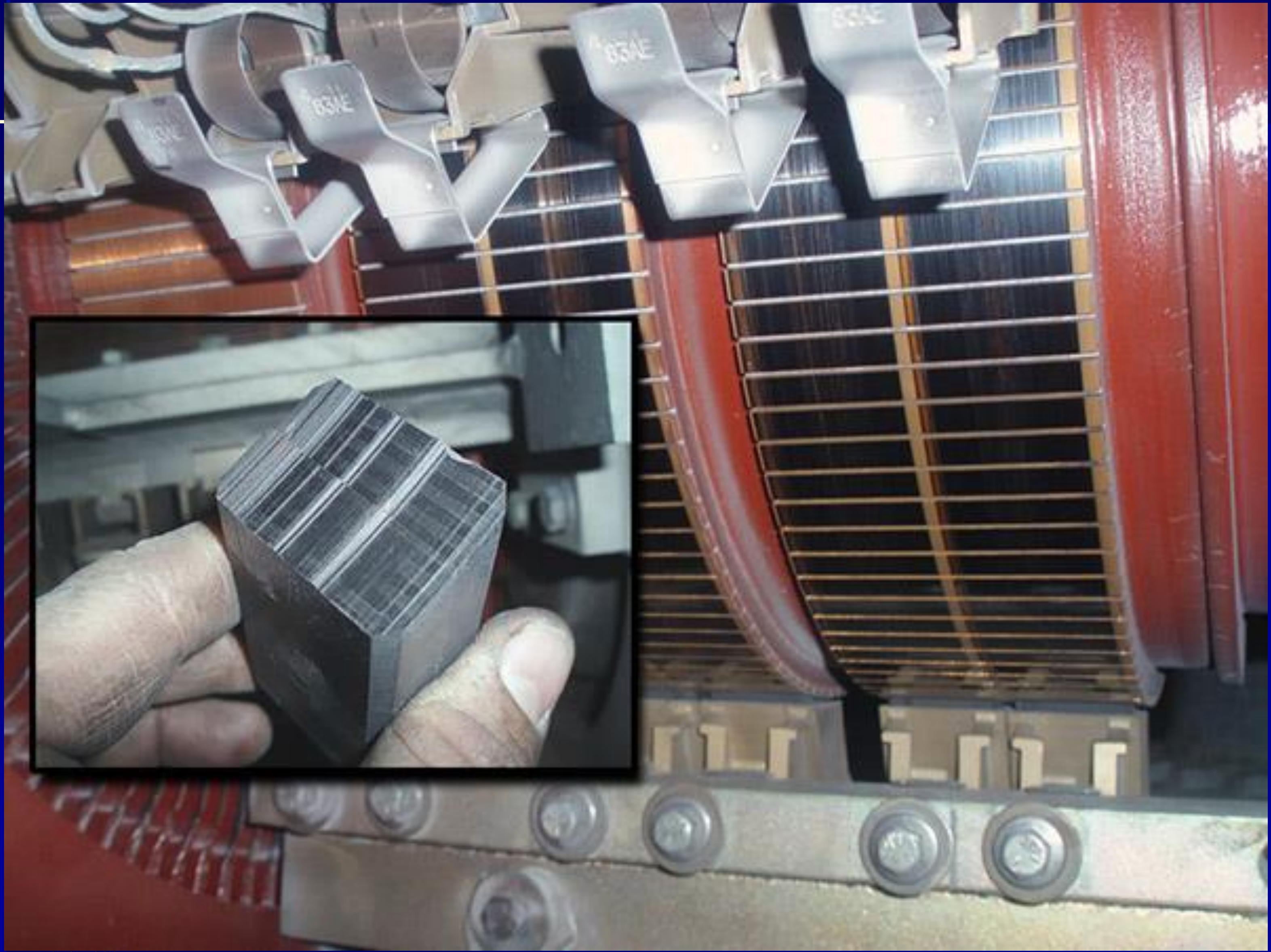
Thyristor switching for Anti- clockwise rotation



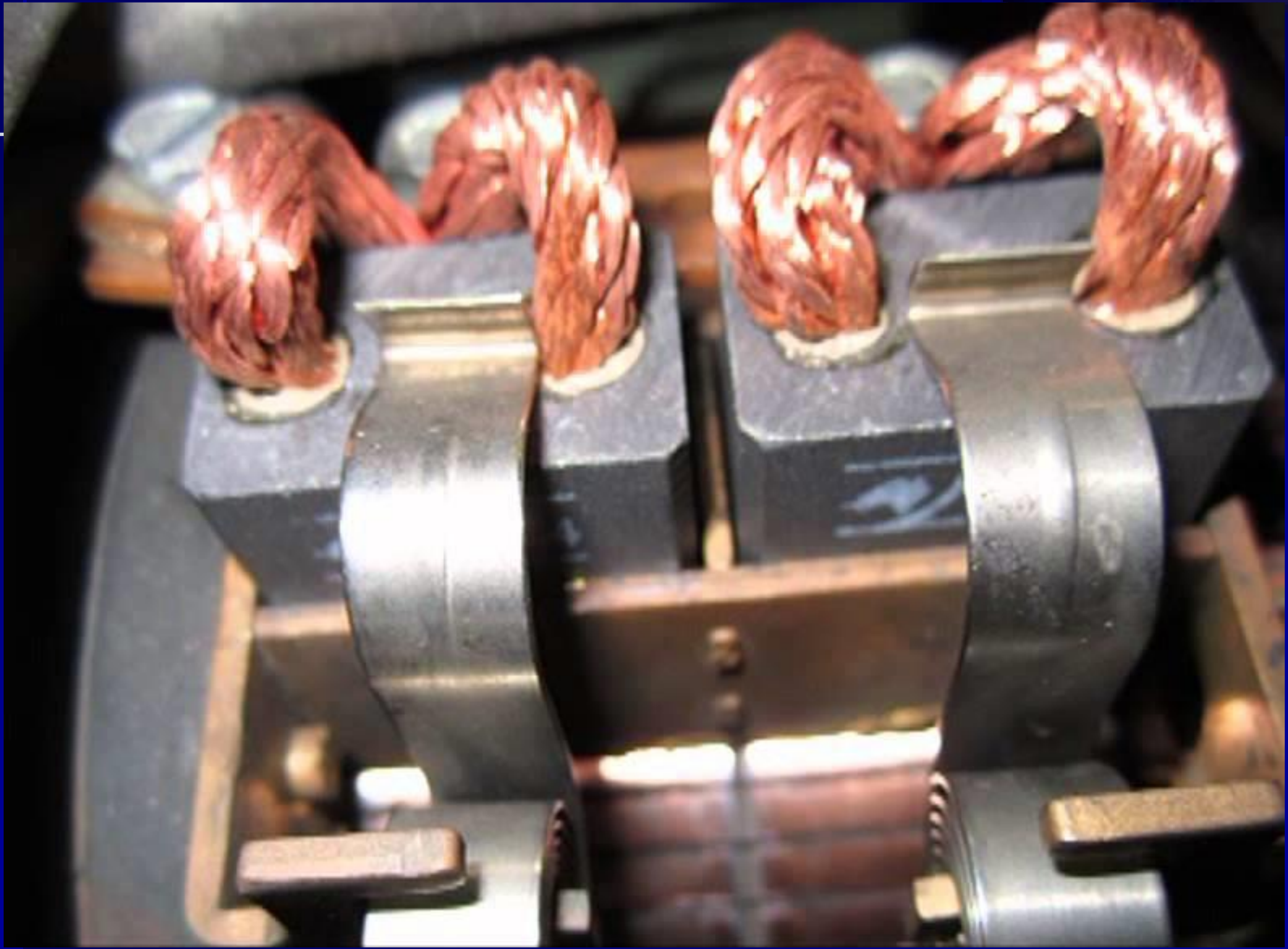
Thyristor switching for Re-generative braking clockwise rotation

Thyristor switching for Re-generative braking anti-clockwise rotation

Maintenance



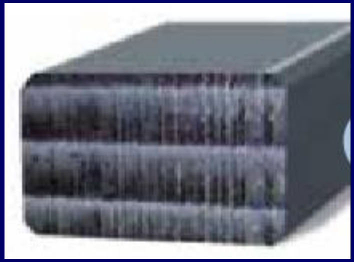
Maintenance



Maintenance

Carbon Brushes:

The carbon brush is a crucial component that will keep machines operating efficiently. However, *“the brushes are to blame”* is a statement commonly heard in industry, but the blame is usually misdirected. One common problem is sparking at the brush face, which is usually the first symptom of trouble elsewhere.




Maintenance

Brush Holders damaged or dirty:

Any physical damage to the holder or an accumulation of dirt on its inside may interfere with the free motion of the brush in the holder and thus result in sparking. The brush must be able to move in and out of its holder in order to maintain effective contact. Visual examination and testing the free action of the brush with the fingers is usually sufficient to reveal this condition. *Thorough cleaning or complete replacement will improve operation.*

Maintenance

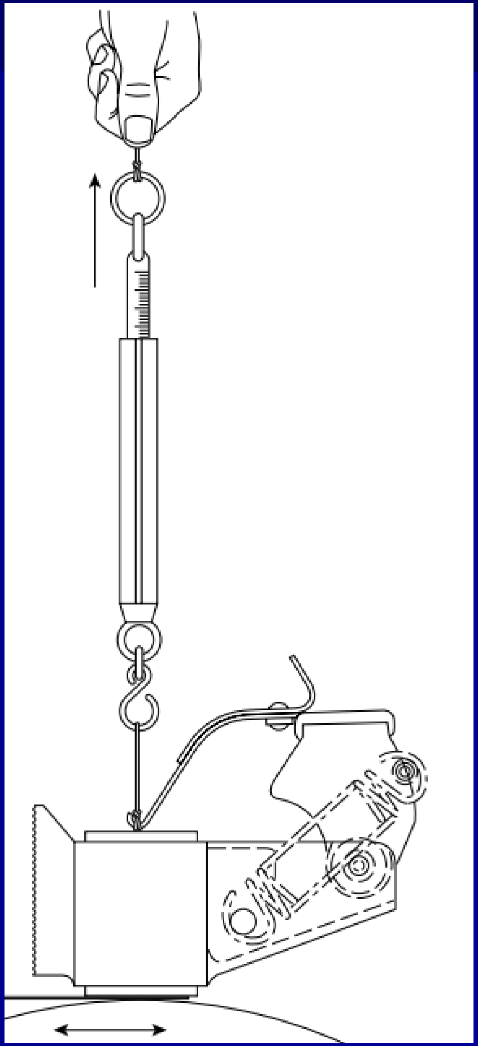
Brushes binding in holder:

When brushes or holders are not of the correct size brushes may bind in their holders. If the brushes are too tight in the holders, their proper motion will be restricted so that they cannot maintain contact with the Commutator and sparking may result. If they are too small, they may bounce in the holders and thus tend to break contact with the Commutator and bring about the same result.

Maintenance

Incorrect spring pressure:

The contact drop of a brush is influenced by the pressure with which it is forced against the Commutator. If the pressure varies from brush to brush, those brushes under more pressure will carry more current and overheat, those with insufficient pressure will bounce and arc. If these faults are suspected, check the spring pressure on each brush with a scale.



Adjust to the level recommended by the manufacturer

Maintenance

Brush holders off, electrical neutral (MNA):

Even though the holders are equally spaced, they may be out of their correct position and cause sparking due to Armature Reaction which may be equally severe on all brushes of the same polarity. Check position, usually marked on brush gear.