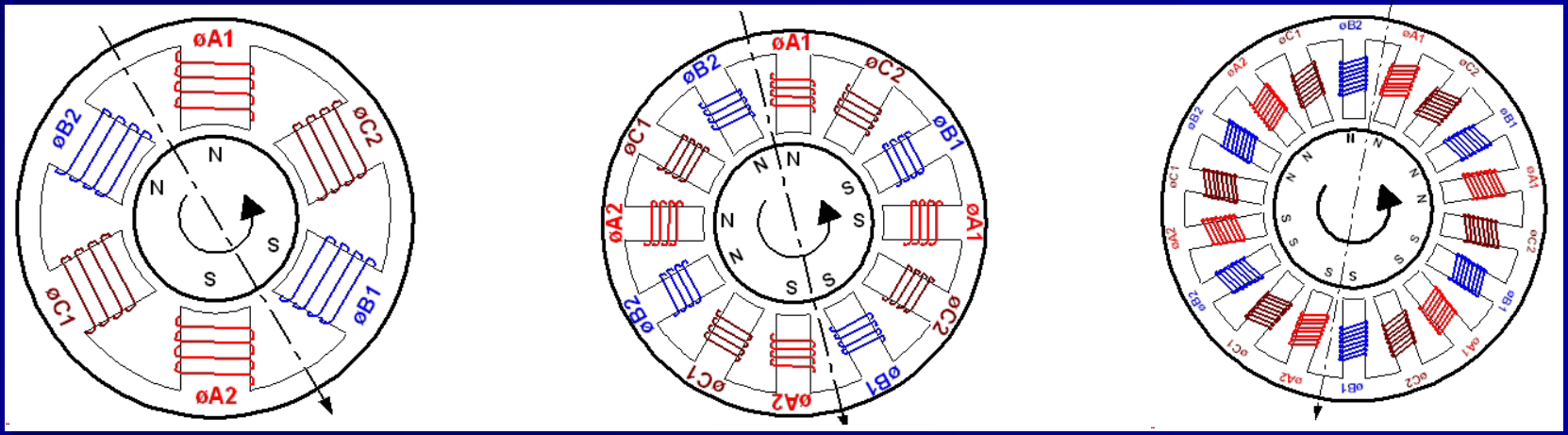
Variable Speed Drives (VSD's)

AC Induction motors (History)

Invented and developed in the early 19th century the Induction motor was manufactured with **fixed** speeds based on the number of poles or pairs of poles ***PER PHASE:***



2 Pole Motor
1 Pair

N_s = RPM

4 Pole Motor
2 Pairs

N_s = RPM

6 Pole Motor
3 Pairs

N_s = RPM

Synchronous Speed (N_s)

To calculate the synchronous speed of an Induction motor:

There are two formulae

$N_s =$ $N_s =$

Asynchronous Speed or Rotor Speed (N_r)

Sometimes referred to as the slip speed

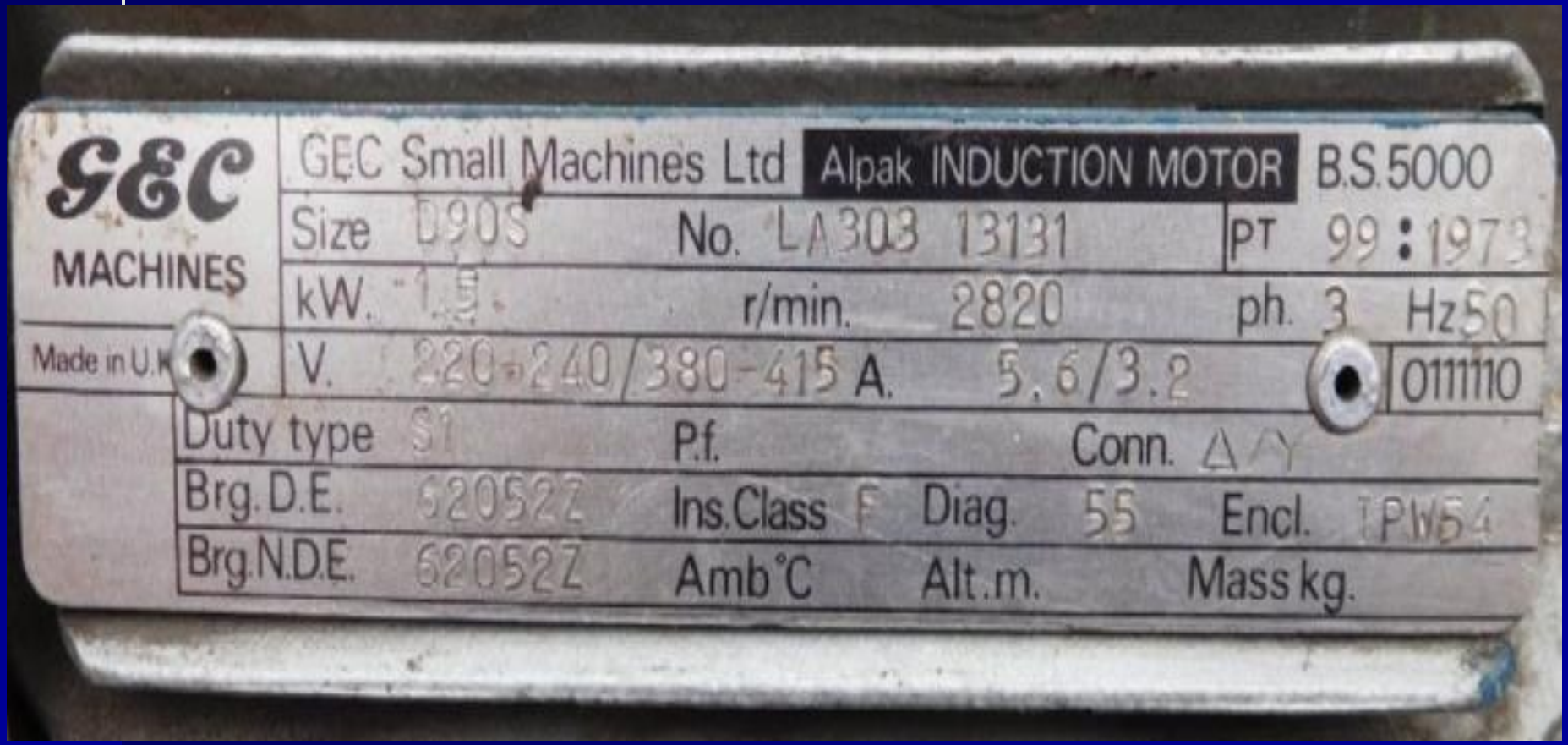
Slip =

And will often be stated as a percentage of synchronous speed: (so multiplied by 100)

So what is the rotor speed of a UK 6 pole motor with 5% Slip?

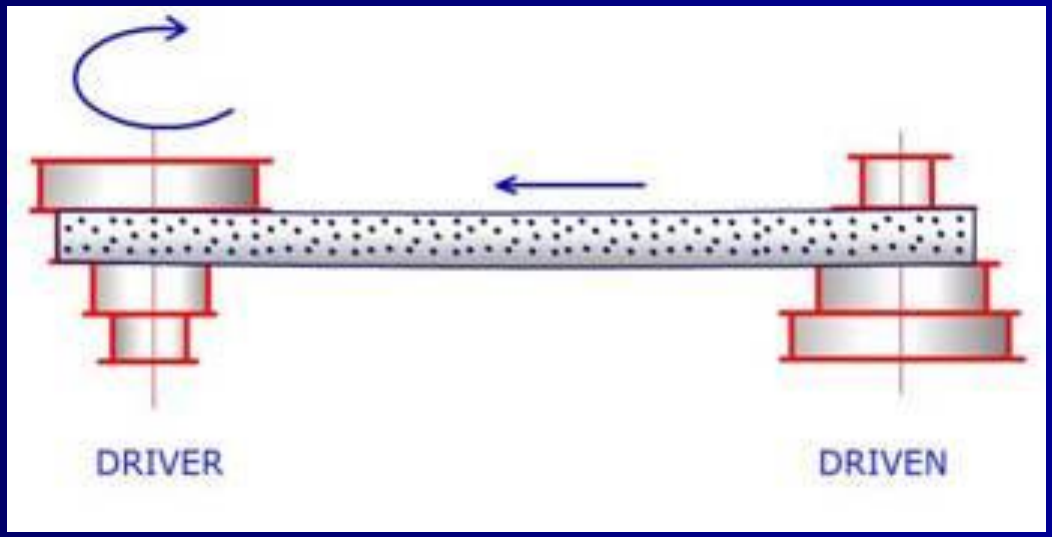
AC Motor Data Plate

What is the percentage slip of this Induction Motor?

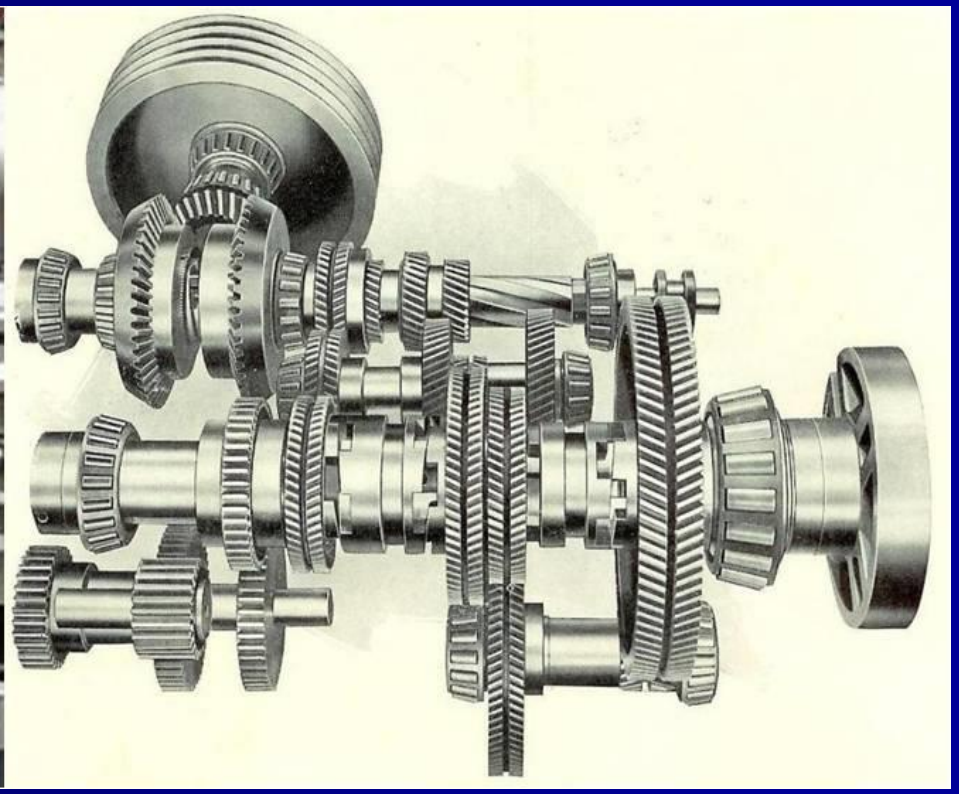


Variable Speed Control of AC Motors

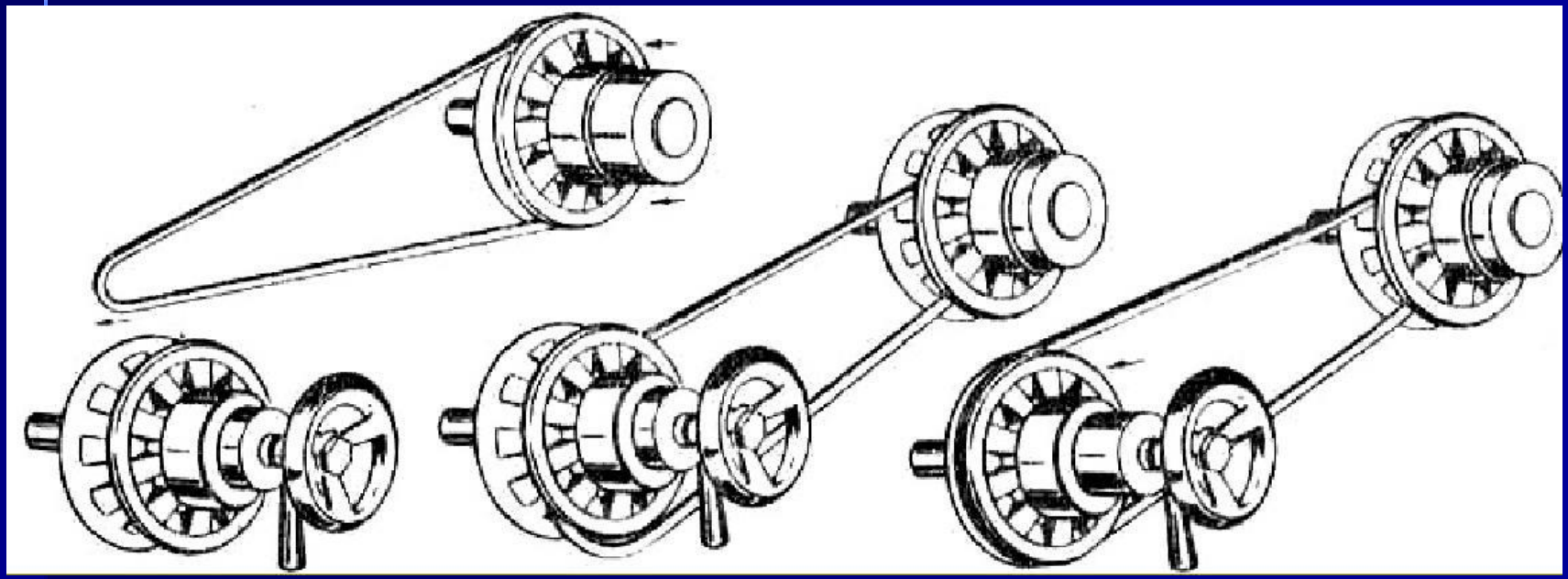
Before the onset of Semiconductors and Micro-electronics variable speed control of AC Induction motors was limited to mechanical solutions



Variable Speed Control of AC Motors



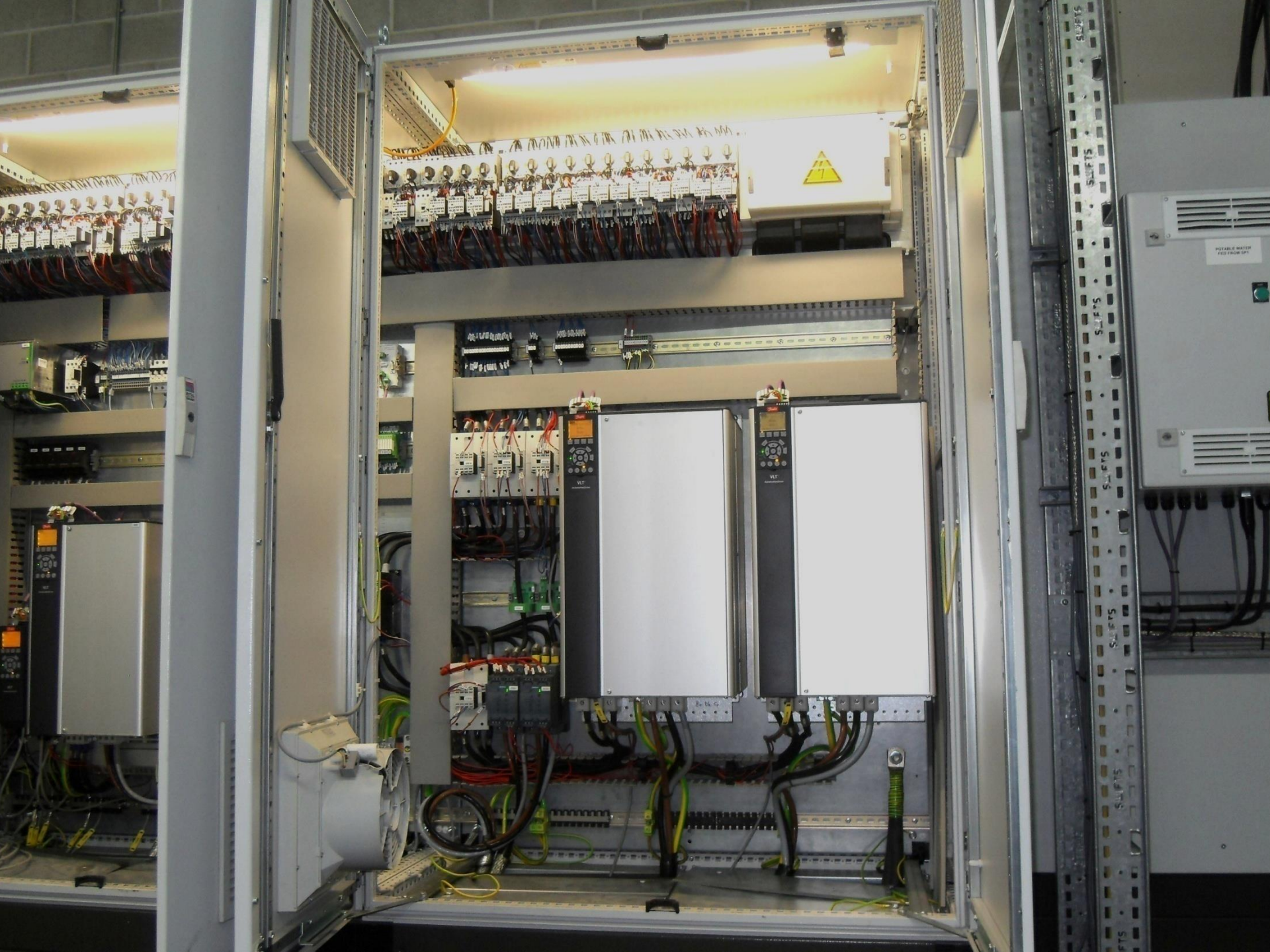
Variable Speed Control AC Motors



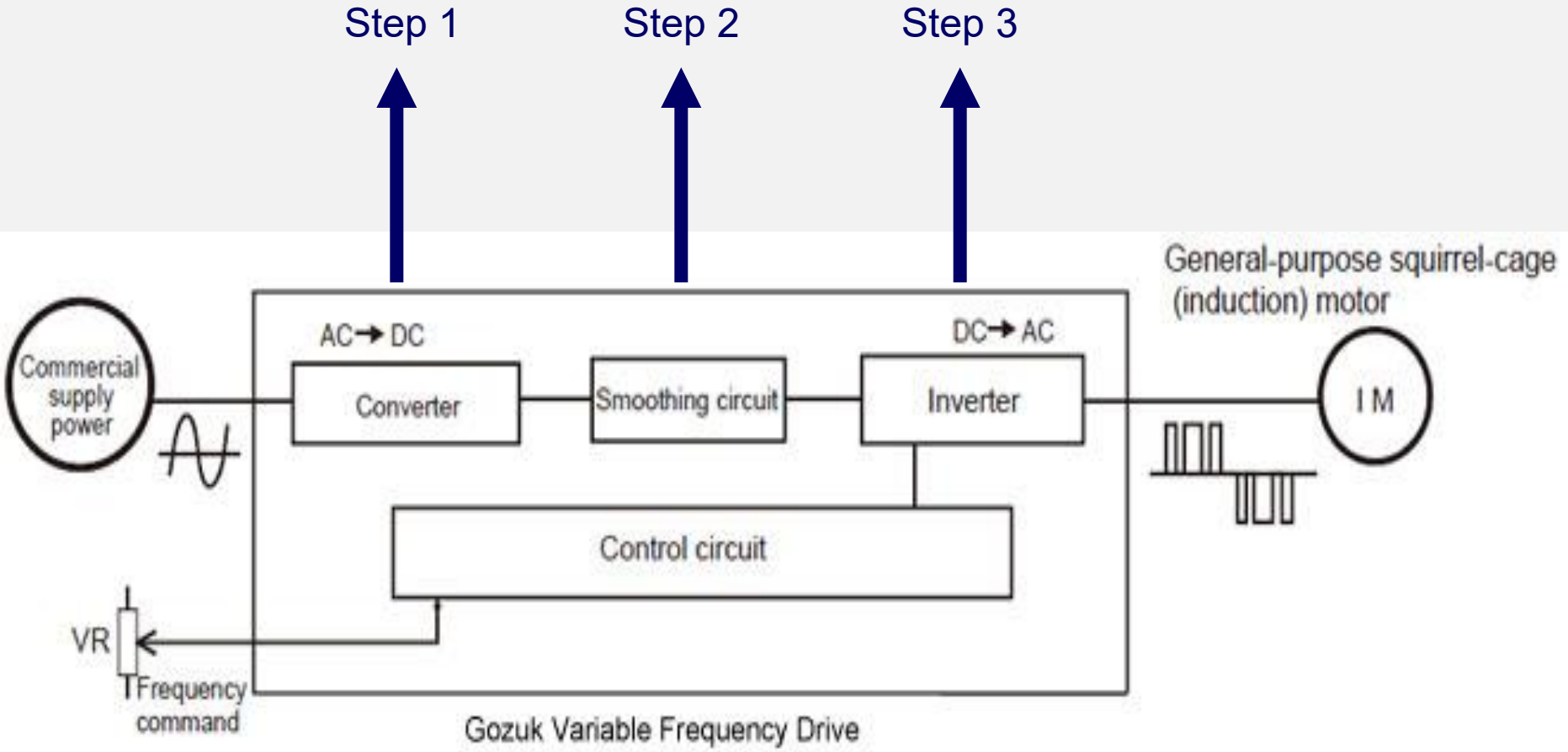
Electrical Speed Control

?

Variable speed (frequency) drives/ inverters



Block Diagram



Step 1

How do you change Single Phase AC to DC?

Single Phase AC to DC?

Step 1

How do you change Three Phase AC to DC?

Three Phase AC to DC?

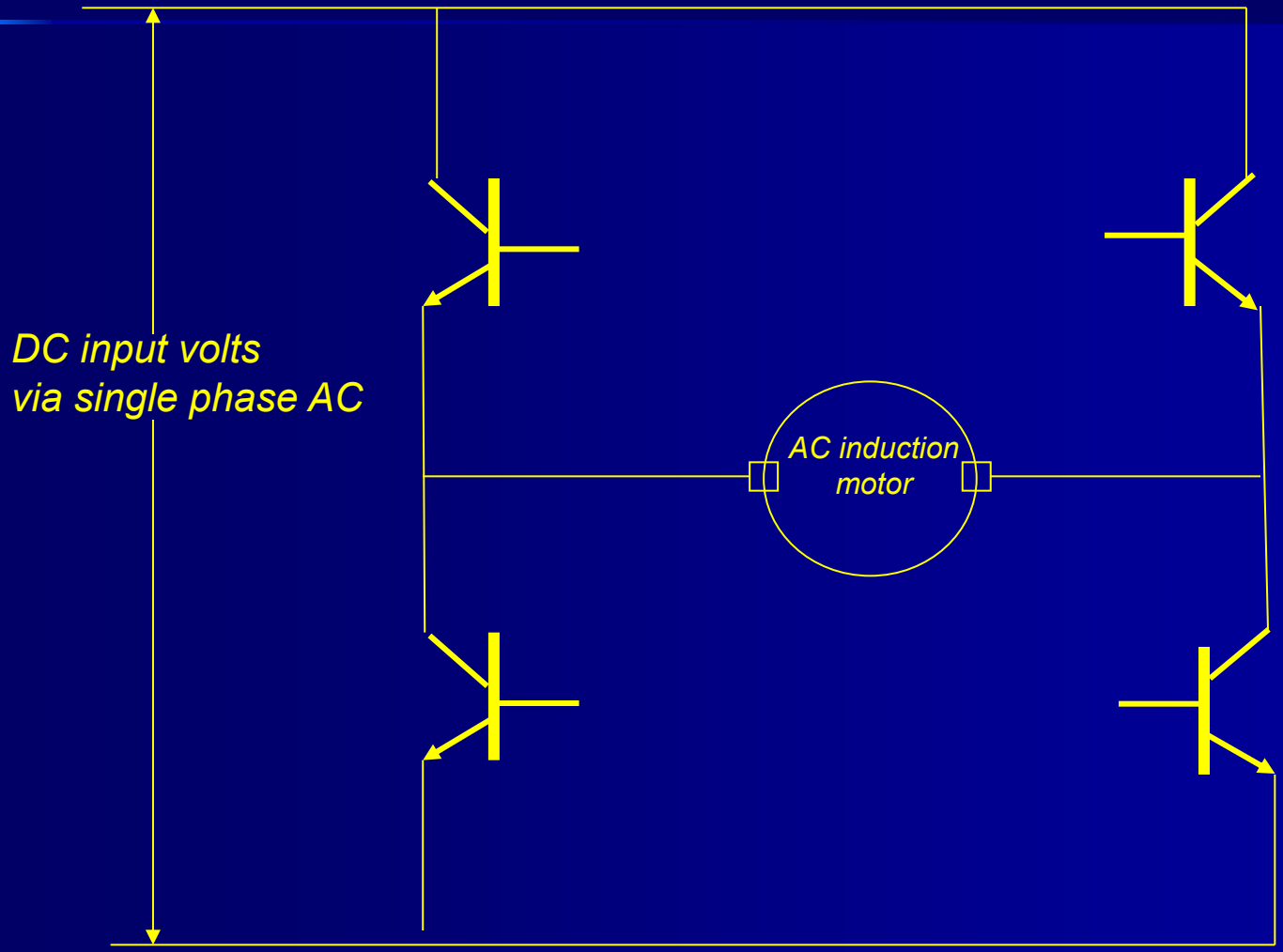
Step 2

How do you smooth Rippled DC?

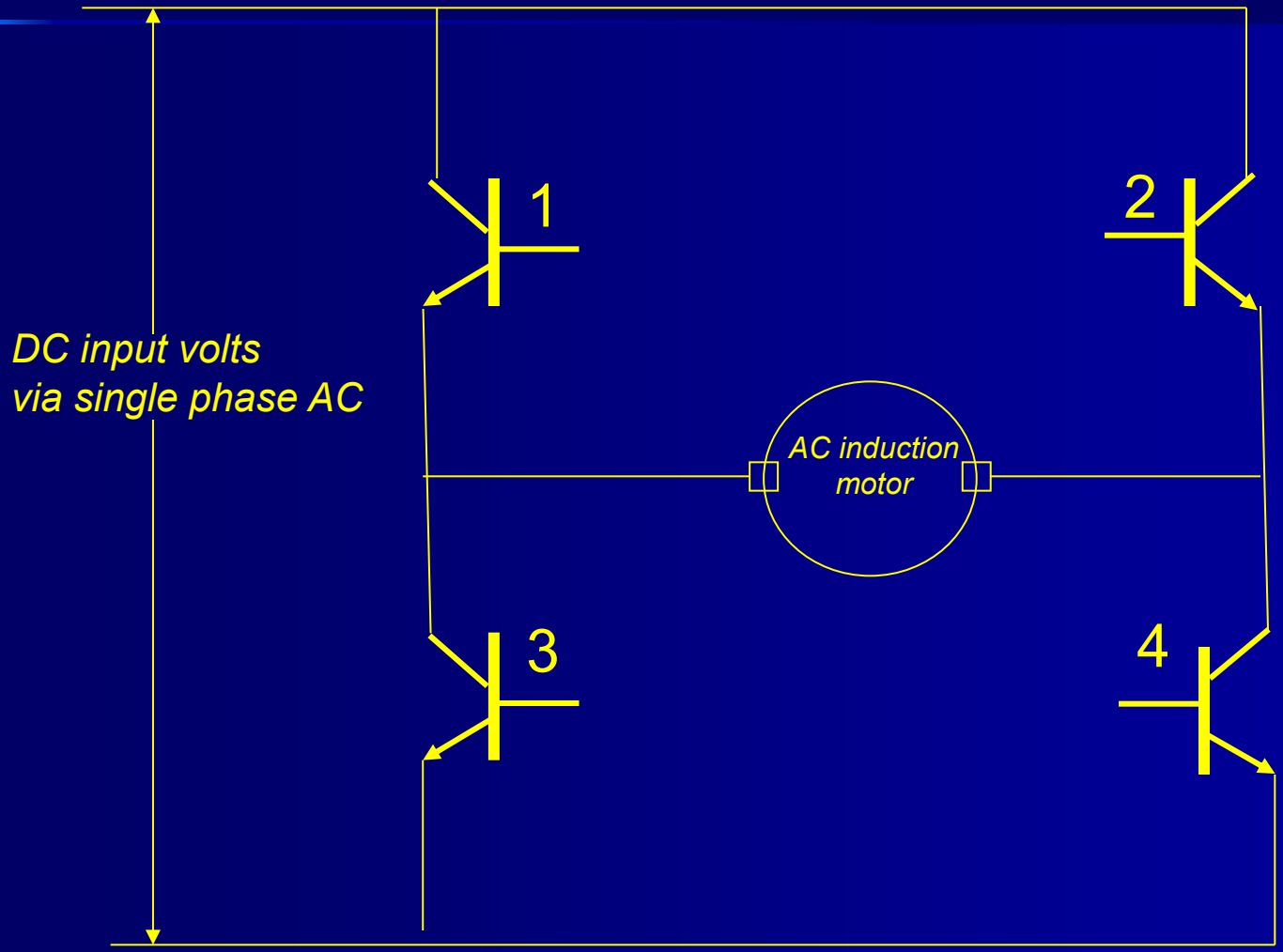
Step 3

How do you change DC back into Single Phase AC?

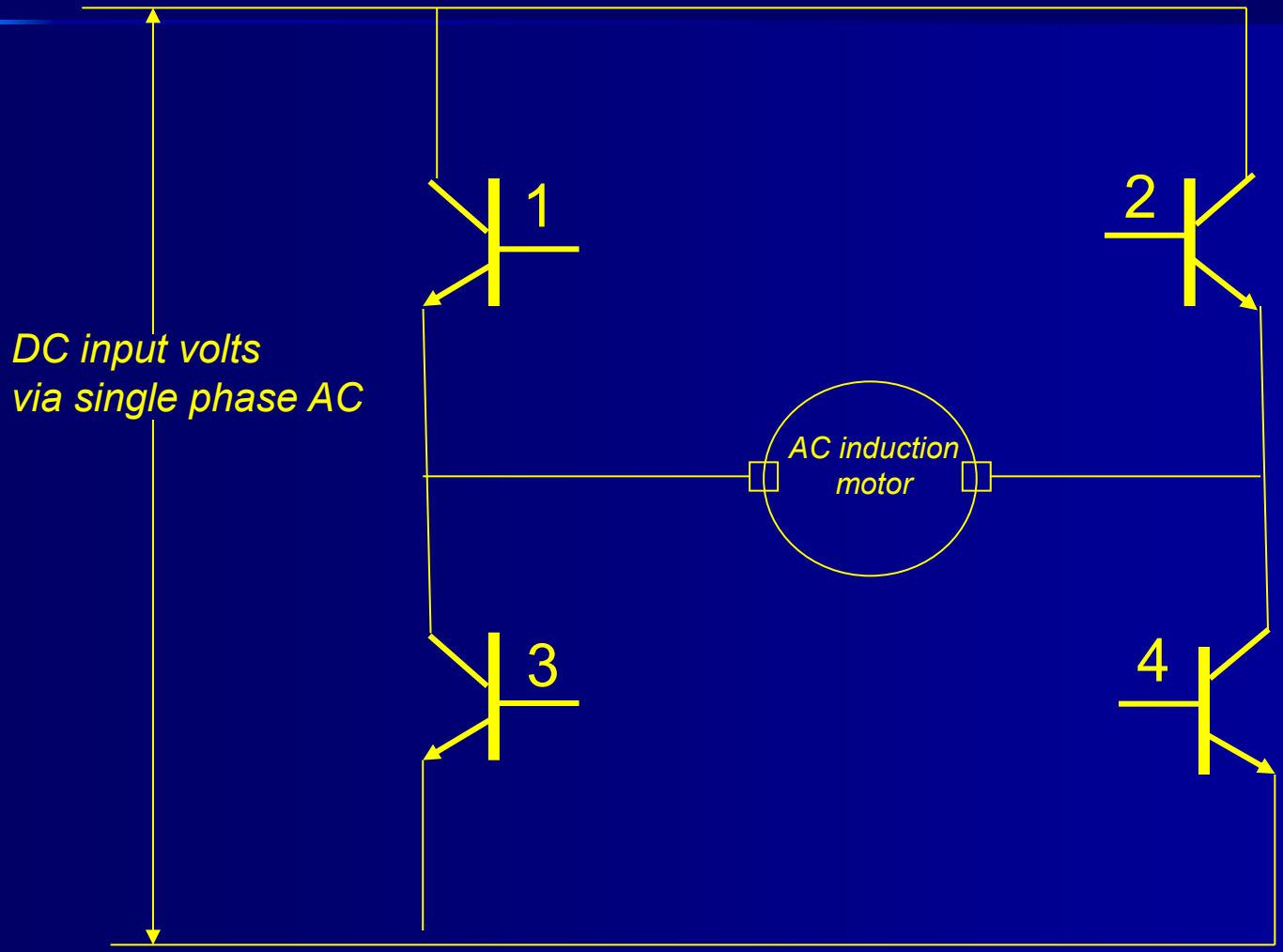
Inverter circuit for single – phase output



Inverter circuit for single – phase output



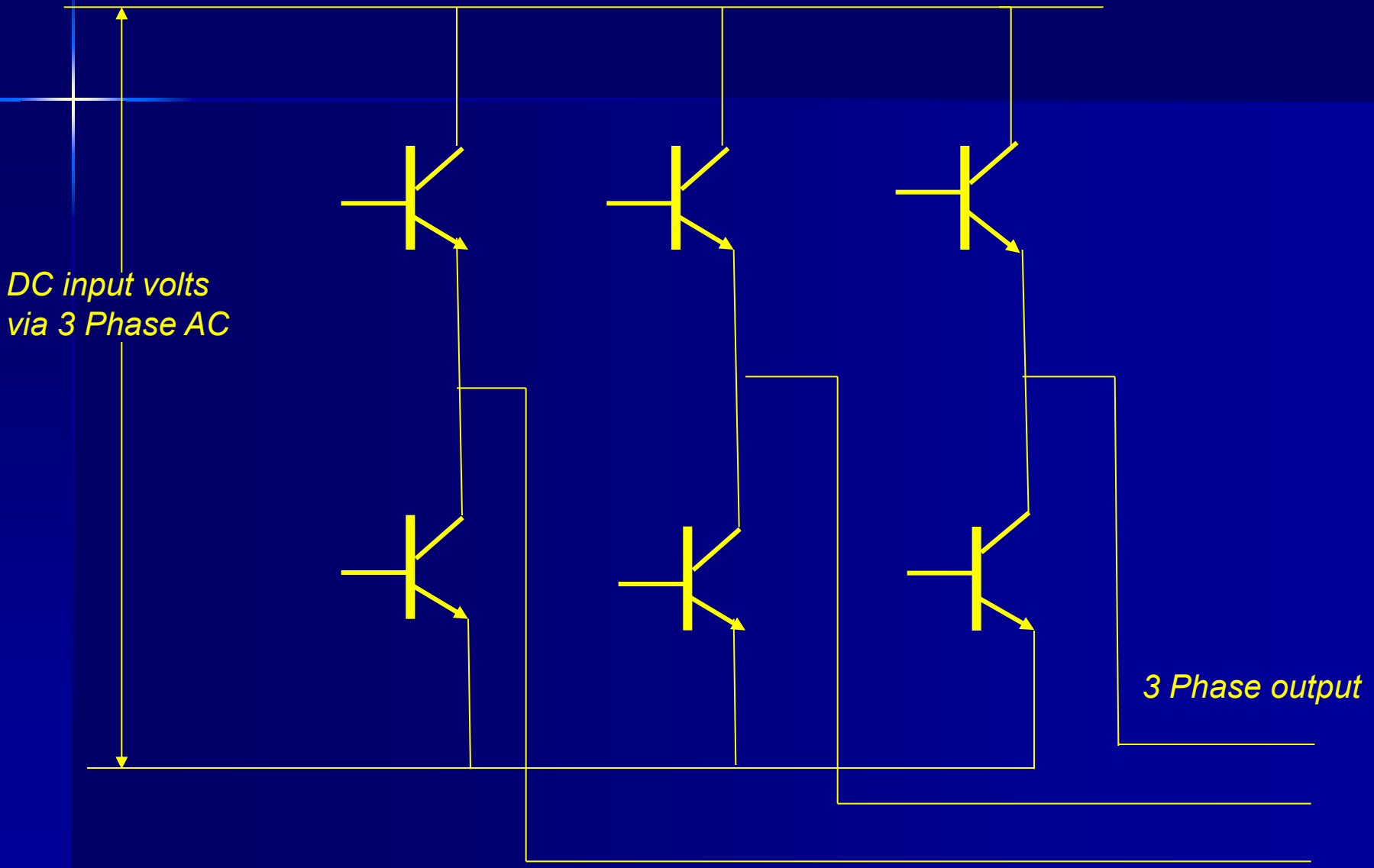
Inverter circuit for single – phase output



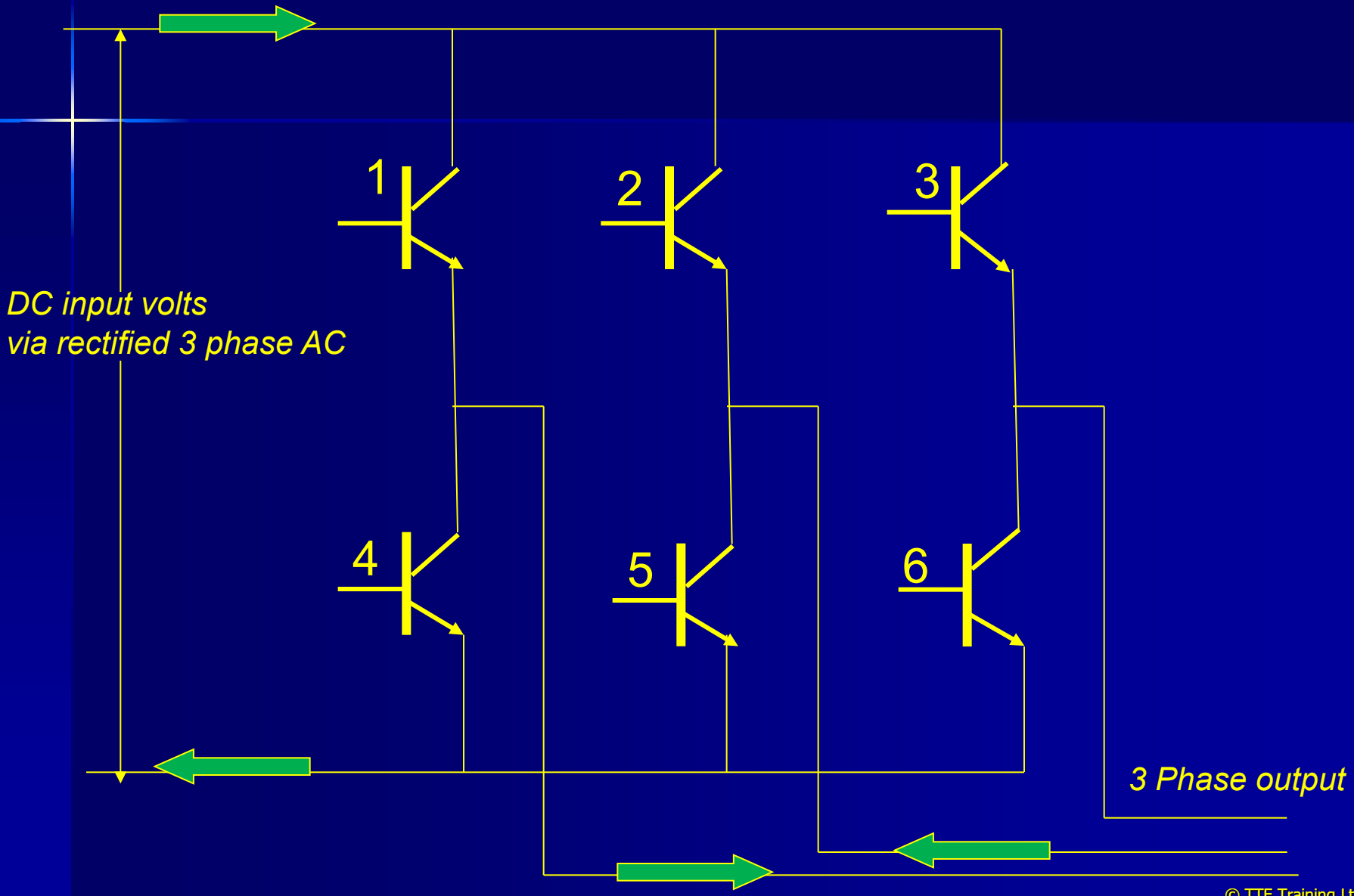
Step 3

How do you change DC into Three Phase AC?

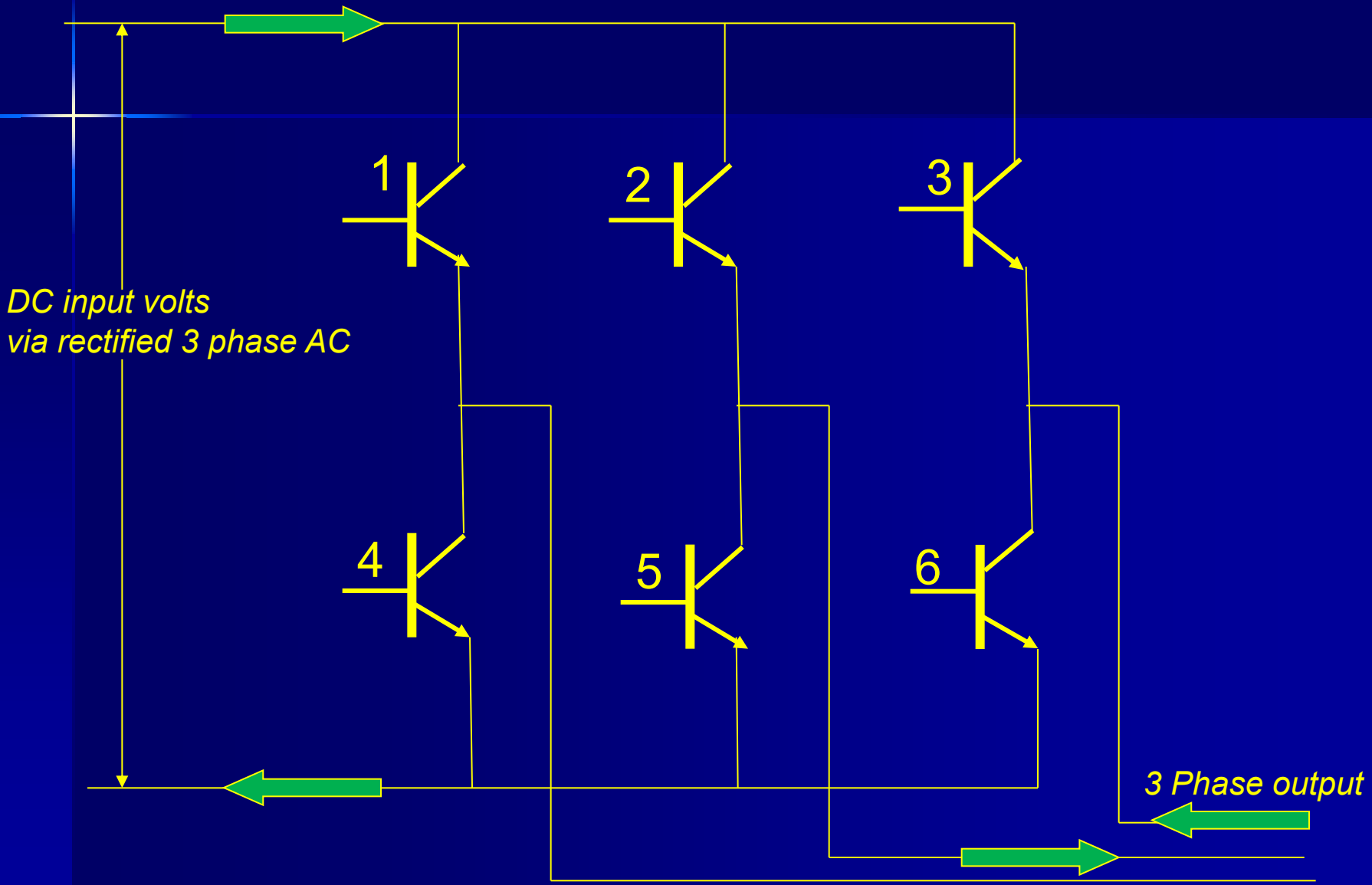
Inverter circuit for 3 – phase output



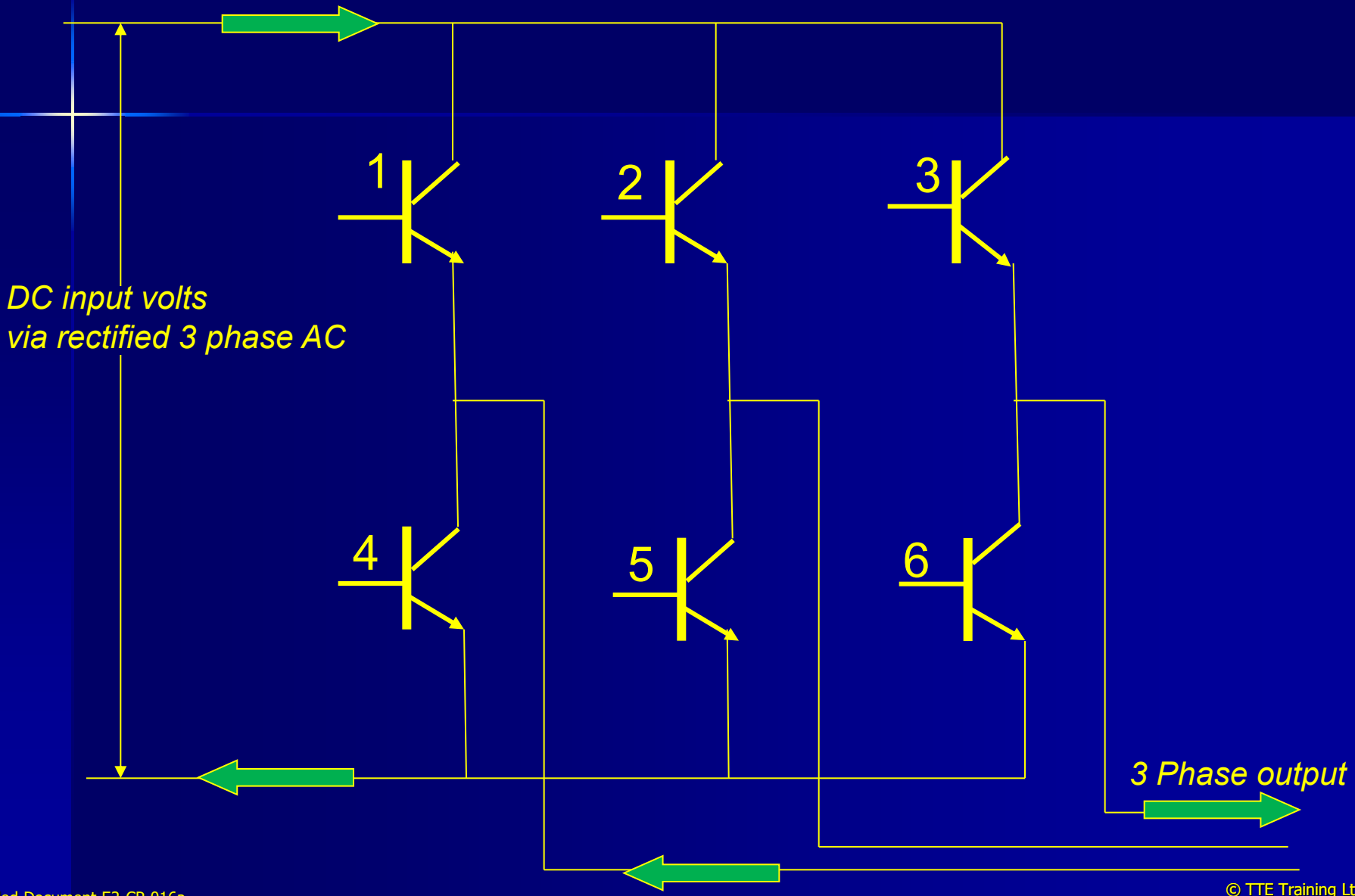
Inverter circuit for 3 – phase output



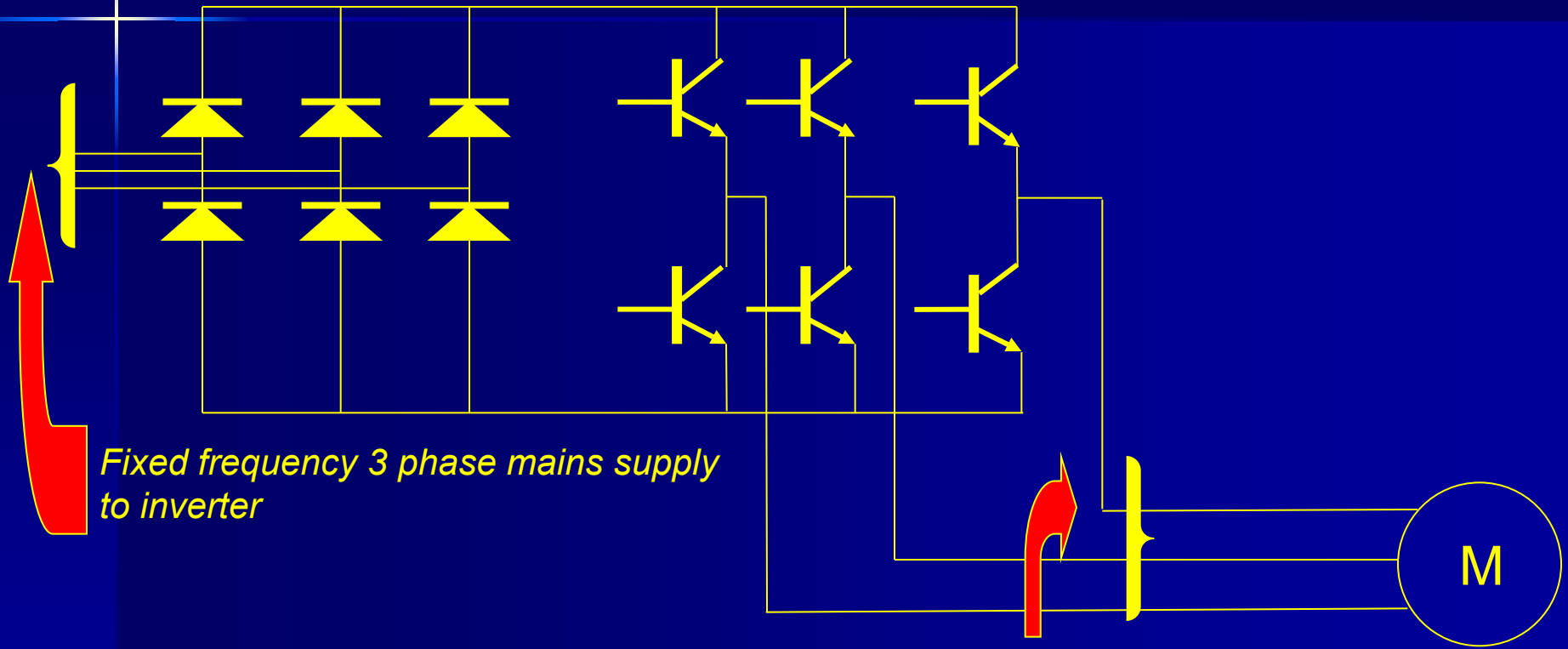
Inverter circuit for 3 – phase output



Inverter circuit for 3 – phase output



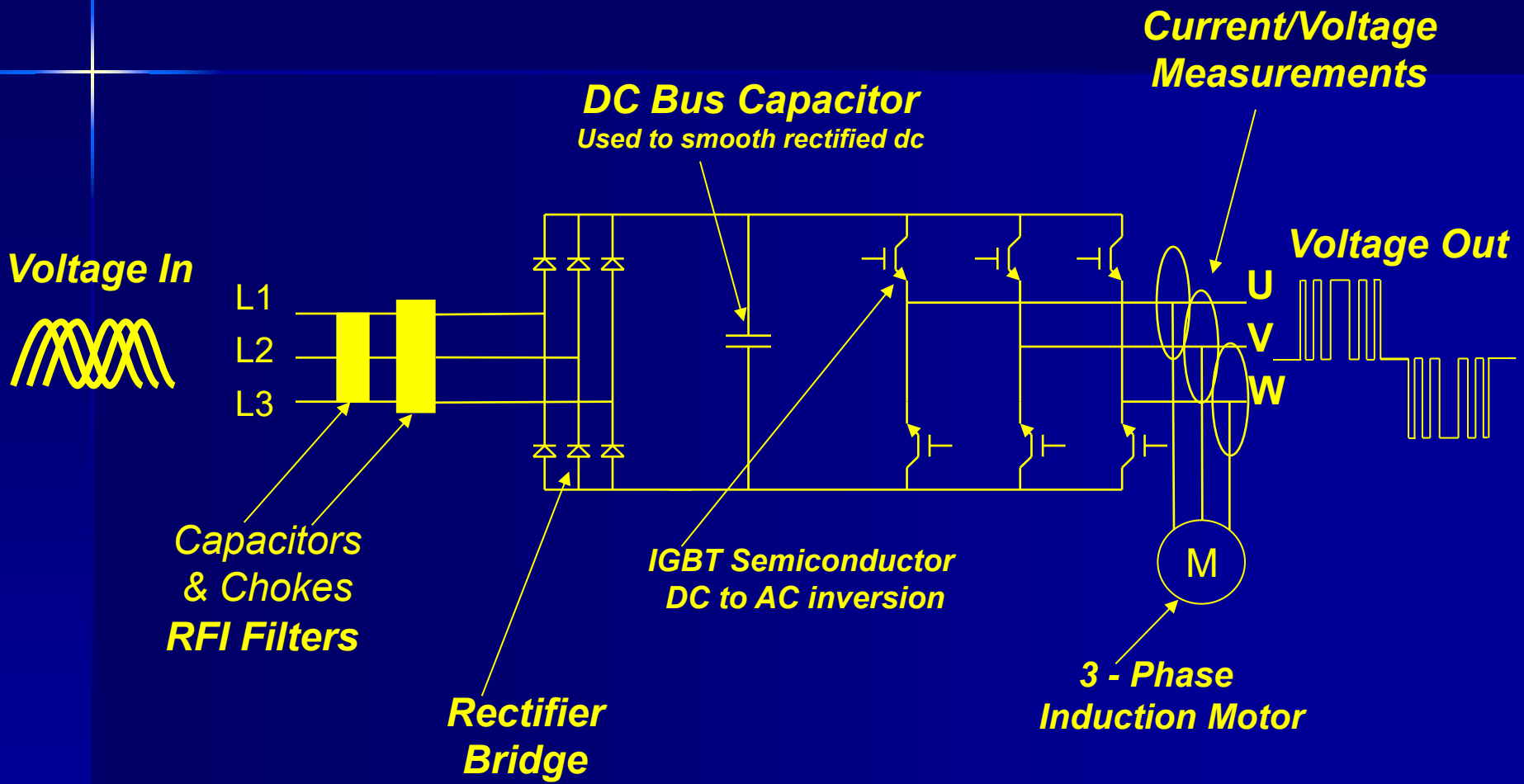
Inverter circuit for 3 – phase output



Fixed frequency 3 phase mains supply to inverter

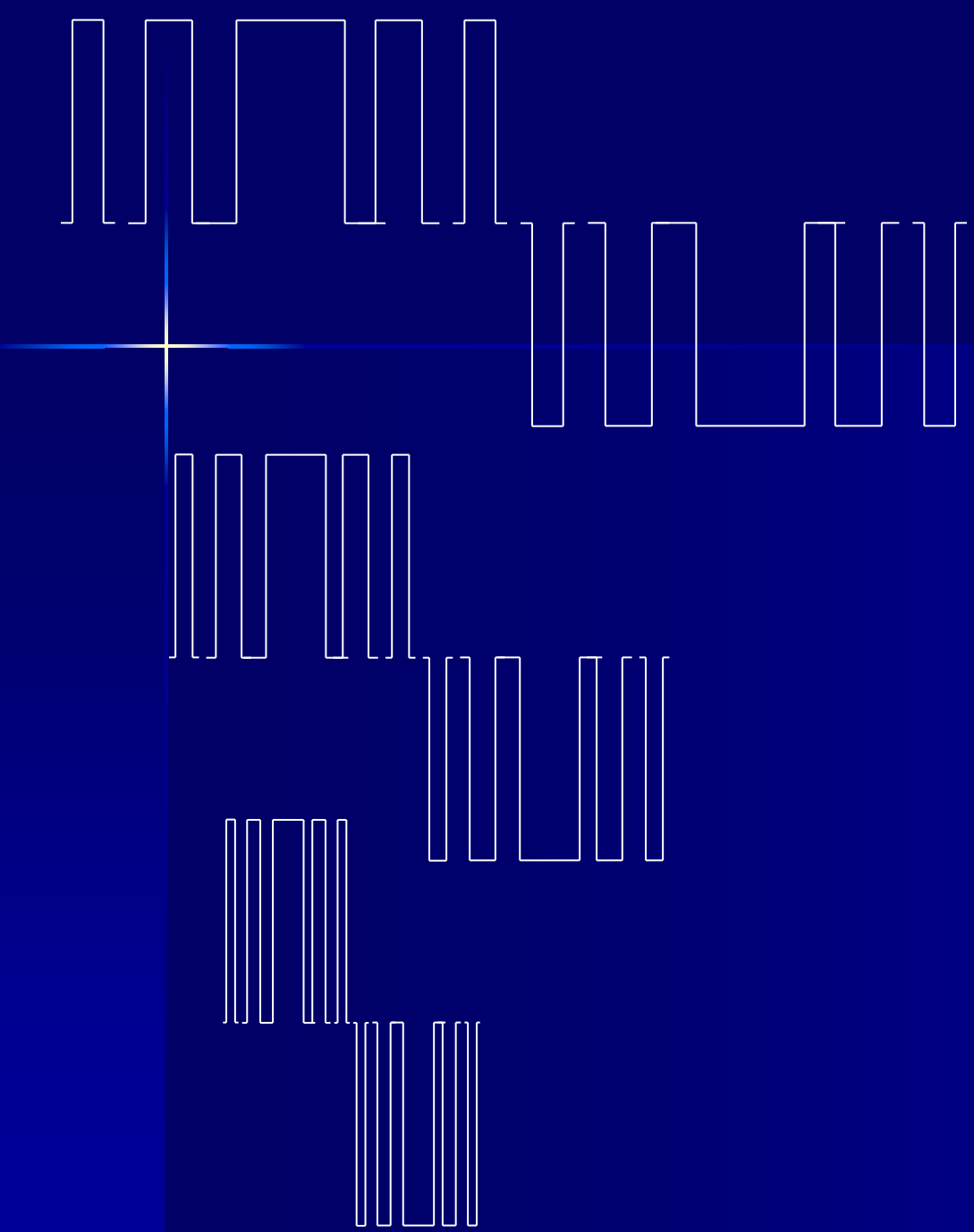
Variable frequency 3 phase output to induction motor

AC Drive Main Circuit

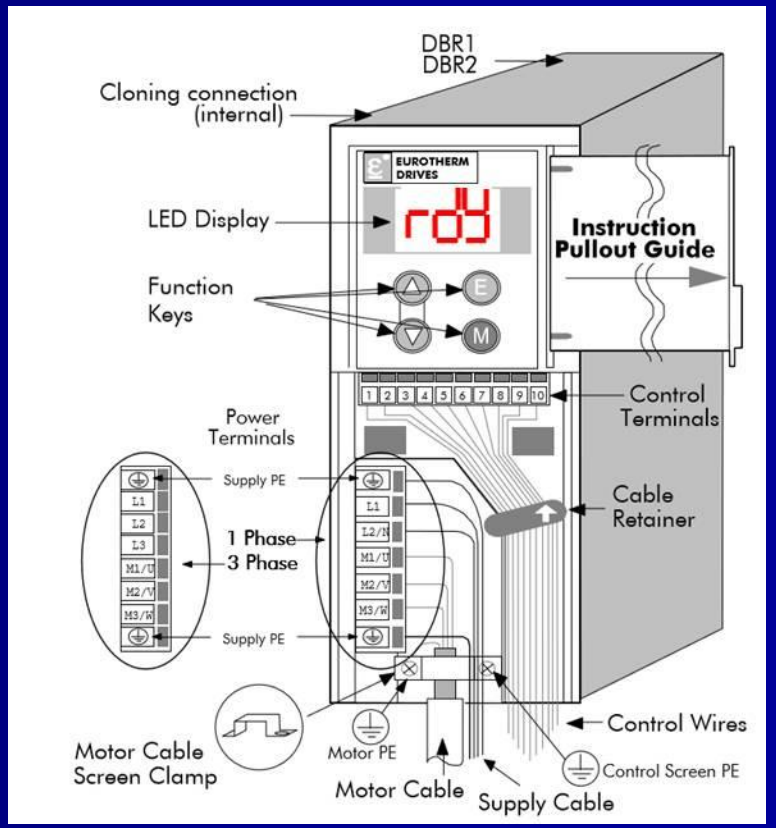


Pulse Width Modulation (PWM)

Varying the frequency

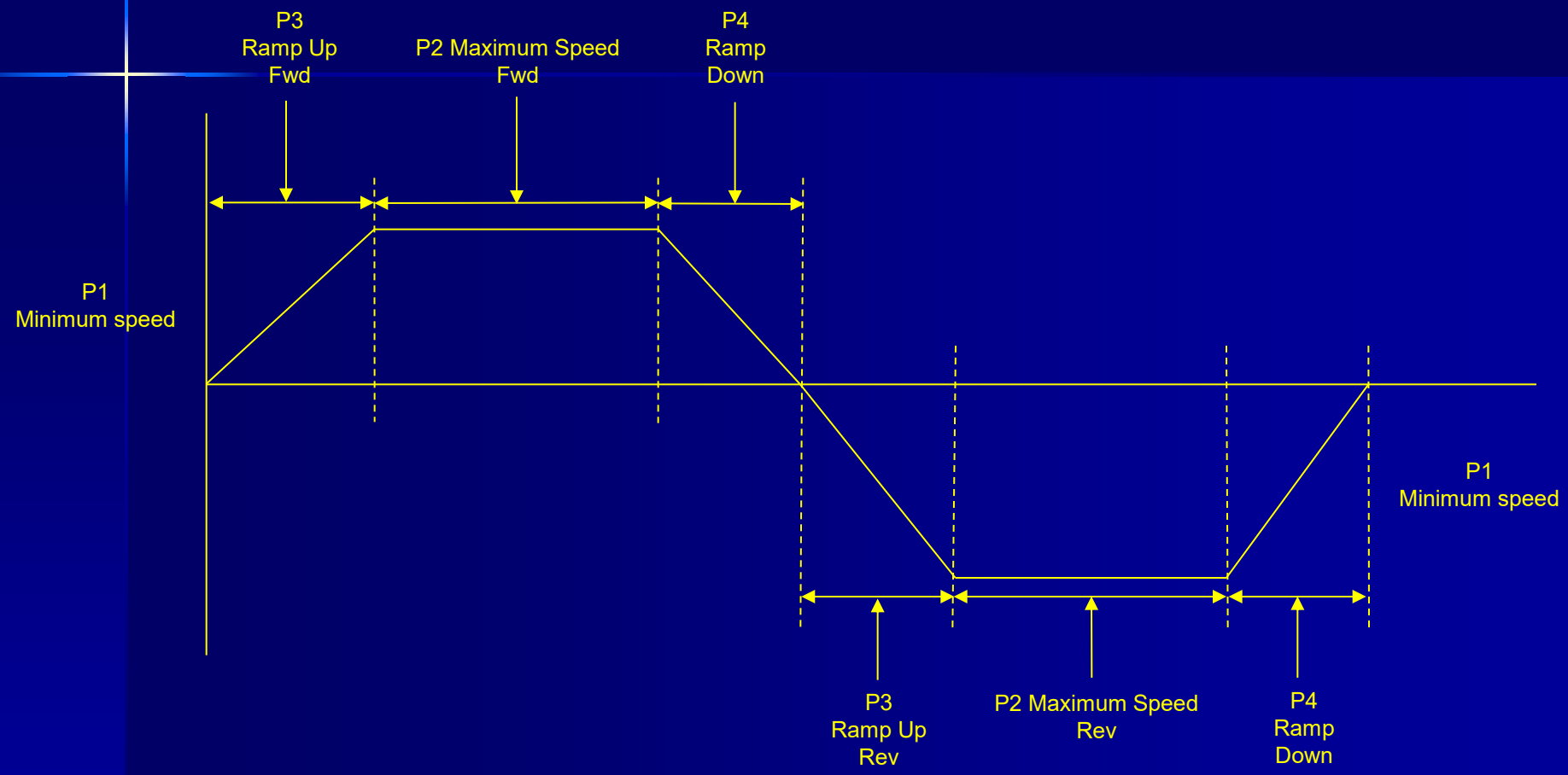


Eurotherm 601 VSD



Example Variable Speed Control Timing diagram

Clockwise / Forward



Anti-Clockwise / Reverse

Parameter	Translation	Description	Range	Factory Default
P1	Minimum Speed	The minimum frequency at which the inverter will run	0 – 240 Hz	0 - Hz
P2	Maximum Speed	The maximum frequency at which the inverter will run	0 – 240 Hz	50 / 60 Hz
P3	Ramp Up Time	The time for the inverter output frequency to ramp up from zero to maximum speed	0.1 – 999s	10s
P4	Ramp Down Time	The time for the inverter output frequency to ramp up from maximum speed to zero	0.1 – 999s	10s
P11	Stopping Mode	Controlled stopping of motor	Ramp Coast Injection	Ramp

P1 0 – 240 Hz	P2 0 – 240 Hz	P3 0.1 – 999s	P4 0.1 – 999s	P11 Ramp = 0 Coast = 1 Injection = 2
Minimum Speed	Maximum Speed	Ramp Up Time	Ramp Down Time	Stopping Mode
10	100	15	10	1
25	75	25	15	0
2	150	45	30	0

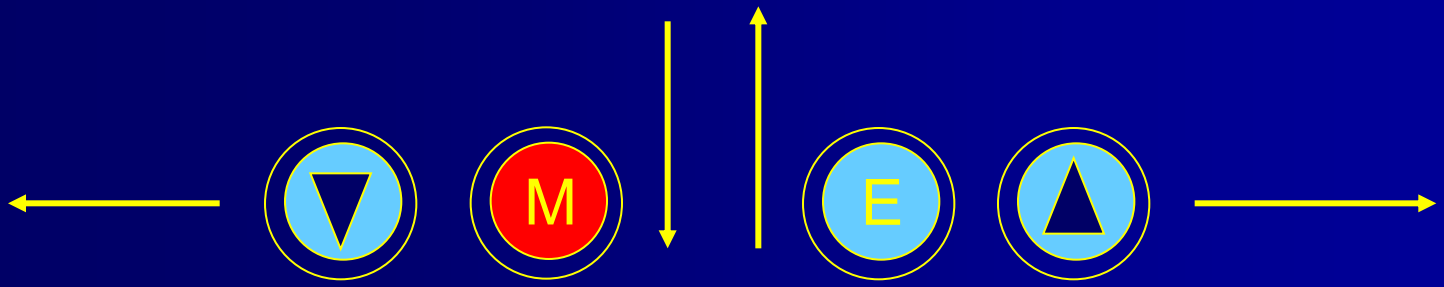
MMI Status Level

rdy *Display Value Level*

Diagnostic values
Display only

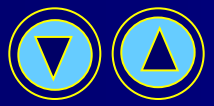
Title Level

P15	d1	d2	d3	P1	P2	..	..	..	P15



4 Function Keys

Current Parameter values are displayed

Use  **to increase / decrease**

Parameter values