Siemens AC/DC EMU Power Circuit

N.D.Turkar/PL/PSTC/IRIEEN/NK

Name of equipment	Equipment Rating
AC Surge Arrestor	34 KV
Potential Transformer	25 KV/150 V
Change Over Switch	25KV AC/1500VDC 1000A
VCB	25KV AC/1000 A
HSCB	1500V DC/1000A
CT(Input/Output)	75/1 A
AC Surge Arrestor	32 KV
DC Surge Arrestor	2 KV
AC Earthing Switch	25 KV, 400A
DC Earthing Switch	3 KV, 400A
Main Transformer	1250 KVA
R 31	30 Ω
R 32	253 Ω
R 41	99 KΩ
R 42	33 KΩ

Traction Motor Data --	(Continuous Operation)	(Maximum)
Voltage	932 V	1403 V
Current	200 A	277 A
Power	240 KW	288 KW
Speed	2000 RPM	3562 RPM
Frequency	101.5 HZ	


1006

ABBREVIATION

1. A&D LD Siemens Automation & Drives, Large Drives
2. PCB Printed Circuit Board
3. CT Current transformer
4. VSD Voltage Sensing Device
5. ESD Electrostatically Sensitive Device
6. EMC Electromagnetic compatibility
7. 4QC Four-quadrant converter
8. EMI Electromagnetic Interference
9. EMU Electrical Multiple Unit
10. AHU Air Handling Unit

ABBREVIATION

11. ACU Auxiliary converter Unit
12. HSCB high speed circuit breaker
13. MVB Multifunctional vehicle bus
14. IGBT Insulated Gate Bipolar Transistor
15. I/O Input / Output
16. HTC high tension compartment
17. PG Cable Gland
18. PWMI Pulse Width Modulation inverter
19. SIBAS Siemens Bahn (Train) Automation System

ABBREVIATION

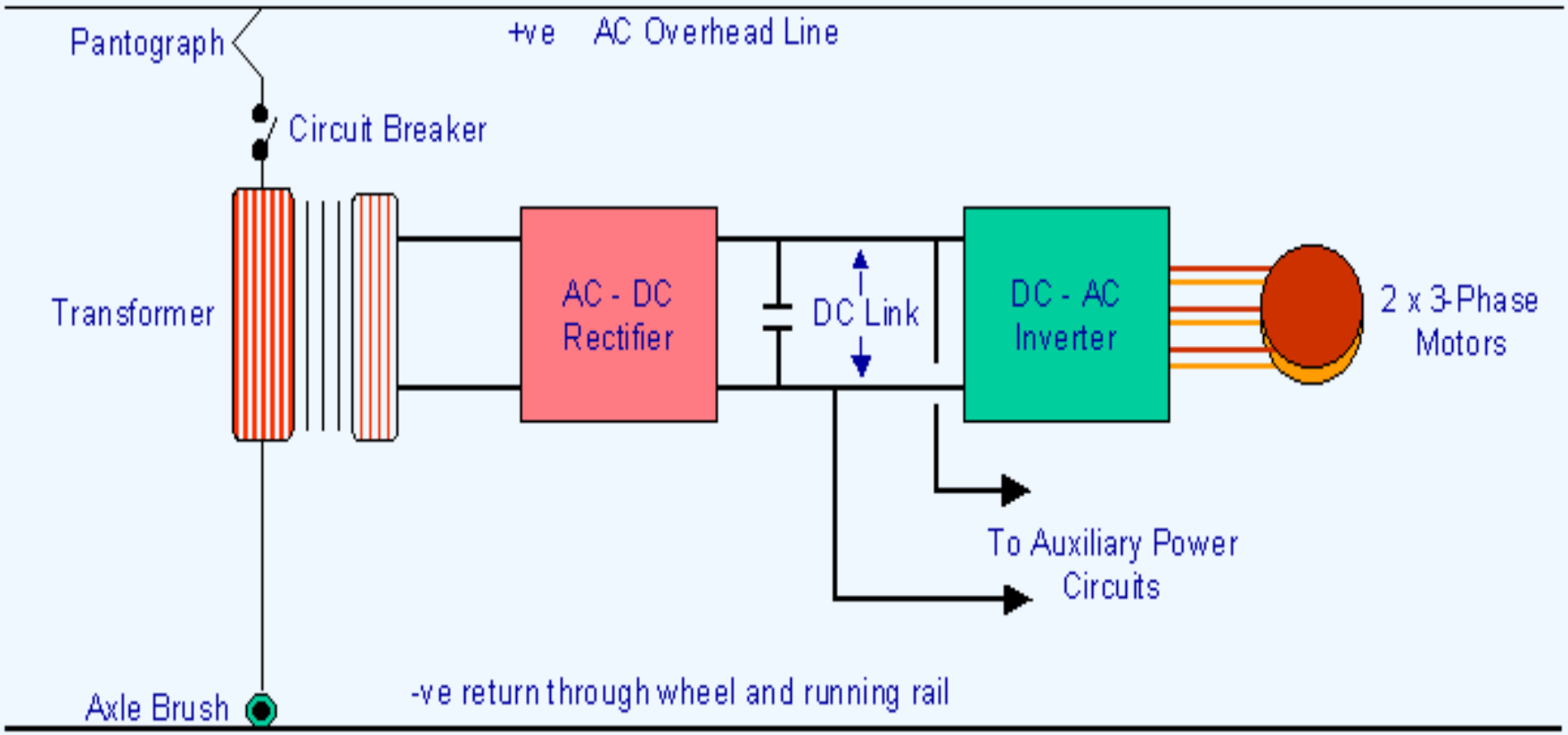
20. SIP Signal Processor Board
21. TCC Traction Converter Cabinet
22. TCU Traction Control Unit
23. CPU Central processing Unit
24. 4QS Four-quadrant controller (4QC)
25. KLIP Intelligent terminal for peripheral interfacing
26. BCU Brake Control Unit

EMU train sets are highly energy efficient and aerodynamically light weight.

Some of the advantages of EMU train sets over conventional loco hauled trains operating at similar speeds are:

1. Higher reliability on account of distributed power units
2. Lower and distributed axle load, thus reducing the track/bridge maintenance and increasing the assets life.
3. Higher acceleration/deceleration performance due to distributed traction/power units
4. Higher floor area utilisation due to elimination of loco and power cars
5. Elimination of reversal at terminal stations leading to better operational efficiency
6. Noiseless and environment friendly due to absence of power generating cars
7. Reduced maintenance and long life of wheels and brake equipments on account of regenerative braking in multiple units
8. Reduced coupler forces

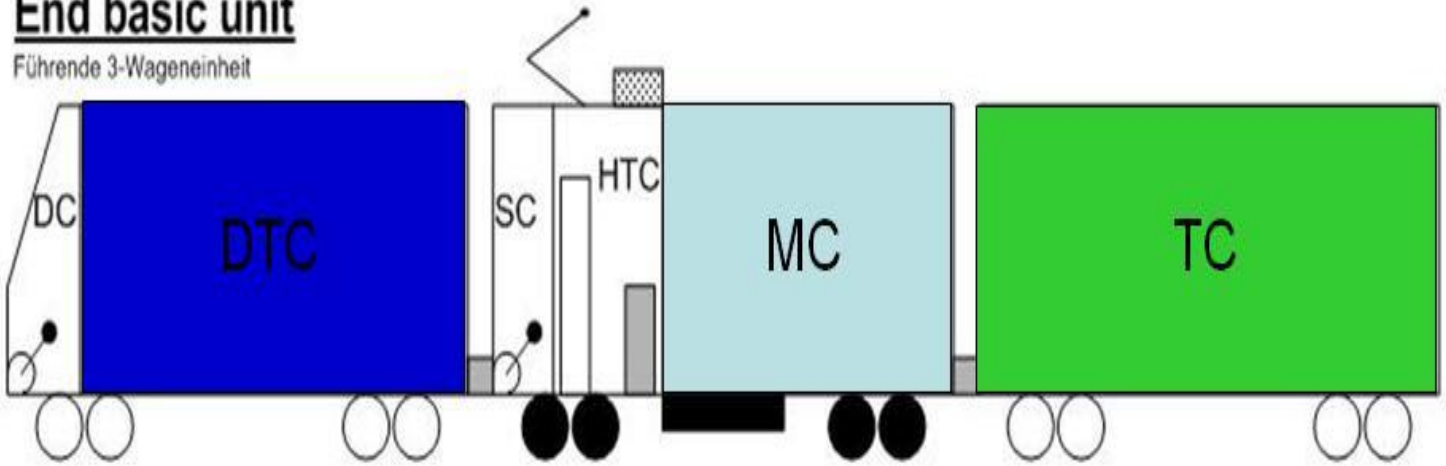
POWER CIRCUIT



Schematic of single phase AC supply powering 3-phase AC motors

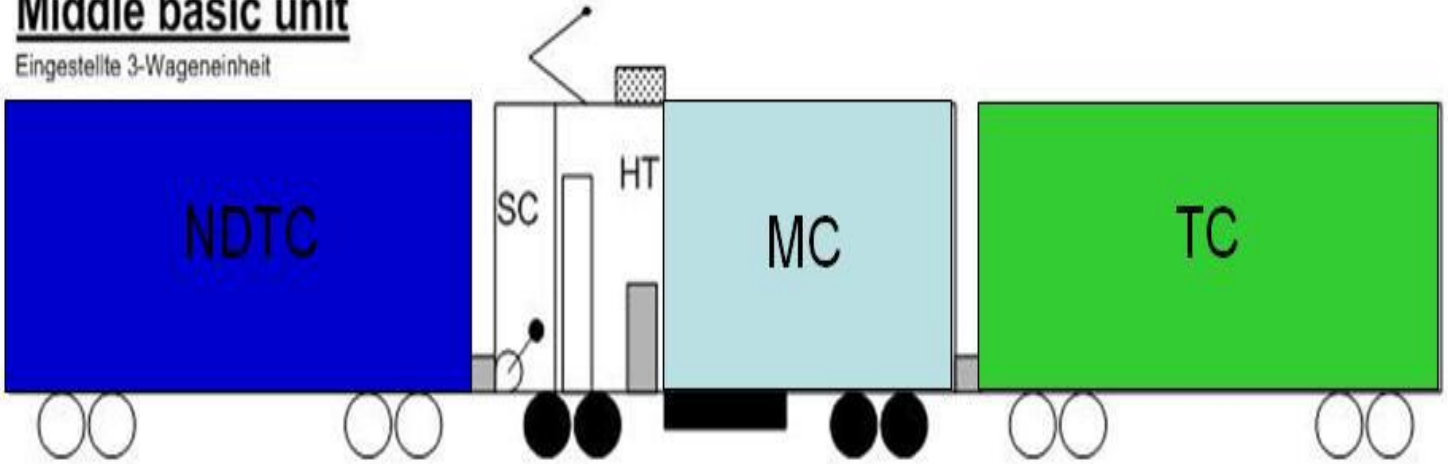
End basic unit

Führende 3-Wageneinheit



Middle basic unit

Eingestellte 3-Wageneinheit



Legend:

DTC	Driving Trailer Car
MC	Motor Car
NDTC	Non Driving Trailer Car
TC	Trailer Car
HTC	High Tension Comp.
DC	Driving Cab
SC	Shunting Cab

Power axle

Trailer axle

Transformer

Brake resistor

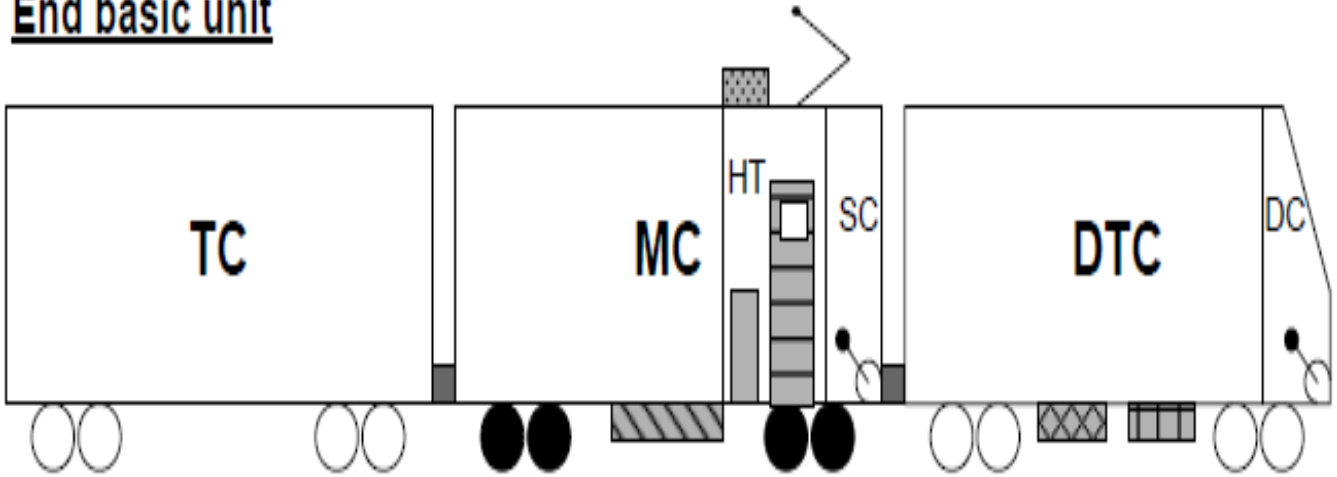
Traction converter

Auxillary converter

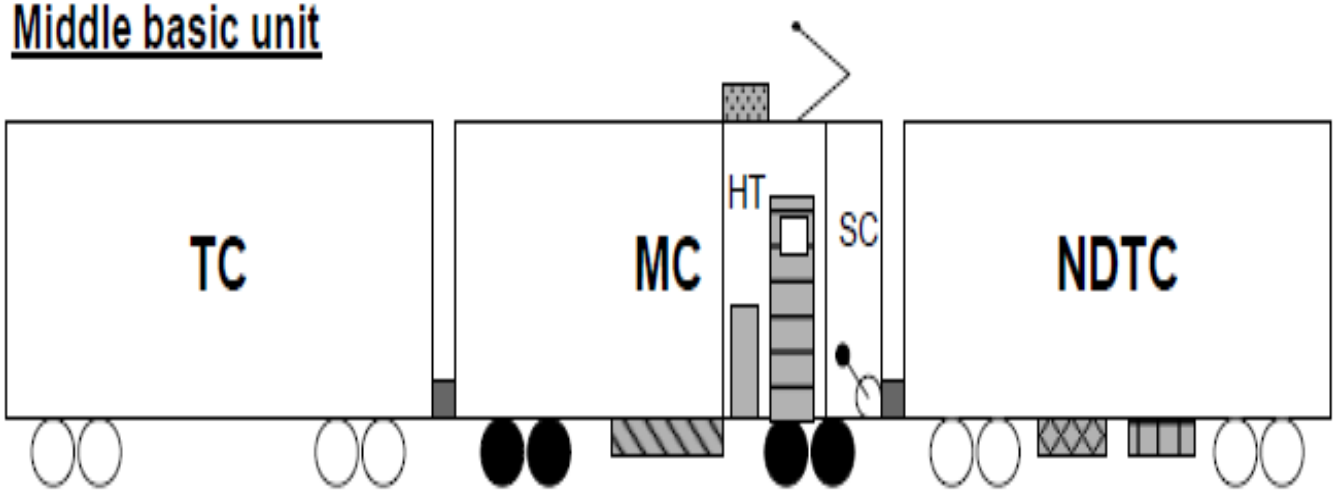
Master controller

Pantograph

End basic unit



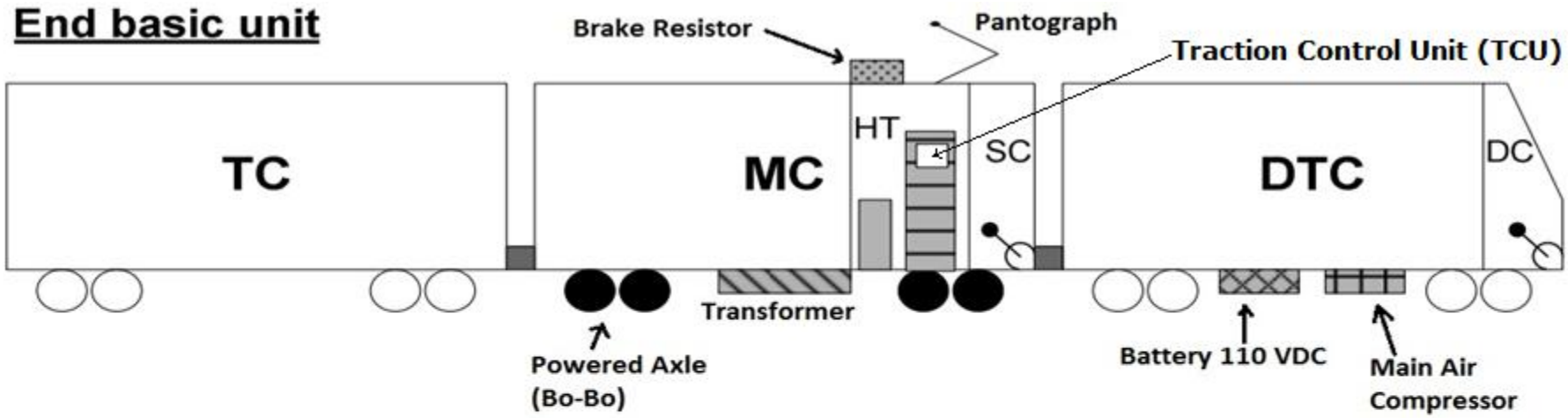
Middle basic unit

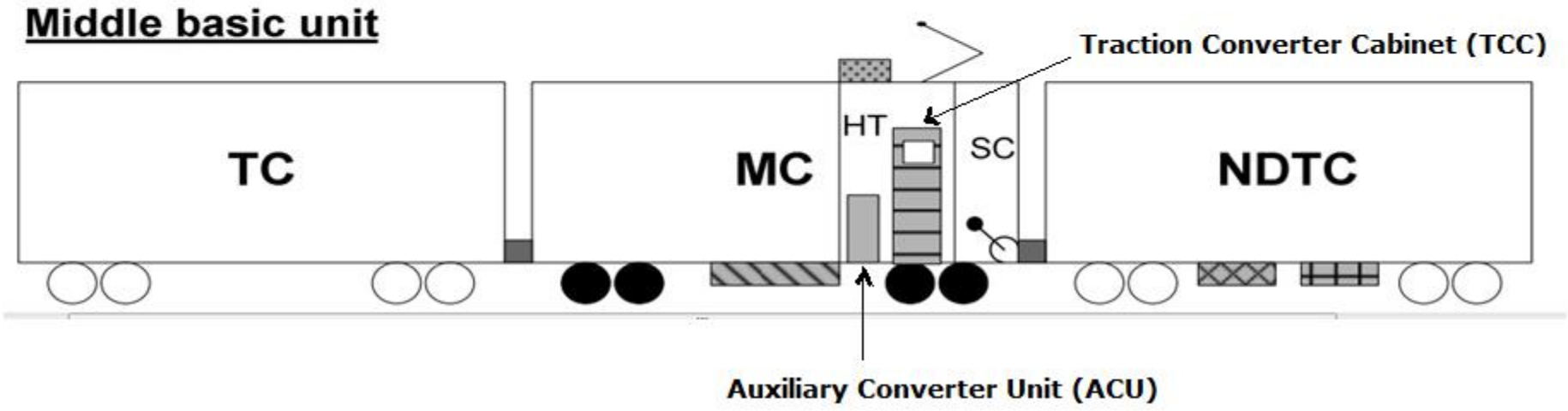


Legend:

DTC	Driving Trailer Car
NDTC	Non Driving Trailer Car
MC	Motor Car
TC	Trailer Car
HT	High Tension Comp.
DC	Driving Cab
SC	Shunting Cab
	Powered axle
	Non Powered axle
	Transformer
	Brake resistor
	Traction converter
	TCU
	Auxillary converter
	Master controller
	Pantograph
	Main air compressor
	Battery (110V DC)

Location of Power and Auxiliary Circuit within the train



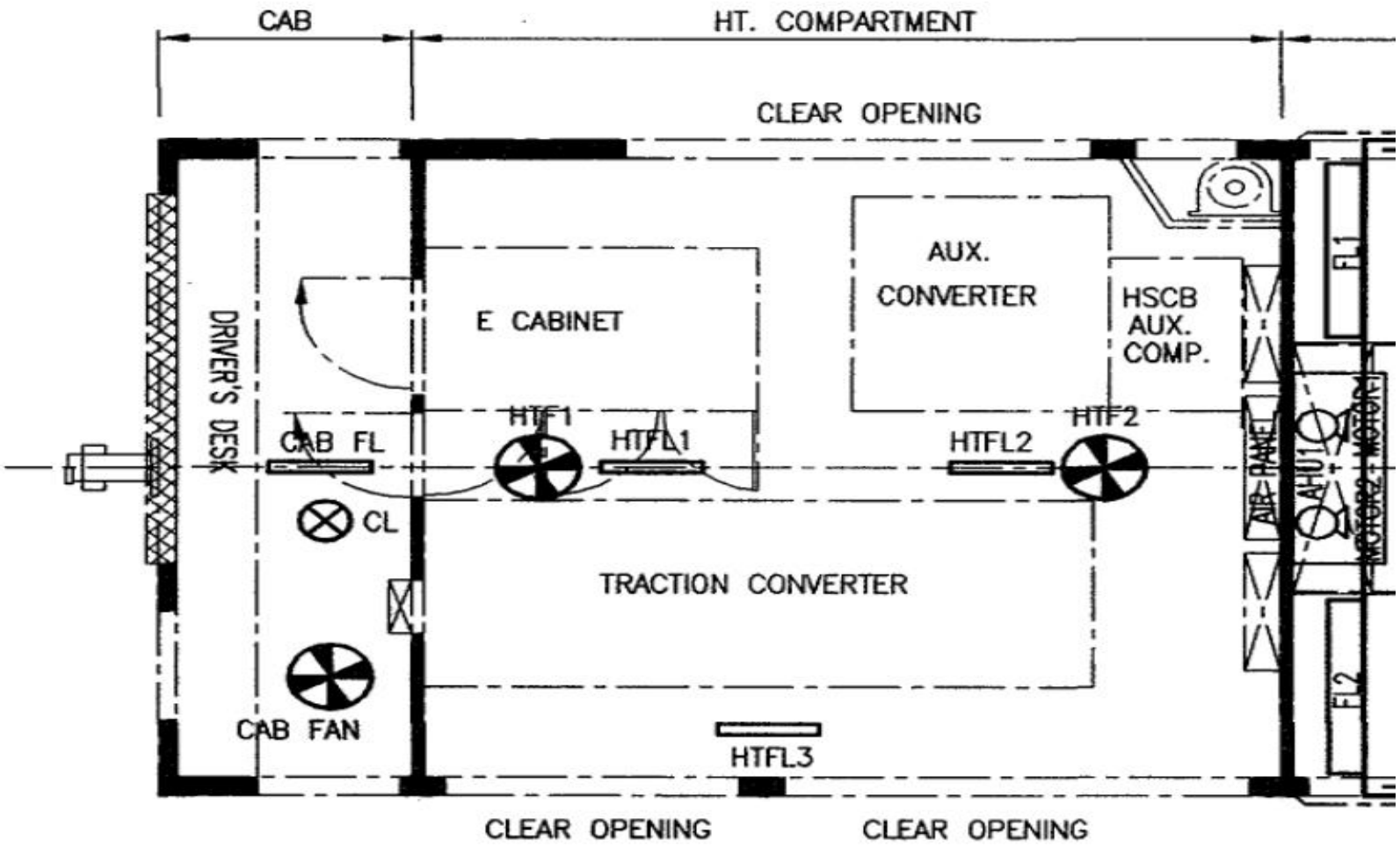


HT – High Tension Compartment
SC – Shunting Cab

EMU Train sets have higher acceleration and deceleration due to which it takes them much lesser time in negotiating speed restrictions and achieving maximum permissible speed. Thus, it is possible to reduce the run time between Howrah and New Delhi up to 3 hours by operating train sets at an existing speed of 130 kmph without any additional expenditure on track and other infrastructure.

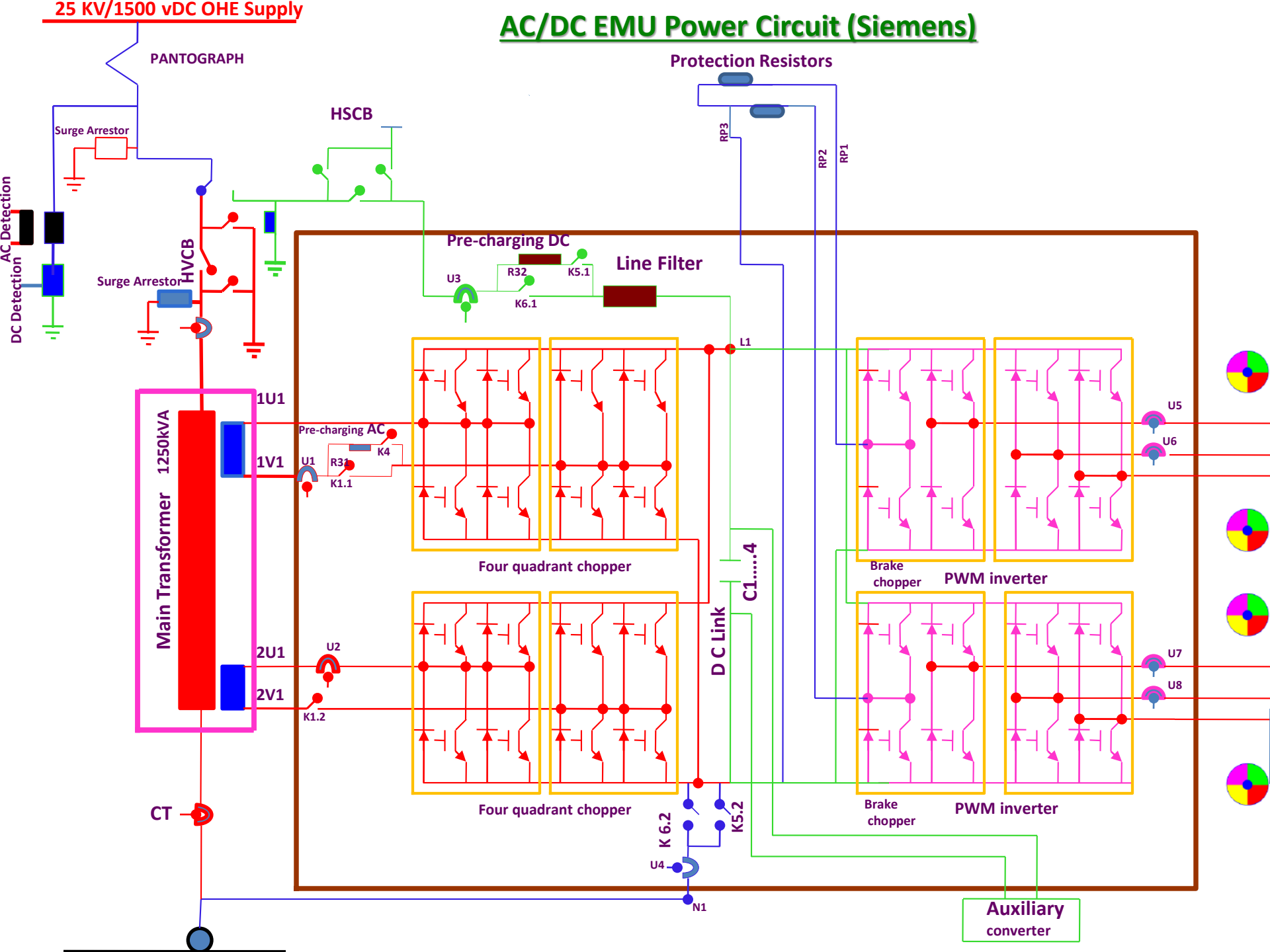
4QC	Four Quadrant Chopper
AC	Alternating Current
ACU	Auxiliary Converter Unit
BCU	Brake Control Unit
DC	Direct Current
DTC	Driving Trailer Car
EP	Electro-Pneumatic Brake (electrical operated pneumatic Brake)
HSCB	High Speed Circuit Breaker (DC Main Circuit Breaker)
HT	High Tension
I/O	Input/Output
IGBT	Insulated Gate Bipolar Transistor
KLIP	Intelligent terminal for peripheral interfacing
MC	Motor car
MVB	Multifunction Vehicle Bus
NDTC	Non Driving Trailer Car
SIBAS	Siemens railway automation system
TC	Trailer Car
TCC	Traction Converter Container
TCU	Traction Control Unit
VCB	Vacuum Circuit Breaker (AC Main Circuit Breaker)

Layout of HT Compartment

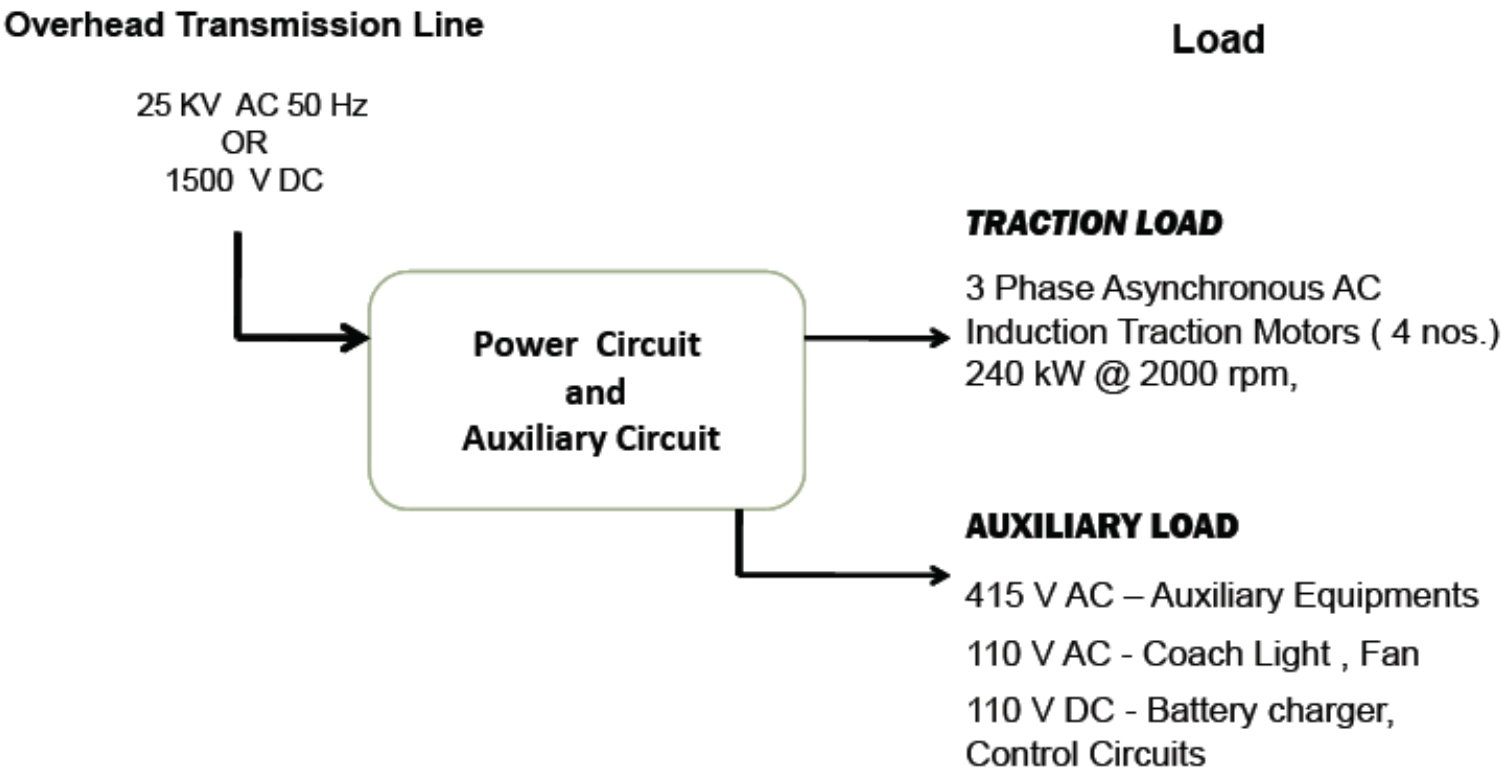


TRACTION CONVERTER CABINET

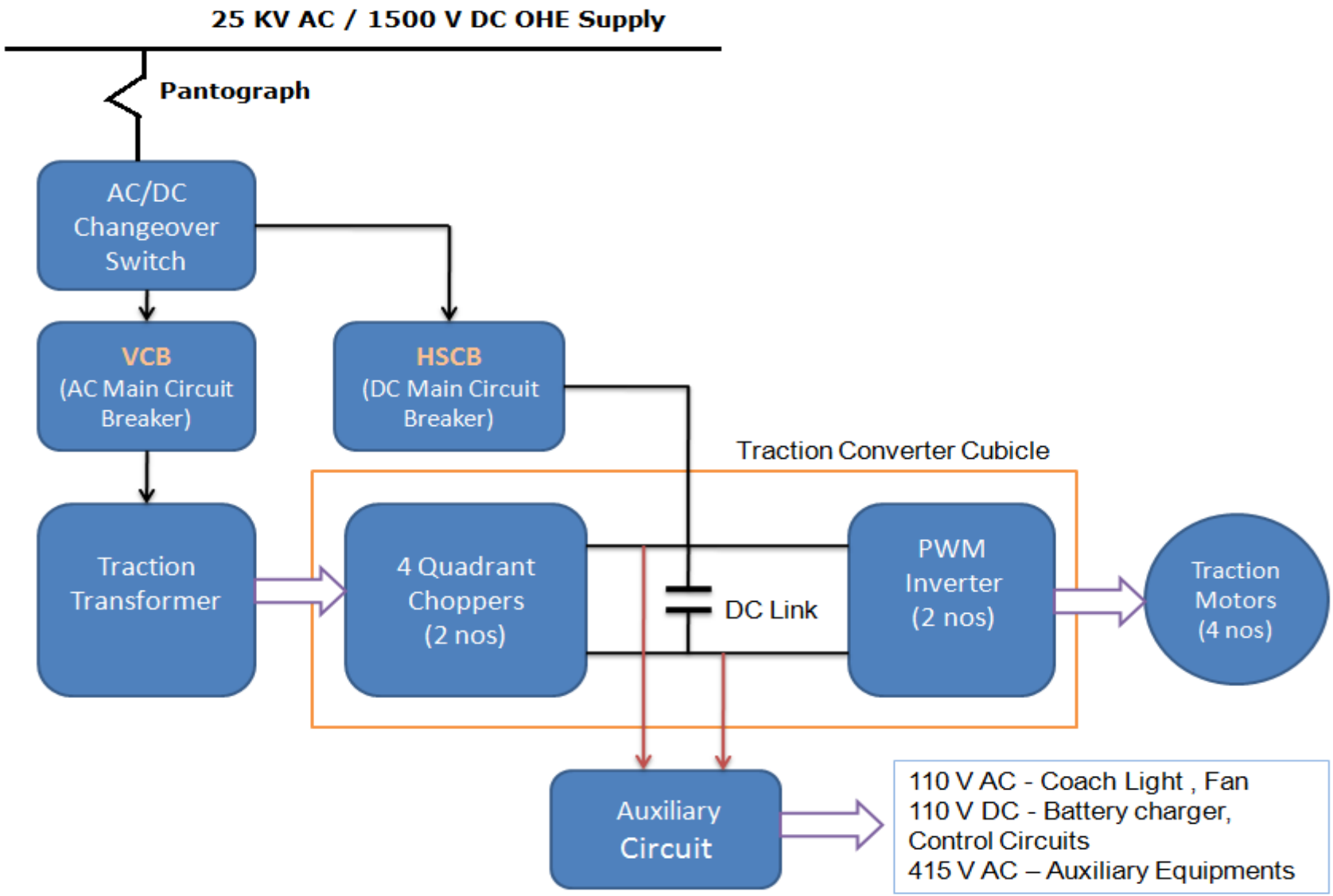
AUXILIARY CONVERTER UNIT


AC/DC EMU Power Circuit (Siemens)
25 KV/1500 vDC OHE Supply
PANTOGRAPH
Surge Arrestor
HSCB
Protection Resistors
RP3
RP2
RP1
AC Detection
DC Detection
Surge Arrestor
HVCB
Pre-charging DC
R32
K5.1
K6.1
U3
Line Filter
L1
Main Transformer 1250kVA
1U1
1V1
2U1
2V1
Pre-charging AC
K4
U1
R31
K1.1
U2
K1.2
Four quadrant chopper
Four quadrant chopper
D C Link
C1.....4
Brake chopper
PWM inverter
Brake chopper
PWM inverter
U5
U6
U7
U8
CT
K 6.2
K5.2
U4
N1
Auxiliary converter

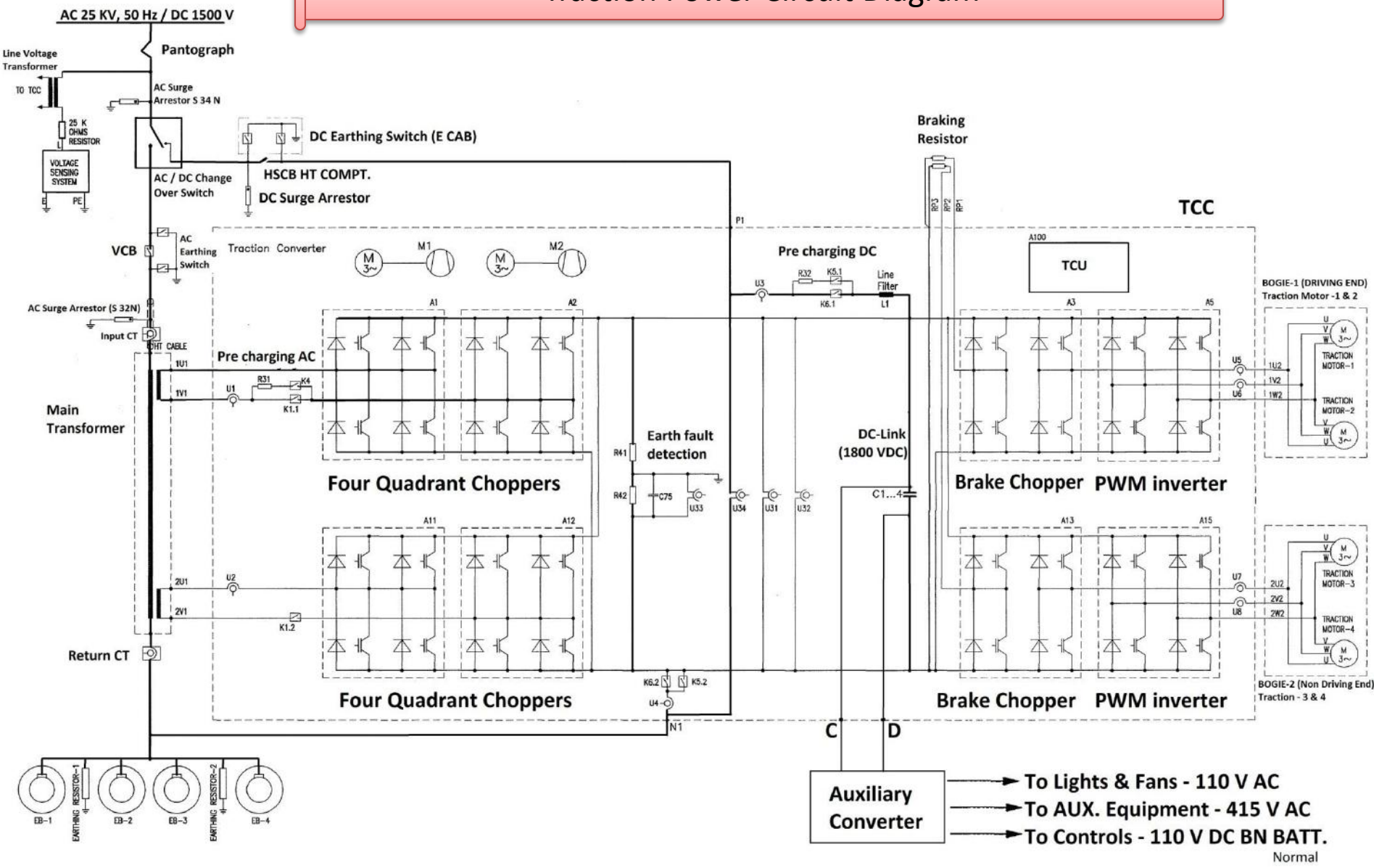
Power and Auxiliary Circuit Requirement



Block diagram of Traction Power Circuit

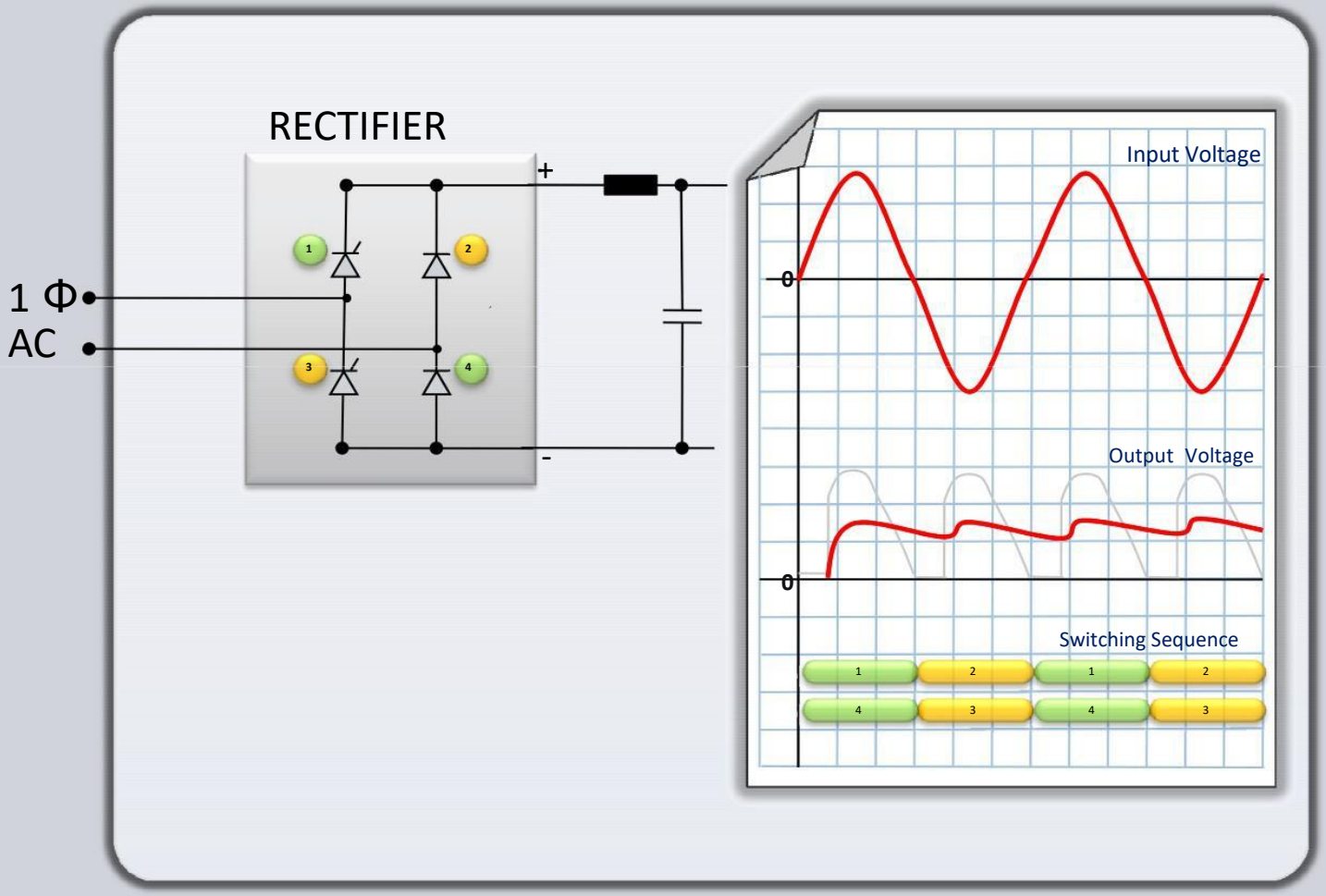


Traction Power Circuit Diagram

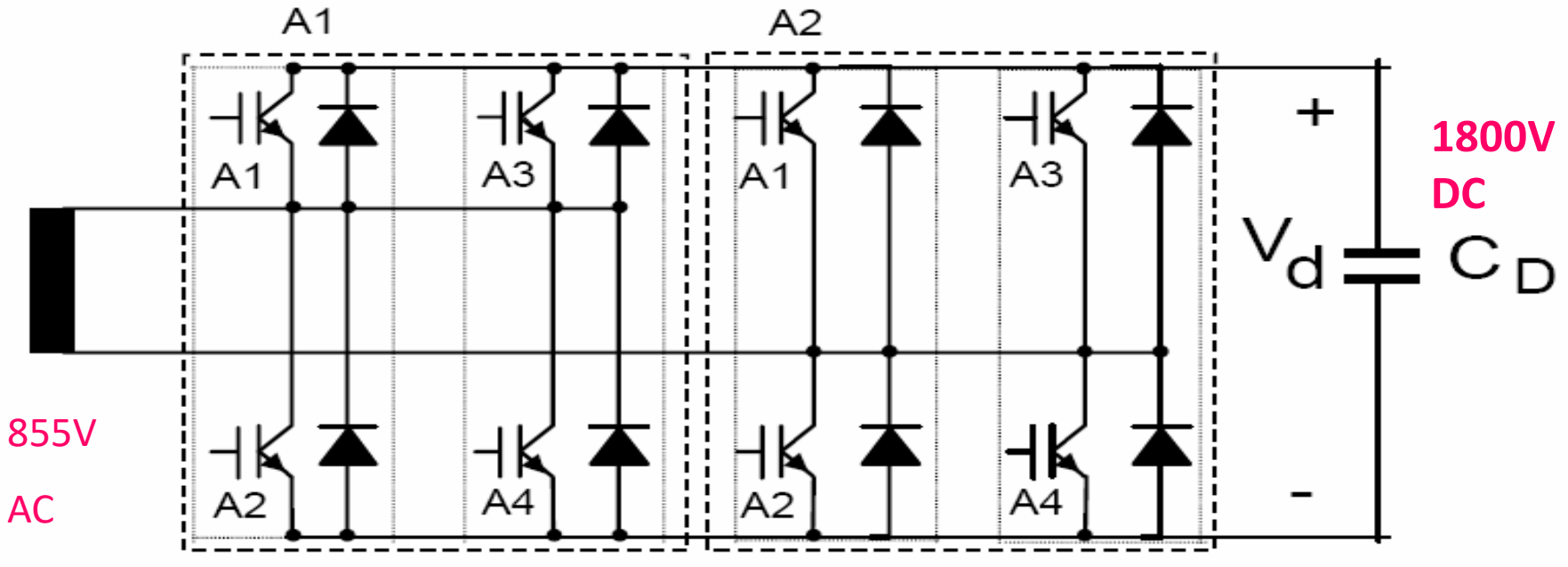


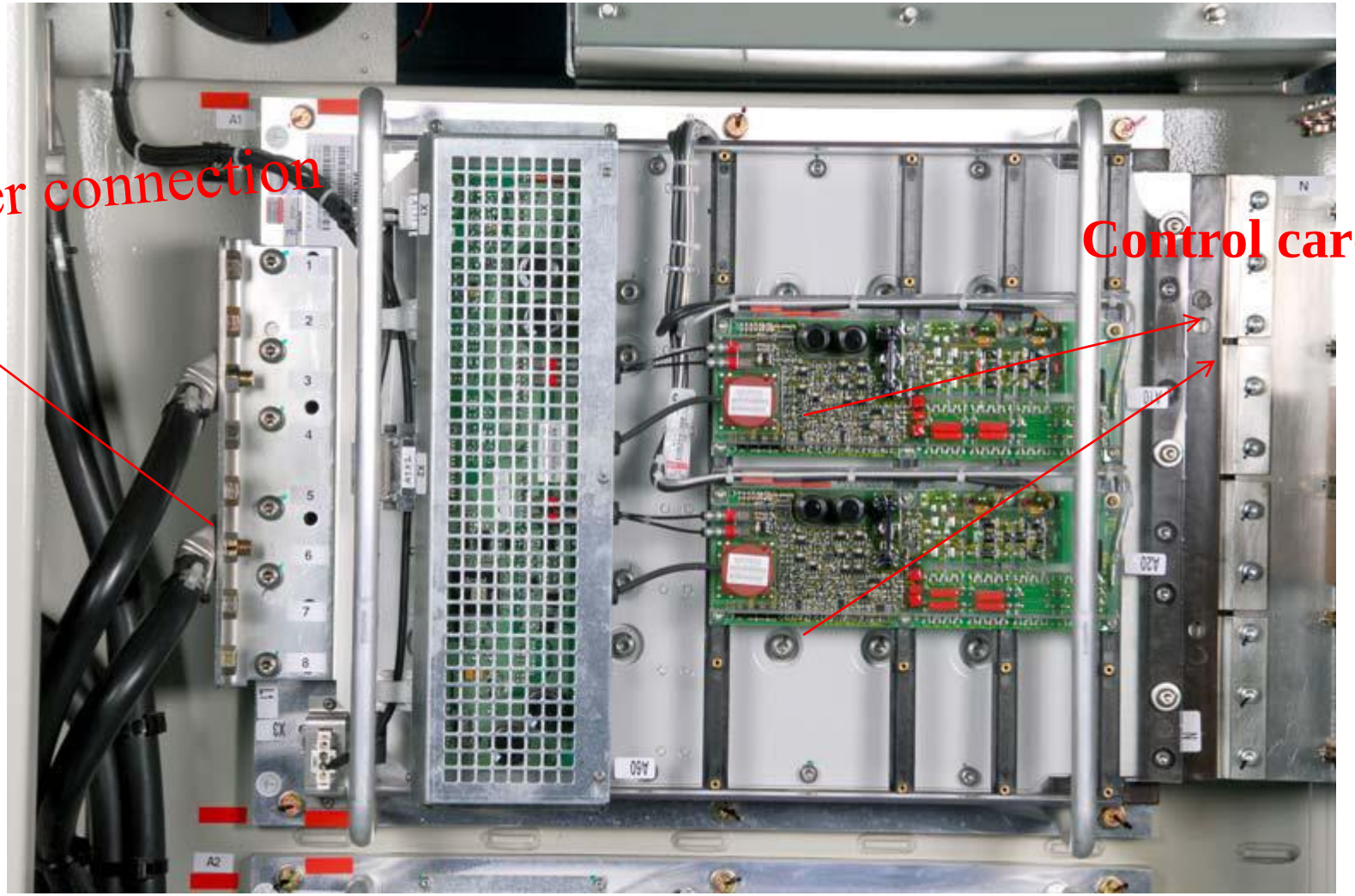
SIEMENS

Semi Controlled Rectifier with Filter



FOUR QUADRANT CHOPPER

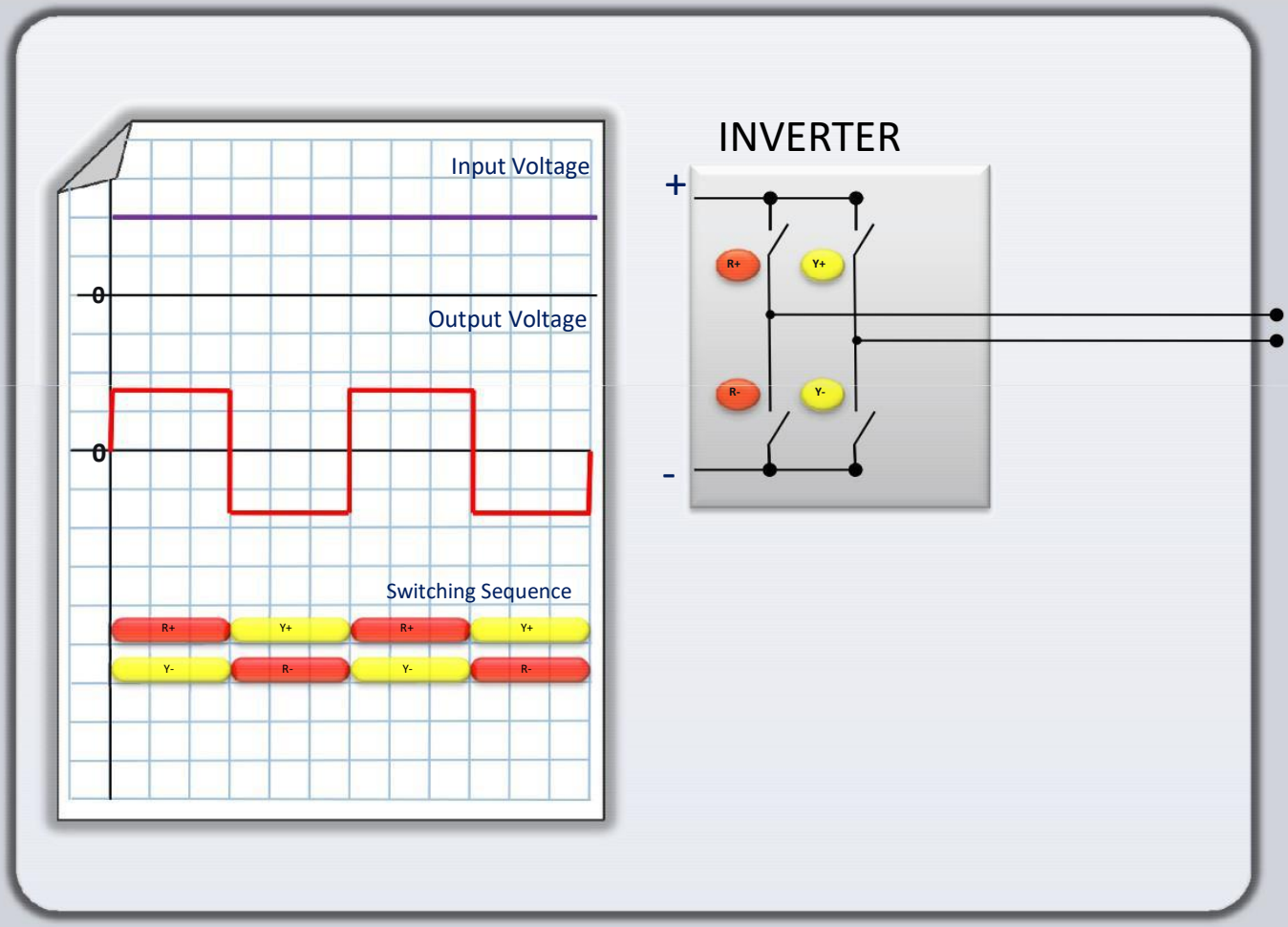




4 Quadrant chopper IGBT module

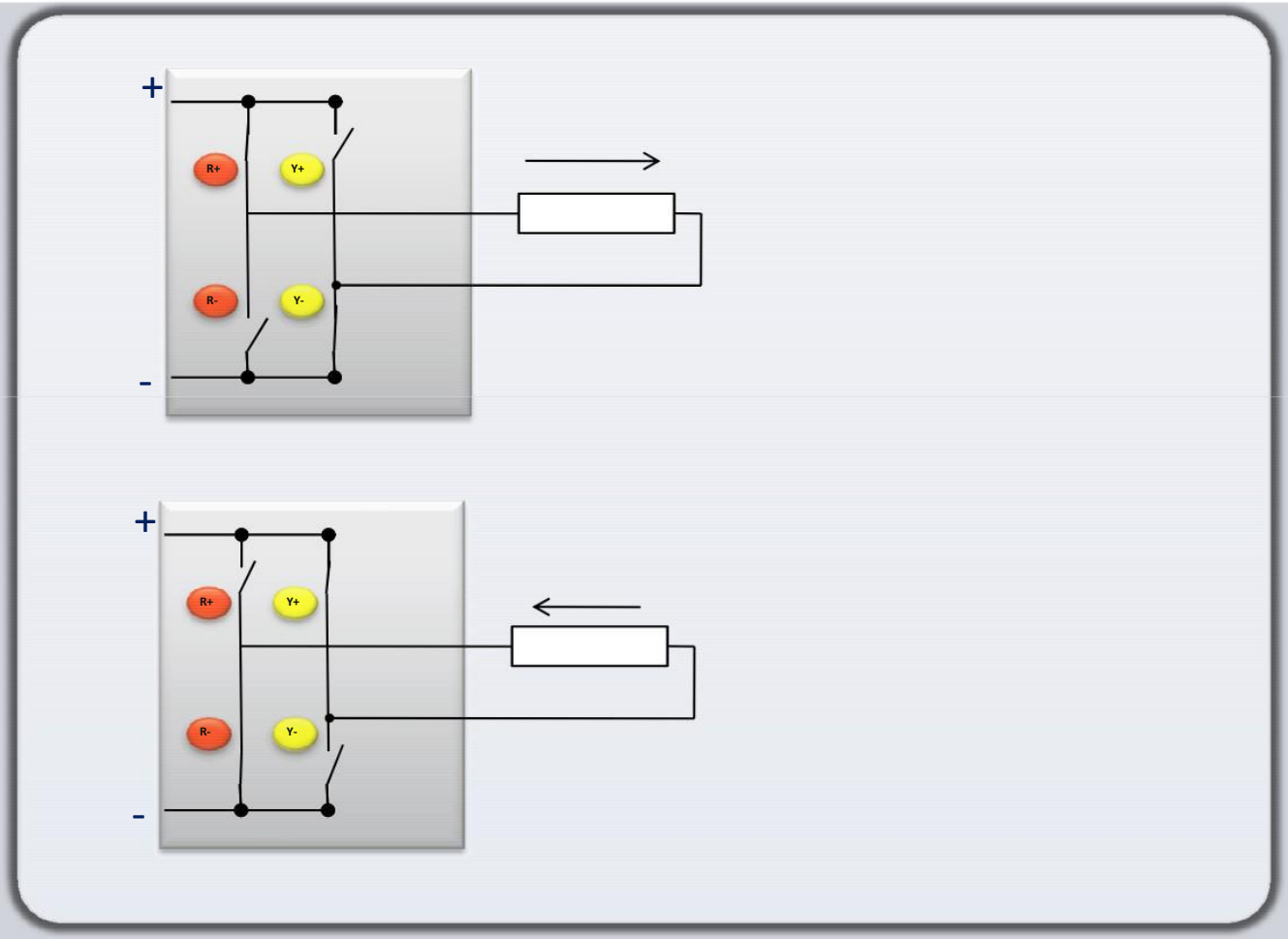
SIEMENS

Single Phase Inverter Concept

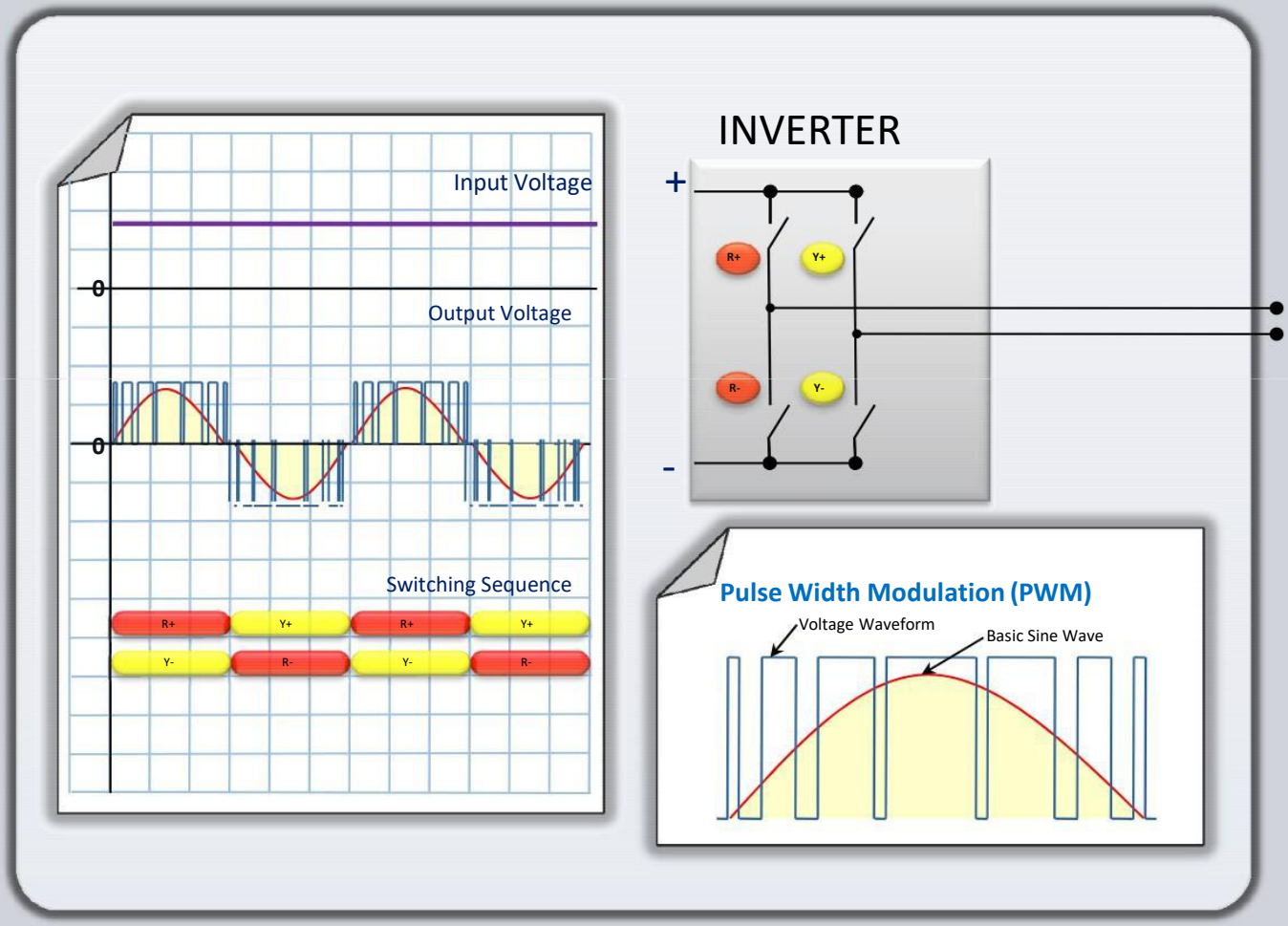


SIEMENS

Single Phase Inverter Concept



Single Phase Inverter Concept - PWM waveform



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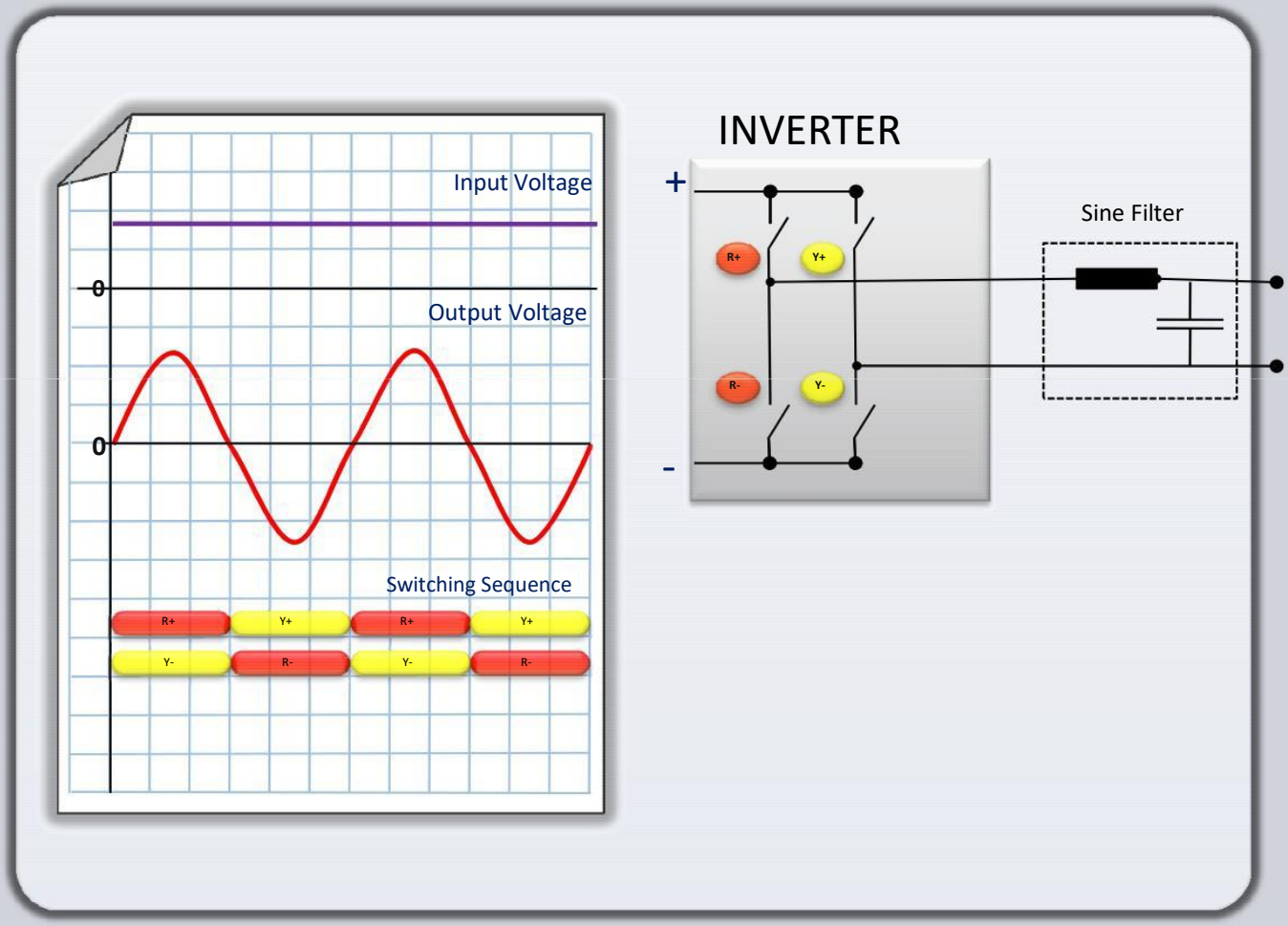
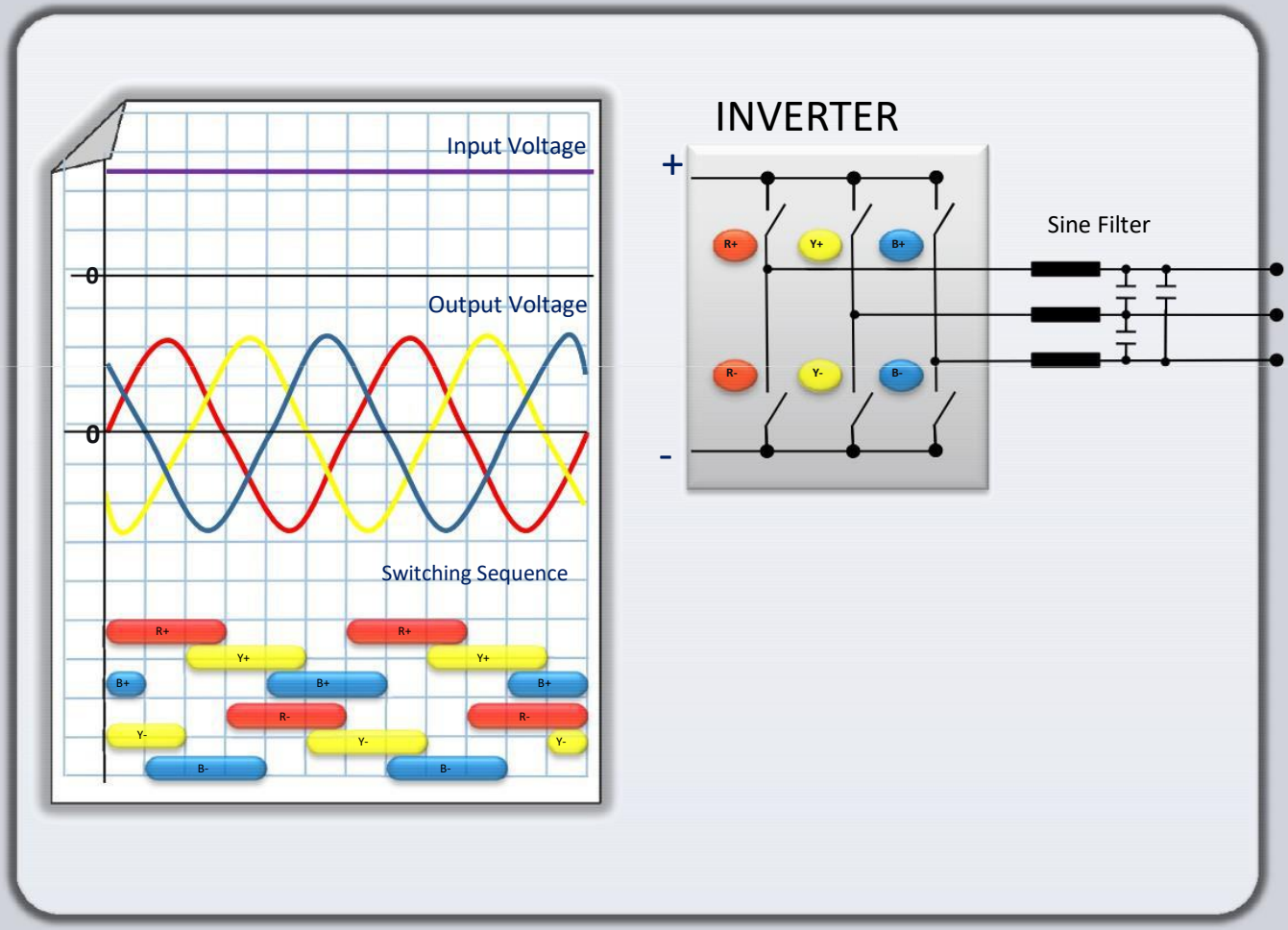
Single Phase Inverter Concept - PWM with Sine Filter



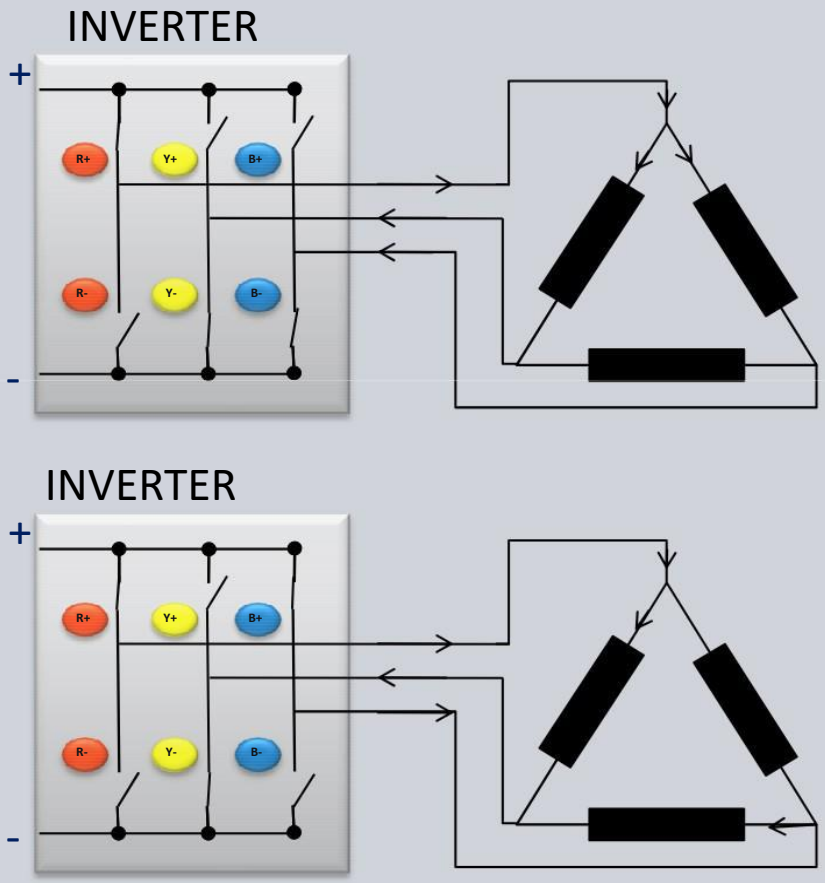
SIEMENS

Three Phase Inverter Concept



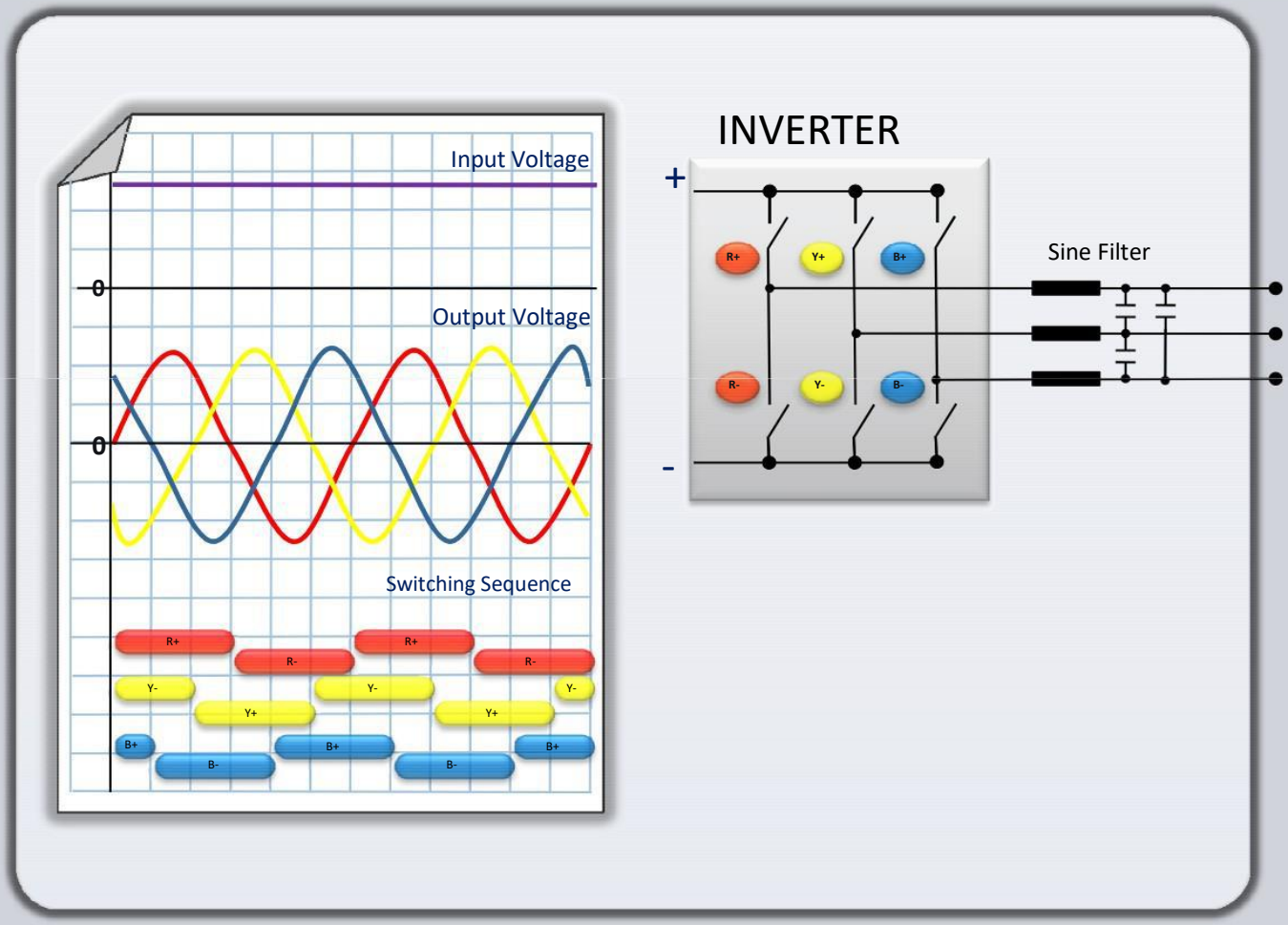
SIEMENS

Three Phase Inverter Concept

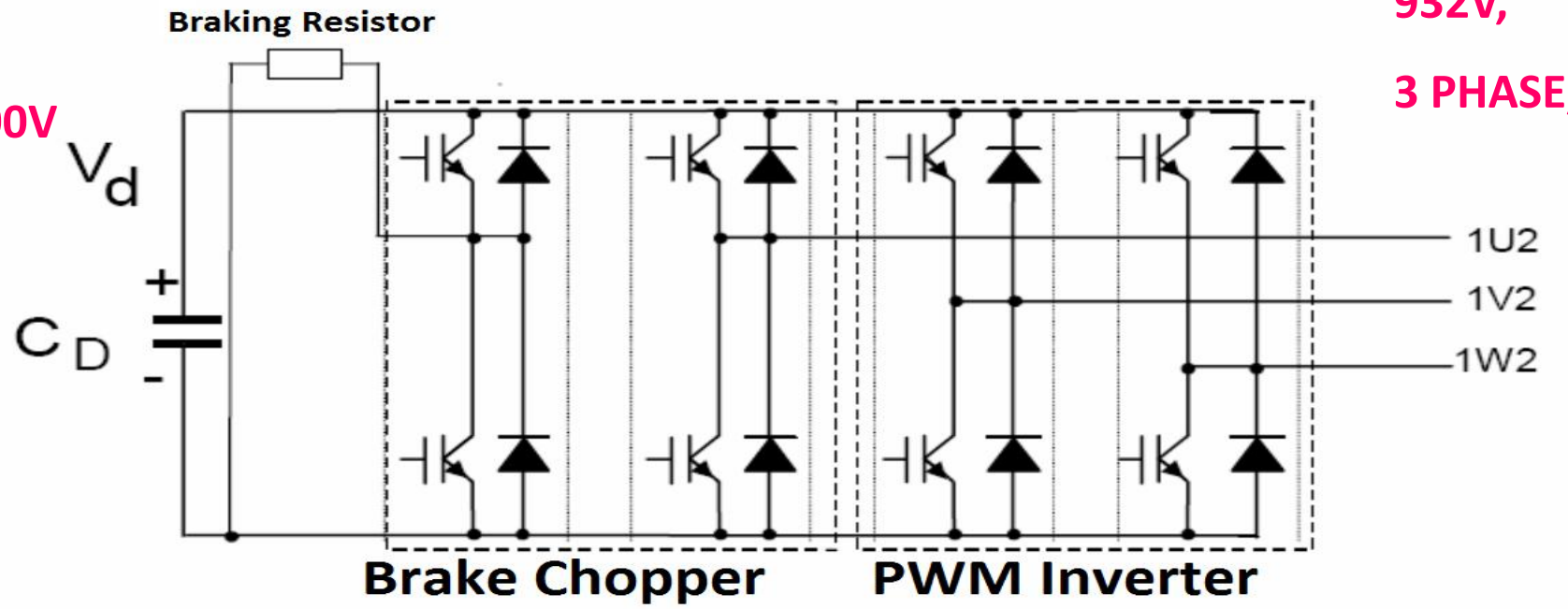


SIEMENS

Three Phase Inverter Concept



PWM INVERTER



932V,

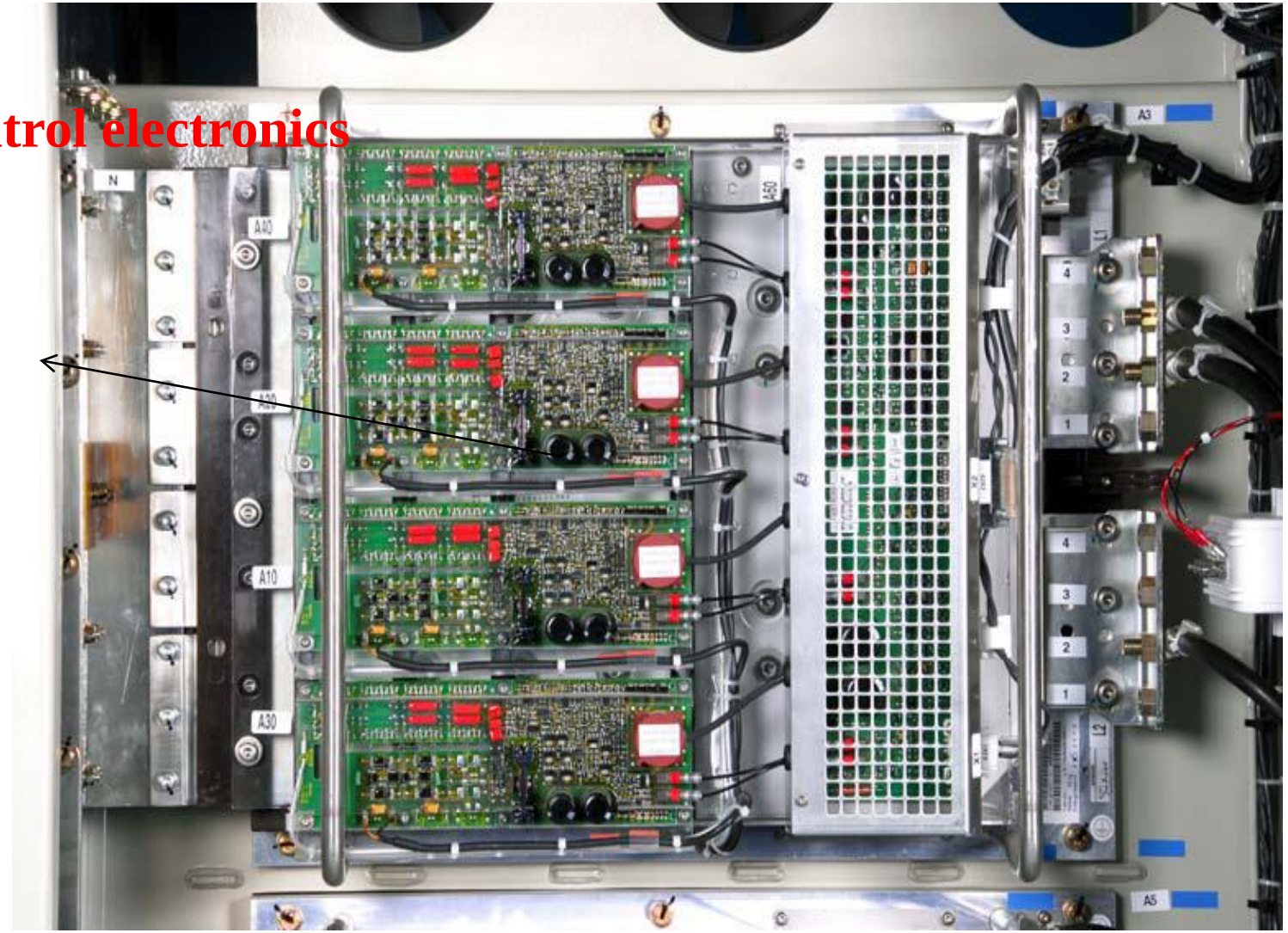
3 PHASE, AC

OUTPUT POWER	2X3 PHASE AC 535KW
OUTPUT CURRENT	2X400A
DC LINK VOLTAGE	1800V
DC LINK CAPACITOR	12mF

PWM INVERTER

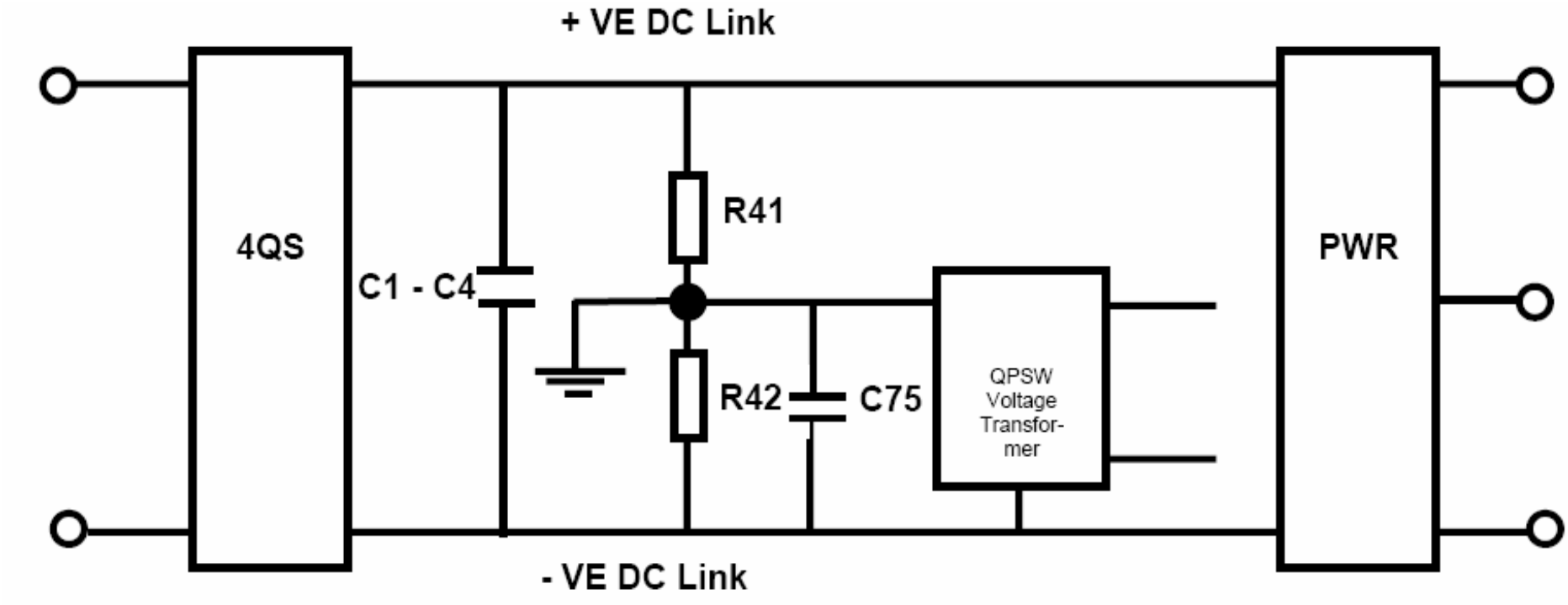
- The DC link voltage is transformed via the PWM inverter into a three-phase **variable voltage variable frequency** (VVVF) output for the supply of the three-phase current-asynchronous-traction motors (external).

Control electronics

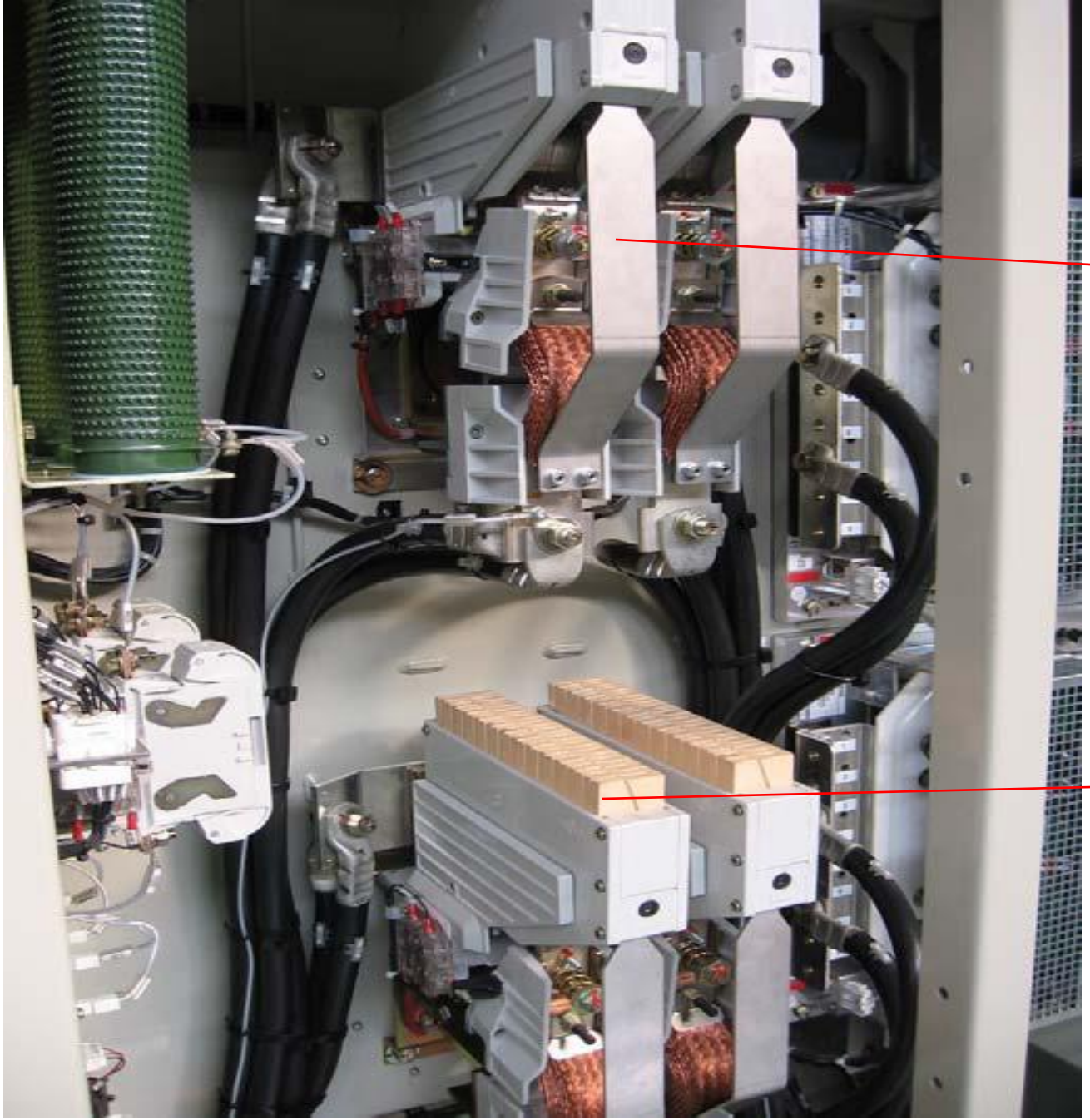


PWM Inverter IGBT module

EARTH FAULT PROTECTION

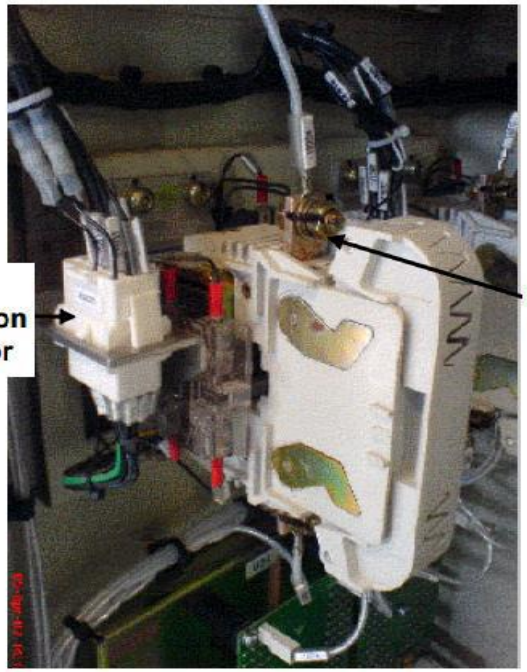


R41- 99K & R42-33K



K1 k6 contactors

Pre-charging resistor plate assembly



Pre-charging Contactor K4

U1, U2, U3, U4, U5, U6, U7 and U8 (Current transducers

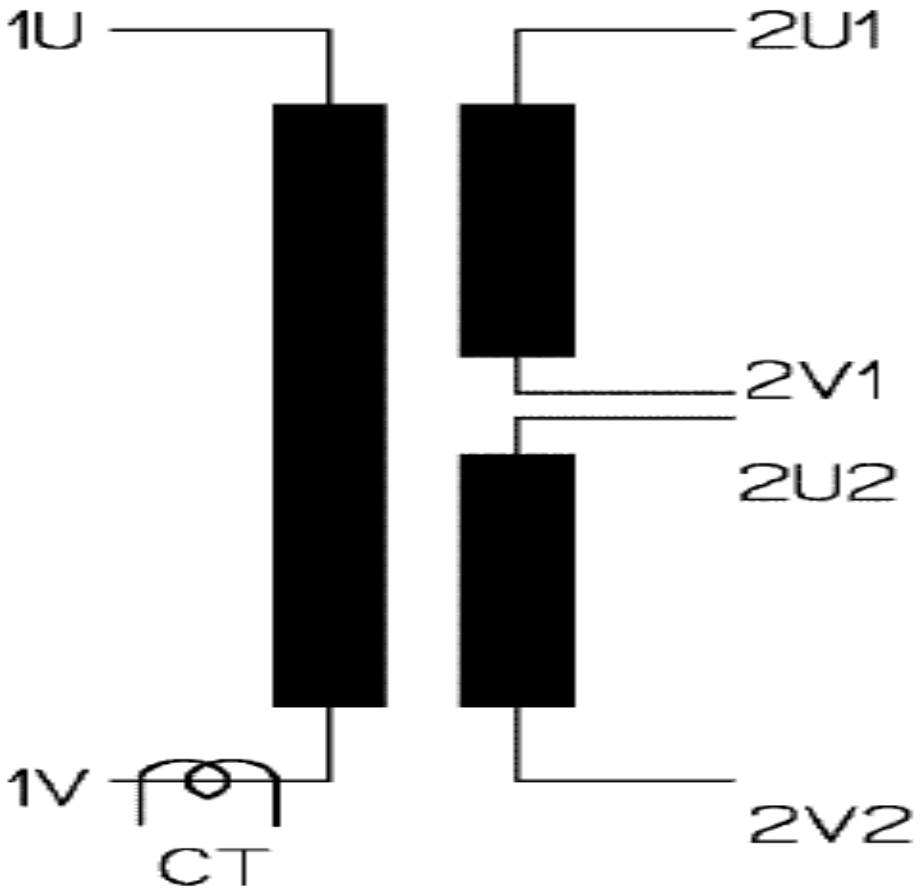
AUXILIARY CONTACTORS

TRACTION TRANSFORMER

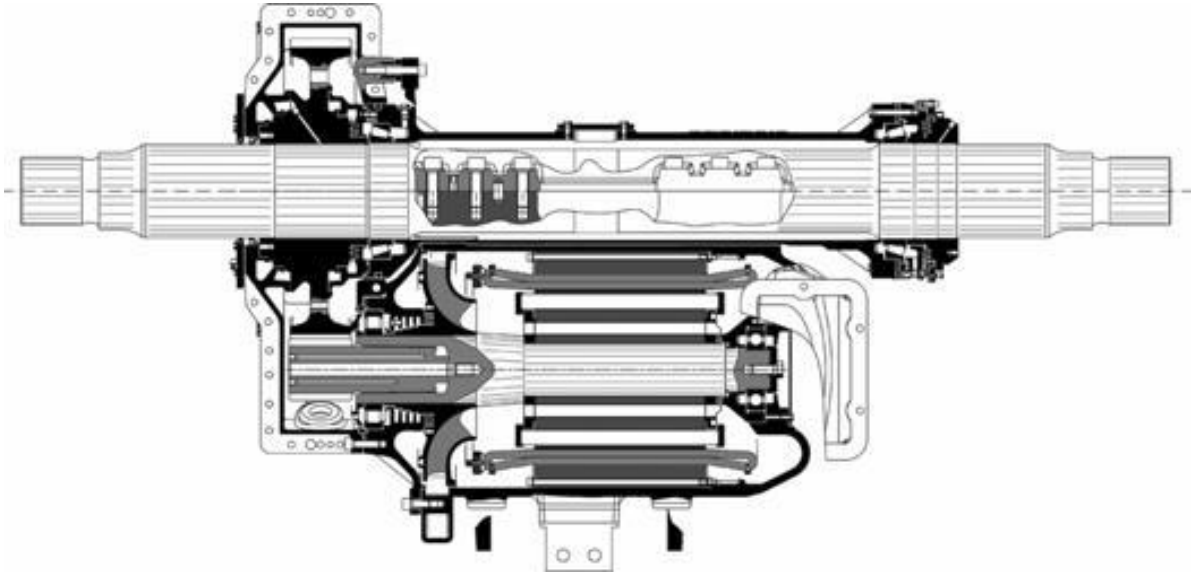
TYPE LOT 1250(ABB)

PRIMARY 1250KVA, 22500V, 55A, 50Hz

SECONDARY 2X625KVA, 2X855V, 2X731A

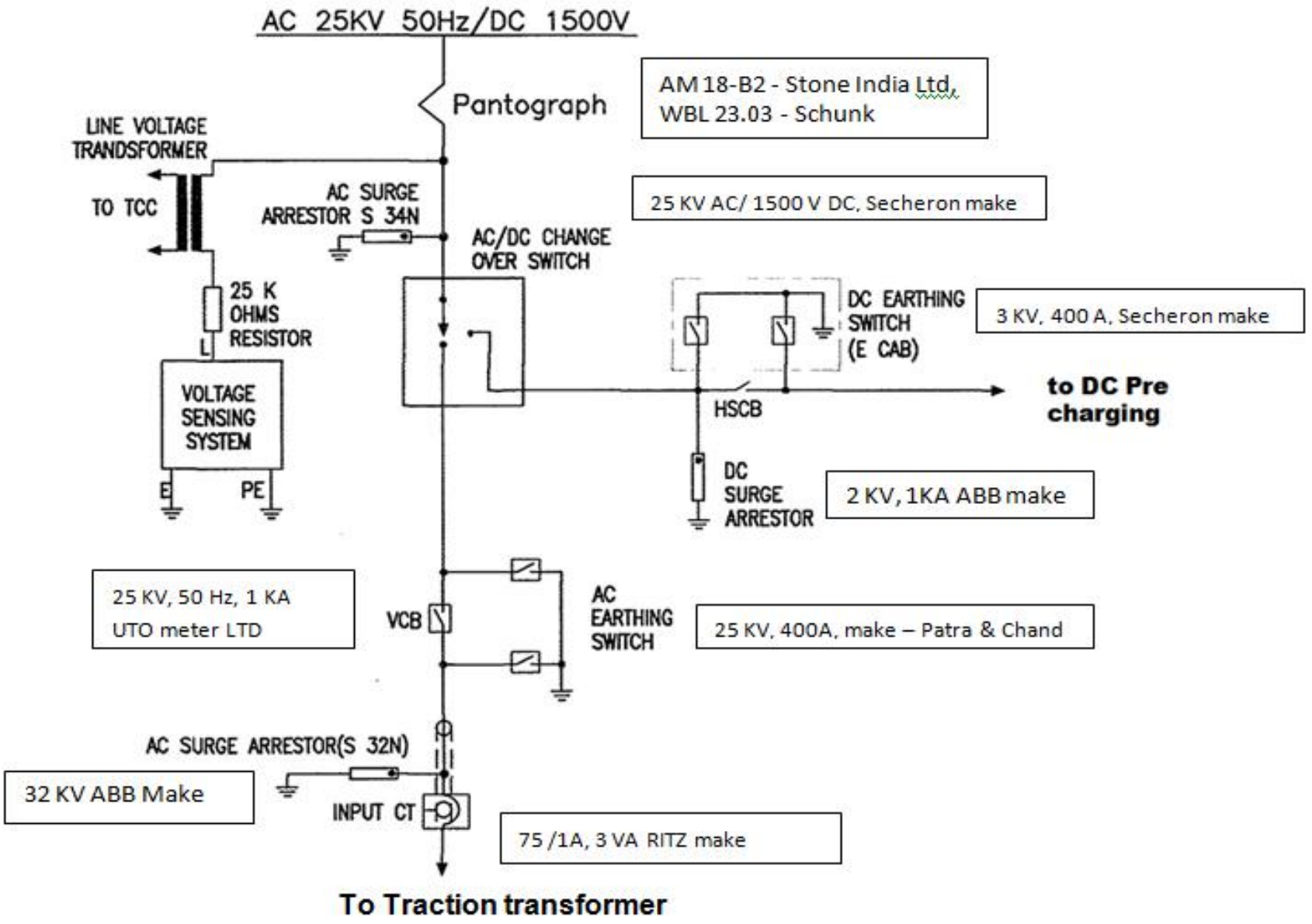


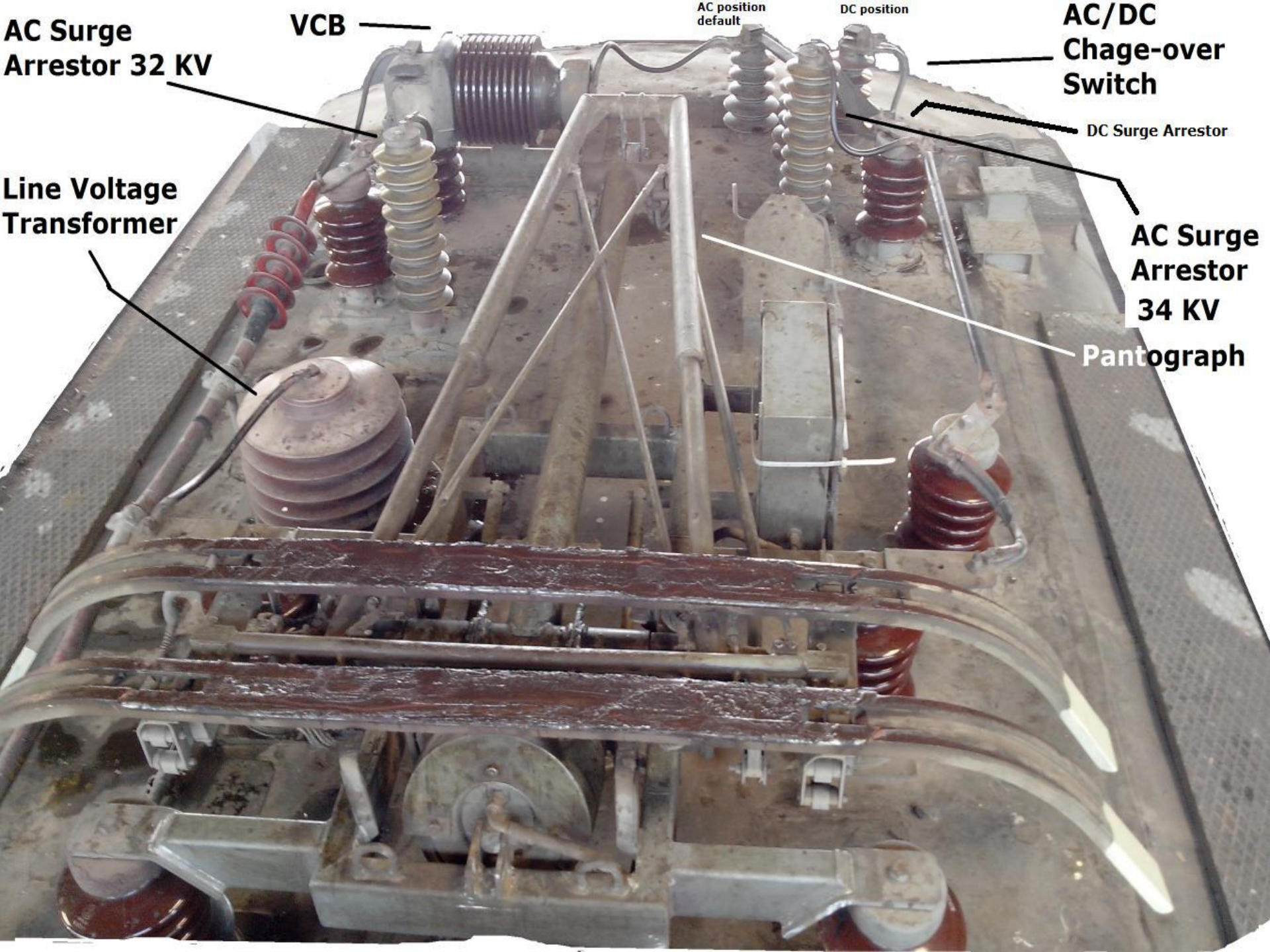
TRACTION MOTORS



SPECIFICATION	IEC60349-2
RATED VOLTAGE	932V
RATED CURRENT	200A
RATED POWER	240KW
RATED SPEED	2000rpm
RATED FREQUENCY	101.5Hz
THERMAL CLASS	200

Current Collection




AC Surge Arrestor 32 KV
VCB
AC position default
DC position
AC/DC Chage-over Switch
DC Surge Arrestor
Line Voltage Transformer
AC Surge Arrestor 34 KV
Pantograph

- Main Traction Transformer is mounted under the Motor coach.

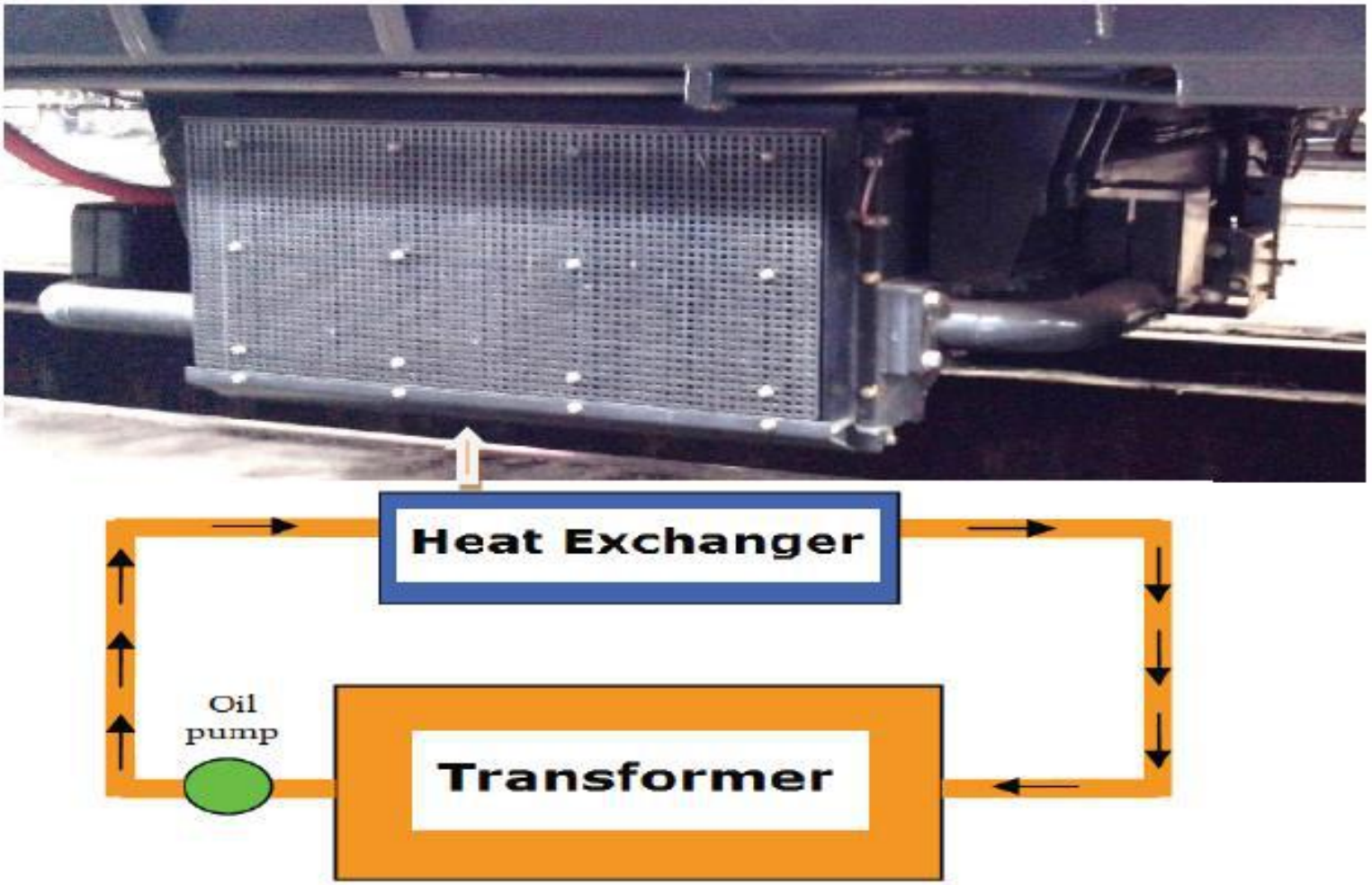


Figure 39: Cooling circuit diagram

- Main Traction Transformer is mounted under the Motor coach.

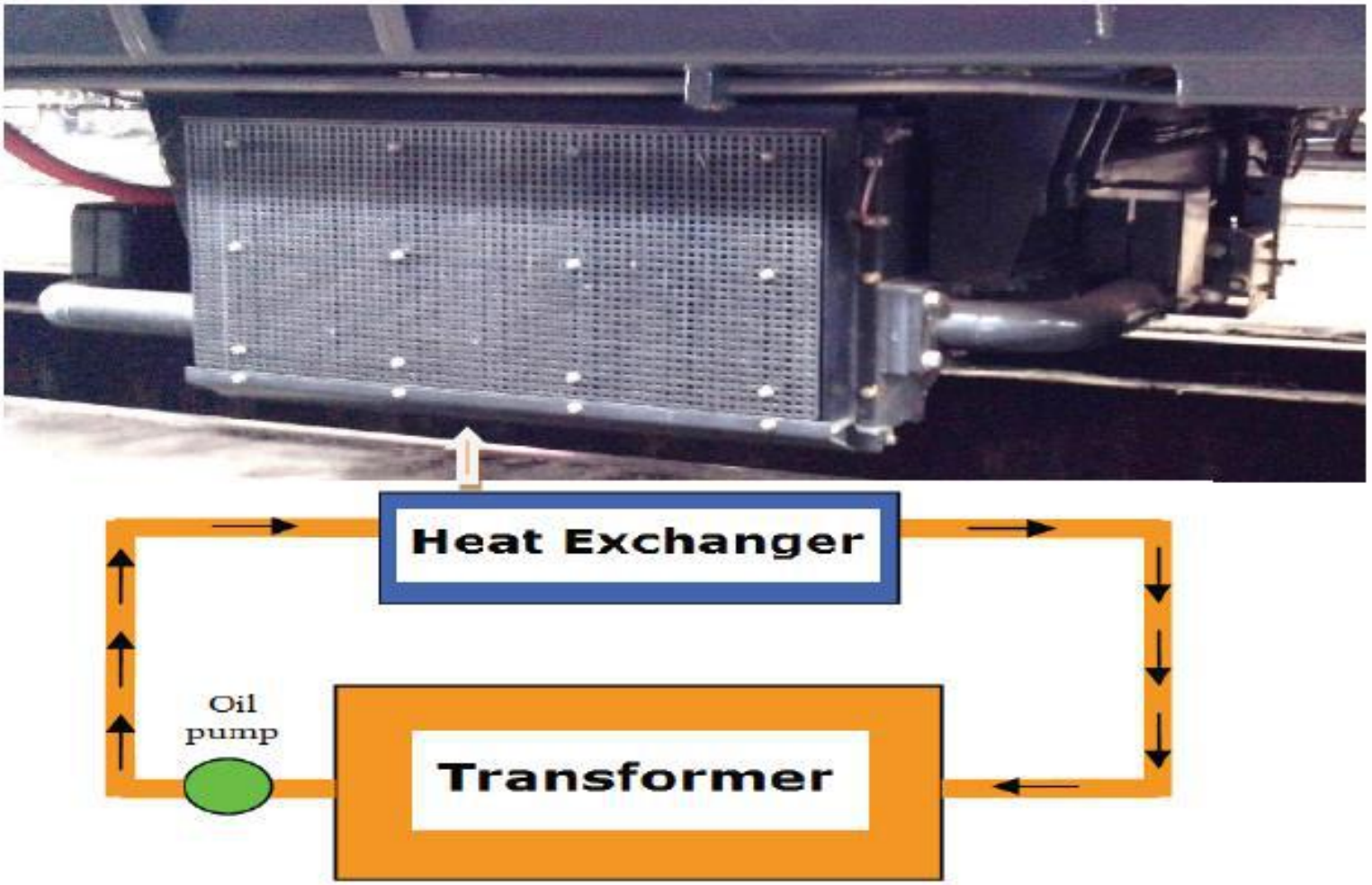


Figure 39: Cooling circuit diagram

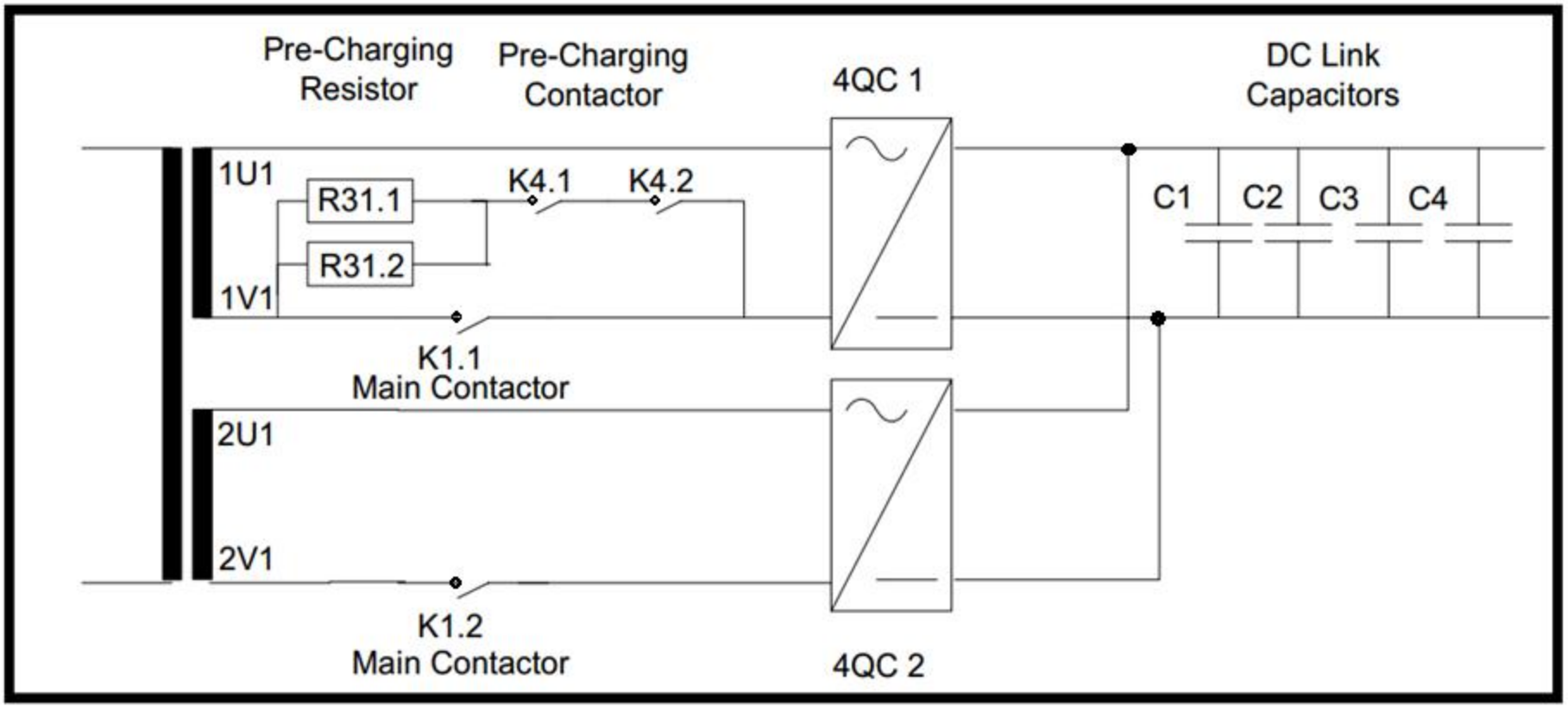
Power flow under AC catenary:

Functional sections of the traction converter in AC Mode :-

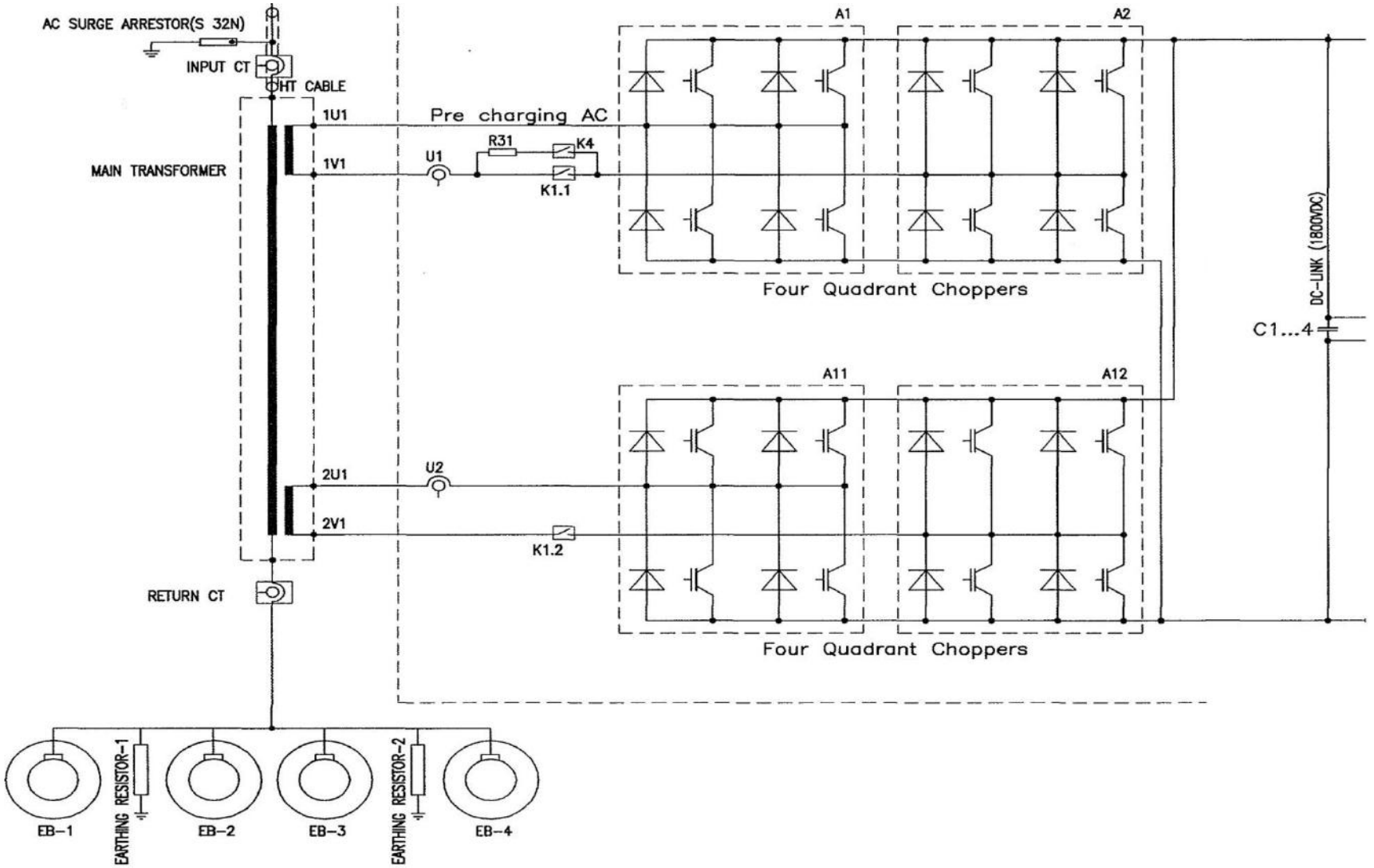
The traction converter consists of the following functional sections in the AC Mode operation:

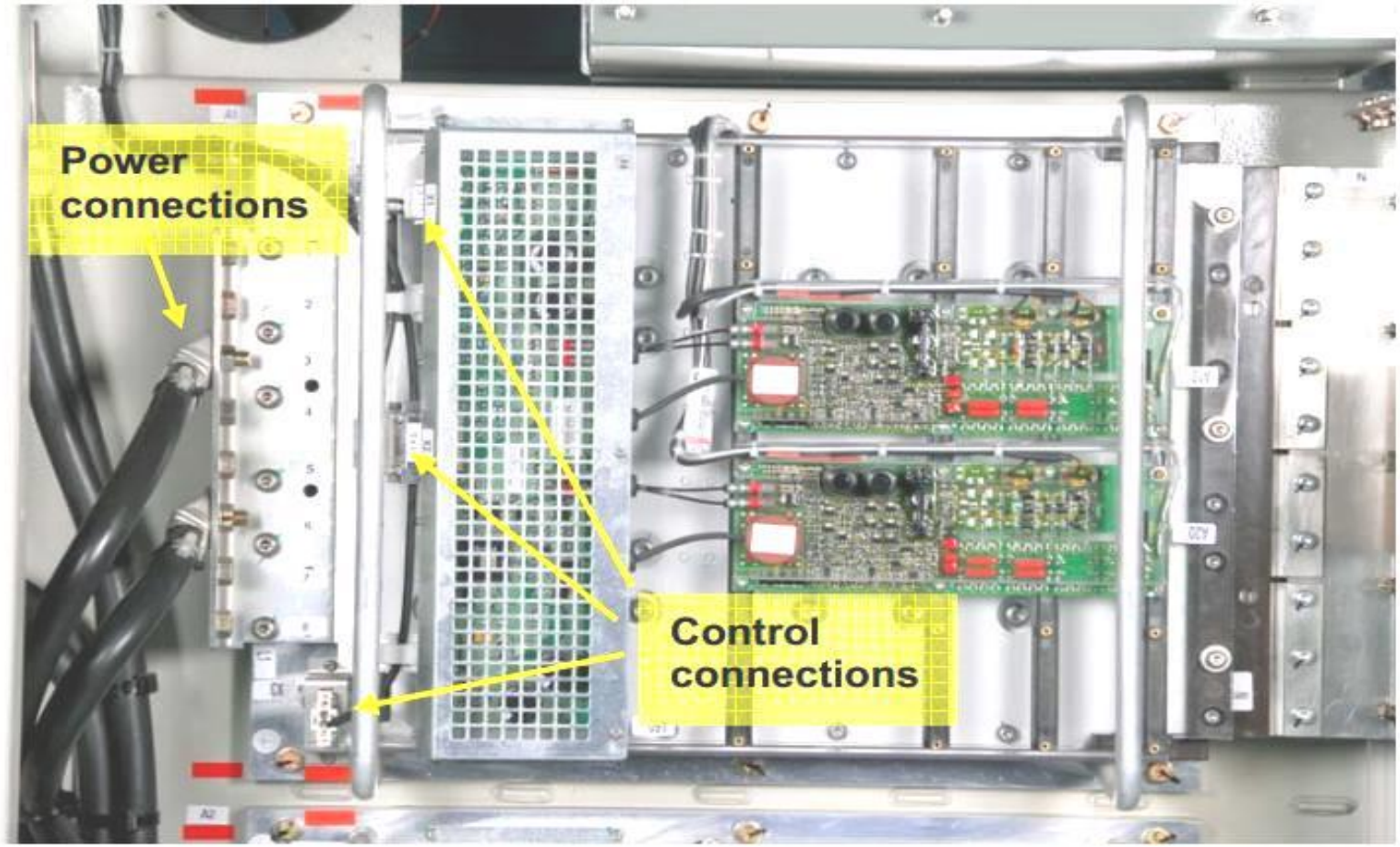
- Input-isolator and pre-charging circuit
- Four-quadrant chopper
- DC link
- Capacitive earth-fault detection
- Pulse Width Modulated Inverter & Braking chopper

Power flow under AC catenary:



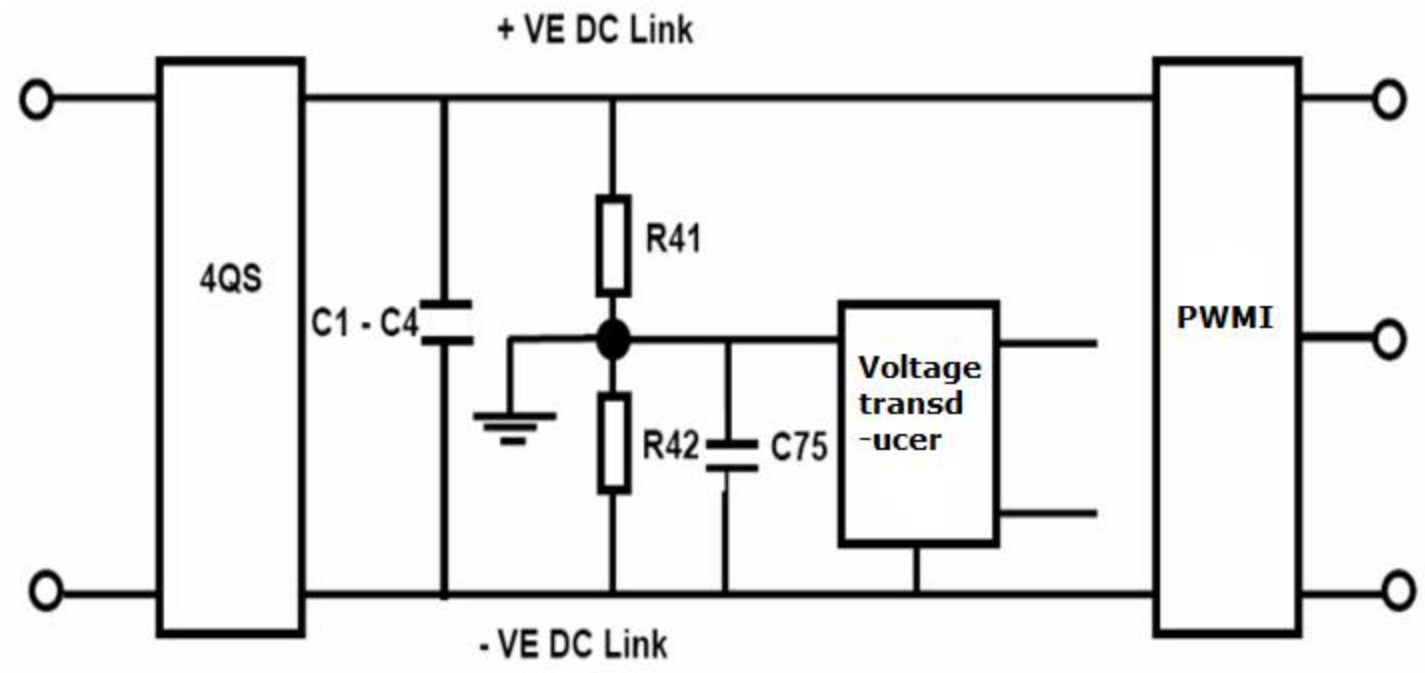
- Secondary winding voltage (1U1-1V1) and (2U1-2V1) --- 855 V at 22.5 KV
- The 4QC operates as a boost /step-up converter
- The DC link voltage maintained at 1800 V DC.


AC SURGE ARRESTOR(S 32N)
INPUT CT
HT CABLE
MAIN TRANSFORMER
1U1
1V1
2U1
2V1
Pre charging AC
R31
K4
K1.1
K1.2
U1
U2
A1
A2
A11
A12
Four Quadrant Choppers
Four Quadrant Choppers
DC-LINK (1800VDC)
C1...4
RETURN CT
EB-1
EARTHING RESISTOR-1
EB-2
EB-3
EARTHING RESISTOR-2
EB-4

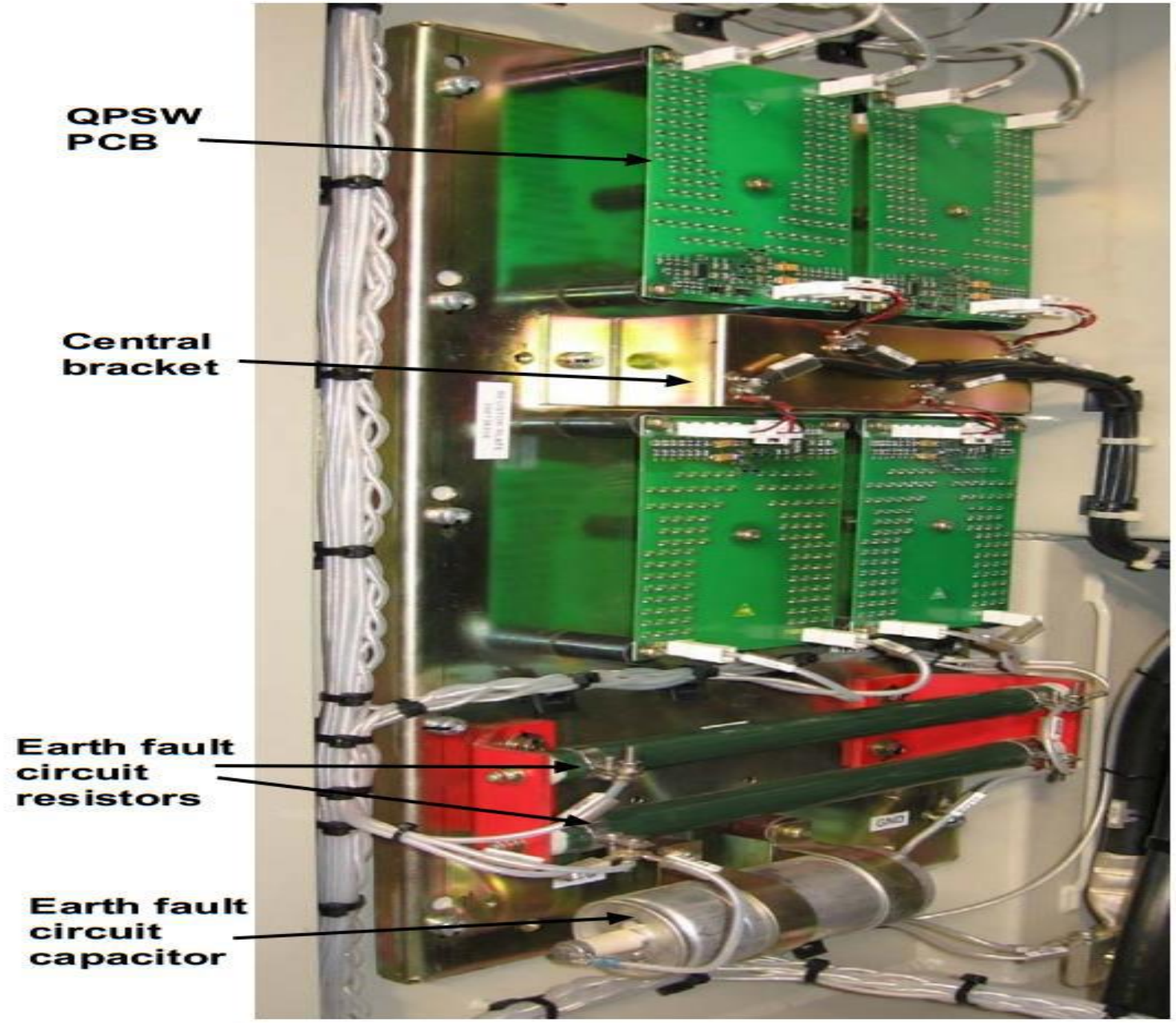


4 Quadrant chopper IGBT module

Capacitive Earth fault Detection in the AC Mode



- R41 = 99K, R42 = 33K
- During normal operation the transducer depicts ¼ of the total DC link volt-age.
- A tolerance of ± 30 % (referring to ¼ of the DC link circuit voltage) is to be taken into consideration.


QPSW
PCB
Central
bracket
Earth fault
circuit
resistors
Earth fault
circuit
capacitor

Power flow under DC catenary:

The traction converter consists of the following functional sections in the DC Mode operation:

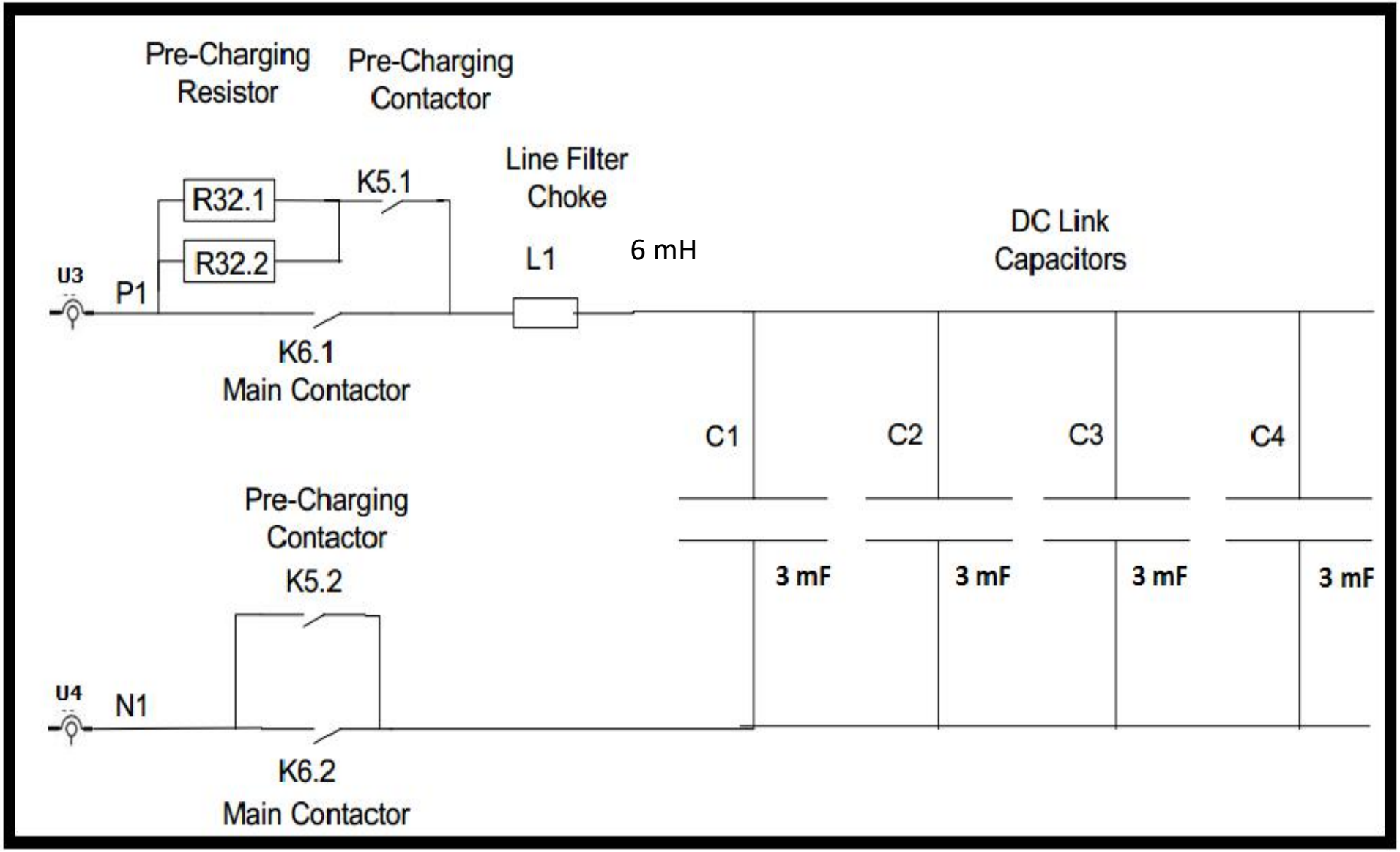
- Input-isolator and pre-charging

  Main Contractor – K6.1 and K6.2

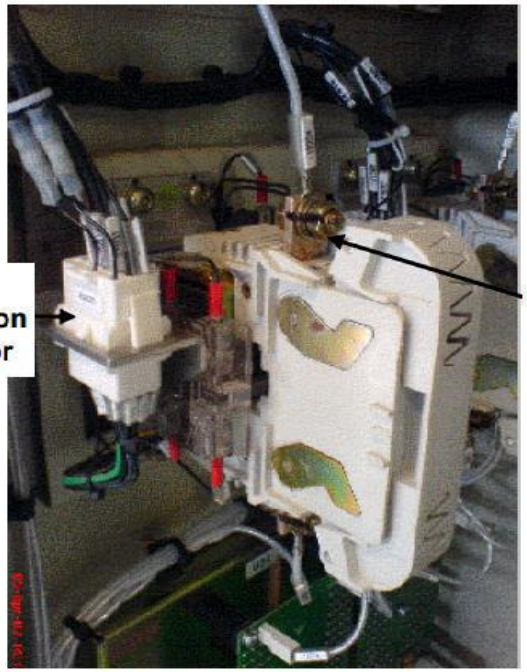
  Pre Charging – K5.1 and K5.2

- Line filter Choke – 6mH -0% to +10 %
- DC link circuit – 12 mF -0% to +10 %
- Earth Fault Detection .
- Pulse width modulated inverter and Brake Chopper .

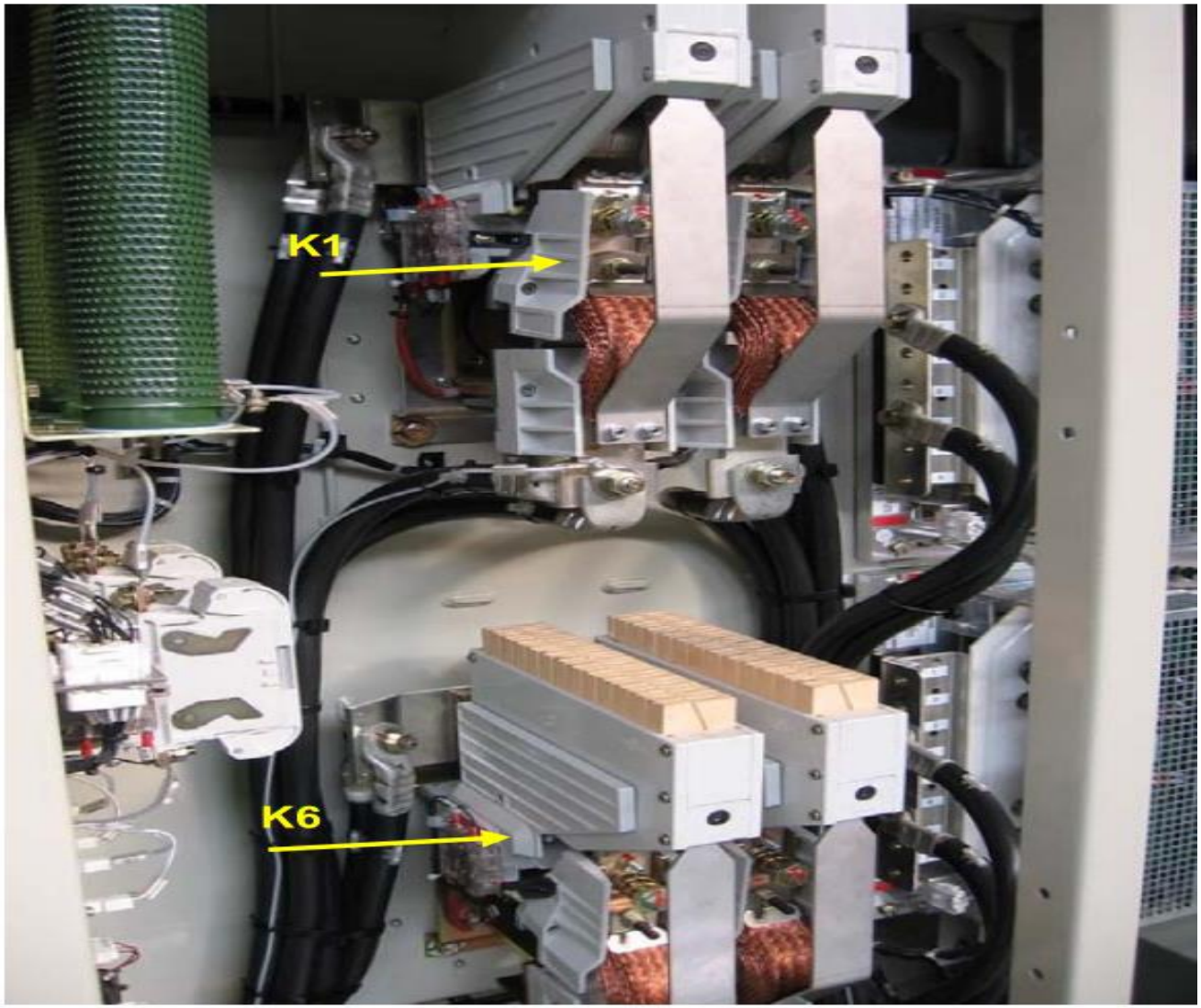
Power flow under DC catenary:



Pre-charging resistor plate assembly



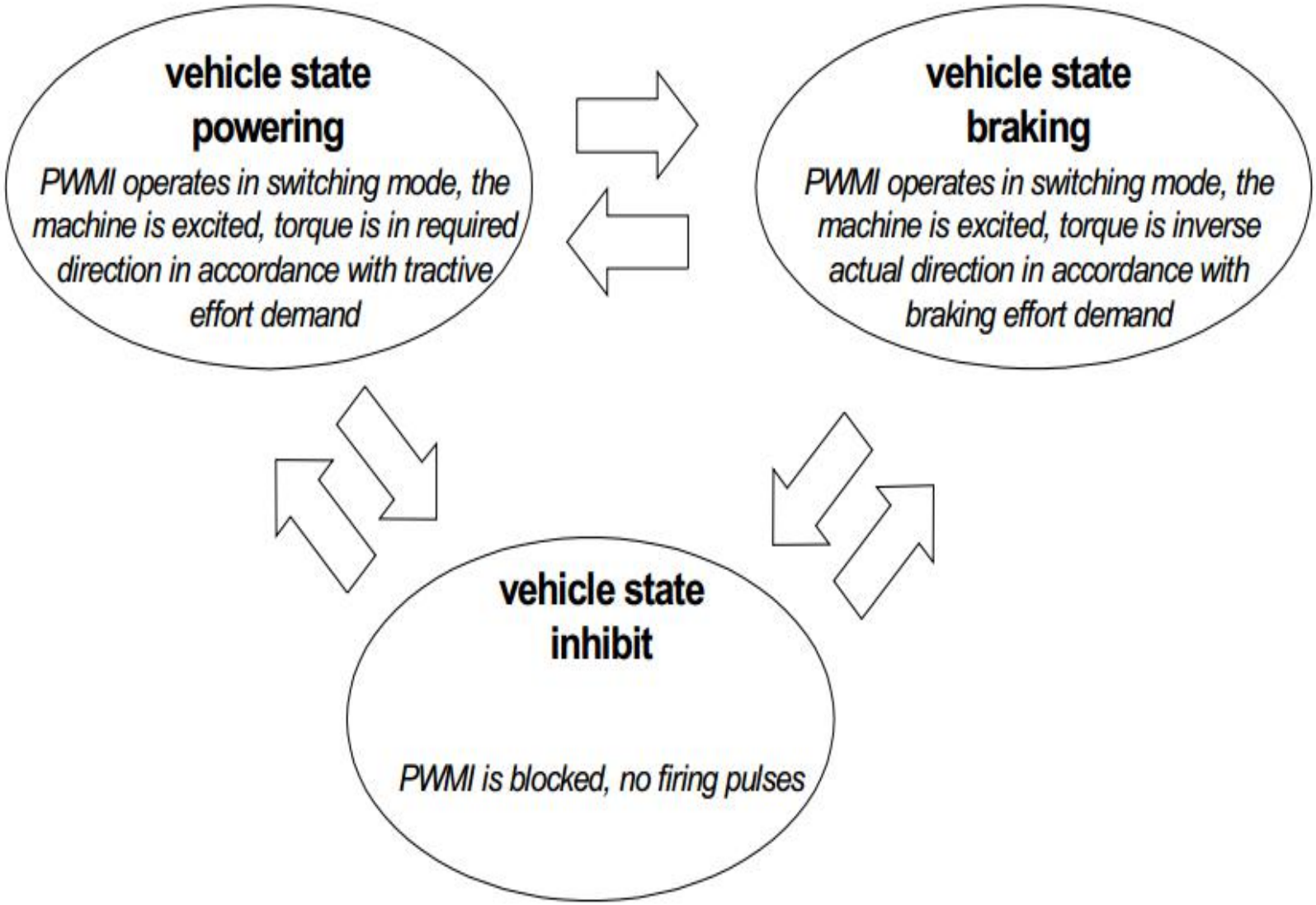
Pre-charging Contactor K4

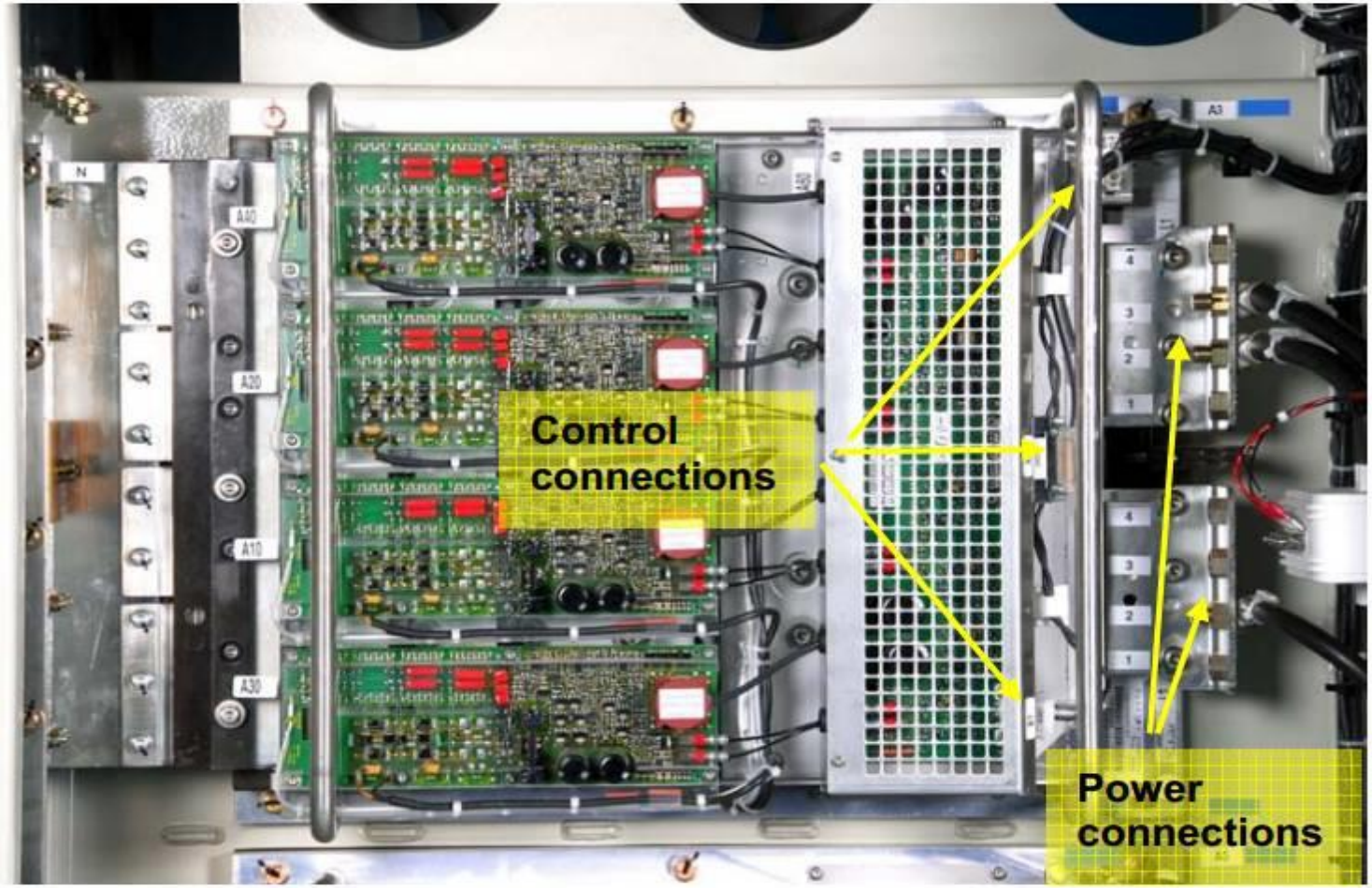


Position of K1 and K6 contactor

Pulse Width Modulated Inverter (PWMI) & Braking Chopper:

Three States of Train





PWM Inverter IGBT module

$$T = \frac{F \bullet d_{wheel}}{2 \bullet z_{mot} \bullet i} \bullet \frac{1}{\eta_{gear}}$$

$$n = \frac{v \bullet i \bullet 60}{3{,}6 \bullet d_{wheel} \bullet \pi}$$

T... = motor.torque...(Nm)

F... = traction.force..(N)

d_{wheel}.. = wheel.diameter..(m)

z_{mot}.. = number.of.motors

i... = gear.ratio

η_{gear}.. = gear.efficiency

n... = motor.speed....(rpm)

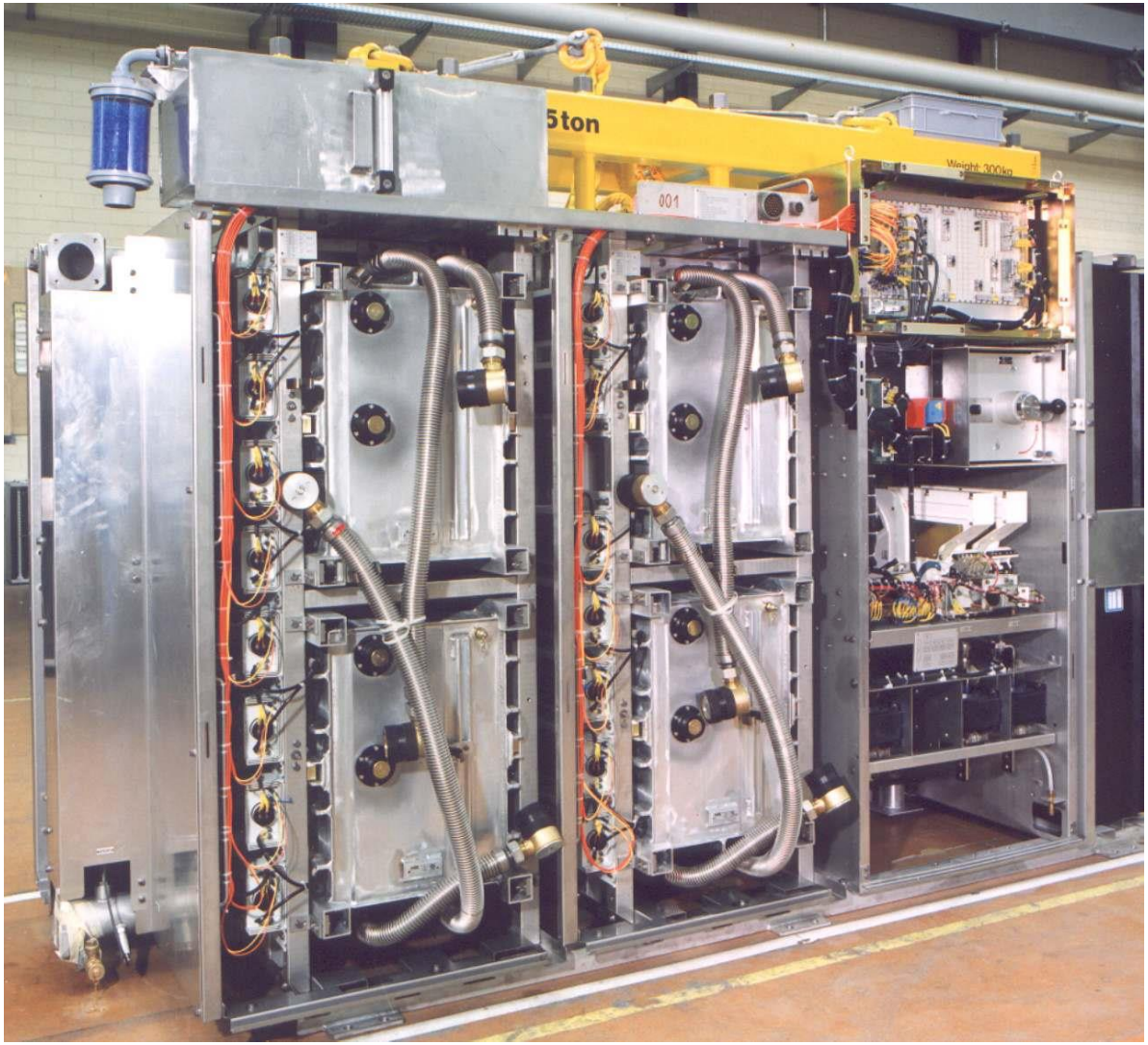
v... = velocity..(kph)

i... = gear.ratio

d_{wheel}.. = wheel.diameter..(m)

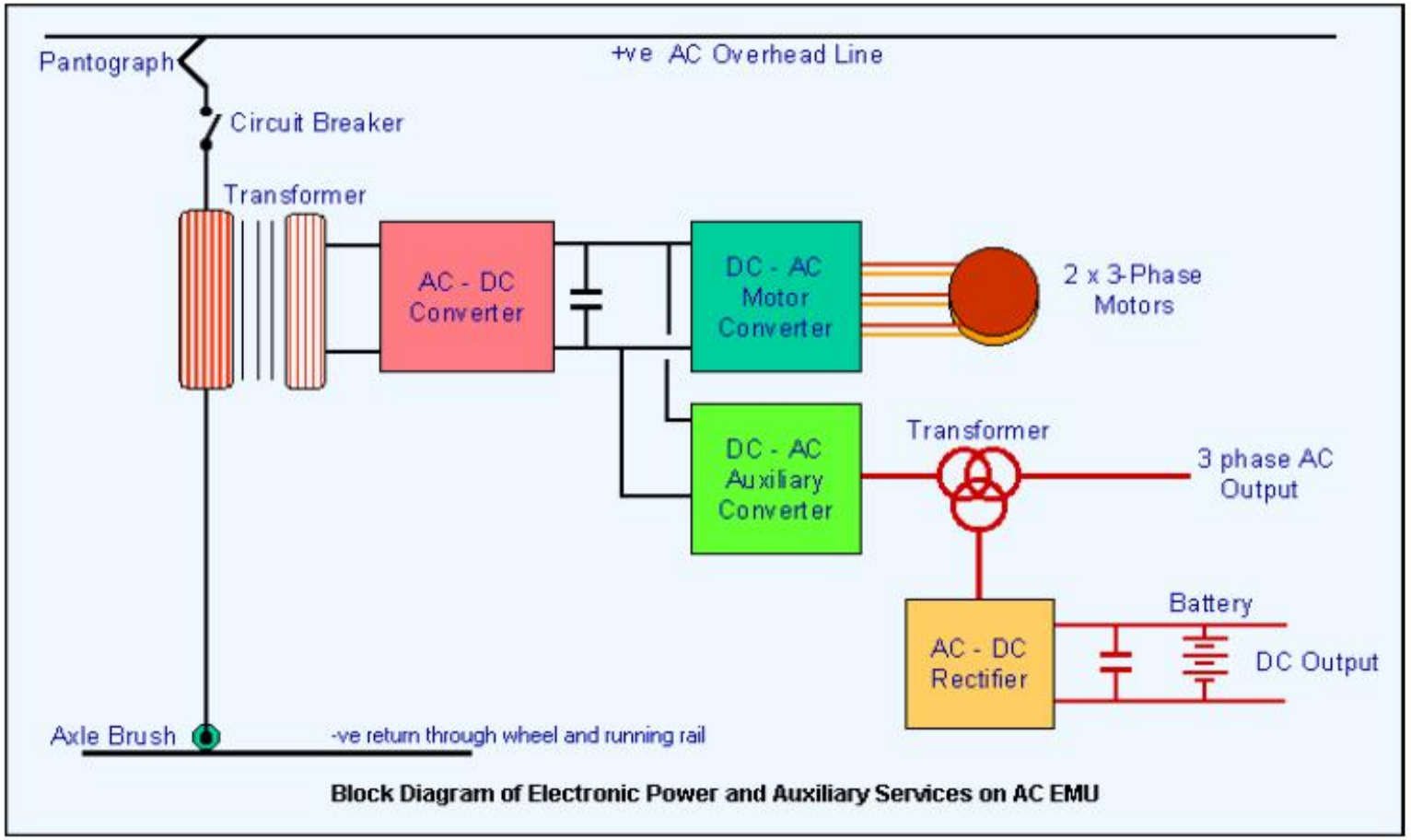
AC Drives of Traction Motor & Auxiliary Motor in 3 – Phase Locomotive

Traction Converter



Auxiliary Converter

AC Drives of Traction Motor & Auxiliary Motor in 3 – Phase Locomotive



Block Diagram of Electronic Power and Auxiliary Services on AC EMU

Thanking You All