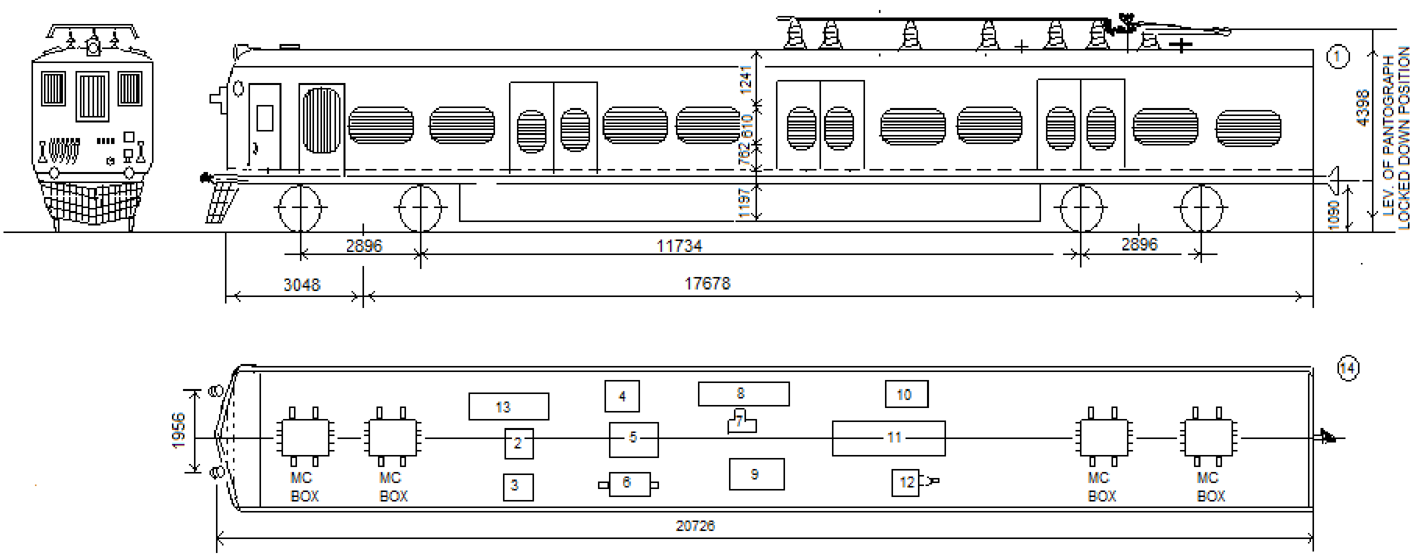
PREFACE

25 KV AC BG Electric Multiple Units (EMUs) are designed to cater the suburban traffic daily in all metropolitan city of India. Whereas Main line EMUs (MEMU) services are replacement to the existing conventional coaches being utilized in passenger trains. Both EMUs and MEMUs are having similar technical characteristics but differ in dimensions, layout and uses.

EMU/MEMUs are specially designed for high rate of acceleration and deceleration with frequent stop. Present formation of EMU rake is of 9 car & 12 car units. 9 car rakes consist of 3 units and a 12 car rake consist of 4 units. . Each EMU unit constitutes 1 motor coach and 2 trailer coaches. Thus 9 car rake is having 3 motor coaches, 2 vendor and 4 plain trailer coaches and 12 car rake is consisting of 4 motor coaches 2 vendor & 6 plain trailer coaches.
Present formation of MEMU is 8 car consisting of 2 Motor coaches and 6 trailer coaches. For MEMU, one unit constitutes 1 Motor Coach and Three Trailer Coaches.

LAYOUT OF MOTOR COACH

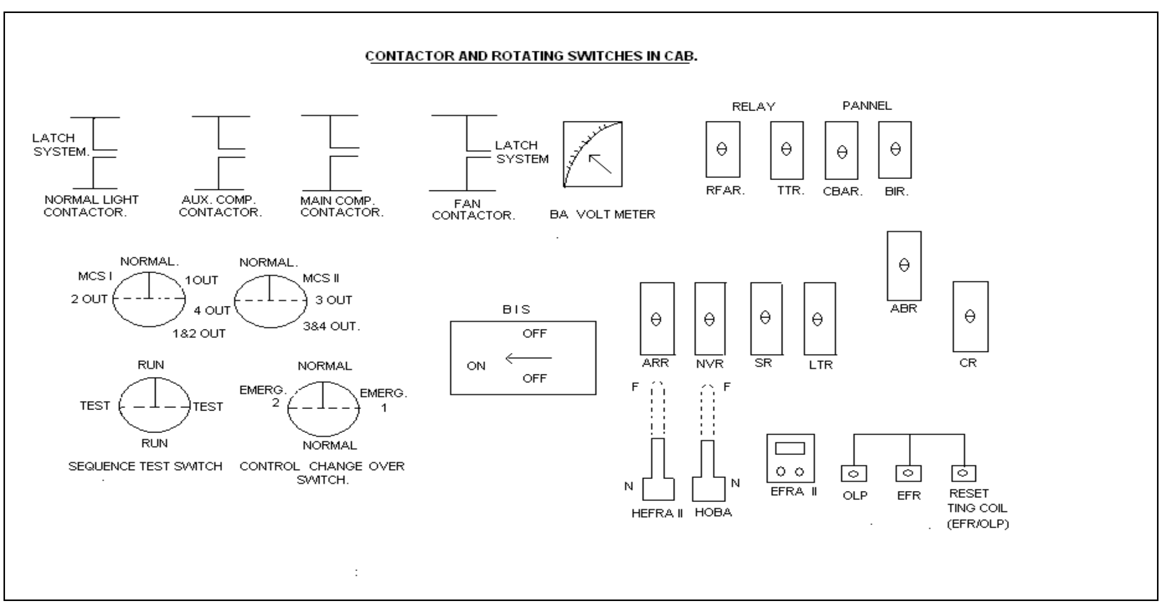


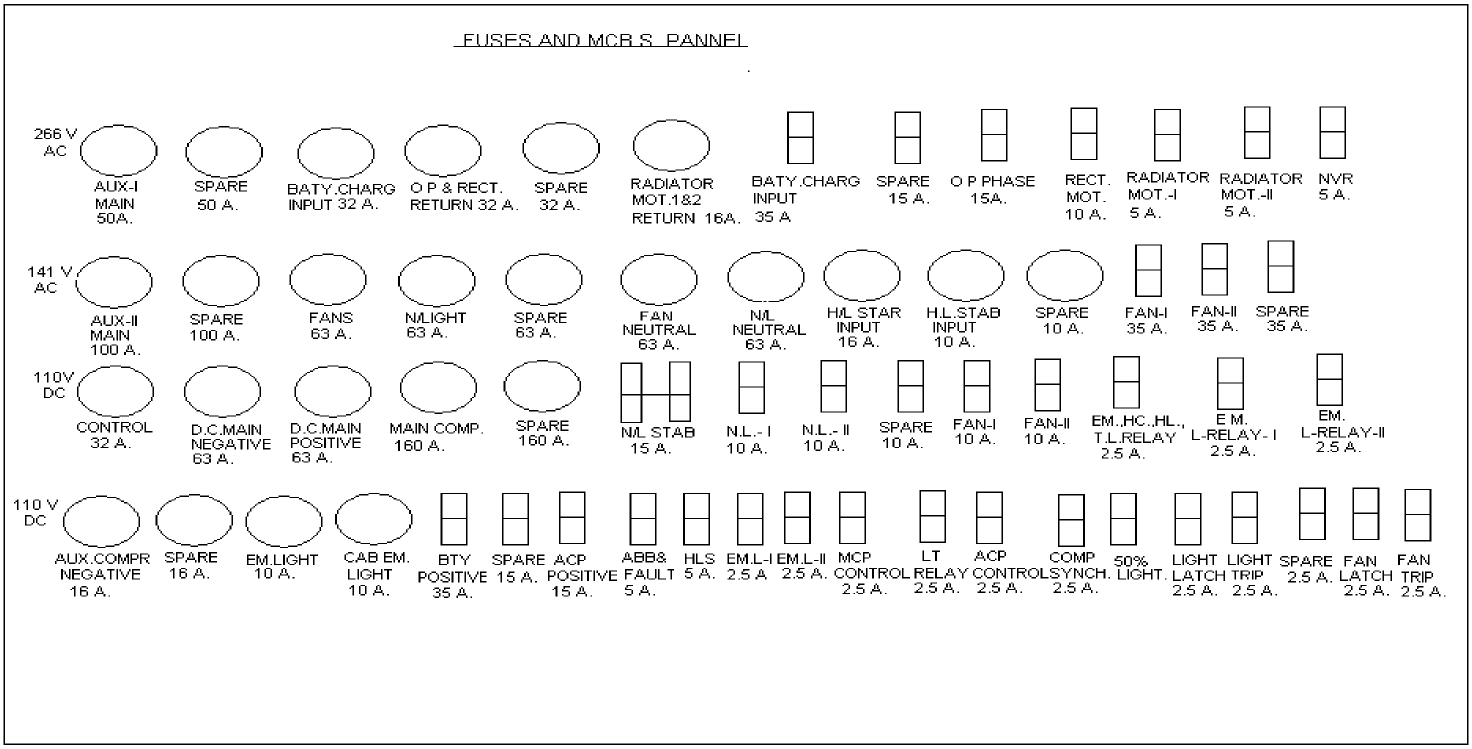
1. PANTOGRAPH-AM 12 25KV.
2. TRANSITION RESISTOR.
3. SWITCH GROUP NO.1.
4. TRANSFORMER OIL COOLER
5. REACTOR CHOKE-1.5 MH,1356 RMS.
6. FIELD DIVERT RESISTOR.
7. OIL PUMP-0.6 M3 /MIN.
8. SILICON RECTIFIER-1280A AT 557 V DC.
9. TAP CHANGER -100 AMP.700V.
10. SWITCH GROUP NO.2.
11. MAIN TRANSFORMER
12. MAIN COMPRESSOR-1075 L/MIN.
13. 95 AH BATTERY BOX- 95 AH
14. BOGIE - BO - BO.

GENERAL DATA

S/ no	Description	EMU		MEMU		Reference
		M/C	T/C	M/C	T/C	
1	Type of Stock	AC BG EMU WAU4		AC BG MEMU		
2	Coach Builder	ICF & BEML		ICF & RCF		
3	Manufacturer of Traction equipments including Tr. Motor, Transformer etc.	BHEL & CGL		BHEL		
4	Unit formation	DMC+TC+TC		DMC+TC+TC+TC		
5	Train formation	3/4 units		2 units		
6	No. of Driving Cabs	2		2		
7	Type of Traction	25 KV AC		25 KV AC		
8	Wheel arrangement	Bo-Bo		Bo-Bo		
9	Brake system	Self lapping electro pneumatic brake system				
10	Axle Load capacity in Tonnes i) Conventional EMU/MEMU ii) HCC	 20.32 20.32	 13.0 20.32T	 20.32 --	 13.0 --	RDSO specification no. K3-B-01, Feb'03 & for EMU T/C- EMU-2/A-9-0-501 and EMU-2/D-9-0-503.
11	Wheel Diameter (New) mm.	952		952		RDSO manual no. CMI-K001 (Apr'2000)
12	Wheel Diameter (Condemning) mm. HCC	877 865	857 865	877 --	857 --	
13	Gear ratio	20:91		20:91		ACTM Volume-III, 1994
14	Train performance per unit rating Horse power Tractive effort (T)	Cont. 896 4.8	1 hr. 1004 5.8			
15	Traction motor rating: Type Volts (V) Current (A) Output (KW) RPM	4601AZ/BZ/BX/BY 4303AZ/CZ Cont. 1hr. 535 535 340 380 167 187 1260 1182	4303BY (BHEL) Cont. 1hr. 535 535 425 465 207 227 1170 1120	C1005 TM (CGL) Cont. 1hr. 563 563 415 455 210 228 1170 1135		ACTM Volume-III, 1994 & Manufacturer's maintenance manual.
16	KVA rating of transformer	1000				
17	Normal acceleration to 40 Kmph Level track, CLR set at 500 Amps.	1.6 Km/Hr./Sec				BHEL Maintenance Manual no. MM/AC-M/EMU/003, Jan'01
18	No. of pass./unit - Normal Crush Dense crush	400 774 1148				ACTM Volume-III, 1994

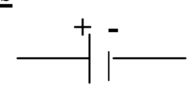
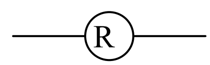
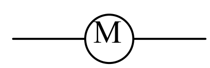
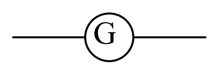
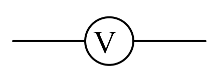
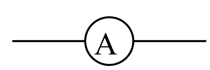
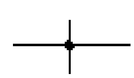
		EMU		MEMU		
		MC	TC	MC	TC	
19	Tare weight	59.3T	C-30.5T D-31.5T	61 T	33.15T	For MEMU (M/C)-Drg. No. MEMU/DMC-9-0-012
20	No. of Seats Vendor Coach	98 --	112 (C type) 88 (D type)	68/81 --	80/108 No Vendor	(i) Drg. No. MEMU/TC_2-9-0-201, (ii) MEMU/DMC_2-9-0-201, (iii) MEMU/TC-9-0-001, (iv) EMU-2/A-9-0-501, (v) EMU-2/D-9-0-503
21	Max. height above rail to top of roof	3810 mm		3886 mm		i) Drg. No. MEMU/DMC_2-9-0-201 ii)EMU/M-9-0-006
22	Max. length of the body	20726 mm		215 67 mm	21337 mm	i) EMU/M-9-0-006 ii)EMU-2/A-9-0-501 iii)MEMU/DMC_2-9-0-201 iv)MEMU/TC-9-0-001
23	Max. width of the body	3658 mm		3245 mm		-- do --
24	Floor height from rail level	1197mm		1278mm		i) Drg. No. MEMU/DMC_2-9-0-201, ii) EMU/M-9-0-006.
26	Height of coach (rail level to panto at home)	4398mm		4255mm		i) Drg. No. MEMU/DMC_2-9-0-201, ii) EMU/M-9-0-006.
27	Min. height above rail level to the lowest fitting on under frame under tare	210^{+5}_{-0} mm 188 (for air spring coaches)		210^{+5}_{-0} mm		i) Drg. No. DMU/DPC_3-2-6-301, ii) Drg. No. EMU-2-6-046.
28	Length of 9 car rake Length of 8 car rake Length of 12 car rake	194.12m 172.638m. 258m.		177.616m.		As measured.
29	Distance between front & rear pantographs: 12 car rake 9 car rake 8 car rake	 226.5 m (approx.) 162 m (approx.) --		 -- -- 140 m (approx.)		-Do-

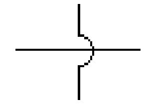
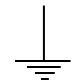
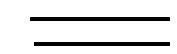




ELECTRICAL

1.0 Symbols:

Sl. No.	Name of the appliance	Symbols
1.	Cell	
2.	Battery	
3.	Receiver	
4.	Motor	
5.	Generator	
6.	Resistance	
7.	Coil	
8.	Fuse	
9.	Voltmeter	
10.	Ammeter	
11.	Terminal	
12.	Switch	
13.	Crossing of wire with contact	

14.	Crossing of wire without contact	
15.	Grounding or earthing	
16.	Direct Current	
17.	Alternating Current	
18.	Choke	

2.0 **Abbreviation used in EMUs/MEMUs:**

S/no.	**Abbreviation**	**Description**
1.	ABB	Air blast circuit breaker
2.	ABR	Air blast circuit breaker relay
3.	ARR	Air blast circuit breaker reset relay
4.	AOVR	Auxiliary over voltage relay
5.	ASR	Auxiliary supply rectifier
6.	AF1,2,3,4	Auxiliary fuse for Auxiliary I & II
7.	AWL	Auto warning light
8.	AB	Alarm bell
9.	AS	Ammeter shunt
10.	BIR	Buchholz indication relay
11.	BIS	Battery isolating switch
12.	BPS	Battery paralleling switch
13.	BIC	Bogie isolating cock
14.	BCFR	Battery charger failure indication relay
15.	BA	Battery
16.	CHBA	Battery charger
17.	CHT	Cable head termination
18.	CR	Compressor relay
19.	CBR	Current balancing relay
20.	CBAR	Current balancing auxiliary relay
21.	CLR	Current limiting relay
22.	CLAR	Current limiting auxiliary relay
23.	CG	Compressor governor
24.	CIC	Compressor isolating cock
25.	CT	Current transformer
26.	DL	Dropping reactor
27.	EFR	Earth fault relay
28.	EFRA-II	Earth fault relay in Aux.-II circuit
29.	EFRP	Earth fault relay primary circuit
30.	EPIC	Electro Pneumatic brake isolating cock
31.	GD	Grounding
32.	GTB	Gear teeth broken
33.	HOBA	Earthing switch for battery negative
34.	HEFRA-II	Switch for Earth fault relay in Aux.-II circuit

35.	HL	Head light
36.	HC	Head code
37.	ICA	Isolating cock for auto brake
38.	KF-1 & 2	Radiator fan motor 1 & 2
39.	K1 & 2	Reverser 1 & 2
40.	LTR	Low tension proving relay
41.	MCS	Motor cut out switch
42.	MSWL	Motor switch white light
43.	MCOS	Motor negative cut out switch
44.	MCB	Miniature circuit breaker
45.	MP	Master controller
46.	NVR	No volt relay
47.	NR1 & 2	Notching relay 1 & 2
48.	NC1,2,3,4	Negative contactor 1,2,3,4
49.	OLP	Over load Primary
50.	OVR	Over voltage relay

51.	OP	Oil pump
52.	OL1,2,3,4	Over load relay for TM 1,2,3,4
53.	OL5,6	Over load relay for tap changer
54.	PB	Parking brake
55.	PTB	Pinion teeth broken
56.	Panto	Pantograph
57.	RF	Rectifier fan motor
58.	RFR	Rectifier fan relay
59.	RFAR	Rectifier fan Aux. relay
60.	SL	Smoothing reactor
61.	SR	Starting relay
62.	SB	Signal bell
63.	TL	Tapping reactor
64.	TT	Transformer thermostat
65.	TTR	Transformer thermostat relay
66.	TSS	Test sequence switch
67.	TLC	Train line cable
68.	T1 to T9	Tap changing contactor 1 to 9
69.	TR	Transition resistor
70.	UFL	Unit fault light
71.	VCB	Vacuum circuit breaker
72.	WGR	Winding grouping relay
73.	WCO	Winding change over switch

3.0 JUMPER & COUPLER:

Four inter vehicular jumper/couplers are used for communicating the electrical feed from driving unit to all its trailer coaches for control & light, fan circuit. These four jumper/coupler arrangements are named as 'A', 'B', 'C', 'D'. New coaches (with air spring) are provided with 5th jumper named as 'E'.

JUMPER 'A'

Pin No.	Wire No.	Concerning Circuit
1.	14.	Control +ve / BA +ve
2.	14.	-do-
3.	14.	-do-
4.	9.	ABB Close
5.	44.	Fan Phase for row – 1
6.	45.	Fan Phase for row – 2
7.	10.	ABB Trip
8.	12.	CR Set
9.	42.	CR Trip
10.	1452.	Audio Visual ckt.
11.	7.	Panto Raise
12.	40.	EP Brake circuit negative
13.	8.	Panto Lower
14.	36.	EP Brake supply positive
15.	37.	EP Unit holding positive
16.	38.	EP Unit application positive
17.	3904.	Parking Brake release in 20034-20035, 20036-20037 and 20038-20039
	1404C	Auto Flasher circuit in 653-654-655 and Spare in other rakes.
18.	39.	Parking brake indication 20034-20035, 20036-20037 and 20038-20039.
19.	40.	EP Brake circuit negative

JUMPER 'B'

Pin No.	Wire No.	Concerning Circuit
1.	5.	Forward
2.	6.	Reverse
3.	1.	Shunt
4.	2.	Half Power
5.	3.	Full Power
6.	25	Alarm bell in air spring rakes.
7.	3A	AOVR coil's positive
8.	A261.	AC N/L Neutral
9.	A226.	AC N/L Phase
10.	A226.	AC N/L Phase
11.	33.	Driving cab emergency light positive
12.	46.	Fan circuit Neutral
13.	46.	-do-
14.	11.	Overload Reset coil's positive
15.	A261.	AC N/L Neutral
16.	13.	Main Compressor Synchronizing
17.	3604	Parking Brake application in all MEMU rakes.
		UFL communication in EMU rakes with air spring.
		Spare in other rakes.
18.	1501	PFD fuse blown indication in EMU coaches provided with air spring rakes.
	4	Weak field in MEMU rake 20038-20039. Spare in other rakes.
19.	14A.	Control Changeover feed (BPS).

JUMPER ‘C’

Pin No.	Wire No.	Concerning Circuit
1.	16.	ABB open indication
2.	19.	Rectifier fuse blown indication
3.	18.	Motor Switch white light
4.	17.	Aux. Rect. Fuse blown indication
5.	15.	Indication ckt. positive
6.	17A.	Battery charger failure indication
7.	A261.	AC N/L Neutral
8.	A261.	AC N/L Neutral
9.	A226.	AC N/L Phase
10.	A226.	AC N/L Phase
11.	15A	AWL ckt. in EMU HWH end driving coaches.
12	15A	AWL ckt in EMUs in KGP end driving coaches.
	3605	Indication for Parking brake application in MEMUs except 20034-20035, 20036-20037 and 20038-20039
13.	31.	Emergency light positive
14.	31.	Emergency light positive
15.	25.	Alarm bell positive
16.	26.	Signal bell positive
17.	14B.	BPS positive for Battery paralleling
18.	14B.	BPS positive for Battery paralleling
19.	20.	Guard’s supply positive

JUMPER ‘D’

Pin No.	Wire No.	Concerning Circuit
1.	A226.	AC N/L Phase
2.	A226.	AC N/L Phase
3.	44.	Fan Phase for row – 1
4.	45.	Fan Phase for row – 2
5.	21.	Light ‘ON’ positive
6.	22A	50% light relay ckt. in air spring rakes.
7.	22.	Light ‘OFF’ positive
8.	23.	Fan ‘ON’ positive
9.	24.	Fan ‘OFF’ positive
10.	20.	Guard’s supply positive
11.	41.	DC 110V negative
12.	41.	-do-
13.	A261.	AC N/L Neutral
14.	A261.	AC N/L Neutral
15.	46.	Fan ckt. Neutral
16.	41.	DC 110V negative
17.	41.	DC 110V negative
18.	32.	Intercom in EMUs without Air spring & MEMUs.
19.	32A.	

JUMPER 'E'

Pin No.	Wire No.	Concerning Circuit
1.	ICS 1	Intercommunication & PA system. Presently kept isolated
2.	ICS 2	
3.	ICS 3	
4.	ICS 4	
5.	ICS 5	
6.	ICS 6	
7.	ICS 7	
8.	Spare	
9.	Spare	
10.	Spare	
11.	Spare	Intercom in EMUs with Air spring
12.	Spare	
13.	1404A	Auto Flasher light circuit in 653-654-655. Spare in other rakes.
14.	15B	
15.	3606	Parking brake release in EMUs with Air spring
16.	3604	Parking brake application in EMU coaches with Air spring
17.	3605	Parking brake application indication in EMU coaches with Air spring
18.	Spare	
19.	Spare	

4.0 POWER CIRCUIT OF EMU:

Current is collected from 25 KV single phase AC OHE supply by means of pantograph and enters to transformer primary through circuit breaker (ABB/VCB), surge diverter and bushing (condenser or cable head type).

The 25 KV is connected to the primary winding of EMU transformer. The another end of the primary winding is brought out by a negative bushing and an insulated cable which is connected to the traction motor earth brushes bearing on the four axles. The earth brushes are insulated from the motor frames thus keeping the transformer return current independent of the farthing of the equipment cases and under frame.

The transformer secondary out put is 700V. The secondary winding consists of two separate windings each of 350 V. One half is tapped into five sections each of 70 V. Whereas the other half is untapped.

Upto half power of the notching sequence, the tapped portion of the winding is used, while for the remaining notches, the two sections are connected in series. The changeover is effected by means of contacts W1 and W2 on the winding changeover switch (WCO). W1 remains closed upto half power and on full power W2 closes and W1 opens. This arrangement gives a total of 10 equal voltage steps by means of 22 regular notches of tap changer through various connections of transformer tapings and voltage dropping reactors.

The switching of the transformer sections is carried out by the tap changing contactors T1 to T9. Contactors T1 to T6 are connected to the transformer tapings and the required voltage is selected. Tap changing is carried out by means of a reactor TL, in conjunction with the two contactors T7 and T8 to give alternate notches with and without the reactor in circuit.

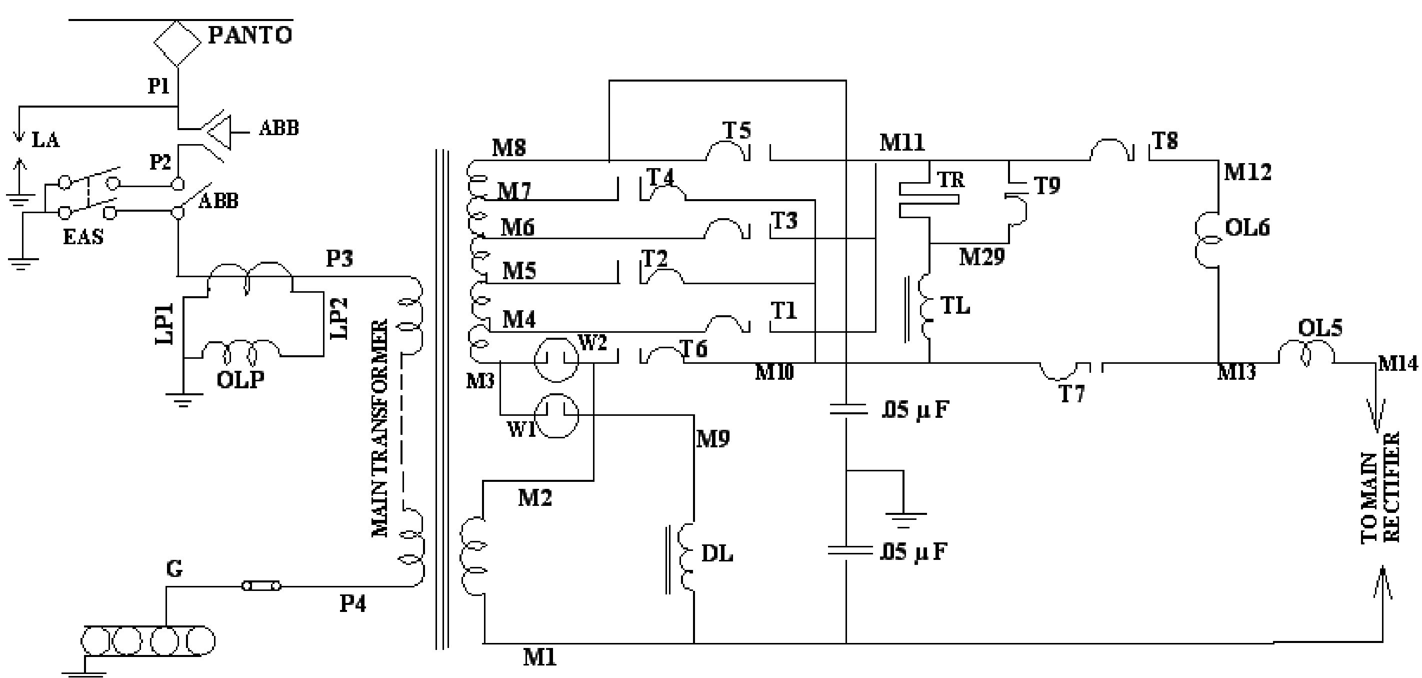
The selected out put voltage is fed through the overload relay trip coils OL5 & OL6 to the main rectifier unit.

2 capacitors of 0.05 microfarads are connected between the two secondary windings and earthed to prevent the build up of high voltages to earth on the windings when they are not connected to traction ckt. earth.

The voltage tapped from TFP secondary by tap-changing contactors is converted to DC by main rectifiers.

The semiconductor type silicon bridge rectifier (HIND/Old type rectifier is having 6 bridges while HIND/ New type rectifier , USHA rectifier and BHEL rectifier are having 3 bridges whereas the NGEF rectifiers are having 4 bridges) converts the voltage from AC to DC. The rectified DC voltage is smoothened by the reactor `SL' and further smoothening is done by ASL which is connected in series with traction motors.

POWER CIRCUIT FOR MAIN TRANSFORMER & TAP CHANGING CONTACTORS



4.1. Pantograph:

It is a collapsible frame work made of metallic tubes and articulated by ball bearings. It is used for smooth and spark-less current collection from OHE and to feed the transformer primary winding through Circuit Breaker. It is designed to maintain the continuous flow of current in spite of oscillation at high speed and the variation in height of the contact wire at different places.

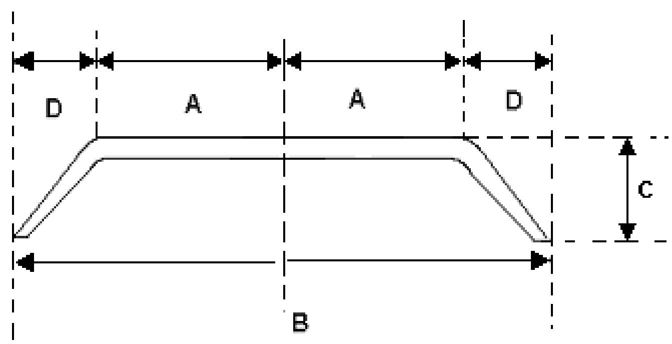
Pantograph is held in the raised position by means of compressed air supplied from panto reservoir in HT compartment. The raising and lowering of pantograph is controlled from driving cab by means of two operating valve (latch type) which are controlled with 110V DC supply.

Parameters – i) Minimum air pressure required to raise – 4.5kg/cm^2
ii) Starts lowering when pressure drops to 3 to 3.5 kg/cm^2
iii) Time taken to raise – 6 to 10 sec.
iv) Time taken to lower – 10 sec.
v) Material of panto strip – Metallized Carbon
vi) Thickness of Carbon strip with bow strap – 50 mm (new)
38.5 mm (cond.)

Main parts of pantograph assembly – i) Servo motor, (ii) Base frame, (iii) Base insulator, (iv) Actuating rod, (v) Push rod, (vi) Anti-balancing tube, (vii) Upper and lower articulation tube, (viii) Spring box, (ix) Panto pan, (x) Bow assembly, (xi) Flexible shunt, (xii) Metallised carbon strip.

Items to be checked to prevent Panto entanglement:

i) Check that the carbon strips are properly fastened with the panto pan and there are no loose fasteners or bent strip or deep groove on the strip. Pantograph strip joints must be smooth so as not to hinder smooth riding of the contact wire on the pan.
ii) Check the bow plunger for free sliding while pressing. Check that the split pins are intact.
iii) Check the horizontality of the panto pan and its free vertical movement. Check the transverse flexibility of the pan by pulling transversely at the middle cross member with a force of 50 kg. The displacement of the pan at the middle cross member should be 36 $\pm$ 5mm. Check that the positioning link is not bent/cracked or dislocated from the fixing pivot. Check the intactness of split pins.
iv) Check the pantograph frame for signs of bending or cracks. Check the springs for any crack.
v) If possible, take the measurement of the pan as shown in the figure.



PANTO TYPE	A	B	C	D
AM-12	520	1800	300	380

4.2 ABB (Air Blast Circuit Breaker):

It is an electro-pneumatic high speed circuit breaker. It extends 25 KV power supply from pantograph to transformer primary winding. The operation of ABB is remote controlled from driving cab and it gets tripped automatically through its protective relays in case of any earth fault or abnormality in electrical system.

ABB is having two pairs of contacts, **Primary** and **Secondary** connected in series. A resistance of 1 lakh ohm connected in parallel of primary contact which is provided across the **arc chamber**. When ABB is closed, both contacts are closed. While opening, primary contact opens first. Resistance remains in circuit to absorb the transient surge and then secondary contact opens. The time delay of opening is produced by **retardation valve**. The circuit interruption takes place within 10 to30 miliseconds.

Supply of air pressure in the system is governed by a pressure switch and a minimum pressure device. The closing and opening of ABB is controlled by operating two electro-pneumatic valves named as **Closing** and **Holding valve**. Closing valve acts during closing only and holding valve holds the ABB in closed position and ABB remains closed so long it remains energized.

Main Parts – i) Air reservoir, (ii) Pin type insulator, (iii) Hollow insulator, (iv) Arc chamber insulator, (v) Primary contact, (vi) Secondary contact, (vii) Insulator with control resistor, (viii) Closing coil, (ix) Holding coil, (x) Control block, (xi) Minimum pressure device.

4.3 VCB (Vacuum Circuit Breaker):

This circuit breaker incorporates all the advantages resulting from recent advances in vacuum switching techniques.

Construction – In VCB, two interrupters are used in series and are mounted in the horizontal support insulators. Each interrupter houses a pair of contacts. The pneumatic dual piston operating mechanism is mounted in the main cradle between the interrupters. The compressed air supplied to it from the main system of the vehicle is regulated automatically within the circuit breaker to 5.0 kg/cm^2; thus consistency of operation is assured. Auxiliary contacts are mounted in the base plate and are driven from the main contacts.

Now single bottle VCB has also been inducted in to service.

Vacuum Principle – Vacuum has excellent insulating properties and therefore very small gaps are required between contact faces to withstand extremely high voltages. The separation of contacts within a vacuum can also rupture large current. When breaking the supply on load, the contact design enables the current to be reduced to a low level before the arc is finally ruptured thus minimizing voltage transients.

VCB has following advantages over ABB :

i) More reliable - Vacuum switching techniques increases contact life, eliminate ionized gases, simplify mechanical arrangement and therefore ensures reliability.

ii) Requires less maintenance – Good contact life can be expected from the vacuum interrupter, its excellent arc extinction properties reducing contact erosion. The contacts are completely sealed in a vacuum chamber making them maintenance free throughout their operating life.

iii) Quieter and more efficient - Vacuum switching techniques have removed the noise associated with ABB. This is achieved as a result of the efficient arc extinction properties of the vacuum switch and the low mechanical inertia of the moving parts.

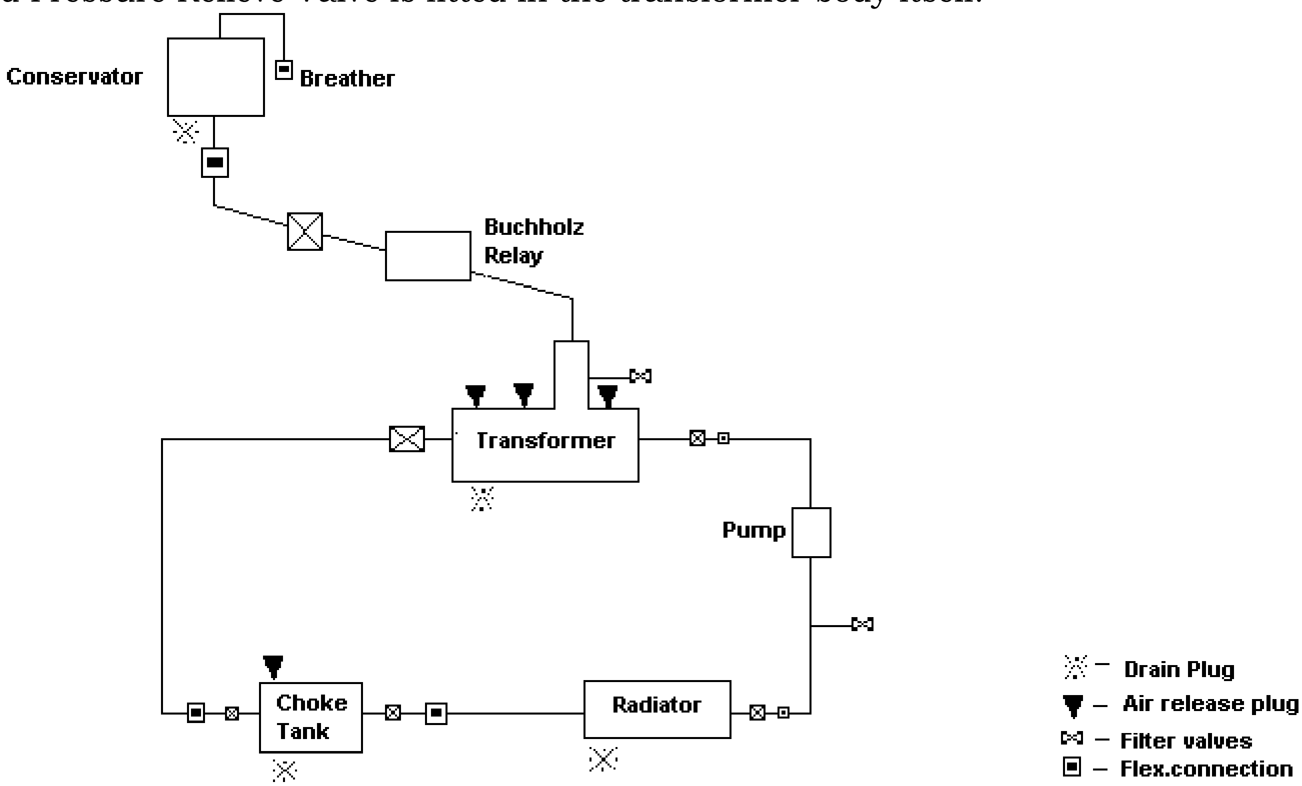
4.4 Main Transformer:

The main transformer is a under gear mounted step down transformer which is having three separate secondary windings, first traction , 2nd Aux-I and 3rd Aux-II.

Rating	: 1000 KVA at 25 KV.
Traction secondary	: 782 V.

Aux. I	: 266V/55 Amps.
Aux. II	: 141V/250 Amps.

The transformer oil circuit consists of a main transformer tank, a reactor tank (including smoothing, tapping and dropping reactors), oil pump and a radiator. The cooling air for the radiator is drawn through the radiator block from the coach sole-bar level by two axial flow fans mounted behind the radiator. The direction of oil flow is from the main transformer through the oil pump to the radiator inlet. From the radiator oil flows to the reactor tank and back to the transformer oil inlet. The oil supply to the transformer is maintained by a conservator tank mounted in the HT Compartment and which is connected to the transformer via. the Buchholz Protection relay, also located in the HT compartment. A newly developed Pressure Relieve Valve is fitted in the transformer body itself.



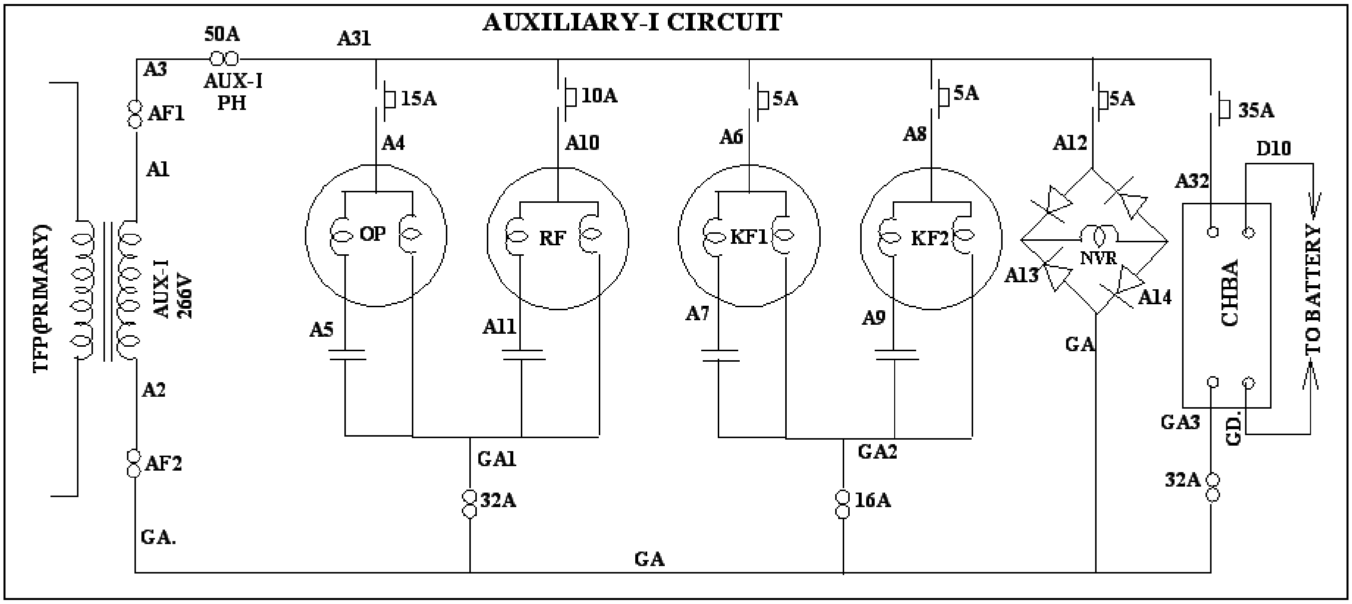
TRANSFORMER OIL CIRCULATION CIRCUIT

<u>Transformer Aux Winding</u>: Two tertiary windings are provided on the main transformer to supply the A.C. aux. Machines (Aux.1) and D.C. low tension circuits (Aux. II) respectively.

<u>Aux. I Circuit</u>**:** The 266 volt winding feeds the single phase A.C. capacitor starts and run motors of aux. machines such as:

(i) One rectifier cooling fan motor (RF),
(ii) Two Radiator fan motors (KF1 & KF2),
(iii) One oil pump motor and
(iv) One Static Battery Charger.

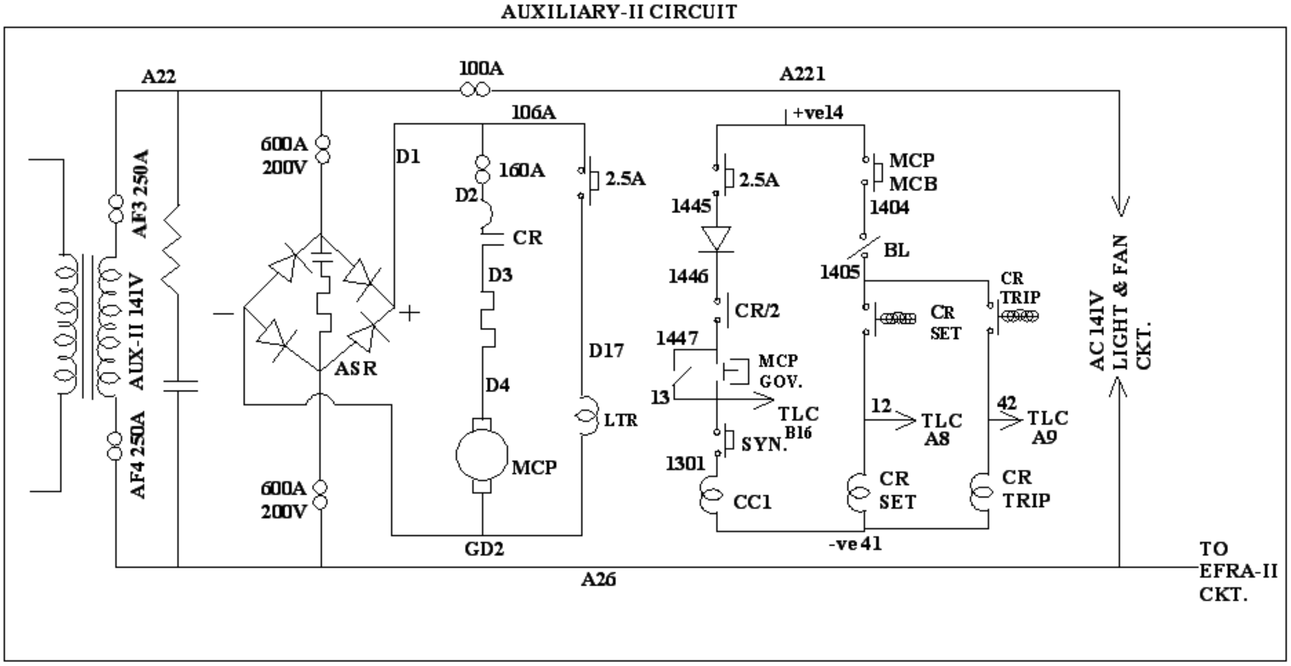
Aux. I circuit is protected by two fuses, AF-1 and AF-2 located within the transformer connection chamber.



Aux-II Circuit**:** 141 volt aux. winding supplies power to the normal lights and fans and the aux. rectifier which in turn supplies the power to the main compressor motor.

The Aux. II circuit is protected by two fuses, AF-3 & AF-4 located inside the transformer connection chamber.

AUXILIARY-II CIRCUIT



4.5 Transition Resistance (TR):

The purpose of this resistor is to ease the duty on opening of the contactor by reducing the circulating current.

4.6 Choke tank:

The choke tank is mounted in under-gear of the motor coach. It consists of SL, DL & TL. Function of the SL, DL & TL are described below:

i) **SL** - The smoothing reactor is called SL. Its function is to smooth the DC out put by eliminating the AC ripples.

ii) DL- The dropping reactor is called DL. The reactor DL is connected in such a position that it is in series with the output of all notches when the tapped half of the secondary winding comes in the circuit. The purpose of the reactor is:

a) To steepen the notching curves on low taps and thus to reduce the notching current swing.

b) To increase the short circuit reactance in the low taps.

c) To provide two extra notches i.e. 11^{th} & 12^{th} notch.

iii) TL – The tap changing reactor is switched into circuit during alternate electrical notches to give an intermediate increase in voltage to make notching and hence acceleration smoother.

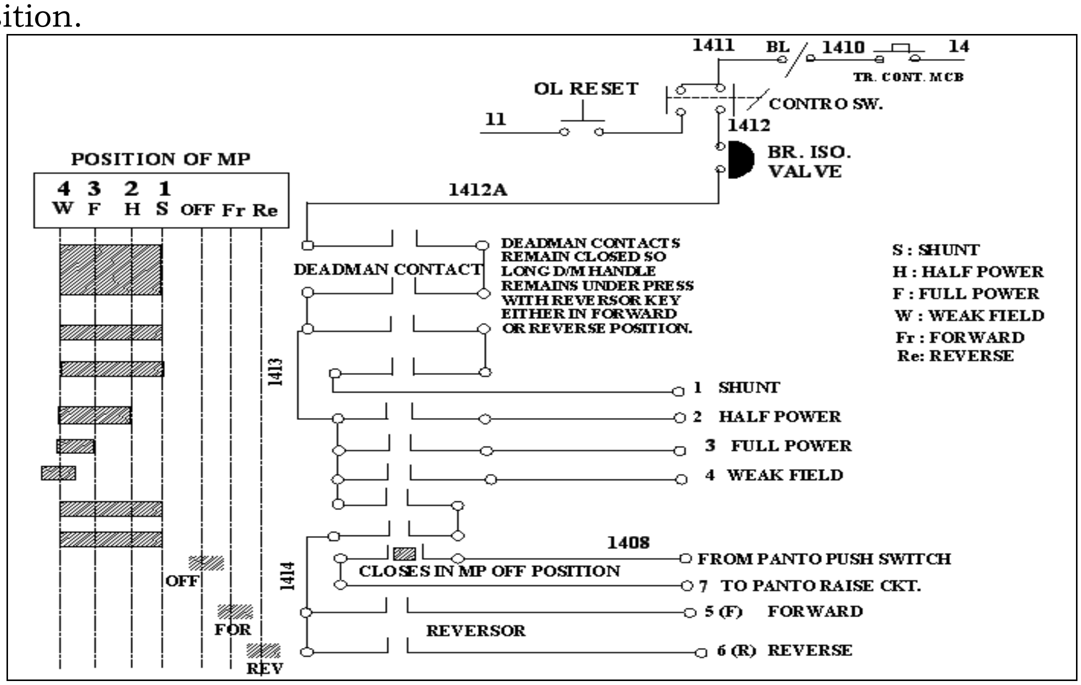
4.7 Master controller:

Master controller is operating equipment by which the direction of train movement is selected and operation of tap changer is being controlled. It has cam operated silver tipped contacts with an accelerating handle and reverser key. Accelerating handle has four positions – Off, Shunt, Half power and Full power. Reverser key has three positions – Forward, Neutral and Reverse. Reverser key decides the direction of train movement i.e. either forward or reverse. Accelerating handle controls the operation of tap changing contactors and thus speed of the train is controlled.

The accelerating handle incorporates Dead-Man-Device which consists of electrical contacts and a pilot valve. When the handle is pressed, the Deadman contacts remains closed. If the handle is pulled to an operating notch, the pilot valve also remains closed. If the handle is released, the contacts get opened to cut off the power and the valve will open to apply the train brakes.

The accelerating handle and reverser key shafts are mechanically interlocked as follows:

- The accelerating handle cannot be operated from ‘Off’ position until the reverser key has been moved to forward or reverse position. Conversely, the reverser key cannot be pulled back to neutral position until the accelerating handle has been moved to ‘Off’ position and pressed.
- When the accelerating handle and reverser key are in ‘Off’ position, the Dead-Man-Device remains inoperative, the Deadman contacts are open and the pilot valve is closed.
- One normally closed interlock is provided between wire no. 1408 & 7 which ensures that pantograph can only be raised if the accelerating handle is in ‘Off’ position.



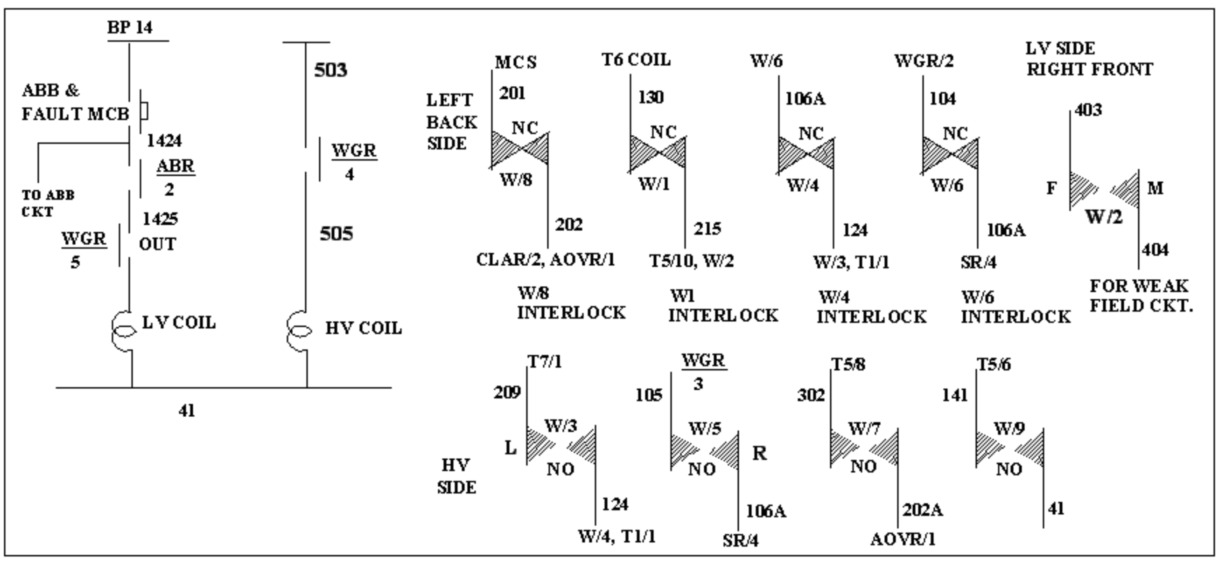
4.8 Tap Changer Cubicle:

The tap changer cubicle consists of Tap changing contactors T1 to T9 (electro pneumatic contactors), one winding changeover switch WCO (its contacts are W1 & W2), one winding grouping relay WGR, one double element relay OL5 & OL6 having a common set of interlock and reset coil.

WCO – This electro-pneumatic switch is driven by a double ended cylinder. It is operated by two separate magnet valves controlled, by air pressure. There is one lever for manual operation.

WCO is having two operating coils LV & HV. During Half power, WCO should remain in LV side (LV operating coil remain energized). During Full power, LV gets de-energized and HV coil gets energized, thus WCO will be thrown to HV side. If MP is brought to 'OFF' position, WCO will be switched back to LV side automatically and remains ready for further progression of Tap changer.

WCO CLOSING CIRCUIT



WGR - It ensured whether WCO is in desired position or not. During full power WGR energized and allows WCO to throw in HV position.

4.9 Switch Group Cubicle:

There are two Switch Group Cubicles in EMU/MEMU Motor Coaches, named as Switch Group Cubicle – I & Switch Group Cubicle – II. Both are fitted on under frame.

Switch Group Cubicle – I consists of Motor contactors for both, positive & negative side for Traction Motor 1 & 2. One reverser K1 for TM1 & 2, one double element overload relay OL1 & OL2 for TM 1 & TM2 respectively. Notching relays NR1 & NR2 which ensure that the operation of the tap changing contactors T1 & T9 occurs in the right sequence and timing.

Switch Group Cubicle – II consists of Motor contactors for both, positive & negative side for Tr. Motor 3 & 4. One reverser K2 for TM3 & TM4, another double element relay OL3 & OL4 or TM 3 & TM4 respectively.

Reverser – Reverser is having two operating coils, one for forward movement and the other for reverse movement of the train. While reverser key is placed on 'Forward' direction and MP is on notch, interlock no.11 of MP will close and it will energize 'Forward' coil (through wire no. 5/ 501 from MP/MCS respectively) of both the reversers. Similar operation will take place while reverser is placed on 'Reverse" position. In this case MP interlock no. 12 will close and it will energize reverse coil (through wire no. 6/601 from MP/MCS respectively) of both the reversers. Two reverser interlocks (one of each reverser) are provided in motor contactor control circuit. Reverser should be thrown to desired position enabling to close the motor contactors.

Air bolt type : Unrestricted
Ferrule between magnet valve and cylinder : 1.6 mm. (restricted)

Notching Relay – Two notching relays (NR1 & NR2) have been provided in tap changer control circuit. These notching relays produce time delay action for closing and opening of Tap changing contactors.
Normally, NR1 closes while T2, T4 or T6 close provided T1, T3, T5 remain open.
NR2 closes in every alternate notch along with contactor T9.
The time delay action is achieved through restricted air pressure. The air pressure is being controlled by air bolts and ferrules provided in the incoming pipe line of the magnet valve.

NR1-	Air bolt drill size- 1.3 mm.
	Ferrule drill size- 1.6 mm.
NR2-	Air bolt drill size- 2.35 mm.
	Ferrule drill size- 1.6 mm.

4.10 Rectifier:

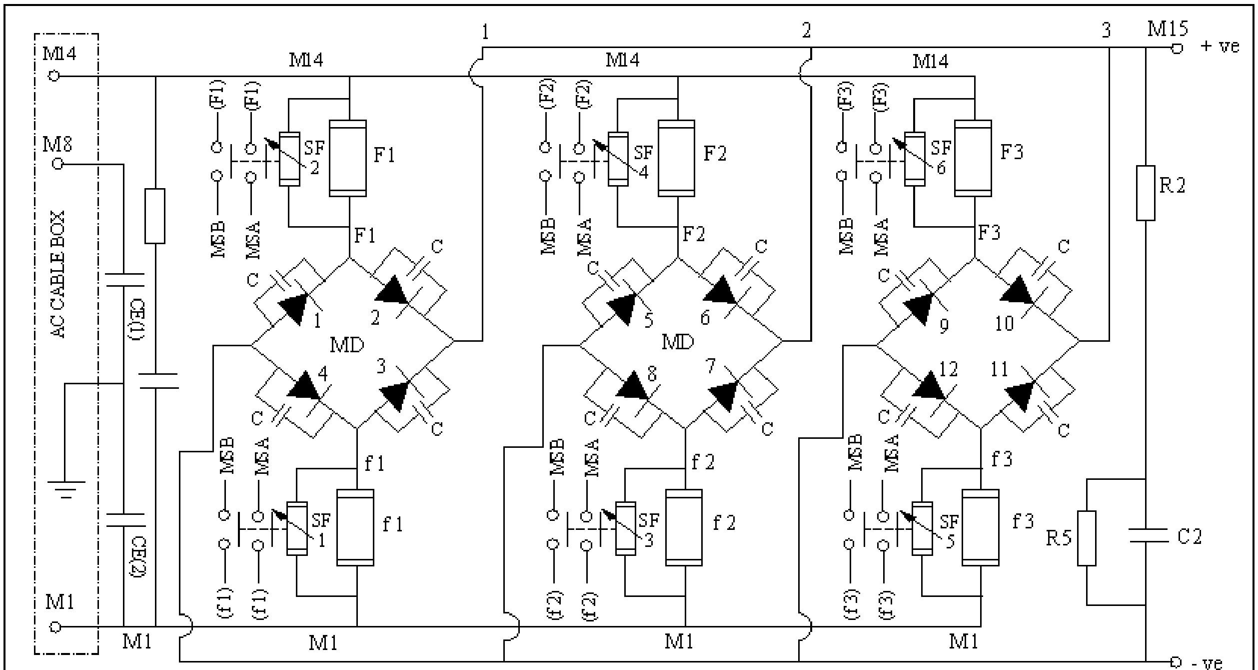
EMU rectifier is an under gear mounted cubicle, divided into two parts – main rectifier unit and Aux. Rectifier unit.

<u>Main rectifier</u> **:** Voltage from the transformer secondary, collected by tap-changing contactors is fed to the main rectifier. The rectifier is having three/four bridges (6 six bridges in Hind/Old type rectifier). Each bridge consists of four silicon diodes and is protected with fuses 1000V/1450A for short circuit protection. Damping network is there. It consists of 8 Ω register in series with a capacitor 16 MFD/1000V across AC input. In addition, earthing protection is also there. The function of rectifier is to convert AC supply to DC for further feeding to traction motor ckt.

Rating:	Input	- 782 V AC, 1ph, 50 HZ
	Output	- 535V DC, 2640 Amps.

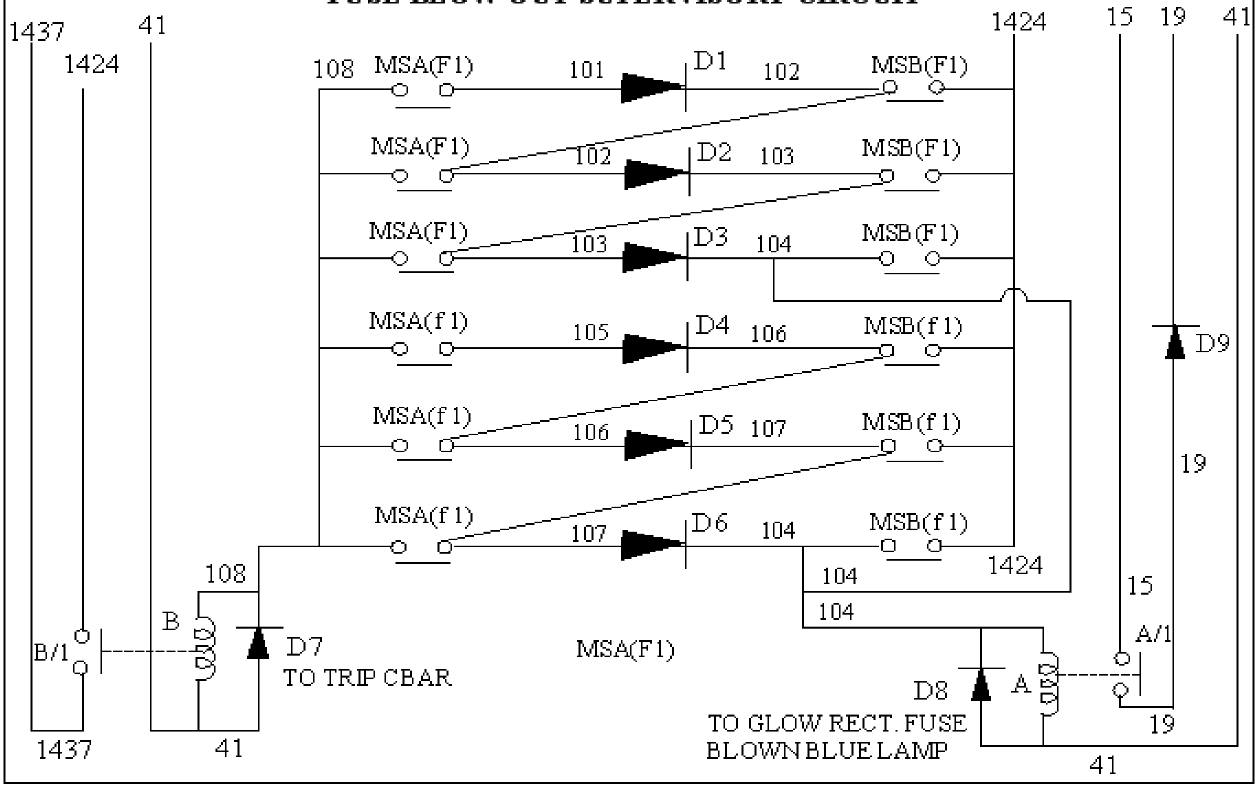
Each diode is provided with an aluminum heat sink which is forced air cooled by rectifier fan motor mounted inside the rectifier cubicle.

For protection of main rectifier, there is a supervisory ckt. comprising of two relays (relay 'A' & relay `B'), trip indicator fuses and micro-switches. Blow out of either or both fuses of the same bridge will energies relay `A' due to the closing of corresponding micro- switches (which gets operated by trip indicator fuses), causing rectifier fuse blown indication lamp to glow in driving cab. Failure of one more bridge will energize relay 'B', which in turn trips CBAR relay. This results in interruption of feed to motor contactors, hence power supply to the traction motor cuts and rectifier is off loaded.



MAIN RECTIFIER

FUSE BLOW OUT SUPERVISORY CIRCUIT



<u>Aux. Rectifier</u> **:** 141V Aux. II winding supplies power to Main Compressor Motor through Aux. Rectifier (ASR). A 'RC' network is provided in the supply from ASR to smoothen the supply to various loads. It consists of a single bridge having 4 diodes. The ckt. is protected from short ckt. of bridge by means of two fuses. It also prevents the blowing out of AF3/AF4 fuses of Aux. II winding of transformer secondary in case of short ckt. in Aux. Rectifier bridge thus ensures uninterrupted power supply in coach lights & fans.

Rating:	AC input	– 155V
	DC output	– 136V
Fuse	300V/300A	

4.11 Traction Motor:

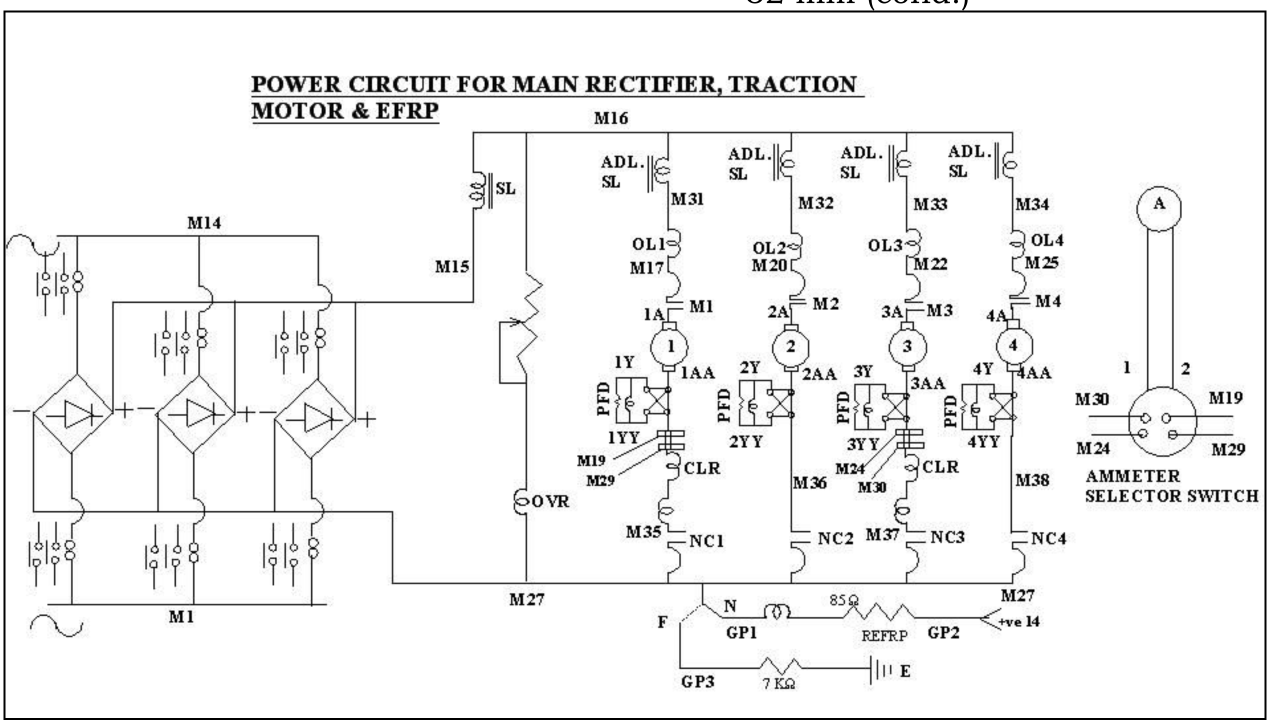
The EMU Traction Motors are DC series, self excitation type motors. There are 4 Traction motors in each motor coach and connected in parallel with the main rectifier DC output.

The motors are axle mounted and nose suspended. A single reduction gear (ratio 20:91) is used for transmission of power to the axle. Each traction motor is operated through individual contactor, both at positive and negative side.

Rating of Traction Motor:

Rating :	**1 hour**	**Continuous**
RPM	1182	1260
Volt	535	535
Amps	380	340
Output	187 KW	167 KW

No. of carbon brush boxes – 4
No. of carbon brush in each box – 2 pairs
Length of the carbon brush – 60 mm (new)
32 mm (cond.)



Permanent Field Diverters are connected across the field coils of each motor to divert the AC ripples and to reduce the heating effect of the motors.

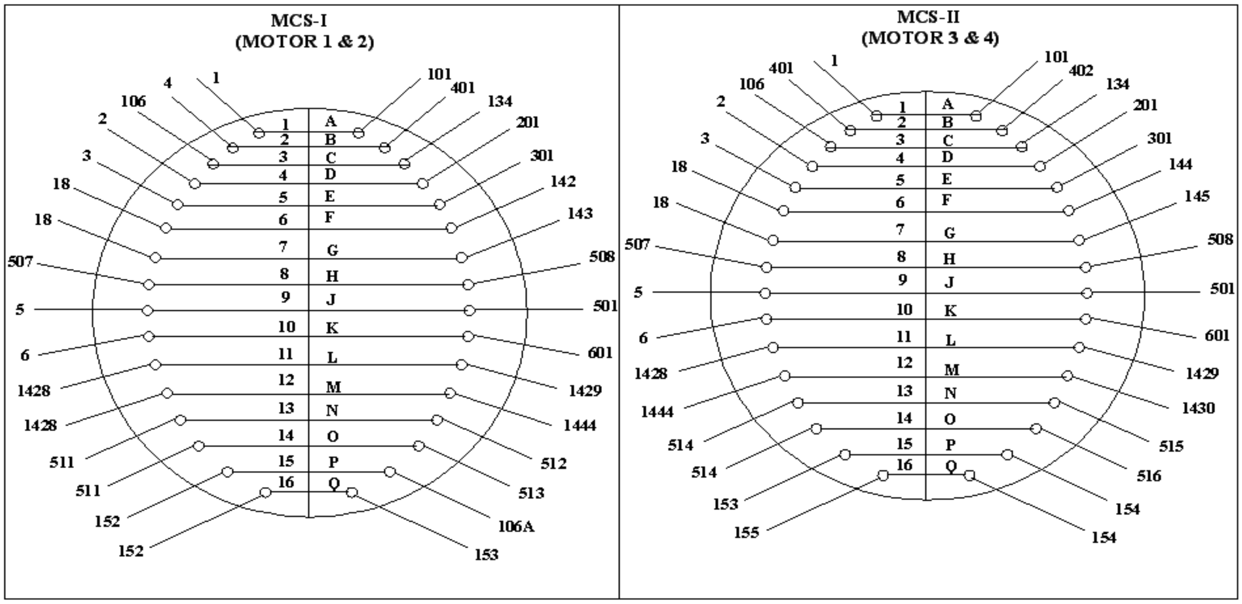
Motor Cut Out Switch: There are two Rotary switches named as MCS1 & MCS2.
Each switch is controlling two Tr. Motors i.e. MCS1 controls TM1 and TM2 and MCS2 controls TM3 and TM4.
Each switch is having 4 positions. For MCS1, the positions are:-

Position 1: Normal : Both Motors are in service.
,, 2: 1 out : TM1 is isolated.
,, 3: 1 & 2 out : Both TMs are isolated.
,, 4: 2 out : TM2 is isolated.

TM3 and TM4 can be controlled in similar manner by MCS2.

Each MCS is having 16 cam operated contacts. These contacts are being operated as per sequential operation of the MCS.
Any two motors, one in each block can not be isolated together. MCS interlocks will prevent progression of tap changer if done so.

CONNECTIONS OF MCS1 & MCS2



5.0 PROTECTIVE DEVICES:

S/No.	Equipment	Description
1.	**OLP (Primary Overload relay)**	Protects transformer primary from over current (set at 160 : 0.7 amps)
2.	**OL5/OL6 (Overload relay 5&6)**	Two overload relay coils OL5 & OL6 form a double-element overload relay. OL5 protects against a direct overload due to a fault in the rectifier or motor circuits & OL 6 protects against four tap change contactors being closed together, for eg. T1, T2, T7 & T8. The electrical interlocking is such that this condition is impossible electrically & could only occur due to mechanical failure of a contactor. Tripping of either OL5 or OL6 causes the air blast circuit breaker to open through its interlock provided in ABB control circuit OL 5 & OL 6 set at 4000 amps.
3.	**TT (Transformer thermostat)**	It prevents rise of transformer oil temperature above 80^0C. In case of TT acting, Transformer Thermostat relay (TTR) is energized and its N/C interlock TTR/1 opens and interrupts the feed to motor contactors. Thus power supply to the motors gets cut off. The relay TTR is provided with an indication flag and self resetting arrangement.
4.	**BUD (Buchholz device)**	In case of gas accumulation of 200cc in transformer tank BUD will act and in turn it will trip ABB/VCB through relay BIR (Buchholz Indication Relay). Relay BIR is provided with an indication flag, a mechanical Latch and a reset button. The N/C interlock of BIR is provided in ABB/VCB control circuit to trip ABB/VCB in the event of Buchholz operation.
5.	**PRV (Pressure Relief Valve)**	This is provided on transformer tank for protection against any flash- over in transformer winding and is set at 0.49 kg/cm^2. When pressure in the tank rises above this safe limit, this valve operates and performs following functions: • Allows the pressure to drop instantaneously by opening a port of about 150mm dia. • Gives visual indication of valve operation by raising a flag. • Operates a micro switch and ABB gets tripped through its interlock in ABB/VCB control circuit.
6.	**NVR(No volt relay)**	It is provided for protection of traction circuit. This is a DC relay in Aux. I circuit fed by a bridge connected rectifier provided in NVR relay panel. In case of no volt in Aux. I circuit. NVR relay will drop out and disconnect the traction circuit by means of its contacts NVR/1 and NVR/2 in control circuit.
7.	**LTR (Low tension proving relay)**	This is provided in Aux. Rectifier (ASR) to prove that fuses AF3 & AF4 are intact and ASR is in sound condition. If there is no ASR output, provided ABB is closed, LTR will not pick up and ASR trip indication (Aux. white light) will glow. In that case, MCP in affected motor coach will stop working.
8.	**RFR (Rectifier Fan Relay)**	Failure of rectifier cooling air flow causes the pallet operated/diaphragm type air flow relay, RFR to drop out and de-energizes its Aux. Relay RFAR.

S/No.	Equipment	Description
9.	**RFAR (Rectifier Fan Aux. Relay)**	Failure of RFR de-energizes the rectifier fan auxiliary relay (RFAR) and its interlock RFAR/II on Motor contactor circuit opens and interrupts the feed to the motor contactors. Thus power supply to the traction motor cuts off & rectifier is off loaded. RFAR remains energized during normal operation of EMU to ensure cooling system of rectifier is working.
10.	**OL 1 to OL 4 (motor over load relay)**	Each traction motor is provided with an over current relay connected in series with traction motor. Whenever any of the traction motor draws over current, concerning overload relay acts and resulting in opening of respective motor contactor and tap changer stops working. Each of the motor over load relay is set at 900 amps.
11.	**CLR (Current limit relay)**	There are two current limit relays (CLR), connected in series with TM1 & TM3 circuit, to limit the current during starting and to achieve smooth acceleration. CLR is set at 500 amps (to drop out).
12.	**CLAR (Current limit aux. relay)**	Current limit aux. relay is provided in LT compartment which remains energised through N/C interlock of CLR. Traction circuit is getting feed through CLAR N/O interlocks which closes on energisation of CLAR.
13.	**EFRA-II (Earth fault relay for AUX II circuit)**	This is a voltage operated relay. This relay is provided for protection against earth fault in Aux. II ckt. Whenever any earth fault takes place in Aux. II ckt., this relay acts and subsequently trips ABB. Tripping of ABB on line can be avoided if HEFRA II (earth fault bypassing switch) is kept in 'Fault' position. The EFRAII relay is to be set manually after rectification of the fault. **Rake should not be allowed from car shed with HEFRA II in 'Fault'.**
14.	**HOBA (Bypass switch for Negative bonding)**	Negative side of the battery is grounded through HOBA. In case of any fuse melting or MCB tripping due to earth fault in control ckt., this switch is to be put in 'OFF' position. A resistance is connected in parallel with switch HOBA. When the switch is kept in 'OFF' position, the faulty current passes through the resistance which restricts the faulty current, hence tripping of MCB or fuse melting can be avoided. **Rake should not be allowed from car shed with HOBA in 'Off' position.**
15.	**SR (Starting Relay)**	Before tap changer starts working, certain conditions are to be full filled. The relay SR is provided to ensure that concerning equipment are in desired condition before allowing the train to start. SR will pick up if: i) Reversers are thrown to the desired direction. ii) Motor contactors are closed. WCO is in LV position. iii) WGR is de-energised iv) Contactors T2, T3, T4, T5 & T6 are not closed or welded.
16.	**OVR (Over Voltage**	This relay is connected across traction motor supply for

	Relay)	protection against over voltage which is set as 540V DC.
17.	**AOVR (Over Voltage aux. Relay)**	Over voltage aux. relay is provided in Switch gr.-I which remains energized through N/C interlock of OVR. Traction circuit is getting feed through AOVR N/O interlocks which closes on energisation of AOVR.

6. <u>AUXILIARY MOTORS</u>

6.1. Main Compressor (MCP): The purpose of Main compressor is to maintain continuous air supply to the electro-pneumatic equipment & brake system of EMU/MEMU to ensure their effective working. The MCP Motor is a DC series motor which gets feed through auxiliary rectifier.

<u>Specification for Compressor</u>
Type : Reciprocating, Air cooled, Forced feed lubricated, Monoblock.
Working pressure : 7 kg/cm^2.
No. of Stages : 2
No. of Cylinder : 3(LP-2, HP-1)

<u>Specification for Motor</u>
Voltage : 110V DC
Current : 99A
Output : 9.12 KW
RPM : 1160

6.2. Auxiliary Compressor (ACP): The purpose of ACP is to create initial air pressure for raising of Pantograph, ABB closing & testing the EP contactors. This ACP is fed from 110V battery & put into service through electromagnetic contactor CC2.

Specification for Compressor
Type : Single cylinder, Reciprocating, Monoblock.
Max. Operating pressure: 8 kg/cm^2
Piston displacement : 150 lpm

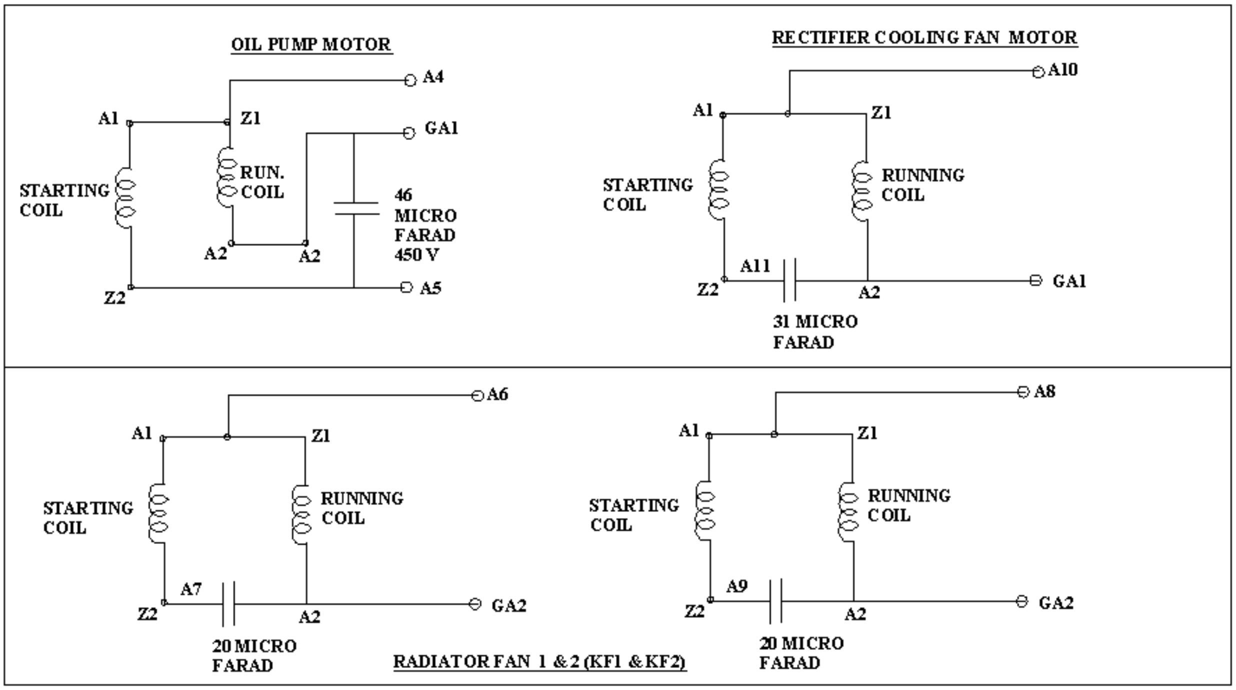
Specification for Motor
Power supply : 110V DC
Current : 8.5A
Power required : 1 HP

6.3. OIL PUMP: It is provided to circulate the transformer oil to keep it cool & the entire unit is mounted in transformer oil pipe line. The motor is of 4 pole, squirrel cage, capacitor start & run type and operates with its rotor immersed in oil. Supply is obtained from transformer Auxiliary-I ckt.
Rating: 1.5 HP, 240V AC, 50 Hz, 6.5 A, Single phase, 1420 RPM.
Pump capacity: 364 lts./min. against 7.32m head.

6.4 RADIATOR FAN & MOTOR: Two radiator fans are provided for forced cooling of transformer oil and are fed by auxiliary 1 circuit of transformer.
Rating: 0.5 HP, 240 V AC, 50Hz, Single phase, 2.5A, 14.10 RPM.

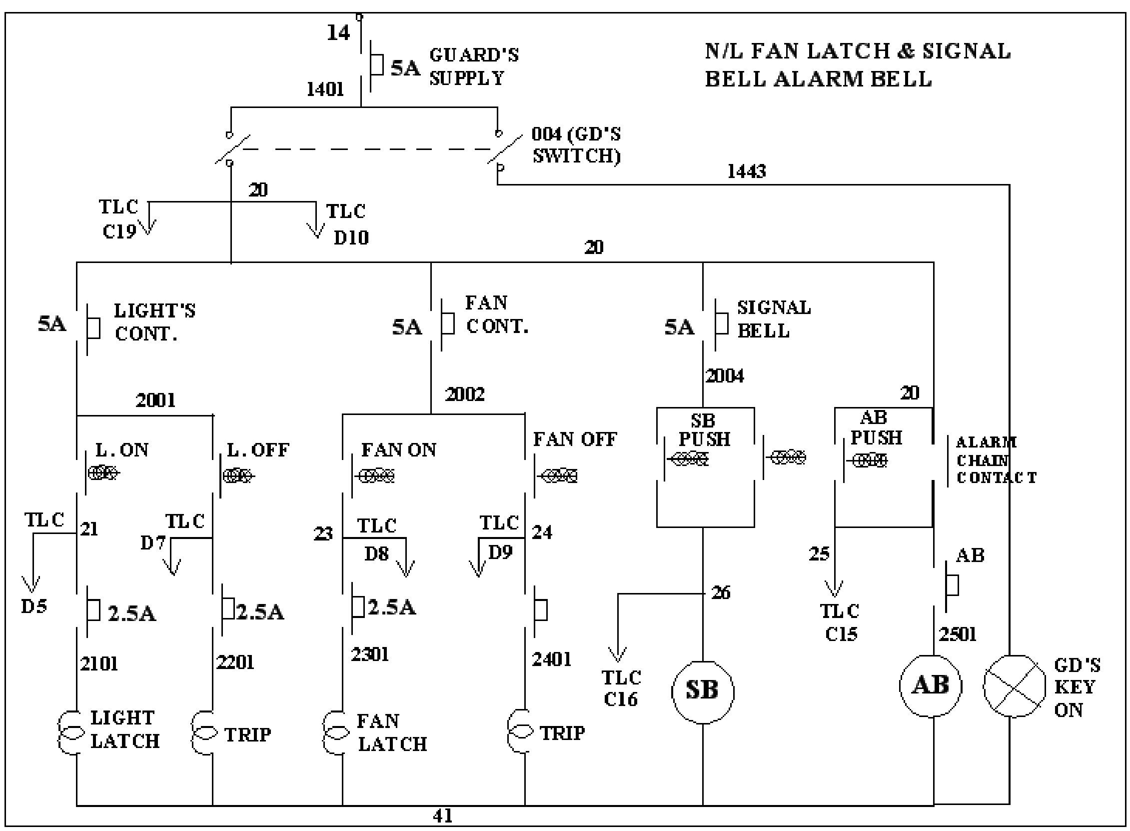
6.5 RECTIFIER COOLING FAN: It is provided to cool the heat sinks of rectifier diodes and is fed by Auxiliary-I circuit of transformer.
Rating: 1HP, 240V AC, Single phase, 3.6A, 1430 RPM.

AUXILARY MOTOR CONNECTIONS



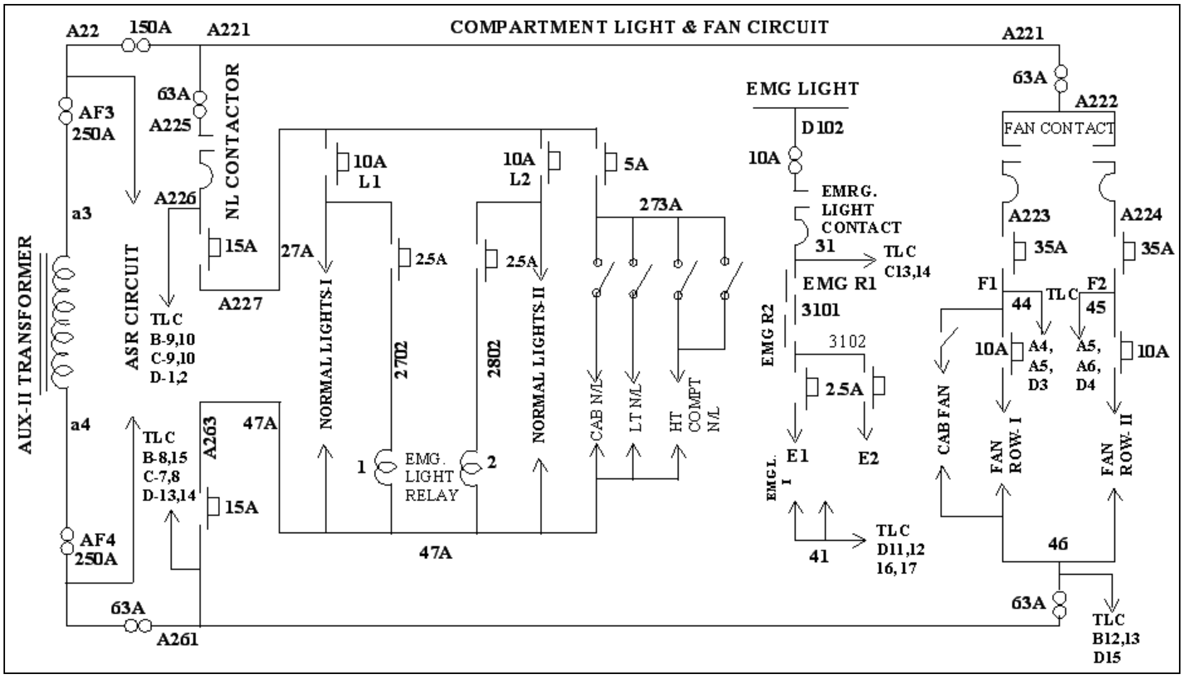
7.0 LIGHTS & FANS:

Compartment fans and lights are connected across AC supply of Auxiliary-II circuit. These are operated by means of latched type contactor. Each contactor is having two operating magnetic coils – one is for 'ON' and the other is for 'OFF'. Closing & opening of contactors are controlled by guard's key & respective push button switches which are connected in control circuit.



7.1 **FANS:** Compartment fans (60W, 110 V) are divided into two rows & connected in zigzag manner. Each row is connected through individual MCB i.e. F1 & F2.

7.2 **LIGHTS:** Normal lights (20 W, 110V) are also divided in two rows and connected in zigzag way and are controlled by MCB L1 & L2 located in MCB panel of coach end.



8. BATTERY AND BATTERY CHARGER

8.1 **Battery:** Battery is provided in EMU to feed entire control circuit, Aux. Compressor, Pantograph & ABB circuit. There are 10 nos. of battery in a motor coach which is connected in series. Each battery is of 10 volts and thus a total of 100 V DC supply is obtained. Each Battery is having 5 cells, each of 2V.
The capacity of battery is 90 Amp. Hour. Battery electrolyte is the combination of sulphuric acid and distilled water at the ratio of 1:8. Permissible limit of specific gravity of the electrolyte in battery full charged condition is 1220 to 1260. The battery circuit is protected by two fuses of 63A and controlled by a switch 'BIS'. One battery voltmeter and one ammeter are fitted in driving cab to ascertain battery voltage and load in the battery circuit.

8.2 **Battery charger:** The battery charger is a simple and rugged arrangement designed to meet the operating conditions and limitations obtaining with 25 KV AC Electric Multiple Units of the Indian Railways. The charger operates from widely ranging AC input supply to deliver a fairly constant DC output voltage upto the rated maximum current so as to charge 50 nos. of 90Ah. capacity lead acid cells at 5 hours rating in addition to feeding the control circuits of EMU/MEMUs.

<u>Rating of EMU Battery Charger :</u>

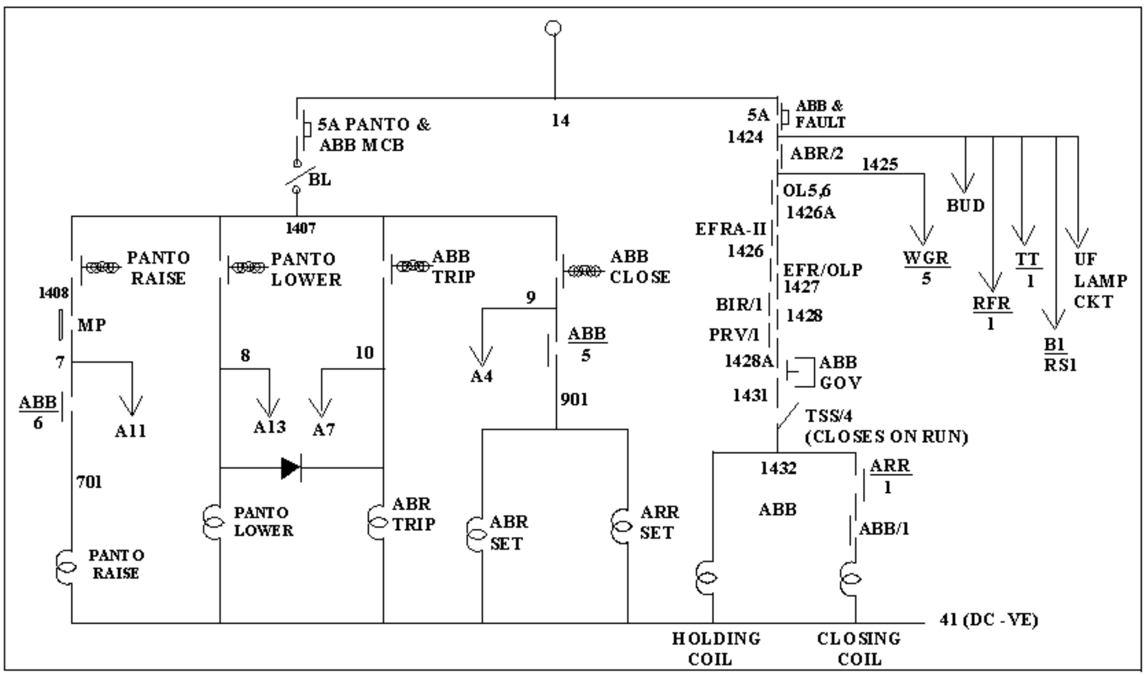
i) Input voltage	:	186V to 292V AC single phase 50 Hz.
ii) Nominal output voltage	:	110 V DC
iii) Ripple content	:	Less than 15% (RMS)
iv) Efficiency	:	80%

9. CONTROL CIRCUIT:

In EMU, control circuit is fed from 110 volt Battery supply. A 32 amps fuse (control fuse) is provided for protection of the circuit. Control circuit is charged through wire no. 14 from Battery positive (BP 14) and negative path is connected to wire no.41. Following circuits come under the control circuit:

- Panto and ABB circuit
- MCP control circuit
- Fault indication light circuit
- Driver's/ Guard's control circuit
- Guard-Motorman communication circuit.

PANTO & ABB CLOSING CIRCUIT



10. INDICATION LAMPS:

Indication lamps are provided in the driver's desk. These lamps give the indication for normal/ abnormal functioning of various equipments & circuits.

S/No.	Indication Lamp	Function
1.	**ABB RED LAMP**	The lamp glows indicate that ABB in one/more unit is in tripped condition.
2.	**AUXILIARY WHITE LIGHT**	It is provided to give an indication for no OHE voltage. LTR does not pick up or there is no ASR output, provided ABB is closed. For normal working, it remains in extinguished condition.
3.	**CHBA FAILURE INDICATION**	This lamp is provided to give an indication for failure of Battery charger. It remains in extinguished condition if the Battery charger is in healthy condition.
4.	**RECTIFIER FUSE BLOWN**	The lamp is provided to give an indication for failure of any one of the rectifier bridges. Normally it remains in

	INDICATION (BLUE LAMP)	extinguished condition.
5.	**EP GREEN LAMP**	It gives the indication that brake valve is charged & EP brake supply is 'ON'.
6.	**MOTOR SWITCH WHITE LIGHT**	The lamp indicates non closing of Motor contactors. It remains in extinguished condition provided all the four Motor contactors are in closed condition.
7.	**UNIT FAULT LAMP**	This lamp is provided on both out side walls of driving cab for visual indication of faulty unit. In new rakes the unit fault lamp is also provided on driver's desk. This lamp glows due to the following reasons: • If TTR acts. • If CBAR acts. • If any of the overload relays OL1, OL2, OL3 or OL4 acts. • If RFAR does not pick up (provided NVR picks up). • ABB does not close (provided ABR is set).

11. GUIDE TO COMMON TROUBLE SHOOTING:

S/No.	Type of defects		Probable causes
1.	**ABB tripping**	i) ICABB	a) Battery voltage less than 85V or 0. b) ABR unlatched. c) ABB fault MCB tripped. d) BIR tripped e) EFRA II tripped. f) EFR/OLP tripped. g) ABB reservoir pressure is less than 5.2 kg/cm^2. h) ABB governor defective. i) PRV acted. j) TSS interlocks defective. k) ABB/1 self interlock defective. l) ARR interlock bad contact/defective. m) OL5/OL6 acted.
		ii) ABB closing but not holding	a) OLP trips. b) ABB holding coil defective.
		iii) ABB trips on power	a) EFR/OLP trips. b) OL5/OL6 trips.
2.	**Total loss of tractive effort**	i) Total loss with MSWL not glowing at all	a) BA voltage 0. b) BI key not operated properly. c) BL not unlocked properly. d) Control switch defective. e) Master controller MCB tripped. f) MP interlocks defective.
		ii) Total loss with MSWL remains glowing	a) BA voltage less. b) MR & BP pressure less. c) Control/Equipment governor defective. d) Reverser not thrown in desired direction. e) RFAR trips. f) TTR trips. g) CBAR trips. h) PB governor defective/ not closing. i) O/L not resetting.
		iii) Total loss with MSWL flicker	a) NVR de-energized. b) SR de-energized.
3.	**Reduction of tractive effort**	i) MSWL remains glowing	a) O/L not resetting in any of the units. b) Check all the items stated in item no. (ii) Under total loss of tractive effort.
		ii) MSWL flickers	a) NVR de-energized in any of the units. b) SR de-energized in any of the units.
4.	**Unit does not respond**	Aux. white light glows with MSWL	a) No tension in OHE. b) Pantograph not raised/broken in all/ any of the three motor coaches.
5.	**AWL glows alone but units respond**	LTR not picking up due to	a) LTR MCB tripped condition. b) Failure of a transformer tertiary fuse AF3/AF4. c) LTR coil burst.

12. SAFETY LIGHTS, GUARD-DRVER COMMUNICATION AND PASSENGER ALARM CHAIN

S/No	Equipment	Description
12.1	Head Light	Twin Beam Head Light ckt. is getting feed through DC-DC converter. Input of the converter is taken from battery. Output of the converter is 24 V DC. The head light unit consists of two bulbs, each of them having two filaments of rating 90/100 W connected in parallel. Normally both the bulbs are glowing together. The DC-DC converter is having two mode of operation, one is normal mode and another is standby mode. In case of failure of the converter in normal mode, standby mode can be used. There is a dimmer switch in driver's control panel. By operating this dimmer switch head light can be set to glow dim whenever necessary. In this case only 90W filament will glow.
12.2	Tail Lamp	Flickering type Tail Lamp ckt. is fed from 110 V battery supply. Total 120 nos. LED are provided in 4 rows connected in parallel. Each row is provided with 30 nos. LED which are connected in series. In case of failure of any one of the LED in any of the rows, that particular row will not glow but the other rows will lit as before.
12.3	Flasher Light	This is provided on all EMUs/MEMUs. As soon as the train stops due to emergency application of brakes, not initiated by the crew, the driver should assume that some portion of his train has derailed/parted or there is some abnormality in the train. He should put on Flasher Light to warn the driving crews of the oncoming trains on the opposite track. The operation of the flasher light may be suspended only after the crew has verified physically that the neighboring track is not infringing. Similarly the crew observing the flasher light should take immediate action to stop the train even with emergency application of brake if necessary and should only restart after the physical verification of the infringement. Flasher light is provided with 120 LEDs (30 LEDs x 4 rows) which are fed from 110V BA supply. An audio unit is provided with flasher light control box in the driving cab which gives audio indication during glowing of flasher light.
12.4	Auto Warning Light	This is provided to make communication with guard and vice-versa when the train passes the auto signal at danger. While AWL switch is put 'ON', it restricts the tap changer to progress beyond shunt notch and thus imposes speed restriction. At the same time a visual indication, provided on driver desk will glow at guard's cab and vice-versa. Motorman has to put the switch 'off' after getting the clear signal. The circuit is fed from 100 V DC supply.
12.5	Signal Bell/ Code Bell	This bell is provided to communicate signals between Driver and Guard. When Guard's key is made 'ON' and 'Bell Push' is pressed, the bell rings. The circuit is fed from 110V DC supply.
12.6	Guard-Driver Communication System (Intercom)	For intercommunication between both, driver and guard, each end driving cab is provided with one microphone with push button and control unit. The circuit is fed from 100 V DC supply and protected by a 2.5 A MCB.
12.7	Passenger Alarm Chain	Alarm chain is provided in every coach along with limit switch, whenever the chain is pulled by the passenger, the limit switch contact gets closed and the bell starts ringing continuously (till switched off) in Driver's and Guard's cab, for their attention. This system is also provided with external indicator at the end of each coach for identification of the coach where from the alarm chain is pulled. Electrical supply to the passenger emergency alarm communication system shall be through the Guard's control key (004 key). The circuit is fed from 100 V DC supply.

13. Microprocessor based Electronic Speed Cum Energy Monitoring system:

With the improvement in electronics technology advanced type microprocessor controlled speedometer evolved which replaces old analog/graph roll type speedometer.
The system continuously indicates and records:

- Speed, time & distance and energy.
- Coasting & dynamic brake mode data

Name of the suppliers: i) M/s MEDHA Servo Drives Pvt. Ltd., Hyderabad (Type- MRT-921).
ii) M/s Autometers Alliance LTD, Noida (Type- Telpro Z).
iii) M/s LAXVEN system, Hyderabad (Type- 2000 E1).
iv) M/s STESALIT Pvt. Ltd., Kolkata.

Name of the major components:

- Speed sensor
- Recorder cum indicator unit
- Main current transformer (CT)
- Main potential transformer (PT)
- Signal conditioning unit (SCU)
- Connector & cable

Speed Sensor (Pulse generator or PG): It is located on wheel no. 5 in HWH end motor coaches & on wheel no. 1 at KGP end motor coach below the driving cab. Opto-electronic speed sensor is used to generate pulse with number directly proportional to the speed of the rake.

Recorder cum indicator unit: Located in driving cab in front of the motorman. RCI unit contains following sub- assemblies:

- Micro controller card (SPNCC)
- Driving card (SPMDR)
- Interface card (SPMIF)
- Memory card
- Digital input card
- Analogue interface card
- Power supply card.
- Mother board
- Alpha- numeric display
- Data entry key
- Memory freeze

Main current transformer (CT): Located on return bushing of transformer. This is a ring type CT use to measure primary current of the EMUs/ MEMUs. Out put of the same is given to the signal conditioning unit.

Main potential transformer (PT): The PT is used to measure the auxiliary winding voltage of the transformer. Out put of the same is given to signal conditioning unit. Micro computer is fed with multiplication factor to obtain the voltage for computation.

Signal conditioning unit (SCU): It converse the incoming signal from PT & CT to low voltage signal which is fed to micro- processor of the recorder for energy monitoring.

Parameters displayed:

- Speed in Kmph
- Distance traveled
- Coasting duration
- Coasting distance
- Real time in Hrs, Mins, Sec.
- Date
- Total energy consumed
- Energy consumed during run
- Energy consumed during halt
- OHE current
- OHE voltage
- Memory status
- Dynamic brake status
- Over speed limit setting
- System fault
- Wheel diameter setting
- Train no
- Driver's ID
- Train load
- Motor coach no.
- Error message
- Memory freeze indicator

Recording System:

Internal memory (inside energy meter): Contains short term memory, error log and configuration memory.
External memory (memory card) - it contains long term memory data in addition to short term, error log and configuration memory.
Short term memory- Contains journey data of about 6-10 Hrs. of travel at 01 sec. (min.) sampling rate. After exhausting the memory space recording could continue on first-in and first-out basis.
Long term memory- Contains journey data of about 45 days of travel at 20 sec. (min.) sampling rate.

Graphical plotting data:

- Speed vs Time
- Speed vs Distance
- Energy vs Time
- Energy vs Distance

Tabular plotting:

- Driver-wise specific energy consumption and coasting/dynamic brake data.
- Specific energy consumption and coasting/dynamic brake data for desired distance & time.

Selective format:

- Only the page desired to view.
- Continuous print out of all pages.
- Between desired time/ distance intervals.
- Data above or below specific speed.
- Data for a particular driver/ train no.

Memory freeze:

- Memory freeze switch is provided under a sealed glass on the master unit.
- In the event of an accident, to stop the recording in the short term data memory, the glass on the front fascia can be broken & the switch can be operated.
- Once the switch is operated, the LED besides the switch will be 'ON' and "Memory freeze on" message in LCD is displayed.

Memory full indication:

- A message on LCD display is provided on the master to give advance warning for down loading the data from memory card when 85% of the memory capacity has been used.

Parameters inside the door (restricted access):

- These parameters can be set by using the key board & internal switch inside the door (accessible only after opening of the door). To set these parameters door shall be opened & speed shall be "0".

Parameters to be set by authorized person:

- M/coach no.
- Name of the shed
- Equipment no.
- Over speed limit for alarm
- Real time in 24 hr. scale
- Date in DD: MM: YY.
- Wheel diameter in mm.

Parameters to be set by the Motorman:

- Train no.
- Driver identification
- Train load
- Dial illumination

Setting of train no.; <u>Driver ID, Train load</u>	i) Press respective key, existing data will be displayed. ii) Type new data by using concerned key pad. iii) Press enter to set the changes and LCD will display "new data recorded" for 3 secs. iv) Cancel key can be used to come out from menu without saving the changes.

Setting of dial illumination:

i) Press “Cancel” key to ensure no other key is pressed.
ii) Press numeric key “1” to set illumination level at minimum.
iii) Press numeric key “2” to increase illumination level to by 10 %
iv) Press numeric key “9” to set illumination level at maximum.
v) Press numeric key “0” to set illumination level ‘off’.

Down-loading of the recorded data:

- The journey data is recorded in both, the internal system memory and also the external memory card as per format of recording selected in system configuration.
- Both the short term memory & long term memory data can be down-loaded.

Reading the data from internal memory

i) Open the door of the recorder.
ii) Internal memory data can be down-loaded into a PC/ laptop by using the RS-232 connector provided inside the door.
iii) The serial communication cable supplied along with the equipment shall be used for this purpose.

Reading the data from Memory card

i) Open the door of the recorder.
ii) Push back/slide the memory card release lever just below the memory card. The memory card will be released.
iii) Connect the memory card to the computer using the data retrieval unit.
iv) Down-load the data into the computer.
v) Format/erase the memory card and take out the card from data retrieval unit.

14. PREPERATION OF EMU BEFORE ENERGISATION

1. Check the rake is under OHE
2. Ensure that MR & BP isolating cocks at the extreme ends are in closed position
3. Ensure that Dead-man’s isolating cock is in open position.
4. Check the oil level in conservator tank is above ‘15^{0}' mark

Energisation of 110 V DC circuit:

1. Close BIS and check that Battery Voltmeter shows more than 90V.
2. Unlock BL and check ABB lamp glows.
3. Press and release ABB close switch or latch ABR manually and ensure that Aux. compressor starts.
4. Ensure that Brake Controller handle and Guard’s emergency handle are in release condition.
5. Ensure that MCS – I & II are in normal position, TSS is on “Run” position & control changeover switch (BIS) is on normal position.
6. Check that the relay targets TTR, CBAR, BIR, EFR & OLP show “set” indication but RFAR shows “trip” indication.
7. Ensure that HEFRA II, HOBA, HEFR (P) are in normal (N) position and all governors bypass switches are in “off” position.
8. Ensure all MCBs are in closed position & all fuses are intact & normal.
9. Ensure that Panto air supply cut out cock is in open position.

10. When ACP stops at 6.5 kg/cm^2, press and release ABB trip switch or unlatch ABR.

Energisation of Motor Coach :

1. Ensure MP is in neutral position (i.e. reverser is not thrown in "Forward" or "Reverse" direction).
2. Press and release Panto raising switch & ensure Pantograph is touching with OHE contact wire. After that press & release ABB close switch and ensure that ABB closes.
3. Press and release "MCP set switch" & ensure that MCP is working and MR pressure increases.
4. When MR pressure builds up more than 6 kg/cm^2, operate BI key to charge BP. Ensure BP pressure increases to 5 kg/cm^2.
5. Ensure effective & normal working of EP Brake, Auto Brake, Emergency Brake & Deadman's device.
6. Check the availability/working of the following safety equipments.
   i) Flasher light/Tail light/Head light/Auto Warning light.
   ii) Guard-driver inter-communication and signal bell.
   iii) Passenger alarm Chain pull device.
   iv) Fire extinguishers/Detonators.

Traction Test:

1. Precautions: Before taking traction, it is to be ensured that MP is on release position i.e. on "ZERO", Brake pipe is charged at 5kg. /cm^2, parking brake/hand brake is in released condition. Check the functioning of brakes (EP, Auto & Emergency). Traction to be taken in brake released condition. Ensure no skid is provided in any of the wheels.

2. Operation: Insert reverser key in its slot over MP, press accelerating handle (dead-man handle), move the reverser in desired direction (forward or reverse) and pull the MP handle to 'shunt' position, 'half power' and then 'full power' according to the sequence.

3. Observations: i) When MP is on power, MSWL flickers & goes away. It indicates that reverser is thrown & motor contactors are closed.
   ii) Relay CLAR will pick up (wire no. 107, 108, 203 & 204 will be charged)
   iii) Relay SR will pick up. It ensures that WCO is in LV position, WGR is de-energized and all motor contactors are closed. Tapping contactors T2 to T6 are open. Relay NVR is energized & negative path for T1 to T6 are connected with wire no. 41.
   On energization of SR, its normally open interlocks get closed in the respective circuits to facilitate the tap changer to work.

4. Progression of tap changer:
   i) MP on shunt-
   - Wire no. 106A will be charged through the contacts of MP, MCS, NVR/1, WGR/2 & W/6 .
   - Wire no. 106 will be charged through SR/4.
   - Wire no. 108 will be charged through CLR1/1, CLR2/1.

ii) 1st notch- Contactor T1, T7, T9 & NR2 will close.

- T1 closes through W/4, T1/1, T9/3,4 (Int. 3 & 4 parallely connected) & maintains by T1/2.
- T7 closes through T7/4, T8/5 & maintains by T7/3.
- T9 closes through T8/3, T2/5, T4/1, T6/4 & maintains by same path.
- NR2 closes through T7/5, T8/1, NR1/4, NR1/3, T9/1 & maintains by same path.

iii) 2nd notch- Contactor T1, T8 close-T7, T9, NR2 open/ de-energizes.

- T1 closes in previous notch.
- T8 closes through T7/5, T8/1, NR1/4, NR2/1 & maintains by T8/2, T7/2.
- T7 opens by T8/5.
- T9 opens by T8/3.
- NR2 de-energizes by T9/1.

iv) MP on half power-

- 204 charges through MP, Auto earning switch, W/8, CLAR.
- 206 charges through M1/1, M3/1, NVR/2, TSS/1.
- 207 charges through NR2/3 (feed cuts when NR2 picks up).
- 209 charges through T7/1 (209 is feeding wire for T1, T3, T5).
- 210 charges through T8/4 (210 is feeding wire for T2, T4, T6).

v) 3rd notch- T2, T8, T9, NR1, NR2 close & T1 opens.

- T2 closes through T1/6, T2/1 & maintains by T2/2.
- T1 opens through T2/3.
- T8 already in closed condition from previous notch.
- T9 closes through T1/5, T3/5, T5/5 and T7/6.
- NR1 closes through T3/3, T2/4 & maintained by same path.
- NR2 closes through T7/4, NR1/1, NR1/2 and T9/1 & maintained by same path.

vi) 4th notch- T2, T7, NR1 close & T8, T9, NR2 open.

- T2 & NR1 closed previously.
- T7 closes through T7/4, NR1/1, NR2/2 & maintains through T7/3, T8/5.
- T8 opens through T7/2.
- T9 opens through T7/6.
- NR2 opens through T9/1.

vii) 5th notch- Contactor T3, T7, T9 & NR2 close & T2, NR1 get open.

- T3 closes through T2/6, T3/1 & maintains by T3/2.
- T2 opens through T3/6.
- NR1 opens through T3/3 & T2/4.
- T7 closed previously
- T9 closes through T8/3, T2/5, T4/1, T6/4 & maintains through same path.
- NR2 closes through T7/5, T8/1, NR1/4, NR1/3, T9/1 & maintains through same path.

viii) 6th notch- Contactor T3, T8 get closed & T7, T9, NR2 get opened.

- T3 closed previously.
- T8 closes through T7/5, T8/1, NR1/4, NR2/1 & maintains by T7/2, T8/2.
- T7 opens through T8/5.

- T9 opens through T8/3.
- NR2 opens through T9/1.

ix) 7th notch- Contactor T4, T8, T9 and NR1, NR2 get closed T3 gets opened.

- T4 closes through T3/4, T4/3 & maintains by T4/2.
- T3 opens through T4/5.
- T8 closed previously.
- T9 closes through T1/5, T3/5, T5/5, T7/6 & maintains by same path.
- NR1 closes through T5/4 & T4/4.
- NR2 closes through T7/4, NR1/1, NR1/2, T9/1.

x) 8th notch- Contactor T4, T7, NR1 get closed & NR2, T8, T9 get opened.

- T4 & NR1 are closed previously.
- T7 closes through T7/4, NR1/1, NR2/2 & maintains by T8/5, T7/3.
- T8 opens through T7/2.
- T9 opens through T7/6.
- NR2 opens through T9/1.

xi) 9th notch- Contactor T5, T7, T9 & NR2 get closed. T4, NR1 get opened.

- T5 closes through T4/6, T5/1 & maintains by T5/2.
- T4 opens through T5/6.
- NR1 opens through T5/4.
- T7 closed previously.
- T9 closes through T8/3, T2/5, T4/1, T6/4 & maintains by same path.
- NR2 closes through T7/5, T8/1, NR1/4, NR1/3 & T9/1.

xii) 10th notch- Contactors T5, T8 get closed and T7, T9, NR2 get opened.

- T5 closed previously.
- T8 closes through T7/5, T8/1, NR1/4, NR2/1 & maintains through T8/2, T7/2.
- T7 opens through T8/5.
- T9 opens through T8/3.
- NR2 opens through T9/1.

Note- On closing of T5 & T8 voltage collection from tapped winding is completed. Then T6 & T7 will close & untapped winding will be connected & after transition tapped winding will be connected again with untapped winding through WCO (HV).

xiii) 11th notch- Contactors T6, T8, T9, NR1, NR2 get closed T5 gets opened.

- T8 closed previously.
- T6 closes through T5/10, W/1 & maintains through T6/1, T1/3.
- T9 closes through T1/5, T5/5, T3/5 & T7/6.
- T5 opens through T6/3.
- NR1 closes through T1/4, T6/2.
- NR2 closes through T7/4, NR1/1, NR1/2 & T9/1.

xiv) 12th notch- Contactors T6, T7, NR1 get closed & T8, T9, NR2 get opened.

- T6 & NR1 closed previously.
- T7 closes through T7/4, NR1/1, NR2/2 & maintains by T8/5, T7/3.

- T8 opens through T7/2.
- T9 opens through T7/6.
- NR2 opens through T9/1.

Note- Untapped winding is connected in the circuit through T6 & T7.

xv) Transition:
Transition starts on 13th notch when MP is brought to full power & wire no. 3 gets charged.
Wire no. 202 will be connected with wire no. 3 through MCS, T5/8, W/7 & AOVR/1.
As wire no. 3 is charged, relay WGR will be energized through T5/7, T6/5 & WGR's interlock over WCO. LV coil will be de-energized & HV coil will be energized. Therefore, WCO will be thrown to HV side.

xvi) 13th notch (after completion of transition)- T1, T7, T9 & NR2 get closed & NR1,T6 get opened.

- T1 closes through W/3, T1/1 & maintains by T1/2 (negative path of T1 will be maintained through W/9).
- T6 opens through T1/3.
- T7 closed previously.
- T9 closes through T8/3, T2/5, T4/1, T6/4 & maintains by same path.
- NR2 closes through T7/5, T8/1, NR1/4, NR1/3, T9/5 & maintains by same path.
- NR1 opens through T1/4.

xvii) 14th notch- Contactor T1, T8 get closed & T7, T9, NR2 get opened.

- T1 closed in previous notch.
- T8 closes through T7/5, T8/1, NR1/4, NR2/1 & maintains by T7/2, T8/2.
- T7 opens through T8/5.
- T9 opens through T8/3.
- NR2 opens through T9/1

xviii) 15th notch- Contactor T2, T8, T9, Nr1 & NR2 get closed T1 gets open.

- T2 closes through T1/6, T2/1 & maintains by T2/2.
- T1 opens through T2/3.
- T8 closed previously.
- T9 closes through T1/5, T3/5, T5/5, T7/6 & maintains by same path.
- NR1 closes through T3/3, T2/4 & maintains by same path.
- NR2 closes through T7/4, NR1/1, NR1/2 & T9/1.

xix) 16th notch- Contactors T2, T7 & NR1 get closed. T9 & NR2 get opened.

- T2 & NR1 closed previously.
- T7 closes through T7/4, NR1/1, NR2/2 and maintains by T8/5 & T7/3
- T8 opens through T7/2.
- T9 opens through T7/5
- NR2 opens through T9/1.

xx) 17th notch- T3, T7, T9 & NR2 get closed and T2, NR1 get opened.

- T3 closes through T7/1, T2/6, T3/1 and maintains by T3/2.
- T2 opens through T3/6.
- T7 closed previously.
- T9 closes through T8/3, T2/5, T4/1, T6/4 and maintains by same path.
- NR1 opens through T3/3 and T2/4.
- NR2 closes through T7/5, T8/1, NR1/4, NR1/3 and T9/1.

xxi) 18th notch – Contactors T3 T8 get closed and T7, T9, NR2 get opened.

- T3 closed previously.
- T8 closes through T8/1, NR1/4, NR2/1 & maintains by T7/2 & T8/2.
- T7 opens through T8/5.
- T9 opens through T8/3.
- NR2 opens through T9/1.

xxii) 19th notch- Contactors T4, T8, T9, NR1 & NR2 get closed & T3 gets opened.

- T4 closes throughT8/4, T3/4, T4/3 & maintains by T4/2.
- T3 opens through T4/5.
- T8 closed previously.
- T9 closes through T1/5, T3/5, T5/5, T7/6.
- NR1 closes through T5/4, T4/4 & maintains by same path.
- NR2 closes through T7/4, NR1/1, NR1/2, T9/1.

xxiii) 20th notch- Contactors T4, T7, NR1 get closed & T8, T9, NR2 get opened.

- T4 & NR1 closed previously.
- T7 closes through T7/4, NR1/1, NR2/2 & maintains by T8/5, T7/3.
- T8 opens throughT7/2.
- T9 opens through T7/6.
- NR2 opens through T9/1.

xxiv) 21st notch- Contactors T5, T7, T9 NR2 get closed & NR1, T4 get opened.

- T5 closes through T4/6, T5/1 & maintains by T5/2.
- T4 opens through T5/6.
- NR1 opens through T5/4.
- T7 closed previously.
- T9 closes through T8/3, T2/5, T4/1, T6/4 & maintains by same path.
- NR2 closes through T8/1, NR1/4, NR1/3, T9/1.

xxv) 22nd notch- Contactor T5, T8 get closed & T7, T9, NR2 get opened.

- T5 closed in previous notch.
- T8 closes through T7/5, T8/1, NR1/4, NR2/1 & maintains by T8/2, T7/2.
- T7 opens through T8/5.
- T9 opens through T8/3.
- NR2 opens through T9/1.