

TRAINSET PROPULSION SYSTEM & AUXILIARY ELECTRICS SILABHADRA DAS PROFESSOR/TRAINSET

SALIENT FEATURES

- Train-18 is 16 car train with 4 basic unit i.e. Two number of end basic unit (DTC-MC-TC-MC) and two number of middle basic unit (NDTC-MC-TC-MC)
- Semi-high speed (160 kmph) multiple unit train-set.
- Train-18 is provided with **IGBT** based energy efficient 3 phase propulsion system and regenerative braking
- Stainless steel car body with continuous window glasses
- All propulsion equipments are shifted from onboard to underslung. All power components such as line & traction converters, auxiliary converter, air compressor, battery box, battery charger, brake chopper resister are mounted under the frame
- Zero discharge vacuum-based bio-toilets
- Modern **bolster-less** design bogies with **fully suspended traction motors**,
- Train-18 has 50% powering i.e. Every alternate coach is powered
- Ethernet backbone



END BASICUNIT



MIDDLE BASIC UNIT

DTC – Driving trailer coach MC – Motor Coach TC – Trailer Coach NDTC – Non-Driving trailer coach

DTC	MC	TC	MC
1. Battery 2. Battery charger	1. Traction Converter 2. Brake Chopper Resistor 3. Traction Motors	1. Transformer 2. Auxiliary Converter 3. Pantograph	1. Traction Converte 2. Brake Chopper Resistor 3. Traction Motors

Formation of Rake (16 coaches): 4 X 4 Basic Units - Each Basic Unit with Four Cars



What is 3 Phase Technology ?

- We used Three phase asynchronous motor controlled by Three phase control electronics according to our requirements.
- What are our requirements ?
- Our requirements are Three phase AC supply With variable voltage and variable frequency for variable Speed and variable torque.
- Our over head supply is single phase 25 Kv Ac and requirement is of three phase VVVF supply for Three phase asynchronous motor

SINGLE PHASE AC V/S THREE PHASE AC



WHY THREE-PHASE TECHNOLOGY BASE DRIVE

- The advantages over direct current drives are :
- Smooth (Step-less) acceleration.
- Reduced weight
- Wear-resistant drives hence less maintenance and high level of reliability as no wearable part like carbon brushes and commutator.
- Good starting properties
- High tractive force over the whole speed range
- Wear-free regenerative brake for reduced maintenance, increased life of wheel and other mechanical component
- energy conservation due to regenerative breaking

Asynchronous traction Motor

The synchronous speed is Ns =120f/p

The motor cannot achieve this speed and runs with a slip 's'

Special features of Three phase asynchronous motor

- The stator winding of the asynchronous motor consists of coils, which are electrically offset by 120°.
- when connected to a three-phase supply, they generate a rotating magnetic field.
- The rotor consists of one winding which is designed with rods With ends shortcircuited by means of rings.
- A rotating magnetic field induces an electromagnetic force into the rotor winding.
- The electric circuit of the short-circuit rotor is always closed, thus creating a current flow which generates another magnetic field (rotor magnetic field).

 \succ The rotor magnetic field attempts to catch up with the rotating field in the process and works as motor.

If the rotor rotates faster than the rotating magnetic field, the engine automatically switches into braking mode as motor works as generator .
 This means that by changing the voltage and the frequency, the output (torque) and the speed (number of revolutions per minute) can be altered.

 $T = K (V/F)^{2} f_S$ Voltage Equation ,V =4.44 Φ fT, v/f will be constant **Equipment in vvvf control** Line converter, DC link and Traction converter and the motor (*single phase inverter fig in separate file*)



IGBT





Typical IGBT

• Insulated Gate Bipolar Transistor

- semiconductor switching device.
- The *IGBT Transistor* has a high input impedance and high switching speeds, is capable of handling large collector-emitter currents
- It offers greater power gain than the standard bipolar type transistor combined with the higher voltage operation and lower input losses
- IGBTs are mainly used in power electronics applications, such as inverters, converters and power supplies

RECTIFIER CONCEPT



RECTIFIER WITH DC LINK FILTER



INVERTER CONCEPT



Single Phase Inverter Concept - PWM waveform



SINGLE PHASE INVERTER CONCEPT - PWM WITH SINE FILTER



THREE PHASE INVERTER CONCEPT



VARIABLE VOLTAGE VARIABLE FREQUENCY (VVVF) DRIVE

type of motor drive used in electro-mechanical drive systems to control AC motor speed and torque by varying motor input frequency and voltage



VOLTAGE CONTROL- Higher amplitude for greater switch closing time



and off switching

POWER SCHEMATIC



Architecture

END BASIC UNIT			М	IDDLE B	ASIC UN	IT	
DTC	MC	тс	MC	MC	тс	MC2	NDTO



MIDDLE BASIC UNIT					END BAS	SIC UNIT	
NDTC2	MC2	тс	MC	MC2	тс	MC	DTC



Ratings of Major Equipments

SI.No	Description of Major Equipments	Rating
1	MAIN TRANSFORMER	PRIMARY-2556KVA
		22.5KV /114A
		TRAC.SECONDARY (4 windings)
		855V AC at 22.5KV for Traction
		Secondary(2 windings)342V AC At 22.5KV for Aux
		CIASS-A INSULATION
2	OUTPUT CT	250A/1A
3	TRACTION CONVERTER	2X532KVA
		I/P-627V RMS-1140V RMS
		O/P- 3PHASE 1430 V RMS, : 2 X 120A,0-175HZ
4	TRACTION MOTOR	CONTINUOUS RATING :210KW,1375V,120A,111.1Hz
		ONE HOUR RATING: 230KW,1375V,130A
5	TRACTION MOTOR	5, 158
	GEAR RATIO	
6	AUXILIARY CONVERTER	INPUT 1- 285-415V SINGLE PHASE 50HZ
		INPUT 2- 285-415V SINGLE PHASE 50HZ
		Inverter Module1 output: 415AC 3 Phase 50Hz,
		200KVA(As per Name Plate): 264KVA(Calculated)
		Inverter Module-2 output: 415AC 3 Phase 50Hz,
		200KVA(As per Name Plate): 264KVA(Calculated)
		Output-3 DC Output(BN,BD): 110VDC,30KW

Ratings of Major Equipments

SI.No	Description of Major	Rating		
	Equipments			
7	PANTO GRAPH	1.5 KV TO 25 KV		
		400A		
8	AC SURGE ARRESTOR	40KV AC		
	(MAIN)			
9	LINE VOLTAGE Transformer	25KV/200V		
10	VCB	25KV AC,50Hz,I=1KA 25KV AC,50Hz,I=1KA		
11	5AC EARTHING SWITCH			
12	HT CABLE	25KV AC		
13	INPUT CURRENT	250A / 1A		
	TRANSFORMER			
14	BRAKE CHOPPER	3.420hm – 4.85 0hm		
	RESISTOR			





The 25kV OHE voltage is connected to the transformer primary winding through the pantograph and Vacuum Circuit Breaker (VCB).

During maintenance, when transformer primary winding is not connected to the OHE line, an earthing switch (connected in parallel to VCB) is used to ground the transformer primary winding and pantograph for safety



- Traction transformer is mounted under slung of trailer coach (TC).
- There are 1 primary winding, 4 traction windings and 2 auxiliary windings in traction transformer.
- Continuous voltage: 19–27.5 kv
- Total transformer continuous rating is 2880 kva under 22.5 kv OHE voltage.
- Each traction winding continuous rating is 603 kva
- Each auxiliary winding continuous rating is 234 kva
- Total approximate weight of transformer is 4900+\-3% kgs.
- One transformer feeds to two motor coaches.
- Traction transformer is oil cooled with help of oil pump and blowers which cool the radiator through which oil is circulated using the oil pump.

% POWER vs. OHE Voltage





BLOCK DIAGRAM OF TRACTION TRANSFORMER

ROOF THROUGH HT CABLE



ROOF THROUGH HT CABLE ARRANGMENT



• 25 KV HT CABLE WITH MECHANICAL PROTECTION RUNNING THROUGH OUT THE ROOF

MECHANICAL PROTECTION FOR HT CABLE









TC COACH RIGID TERMINATION OF HT CABLE AT VCB

SEMI RIGID HT CABLE TERMINATION AND INTER COACH JUMPER CABLE

LINE AND TRACTION CONVERTER

- Each basic unit has 2 motor coaches and each motor coach has 4 traction motors.
- Each motor coach has 2 nos. of line and traction converter (LTC) mounted under slung and each control two traction motors of a bogie.
- Input power to line converter comes from transformer kept in adjacent trailer coach.
- Line and traction converters are forced air cooled.



LINE AND TRACTION CONVERTER



- Line and traction converter cubicle consists of
- -Line converter
- -DC link
- -Brake chopper (BCH) circuit
- -Traction inverter (TI)
- -Line and traction controlunit

LINE CONVERTER

- The line converter interfaces with transformer secondary traction winding AC voltage on one side and DC link on the other side.
- Main function of line converter is to maintain stable dc link voltage at 1800 V irrespective of line and load variations at unity power factor
- The line converter consists of single phase full bridge rectifier with IGBT as active switching devices

DC LINK CAPACITOR

- LTC unit consists of 2 DC link capacitors.
- Dc link capacitor is used to buffer the energy differences between line-side and motor-side of the converter
- DC link capacitor absorbs the harmonic currents produced by line side and motor-side of the converter, thus reducing the ripple voltage
- DC link capacitor is used to limit the switching over voltages of IGBTs.

BRAKE CHOPPER CIRCUIT

- Brake chopper circuit comprises of BCH IGBT module and BCH resistor.
- The brake chopper circuit is used to limit the over-voltages in dc link capacitors during abnormal conditions or during transients.
- Over voltages in the dc link capacitors may occur due to:
 -non receptive OHE during regeneration
 - transient load conditions.
- Brake chopper resistor is used to limit the DC link voltage during the dynamic conditions
- It is also used to discharge the high voltage DC link capacitors after panto down.



TRACTION INVERTER

- Main function of TIC:
- © converts the DC input voltage to 3-phase variable voltage variable Frequency output
- Traction motor torque will be controlled both in motoring mode and Braking mode
- Controls wheel slip/slide
- Performs various fault diagnostics.



LINE & TRACTION CONTROL UNIT (LTCU)

• Line & traction control unit (LTCU) controls both the line converter and traction inverter and communicates with the main control unit (MCU) through CAN interface. All the LTCU's are similar in construction





AUXILIARY POWER SYSTEM

- Converter unit is required to generate 2 different types of voltages to serve these loads. Those are
- - 415VAC, 3phase, 50hz
- - 110vdc.

415VAC, 3phase, 50hz loads:

- Rmpu
- Cab ac
- Main compressor
- Traction converter cooling blowers
- Transformer radiator fan
- Transformer oil pump
- Water pump for toilettank
- Aux converter cooling blower.

110 V DC :

- Battery charging
- Coach, vestibules and driver cabin normal lights
- Coach and driver cabin emergency lights
- Twin beam/auxiliary head light, marker light, tail light, flasher light, cluster light, spot lights, passenger alarm indication light, electronic signal bell
- Control electronics loads :PIS, CCTV, relays, contactors, driver desk, brake systems and all other control units
- Auxiliary compressor for pantograph
- Emergency ventilation blowers
- 110vdc toilet loads, seat lights & doors.

AUXILIARY CONVERTER

- Auxiliary converter is a PWM based IGBT converter, which
- Converts 285VAC-450VAC in to two outputs
- Output-1: 415vac (L-L), 3-Φ, 50hz
- Output-2: DC output is isolated from input by using DC -DC
- Transformer. DC output is connected to BN bus.

Auxiliary power supply consists of two cubicles.

- Auxiliary converter unit (ACU)
- ACU consists of below modules
- 1) AC1 module
- 2) AC2 module
- 3) DC converter module
- Battery charging system (BCS).

AC-1 & AC-2 modules consist of below sections:

- i. Line converter section
- ii. Inverter section
- iii. Master & module control section (both control & communication)
- The **line converter section** takes the input (variable single phase AC input) from secondary winding of main transformer and converts to fixed dc-link by controlling pulses of the IGBT's by using DSP controller. Full bridge architecture is used for the line converter.

• The **inverter section** takes the input from common DC link. The IGBT based inverter section is provided after DC link capacitor. A three phase full bridge architecture is used for the inverter.

- There is a **master controller section** which controls the line converter &inverter. It is also responsible for monitoring and protecting the complete auxiliary converter unit and records the faults in the memory.
- It also interfaces to TCMS to get commands and to send status to display at driver cabin through ethernet communication.
- **415 V AC output section** It consists of sine filter inductor, capacitor, current transformers, ELD sensor & output contactor.
- 3 Phase 415 VAC, which is passing through sine filter capacitors for filtering PWM sine waveform to pure sine waveform. After filtering, the output is connecting to output terminal through output contactor.

• ACU DC CONVERTER MODULE

- DC converter takes supply form common dc-link of AC2 and converts DC link voltage to isolated and regulated 110vdc output by controlling pulses of IGBTs by using DSP controller.
- The output of DC converter is fed to BN (battery normal) loads, BD (battery direct) loads as well as battery charger.

• BATTERY CHARGING SYSTEM

- Battery charging system (BCS) is a PWM based IGBT converter, which is getting supply from BN bus and charge the battery with constant voltage & constant current limit topology.
- Used to provide the 110vdc supply for battery charging by taking supply from BN bus (115vdc-130vdc).







DTC - Bottom View - Equipments

DRIVING TRAILER COACH



NON DRIVING TRAILER COACH





MC - Bottom View - Equipments

	QIT
TRACTION CONVERTER	2 NOS
TRACTION MOTOR JUNCTION BOX	4 NOS
BRAKE CHOPPER RESISTANCE	1 NO
WATER PUMP	1 NO
EARTHING SWITCH	1 NO
ISOLATION TRANSFORMER	1 NO
Pneumatic Skids	3 Nos
Brake module	1 no.

TRAILER COACH Pneumatic skid

/ Isolation Transformer	Brake Modules	/ Water Pump	
Power	Traction Transformer Aux Converter		
Coupler S Panto Skid with Aux Compressor	IS/IC Po	wer Tray	Power Coupler/
Pneumatic skid	TC UNDERFRAME EQUIPMENTS	QTY	
	MAIN TRANSFORMER	1	
	AUX CONVERTER	1	
	EARTH RETURN CT BOX	1	
	WATER PUMP	1	
	ISOLATION TRANSFORMER	1	
	Pneumatic Skids	3 Nos	
	Brake module	1 no.	

RAKE FORMATION Multiple units formed joining Basic units of 4 car

COMPARISION BETWEEN TRAIN 18 & NEW TRAINSET RAKE

S/N	Parameter		Train 18	Trainset
1	Time to reach 160 kmph		145s	140s
2	2 Redundancy for Auxiliary Converter		50% RMPU functioning in case of basic unit failure	100% RMPU functioning in case of basic unit failure
3	3 HT cable Elec protection		Ву СТ	By CT & VCB without earthing switch
		Mech	No	Yes
4	Disaster light		No	Yes (4 nos./coach)
5	Platform side camera		2Nos/DTC (Only EBU)	2Nos/DTC + 2Nos/NDTC (DTC/EBU + NDTC/MBU)

DIFFERENCE BETWEEN TRAIN 18 & TRAINSET

S/N	Parameter	Train 18	Trainset
6	Synchronized 415 v bus	Not available	Available
7	Battery	300 AH VRLA battery	Explosion proof lithium-iron- phosphate batteries 684Ah combined with battery charger
8	HVAC	Direct switch on control	VVVF control for higher efficiency (for one compressor)
9	SIL certification of TCMS	nil	SIL 2 (safety integration level)
10	Ventilation duct for TM	No. Part of TM itself	Yes. Provided on sidewall
11	Signal exchange light	Νο	Yes (2 nos/DTC)

DIFFERENCE BETWEEN TRAIN 18 & TRAINSET

S/N	Parameter	Train 18	Train set
12	Fire detection system	Smoke detection only in RMPU unit.	FIRE DETECTION SYSTEM in all coaches
13	Fire survival cable	Available for plug door	For PA/PIS, ETB circuit, Passenger Alarm, Fire detection system and Door system.
14	Traction motor connection	By Junction box	By plug and socket assembly
15	Display unit for passengers	For PIS above IC door - 2 nos/C. For infotainment system (24") – 4 nos.	For PIS above IC door- 2 nos/C. For PIS & Infotainment system (32") – 2 nos.
16	CCMS	NO	YES (for air conditioning monitoring & control and communicating information/alert to control centre/maintenance staff through GSM/GPRS)

PROTECTIONS

Line Converter Protections:

- Transformer Primary over voltage and under voltage
- Traction Transformer Secondary over current
- IGBT Heat Sink over Temperature
- Failure of Pre-charging contactor / resistor
- Failure of Main contactor.

DC Link Protections:

- DC Link Over Voltage
- DC Link Short Circuit
- Earth leakage.

Traction Inverter protections:

- Output Over Current
- Output short circuit
- IGBT Heat sink Over temperature
- Traction Motor Over temperature
- Traction Motor Over Speed
- Phase Imbalance.

THANK YOU