सत्यमेव जयते

भारत सरकार
रेल मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

अनुसंधान अभिकल्प एवं मानक संगठन

RESEARCH DESIGNS AND STANDARDS ORGANISATION

SPECIFICATION FOR 4.5 kW UNDERSLUNG CONSTANT VOLTAGE, REGULATED CUM EMERGENCY BATTERY CHARGER FOR LHB COACHES

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S. N.	Date of Revision/amendment	Revision/ Amdt.	Page No.	Reasons for Revision
1	--	Rev '0'	20	First issue-15.02.2016
2	04.06.2018	Rev '1'	21	• To standardize IGBT based, natural cooled 4.5 kW underslung RBC without on-board display panel for both AC & Non AC LHB EOG/HOG coaches and incorporate emergency battery charger unit into it. • Change in temperature of magnetics & in some of the, technical requirements based on the feedback from prospective manufacturers.
3	07.06.2024	Rev '2'	24	• This revision has been proposed to improve maintainability and reliability based on feedback. • Seperation of Schedule of Technical Requirement(STR) from Specification

अनुमोदित
APPROVED

7/6/2024

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SPECIFICATION FOR 4.5 kW UNDERSLUNG CONSTANT VOLTAGE, REGULATED CUM EMERGENCY BATTERY CHARGER FOR LHB COACHES

0.0 FOREWORD:

0.1 At present, 4.5 kW Underslung Constant Voltage, Regulated Cum Emergency Battery Charger (RBC Cum EBC) is in use on LHB AC/Non-AC EOG/HOG type of coaches:

Type of coach	Type of battery	Rating of RBC
AC & Non AC LHB EOG/HOG	70 Ah/ 120 Ah Lead Acid	4.5 kW Underslung Constant Voltage, Regulated Cum Emergency Battery Charger

0.2 Need has been felt to standardize further IGBT/SiC based natural cooled 4.5 kW Underslung Constant Voltage, Regulated Cum Emergency Battery Charger (RBC Cum EBC) and improving maintainability, reliability. Opportunity has also been availed to revise certain technical parameters/requirements based on feedback from manufacturers/PUs. This specification supersedes to Rev-1 of specification.

1.0 SCOPE

This specification covers the design, manufacture and supply of natural cooled, IGBT/SiC based & DSP controlled, Underslung Constant Voltage, Regulated Cum Emergency Battery Charger for all type LHB coaches.

2.0 REFERRED SPECIFICATIONS:

The equipment shall generally comply the relevant clauses of the following specifications with latest version:-

i)	Railway applications- Electronic equipment used on rolling stock	IEC:60571
ii)	Reliability of electronics Used in rolling stock Application	ELRS/SPEC/SI/0015-Oct-2001
iii)	EMI/EMC compatibility	IEC:61000
iv)	Vibration & Shock test	IEC:61373
v)	Degree of ingress protection	IEC:60529
vi)	IGBT/SiC power devices	IEC:60747/IS: 3700
vii)	Semiconductor fuses	IEC:60269-4
viii)	Steel for general purpose- SS 304	IS:10632 Pt 3
ix)	Method of random sampling	IS:4905
x)	Power inductors	IEC:60310
xi)	Capacitor for power electronic	IEC:61071
xii)	E-beam cables	ELRS/SPEC/ELC/0019 Rev. 3
xiii)	Danger Notice Plate (Anodizes aluminum)	IS:2551
xiv)	Low voltage switchgear	IS:8623
xv)	Fire flammability	EN 45545
xvi)	Adequate creepage distance and clearance from the live terminals to earth and between live parts.	IEC: 60947-1.
xvii)	Random Sampling and Randomization Procedure	IS 4905

3.0 OPERATING CONDITIONS:

The equipment shall generally be suitable for the following prevailing operating conditions.

3.1 Environmental conditions

i)	Train Speed (max)	200 Kmph
ii)	Maximum ambient air temperature	55°C
iii)	Minimum ambient air temperature	-10°C
iv)	Max. relative humidity	98%
v)	Coastal area	Humid, Salt laden and corrosive atmosphere.
	Conditions in the coastal area can be as under:	
a.	Max. pH value	8.5
b.	Sulphate	7 mg/litre
c.	Max. concentration of chlorine	6 mg/litre
d.	Max. Conductivity	130 micro Siemens/cm
e.	Annual rainfall	Ranging between 1750 to 6250 mm with thunder storm & lightning
vi)	Altitudes (max)	1776 m above sea level
vii)	Dust content in air (max)	1.6 mg/m^3

3.2 Shock and Vibrations:

The equipment shall comply the shocks and vibration as per IEC-61373. Parameters of test severity for equipment which mounted under the car body is:-

(a) Maximum vertical acceleration : 3g
(b) Maximum longitudinal acceleration : 5g
(c) Maximum transverse acceleration : 3g
('g' being acceleration due to gravity)

Parameters	Functional Random Vibration		
	Vertical	Longitudinal	Transverse
ASD level (m/s2)2/Hz	0.0166	0.0073	0.0041
RMS value m/s2, 2Hz to 150 Hz	0.750	0.500	0.370
Parameters	**Simulated long life at increased Random Vibration**		
	Vertical	**Longitudinal**	**Transverse**
ASD level (m/s2)2/Hz	0.532	0.234	0.131
RMS value m/s2, 2Hz to 150 Hz	4.25	2.83	2.09

3.2.1 Because of track irregularities & other operational conditions prevailing in India, level of shocks and vibrations to which RBC is likely to get subjected to may be far more than actually given in IEC for underslung mounting arrangement. Measured data of vibration levels at critical locations of existing underslung cubicle and its mounting arrangement can be used for design and in case of any doubt, the manufacturer must carry out instrumented trials on existing stock for measurement of shock and vibrations in consultation with PUs/RDSO, Lucknow at design stage only. The fitting and its mounting arrangement shall be so designed that the performance is not adversely affected due to such high vibrations and shocks.

4.0 TECHNICAL SPECIFICATION:

4.1(i) The main Regulated Battery Charger (RBC) shall be suitable for the following input and output data:

SN	Type	Constant voltage with current limiting feature
i)	Input voltage	
	• Nominal voltage	415 V AC, 3-phase, 4-wire system
	• Operating voltage range	415 V ±15% , 50 Hz±3%
	THD (max)	
	• Voltage	≤ 8% at 50% load to 100% load
	• Current	≤ 8% at 50% load to 100% load
	• PF	Not less than 0.98 at 100% load & 0.96 at 50% load at rated output voltage of 122±2% Volts
ii)	Output (DC)	
	• Type	Fully insulated from coach body on both positive and negative sides
	• Nominal voltage	122 Volt
	• Output Voltage	110V to 135 volts (settable with the help of Key pad)
	• Output current	35A Maximum
	a)-Battery charging current	7A to 15A (settable with the help of Key pad)
	b)-Other Loads	20A
	• Type & Ah rating of batteries	Lead acid, 70/120 Ah(both flooded and VRLA)

4.1(ii) There shall be a Separate input supply for Emergency Battery Chargers (EBC) from SBC to avoid failure of both RBC & EBC, due to common input supply. The Emergency Battery Chargers (EBC) shall be suitable for the following input and output data:

i)	Input voltage	Single phase 240 V AC , 50 Hz±3%
ii)	Operating voltage range	240 V ±15% , 50 Hz±3%
iii)	THD	≤ 8% at full load for voltage and current
iv)	PF	Not less than 0.98 at 100% load
iii)	Output voltage	105V-122V DC (Settable with the help of key pad)
iv)	Output current	22A (Max.)
v)	Output Power	2.6 kW (Max.)

4.2 REGULATION:

RBC shall maintain a constant DC output voltage of 122±2% volts for battery charging during normal operation in the entire range of input supply and load (Charging load 15 A (Maximum) and other load 20 A (Maximum).

4.3 EFFICIENCY:

Efficiencies of the RBC at minimum, nominal and maximum input voltage shall not be less than 85% and 92% at half load and full load respectively and efficiency of the EBC at minimum, nominal and maximum input voltage shall not be less than 90% at full load

4.4 RIPPLE CONTENTS:

Output voltage and current ripple factors (r.m.s.) shall be less than 2% and 3% of the set voltage & current respectively for RBC and shall not be more than 2% r.m.s of set value for voltage at full load for EBC, when measured across a resistive load.

4.5 PROTECTIONS:

4.5.1 Over voltage:

Output over voltage protection shall be provided by tripping of the RBC at 136±2 V DC with 2 second delay to avoid spurious tripping.

4.5.2 Current limit:

Battery charging current shall be limited to set value (7-15 Amps) and total output shall be limited to 35 A (Maximum).

4.5.3 AC input:

20 Amps three pole MCB shall be provided in switch board cabinet and LV panel in LHB AC coaches and Non AC coaches respectively for main circuit. 25 Amps single pole MCB shall be provided in switch board cabinet and LV panel in LHB AC coaches and Non AC coaches respectively for emergency circuit.

4.5.4 Output fuse:

40 A blade type/Plug-in type HRC fuse in +ve other load circuit shall be provided in the terminal box.

4.5.5 AC over / under voltage protection:

RBC shall deliver 100% load up to input of 300 V and 35% load in the event of single phasing. Input AC under and over voltage protection shall be set at 300±5V and 480±5V. Input AC under and over voltage shall be auto reset type. RBC shall automatically restart when input voltage is over 300 Volt or below 480 Volt.

4.5.6 Self-reset feature

RBC shall have self-reset feature for trips on any faults except output short circuit, output over voltage and overload. The system shall be locked in trip condition after three consecutive restart attempts at an interval of 5 seconds and RBC shall automatically reset if trip condition is normalized. EBC should start automatically if RBC is not able to reset automatically before locked in.

5.0 GENERAL REQUIREMENTS

5.1 Active front end converters of RBC before isolation transformer shall be IGBT/SiC based, while active front end converters of EBC before isolation transformer shall be IGBT/SiC/MOSFET based. However the converter after isolation transformer may be IGBT/diode based. The battery charger shall be digital signal processor (DSP) based. All protection and control parameters shall be settable from display unit through keypad provided on it with LCD display. While designing the unit, care shall be taken so that PF

at input side shall not be less than 0.98 at rated output voltage of 122±2% Volts and current of 35 Amps and shall not be less than 0.96 at rated output voltage of 122±2% Volts and 50% load. Total Harmonic Distortion Contribution (THD) by the unit shall not cross the limit of ≤8 % for the input line current/voltage at 50% load to 100% load.

5.2 Overall size of the RBC unit including terminal box with EBC feature, shall not be more than as specified in RDSO drawing No. RDSO/PE/SK/AC/200-2018 (Rev'0') as Annexure-2. However manufacturer may be design the RBC unit in less dimensions (Size). The mounting dimension of underslung cubicle shall be 850 mm (L) X 300 mm (D) and thickness of bracket for underslung mounting shall be minimum 5mm. However, RDSO/PUs reserves the right to change the dimensions at the time of design approval or prototype approval. RBC shall be as compact and as lighter in weight as possible and total weight shall not exceed 125 kg. Indicative back view (Shape) with dimensions 500 mm (L) X 160 mm (D) X 90 mm (lower from the top) for RBC unit in RDSO drawing No. RDSO/PE/SK/AC/200-2018 (Rev'0') as Annexure-2 is for dimension purpose only.

5.3 Aluminum anodized plate shall be provided for terminal markings i.e. input AC (R, Y, B) & output DC+, DC+(WSD) DC- & BC+ for RBC and input AC & Neutral for EBC. The termination of internal connections shall facilitate palm-to-palm connections. Not more than one wire shall be terminated on one terminal. Terminal blocks shall be 'Cage clamp type' with 20 % terminal blocks spare of Wago/Phoenix make suitable for input terminal ST 10 capable of max. 16sq mm cable & Output terminal ST 16 capable of max. 25sq mm cable. Terminal block facing shall be on the front side in terminal box.

5.4 Cubicle shall be made of minimum 2.0 mm thick, SS-304/S2 or SS-304/L grade stainless steel sheet conforming to IS: 10632 Pt-3 and will be without exterior/interior painting in prototype unit. However Exterior/interior painting (Black/Grey) with fire retardant paint may be done during regular production for better heat dissipation and to avoid rusting due to welding & hitting of stone.

5.5 All the hardware including those used for electrical terminals shall be stainless steel hexagonal head screws/ ALLEN head screw and nuts conforming to SS-304. Plain and spring washers shall be used as per the requirements of fastening arrangement. Screws used for mounting of the components shall preferably be on tapped holes, wherever necessary.

5.6 All the equipment/sub-assemblies/components used in the charger shall be of proven design and suitable for rolling stock application. Refer bill of materials given in Annexure-1. However other items, which are used in the RBC also, shall be included in the list of bill of material (BOM) submitted by the manufacturer.

5.7 Input supply shall be either from local supply at stations, DA set supply of generator car or Loco mounted static HOG converter.

5.8 Component's rating; type and make as approved by RDSO/PUs (wherever applicable) shall only be used. Final Quality documents shall consist of QAP (as per the RDSO/PUs latest standard format), mechanical drawing, electrical circuit diagram/functional block diagram, Operation & Maintenance manual and complete bill of materials, approved by RDSO/PUs based on the prototype test report and observation/ feedback. Approved drawings, make/grade of components shall not be subsequently changed without prior approval of RDSO/PUs.

5.9 IGBTs or SiC shall be used as power devices. Voltage rating of power devices shall be so chosen that at least 25% margin is available after taking into consideration the DC link voltage jump on account of inductance and capacitance in the circuit. Current rating of devices shall be such that the junction temperature has thermal margin of at least 10^0C in the worst input, output and ambient conditions with 25% clogging/in-effective each heat sinks area. Maximum junction temperature of selected power device shall be submitted at design approval stage for approval of RDSO.

5.10 All electronic components used shall be of industrial (Minimum 85^0C) or higher grade. Only long life dry type Capacitors having self-healing feature and suitable for operation up to 105^0C shall be utilized in the main power circuit DC bus. Electrolytic Capacitors suitable for operation up to 105^0C may be utilized in control power supply, control circuit and emergency circuit. Capacitors should however not require any replacements during the service life of the RBC unit.

5.11 All control, auxiliary circuit electronics and PCBs shall be transparent conformal coated/covered to keep them free from moisture, mould growth and dust etc.

5.12 Entire electronics of the equipment shall be reliable and shall comply with RDSO Specification No. ELRS/SPEC/SI/0015-Oct-2001 or latest for reliability requirement.

5.13 There shall be no damage to any of the semiconductor devices in either the input or output circuits due to short circuit at the output.

5.14 Heat generated by the power devices shall be dissipated through adequately sized heat sinks. Heat sinks should be extruded aluminum and shall be so sized/selected that temperature rise within prescribed limits is maintained even with 25% clogging/in-effective of outer surface of each heat sink.

5.15 Choke (inductor) and transformer may be provided in a separate compartment/cubicle (if required for better thermal management) but shall be provisioned within overall size as specified in RDSO Drawing No. RDSO/PE/SK/AC/200-2018 (Rev'0').

5.16 Complete windings of transformer/choke shall be done with polyesterimide over coated with polymide-imide enameled copper wire/strip or copper foil with appropriate nomex paper. The copper wire shall be class 200 as per IS 13720 Pt. 13.Impregnation shall be done by FT 2005/500EKor 50 VT of Dr BECK through vacuum pressure impregnation method.

5.17 High frequency natural cooled transformer with H-class insulation shall be used to step down the voltage and to provide isolation. Manufacturer will however be free to use the transformer core as common as to input filter inductance. Only virgin core shall be used in high frequency transformer. Released core shall not be used in any condition.

5.18 Galvanic isolation shall be provided between input & output.

5.19 All materials used in the manufacturing of the RBC Cum EBC shall ensure surface flammability, smoke density, burning behavior and fire testing against the test methods and performances detailed in EN 45545.

5.20 The front door of terminal box shall have top hinge type opening with suitable stopper arrangement for holding the door for easy maintenance and shall be located on upper

side of the left face of the unit. Maximum six (06) Nos. bolts shall be allowed for tightening of front door of terminal box, to easy attend of blown fuse during en-route emergency. Cable entry holes shall be provided on its bottom. Terminal box shall have four Nos.23 mm and one No.29 mm plain holes through which PMA end fittings with flexible PMA conduits will be provided in the bottom which will be IP68 protection. RBC unit shall however be supplied with these holes in blocked condition.

5.21 Suitable zero halogen, low smoke, fire retardant neoprene/EDPM rubber gaskets, complying Hazard level as per HL-3, according to EN 45545-2, shall be provided on the covers to prevent ingress of water, dust and moisture..

5.22 Three potential free contacts shall be provided in the terminal box of RBC cum EBC for using them for indication on switch board cabinet and LV panel for AC and Non AC Coaches respectively for RBC Healthy/defective, battery not healthy and EBC ON. But at battery full charge condition, RBC defective indication shall not glow.

5.23 Battery charging current shall be measured internally and battery voltage shall be measured across output battery connection terminals.

5.24 RBC shall start functioning without any human intervention with the availability of input power supply without any need for switching 'ON' and 'OFF', even if battery is not available in coach, RBC shall switch ON and capable to feed to load point.

5.25 The RBC shall be so designed that it is totally free from maintenance or require very little occasional maintenance/attention. MTBF should not to be less than $4x10^4$ working hours.

5.26 Adequate creepage distance and clearance shall be maintained from the live terminals to earth and between live parts as per IEC: 60947-1.

5.27 Additional plate is to be welded on the outside of the cover of RBC and marking plate which made out of 1 mm thick anodized aluminum sheet with letter etched painted white in black background , riveting to be done over the above additional plate.

5.28 Two stainless steel earthing pad with tapped hole and M10 stainless steel bolt with flat surface & spring and flat washers shall be provided on left and right sides of the unit for earthing with coach body. Two 300 mm long, 16 sq. mm Tin plated copper braided cables duly crimped on both ends shall also be supplied with each RBC.

5.29 Danger plate as per IS: 2551 (latest edition) made out of 1 mm thick & 200 mm x 150 mm size anodized aluminum sheet, shall be riveted on outer side of the cover of unit with letter etched and painted white in red background. A trouble shooting metallic board indicating glowing of fault LEDs and their remedial measure at suitable place shall also be provided on front door.

5.30 Use of silicon coated, wire wound resistors and metal film resistors are recommended. All the PCBs used shall be of FR-4 or better with good workmanship.

5.31 Manufacturer shall provide a screen-printed single line diagram inside the front openable cover of unit at suitable place.

5.32 Equipment cubicle / body shall not be connected to any circuit / PCB and shall not be used for any type of earthling or shielding.

5.33 The unit shall be designed for natural cooling.

5.34 Earth leakage detection for both positive and negative lines shall be provided. RBC shall not trip after detection of earth leakage 30mA on one of the lines or both the lines. Earth leakage in respective lines (positive or negative) shall be indicated through an LED (permanent lit). Output DC +ve or –ve terminal should not to be connected to earth in any way, so that the earth detection relay installed in SBC(Switch board cabinet) of AC coaches should not detect earth fault and misbehave.

5.35 While RBC unit is under manufacture/assembly, photographs of various assemblies/sub-assemblies at various stages of development shall be taken and submitted along with internal test results of prototype to RDSO/PUs.

5.36 Front door of RBC Cum EBC shall be openable (hinge on top) and shall have suitable stopper arrangement for holding the door for easy maintenance. At least M8 hexagonal head slotted Stainless steel (SS) bolt/ALLEN head screw shall be provided for proper tightening of the door..

5.37 Complete power module Including Input Rectifier and DC-DC stage along with Control Electronics, Gate Drivers, Power supplies etc. shall be on minimum number of PCBs for RBC and EBC individually and shall be easily replaceable by opening few Bolts only.

5.38 The manufacturer shall comply Hazard Level-3 (HL-3) of specification No. EN- 45545-2 (Railway applications- Fire protection on Railway vehicles).

6.0 SPECIAL REQUIREMENTS:

6.1 At pre-fixed time (settable) weekly or as defined by user Railways, RBC shall be automatically switched 'off' (zero output) and the DC load will be transferred fully to battery for 30 minute (max.). EBC not to be activated in this condition. During this period battery voltage shall be monitored. RBC should start functioning normal after 30 minute or before, if battery voltage falls below cut off voltage (settable through Key pad). If battery voltage drops below cut off voltage i.e. 100V (settable through Key pad) in less than 30 minute, 'battery not healthy' indication shall glow on indication panel and also on SBC/LV panel.

6.2 Regulated Battery Charger (RBC) cum Emergency Battery Charger (EBC) will have the following two modes:

6.2.1 Normal mode, wherein RBC will give full output i.e. 4.5kW & main circuit of RBC will operate and 2.6 kW EBC circuit will be in standby mode.

6.2.2 In the event of failure of normal mode i.e. failure of RBC circuit, Emergency mode will be automatically activated and EBC circuit will operate. EBC will be separate identical circuit but operating at 240 V input (any of the phase & neutral) for feeding 2.6 kW coach load at 105V -122V DC (operating voltage range). In case of tripping of RBC, the EBC should start automatically. As soon as fault is cleared in RBC, automatically the RBC should take over from EBC circuit. Activation of Emergency mode will be indicated on indication panel through an LED.

7.0 PROTECTIONS & INDICATIONS

7.1.1 PROTECTIONS FOR RBC

The RBC shall necessarily have the following protective features:

- Input supply over voltage set at 480±5 V.
- Input supply under voltage set at 300±5V.
- Output short circuit protection for both battery charging and load circuits preferably by blocking firing pulse.
- Output overvoltage trip at 136±2 Volts.
- Over load protection at 35 +20% Amp for 60 seconds.
- Thermal over load of semiconductors.
- Capacity to withstand input of 510V AC for two minutes without any damage to any part of the RBC.
- Reverse polarity protection in battery circuits.
- Output current/ voltage limiting feature

7.1.2 PROTECTIONS FOR EBC

The EBC shall necessarily have the following protective features:

- Input supply over voltage set at 240+15% V
- Input supply under voltage set at 240-15% V
- Output current limit @ 24 Amp.
- Output short circuit
- Reverse polarity
- Capacity to withstand input of 300V AC to EBC for two minutes without any damage to any part of the EBC.

7.2 INDICATIONS:

Following indications through 5 mm LEDs of any colour other than RED visible through fire retardant UV resistant poly carbonate sheet on front wall of the unit (up to 135 mm from the top)-shall be provided. Marking of indications should be clearly visible.

- Input AC ON– R, Y, B(3-Phase)
- Battery Charger "ON"
- Single phasing
- Positive earth leakage (> 30 mA)
- Negative earth leakage (> 30 mA)
- Battery not healthy/Battery deep discharge
- Emergency mode ON
- Output fuse blown

7.3 FAULT DIAGNOSTIC:

The RBC shall have following features fault diagnostics features accessible through key pad/down loading. Events which are not failures but indicate about failures also should be logged and downloaded through USB port on commercially available USB pen drive.

i. Display of following faults with brief description.
   - Input under voltage <300Volts
   - Input over voltage >480Volts
   - Reverse polarity for battery circuit
   - Input single phasing

- Output short circuit
- Over Temperature
- Output overvoltage >135V
- Over current
- Earth leakage for both lines

Diagnostic system shall be capable of recording at least last 500 latest faults with real time clock with override feature i.e. first come first out FIFO).There shall not be provision for deletion or clearing of the fault data.

ii. Communication port for down loading of faults:

RBC shall be provided with self-checking watch dog feature and facility to down load data through USB port on commercially available USB pen drive. This data shall be directly openable in Microsoft office word OR Microsoft office excel worksheet and shall have date, time & stamp. Key pad and USB port should be in front of the unit for easy accessibility.

iii. Format for the downloading data shall be as follows (for illustration purpose):

Date	Time (24:00:00hr)		Brief Description	Fault values
	From	To		
11/11/16	15:09:56	15:10:05	Over Temperature	Temperature of ... item 95°C

iv. Fault description shall be as per the following:

Input supply over voltage	IP-OV
Input supply under voltage	IP-UV
Output over voltage	OP-OV
Output over current	OP-OC
Output short circuit	OP-S/CKT
Over temperature	OT
Reverse polarity	RP
Input single phasing	S-PH-R
Input single phasing	S-PH-Y
Input single phasing	S-PH-B
Positive Earth leakage	P-ELD
Negative Earth leakage	N-ELD

Note:- Only fault data shall be logged in memory.

8.0 CABLES

8.1 Minimum number of wires/cables shall be used. Use of insulated copper bus bar is preferable. The wires/cables below 10 Sq.mm shall be copper with PTFE insulation of reputed make and higher than 10 Sq.mm e-beam cables as per RDSO Specification No. ELRS/SPEC/ELC/0019 (Rev'4") or latest of RDSO approved make shall be used. The use of PVC cables/wires is not acceptable. Outer sleeves/cable ties, heat shrinkable sleeves on terminals, if used, shall be low smoke, halogen free and fire retardant.

8.2 All the electrical connections including incoming and outgoing of transformer shall be of crimped type sockets and numbered/ferruled with cable markers corresponding to the wire numbers of the schematic diagram and neatly bunched over suitable insulated stiffeners with fire retardant ties.

9.0 TESTS:

Prototype, Type, Acceptance, Routine and Investigation tests on RBC cum EBC will be conducted at firm's premises and during Prototype/Type test, some tests for which facility is not available at the firm premises, will be carried out at any NABL or Govt. Lab or lab which has been accredited by an accreditation. After the outside agency test, performance test shall be witnessed by RDSO/PUs representative before sealing the unit.

RDSO/PUs may conduct surprise check on manufacturing process and quality control along with any of the test to ensure quality of product and its conformance to RDSO's specification.

9.1 PROTOTYPE TESTS:

Prototype of the RBC cum EBC will be inspected / tested by RDSO at manufacturer's premises. This prototype sample shall however not to be commissioned in the field and the same shall be kept in the premises of the manufacturer under sealed condition till first quality audit/type test/re-validation test which are earlier for reference.

9.2 TYPE TESTS:

Type tests shall be carried out on one RBC cum EBC of given design to verify the requirements specified. Some or all the type tests may be repeated whenever required by RDSO/PUs on sample basis, so as to confirm the quality of the product to meet the specified requirements. In addition, the manufacturer shall repeat the type test to be witnessed by representative of RDSO or purchaser either totally or in part in following cases without any additional cost: -

- Modification of equipment likely to affect its function.
- Repeated failure of equipment or variations established during routine tests
- Resumption of production after an interruption of more than two years.
- In any other condition where RDSO/Purchaser felt necessity of the type test.
- In case of any change in Bill of Material (BOM), drawings(Mechanical & Electrical) or design of unit.

9.3 ACCEPTANCE TESTS:

The acceptance tests are to be conducted in the presence of Railways' nominated representative on the samples selected at random or on all as agreed between purchaser and manufacturer or as per IS: 4905 to establish conformity of the lot to be supplied with the requirements of the specification. Test shall be chosen as per the test scheme of specification (Clause No. 11.0).

9.4 ROUTINE TESTS:

These tests are to be carried out to verify the properties of the RBC cum EBC corresponding to those measured during prototype / type test. Routine tests are to be conducted by the manufacturer on each equipment and all the records of test results shall be maintained with traceability. The same shall be produced before the Railway's inspecting officer / representative for verification.

9.5 INVESTIGATION TESTS:

Based on the performance, field experience, and critical failures or in view of the improvement measures, investigation test shall be carried out at no extra cost. These tests shall be specially requested either by RDSO or user or by the manufacturer.

10.0 DETAILS OF TEST:

10.1 Visual Inspection:

The various approved drawings (Electrical & Mechanical), QAP, Bill of Material (BOM) of the assembly/sub-assembly, components used and approved with design documents shall be checked along with aesthetics, design, workmanship, adequate creepage distance & clearance from the live terminals to earth & between live parts. All the hardware including those used for electrical terminals , plain and spring washers as per the requirements of fastening arrangement, screws used for mounting of the components (as per clause No. 5.5) and general construction of the equipment also shall be verified during visual inspection.

10.2 Performance Test:

10.2.1 RBC Circuit:

Connect the RBC to the AC input and record the parameters at low, nominal and high input voltage i.e. 350 V, 415V and 480 V respectively for 10%, 50% and 100% loads. Record Input Voltage (r.m.s), Input Current (r.m.s), Input Watts, Input power factor, input voltage & current harmonics, DC Output Voltage, DC Output Current (Amps), DC Output Watts, r.m.s & peak-to-peak ripple for output voltage and Current, percentage regulation and efficiency. The ripple of the output shall not be more than 2% r.m.s of set value for voltage and 3% r.m.s of set value for current at all loads and waveforms shall be recorded through storage Oscilloscope. Performance Test shall be repeated after the temperature rise and endurance test for 10%, 50% & 100% loads at input voltage i.e.350 V, 415 V & 480 V and record Input Voltage (r.m.s), Input Current (r.m.s), Input Watts, Input power factor, DC Output Voltage, DC Output Current (Amps), DC Output Watts and efficiency.

10.2.2 EBC Circuit:

After switching off (zero output) the RBC circuit, the DC load will be transferred to EBC circuit and the parameters (Input Voltage (r.m.s), Input Current (r.m.s), Input Watts, Input power factor, input voltage & current harmonics, DC Output Voltage, DC Output Current (Amps), DC Output Watts, r.m.s ripple output voltage and efficiency at nominal input voltage and100% load shall be recorded. The ripple of the output shall not be more than 2% r.m.s of set value for voltage at full load and waveforms shall be recorded through storage Oscilloscope.

10.3 Short Circuit Test:

Short the output terminals and switch ON the RBC at low, nominal and high input AC voltage and measure the short circuit currents. On removal of short, the charger shall start normally after power reset i.e. OFF/ON. Short the output terminals and switch ON the EBC at nominal input voltage and100% load and measure the short circuit currents.

10.4 Surge Test:

This test shall be conducted as per IEC-60571 and the waveforms shall be recorded through storage oscilloscope.

10.5 Dielectric Test:

When the RBC is cold, dielectric test shall be carried out after disconnecting capacitors and shorting semiconductor devices, primaries of trigger unit, pulse transformers earthed and disconnecting special card, if necessary before applying test voltage. The test voltage for different type of the circuits are as under:

i) 415V ac circuits- 2000V (r.m.s), sine wave, 50 Hz for 1 minute.
ii) 110V dc circuits- 1500V (r.m.s), sine wave, 50 Hz for 1 minute.

Test is considered satisfactory if there is no flash over or tripping of dielectric test equipment set at 30 mA leakage current.

10.6 Insulation Resistance:

This shall be done with the help of 500V megger prior to the starting of all the tests and after heat run. This test shall also be done before and after the dielectric test. Insulation resistance shall not be less than 10 M-Ohms for all circuits.

10.7 Weight:

RBC shall be as compact and as lighter in weight as possible and total weight shall not exceed 125 kg.

10.8 Output Current/ Voltage Limit Test:

- Set the battery charging current limit at 7 Amps through key pad and load the RBC at nominal AC input Voltage to its 100% capacity. Note down DC Voltage. Now, load the RBC beyond 100% and record the drop in output voltage. Now, set the current limit at 15 Amps using keypad and repeat the test.

- Set the voltage at 122 Volts through key pad and load the RBC at nominal AC input Voltage to its 100% capacity. Note down DC Voltage. Now, load the RBC beyond 100% and record the drop in output voltage. Now, set the voltage at 128 Volts using keypad and repeat the test.

10.9 Vibration and Shock Test:

The RBC together with its mounting arrangements (including shock-absorbing devices, if provided) shall be subjected to the vibration and shock test as per IEC: 61373, category-1 class-A.

10.10 Endurance test:

The manufacturer shall conduct rigorous test of the RBC for minimum 52 Hrs. continuously at full load of 35 Amps i.e. 15 Amps battery load and 20 Amps resistive load. The input supply voltage shall be at minimum i.e. 350-355 V. This test may be done in continuation to temperature rise test.

10.11 Dry Heat and Damp Heat Test:

The dry heat and damp heat test shall be conducted as per relevant clauses of IEC: 60571 on all the electronic cards/PCBs used in the RBC Cum EBC.

10.12 Salt Mist:

Salt mist test shall be conducted as per Class ST-1 of IEC: 60571 on all the electronic cards/PCBs used in the RBC Cum EBC.

10.13 Temperature Rise:

It shall be carried out without inside and outside painting of cubicle. 25% outer surface area of each heat sink shall be covered with insulating material during this test. RBC shall be loaded to full load current corresponding to 35 A DC rating with minimum input voltage of 350V AC± 5volts. The temperature rise shall be recorded with the help of temperature recorder having at least 12-14 sensors mounted at the specified reference points on the body of semiconductors, transformer/inductor, filter capacitors and other components till stabilization of the temperature at all the locations. The maximum-recorded temperature under worst loading conditions of the electronics/devices on the PCBs, when measured at half inch away from identified critical components shall be corrected for 55ºC and compared with maximum permissible temperature (as per the component data sheet). The corrected temperature of the semiconductor devices shall have a safety margin of minimum 10^0C.

Temperature of the transformer/inductor shall not exceed 135 ºC when corrected to 55^0 C.

The temperature rise in the inductors/transformer windings shall also be measured by resistance method.

10.14 Test for IP-65 protection and Water proof-ness test:

RBC shall be tested as per IP-65 protection against ingress of dust and water as per IEC-60529, during prototype/type test. The water proof-ness test shall be done on the unit by dipping the equipment in water for one hour under de-energized condition leaving 135mm from the top. Water shall not enter into the unit. Water proof-ness test shall be conducted at least one sample per lot (lot size shall be 20) randomly selected in acceptance test and routine test. Records of routine test may be obtained from respective manufacturers during acceptance test.

10.15 Trigger Equipment Test:

The object of this test is to verify that the firing pulse comply with the design. The blocking of firing pulse for output short circuit shall also to be checked. The firing pulse shall be recorded through storage oscilloscope.

10.16 Load Break Test:

A contactor or a DC knife switch shall be connected in series with the load. After the rated current has been flowing in load for 1 min. the load shall be broken through the contactor. The test shall be repeated three times. No damage shall occur to any part of the RBC.

10.17 Input under Voltage/ Over Voltage On full load i.e. 35Amps:

The input voltage shall be reduced below 300V and the RBC shall switch "OFF" prior to 295 volt and automatically switch "ON" after the input voltage exceeds 305 volts. The input voltage shall be increased beyond 480 V AC and the RBC shall switch "OFF" prior to 485 Volts. The voltage shall be further raised to 510V AC & 300V AC to RBC & EBC respectively and maintained for two minutes. There shall be no damage to any of the components of the RBC/EBC. The RBC shall automatically switch "ON' when the voltage is reduced below 480 V AC but before 475 V.

The EBC shall automatically switch "ON' when voltage is exceeds 204 V AC but before 210 V AC, after under voltage tripping. The EBC shall automatically switch "ON' when the voltage is reduced below 280 V AC but before 275 V AC, after over voltage tripping.

Input under voltage test also shall be carried out at reduced load-35% i.e.12.25 Amps or event of single phasing. Input AC under and over voltage shall be auto reset type. RBC shall automatically restart when input voltage is over 300 Volt or below 480 Volt.

10.18 Acoustic Noise Measurement:

The sound level shall be measured in order to ensure that it is not exceeding the limit value of 60 dB (A) at a distance of 0.5 meter away from the equipment in all the four directions. Tests shall be performed at 10%, 50% load and full load with minimum input voltage.

10.19 BURN-IN TEST:

To ensure the reliability of the components, Burn-in tests as per RDSO specification No. ELRS/SPEC/SI/0015 or latest for reliability of electronics used in rolling stock application shall be conducted on every card in energized condition for three cycles.

10.20 Low Temperature Storage Test

Low temperature storage test shall be conducted as per IEC: 60571 and IEC 60068-2-1on the Cards/.PCBs of RBC Cum EBC. Cards/.PCBs is placed, without any voltage applied, in a test chamber. The temperature value for the test is -40°C and the time period after stabilization is 16h.

10.21 Harmonic Content Measurement

Voltage and current harmonics for RBC shall be measured at the input side of the unit. THD contributed by the unit should not be more than 8% (THD ≤8%) at 50% load to full load (resistive load) at nominal, max and min input AC voltage.

Voltage and current harmonics for EBC shall be measured at the input side of the unit. THD contributed by the unit should not be more than ≤8% at full load and operating voltage range 240 V ±15%.

10.22 EMI/EMC Test:

EMI/EMC test shall be conducted as per relevant clauses as mentioned in the IEC: 61000 with Severity Level-3 & Performance/Acceptance criteria-A for the following:-

i. RFI radiated test: as per IEC 61000 – 4 – 3
ii. RFI conducted test: as per IEC 61000 – 4 – 6
iii. Electrical fast transients test: as per IEC 61000 – 4 – 4
iv. Power frequency magnetic field test: as per IEC: 61000 – 4 – 8

No degradation of the system & malfunctioning shall be allowed during or after the test.

10.23 Over load protection:

An overload capacity of 20% of full load for 60 seconds at nominal input voltage shall be built in the design. During over loading for 60 second, over load limit will be at 42 amp. i.e. 20% over of full load after that the overload limit will reduce to 35 amp. It means if output current is more than 35 amps. for 60 second, after 60 seconds current limit will be at 35amp. The feature of overload protection shall be by limiting output current.

10.24 Functioning at reduced load in case of single phasing:

Unit shall detect & indicate single phasing at the input side. However, the battery charger shall function and deliver at least 35% of the full load. Test to be conducted in all phases i.e. R, Y, and B.

10.25 Reverse polarity protection:-

Reverse polarity protection shall be provided for battery circuit. The RBC & EBC shall sense the reverse polarity and RBC/EBC shall trip on detection of reverse polarity.

10.26 Output over voltage protection:-

Over voltage protection shall be provided to avoid the equipment supplying high voltage beyond the 135 Volts. Tripping of the RBC should be set at 136±2 V DC.

10.27 Earth leakage detection test

During testing high resistance earth path to be created to check earth fault protection. Detection of earth leakage below 30 mA but more than 25 mA in each line (positive & negative lines) shall be tested by creating high resistance earths. Leakage currents at which indication comes shall be noted for future reference. However RBC shall not trip, when the leakage current shall be 30mA and earth fault indication shall be appearing. Earth fault condition shall also be created by direct short between phase and RBC frame to ensure that the unit can withstand this condition also.

10.28 Emergency mode operation test

By simulating any fault condition which can be observed during service, is created in the main circuit and it will be checked if Emergency mode as per clause No. 6.2 comes into operation and Emergency mode indication glows. In case of tripping of RBC, the EBC should start automatically. As soon as fault is cleared/rectified in RBC, automatically the RBC should take over circuit from EBC

10.29 Battery health status test

The RBC shall be switched off (zero output) for 30 minutes and 20 A loads will be transferred on Battery attached. RBC will monitor battery voltage and the battery health status feature as per clause No. 6.1 will be verified.

10.30 Tests on Transformer and Inductor: If manufacturer desire to use self made Transformer and Inductor, then separate approval is required, during prototype/type test following tests shall be conducted. If, Transformers / inductors is a BOM (Bill of material) item then complete test results shall be submitted at the time of prototype testing.

- Continuity
- Winding Resistance
- Series Inductance
- HV-Testing
- Insulation Resistance

10.31 MARKING:

The RBC shall be marked/screen printed with the following information:-

- Type /Make
- Contract No.
- S. No- 8 digit i.e. Month (2digit)/Year(2digit)/Eqpt. No.(4 digit)
- Month & Year of manufacture
- Input operating voltage range
- Output voltage range
- Wattage
- Output current
- Frequency

In addition to this the make shall also be embossed on RBC unit with the help of additional plate duly welded front side on the body of the unit which shall be legible and lasting till equipment life. Manufacturer shall also provide a name plate inside the front openable cover of unit at suitable place.

11.0 TEST SCHEMES:

S. No.	Type of Test	Clause No.	Prototype Test	Type test	Acceptance test	Routine Test
1	Visual Inspection	10.1	Yes	Yes	Yes	Yes
2	Protection & Indication	7.0	Yes	Yes	Yes	Yes
3	Performance test	10.2	Yes	Yes	Yes	Yes
4	Short circuit test	10.3	Yes	Yes	Yes	No
5	Surge test	10.4	Yes	Yes	No	No
6	Dielectric test	10.5	Yes	Yes	Yes	Yes
7	Insulation resistance	10.6	Yes	Yes	Yes	Yes

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8	Weight	10.7	Yes	Yes	Yes	Yes
9	Output current limit	10.8	Yes	Yes	Yes	Yes
10	Vibration & shock test	10.9	Yes	No	No	No
11	Endurance test	10.10	Yes	Yes	No	No
12	Dry heat & damp heat	10.11	Yes	No	No	No
13	Salt mist test	10.12	Yes	No	No	No
14	Temperature rise test	10.13	Yes	Yes	*Records to be verified	Every 50th Equipment
15	IP-65 protection/Water proof-ness test	10.14	Yes	Yes	one sample per lot	*one sample per lot
16	Trigger equipment test	10.15	Yes	Yes	No	No
17	Load break test	10.16	Yes	Yes	Yes	Yes
18	Input U/V & O/V Test	10.17	Yes	Yes	Yes	Yes
19	Acoustic noise	10.18	Yes	Yes	No	No
20	Burn-in test	10.19	Yes	No	*Records to be verified	Every 50th card
21	Low Temperature Storage Test	10.20	Yes	No	*Records to be verified	Every 50th card
22	Harmonic Content Measurement	10.21	Yes	Yes	Yes	Yes
23	EMI/EMC	10.22	Yes	No	No	No
24	Over load protection	10.23	Yes	Yes	Yes	No
25	Single phase protection and functioning at reduced load	10.24	Yes	Yes	Yes	No
26	Reverse polarity test	10.25	Yes	Yes	Yes	Yes
27	Output over voltage protection	10.26	Yes	Yes	Yes	No
28	Earth leakage test	10.27	Yes	Yes	Yes	No
29	Emergency mode operation test	10.28	Yes	Yes	Yes	No
30	Battery health status test	10.29	Yes	Yes	Yes	No
31	Tests on Transformer and Inductor	10.30	Yes	Yes	No	No
32	Marking	10.31	Yes	Yes	Yes	Yes

*Records from respective Manufacturers to be obtained.

12.0 SCHEDULE OF TECHNICAL REQUIREMENTS:-

The manufacturer shall fulfill the requirement of Schedule of Technical Requirement (STR) No. RDSO/PE/STR/AC/0039-2020(Rev '0') for 4.5 kW Underslung Constant Voltage, Regulated Cum Emergency Battery Charger for LHB Coaches.

13.0 WARRANTY:.

The complete RBC Cum EBC shall be warranted for a satisfactory performance for a period of 60 months from the date of commissioning or 72 months from the date of supply whichever is earlier. Any design defect, defective material, underrated component used, etc. have to be corrected and merely replacement of defective parts

will not be considered adequate. Complete investigation report of each major defect/failure shall be submitted to RDSO.

14.0 PRE-COMMISSIONING AND COMMISSIONING TESTS:

Unpack the RBC Cum EBC and check that it is not damaged. Energize the RBC and check the performance test by connecting resistive load before fitment on the coach. Mount the RBC Cum EBC on the coach and conduct the following: -

- Proper mounting of the cubicles and its rigidity
- Insulation and dielectric test.
- Performance test at nominal voltage and full load.
- Proper functioning of protections, indications and fault logging by simulation method.
- Emergency mode operation
- Battery health status

Above tests shall be conducted in presence of the engineers / representatives nominated by the competent authority of the purchaser / Railways.

15.0 SAMPLING:

The methods for Random Sampling and Randomization Procedure shall be done as per IS: 4905.

16.0 SPARES AND MAINTENANCE MANUAL:

A list of spares required for maintenance shall be submitted in printed form and neatly compiled in a booklet form at the time of supply. The supplier shall supply free of cost maintenance manuals duly approved by RDSO to purchaser / Railways at the rate of one per 4 units. The maintenance manual shall consist of introduction, working principle, description, schematic drawings, cubicle drawings, instructions for installation and troubleshooting, precautions while trouble shooting, list of components replaceable with brief specifications and their makes.

17.0 APPROVAL OF DESIGN / DRAWINGS BEFORE MANUFACTURING OF PROTOTYPE:

The manufacturer shall submit the following to RDSO for provisional approval before manufacturing the prototype unit.

a) Clause wise compliance of the specification along with deviations, if any.
b) Working principle, schematic diagrams, detailed design calculations, specification of components and cubicles drawings, weight, efficiencies etc.
c) Bill of materials.
d) Details of protections provided, their set values, range and working principle.
e) Details of semiconductor devices used their specification and data sheets.
f) Safety margins in voltage, current and junction temperature for semiconductor devices, inductors and transformer etc along with their limit values.
g) Output voltage regulation.
h) Duty cycle considered for the RBC for continuous and short time ratings.
i) Quality Assurance Plan (QAP) as per standard format.

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Based on provisional approval of design/drawings, the prototype unit shall be manufactured after incorporating all the modifications found necessary.

The manufacturer shall also submit details like make, type, grade, rating and loading of various electronic components used in the circuit along with reliability prediction, and calculations based on actual loading of various components. The temperature rise of the various components under the most adverse conditions shall also be declared. The

battery charger shall be accepted for prototype test, only if the reliability prediction calculations show that MTBF is not less than $4x10^4$ working hours.

18.0 INFORMATIONS TO BE SUBMITTED WITH OFFER FOR PROTOTYPE TESTING:

The manufacturer must submit the following information along with the internal test results to RDSO.

a) Internal test results
b) Colored photographs of prototype RBC clearly showing the outside and inside details in all directions.
c) Final clause wise compliance of the specification along with deviations, if any.
d) Final bill of materials along with deviations, if any.
e) Final circuit/schematic diagram
f) Final mechanical/cubicle diagram

19.0 FAILURES DURING WARRANTY PERIOD:

The under warranty failures shall be attended by the supplier. The details of failures, action taken, investigation report, failure analysis and action to be taken to prevent re-occurrence of similar failure in future if any, shall be submitted to RDSO, purchaser/ Railways. In case of repeated failures, necessary changes in design shall be made by the manufactures after approval of RDSO. Any investigation tests, if necessary, shall be arranged / conducted by the manufacturer.

20.0 TRAINING:

The supplier shall train the few supervisors of the Railways free of cost for operation & maintenance under the guidance of skilled engineers. PUs in consultation with the Zonal Railways should issue a training program for acquaintance, diagnostic, failure identification for each manufacturer of RBC Cum EBC. A feedback of having completed training should be obtained from Railways and manufacturer.

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ANNEXURE-1

BILL OF MATERIAL FOR REGULATED BATTERY CHARGER

SN	Item Description	Make	Remarks
1	DSP (Digital Signaling Processor)	Texas USA/ Microchip/Motorola	-
2	Dry type long life Capacitor for main circuit	EPCOS/ALCON/ Hittachi / Nippon/ Philips, Deki, C.G.Electric, WIMA	
3	Dry type long life /Electrolytic Capacitor for emergency circuit	EPCOS/ALCON/ Hittachi / Nippon/ Philips/ Nichicon	
4	IGBT(High Frequency)	Semikron/ Mitsubishi/EUPEC(Infineon)	-
5	SiC Power Devices	ROHM/IOR	
6	Gate driver card, Power Supply card and Master controller unit (card)	It shall be from Power devices vendors or from the reputed sources, if required in the circuit design.	
7	Electronic Components	-	Industrial Grade suitable for 85ºC(Min.)
8	PCBs	-	FR-4 or better
9	Diode	Semikron/ IXYS/VISHAY / MACMIC	
10	Switchgear	GE/ABB/C&S/Siemens/L&T/ Schneider	-
11	Fuse	L&T/BUSSMANN/C&S Siemens/FERRAZ	
12	Inductor and Transformer	EPI/ ARYA/Bhurji/EMD	If self-made, test report shall be submitted with internal test results & separate approval is required, during prototype test and tests shall be conducted. as per clause No. 10.30
13	Thermal switch	Mikron/Honeywell	-
14	Cage type terminal blocks	Wago/ Phoenix	Suitable for 10 to 25 Sq.mm cable
15	Contactor	L&T/C&S/ Siemens/ Schneider/ABB	
16	Thyristor	Semikron/ IXYS/Ruttonsha	
17	Hall sensor	LEM/Electrohms/Honeywell/ABB	
18	Wires/Cables of size more than 10 sq mm	As per RDSO Specification No. ELRS/ SPEC/ ELC/0019(Rev'4') or latest and RDSO approved make	

Note: For other item, test report/data sheet of the OEM of the components shall be submitted along with design details for examination and item for which RDSO approved makes exist, shall be procured from them only.

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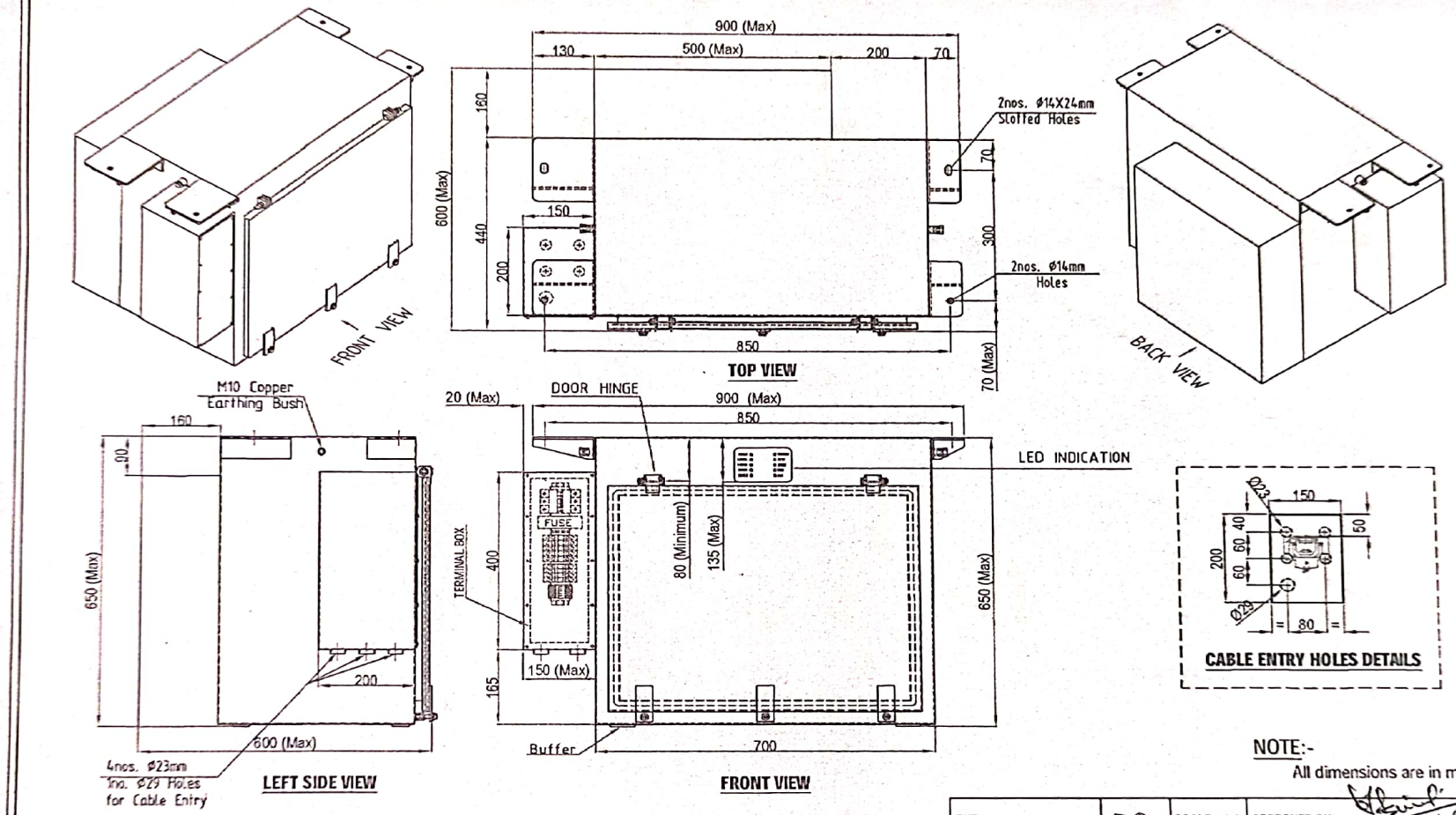
Annexure-2



NOTE:-
All dimensions are in mm.

REF.-		SCALE - 1:1	APPROVED BY - 01.6.2018 (FOR D.G)
GA LAYOUT OF 4.5 KW UNDER SLUNG TYPE CONSTANT VOLTAGE REGULATED BATTERY CHARGER CUM EMERGENCY BATTERY CHARGER FOR L.H.B. COACHES			SUPERSEDES
RDSO/PE/SK/AC/200 - 2018 (REV. '0')			SUPERSEDED BY

DT.		01-06-18
D	MRK	
C	SKS	

STATUS	REV/ALT	REF. NO.	DESCRIPTION	APPD. BY	DATE

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