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सत्यमेव जयते

भारत सरकार GOVERNMENT OF INDIA
रेल मंत्रालय MINISTRY OF RAILWAYS

Introductory Booklet on Solar Energy for Coaching Stock



END USER: Coaching Maintenance Staff

CAMTECH/EL/2020-21/Solar Energy/1.0

February, 2021

अआमा रेंRDS
रेल अग्रदूत Transforming Railways

AN ISO 9001:2015 Certified Organisation
उत्कृष्ट अनुरक्षण प्रौद्योगिकी केन्द्र
EXCELLENCE IN MAINTENANCE

Indian Railways
Centre for Advanced Maintenance Technology

Maharajpura, GWALIOR - 474 005

Introductory Booklet

on

Solar Energy for Coaching Stock

QUALITY POLICY

"We at RDSO, Lucknow are committed to maintain and update transparent standards of services to develop safe, modern and cost effective railway technology complying with statutory and regulatory requirements, through excellence in research, designs and standards by setting quality objectives, commitment to satisfy applicable requirements and continual improvements of the quality management system to cater to growing needs, demand and expectations of passenger and freight traffic on the railways through periodic review of quality management systems to achieve continual improvement and customer appreciation. It is communicated and applied within the organization and making it available to all the relevant interested parties."

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FOREWORD

Limited resources and growing demand of energy poses a clear need for energy generation from alternative and renewable sources of energy. The earth is blessed with enormous amount of solar energy and it is an in-exhaustive, reliable & non-polluting source of power. To minimize dependency on crude oil major portion of which is imported and burdens on economy, the Indian Railways is focusing on harnessing solar energy for its power requirements.

Railway is also working to utilize solar energy for passenger coaches, DEMU coaches by providing roof top solar plants on coaches in order to meet the electricity needs in moving trains and to reduce diesel/Electricity consumption and carbon dioxide emissions.

CAMTECH has prepared this Booklet on "Solar Energy for coaching stock with the objective of creating awareness and to disseminate knowledge on the subject. I am sure that this handbook will be useful to the users.

CAMTECH Gwalior ***Jitendra Singh***
Date:24.02.2021 ***Principal Executive Director***

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PREFACE

Concerns over global climate change, local air pollution & resource scarcity make the alternative and renewable sources of energy attractive worldwide. Solar energy is the most preferable option among all renewable sources of energy. Indian Railways is working on fast pace on harnessing solar energy by providing roof top Solar plants on establishment & station buildings. In order to meet the electricity needs in moving trains and to reduce diesel consumption and carbon dioxide emissions, Railways is also installing Solar Photovoltaic Power System on the rooftop of DEMUs/ Passenger Coaches. IROAF (Indian Railway Organisation for Alternate Fuel) has been established to explore possibilities in proliferating new sources of environment friendly fuels/Energy in Indian Railways.

CAMTECH has prepared this Introductory Booklet on "Solar Energy for Coaching stock" with the objective to disseminate basic knowledge and specific information on Photovoltaic (PV) modules provided on roof top of DEMU coaches/passenger coaches. This booklet comprises advantages of solar energy in coaching stock, schematic layout, details of components used, trouble shootings and maintenance etc. This will be helpful for enhancing the knowledge of users.

I am sincerely thankful to all field personnel, manufacturers who helped us in preparing this booklet. Technological up-gradation & learning is a continuous process. Please feel free to write us for any addition/ modification in this handbook.

CAMTECH, Gwalior ***Himanshu Maheshwari***
Date: 22.02.2021 ***Dy. Director Electrical***

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ISSUE OF CORRECTION SLIP

The correction slips to be issued in future for this handbook will be numbered as follows:

CAMTECH/ EL/2020-21/Solar Energy/1.0/C.S. # XX date---

Where "XX" is the serial number of the concerned correction slip (starting from 01 onwards).

CORRECTION SLIPS ISSUED

Sr. No.	*Date of Issue*	*Page no. & Item no. modified*	*Remarks*

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DISCLAIMER

It is clarified that the information given in this booklet does not supersede any existing provisions laid down by the Railway Board, RDSO and OEM's Manual. This document is not statuary and instructions given are for the purpose of guidance only. If at any point contradiction is observed, then Railway Board/RDSO guidelines and OEM's Maintenance and Operating Manuals may be referred.

OUR OBJECTIVE

To upgrade maintenance technologies and methodologies and achieve improvement in productivity and performance of all Railway assets and manpower which inter-alia would cover reliability, availability, utilization and efficiency.

If you have any suggestion & any specific comment, please write to us:

Contact person:		Dy. Director (Electrical)
Postal Address:		Centre for Advanced Maintenance Technology, Opposite Hotel Adityaz, Near DD Nagar, Maharajpur, Gwalior (M.P.) Pin Code – 474 005
Phone	:	0751 - 2470740
Fax	:	0751 – 2470841
E-mail	:	direlcamtech@gmail.com

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ABBRAVIATIONS

DEMU	Diesel Electric Multiple Unit
IROAF	Indian Railway Organisation for Alternate Fuel
PV	Photovoltaic
AJB	Array Junction Box
DCDB	Direct Current Distribution Box
KWP	Kilowatts Peak
KWH	Kilowatts Hour
HOG	Head On Generator
EOG	End On Generator
SG	Self Generating
SPV	Solar Photovoltaic
DPC	Driving Power Car
SSC	Solar Charge Controller
CCU	Charge Controller Unit
TC	Trailer Coach
ASTM	American Society for Testing and Materials
SPD	Surge Protection Device
MPPT	Maximum Power Point Tracking
LCD	Liquid Cristal Display
LED	Light Emitting Diode
CKT	Circuit
AH	Amp. Hour
VRLA	Valve Regulated Lead Acid

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1. INTRODUCTION

Concerns over global climate change, local air pollution & resource scarcity make the alternative and renewable sources of energy attractive worldwide. The sources of energy that are inexhaustible as they are replaced by nature and can be replenished in short time period are known as renewable energy resources. Sunlight, wind, biomass, water, geothermal, and so on, which can be harnessed continuously, are termed as renewable energy sources.

The Indian Railways is a largest railway networks in the world. It is also one of the largest consumers of diesel in the country, which includes traction requirement as well as the use of coach lights, fans, AC, etc. The train rooftops however remain continuously exposed to the sun during the day time, except when it is cloudy. In Indian conditions, the number of sunny days is 300 (out of a total of 365 days in a year). Thus, solar energy was being wasted, in fact, further heating the coaches resulting in increased cooling requirement. If the train rooftops are covered by specifically designed flexible solar modules, then the train will become a mobile source of generating electricity (solar energy) from solar radiation.

Railway is harnessing solar energy by providing roof top Solar plants on establishment & station buildings. In order to meet the electricity needs in moving trains and to reduce diesel/Electricity consumption and carbon dioxide emissions, railway is also installing Solar Photovoltaic Power System on the rooftop of DEMUs/Passenger Coaches/Guard Brake vans.

IROAF (Indian Railway Organisation for Alternate Fuel) was established to explore possibilities in proliferating new sources of environment friendly fuels/Energy in Indian Railways. IROAF has taken initiative to provide Solar Energy System on roof top of Trailer Coaches of DEMUs. It resulted

minimizing the fuel consumption as well as reduce environmental pollution and thus provide cleaner environment. It cost effectiveness is also another advantage. The solar energy generation system provided in DEMUs is supported with a battery bank to power the passenger facilities uninterrupted even during evening hours as well as on a rainy day.

As pilot project, IROAF has finalized appropriate technology and has conducted trials to providing Solar Energy System on roof top of Trailer Coaches of 1600 HP DEMUs.

2. ADVANTAGES OF SOLAR ENERGY ON COACHES

- By covering the roof using the solar panels, the coach temperature may come down by 2-degree Celsius, providing better comfort to the passengers.
- Reduction in diesel consumption as well as reduce environmental pollution.
- It cost effectiveness is also another advantage.
- Long life of solar modules, fast response and high reliability.
- Minimum maintenance.
- Suitable for moving loads/objects

3. FINANCIAL SAVING AND RATE OF RETURN

Financial calculation of 4.5kWp solar energy generation

Capacity of Solar power generating system	4.5 KWP
Average Energy Generation per day (kWh)	12
No. of days in Year	300

System Life (in Years)	25
Total energy generated in life time (kWh)	90,000
Cost of System (in INR)	8,50,000
Cost of Electricity/ kWh (in INR)	8.89
As per press release on HOG by ministry of Railways on 17 Sept 2019	
Cost of Electricity /kWh- Self Generating (Diesel Traction) (in INR)	36
Cost of Electricity /kWh- End on Generation (EOG) (in INR)	22
Cost of Electricity /kWh- Self Generating (Electric Traction) (in INR)	12.37
Saving /kWh	
Saving /kWh- Self Generating (Diesel Traction) (in INR)	27.11
Saving /kWh- End on Generation (EOG) (in INR)	13.11
Saving /kWh- Self Generating (Electric Traction) (in INR)	3.48
Note: Cost of non solar Electricity and savings are not adjusted for future inflation.	
Payback period with SG Diesel Traction	8.7 years
Payback period with EOG Traction	18 years
Payback period with SG Electric Traction	67.8 years
As per financial saving and rate of return, solar system has better economics in Diesel Traction.	

4. LOAD CALCULATIONS

Hotel Load of a Trailer Coach

The lights and fans load of a Trailer Coach is approximately 10 KWh a day on a 110 volt DC circuit. The approximate roof area of a Trailer Coach is 39 sq. mtr. which can be utilized for mounting of Solar Panels to deliver minimum of 10 KWh on a sunny day.

A. Load break up in each Trailer Coach of DEMU is as follows:

i)	Fans	:	1080 Watts
ii)	Lights	:	720 Watts
iii)	Display Boards 2 x 10	:	20 Watts
iv)	Mobile charging Points (06 nos.) @ 10 watts each	:	60 Watts

B.

1. The total Hotel Load per day	:	10 KWH
2. Installed Solar PV system	:	4.5 KW
3. Average Insolation per day	:	3.5 Hrs.
4. Total Solar Generation per day (2×3)	:	15.75 KWH
5. Total battery Capacity (110 V× 120 AH)	:	13.2 KWH
6. Excess Solar Energy Generation (4-1):		5.75 KWH

This surplus will be used to top up the battery as and when required by the battery.

5. SOLAR ENERGY SYSTEM

Photovoltaic solar system use the light available from the sun to generate electricity and feed this into the Battery as well as load. The PV panels convert the light reaching them into DC power.

The amount of power they produce is roughly proportional to the intensity and the angle of the light reaching them. They are therefore positioned to take maximum advantage of available sunlight.

6. BLOCK DIAGRAM OF SOLAR SYSTEM IN COACH

The Solar PV Modules array (Combination of several solar panels with supporting structure) generated and converts the solar energy of the sun to DC power. The output power from SPV would be fed to the Solar Charge controller which regulates the DC produced by SPV array to 110 V DC for battery & also for DC Load. In day time the when solar power is sufficient the solar power will the charge the battery as well as cater the DC load. In night time the solar power is low or not sufficient the battery can cater the whole the load. Generally the DPC (Driving Power Car) supply will be in cut off mode. If solar power is not available and battery is also deep discharged then DPC supply/Auxiliary power control supply of DEMU will come to cater the load. The switching of solar power to DPC mode will be auto mode.

Charge controller is capable of operating the complete system for safe and efficient operation and includes the protection, Over voltage/ under voltage protection, short circuit protection system etc. The output power from charge controller directly goes to solar DCDB and DCDB will distribute the load. (Like Fans, Light & Emergency Light).

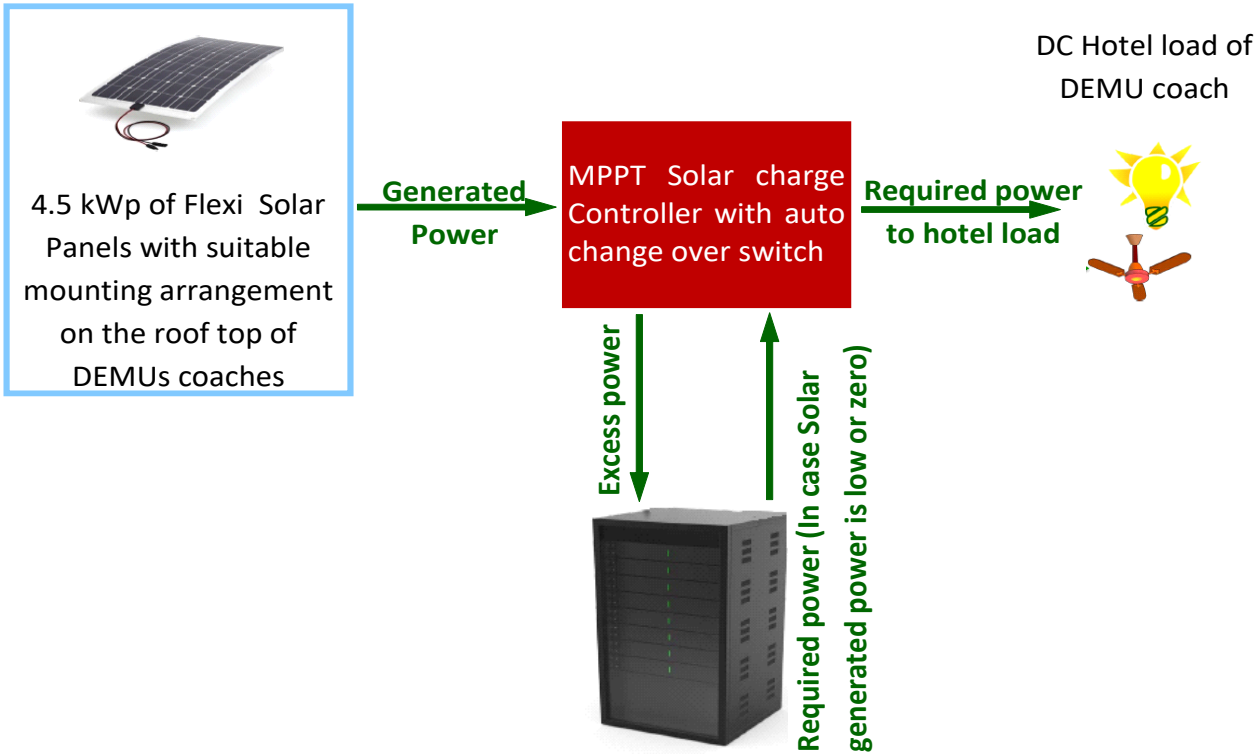


Figure 1: Solar Energy System

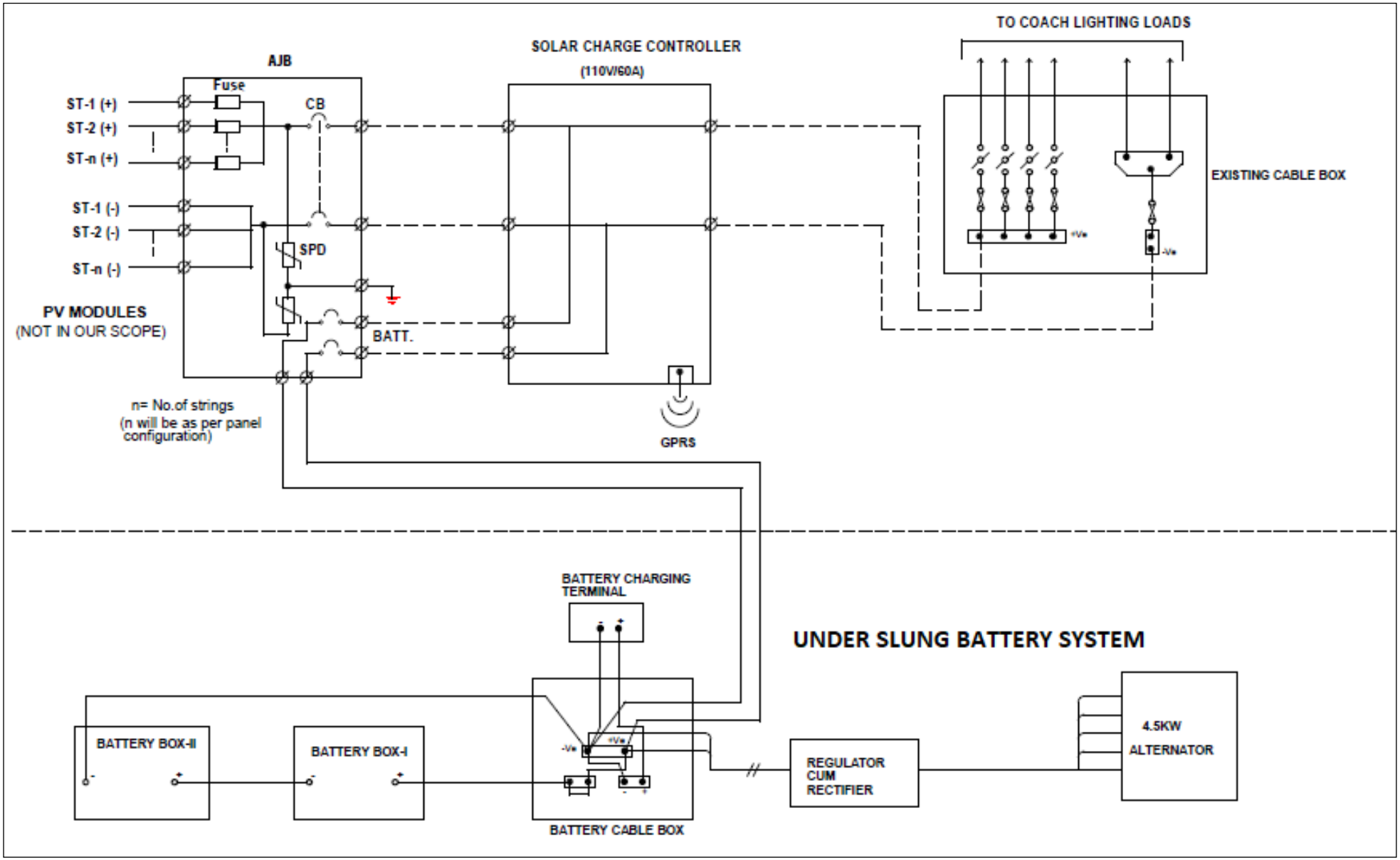


Figure 2: Block Diagram of 4.5 kWp Solar System of Non AC passenger coaches

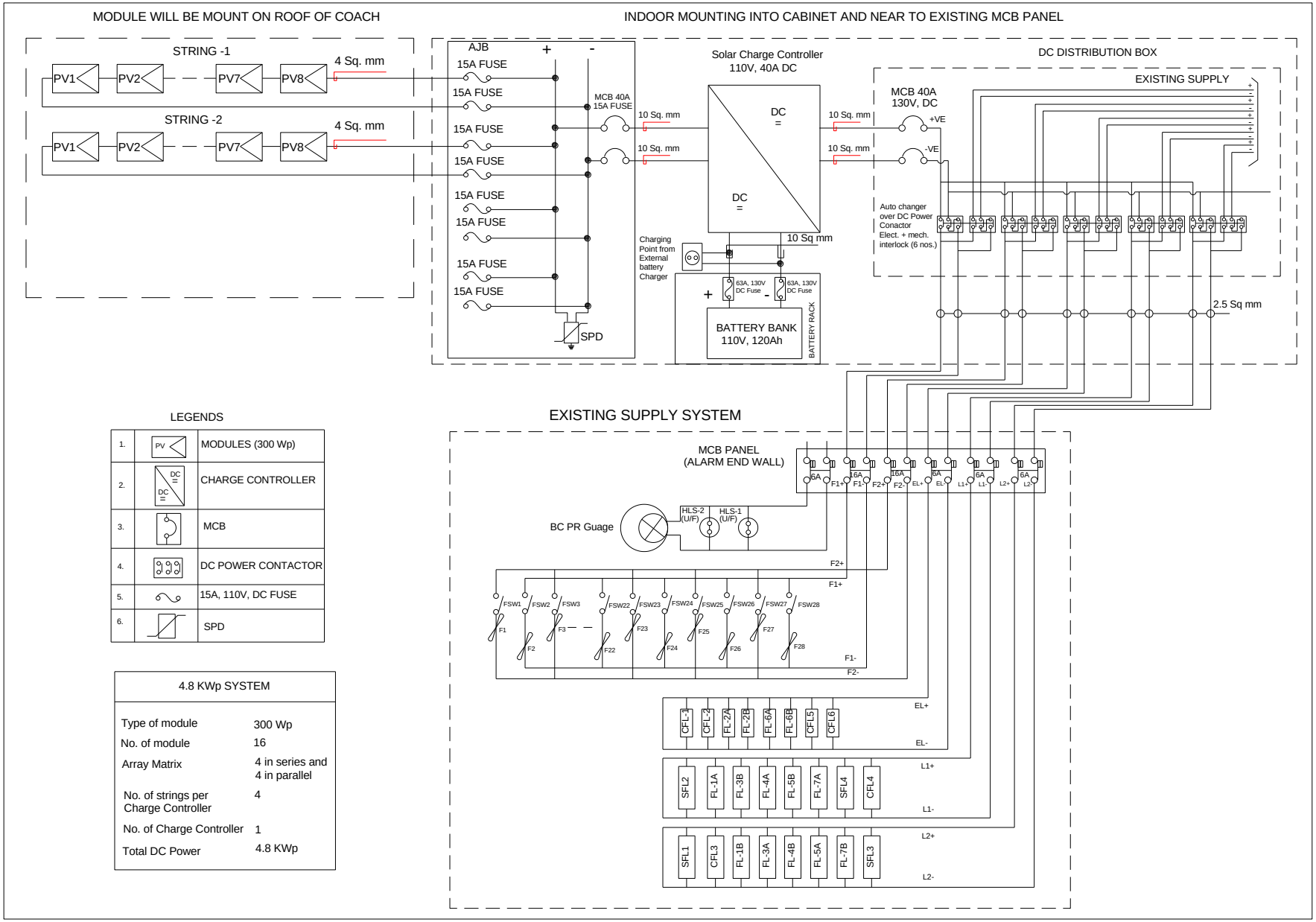


Figure 3: Block Diagram of 4.8 KWp Solar System of DEMU coaches

7. COMPONENTS OF SOLAR ENERGY SYSTEM IN COACHING

- Solar panel (Photovoltaic Modules)
- Array junction box
- Solar Charge controller
- Battery
- Wires , cables , protective fuse and support structure
- Load (DC)

7.1 Solar Panel (Conventional)



Figure 4: Solar Panel

Conventional/rigid SPV panels are used and fitted by mounting MS frame on the roof top of coaches, which is usually installed by puncturing the roof of the railway coaches.



This may have an impact on the lifespan of the coaches. Also, this mounting method leads to the additional weight on coach and also increases the height of the coach by 7 inches. The increase in height and weight are leading to more fuel consumption whilst the trains are running.

Questions were arising that how to best utilize the railway coach roof space to generate solar energy, without increasing the traction load.

There have been number of experiments with conventional solar panels. However, the innovative technology of flexible solar panel to cover the full roof of the railway coach with specialized pasting technologies is considered a better option than standard solar panel modules.

7.1.1 Description of conventional Solar panel

a) Output of solar power plant 4.8 KWp
b) Wattage of each module 300 Wp
c) Total No. of module 16 Nos.
d) No. of modules in series 8
e) No. of parallel combination 2 Nos.
f) PV Module type Poly crystalline

g) Physical Dimensions (Length 1960 mm x Width 990 mm x Thickness 40mm)

h) Electrical Parameter

i.	Maximum Power Rating	300 Wp
ii.	Rated Current	8.20 A
iii.	Rated Voltage	36.60 V
iv.	Short Circuit Current	8.60 A
v.	Open Circuit Voltage	44.80 V

i) Mounting Arrangement (Galvanized Steel structure) — Fixed Type

7.2 Flexi Solar Panel



Figure 5: Flexi Solar Panel

Indian Railways now planned to use 4.5 kWp Solar Photovoltaic Power System with flexi solar PV panels with 09 Bypass Diodes are used on the rooftop of DEMUs/ non-AC Passenger Coaches to meet the electricity needs in moving trains.



The Flexi Solar PV (Photovoltaic) Modules array converts the light energy of the sun to DC power. The module mounting arrangement is used to hold the module in position. The DC power is converted to 110 V DC by CCU to supply DC loads such as lights, fans, battery charging etc. within the DEMU. Solar Power is integrated with the existing auxiliary power supply system of the DEMU.

7.2.1 Salient features of flexi solar panels

- These flexible photovoltaic modules are laminated with special polymers instead of glass.
- The special feature is Lightness and Flexibility. There are 9 zones instead of traditional 3 zones cell structure there by substantially reducing the adverse effect of shadow, dust, bird dropping etc. and maintain similar efficiency.
- Flexi Solar Panels Curves up to 30 degrees can be easily mounted on the curved roofs of DEMUs/passenger coaches. Flexi Solar Panels are 82 % lighter than other solar modules and Reduces traction efforts by 82% as compared to traditional SPV modules due to reduction in weight of SPV Modules.

7.2.2 Technical detail of flexi solar panels

Sn.	***Description***	***Rating***
1.	Power rating of Flexi Solar Panel	285Wp
2.	Dimension of 285Wp Flexi Solar Panel	1558 mmX996mmX2mm
3.	No. of By Pass Diodes per Panel	09Nos
4.	Confirming to IEC/IS Specification	IEC:61215 Ed 2 /IEC: 61730 –I :2007, IEC : 61730-II : 2007, IEC: 62804:2015
5.	Type of Solar Cell	Mono Crystalline
6.	Type of top layer of panel	Ethylene Tetra Flouro Ethylene (ETFE)
7.	No. of Flexible Solar Panels in one coach of Solar Power Generating Set	16 nos.
8.	Open –circuit voltage	34.90 V
9.	Operating voltage	29.15 V
10.	Maximum system voltage for which the module is suitable	1000 V
11.	Operating current	9.8 A
12.	Short circuit current	9.97 A
13.	Module Wp and tolerance	285 Wp + 3%
14.	Efficiency of the module	> 15%
15.	Fill factor of the module	>72%
16.	Approximate Weight of panel	~3.4 Kg

7.2.3 Module mounting arrangement

- Flexi Panels is pasted on roof top of Trailer Coaches (TC) of DEMUs/passenger coaches. The Module Mounting Arrangement is a combination of:
- High strength double sided tape on the perimeter of Solar panels.
- Polyurethane adhesive around the centre of Solar panels.
- Elastic Adhesive Sealant.
- The mounting arrangement of flexi panel is suitable for outdoor mobile application for >150 KM/H speed. The service life of mounting arrangement is more than 25years.

7.2.4 Double sided acrylic foam tape

- Acrylic foam tape is of minimum 1 inch wide and thickness in the range of 2 –2.5 mm having a closed cell construction is used to avoid any ingress of water/air.
- It has a minimum foam density of 700 Kg/m3 for high durability and strength and a minimum Surface Resistivity (ohm/square) of 1014 to avoid any surface leakage of current.
- The acrylic foam tapes conforms to ASTM D 3330 (American Society for Testing and Materials) for the peel adhesion (mm 300 N/100 mm) and have at least 10,000 minutes static shear resistance as per ASTM D3654.
- The Acrylic foam tape have been tested against sustained wind speed of a minimum of 150 kmph as per (ASTM E330).

- Acrylic foam has been tested for its strength retention, under water submersion for a minimum of 5 years and should have 25 years of service life modeling.

7.2.5 Adhesive Sealant

- The adhesive sealant with suitable bead size is applied as to the designed by firm with Flexible solar panels.
- The adhesive sealant is single component moisture curing polyurethane sealant with preferably sausage pack of about 600 ml that ensures easy application with normal curing under atmospheric conditions.
- The adhesive shore A hardness between 55 and 60 as per ASTM C661 guidelines and elongation at break more than 300% (as per ASTM D412).

7.2.6 Edge Sealing Tape

The sealing of Flexible solar panels is carried out on its periphery with a minimum of 2 inch wide and 2mm thick translucent, single side coated pressure sensitive acrylic adhesive tape with ionomer backing, having an elongation of 530% at break when tested as per ASTM D3759.

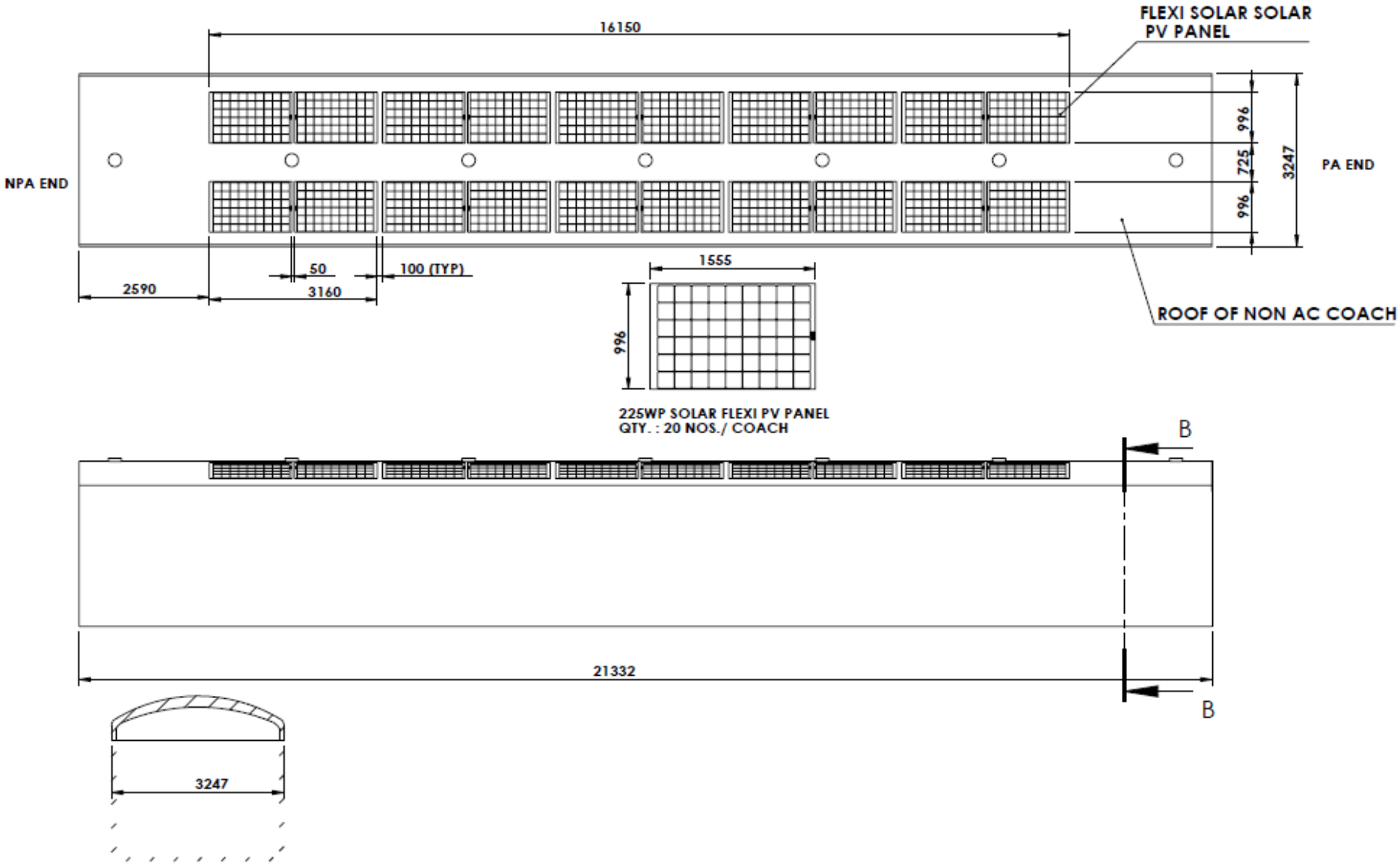


Figure 6: Lay Out Plan for 4.5 Kwp Solar Panel System with Flexi Solar Panels

7.3 Solar Array

Combination of several solar panels with supporting structure called an array. A solar array can be defined as solar panels arranged in a group to capture maximum amount of sun light to convert it into usable DC electricity. Multiple cells make up a solar panel, and multiple panels (modules) can be wired together to form a solar array.

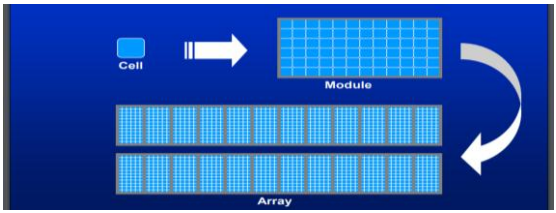


Figure 7: Solar Array

7.4 AJB & DC DB



Figure 8: AJB & DC DB

Array Junction Box (AJB)

Array Junction Boxes are provided in between Flexi Solar PV (Photovoltaic) Modules array and CCU (Current Control Unit). DC Disconnector/MCCB of suitable rating for connection and disconnection of array section are provided. Surge Arrestor is also incorporated for surge protection. Meters are provided for measuring the array voltage and array current.

An array junction box is used to combine the DC cables of the Flexible solar panel arrays with DC HRC fuse protection or DC PV fuse protection for the outgoing DC cables to the CCU. The Junction Box is mounted close to the CCU.

The DC array junction box is of the thermo plastic to IP 65, DIN-rail mounting type and is comprise the following components and cable terminations:

1. Incoming positive and negative DC cables from the Flexible solar panels.
2. DC HRC fuses and suitable DC circuit breaker (the cables from the Flexible solar panels from the roof top is connected to this circuit breaker on the incoming side)
3. Suitable DC surge protection device (SPD).

Direct Current Distribution Box (DCDB)

The Output of the solar power plant is connected with DCDB through solar charge controller output. DCDB have MCB for short circuit & over current protection. There are DC contactors / Auto Change over switches which will transfer the supply to load from DPC (Diesel Power Car) supply either solar supply. The changing of power from solar to DPC will be in auto mode.

7.4.1 Technical specification of AJB & DC DB

SN.	*Description*	*Rating*
1.	Rating of AJB	2 Input Array Junction Box
2.	Input Parameters	
3.	No. of Inputs-PV	02
4.	No. of Input -Battery	01
5.	No. of fuse per input	01 nos. in + ve side
6.	Fuse rating	15A/1000VDC
7.	Output Parameters	
8.	Output MCB –PV	32A, 3pole
9.	Output MCB-Battery	63A, 2Pole
10.	Output SPD Type	Type-II, SPD
11.	Enclosure Details	
12.	Enclosure material	Poly Carbonate
13.	Cover Type	Transparent Cover
14.	Degree of Protection	IP-65
15.	Color	RAL-7035

7.5 MPPT (Maximum Power Point Tracking) Solar Charge Controller

MPPT Solar Charge Controller confirming to IEC 61683 and 60068-2 is provided between the array junction box and DC loads, battery and auxiliary power supply. The CCU (Charge controller unit) is convert the power generated from Flexible solar panels to 110V DC which is used to feed the hotel loads of the DEMU/TC. The excess power is used to charge the batteries which are feed the load during night or non sunny days. In case of non availability of solar energy

and full discharge of battery, an Auto change over switch is provided at suitable location in system to switch over to the hotel load supply through auxiliary power supply of DEMU.

Charge controller is also control the amount of charge flowing in and out of the battery. It acts like a voltage regulator. Primary function of a charge controller in a PV system is to manage rate and amount of charging the battery.

The CCU have integrated Energy meter, Volt Meter, Amps Meter and Data Logger. Graphical user interface (through LCD display) is provided with adequate protection, which is display, PV Voltage, PV Current, Battery voltage, PV KWh Cumulative, Date Wise PV KWh Generated in last 30 Days, Monthly Generated KWh and other related parameters. No separate energy meter, Volt meter & Ammeter are required.

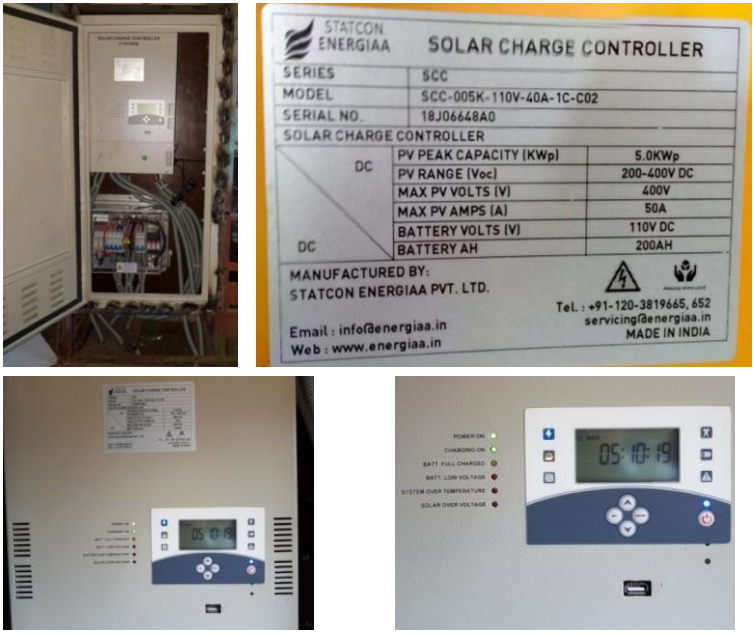


Figure 9: MPPT Solar Charge Controller

7.5.1 LED indications in Charge controller

1. Power ON
2. Charging ON
3. Battery full charged
4. Battery Low voltage
5. System over temperature
6. Solar over voltage

7.5.2 Technical Detail s of MPPT Solar Charge Controller (CCU)

Description	**Rating**
Rated capacity	110 V, 40 Amp.
Input Parameters	
Type of Solar Charge Controller	MPPT
IEC/IS	IEC 61683 and 60068-2
PV input voltage range	200 – 400 V DC
PV input Total	6.6 kWp
Max open circuit voltage (Voc)	380V
MPPT range	150-300 V
Charge controller type	MPPT
Peak Efficiency	>94%
Noise Level	less than 60 dBA (nominal) at 1m
Battery Side	
Nominal Voltage Boost Voltage Output Voltage Float Voltage Battery Type	110V 133V 118.2V VRLA

Graphical User Interface	
LCD Display	• Charger ON/OFF, Charger Fail, Fault • PV Voltage, Current, PV KWH Cumulative, battery voltage/ Battery Current PV KWH Generated in last 30 days, Monthly Generated KWH yearly Generated KWH • Over load, Over Temperature
Indications	Power ON, Charging ON, battery full charged, battery Low voltage, system over Temperature, solar over voltage
Protections	PV & Battery reverse polarity protection Over–voltage both at input and output Over current both at input and output Over temperature Short circuit protection battery side Transient surge protection Overload Battery current limit Reverse Flow of Power
Communication	
RS-485	RS-485 via Modbus (all the monitoring parameters and faults will be provided on RS-485)
Data-Logger	With minimum 06 months storage capacity
Data Monitoring	Via GRPS

7.5.3 Controls, indicators and components of solar charge controller

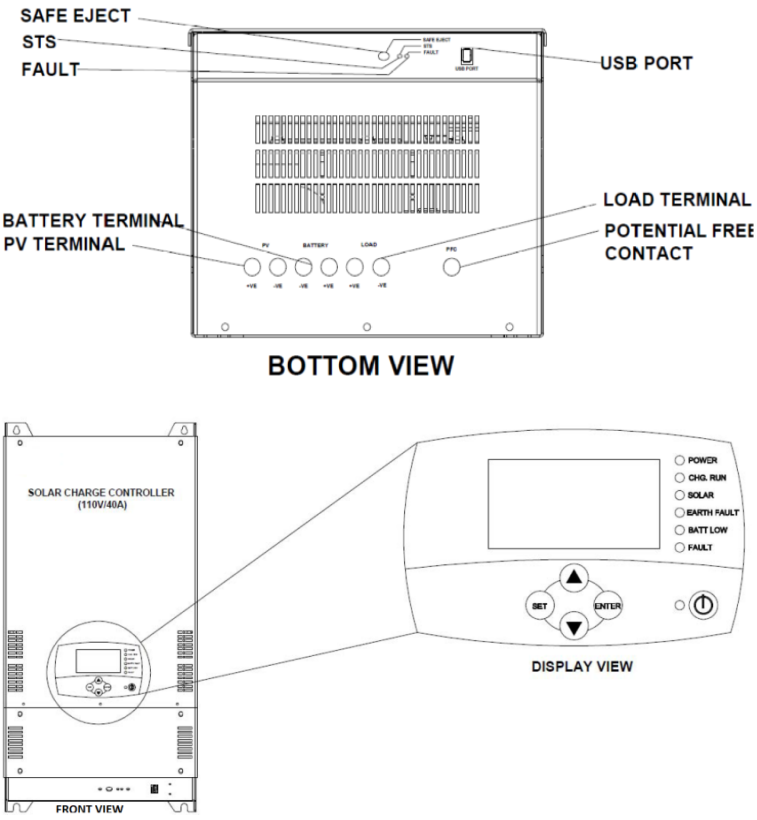


Figure 10: Bottom and Front View of Solar Charge Controller

- **PV Terminal**

  These terminals are used for connecting the wire coming from solar panel as a input terminal of solar charge controller.

- **Battery Terminal**

  These terminals are used for connecting the battery bank into the solar charge controller.

- **Load Terminal**:

  These terminals are here for connecting the dc load.

- **Potential Free Contact**

  It is providing in spare for user purpose.

- **USB Port**

  In this port we insert the pen drive for taking data from the solar charge controller.

- **Safe Eject**

  This is the push button switch which ensures the safely removal of PEN Drive, if we don't follow it logged data might get damaged.

- **STS**

  This LED shows the healthy status of data transferring into pen drive.

- **ERR**

  This LED shows the error status of data transferring into pen drive.

- **Display**

  User can see the entire parameter i. e Battery volt, PV volt etc. on LCD display and can switch on/off the solar charge controller by pressing 'ON/OFF' key (Right down corner of display keypad) after connecting the battery bank and PV supply into the solar charge controller.

- **Fault Display**

  Press KEY ENTER while in auto mode to see the Fault Indication in SSC (Solar Charge Controller).

ICON Fault will be displayed and Consecutive Number will also be displayed if any what type of fault has been occurred and fault LED will ON.

Type of fault	***Display***
Battery over volt	Fault*2
Fan Fail	Fault*3
Solar over volt	Fault*4
Solar Over Load	Fault*5
System Short Ckt	Fault*7
Battery Under volt	Fault*8
Battery Loose Flag	Fault*9
DC Bus Error	Fault*B
DC Earth Fault	Fault*C

7.5.4 Data Logger

MPPT Solar Charge Controller has data logger (storage capacity minimum 6 months) and remote monitoring and data acquisition facility through Web Portal.

4 Channel SD card data logger Model –SD400



Solar Data Logger systems are used for the data acquisition of Site parameters with proper sensors and for continuous data acquisition of solar power plant parameters at site.

Specifications:

- 4-Channel Analog Inputs
- Operates with any 12 to 24VDC Power Supply.
- High Accuracy 16-Bit ADC for data conversation.
- Min Log Time Interval is 1 Sec.

- Very Accurate data log interval timing with RTC.
- Data Logging with Date and Time Stamp on Micro SD Card in CSV format. This can be easily open with any EXCEL program.
- Green Color Back lit LCD Display with four rows. First row for A and B Channel Data Display. Second row for C and D Channel Data Display. Third row for Date and Time Display. Fourth row for No. of data logged in current file.
- RTC Based Real Time Clock to provide accurate timing even after power failure.
- Logs data on to Micro SD Card similar to used in our cell phone. So not required costly compact flash card.
- Creates file automatically after 65000 data logs in single file with real date time format.
- Scaling of Analog Inputs, Log time Interval Setting and Date/ Time Change options available through SD Card using simple txt formatted files. So not required to move to PC for all these actions every time.
- Very easy and convenient way to get complete analysis of Batch Process Parameters for particular Batch. Just make logger ON at Batch Start Command and OFF at Batch Stop Command. You will get single file with real time date stamp with all parameter values logged with time stamp.
- 2 GB Micro SD Card supports up to 1 and ½ years data logging at data log time interval set to 1 sec. At higher interval you can log years of data on single Micro SD Card.

7.6 BATTERIES

110 V/120 Ah VRLA batteries are provided in the coaches equipped with Solar panels to store the energy produced during a full sunny day.

Calculation of Battery working hours

- Load of the passenger coach, P= 1800W
  Voltage = 110V
  Current flow (I) = P/V =1800/110 = 16 Amp
  Battery Hours = (120Ah x 0.8)/ rate of current drawn
  = (120 x 0.8)/16 = 6 Hrs

- To control the charging and discharging of the charge, charge controller is provided in the system.

7.7 Technical Specification of Wire

1. Electron beam cable will use as per RDSO's specification no. ELRS/SPEC/ELC/0019 (latest version).
2. Electron beam cable details are as follows:
   i. Solar Array to Array Junction Box: 1CX4mm2
   ii. Junction Box to Solar Charge Controller: 1CX16mm2
   iii. Solar Charge Controller to Battery Bank: 1CX16mm2

7.8 Technical Specification of DC Energy Meter

SN.	*Description*	*Rating*
1.	Energy Meter Capacity	30 kW
2.	Supply Voltage Range	0-150 V
3.	Type of Display	DC Voltage, DC Current, kW/ kWh

4.	Life Cycle of Battery	3500 cycles, after that the battery will have 80% of its rated capacity
5.	IEC / IS	Battery Conforming to IEC 62133Cell Conforming to IS 16046
6.	Depth of Discharge	90%

8. MAINTENANCE

8.1 Solar panels

- Clean the module surface regularly with water spay, dry/wet cloth.
- Check all the cable and wiring connections for their firmness.
- Check that there is no corrosion in the modules and there is no seepage of rain water.
- Do not use any detergent for cleaning the module.
- Do not use sharp edged materials to remove bird dropping.
- Do not touch the surface of the module with oily or greasy hands



Figure 11: Solar Panel

8.2 Battery

- Inspect battery for any abnormality.
- Check battery enclosure box for proper ventilation.
- Do not attempt to fiddle with the circuits and the wiring.

8.3 Electronic components

- It is essential to regularly maintain the electronic components as given below:
  i. Regularly verify the voltage set points of charge controller with regard to battery specifications and system requirements.
  ii. Check connections for corrosion and loose wires.
  iii. Check for any unusual noises from charge controller.
  iv. Ensure that charge controller is in a sheltered, clean and well- ventilated environment.

8.4 Wiring

- Check wiring connections for corrosion and loose connections.
- Check wire insulation for degradation.
- Ensure that all metal equipment cases and frames in the system are well grounded.
- Check the operation of all LEDs.
- Check circuit breakers and fuses.

The following inspections and maintenance tasks are recommended for best controller performance:

- Check that the controller is securely mounted in a clean and dry environment.
- Check the wiring to make sure insulation is not damaged by sunlight, frictional wear, insects or rats etc. Replace if necessary.
- Tighten all the terminals. Inspect for loose, broken, or burnt wire connections.
- Pay attention to any troubleshooting or error indication. Take necessary corrective action.

9. TROUBLE SHOOTING

S.No.	Symptoms	Possible cause	Correction
1.	Charging LED indicator off during daytime when sunshine falls on PV modules properly.	PV array disconnected	Check that PV and battery wire connections are correct and tight.
		Battery voltage higher than over voltage disconnect voltage.	Check battery voltage. Disconnect the solar module
		Battery over discharged	The controller did cut off the load output automatically.
2.	Solar panels not giving the desired power even on bright sunny days.	• Dusty panels • Loose connection at panel Terminals. • Loose	• Clean the panels at least • once in a week with water • Tight all the loose connections found

S.No.	Symptoms	Possible cause	Correction
		connection at the Combiner box terminals. • Loose connection at Charge Controller. • Cut in solar cables	at solar panels • Tight all the loose connections found at solar combiner box. • Tight all the loose connections found at Charge controller terminals.
3.	Output voltage is not available	Input DC Voltage is not Available	Make it available first.
		ON/ OFF switch is kept in OFF position.	Check the position of ON/ OFF Switch and keep it at ON position.
		Polarity	Check the Battery connection polarity.
		System is trip DC under voltage condition.	Assures input DC range is above the DC under voltage cut Setting
5	Solar Charging is not available	PV Voltage is not available	Make it available first
		PV MCB switch is kept in OFF position	Check the position of PV MCB and keep it at ON position
		ON/OFF switch is kept in OFF position.	Check the position of ON/OFF switch

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S.No.	Symptoms	Possible cause	Correction
			and keep it at ON position.
		PV is connected in reverse Polarity.	Check the PV connection polarity.
		Check the Input PV range is within the specified range	Input PV range should be within the specified range.

REFERENCES

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4. Presentation of M/s KAHO Solar Limited, Noida.
5. Block diagrams and photographs received from M/s KAHO Solar Limited, Noida.
6. Operation and Maintenance Manual of M/s Jakson Engineers Limited, Noida.
7. Block diagrams and photographs received from M/s Jakson Engineers Limited, Noida.

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NOTE

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CAMTECH is continuing its efforts in the documentation and up-gradation of information on maintenance practices of electrical assets. Over the years a large number of publications on electrical assets have been prepared in the form of handbooks, pockets books, pamphlets & video films etc. These publications have been uploaded on the internet as well as rail net.

For downloading these publications please do following:

1. On internet visit :www.rdso.indianrailways.gov.in

   Go to Directorates → CAMTECH → Publications for download→ Electrical Engineering

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For any further information regarding publications please contact:

Dy. Director (Elect.) BSNL:		0751- 2470740 (O)
Rly. :		03747203
SSE/Electrical	:	9425341810
E-mail	:	direlcamtech@gmail.com
Fax	:	0751- 2470841
Write at	:	Dy. Director (Electrical) Indian Railways Centre for Advanced Maintenance technology, In front of Hotel Adityaz, Airport Road, Maharajpur, Gwalior, Pin code – 474 005