Template for submitting comments/inputs on Draft revision of GR on "HYBRID (AC + DC) UNINTERRUPTED POWER SUPPLY SYSTEM (TEC 66160:2024)"-

Name of Manufacturer/Stakeholder:

Organization:

Contact details:

Clause No.	Clause Description	Comments, if any	Remarks, if any

Note: The comments/inputs on the draft GR (Standard No. TEC 66160:2026) may be furnished in the above format through email to adgfa-tec-dot@gov.in **with copy to** dirfa.tec@gov.in **and** ddgfla.tec@gov.in **at the earliest and within prescribed time period.**

वर्गीय अपेक्षाओआवश्यकताओं के लए मानक टीईसी ६६१६०: २०२६४

STANDARD FOR GENERIC REQUIREMENTS TEC 66160:20264

हाइब्रिड (एसी + डीसी) निर्बाध वद्युत आपूर्ति प्रणाली

HYBRID (AC + DC) UNINTERRUPTED POWER SUPPLY SYSTEM

ISO 9001:2015

दूरसंचार अभियांत्रिकी केंद्र

दूरसंचार विभाग, संचार मंत्रालय, भारत सरकार

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FOREWORD

Telecommunication Engineering Centre (TEC) is the technical arm of the Department of Telecommunications (DOT), Government of India. Its activities include:

- Framing of Standards for Generic Requirements for a Product/Equipment, Standards for Interface Requirements for a Product/Equipment, Standards for Service Requirements
- Formulation of Essential Requirements (ERs) under Mandatory Testing and Certification of Telecom Equipment (MTCTE) Policy
- Field evaluation of Telecom Products and Systems

- Designation of Conformity Assessment Bodies (CABs)/Testing facilities
- Testing & Certification of Telecom products
- Adoption of Standards
- Support to DoT on technical/technology issues

For the purpose of testing, four Regional Telecom Engineering Centers (RTECs) have been established which are located in New Delhi, Bangalore, Mumbai, and Kolkata.

ABSTRACT

This document contains the generic requirements of Hybrid (AC + DC) Uninterrupted power supply (UPS) System based on Switch Mode Power Supply (SMPS) techniques for providing uninterrupted AC power and also DC power to the equipment's associated with various Telecom systems , working on 230V AC and / or 5V DC Power supply. These power supplies are capable of catering to load requirements up to 4KVA for DC & AC Operated telecom equipment's. It is envisaged in this GR that input sources for this type of hybrid power supply system are from SPV power source, Grid supply (or a DG set) and Lithium ion battery as per availability. This type of UPS system shall have provision, so that, when both the output of SMPS and SPV power source are available, SPV power source shall deliver the load as per its available power and rest of the load shall be taken care of by SMPS/ Battery.

CONTENTS

HISTORY SHEET

Sl. No.	Title	Standard/ Document No.	Remarks
1.	Hybrid (AC + DC) Uninterrupted Power Supply Systems	TEC 66160:2024	Release 1
2.	Hybrid (AC + DC) Uninterrupted Power Supply Systems	TEC 66160:2026	Release 2

REFERENCES

S.No.	*Document No.*	*Title/Document Name*
1.	CISPR 11 (2015)	Industrial, scientific and medical equipment - Radiofrequency disturbance characteristics - Limits and methods of measurement
2.	QM-118	Quality reliability in product design.
3.	QM-202	Pictorial guidelines for Visual assessment of quality of printed board assemblies (PBA) & discrete terminal assemblies.
4.	QM-204	Guidelines for workmanship standards for repair & modification of printed wiring board assemblies.
5.	QM-205	Guidelines for standard of workmanship for printed boards.
6.	QM-206	Guidelines for standard of workmanship for printed boards assemblies
7.	QM-207	Guidelines for soft solder and fluxes for Telecom Equipments.
8.	QM 210	Guidelines for standard of workmanship for surface Mounting Devices.
9.	TEC 14016:2010 (old no. QM-333:2010)	Standard for Environmental testing of Telecommunication equipment.
10.	IS: 101	Methods of Sampling & Test for Paints, Varnishes & Related Products.

11.	IS: 168	Ready Mixed Paint, Air Drying, For General Purpose-Specification
12.	IS: 613	Standard on Bus-bars
13.	IS: 1359	Specification for Tinning requirements.
14.	IS: 1554 with Amend. -1 (June 1994)	Standard for Cables & Wires.
15.	ISO-9001-2015	Quality Management Systems Requirements.
16.	IEC 61643 – 31	Low Voltage Surge Protective Device – Part 41: Surge Protective Device connected to low voltage power system – Requirement and Tests
17.	IEC 61000-4-2	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
18.	IEC 61000-4-3	Electromagnetic compatibility (EMC) - Part 4-3 : Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test
19.	IEC 61000-4-4	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test
20.	IEC 61000-4-5	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test
21.	IEC 61000-4-6	Electromagnetic compatibility (EMC) - Part 4-6:

		Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields
22.	IEC 61000-4-11	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current up to 16 A per phase
23.	IEC 61000-4-18	Electromagnetic compatibility (EMC) - Part 4-18: Testing and measurement techniques - Damped oscillatory wave immunity test
24.	IEC 61000-4-34	Electromagnetic compatibility (EMC) - Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with input current more than 16 A per phase
25.	TEC 66110 : 2024	TEC GR on 'SMPS BASED POWER PLANTS'
26.	TEC 66130:2024	TEC GR on 'LIGHTENING AND SURGE PROTECTION OF TELECOM SITES'
27.	TEC10009: 2024	TEC GR on 'Audio/video, information and communication technology equipment – Part 1: Safety requirements 'SAFETY REQUIREMENTS OF TELECOMMUNICATION EQUIPMENT'
28	UL 950	Standard for information technology equipment including electrical business equipment

Note: Unless otherwise explicitly stated, the latest approved issue of the standard/GR/IR, with all amendments in force, listed in references, shall be applicable.

CHAPTER 1

1 Introduction:

1.1 Hybrid (AC + DC) Uninterrupted power supply (UPS) System (HUPS system) shall be suitable for operation from SPV power source, Grid supply (or a DG set) and Lithium ion battery.

1.2 This document contains the generic requirements of Hybrid (AC + DC) Uninterrupted power supply (UPS) System based on Switch Mode Power Supply (SMPS) techniques for providing uninterrupted AC power and also DC power to the equipment associated with various Telecom systems, working on 230V AC and / or optional 5V DC Power supply. This type of power supply is so designed so that, when both the output of SMPS Rectifier and SPV power source are available, load requirement is met by SPV (Solar Photo Voltaic) Source. SPV power source shall deliver the load as per its available power, remaining load shall be taken care of by SMPS/Battery as per the preference given by the purchaser.

1.3 The hybrid UPS system envisaged in this GR is capable of catering to load requirements up to 4KVA for DC & AC Operated telecom equipments and having redundancy of rectifier units / modules in Hot Standby and Hot Swappable mode.

1.4 All the requirements described in chapter 2 of this document are suggestive requirements and shall be decided by the purchaser at the time of procurement/ tender as per his requirements. However, the requirements described in Chapter-2 will not be tested/ verified by TEC.

1.5 For all TEC standards/specification and other standards referred in this document, the latest release/issue with all associated amendments, addendum and corrigendum shall be applicable

2 Functional Requirements:

Basic Functional Blocks of the system is shown as below:-

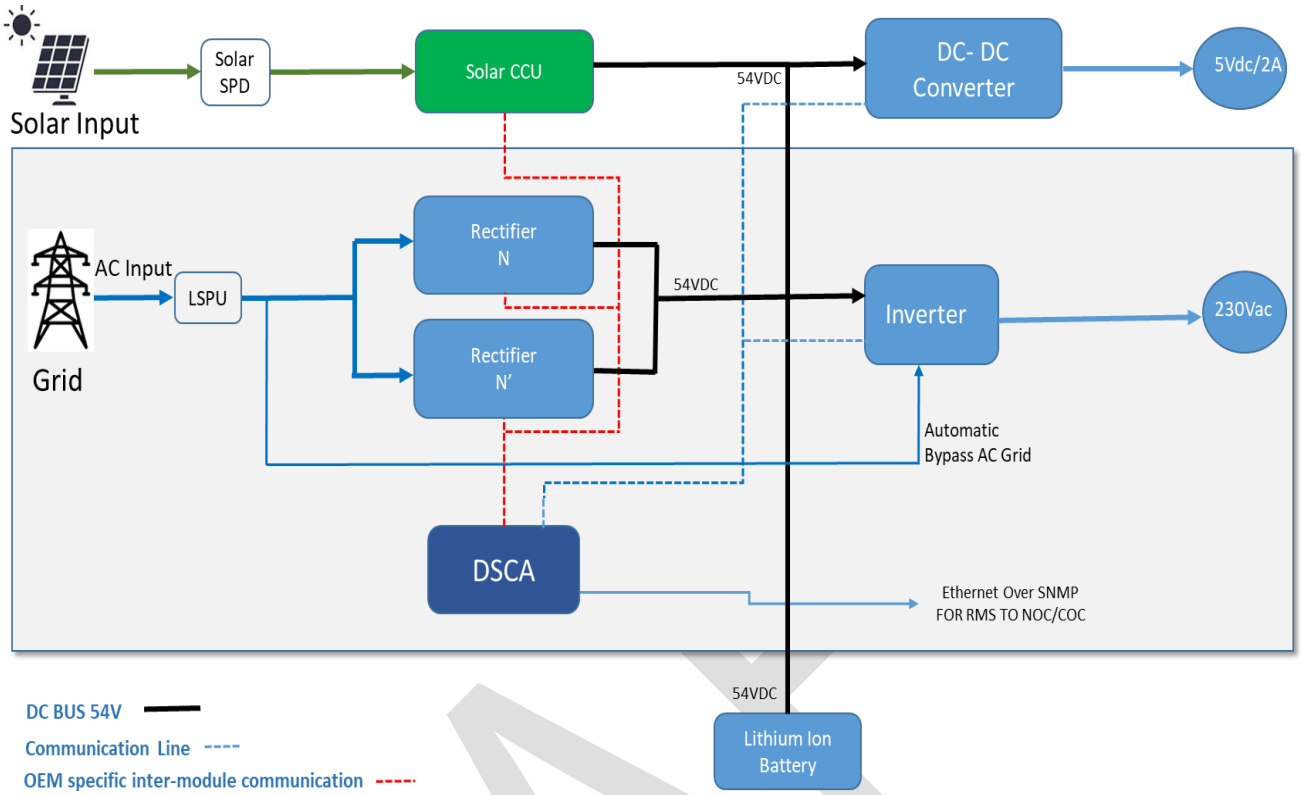

Fig.1 Typical block-schematic layout of Hybrid UPS System

System consists of following major power and control Units / modules: -

a) Rectifier Unit / Module (Hot Standby and Hot Swappable mode)

b) Solar CCU Unit / Module (optional)

c) Inverter Unit / Module

d) DSCA

e) DC-DC Converter (optional)

The internal communication from all the modules /units to DSCA shall either CAN / RS-485 with OEM specification. In respect of DC-DC converter, alarms can be extended in the form of potential free NO/NC Contacts in

case of no specific requirement from the purchaser/procurer for RS-485 / CAN interface. For remote monitoring, system shall support SNMP (Simple Network Management Protocol). However, system shall also support RS-485 modbus communication additionally if it is required by the purchaser/procurer

Following are the other connected power Sources: -

a) Solar (SPV) Panel

b) Li-ion Battery

3 Operational Requirements:

3.1 Rectifier Unit / Module

Rectifier unit / module shall convert AC input voltage into 54Vdc output. Rectifier unit / module design shall meet following specifications.

3.1.1 **AC input voltage**: There shall be an inbuilt automatic cut-off to protect the rectifier unit whenever the input voltage is beyond the specified operating range (nominal 230 volts AC) for single phase operation. The single phase AC input voltage range of the rectifier shall be between 100 V and 300 V.

3.1.2 **DC output voltage :** The DC output voltage of the rectifier shall be 54Vdc.

3.1.3 **DC output voltage range:** The DC output voltage range of the rectifier shall be between 42Vdc to 56Vdc.

3.1.4 **Voltage Harmonic distortion (V_{thd})**: The total line harmonic voltage distortion shall not be more than 5% under all working conditions.

3.1.5 **Current Harmonic distortion (I_{thd}):** The total current harmonic distortion contributed by the Hybrid Power System unit at the input shall not exceed

10% for input voltage range 90V-300V for load between 50 to 100% of the rated capacity. Load Capacity shall be sum of AC output & Battery charging power.

3.1.6 **Input Power Factor:** The true input power factor at nominal input, output, and full rated load shall be better than 0.98. In any other working condition and load between 50% to 100% shall be better than 0.95. Only active power factor correction shall be employed for the purpose.

3.1.7 **Peak to Peak Ripple:** Battery charging circuit ripple Voltage shall not exceed 300mV (without battery connected) at rated capacity & Nominal Input Voltage.

3.1.8 **Soft start feature:** Slow start circuitry shall be employed such that the input current and input voltage of the rectifier unit reach their nominal value within 10 seconds. This feature is employed to avoid sudden loading on the input source.

3.1.9 **Load regulation:** The DC output voltage shall be limited to ±5% of the set voltage & return to their steady state within 20 ms for any load of 25% to 100%.

3.1.10 **Line regulation:** The DC output voltage overshoot for a sudden change in AC mains from specified lowest to highest and vice-versa shall not cause shut-down of the rectifier module and the voltage overshoot shall be limited to +/-5% of its set voltage and return to steady state within 20 ms.

3.1.11 **Current Limiting (Voltage droop):** The Current Limiting (Voltage Droop) shall be provided for the operation of the rectifier. The current limiting shall be continuously adjustable between 50 to 100% of rated output current for output voltage range of 42Vdc to 56Vdc. For test purposes upper limit of 100% +5%

and lower limit of 50% -5% shall be acceptable. The current limit adjustment shall be provided through a menu driven program on DSCA.

3.1.12 **Load Sharing:**-For n+n' configuration, load sharing should be within +/- 10 % for working rectifiers.

3.1.13 **Operating Temperature:** The operating temperature of the rectifier is 0°C to 50°C. De-rating is allowed when the temperature is above 50°C and until 75°C. When the temperature is > 75°C, thermal shutdown is allowed.

3.1.14 **Cooling:** Forced cooling is permitted in the rectifier module

3.1.15 **Redundancy:** Rectifier shall be so designed that redundancy shall work in Hot Standby and Hot Swappable mode with 7 days cyclic operation. When installed Rectifiers are in healthy condition, only main rectifier unit(s) / module(s) (n for n+n' configuration where n= nos of main rectifier units / modules and n'= nos of hot standby rectifier units / modules) should support the battery charging & inverter load. In case of failure of working rectifier, available rectifier input power should be connected & turn on to resume the load back to hot standby (n') rectifier unit(s) / module(s) from solar source / battery. For maintaining same run-hrs. cyclic function should also be employed to enhance the rectifier life. Period of cyclic operation shall be modified as per the requirement of purchaser/procurer.

3.1.16 **Protections:** The module Shall be protected against the following conditions.

- Over temperature
- Short circuit
- Overload
- Input high/low voltage
- Output over voltage
- Temporary Over Voltage (TOV) 350V for 1 minute.

3.1.17 **LED/LCD Indication:** There are three types of indicators either built into the rectifier or to be displayed in common LCD panel. The green colour LED light indicates its health, the Yellow/Amber colour LED light indicates a warning, and the major is indicated by the red LED light. In case of not providing above LED indicators, status of the rectifier (Healthy / Warning / Major) shall be displayed in common LCD panel.

3.1.18 Rectifier Rating

Configuration of System:

Basic Rectifier and Inverter rating shall be as per the table given below.

System ultimate Output Load capacity	Basic Inverter	Basic Rectifier	No. of rectifiers in system
0.5KVA	0.5KVA	>= (1.1 x Inv. DC input power) + (Battery charging power)	No. of Rectifier = n+n' (n' = hotstandby)
1KVA	1KVA	>= (1.1 x Inv. DC input power) + (Battery charging power)	No. of Rectifier = n+n' (n' = hotstandby)

2KVA	1KVA	>= (1.1 x Inv. DC input power) + (Battery charging power)	No. of Rectifier = n+n' (n' = hotstandby)
3KVA	1KVA	>= (1.1 x Inv. DC input power) + (Battery charging power)	No. of Rectifier = n+n' (n' = hotstandby)
4KVA	1KVA	>= (1.1 x Inv. DC input power) + (Battery charging power)	No. of Rectifier = n+n' (n' = hotstandby)

Example:-

Load Power	Li-ion Battery (LiB)	Batt AH	Charging Power @ 0.2C, 54V	Inverter DC Input Power	Basic Rectifier Rating	Selected Rectifier
(VA)	(VAH)	(48V)	(Watt)	(Watt)	(Amp)	(Amp)
User Entry	User Entry	LiB / 48V	Batt AH x Charge Rate (0.2) x	Load Power x PF (0.8) / Inverter Efficiency (0.85)	[1.1 x Inv. DC I/P Power + Charging Power] / 48	-

			54V			
1000	4800	100	1080	941	44	50A

3.2 Solar Charge Controller Unit / Module (Solar CCU): Solar charge controller module shall convert Solar PV Panel / Array input voltage into 54V DC output voltage using MPPT technology. The Solar Charge Controller shall have galvanic isolation and telecom equipment should never be allowed to get exposed to the un-isolated source of power. Solar CCU shall meet following specifications.

3.2.1 Input Voltage (Nominal): The nominal input voltage (DC) shall be specified by the manufacturer based on maximum power point tracking voltage (Vmp) as per

SPV Panel datasheet and based on solar panel capacity / rating conveyed by the purchaser / procurer. For example, 1KW Solar CCU, nominal input voltage will be 42*2=84Vdc where 42Vdc is Vmp Voltage of 1 SPV Panel of 500 W (Based on OEM / manufacturer SPV Panel Datasheet).

3.2.2 Input Voltage (Range): The allowable input voltage (DC) range is to be specified by the manufacturer based on SPV Panel datasheet and considering solar panel capacity / rating conveyed by the purchaser / procurer. Solar CCU should provide full output power up to input voltage "Vmp*N–10%" (Vmp should be derived from SPV Panel datasheet, N is no's of SPV Panel connected in series.). Linear de-rating of solar CCU is allowed below "Vmp*N– 10%".

3.2.3 DC Output Voltage : The DC output voltage is 54Vdc.

3.2.4 **DC Output Voltage Range:** The DC output voltage can vary between **42Vdc and 56Vdc**.

3.2.5 **DC Output Current**: The current rating of solar module will depend upon the load current and battery charging requirement. As an example- for 1KW full rated load (Inverter Output Power + battery Charging Power), considering DC output voltage of 54V, DC Output Current shall be 18.5Amp.

3.2.6 **Power Conversion Efficiency:** The Power Conversion Efficiency: Under nominal input and output conditions, the power conversion efficiency shall be ≥ 93% and Solar CCU (MPPT) tracking efficiency ≥98%. For validation of this parameter, test reports of NABL accredited / TEC designated lab shall be allowed.

3.2.7 **Peak-to-Peak Ripple:** The peak-to-peak ripple in the output voltage is **less than** 300mV..

3.2.8 **Soft Start Feature:** To prevent sudden loading on the input source, a **soft start feature** is required.

3.2.9 **Load Regulation**: The DC output voltage must remain within **±5%** of the set voltage and return to steady state within **20ms** for any load ranging from **25% to 100%**.

3.2.10 **Line Regulation**: During sudden changes in input voltage (from lowest to highest or vice versa), the DC output voltage overshoot must not cause module shutdown. The overshoot is limited to **±5%** of the set voltage, returning to steady state within **20ms**.

3.2.11 **Current Limiting**: The system must incorporate **current limiting** to manage voltage droop.

3.2.12 **Operating Temperature:** The operational temperature range is 0°C to 50°C. De-rating is allowed when the temperature is above 50°C and until 75°C. Beyond 75°C, thermal shutdown is permissible.

3.2.13 Cooling: Forced cooling is permitted in the Solar CCU

3.2.14 Construction: The solar charge controller is so designed that it can be plugged into a connector fixed within the hybrid ups system chassis.

3.2.15 Interface with DSCA: The Solar CCU communicates with the **DSCA** (Distribution, Switching, Control, Alarm and Monitoring unit) to share alarms and data. Additionally, it can charge the battery in a manner similar to how the rectifier charges the battery, following commands from the DSCA.

3.2.16 Protections: The module is safeguarded against the following conditions:

- Over temperature
- Short circuit
- Overload
- Input high/low voltage
- Output overvoltage

3.2.17 LED/LCD Indication :

The LED indicators provide visual feedback on solar CCU as under:

I. Green: Healthy II.

Yellow/Amber: Warning

III. Red: Major

In case of not providing above LED indicators, status of the solar CCU (Healthy / Warning/ Major) shall be displayed in common LCD panel.

3.3 Inverter module

Inverter module converts DC input voltage into 230Vac output. The inverter shall be based on Switch Mode Power Supply (SMPS) techniques using switching frequencies of 20KHz and above. It shall also have AC bypass option. Following specifications are applicable for Inverters rated upto 4KVA.

3.3.1 Inverter input voltage

i) Inverter input voltage 54Vdc ii) Inverter input voltage (Range) 42Vdc to 57Vdc

3.3.2 Inverter Bypass Voltage Inverter Bypass voltage range is 176Vac to 265Vac. In case of failure of inverter output section, Inverter shall go to bypass mode. Output of inverter in bypass mode shall be 176Vac to 265Vac. If bypass voltage is beyond the defined range, Inverter shall disconnect the load from the bypass supply.

3.3.3 AC output Voltage AC output Voltage at Nominal 230Vac ±5% Uninterrupted single phase sine wave output.

3.3.4 Output Frequency Out of Range: The inverter shall trip, if the output frequency goes beyond +/- 2Hz of the nominal 50 Hz.

3.3.5 Load transfer

I. **Transfer to standby power** – 10ms

Provision of automatic transfer of load to stand by power (AC mains, DG Set or VR) within 10ms, in the event, the inverter/s fail/s to take load due to any reason.

II. **Transfer back to inverter** – 10ms

Transfer of load back to inverter unit/ system shall also be automatic but it shall take place, only after the inverter output has stabilized and is within the specified limits. Transfer time in this case shall also be within 10ms.

3.3.6 Inverter output power: The inverter shall be capable of delivering a continuous uninterrupted single phase sine wave full output power as per its rating up to 4 KVA and purchaser will decide inverter capacity starting from 0.5KVA to 4KVA.

3.3.7 Power Factor: The Power Factor with resistive full load and at nominal input shall be near unity (>=0.99) without the use of Power Factor improvement capacitors.

3.3.8 Transient Response: The transient overshoot shall not exceed 10% with battery floated under the following conditions provided it gets restored within regulating range within 60ms:

i) Load Switch ON ii) Step change of input voltage specified in the GR.

iii) Load change from 100% to 10% and vice versa

3.3.9 Total Voltage Harmonic Distortion: The Total line harmonic voltage distortion The Total line harmonic voltage distortion shall not be more than 3% for resistive load and shall not be more than 5% for non-linear load..

3.3.10 Overload Protection

(a) 105%-125% overload time≥180s, (b)126%-150% overload time≥30s ;

Recovery with 90% load. within 60sec.

3.3.11 Operating Temperature: Operating temperature of the inverter is 0°C to 50°C De-rating is allowed when the temperature is above 50°C and until 75°C. When. the temperature is > 75°C, thermal shutdown is allowed.

3.3.12 Cooling: Force cooling with inbuilt fan.

3.3.13 Interface with DSCA: Shall communicate with DSCA to share its alarms and data.

3.3.14 Protections

Inverter should be protected against any such condition

- Over temperature
- Short circuit
- Over load
- Input high/low voltage
- Reverse polarity

3.3.15 LED indications (optional): The LED indicators shall provide visual feedback either on inverter or to be displayed in common LCD panel in respect of following status: -

- Load on Inverter
- Load on Bypass
- Alarm
- Rev. polarity

In case of not providing above LED indicators, status of the Inverter (Load on Inverter / Load on Bypass / Alarm / Rev. polarity) shall be displayed in common LCD panel.

3.4 DSCA (Distribution, Switching, Control, Alarm and Monitoring unit)

The hybrid power system shall consist of a common controller called DSCA, based only on menu driven Micro Processor Controlled Techniques for control, monitoring & alarms. It shall control the operation of rectifier/Solar charge controller, battery charging etc. It shall monitor alarms, various parameters and report them to the remote monitoring system. DSCA shall display its Software version.

3.4.1 For remote monitoring purpose, system shall support SNMP (Simple Network Management Protocol) v2 or higher version.

3.4.2 . However, system shall also support RS-485 modbus communication additionally if it is required by the purchaser/procurer.

3.4.3 DSCA shall have the remote software up-gradation feature through Over the Air (OTA) using Ethernet interface. However, DSCA shall also support remote software up-gradation feature using RS485 interface as applicable.

3.4.4 Setting of all the parameters shall be through menu-driven microprocessor control only. Use of potentiometer at any stage is precluded. The failure of Microprocessor or DSCA shall not affect the setting of individual rectifier / Solar charge controller / Inverter / DC-DC converter module and none of the parameter shall be disturbed. (Purchaser may decide about redundancy of DSCA based on its application.) Only the setting of new parameters from DSCA, shall be affected. In the event of failure of DSCA, all the modules shall take care of the load on latest settings.

3.4.5 There shall be a provision for Automatic isolation/reconnection of battery from the load. The operate and release voltages for the above conditions shall be as follows:

- Cut-off Voltage (V): 42V to 44 V.
- Reconnect Voltage: 48V.

3.4.6 DSCA shall communicate with Li-ion battery BMS to monitor the parameters and alarms and control the charging current of battery. Charging voltage shall be 54.0V or specified by the purchaser based on the requirement.

3.4.7 Battery path Current Limit: Battery Charging Current shall be settable from 10 to 50% of battery AH capacity.

3.4.8 Protections: Failure of control and sensing circuitry of DSCA shall not cause any hazard. The voltages of the system shall not abnormally increase to endanger the load.

3.4.9 Monitoring Alarms and Indications: Visual indications/display shall be provided by means of bright LCDs/LEDs on DSCA to indicate the following minimum conditions (but not limited to) :

a) Battery Voltage High (above 56V)/Low (below 45.6V)

b) Rectifier fail

c) Mains fail

d) Mains "ON"/Battery Discharge

e) Fan Fail (in case fan provided at rack level)

f) Battery Fail or Battery missing (separate for each Battery)

g) Battery isolated from the load

h) Lightning and surge protection

i) Solar charge controller fail

j) Inverter fault

k) Inverter overload

l) DC-DC Converter fail (If converter provided)

m) AC output voltage abnormal

3.4.10 DSCA shall have inbuilt logic to maximize solar utilization.

3.4.11 Other Features (optional)**:** The purchaser may decide the requirements for optional Management features like

a) Energy saving Management,

b) Battery Efficiency & Management,

c) Data Logging of all the parameters and alarms which may be downloadable in excel or any readable format.

d) Ability to calculate and display run hrs with input power source from EB, Solar, Battery as applicable,

e) USB port or any other secured mode to download log file in pen drive, other authorised storage devices, etc.

3.5 DC-DC Converter: Following specifications are applicable.

3.5.1 Input Voltage : The input voltage is 54 Vdc, and the input voltage range is between 40 Vdc and 57 Vdc.

3.5.2 Output voltage: The output voltage of the converter shall be 5Vdc, 2A. Purchaser shall specify other requirement of output voltage and current of the converter, if any.

3.5.3 Output Power: The output power of the converter shall be 10W. The purchaser may specify for the higher capacity requirement.

3.5.4 Operating temperature: The operating temperature of the converter is 0°C to 50°C without de-rating.

3.5.5 RS485 / CAN communication: DC-DC converter shall communicate with DSCA through RS485/CAN for alarms and data as specified by the purchaser/procurer. In case of no specific requirement from the purchaser/procurer

for this interface, DC-DC converter shall extend alarm in the form of potential free NO/NC Contacts. **3.6 Solar (SPV) Panel**

3.6.1 Solar (SPV) Panel is not part of the HUPS envisaged in this GR and it only provides one of the input power supply sources. Purchaser / procurer shall ensure appropriate capacity, quality, protection of solar module / panel /array and structure including termination box of such solar system to meet the requirement. Solar Panel / SPV Power Generating Source connected to HUPS shall be compliant to TEC relevant standard as specified by the Purchaser / procurer.

3.6.2 Explanation mentioned here is for information and mainly related to interface requirements to connect SPV panel to HUPS.

3.6.3 The SPV modules, being used for Telecom supply, need to be characterised at NPL (National Physical Laboratory) or any other recognised Test Lab. for each type of cells used. The manufacturer will give the spread-in of silicon cells used by him.

3.6.4 Electrical requirements: The module must deliver full current to the load corresponding to the terminal voltage of power generating source 54V for 48V SPV power generating source, plus the diode drop and cable drop at a maximum expected cell temperature (55°C).

3.6.5 Insolation: The mean Insolation on any panel kept at optimum tilt at places where the solar panel is to be used shall be 4.5 KW hour/m2/day.

3.6.6 Minimum stipulated life: The de-rating factor of 0.5%/year of the SPV Generating Source/module rated power is permissible. The module/SPV power generating source shall deliver at least 90% of its rated power in 10th year.

3.6.7 **Peak (Maximum) Power Output:** The SPV Module shall deliver minimum specified rated power at maximum power point of "IV Curve" at standard condition of 100 mw/cm2 solar intensity at 25 deg C AM 1.5.

3.6.8 **Cells:** Cells can be either mono-crystalline or Polycrystalline encapsulated or mono PERC Silicon Cells. All the cells used in a module shall be identical, of regular shape and shall have the same rating with tolerance +/-5%. The actual rating of the modules in a panel shall be within 5% of the average rating of the four modules. While in an array, the rating of the panels shall also be within 5% of the average rating of the panels in the SPV power generating source.

3.6.9 **Considering** the application and Geographical location of India, the number of cells in series in a module shall be 36.

3.6.10 **Open circuit Voltage:** Maximum, minimum and nominal Voltages to be specified, by the manufacturer, at 25 deg C, but in no case it shall be less than the specified value.

3.6.11 **Short circuit Current:** To be specified by the manufacturers.

3.6.12 **Voltage de-rating:** shall not be more than -0.5% per degree C above 25 degree Cell temperature.

3.6.13 **Conversion efficiency and Fill factor:** Conversion efficiency of the encapsulated cell, at peak power, shall not be less than 20% for mono perc and for other technologies that of module shall not be less than 12%. Fill factor shall be better than 68%.

4 Other Requirements:

The general features of system shall be as under: -

4.1 Efficiency

Efficiency of the Hybrid UPS system while working on Rectifier and Inverter shall be more than 85% for nominal input, output, and full-rated load (Inverter output power + battery charging power). It shall be more than 80% for other specified Input, output conditions, and the load shall be between 50% to 100%.

4.2 Solar CCU and DC-DC Converter are optional. However, HUPS shall be able to support addition of Solar CCU and DC-DC Converter unit/ module as and when required in the same system.

4.3 Constructional Features:

The HUPS structure shall be made up of rigid frame work of steel profiles and shall be free of sharp edges or sharp corners. The structural strength of the rack shall be able to withstand the ultimate mechanical load capacity of the shelf without any deformity. The gauge of metal sheet for load bearing part shall not be less than 1.5 mm and for rest of the parts shall not be less than 1.2mm. Sheet used in manufacturing Shall be Galvanized (GI – ≥80gsm) or MS Iron.

The Power System shall be 19" rack or floor mounted as or as specified by the purchaser/procurer

Power System shall have provision to accommodate following units in 19" (482.6 mm) Sub-rack or in the box specified by the purchaser:

1. Float Rectifier-cum-Float Charger (FR/FC)
2. Solar Charge Controller Unit (CCU)
3. DC to AC Inverter
4. DC to DC Converter
5. Distribution, Switching, Control, Alarm and Monitoring (DSCA) unit

Proper thermal engineering shall be done by the manufacturer so as to ensure the uninterrupted use of the equipment.

Power System / Shelf Shall conform to the latest issue of IS 101 and IS 168. The structure and panels shall only be powder coated. The thickness of powder coating shall be between 60 to 100 Micron. The Colour used shall conform to IS 5 latest issue.

Colour scheme shall be as follows:

I. Sub rack: RAL7035, (Light Grey)

II. Units / Modules and inside: Shall harmoniously match with shelf colour.

The individual modules shall be easily mounted to/removed from the front side of the rack. The Module shall be designed to slide into the sub-rack on a suitable mechanical arrangement. The associated AC input, DC output connections, Control, alarms & interface cable connecting the modules shall be connected /

disconnected easily without causing any interruption in the supply and damage to load or other working module

4.4 Lightning and Surge protection:

4.4.1 Stage-2 Lightning and Surge Protection for AC input

Stage-1 Lightning and Surge Protection is not in the scope of system. Stage2 Lightning and Surge Protection for AC input of Site against the lightning and high voltage surges shall be as per GR of lightning and Surge Protection of Site (GR No. TEC 66130:2024). Purchaser may decide to buy Stage -1 & 2 protection devices for equipment safety against lightning and surges.

4.4.2 Stage – 2 Surge protection device shall be provided inside the HUPS in compliance of GR No. TEC 66130:2025 or latest.

4.4.3 Protection of charge controller from SPV array side

Surge protection Device on input side of Solar CCU shall consist of MOV surge-arrestors (Type II) connected between +ve and ground, –ve and ground. SPD shall be able to discharge max current (8/20 µsec) of 40KA & nominal discharge current of 20KA (8/20 µsec). SPD shall have Iscpv (short-circuit current rating) value as per the total SPV system current with a minimum value 1000A of Iscpv. SPD shall have thermal Disconnection for fail safe operation. SPD shall comply to the IEC 61643-31 standards ~~and shall be certified from labs accredited by ILAC signatories from non- border~~

~~sharing countries or TEC designated labs as applicable as per prevalent instructions MTCTE instructions.~~

4.5 Bus-bars, Cable & Wiring:

Tinned Bus-bars or tinned High conductivity electrolytic copper strips with purity of 99.90% (min) as per BIS standard IS: 613 latest issue, be able to withstand maximum Load current. Nuts & bolts shall be of stainless steel with tinned copper washers only. The tinning shall be in compliance of IS 1359: 1992 and its thickness shall be 10 µm(minimum).

All the wires and cables including Uninyvin cables used shall be fire retardant as per IS 1554 with amendment 1 (June 94). All the cables & wires used shall also be Rodent & reptiles repellent. Uninyvin cables are also allowed to use in system.

4.6 Accessibility & Terminations

All the termination points for AC input, solar, battery, load and earthing shall be easily accessible from front, top & rear with proper labelling and safety compliance.

All the AC, DC Control & alarm cabling shall be supplied with the Power Shelf.

4.7 Name Plate:

A name plate anodised, screen printed or any other better arrangement ensuring better life expectancy shall be suitably fixed inside / on shelf and contain following information:

1. TEC Standard Number:
2. Manufacturer's name:
3. Model No.:
4. Unit Serial No.:
5. TAC No.
6. Output Voltage and Current (AC):
7. Battery Voltage (DC): 48 V
8. Year & Month of manufacturing:

4.8 Documentation:

Technical literature in English with complete layout, detailed block schematic and circuit diagrams of its assemblies shall be provided. All aspects of installation, operation, maintenance, trouble shooting and replacement shall be covered in this manual. This manual can be provided as a soft copy or QR code and/ or hard copy as specified by the purchaser. Label or suitable arrangement for address and telephone numbers of Maintenance centre shall also be provided.

4.9 Remote Monitoring of Hybrid UPS and Remote Communication Protocol

DSCA controller shall having the necessary features to exchange information between Hybrid UPS system & Remote Site monitoring equipment through

SNMP and RS485 Modbus Communication as specified at Section 1.3 of TEC GR 66110: 2024. OEM / Manufacturer of HUPS shall ensure that HUPS shall be interoperable with the equipments / products that need to be connected with the HUPS system. Further, in case of any problems / issues in interoperability, the concerned manufacturer /OEM shall extend support / help in solving the problems / issues. List of alarms and parameters to be extended over (a) SNMP for remote monitoring (b) RS485/CAN/MODBUS for internal communication shall be as per TEC GR 66110 : 2024 in addition to specifically mentioned in this document. Purchaser may specify the additional alarms to be extended for remote monitoring over and above the alarms listed in TEC GR 66110:2024.

5 Quality Requirements:

5.1 Components:

The component parts of the equipment shall be of professional grade of reputed manufacturer to ensure prompt and continuous service and delivery of spare parts. Use of potentiometer is precluded. Switching components used on the AC input side shall be rated at 600V (minimum)

5.2 Power transformers and Chokes

Power transformers & chokes shall use class B or higher grade of insulation. The transformers and chokes shall be wound with copper wire and provided with adequate insulation.

5.3 Fuses or circuit breakers shall be provided wherever appropriate for the protection against failure of control/sensing circuit. Fuses shall conform to B.I.S specification.

5.4 **Meters:** There shall be provision to monitor Parameter of the system with the help of DSCA Display or external meter to read voltage and current of the

System, Battery, CCU. Display resolution Shall be such that it is clearly and unambiguously readable from a distance of 1 meter.

I. Current: ± 1.5% of the range or better, shall be able to read up to full digit for meter range 50A & above and 1 place decimal for lower meter range.

II. Voltage: ± 1.5% of the range or better with a resolution of one decimal point in case of DC voltmeter and full digit in case of AC voltmeters.

5.5 Component Approval: The components used in Hybrid UPS System, shall be certified by recognized National/International Institutions and approved by CACT wing. Components shall neither be combustible nor support combustion. NABL approved test reports are also be acceptable as an alternative to approval of CACT wing.

5.6 Quality and Workmanship: The equipment shall manufacture in accordance with international quality management systems ISO-9001-2015, for which the manufacturer shall be duly accredited. A quality plan describing the quality assurance system followed by the manufacturer would be required to be submitted.

5.6.1 The equipment shall be manufactured as per the latest Guidelines indicated in Quality Manuals QM-118 (Quality reliability in product design), Manuals QM202 (Pictorial guidelines for Visual assessment of quality of printed board assemblies (PBA) and discrete terminal assemblies), QM-204 (Guidelines for workmanship standards for repair & modification of printed wiring board assemblies), QM-205 (Guidelines for standard of workmanship for printed boards), QM-206 (Guidelines for standard of workmanship for printed boards assemblies), QM-207 (Guidelines for soft solder and fluxes for

Telecom Equipments) and QM 210 (Guidelines for standard of workmanship for surface Mounting Devices).

5.6.2 All wiring shall be neatly secured in position and adequately supported. Metal panel or cover holes through which the wires or cables pass shall be suitably bushed.

5.7 BURN IN TEST: The fully equipped rack shall be capable of withstanding a burn-in test for 72 hours at an ambient temperature of 50· C when the equipment is working at full rated load. This test may be performed in a temperature controlled room with free air flow. The ambient temperature shall be measured at a distance of 1 foot from the equipment under test. The necessary set-up for the purpose shall be provided by the manufacturer.

5.7.1 The temperature rise of the heat dissipating components above the ambient, measured directly or at heat sink in the first eight hours of the test, shall not be more than:

5.7.2 Transformers and Chokes: 70°C for Grade B insulation.

For higher grade of insulation, higher temperature rise may be permissible, subject to the following conditions:

i. It is at least 20°C below the permissible limit for the grade of insulation used.

ii. The temperature rise shall be at least 30°C below Curie temperature of the magnetic material.

iii. This temperature shall neither affect other components nor shall lead to fire hazard.

5.7.3 Semiconductor devices: 60°C or as per component spec.

5.8 Insulation Resistance Test: The insulation resistance of the complete Hybrid UPS System when tested with a 500V DC megger shall not be less than 5meg ohms for the following conditions:

- Interconnected Input terminals and Earth

- Interconnected Output terminals and Earth

- Interconnected Input terminals and Interconnected output terminals.

5.9 Voltage Proof Test: No breakdown or abnormal temperature rise shall occur, when-after EMI/RFI capacitors and MOVs/Tranzorbs etc. removed from the circuit.

Test to be Conducted as per module/ unit-wise

Rectifier

1. 1.5KVAC between Earth and AC input
2. 650V DC between DC output and Earth
3. 2KVAC between AC input and DC output

Inverter

1. 650V DC between input and earth
2. 1.5KVAC between AC Output and Earth
3. 2kVAC between DC Input and AC output

Solar CCU

1. 650V DC Input and Earth
2. 650V DC Output and Earth

3. 1200V DC between DC Input and DC Output.

DCDC converter

650V DC between Input and Earth

Alternatively, without removing EMI/RFI capacitors, the lightning protection circuitry and Tranzorbs etc., but with EMI/RFI discharge resistors removed:

Rectifier

1. 2150V DC between Earth and AC input
2. 650V DC between DC output and earth
3. 2150DC between AC input and DC output

Inverter

1. 650V DC between input and earth
2. 2150V DC between AC Output and earth
3. 2150V DC between DC input and AC output

CCU

1. 650V DC input and earth
2. 650V DC output and earth
3. 1200V DC between DC Input and DC Output.

DCDC converter

1. 650V DC between Input and Earth.

This DC voltage test is in accordance with UL950 & IEC 950 Standards.

Note: This Test is to be conducted on each of the basic units/module of the system.

5.10 Noise & Vibration:

The fully equipped power shelf at full load shall not contribute more than 15 dB (weighted) to the ambient noise level taken as 45dBA. It shall be measured at a distance of 1 metre from the unit & 1.25m above the floor level in the Acoustic Range. The correction factor for Total Noise when the ambient noise level is more than 45dBA, shall be as given below:

Ambient Noise	Correction Factor	Ambient Noise	Correction Factor	Ambient Noise	Correction Factor
45dBA	0dB	51dBA	1.41dB	57dB	3.69dB
46dBA	0.18dB	52dBA	1.73dB	58dB	4.17dB
47dBA	0.39dB	53dBA	2.07dB	59dB	4.68dB
48dBA	0.61dB	54dBA	2.43dB	60dB	5.21dB
49dBA	0.86dB	55dBA	2.82dB		
50dBA	1.12dB	56dBA	3.25dB		

Note: The correction Factor shall be added to the limit of 60 dBA to arrive at the limit when the ambient is greater than 45 dBA

5.11 Field Trial : For new products field trial may be carried out by purchaser for the period of one month.

5.12 MTBF & MTTR:

I. **MTBF** of the each module/unit shall not be less than 100,000 hours excluding fan.

II. **Module Replacement Time:** The mean time to replace / restore (MTTR) a faulty module/unit (Rectifier, Inverter, CCU, DC-DC Converter) shall be less than 2 minutes.

5.13 Environmental:

Each system shall be capable of operating in conditions conforming to TEC 14016:2010 (old no.QM-333:2010, category B2 or D whichever applicable). It shall also comply with vibration requirements of clause 12.0 of TEC 14016:2010 . The system shall also be capable of working in saline atmosphere of coastal areas and up to an altitude of 3000 metres in compliance of TEC 14016. The environmental tests shall be performed by configuring the power System as follows:

i. DSCA for ultimate capacity ii. One

FR/FC, INVERTER, CCU & Converter.

6 EMI/ EMC:

6.1 Radio Frequency Interference (RFI) Suppression

The system (FR/FC, CCU, INVERTER & DSCA modules) shall be designed to minimize the level of electromagnetic interference (EMI), both conducted and radiated, detected in its vicinity and generated by the module and shall comply the following clauses:

I. Conducted and Radiated Emission from the Power equipment.

Name of EMC Standard: CISPR 11 (2015) or latest

"Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement ".

Limits: -

a) To comply with Class A of CISPR 11 (2015) or latest.

b) The values of limits shall be as per relevant tables under CISPR11 (2015) or latest.

II. Conducted Susceptibility Limits: Power equipment used in Telecom Network shall not malfunction when high voltage surge as specified below is superimposed at the input power mains to the power equipment, for more than two seconds as per IEC 61000- 4-18. The equipment shall also not fail or degrade in performance after the surge is withdrawn.

Test levels:

Voltage Rise time (First peak) : 75 nano sec +/- 20%.

Oscillation Frequencies : 100KHz & 1 MHz +/- 10%

Repetition rate : at least 40/s for 100KHz and 400/s for 1 MHz

Decaying : 50% of the peak value between the 3rd & 6th periods

Burst duration : not less than 2s

Surge amplitude : 250V(-10%) to 2.5 KV(+10%)

Wave shape : Damped

Level	Open Circuit output test voltage (kV)	
	Slow damped oscillatory wave (100KHz,1MHz)	
	Line to Line	Line to Ground
2	0.5	1

III. Electrostatic discharge (ESD) immunity limits: The limits and test methods as per IEC 61000- 4-2, (both Contact discharge method and Air discharge method) as given below:

Test level:

Contact discharge		Air discharge	
Level	Test voltage (KV)	Level	Test voltage (KV)
2	4	3	8

IV. Electrical fast transient/Burst immunity limits: The limits and test methods as specified in IEC 61000-4-4.

Test level:

Open–circuit output test voltage (+/-10%) &repetition rate of impulses (+/-20%)		
Level	On Power supply port, Protection Earth	
	Voltage peak KV	Repetition rate KHz
2	1	2.5
Rise time of one Pulse duration	- 5 ns +/- 30% Impulse - 50 ns +/- 30%	

V. Radiated radio-frequency Electromagnetic field immunity limits: The limits and test methods as specified in IEC 61000-4-3.

Test Level:

Frequency range : 80 MHz to 1000 MHz	
Level	Test field strength V/m
3	10

VI. Surge immunity limits: The limits and test methods shall be as specified in IEC 61000-4-5 “Testing & Measurement techniques for Surge immunity test" for the following limits:-

For mains power input ports:

(a) 1.0 kV +/- 10% peak open circuit voltage for line to ground coupling

(b) 0.5 kV +/- 10% peak open circuit voltage for line to line coupling

(c) 4.0 kV +/- 10% peak open circuit voltage for line to ground coupling (d) 2.0 kV +/- 10% peak open circuit voltage for line to line coupling

VII. Radio-Frequency Conducted Susceptibility immunity limits: The limits and test methods as per IEC 61000-4-6.

Test level:

Frequency range : 150KHz to 80MHz	
Level	Voltage level (e.m.f.)
2	3

VIII. Immunity to voltage dips & short interruptions (applicable to only ac mains power input ports, if any):

Name of EMC Standard: As per IEC 61000-4-11 (2004) (with Input current less than 16A) / IEC 61000-4-34 (2015) (with Input current more than 16A) as applicable “Testing & measurement techniques- voltage dips, short interruptions and voltage variations immunity tests" for the following limits: -

i. a voltage dip corresponding to a reduction of the supply voltage of 30% for 500ms (i.e. 70 % supply voltage for 500ms)

ii. a voltage dip corresponding to a reduction of the supply voltage of 60% for 200ms; (i.e. 40% supply voltage for 200ms)

iii. a voltage interruption corresponding to a reduction of supply voltage of > 95% for 5s.

iv. a voltage interruption corresponding to a reduction of supply voltage of >95% for 10ms.

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016 (old no. TEC/SD/DD/EMC-221/05/OCT-16).

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016 (old no. TEC/SD/DD/EMC-221/05/OCT-16).

7. Safety Requirements:

The equipment shall conform to relevant safety requirements as per IS 16242 (Part 1) : 2014/ IEC 62040-1 : 2017+ AMD1:2021+ AMD2:2022 or latest as prescribed under Table no. 1 of the TEC document 'SAFETY REQUIREMENTS OF TELECOMMUNICATION
EQUIPMENT': TEC10009: 2024.

CHAPTER 2

8 Guideline For The Purchaser/User:

8.1 The purchaser must ensure the availability of separate coordinated Stage-I & II protection devices, as per GR No. TEC 66130:2024 at telecom site, for protection of the Power System, against lightening and high voltage surges.

8.2 The purchaser shall specify the rack dimension for any specific requirement. The type of rack – floor mounted or wall mounted – shall also be specified.

8.3 The purchaser may specify the requirement of field-trial. Feedback, if any, may be furnished to TEC for improvement in the GR.

8.4 The purchaser/procurer shall specify the requirements for optional management features like Battery Health Monitoring, Energy Saving Management, proper functioning during voltage and phase outages, Solar efficiency and Fuel Saving Management, Battery Efficiency & Battery Management, Rectifier Control – Efficiency Management, etc.

8.5 RS 485 and Ethernet (SNMP) communication cable of suitable length shall be protected with surge protection devices (to be decided by purchaser) to be mounted on both side of the cable.

8.6 Purchaser may specify the additional alarms to be extended for remote monitoring.

8.7 Purchaser may specify the preference of load sharing among input sources.

8.8 Purchaser may specify the requirement for Solar CCU and DC-DC Converter.

8.9 Purchaser may specify the requirement of LED indication on the respective unit / module or on LCD panel regarding health of the respective unit / module (clause 3 of chapter 1 refers).

9 Ordering Information:

The following items need to be specified while ordering by Tendering Authority depending on the requirements.

I. Capacity of the battery proposed in Ampere Hours.

II. Solar Panel / SPV Power Generating Source capacity required, specifying TEC relevant standard.

III. Voltage (If different than 5V) and power rating of DC-DC converter.

IV. Height and depth requirement of Hybrid power system.

V. Capacity of the rectifier unit / module (Table on rectifier rating given in clause 3.1 refers)

VI. Inverter output ports

VII. Battery breakers details (quantity and rating)

VIII. Additional requirement of RS485 modbus communication for remote monitoring (Default SNMP)

IX. Period of cyclic operation of rectifier (Default 7 days)

X. In the document, some features (which have been marked as per purchaser / procurer requirements) needs to be examined by the purchaser / procurer and suitably specified in the tender conditions / ordering information as per their requirement.

Important Notes:

1. Load shall include equipment load, battery charging and other load (inverter etc.) if any. Higher battery load for Lithium battery may be considered.

2. While choosing the power System the user shall ensure that the redundancy requirement of rectifier has been taken care of.

3. Float & Charge voltage shall be normally 54.0V in case of Li-ion battery compatible power System. However, the purchaser may also specify Float & Charge voltage based on their requirements. Also, of required,

the purchaser may specify the battery path current in respect of Li-ion battery, if required.

10 Specific Items To Be Mentioned In The Certificate:

Following details of HUPS shall be mentioned on TAC-

1) MAKE AND Model number of the major parts- Rectifier, Inverter, CCU, DCDC & DSCA.

2) Software Version (Wherever applicable) of DSCA, Rectifier, CCU.

ABBREVIATIONS

A or Amps	Amperes
AC	Alternate Current
AH	Ampere Hour
BIS	Bureau Of Indian Standards
CAN	Controller Area Network
CACT	Component Approval Centre of Telecommunication
CCU	Charge Controller Unit
CIGRE	International Conference on Large High Voltage Electric Systems
dB	Decibel
dBA	Decibel Absolute
DC	Direct Current
deg C	Degrees Celsius

DG	Diesel Generator
DOT	Department of Telecommunication
DSCA	Distribution, Switching, Control, Alarm and Monitoring Unit
EB	Electricity Board
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
ESD	Electrostatic Discharge
gL/gG	General line/General Gracia (slow action fuses)
FR/FC	Float Rectifier cum Charger
FR/BC	Float Rectifier cum Battery Charger
GR	Generic Requirements
HUPS	Hybrid Uninterrupted Power Supply System
IEC	International Electro-technical Commission
IS	Indian Standards
ISO	International Organisation for Standardisation
ITU-T	International Telecommunication Union- Telecommunication.
IV	Current vs Voltage
KHz	Kilo Hertz
KV	Kilo Volts
KW	Kilo Watts
LED	Light Emitting Diodes
LCD	Liquid Crystal Device
MCB	Miniaturised Circuit Breaker

MHz	Mega Hertz
MOV	Metal Oxide Varistor
MPPT	Maximum Power Point Tracking
MTBF	Mean Time between Failures
MTTR	Mean Time To Restore
ms	milli seconds
NPL	National Physical Laboratory
OTA	Over the Air
PBA	Printed Board Assemblies
PF	Power factor
QM	Quality Manual
RFI	Radio Frequency Interference
RTEC	Regional Telecom Engineering Centre
SMPS	Switch Mode Power Supply
SNMP	Simple Network Management Protocol
SPV	Solar Photo voltaic
SPD	Surge Protection Device
T & D	Technical & Development
TEC	Telecommunication Engineering Centre
TAC	Type Approval Certificate
TOV	Temporary Over Voltage
V	Volts
W	Watts