SPECIFICATION

OF

SOLAR CHARGE CONTROLLER UNIT

FOR

USE IN S&T APPLICATIONS ON INDIAN RAILWAYS

Version 0

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SIGNAL DIRECTORATE

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Abstract **This document defines Specification of Solar Charge Controller Unit for Use in S&T Applications on Indian Railways.**			

Document control Sheet

Name	Organisation	Function	Level
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AMENDMENTS

Version	Chapter/ Annexes	Amendments	Issue date
Version 0		First issue	04.10.2004
Amendment 1	Following clauses modified/ amended /included for typographical errors, regrouping/inclusion of tests and other technological requirements etc. 3.1, 3.6, 3.12, 4.1.1, 4.1.2, 4.1.9, 4.5.1, 4.5.3, 4.6, 4.6.4, 4.7.1, 4.7.2, 4.7.3, 5.1, 5.3, 5.4, 6.5, 6.10.1, 6.10.5, 6.11.1(i) & 12.0 **New Clauses added** 3.10, 3.13, 4.1.12, 4.1.14, 4.2.1, 4.4.3, 5.2, 6.4.1 & 6.10.9	Second issue	28.02.2006

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Abbreviations used

CDIL	Continental Devices of India Ltd
CRCA	Cold Rolled Carbon Annealed
DC	Direct Current
HIREL	High Reliability
IEC	International Electrotechnical Commission
IR	Insulation Resistance
IRS	Indian Railway Specification
IPS	Integrated Power Supply
IS	Indian Standard
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LMLA	Low maintenance Lead Acid
MCCB	Moulded Case Circuit Breaker
PCB	Printed Circuit Board
PVC	Poly Vinyle Chloride
RDSO/SPN	RDSO Specification
RH	Relative Humidity
SMPS	Switch Mode Power Supply
SPV	Solar Photo Voltaic
VRLA	Valve Regulated Lead Acid

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

DRAFT SPECIFICATION

OF

SOLAR CHARGE CONTROLLER UNIT

FOR USE IN S&T APPLCATIONS ON INDIAN RAILWAYS

0. FOREWORD

0.1 This specification is issued under the fixed serial No. RDSO/SPN/187/2004 followed by the year of adoption as standard or in the case of revision, the year of latest revision.

0.2 This specification requires reference to the following specifications:

IRS: S 23	Electrical Signalling & Interlocking equipment.
IRS:S 76/89	PVC Insulated Cables & Wires for Indoor Signalling.
IRS: S 84/92	Solar Photovoltaic Module.
IS: 694	PVC Insulated Cables for Working Voltage upto 1100V.
IRS:S 88/93 or latest	Low Maintenance Lead acid Stationary cells
IS: 9000	Basic environmental testing procedure for electronic and electric items.
IS: 2147	Degree of protection provided by enclosure for Low voltage switch gear and control gear
RDSO/SPN /144/ 2004	Safety And Reliability Requirement Of Electronic Signalling Equipment
RDSO/SPN/165/2004	Integrated Power Supply

0.3 The latest issue of the above mentioned specifications is automatically implied.

0.4 This specification is intended chiefly to cover the technical provisions relating to supply of materials and does not include all the necessary provisions of a contract.

1. SCOPE

1.1 The specification covers the general and technical requirements and tests for Solar Charge controller unit suitable for Solar Photovoltaic (SPV) Module as per IRS: S 84/92 (for use in Signalling & Telecommunication Installation on Indian Railways) for correctness of its material, design, manufacture, testing procedure and electrical characteristics.

2. DEFINITIONS

2.1 For the purpose of this specification, terminology given in IRS: S 23 shall apply.

2.2 The definitions given in clause 2.0 of IRS: S 84/92 shall apply.

3. GENERAL REQUIREMENTS

3.1 The Solar charge controller unit is the interface between SPV module, Battery and load. It shall receive electrical energy from SPV-module and charge battery of suitable capacity, as well as feed the load directly during sunshine.

3.2 The charge controller shall be suitable for charging either LMLA batteries as per specification IRS: S 88/93 (latest) or VRLA batteries as per specification IRS: S 93/96 A (latest) as required by purchaser.

3.3 Normally charge controller output shall be floating for signaling applications. However, it shall have common positive which may be grounded for telecom applications.

3.4 Provision for mounting the charge controller on the wall or floor shall be provided as required by the purchaser.

3.5 There shall be provision of access points to measure input voltage from SPV module as well as output voltage to battery/load.

3.6 Electro Mechanical relays shall not be used, except for alarm extension.

3.7 Maximum voltage drop between SPV module & battery terminal shall not be more than 0.8V and between battery & output terminals to load shall not be more than 0.7V. However, in any case total voltage drop from SPV module to DC bus bar shall not be more than 1.8V.

3.8 The cable size used for interconnection of SPV, charger controller and battery shall be minimum 2 x 25sq.mm Cu cable.

4. TECHNICAL REQUIREMENTS

4.1 Construction

4.1.1 The cabinet shall be made of Cold Rolled Carbon Annealed (CRCA) mild steel sheet of thickness not less than 1.6 mm ±0.12mm as specified in IS 513-1994.

4.1.2 The cabinet made of Cold Rolled Carbon Annealed (CRCA) steel sheet shall be treated with zinc chromate primer followed by electrostatic epoxy powder coating paint finish. Passivation shall be done through seven stage process. Small metal parts inside cubicle e.g. nut, bolts and washers shall be made corrosion free either by use of proper material (e.g brass) or be galvanized / chrome plated.

4.1.3 All fuses, meters, switches, cable entry/exit points and indication lamps used in cabinet shall be suitably marked. Phoenix or Wago make connectors as per IEC 947 shall be provided at input / outputs.

4.1.4 The cabinet shall be provided with rubber gasket at door and rubber grommet at cable entry.

4.1.5 All meters and LED indications shall be on the front cover. The front cover shall be of hinged type for charge controller of rating greater than 500VA.

4.1.6 Layout of the components & wiring shall be such that all parts are easily accessible for inspection, repairs and replacement.

4.1.7 All non-current carrying metal parts shall be bonded together and earthed. An earth terminal of minimum 4mm (dia) wire and with suitable marking shall be provided.

4.1.8 The cables and wires used shall be neatly secured in position by bunching /strapping and adequately supported.

4.1.9 Captive screws with washers shall be used for charge controller to avoid the falling of screws during maintenance.

4.1.10 The cabinet shall have provision of natural / forced ventilation as considered necessary. Ventilation openings shall be less than 3mm size and covered with a suitable mesh for protection against entry of rodents, lizards etc. The protection shall conform to IP 31-type protection as specified in table 1 of specification no. IS: 2147.

4.1.11 The charge controller unit of 1000VA and above shall have forced cooling and only DC fan shall be used. The switching ON and OFF of the fan shall be temperature controlled at $65^{o}C$ & $40^{o}C$ respectively.

4.1.12 The layout of the components and wiring shall be such that all parts are easily accessible for inspection, repair & replacements.

4.1.13 The charge controller unit shall have input terminals for SPV connection. The controller output, battery and load shall be connected on common DC bus bar.

4.2 **Hardware**

4.2.1 Hardware requirement shall be as per clause 5.1 of latest RDSO/SPN/144/2004. ICs and other components used in the equipment shall be of industrial grade with operating temperature range -25 deg.C to +85 deg.C and shall conform to HIREL programme of CDIL or equivalent. Capacitor used should be certified for at least +105^{o} C.

4.2.2 The protection against electronic interference shall be provided as per clause 5.2 of latest RDSO/SPN/144/2004.

4.2.3 The diagnostic facility shall be as per clause 5.3 of latest RDSO/SPN/144/2004.

4.2.4 The current/voltage rating of the semiconductor devices shall be at least more than twice the current/voltage passing through them. The temperature rise of the shall not exceed 50ºC above ambient at full load or 20ºC less than that specified by the manufacturer whichever is less.

4.3 Printed Circuit Board

4.3.1 The Printed Circuit Board shall conform to Clause 6.0 of latest RDSO/SPN/144/2004.

4.4 Wires & Cables

4.4.1 All cables and wires shall be of copper conductor and shall conform to IRS: S 76-89/ IS: 694. The gauge of wiring shall be such that the current density does not exceed 3 Amps/sq.mm.

4.4.2 All external cables shall be weather resistant.

4.4.3 All connections shall be made through crimped eyelets and shall be numbered with PVC cable marker rings corresponding to the numbers / letters shown in the schematic wiring diagram. Soldering shall be used only where use of crimped eyelets is not possible.

4.4.4 All cables shall be suitably marked or colour coded for easy identification.

4.5 Switches, Fuses & Terminals

4.5.1 MCCB shall be provided for protection of SPV-module against short circuit and ground faults.

4.5.2 All current carrying terminals shall be of brass and shall be plated for protection against corrosion.

4.5.3 All switches, fuses, shunts and terminals shall be properly mounted keeping in view requirements of meggered insulation resistance and high voltage.

4.6 **Meters:** The following digital meters of 3 ½ digit LCD/LED display having 12mm numerical display height shall be provided on the front door.

4.6.1 DC Voltmeter shall be provided in the charge controller to indicate SPV array voltage/ Charge controller output by selection through a push type selector switch. The voltmeter shall be capable of measuring 150% of the maximum output voltage of the system.

4.6.2 DC Ammeter shall be provided in a charge controller to indicate battery current (charge/discharge). The ammeter shall be capable of measuring 150% of the rated current of the system.

4.6.3 The digital meter shall have an accuracy of ±1%, ±3 Digit or better.

4.7 Lightning Protection

4.7.1 An external interceptor with down conductor connected to proper earth for protection against direct lightning shall be provided by the Railways. It shall be installed at a distance of 0.5 metre (min.) from the SPV array. The cone of the protector shall be capable of providing protection to the whole SPV array and at the same time it shall not obstruct the sunlight to array.

4.7.2 The charge controller shall have relevant lightning & surge protection at the input & output as per Cl. 3.12 of RDSO/SPN/165/2004 (latest) for SMPS based Integrated Power supply system.

4.7.3 The input line protection shall consist of B+C type lightning protection between positive to earth, negative to earth and positive to negative in DC path from the SPV array to charge controller. However, the output of the charge controller shall have a suitable Class ‘D’ protection connected between positive to earth, negative to earth and positive to negative terminals.

4.8 Earthing

4.8.1 The Charge controller unit and its individual modules shall have earth terminals and shall be properly earthed to the charge controller cabinet.

4.8.2 Zonal Railways shall provide earthing arrangement as per IS: S 3043 and directions issued by RDSO for Lightning & Surge protection for signalling equipment vide letter no. STS/E/SPD dt. 22.6.2004. The earth resistance shall not be more than 2 ohm. Earth provided shall preferably be maintenance free using earth resistance improvement material.

5. PERFORMANCE REQUIREMENTS

5.1 Rating and Adjustment

i) Nominal rated Voltage of module –12V / 24V / 48V / ~~60V~~/ 110V.

ii) Nominal rated Current of module–10/20A

iii) Capacity of charge controller: n x rated current of the module. The number of modules as required for meeting particular load shall be housed in n+1 configuration (where 'n' is no. of modules selected as per requirement i.e. load + C/10 of the batteries).

iv) The charge controller modules shall be suitable for operating in parallel on active load sharing basis with one or more modules of similar type, make and rating.

v) The current sharing shall be within ± 10% of the individual capacity of each module in the system when loaded between 50 to 100% of its rated capacity.

vi) As the output from SPV-module varies widely depending on the intensity of the sun, the charge controller shall be suitable to accept –10% to + 35% input voltage range and charge the battery at regulated constant output voltage.

vii) Regulated output voltage at battery terminals: 2.4V± 0.05/cell for LMLA batteries or 2.3V± 0.05/ cell for VRLA batteries, plus the voltage drop from SPV to batteries for load variation from no load to rated load of the unit.

viii) For VRLA battery, provision for temperature compensation due to variation of ambient temperature shall be made in charge controller. The temperature compensation coefficient shall be –3mV/ deg.C/ cell.

The type of charge controller shall depend upon the LMLA/ VRLA battery used and shall be clearly labeled accordingly.

ix) Idle current / battery reverse leakage current consumption, when SPV-module is not charging the battery, should be less than 100mA.

x) Controller's overall efficiency shall be in excess of 80% for less than 500VA and 85% for more than 500VA capacity at full load and rated input.

xi) The output p-p ripple of charge controller unit shall not be more than 50mV at full load.

xii) Voltage setting levels shall have provision to vary the output voltage with the lock nut facility. However, under normal conditions, the individual potentiometers shall be factory set at the specified values and locked in position.

xiii) Whenever solar charge controller unit is used alongwith IPS, SMR output of IPS shall be terminated on the same DC bus bar alongwith battery and load.

Whenever solar power is healthy as per clause 5.1 (vi), it shall be given priority for feeding the load. If solar power is not healthy and mains is available, the IPS shall feed the load. However, as soon as solar power again becomes healthy, the load shall be automatically transferred to solar power.

5.2 Charging Characteristics

The charge controller shall be capable of operating in "Auto Float cum-Boost charger" mode. It shall be programmed to operate as a float or Boost charger depending on the condition of the battery being sensed by the switching/control unit.

a) Auto Float Mode

i) Normal Float & Boost voltage for LMLA battery shall be 2.15V/cell & 2.42V/cell and for VRLA battery shall be 2.25V/cell & 2.3V/ cell respectively. The module should have a range from 2.0 – 2.3V/cell in float mode & 2.2 – 2.5V/cell in boost mode to meet the requirement of LMLA as well as VRLA batteries.

ii) The DC output voltage shall be maintained within ± 0.05V/cell of the set value in the range no load to full load when measured at the output terminals over the full specified input range.

b) Auto Boost Charge Mode

If the current across battery terminals increases by 8-12% of the rated current (n x 10/20A), the output voltage of the charger shall automatically change to boost mode. It shall continue to give this constant output till the batteries get fully charged i.e. 2.4V/cell for LMLA and 2.3V/cell for VRLA battery and the current drawn by battery is reduced to less than 5% of the rated current value.

The output current during boost charging shall be maintained constant (within ±5% of the selected value) with input voltage varying between the limits as specified in Cl. 5.1 (vi) and the DC terminal voltage varying from 1.8V/cell to 2.4V/cell.

5.3 Protections

a) It shall have protection for polarity reversal at SPV input.
b) Due to overload or short circuit at the load terminals, the current supplied by the Charge controller unit will be limited within 110% of its rated current with its output voltage shall droop. The output voltage will come back to normal automatically with the removal of overload or short circuit.
c) It shall also protect the circuitry if the battery is connected with reverse-polarity.
d) The control circuit shall disconnect the load if the battery terminal voltage goes below a preset value due to over discharge. It shall reconnect the load when battery is sufficiently charged. Battery low cut off level shall be 1.85/cell and battery reconnection level shall be 2.15V/cell.
e) A blocking diode shall be provided in the charge controller to avoid discharge of battery through SPV modules.

5.4 Indications & Alarms

5.4.1 Indications

Charge Control Unit shall provide the following visual indications –

a) Auto float	-	Green
b) Auto Boost	-	Green
c) Battery Reverse Polarity	-	Red
d) Overload/ Short Circuit	-	Red
e) Battery Low Cut off	-	Blinking Red
sf) No output voltage	-	Blinking Red
g) Fan fail (if fan provided)	-	Red

5.4.2 Alarms

It shall provide warning alarm (buzzer) for battery low cut off and no output voltage. The alarms can be reset through a push button switch. However, the indication shall continue till the fault persists. Potential free contacts shall also be provided to extend these alarms for remote monitoring.

6. TESTS & REQUIREMENTS

6.1 Condition of tests – All tests shall be carried out at ambient atmospheric conditions.

6.2 For inspection of materials, relevant clause of this specification shall apply.

6.3 Type test

6.3.1 Only one charger of each type and output rating shall be tested for this purpose. The charger shall successfully pass all the type tests for proving conformity with this specification. If the charger fails in any of the type tests, the purchaser or his nominee at his discretion may call for another charger of the same type and output rating and subject it to all tests or to the tests(s) in which failure(s) occurred. No failure shall be permitted in the repeat test(s).

For getting initial type approval covering full range, the manufacturer shall submit the Solar charge controller units as given below –

SN	Solar charge controller	Module configuration	Approved for
1	110V/20A	110V/10A module in n+1 configuration	12/24/48/110V, 10A
2	110V/40A	110V/20A module in n+1 configuration	12/24/48/110V, 20A

Note: If the rating of prototype sample submitted is lower than 110V i.e. 12/24/48V, then approval will be accorded from 12V to the offered rating of the charge controller.

6.4.2 Type tests shall comprise of following tests and it should be carried out in the given sequence:

a) Visual inspection (Cl.6.7)
b) Insulation resistance (Cl. 6.8)
c) Applied High voltage test (Cl. 6.9)
d) Performance test (Cl. 6.10)
e) Environmental /Climatic test (Cl. 6.10.6)

6.4.3 The manufacturer shall furnish following information at the time of type approval-

a) Details of components i.e. semiconductor devices, capacitors etc. used alongwith data sheets.
b) Bill of material for PCB cards.
c) Compliance to Cl. 4.2 for safety margin with voltage and current ratings of the components.
d) Clause wise compliance report of the product as per specification for verification by the inspecting authority

6.5 **Acceptance tests**: Following shall constitute Acceptance tests and shall be conducted on each Solar charge controller unit as per the sampling plan given below -

a) Visual inspection (Cl.6.7)
b) Insulation resistance (Cl. 6.8)
c) Applied High voltage test (Cl. 6.9)
d) Performance test (Cl. 6.10)

Lot size	Sample size for performance test as per Cl. 6.10	Sample size for other than performance test
2-8	2	1
9-15	3	1
16-25	5	2
26-50	8	2
51-100	13	3
101-150	20	3
151-200	32	3

6.6 **Routine Tests**: Following shall constitute routine tests and shall be conducted by manufacturer on each Solar charge controller unit:

a) Visual inspection (Cl. 6.7)
b) Insulation resistance (Cl. 6.8)
c) Applied High voltage test (Cl. 6.9)
d) Performance test (Cl. 6.10)

6.7 **Visual Inspection**: The Charge Controller Unit Cubicle, cables shall be visually inspected to ensure compliance with the clause 3 & 4 of the specification

6.8 **Insulation Resistance Tests**: This shall be carried out after the high voltage test and after the climatic test have been completed. The measurement shall be made at a potential of 500V DC. The insulation resistance shall be measured between –

a) Input and earth
b) Output and earth

When measured at a temperature of 40ºC and 60% RH the value of insulation resistance shall not be less than 10 M ohms for complete charge controller and shall not be less than 100 M ohms for transformer. In case the prevalent values of temperature & RH at the time of measurement are different from those specified above, the IR value shall be obtained from table 'A'.

TABLE 'A'

Value of Insulation Resistance at different Temperature and Relative Humidity

R.H	25ºC	30ºC	35ºC	40ºC
60%	100 M.ohm	100 M.ohm	100 M.ohm	100 M.ohm
65%	100 M.ohm	90 M.ohm	85 M.ohm	80 M.ohm
70%	80 M.ohm	70 M.ohm	65 M.ohm	60 M.ohm
75%	60 M.ohm	53 M.ohm	47 M.ohm	43 M.ohm
80%	42 M.ohm	36 M.ohm	33 M.ohm	30 M.ohm
85%	29 M.ohm	25 M.ohm	22 M.ohm	13 M.ohm
90%	20 M.ohm	16 M.ohm	13 M.ohm	10 M.ohm
95%	15 M.ohm	10 M.ohm	7 M.ohm	5 M.ohm
100%	10 M.ohm	6 M.ohm	3 M.ohm	1 M.ohm

6.9 **Applied High Voltage Test:** The charge controller shall withstand for one minute without puncture and arcing, a test voltage of 2000 V DC applied between DC line terminals & earth.

6.10 **Performance Test**

6.10.1 The voltage at rated current of the charge control unit shall be measured. It shall comply the clause 5.1 Pt.(iii) and the charging characteristics shall be in compliance to Cl. 5.2.

6.10.2 **Control and adjustments:** It shall be checked to ensure compliance with clause 5.3.

6.10.3 **Protective Test**: It shall be checked to ensure compliance with clause 5.4.

6.10.4 **Over load and short circuit test:** During this test, all fuses shall be short-circuited. A suitable D.C. source shall be connected at SPV terminal. By connecting a suitable load at load terminals, overload test shall be checked as per clause 5.4 (c). Again a suitable D.C. source shall be connected at battery terminals and by suitable arrangement of load, short circuit test shall be checked as per clause 5.4 (e).

6.10.5 **Reverse Battery Connection:** A fully charged battery bank when connected with reverse polarity across the battery terminals of the Charge control unit should result in fuse blowing and reverse battery indication appearing. The charger shall also be protected against damage due to reverse battery connections. During this test, working of alarm / indication shall also be checked.

6.10.6 Polarity reversal at SPV input: For polarity reversal test at the SPV input, a DC power supply shall be connected at the SPV input with reverse polarity. A short circuit current, which is equal to the rated current of the control unit, will flow and there should not be any damage to the control unit including the input fuse.

6.10.7 Indication & Alarm shall be checked to ensure compliance with clause 5.4.

6.10.8 **Battery Reverse Current consumption / idle current consumption test**: This shall be carried out when SPV module is not in operation / charging to ensure compliance with clause5.1 (iv).

6.10.9 The psophometric noise (e.m.f. weighted at 800 Hz) with a battery of appropriate capacity connected across the output should be within 5mV while delivering the full rated load at nominal input. For test purpose, this shall be taken as equivalent to 10mV when the battery is not connected.

6.11 **Environmental/ Climatic Tests**:

6.11.1 The climatic test of Solar Charge Controller unit shall consist of following conforming to RDSO/SPN/144/2004 as per category "track-side outdoor equipment".

i) Vibration test as per Severity I (the test sample shall be forwarded alongwith vibration test report from ISO certified National/ International lab for conducting further type tests).
ii) Change of temperature test from -10ºC to 70ºC for three cycles (IS:9000 Pt.XIV Section II)
iii) Dry heat test at 70ºC ± 2ºC at full rated output for 16 hours duration as per IS: 9000 (part-III)
iv) Damp heat (cyclic) test for 6 cycles as per IS: 9000 (Part V) sec.1&2 at 40ºC & 95% RH.
v) Damp heat (Steady State Storage) test for 4 Days as per IS: 9000 (Part IV) at 40ºC & 93% RH.
vi) Cold test at 0ºC for two hours duration as per IS: 9000 (Part II).
vii) Salt Mist Test
viii) Dust test for one hour as per IS 9000 Pt.XII.

After completion of the test period, item shall be removed from the chamber and allow to recover as per recovery conditions given in the specification.

6.11.2 Final measurements: For tests corresponding to Clause 6.11.1 the cubicle shall not show any apparent damage or deterioration. The charge controller unit shall satisfy the requirement as per clause 6.10 and insulation resistance of electrical cubicle shall be as per clause 6.8.

7 PACKING

The packing should be as per clause 14.0 of RDSO/SPN/144/2004.

8 MARKING

8.1 The marking should be as per clause 14.0 of RDSO/SPN/144/2004.

8.2 Label on charge controller shall indicate as to whether it is for LMLA or VRLA battery.

9 DOCUMENTATION

Two copies of Instruction & Maintenance manual shall be provided as per clause 13.0 of latest RDSO/SPN/144/2004.

10 INFORMATION TO BE SUPPLIED BY THE PURCHASER

10.1 Charge controller module rating as per signaling load: 12/24/48/110V, 10/20A.

10.2 Type of battery - LMLA or VRLA battery for which it will be used.

10.3 Type of mounting : Wall/Floor

11. LIST OF SPARES

The following spares shall be supplied along with each unit in addition to spares required for commissioning the unit:

i) Blocking diode	- 1 No.
ii) Indicating Lamps & fuses	- 1 set
iii) Charge controller module	- 1 No.

Provision of mounting of spare charge controller module shall be made within the charge controller itself. Spare lamps & fuses shall be tied in a polythene bag & attached suitably inside the cover.

12. GUARANTEE

The manufacturer supplying equipment to this specification shall be responsible to replace free of cost to the department any components of the units if they become faulty due to any reason (except due to wrong handling) within a period of 24 months from the date of dispatch or 18 months from the date of commissioning of the system into actual service, whichever is earlier.

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