



Connector & Electrical Technical Guidelines - Summary



Enhancing Interoperability of 12V Solar Home Systems and Appliances

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Image: Fenix International

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The document has been written by Chris Moller (Evonet) with guidance from Drew Corbyn (GOGLA) in consultation with:

GOGLA's Technology Working Group:

Angaza (Chad Norvell)
Azuri Technologies (Nigel Preston, Duncan Barclay)
Biolite Energy (Ryan Gist)
BBOX (Phillip Homer, Fabian Iriarte)
Fosera (Daniel Goldbach)
Global Ice-tec (M. Schohe)
Opes Solutions (Allan Chen)
Simusolar (V. Vaidya)
Solaris Offgrid (Benjamin David)
Solarworx (Felix Boldt, Jakob Schily)
Sun King (Martin Sun)
SUNami Solar Kenya (Godfrey Simiyu Katiambo)

CLASP (Elisa Lai, Ari Reeves, Makena Ileri, Riley Macdonald)

Open DC Grid (Jim Gula, Martin Jäger)

University of Twente (Jelena Popovic)

Valuon Strategic (Vimal Mahendru)

VeraSol (Arne Jacobsen, Tom Quetchenbach).

Disclaimer

At various points in this document, links are provided to specific products. These links are provided as an indication of one possible source of the product, and are not intended to imply any endorsement or suitability of any particular product.

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to enhance 12V Solar Home System and Appliance interoperability

Table of Contents

- 1. Purpose and Status of this document.....5
 - 1.1. Numbering of Guidelines.....6
- 2. Electrical and Connector Guidelines for a 12V Supply Socket.....7
 - 2.1. Output Port Voltage Range [SV].....7
 - 2.2. Output Port Current Rating [SP].....7
 - 2.3. Overload protection [SO].....8
 - 2.4. Protection of SHS against misuse [SM].....8
 - 2.5. Status Indicators on the SHS [SI].....8
 - 2.6. Power Supply Connectors [SC].....9
 - 2.7. SHS Extras and Accessories [SX]..... 10
 - 2.8. Labelling of SHS Output Ports [SL] 10
 - 2.9. Additional Information for the SHS User Manual [SU]..... 11
- 3. Guidelines for Appliances [A]13
 - 3.1. Appliance Operating Voltage Range [AV].....13
 - 3.2. Appliance Current Rating [AP].....13
 - 3.3. Appliances and Galvanic Isolation [AG] 14
 - 3.4. Connectors for 12V Appliances [AC]..... 14
 - 3.5. Labelling on appliances [AL]..... 15
 - 3.6. Status indicators on the appliance [AI] 16
 - 3.7. Additional Information for the Appliance User Manual [AU]..... 16
- 4. Product Testing17

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1. Purpose and Status of this document

This summary document is associated with the full Technical Guidelines that is written for the Connect Affiliates. It summarizes the guidelines in the full document, "Connector Electrical Technical Guidelines v1.2 draft 2021-12-10", to which reference is made in several places.

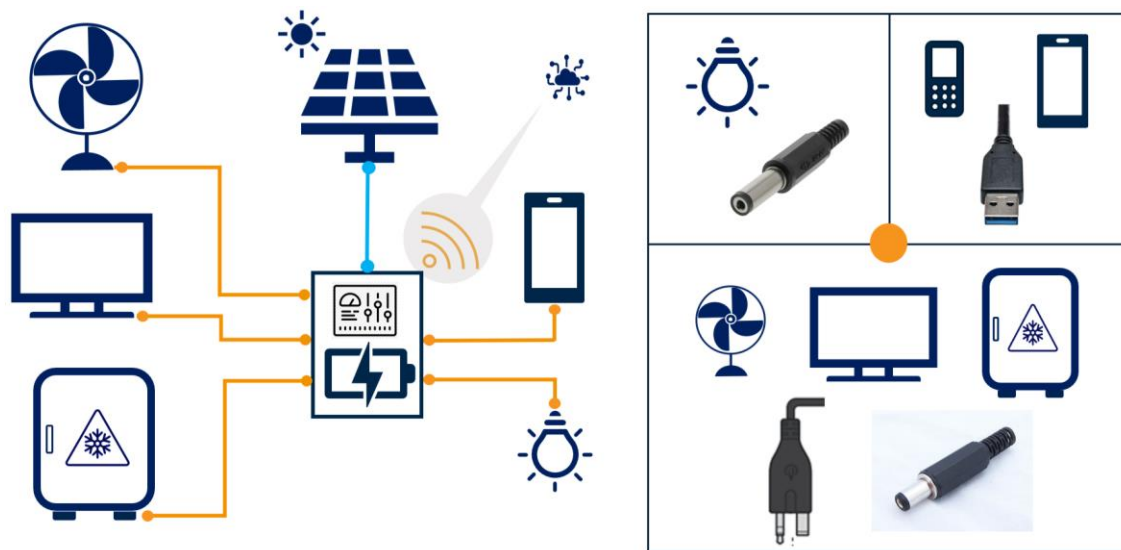
The main document and this summary comprise a series of guidelines that it is hoped Connect Affiliates will adopt. They do not have the force of a mandatory requirement or standard, and will not result in a certificate of compliance. Membership of the Connect Affiliates interest group is not conditional on compliance with any of these guidelines.

Every guideline in this document is a recommendation to consider a particular issue, and if technically possible and affordable, to incorporate it in product designs. Eventually, it is hoped that as new products are designed, all Connect Affiliates' product designers will choose to adopt the guidelines in this document, and thereby ensure their products' compatibility with other products that also adhere to these guidelines.

The initial focus of the Connect Initiative, and the scope of this document, is on the following product categories and uses:

- SHS Kits up to 350Wp (PV module) in-line with Verasol and IEC industry standards
- SHS Kits with 12V outputs; and
- Primarily for household use cases, for loads and appliances up to 100W (and therefore excluding high power applications such as solar water-pumps or agri-processing; and
- For both 'Basic' and 'Smart' loads (where 'smart' is with PAYGo activation and/or device control, and 'basic' is without).

SHS Kit & Appliance schematic, Universal Family of Connectors



1.1. Numbering of Guidelines

Guidelines are numbered. As further revisions of this document and the full Technical Guidelines are produced, these numbers will not change. Guidelines relating to SHS electricity supplies start with "S", and those relating to appliances with "A". A second letter indicates:

- V – Voltage
- P – Power and Current
- O – Overload Protection
- A – Protection against abuse (SHS only)
- I – Status Indicators (SHS only)
- G – Galvanic Isolation (appliances only)
- C – Connectors
- L – Labelling of ports
- U – User Manual information
- T – Test procedures (not in this summary)

The order of these sections has been changed from earlier versions of the documents, to more closely represent the stages within the product design process at which each factor needs to be considered:

- At Product Design time
- Product packaging and labelling
- Authoring the User Manual
- Testing the product.

2. Electrical and Connector Guidelines for a 12V Supply Socket

2.1. Output Port Voltage Range [SV]

It is clear that there should be agreement between the supply and the appliance on the operating voltage. The appliance should be capable of operating correctly over the entire range of voltage that the supply can deliver – not just at the nominal 12V.

- SV.1** The output port voltage should not exceed 15.0V (as specified by -9-5 and -9-8) under any foreseeable circumstances
- SV.2** The output port voltage should not fall below 10.5V (as specified by -9-5 and -9-8) under any foreseeable circumstances, unless the SHS indicates visibly or audibly that it is operating in a battery-nearly-exhausted mode.
- SV.3** A clear visual indication should be given (eg a flashing battery level LED) to indicate that low-battery mode is in operation
- SV.4** In low-battery mode, the terminal voltage should not fall below 9.0V.
- SV.5** Where applicable, the Exceptional Steady-State Overvoltage Upper Limit – Battery Disconnect Test specified in [-9-5] Annex DD §4.3 should pass.
- SV.6** Where a DC-DC converter is present between the battery and an SHS output port, the transient response should be studied, and determined to be unconditionally stable.
- SV.7** When the battery is discharging, the cut-off voltage at which low-voltage mode or under-voltage take effect should be lower than the voltage at which power is restored during charging. A difference of 50mV is suggested.

2.2. Output Port Current Rating [SP]

- SP.1** B3.5 and S3.5 output ports should have published maximum steady-state current ratings no greater than 3.5amps (but may be less). This may be the total current for a group of B3.5/S3.5 ports connected in parallel.
- SP.2** B8 and S8 output ports should have published maximum steady-state current ratings no greater than 8.0amps (but may be less). This may be the total current for a group of B8/S8 ports connected in parallel.

2.3. Overload protection [SO]

Overload detection may be current- or voltage-based. The actual behaviour is a function of the stated rated current of the port or group of ports.

- SO.1 Current-based overload protection should follow a time curve within the boundaries set by §3.4.2.3 of the main document.**
- SO.2 Voltage-based overload protection should follow a time curve within the boundaries set by §3.4.2.4 of the main document.**
- SO.3 Overloading should cause a trip requiring a manual reset, to avoid power cycling, and indicate to the user that remedial action is required.**

2.4. Protection of SHS against misuse [SM]

By granting interoperability, we are permitting the user to experiment with appliances of their choosing. As there are many, many grey market appliances that a user may attempt to plug into an SHS, it is essential that they do not cause permanent damage to the SHS. (We can't promise that the appliance in question won't be damaged.)

- SM.1 Connecting a power source to any output port of the SHS should not cause power to flow into the battery. This should apply regardless of whether the equipment is turned on.**
- SM.2 Negative voltages applied to the output (for example the turn-off spike of an inductive load) should be clamped with a diode, as defined in §3.6.2 of the main document.**
- SM.3 If an SHS is deemed repairable, the output should be protected with an internal non-user-replaceable fuse of a value greater than could be tripped by the overload protection.**

2.5. Status Indicators on the SHS [SI]

The introduction of the flexibility to use many different appliances opens up many possibilities for the reason why a particular combination will not work. It is highly desirable that the user is supported with visible or audible indication of whether an appliance is not functioning because:

- a) It is electrically incompatible
- b) The SHS is in some particular state (for example a low-voltage mode)
- c) Something has been damaged or otherwise failed

This is important, as each has a different remedy. It is doubly important, as now several suppliers may be involved.

SI.1 The user should be given a different visual or audible indication for each of the following exceptional conditions, rather than simply experiencing the power being turned off:

- Power demand/system current over the permissible limit
- Battery stored energy nearly exhausted (audible warning also desirable)
- Battery stored energy exhausted
- Battery failure
- Equipment overheating
- Any other protective measure that is in effect, causing the output to be disabled or in some special condition (eg low-voltage mode)

SI.2 It is highly desirable that a consistent convention is adopted between Connect Affiliates on the visual indicators to be used to indicate the various possible states of the SHS.

A consensus between the members should define the conventions to be adopted, with options depending on how many LED or other visual indicators are on the product

2.6. Power Supply Connectors [SC]

[Flexibility, Designed Boundaries]

No compromise is possible on the standardisation of the connectors – a standard connector must be defined, if interoperability is to be achieved.

Two current ratings are defined – max. 3.5Amps and max 8Amps. Different connectors are specified for the two.

Basic (B3.5, B8) sockets are defined without digital signalling. Smart (S3.5, S8) sockets include digital signalling.

SC.1 The B3.5 socket should be designed to mate with a barrel plug of 5.5mm outside diameter, 2.5mm inside diameter.

SC.2 The polarity of the B3.5 socket should be centre-positive.

SC.3 The S3.5 smart socket should comprise a B3.5 socket as defined above and, at a distance of 13.5 ± 0.3 mm from it centre-to-centre, a 3.5mm audio stereo jack socket.

SC.4 The face of the S3.5 audio socket should be in the same plane as the face of the barrel socket ± 0.3 mm.

SC.5 The connections on the S3.5 audio jack should be:

- Tip – D+
- Ring – D-
- Shank – GND

- SC.6** At least one B3.5 socket on the product should have a hole at a distance of 13.5 ± 0.3 mm centre-to-centre, to accommodate the 3.5mm jack plug component of the S3.5 plug. The hole should be at least 16mm deep, 3.8mm diameter and be blind. The hole should not contain any contacts. As an alternative, an adapter may be made available as shown in §3.8.1.3 of the main document.
- SC.7** The B8/S8 power socket (for loads up to 8amps) should be suitable for a 3-pole barrel plug 7.4mm OD, 5.0mm ID with a 0.6mm centre gold pin (colloquially known as a "7406 jack").
- SC.8** The polarity of the B8/S8 socket should be outside negative, inner positive. The receptacle for the centre pin should be used for signalling in smart supplies, and not connected in supplies that are not smart-capable.
- SC.9** Sockets should where possible be recessed, to provide additional resilience against sideways force on appliance leads.


2.7. SHS Extras and Accessories [SX]

To provide the highest possible level of flexibility in the use of the SHS, it is recommended that certain accessories are made available by the manufacturer (presumably at an additional charge):

- SX.1** It is recommended that the manufacturer should offer extension leads as standard accessories, to discourage the use of unsuitable products or users' own wire.
- SX.2** It is recommended that an adapter should be made available by the manufacturers of products that only have B8/S8 connectors, comprising a combination 5521 socket and 3.5mm stereo jack socket, and a short lead to an S8/B8 plug.
- SX.3** It is recommended that adapters to allow a 5521 plug to connect to an SHS equipped with 5525 sockets should be included within the list of available accessories.

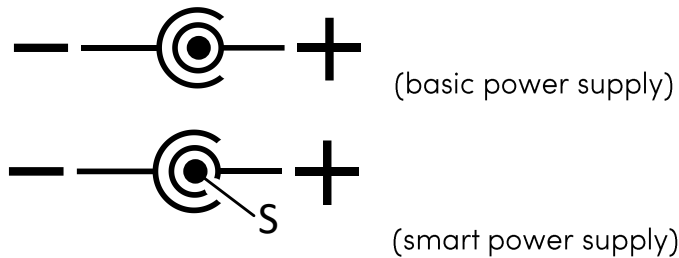
2.8. Labelling of SHS Output Ports [SL]

It is essential that the user is given clear indication of issues that are not immediately visible and that might cause incompatibility. This information should be given in the User Manual, but as we all know, these are rarely read. It is therefore necessary that the information is labelled on the equipment itself as well. As the information relates to the output ports, the information should be provided as near the port to which it relates as possible within the constraints of space.

- SL.1 **Voltage – B3.5/S3.5/B8/S8 sockets - The power output port should be clearly labelled "12VDC" adjacent to the port. The symbol "12V  " (Unicode U+2393) may also be used.**
- SL.2 **Voltage – equipment with three NMC cells – These should be labelled 11.1VDC (not 12VDC).**
- SL.3 **Connector Polarity - The following symbol should be present on the box near the B3.5/S3.5 power socket, and also in the user manual:**



- SL.4 **Connector Polarity - The following symbol should be present on the product near the power socket, and also in the user manual:**



- SL.5 **Ports should be labelled with their rated steady-state current capability, according to the criteria of §3.8.1 of the main document.**
- SL.6 **If a USB Type A socket is provided, it should have the maximum current labelled (eg "0.5A" or "2.1A"). If a fast charging protocol is supported, text indicating that or the relevant proprietary symbol should also be included. If the voltage for fast charging exceeds 5V, this should also be indicated, eg "QC3.0: 5V/3A 9V/2A"**
- SL.7 **(If a USB-C socket is provided, the correct labelling to be used is still under discussion – the official USB-C specification makes no mention of labelling, despite there being many subsets of USB-C functionality.)**

2.9. Additional Information for the SHS User Manual [SU]

The User Manual should contain all of the information included in the labelling section above, with a written description of the meaning of any symbols used. In addition the following Guidelines should be met:

- SU.1 **Local language translations of the User Manual should be provided.**
- SU.2 **The published product literature and User Manual should include a Technical Specification.**

- SU.3** The published User Manual should include a warning about connecting inappropriate load appliances.
- SU.4** The published User Manual should include a warning against adding one's own wiring to increase the reach of the system.
- SU.5** It is recommended that specific instructions are included in the user manual warning against using an SHS to charge a rechargeable battery unless specific measures are taken.
- SU.6** It is recommended that a warning is provided against plugging a mains power supply into an output port of the SHS for any reason at all.
- SU.7** The deep-discharge waiver in the remark to [-9-5] Table EE.3 should not apply unless all the guidelines in this document for low-voltage modes are met.

Appliances

3. Guidelines for Appliances [A]

3.1. Appliance Operating Voltage Range [AV]

- AV.1** The appliance should continue to function correctly when supplied with a voltage of 15.0V when under maximum load.
- AV.2** The appliance should continue to function correctly when supplied with a voltage of 10.0V when under maximum load.
- AV.3** If the ratings plate on the appliance or the Technical Specification in the User Manual indicates a wider voltage range, it should be tested over this range.
- AV.4** An appliance that is intended to continue in operation in 'low-voltage mode' should continue to operate correctly down to a minimum supply voltage of 9.0V.

3.2. Appliance Current Rating [AP]

The "full load" condition under which the appliance will draw maximum current must be established. This will be different for every type of appliance – it may be a mechanical load, or a heating or cooling requirement, or several other things.

- AP.1** The power requirement of an appliance should be indicated on the ratings plate and in the User Manual in amps, rather than watts.
- AP.2** Appliances fitted with B3.5 or S3.5 plugs should not have a ratings plate current exceeding 3.5amps.
- AP.3** Appliances fitted with B8 or S8 plugs should not have a ratings plate current exceeding 8amps.
- AP.4** The power lead on the appliance should be able to withstand a fault current of 8Amps indefinitely without permanent damage.
- AP.5** The load current is permitted to exceed the maximum rated current (or the current calculated above), for example when first connected to power, when starting under full load at either its maximum or minimum operating voltage (or at any other time) but the duration should be limited.

3.3. Appliances and Galvanic Isolation [AG]

- AG.1** It is recommended that product designers should consider the issue of unintended ground loop currents very carefully for all products that include signal ports in addition to the power input port.
- AG.2** It is recommended that products that include signal ports in addition to the power input port should include specific measures to eliminate unintended current flows between power ports and signal ports.

3.4. Connectors for 12V Appliances [AC]


- AC.1** Appliances should have a free power plug on a lead. The lead may optionally be detachable from the appliance.
- AC.2** Every barrel plug should be selected to mate with the specified reference jack socket (TBD) and when mated to deliver the required mechanical and electrical properties.
- AC.3** Basic appliances should be able to plug into both Basic and Smart supplies.
- AC.4** A paid-off PAYGo Smart appliance should also be able to plug into a Basic supply, perhaps by means of an adapter.
- AC.5** A detachable B3.5 or S3.5 lead may have identical connectors on both ends – or very obviously different connectors on the two ends.
- AC.6** (deleted)
- AC.7** A detachable lead should NOT be compatible with IEC60320 unless the appliance is capable of being powered from 230VAC.
- AC.8** The B3.5 plug should be a barrel plug of 5.5mm outside diameter, 2.5mm inside diameter. The barrel length should be 12mm, and the tuning fork variety of inner contact is preferred.
- AC.9** The polarity of the B3.5 socket should be centre-positive.
- AC.10** The S3.5 smart plug should comprise a B3.5 plug as defined above and, at a distance of 13.5 ± 0.3 mm from its centre-to-centre, a 3.5mm audio stereo jack plug. The connections on the S3.5 audio jack plug should be:
- Tip – D+
 - Ring – D-
 - Shank – GND
- AC.11** The B8/S8 power plug (for loads up to 8amps) should be a 3-pole barrel plug 7.4mm OD, 5.0mm ID with a 0.6mm centre gold pin (colloquially known as a "7406 jack plug").
- AC.12** The polarity of the B8/S8 plug should be outside negative, inner positive. The centre pin should be used for signalling in smart appliances, and not connected in appliances that are not smart-capable.

AC.13 Regardless of the power the appliance requires in order to operate, the power lead supplied with the appliance should be capable of carrying 8amps continuously, without giving rise to a risk of burns or causing fire, even when wrapped in flammable thermally-insulating material.

3.5. Labelling on appliances [AL]

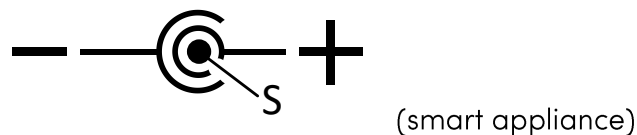
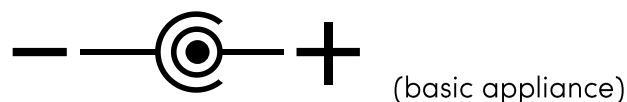
[Documented Boundaries]

It is essential that the user is given clear indication of issues that are not immediately visible and that might cause incompatibility. This information should be given in the User Manual, but as we all know, these are rarely read. It is therefore necessary that the information is labelled on the appliance itself as well.

- AL.1** The appliance should have a readily-visible ratings plate or printed ratings box giving basic compatibility information.
- AL.2** The ratings plate should be clearly labelled "12VDC". The symbol "12V  " may also be used. An operating voltage range may also be provided, eg "9-15VDC".
- AL.3** If the appliance is approved for continued operation when the SHS has switched into a battery-nearly-exhausted mode, this should be clearly indicated on the appliance, for example by a minimum operating voltage of 9V.
- AL.4** Connector Polarity – For a B3.5 or S3.5 appliance, the following symbol should be present on the ratings plate, and also in the user manual:



- AL.5** Connector Polarity – For a B8 or S8 appliance, the following symbol should be present on the product near the power socket, and also in the user manual:



- AL.6** If the power lead is detachable, the symbols above should refer to the connector on the appliance, not the one on the other end of the power lead. (They may need to be modified for different types of connector.)
- AL.7** Ports should be labelled with their rated steady-state current requirement, according to the criteria of §5.4 of the main document.

3.6. Status indicators on the appliance [AI]

Most status indicators on an appliance will relate to the function that it performs. However, two status indicators are entirely general:

- AI.1** An appliance that has a mode in which it has power but is not visibly operating (for example, it is in “standby”) should have a visible indicator when in this mode to show that it is receiving power.
- AI.2** An appliance that supports 'low voltage mode' should have a status indicator to show that this mode is in effect.

3.7. Additional Information for the Appliance User Manual [AU]

[Documented Boundaries]

- AU.1** The published product literature and User Manual for the appliance should include a Technical Specification. This should provide basic information necessary for a potential technically qualified user or their advisor to assess the suitability of the product for any particular situation. This should include at least:
 - Nominal operating voltage (12V) or voltage range
 - The rated current
- AU.2** Where appliances (for example, lights) have a daisy-chaining capability, the maximum number of appliances in the chain should be specified.
- AU.3** Where an appliance incorporates connectors for purposes other than solely for the delivery of power (ie digital communications, audio, video, radio aerials etc), and if specific measures have not been taken within the product to avoid galvanic isolation problems, the User Manual should contain advice about the potential issues. The following wording is suggested:

"WARNING: Unreliable performance may be experienced when connecting this product to other equipment powered from the same SHS."

(The User Manual should also contain information to enable the distributor, user or potential purchaser to calculate the likely energy consumption in normal use, and hence the likely run-time. However this is outside the scope of these documents.)

(The User Manual should also contain information within the Technical Specification of the environmental operating limits for the appliance. However that too is outside the scope of these documents.)

4. Product Testing

Some general guidelines are provided for testing.

- T.1 It is recommended that before product design and packaging are finalised, prototypes should be tested in the most extreme environments they are likely to encounter in normal use in the field.**
- T.2 It is recommended that testers identify the most challenging electrical conditions consistent with the published Technical Specification, and products are tested to confirm that they achieve their stated performance under these conditions**
- T.3 It is recommended that manufacturers have connectors that they plan to incorporate into their products validated by a testing service for performance with a standard reference connector.**

The main document describes procedures that may be employed by manufacturers to confirm that their products have met the guidelines and recommendations in the document.

(ends)