

USER MANUAL

Lithium Battery

WP-ION POWER PLUS 12 V 160 Ah

12.9 V/160 AH (2.1 KW LIFEP04)



User Manual WP-ION Power Plus 12 V 160 Ah

Lithium Iron Phosphate battery

Dear customer,

This manual contains all the information necessary to install, use and maintain the Whisper Power Li-ion battery. We kindly ask you to read this manual carefully before using the product. In this manual, the Whisper Power WP-ION Power Plus 12 V/160 Ah Li-ion battery will be referred to as: the Li-ion battery.

This manual is meant for the installer and the user of the Li-ion battery. Only qualified, certified personnel may install and perform maintenance on the Li-ion battery. Please consult the index at the start of this manual to locate information relevant to you.

The boundaries of its use, as described in this manual should always be upheld. The Li-ion battery may not be used in medical or in aviation related applications. The Li-ion battery may not be used for any purposes other than described in this manual. Using the Li-ion battery for any other purpose will be considered improper use and will void the warranty of the product. Whisper Power cannot be held responsible for any damage caused by improper, incorrect or unwise use of the product. Read and understand this manual completely before using the product.

During the use of the product, user safety should always be ensured, so installers, users, service personnel and third parties can safely use the Li-ion battery. This is the original manual, keep it in a safe location! Please consult www.whisperpower.com for the latest version of all manuals.

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1. Introduction

1.1. Product description

The WP-ION Power Plus 12 V/160 Ah is a Lithium Iron Phosphate rechargeable battery. The unique combination of state-of-the art technology and smart software makes this Li-ion battery a robust, safe and easy to use energy storage solution.

Compared to conventional lead acid batteries, the Li-ion battery offers an enormous weight and space saving. It is very efficient, has extremely high performance and is maintenance free.

Moreover, the Li-ion battery uses exceptionally safe Lithium Iron phosphate (LiFePO₄) technology. With its integrated battery management system the Li-ion battery is protected from deep discharging, overcharging and overheating.
External disconnect device is required!

Potential applications of this Li-ion battery include: off grid power supply, marine power supply, medium for (renewable) energy storage (traction) battery for vehicles.

In Appendix I, the Declaration of Conformity for the Li-ion battery is given.



1.2. Glossary of Terminology

BMS	Battery Managent System
Charge cycle	A period of use from fully charged, to fully discharged, and fully recharged again.
Endurance Life-cycle	The products maximum lifespan, achieved by following the guidelines presented in this manual.
BCI/WIB	Battery Communication Interface / Whisper interface box
LiFePO ₄	Lithium Iron Phosphate
SoC	State of charge
CCCV	Constant Current - Constant Voltage
DoD	Depth of Discharge

Table 1. Glossary of terminology

1.3. Used symbols

The following icons will be used throughout the manual:

-  **Warning!** A warning indicates severe damage to the user and/or product may occur when a procedure is not carried out as described.
-  **Caution!** A caution sign indicates problems may occur if a procedure is not carried out as described. It may also serve as a reminder to the user.

2. Product specifications

2.1. Product features

- Traction battery
- Lithium Iron Phosphate (LiFePO4): Safe Li-ion technology
- Integrated BMS (Battery Management System), external interruption device needed
- Glass fiber reinforced plastic (GRFP) Casing, Aluminum / PE sandwich side panels
- Terminals for 2 x 95mm² wire connection per terminal
- Integrated fuse, 72V / 500A
- 3C continuous discharge (480A)
- Wired communication interface: CANopen
- Battery monitoring / History Storage
- Adaptive cell balancing
- Configurable in serial or parallel connection
- Output for bi-stable relay / latching relay

2.2. General product specifications

Product name	WP-ION Power Plus 12 V/160 Ah
Producer	Whisper Power
Battery type	Lithium Iron Phosphate (LiFePO4) / Traction battery
EAN number	8718531360570
Cycle life	> 2000 (0.3C continuous discharge, DoD 100%)*

Table 2. General product specifications

*The cycle life value given above is an indication at 23°C. The Li-ion battery cycle life depends strongly on temperature and the applied charging and discharging loads. For more information on the cycle life of the Li-ion battery, appendix II may be consulted.

2.3. Technical specifications

Mass	26.9 kg +/- 0.250 kg
Ingress protection rating	IP50

Table 3. Technical specifications

2.3.1. Battery designation

Battery designation according to EC61960	4IFpP85/170/245
--	-----------------

Table 4. Battery

2.3.2. Electrical properties (23°C)

Open Circuit Voltage*	13.2V dc
Nominal voltage**	12.9V dc
Rated capacity	160Ah
Charge method	CCCV
Charge voltage	14.3V...14.6V
End-of-discharge voltage	8V dc
Charge current	Max 160A (1C)
Discharge current continuous	480A (3C)
Discharge current 10 seconds	800A (5C)

Table 5. Electrical properties (23 °C)

*Open Circuit Voltage at 50% SoC, no load
**Nominal voltage (V) at 50%, SoC, 0.2C discharge
More information on the Li-ion battery's discharge performance and capacity may be found in Appendix II.

2.3.3. Dimensions (±1mm)

Height (H)	314 mm
Width (W)	417 mm
Thickness (T)	227 mm

Table 6. Dimensions

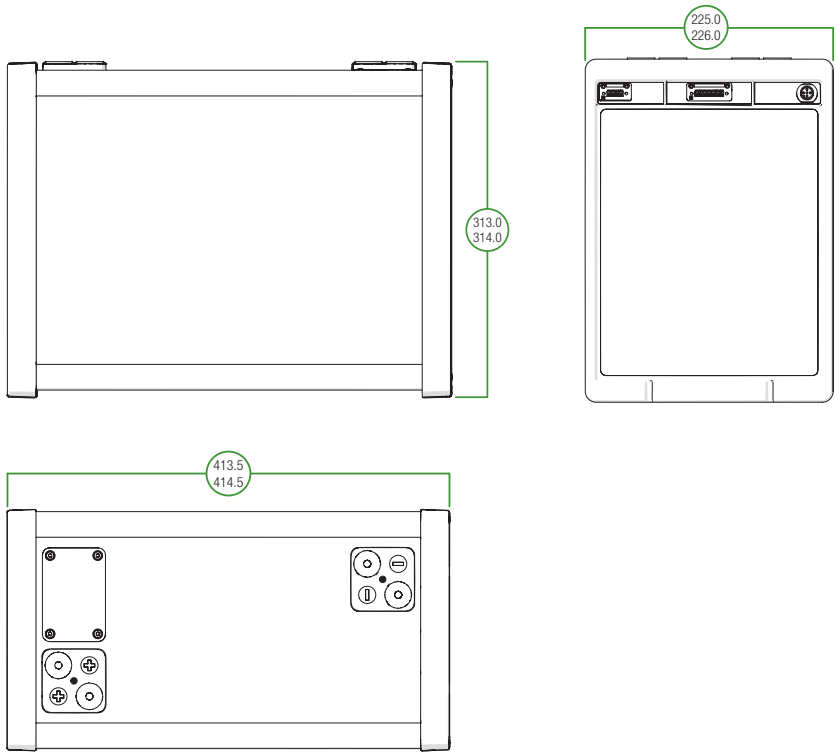


Figure 1. Dimensions

2.4. Environmental conditions



Warning! The Li-ion battery may only be used in conditions specified in this manual. Exposing the Li-ion battery to conditions outside the specified boundaries may lead to serious damage to the product and/or the user.

Use the Li-ion battery in a dry, clean, dust free, well ventilated space. Do not expose the Li-ion battery to fire or water or solvents.

When the Li-ion battery is placed in an enclosed environment without air circulation, it is advised to

provide 2 ventilation holes of 100mm x 100mm each. This helps to prevent the heat built-up.

Recommended charge temperature range*	0°C to +45°C
Discharging operating temperature range	-10°C to +55°C
Short term (<1 month) storage temperature range	-20°C to +45°C
Long term (>1 month) storage temperature range	-10°C to +20°C
Relative humidity	10-90%
Corrosion	Salt-contaminated atmosphere up to 1 mg salt per m³ of air, at all relevant temperatures and humidity conditions. Applicable to equipment located in open air and made of material subject to corrosion.
Placement angle (continuously)	Up right
Vibrations and shocks	According UN38.3

Table 7. Environmental conditions
(1) Charging below 0 °C only with reduced charge current. This might result in degraded cycle life.

2.4.1. Marine use

Parameter	Class	Location
Temperature	A	Machinery spaces, control rooms, accommodation, bridge
Humidity	B	All locations except as specified for location A
Vibration	A	On bulkheads, beams, deck, bridge
EMC	B	All locations including bridge and open deck

Table 8. Marine use

2.5. Required tools

- 13mm Hexagon socket wrench
- Torque wrench
- TORX key for fuse cover

2.6. Components

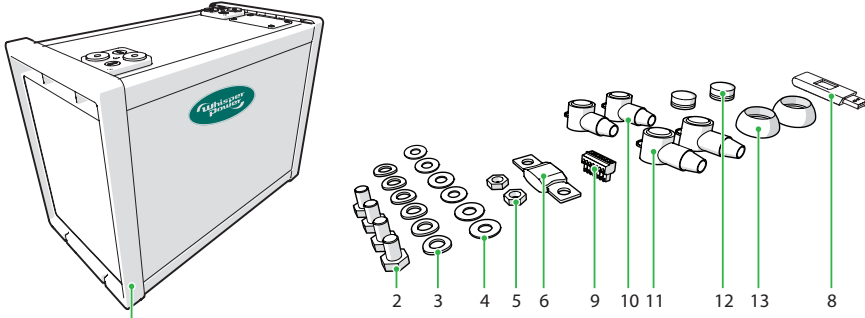


Figure 2. Components

2.6.1. List of components

1. (1x) WP-ION Power Plus 12 V/160 Ah Battery
2. (4x) M8 Bolt
3. (6x) M8 Spring washer
4. (6x) M8 Plain washer
5. (2x) M8 Nut
6. (1x) Mega Fuse 72V/500A
7. (1x) Phoenix plug 7
8. (2x) Terminal cover, Red
9. (2x) Terminal cover, Black
10. (1x) Terminal protection cap, Red
11. (1x) Terminal protection cap, Black
12. (1x) USB stick (manual)

2.7. Connections, indicators and battery controls

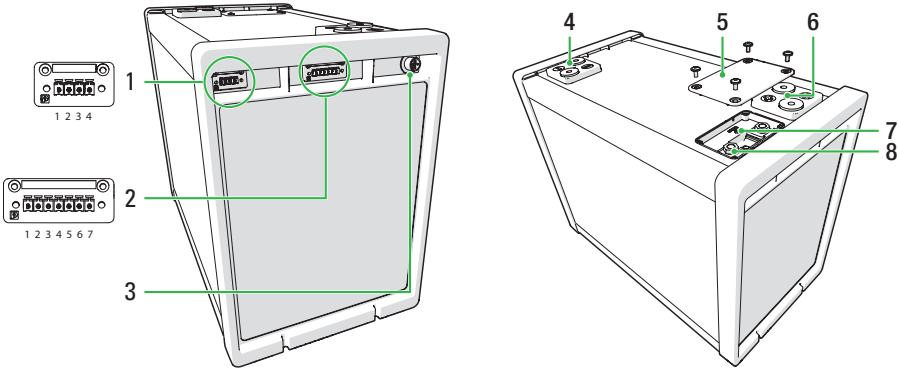


Figure 3. Connections, indicators and battery controls

- 1. Con 1 (Output for BI-Stable Relay; Phoenix FRONT-MC 1,5/4-STF-3,81 1850877)
- 2. Con 2 (I/O Connection 7; Phoenix FRONT-MC 1,5/7-STF-3,81 1850903)
- 3. Con 3 (CANopen; 5-pin “micro” style connector)
- 4. Terminal - (2x 95mm2 wire connection)
- 5. Fuse cover
- 6. Terminal + (2x 95mm2 wire connection)
- 7. Reset button
- 8. Fuse connections

2.7.1. Con1 (Output for BI-Stable Relay)

PIN #	Output range (12V dc)	Function
1	2.7A (continuous) 15A (100ms pulse)	+, OFF
2	2.7A (continuous) 15A (100ms pulse)	-, ON
3	2.7A (continuous) 15A (100ms pulse)	-, OFF
4	2.7A (continuous) 15A (100ms pulse)	+, ON

Table 9. Con1 (Output for BI-Stable Relay) Output Functions

2.7.2. Con2 (I/O connection 7)

PIN #	Range	Function
1	max 30 V dc	+ (Plus)
2	0-10 V dc	AN_SOC (Analogue state of charge)
3	NA	Nc (Not connected)
4	5A max 48V dc max	Rc, (Relay common contact)
5		Rnc, (Relay normally close contact)
6		Rno, (Relay normally open contact)
7		GND, (Ground)

Table 10. (I/O connection 7)

2.7.3. Con 3 (CANopen; 5-pin “micro” style connector)

PIN #	Signal	Description
1	CAN_SHLD	Optional CAN Shield
2	CAN_V+	Optional CAN external positive supply (dedicated for supply of transceiver and optocouplers. if galvanic isolation of the bus node applies)
3	CAN_GND	Ground / OV
4	CAN_H	CAN_H bus line (dominant high)
5	CAN_L	CAN_L bus line (dominant low)

Table 11. Con 3 (CANopen; 5-pin “micro” style connector)

2.8. Peripheral equipment

2.8.1. Obligatory

In order for the Li-ion battery to be used safely, an external switch off device must be installed. This should either be a relay or latching relay (bi-stable) controlled by the battery’s BMS or a relay or latching relay controlled by a remote switch (CAN controlled). If an external switch off device is not installed the warranty of the Li-ion battery will be void.

2.8.2. Optional Components

The Li-ion battery can be used in combination with a number of (Whisper Power) products:







Article number	Article name		code
50214814	WP Power Plus Whisper Interface box WIB 12 V / 350 A		C
50214816	WP Power Plus Whisper Interface box WIB 24 V / 350 A		C
50214817	WP Power Plus Whisper Interface box WIB 24 V / 600 A		C
50214818	WP Power Plus Whisper Interface box WIB 48 V / 350 A		C
50214819	WP Power Plus Whisper Interface box WIB 48 V / 600 A		C
40290253	WP Power Plus Relay 9-36 V / 500 A		C
40290254	WP Power Plus Relay 12-42 V / 190 A Bi-stabile relay + cable 1 meter		C
40290255	WP Power Plus CAN bus cable 0.6 meter		C
40290256	WP Power Plus CAN bus Power cable		C
40290257	WP Power Plus CAN bus splitter		C
40290258	WP Power Plus CAN bus terminator female		C
40290259	WP Power Plus CAN bus terminator male		C
40290340	WP Power Plus CAN bus cable to whisper connect		C
40290346	WP ION Power Plus, bracket kit 12 V 160 Ah		C

Table 12. Optional components that can be used with the Li-ion battery

3. Safety guidelines and measures

3.1. General

- Do not short-circuit the Li-ion battery.
- Treat the Li-ion battery as described in this manual.
- Do not dismantle, crush, puncture, open or shred the Li-ion battery.
- Do not expose Li-ion battery to heat or fire. Avoid exposure to direct sunlight.
- Do not remove the Li-ion battery from its original packaging until required for use.
- In the event of the Li-ion battery leaking, do not allow the liquid to come in contact with the skin or eyes. If contact has been made, wash the affected area with copious amounts of water and seek medical advice.
- Do not use any charger other than that specifically provided for use with the Li-ion battery.
- Observe the plus (+) and minus (–) marks on the Li-ion battery and equipment and ensure correct use.
- Do not use any battery which is not designed for use with the Li-ion battery.
- Do not mix batteries of different manufacture, capacity, size or type within a device.
- Keep the Li-ion battery clean and dry.
- Secondary batteries need to be charged before use. Always use the correct charger and refer this manual for proper charging instructions.
- Do not leave the Li-ion battery on prolonged charge when not in use.
- After extended periods of storage, it may be necessary to charge and discharge the Li-ion battery several times to obtain maximum performance.
- Retain the original product documentation for future reference.
- Remove the Li-ion battery from the equipment when not in use.



Warning! Keep the Li-ion battery away from water, dust and contamination.

3.2. Disposal



Dispose of the Li-ion battery in accordance with local, state and federal laws and regulations. Batteries may be returned to the manufacturer.
Do not mix with other (industrial) waste.

3.3. Safety symbols and markings on product

Several safety symbols and markings can be found on the product. These markings are displayed below. Never remove these markings!



The meanings of the symbols:









	Shield eyes
	Note operating instructions
	Battery acid
	Explosive gas
	No smoking, no naked flames, no sparks
	Keep away from children
	Dispose of the Li-ion battery in accordance with local, state and federal laws and regulations. Batteries may be returned to the manufacturer. Do not mix with other (industrial waste)
	This product, or sections of this product can be recycled

Table 13. Safety symbols

4. Installation

4.1. General information



Warning! Never install or use a damaged Li-ion battery.



Caution! Do not reverse connect the Li-ion battery(polarity)

When connecting several batteries in series or parallel, always use batteries of the same brand, type, age, capacity and state of charge.

4.2. Unpacking

Check the Li-ion battery for damage after unpacking. If the Li-ion battery is damaged, contact your reseller or Whisper Power. Do not install or use the Li-ion battery if it is damaged!

4.3. Preparing the battery for use



Caution! Do not operate the Li-ion battery beyond published maximum specifications.



Caution! In case of an under-voltage shutdown, charge immediately.



Warning! Always remain within the limits indicated in chapter 2 during the use of the Li-ion battery.



Caution! This Li-ion battery stores fault conditions internally, like excessive charge current or deep discharge situations. Whisper Power uses this information in the warranty process



Warning! Do not overcharge the Li-ion battery.

4.3.1. Placement of the battery

Before it is used, the Li-ion battery must be positioned in such a way that it will not move around in its compartment during use. If necessary, the Li-ion battery may be fixed in place by means of Whisper Power mounting brackets. The brackets can be screwed in place by means of bolts or screws (See Figure 4).

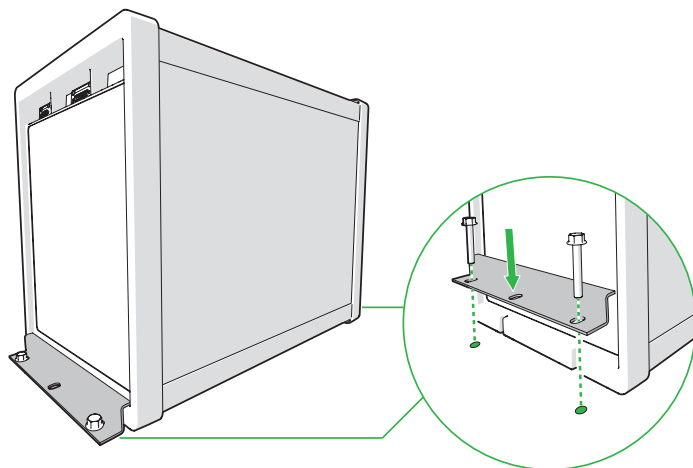


Figure 4. Installing the Li-ion battery using the Whisper Power mounting brackets

4.3.2. Placement and removal of a fuse

Before the Li-ion battery can be used, the internal fuse needs to be installed into it. The 72V/500A fuse is supplied with the Li-ion battery. Other fuses may only be used in the product when they are approved by Whisper Power for this application.

Use the following steps to (re)place the fuse in the Li-ion battery (Figure 5):

1. Disconnect the negative wire from the - pole of the Li-ion battery (see paragraph 4.5.5. for the details).
2. Disconnect the positive wire from the + pole of the Li-ion battery.
3. Unscrew the fuse cover using the fuse TORX key.
4. Unscrew the fuse contacts using a 13mm wrench.
5. Place the (new) fuse between the contacts, place washers and spring washers and tighten the fuse contact points to 20Nm.
6. Fasten the fuse cover.
7. Proceed to the next paragraph to read the instructions on installing the Li-ion battery in an electrical circuit.

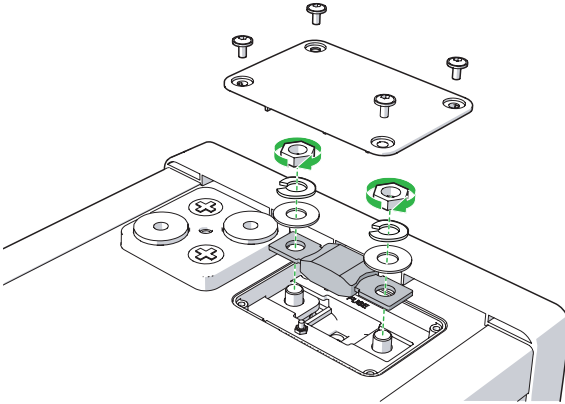


Figure 5. Install a fuse

4.4. Connection wires

Use appropriate wire for the connection wires to ensure no overheating or unnecessary losses occur. Use appropriate fuses matching the wires and load. See appendix III for more details.

4.5. Installing the mandatory Battery Disconnect device



Warning! Always connect the relay between the + or - terminal of the battery and the load.



Warning! Never use the Li-ion battery without a properly installed Battery Disconnect device (relay or latching relay).

An external Battery Disconnect device must be installed between the + or - terminal of the Li-ion battery and the load. The protection of the Li-ion battery is possible by one of the following ways:

1. Connect a bi-stable relay to the Li-ion battery's Con1 output.
2. Connect a normal relay to the Li-ion battery's Con2 (I/O connection 7) output.
3. By using the WP WIB (Battery Interface Box).
4. By using the WP BCI-C1 (Battery Communication Interface) and a normal relay.

4.5.1. Connecting a bi-stable relay to the Li-ion battery

1. When using a bi-stable relay connect it to Con1 output as displayed in Figure 6. The Con1 output controls both the ON coil and the OFF coil of the bi-stable relay. The output of Con1 can be found in Table 9.

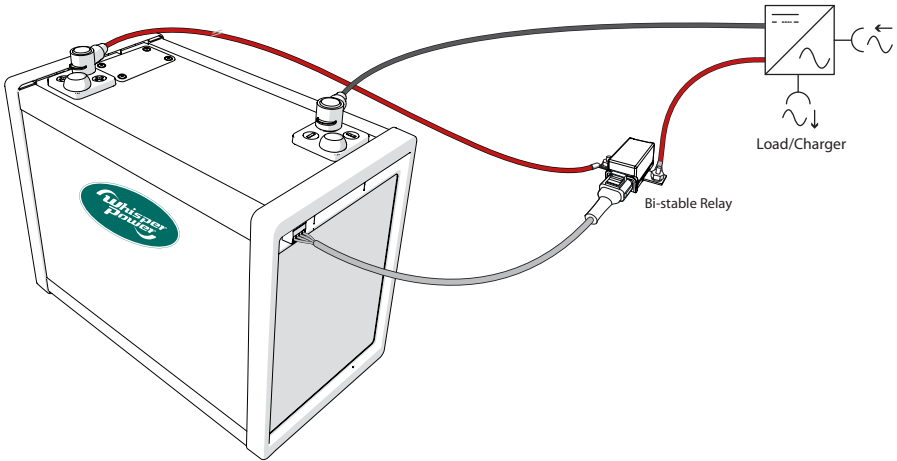


Figure 6. Connect a bi-stable relay as Battery Disconnect device

4.5.2. Connecting a normal relay as Battery Disconnect device

1. When using a normal relay, connect it to Con 2 (I/O Connection 7), Pin 4 (Rc) and Pin 5 (Rnc) as displayed in Figure 7.

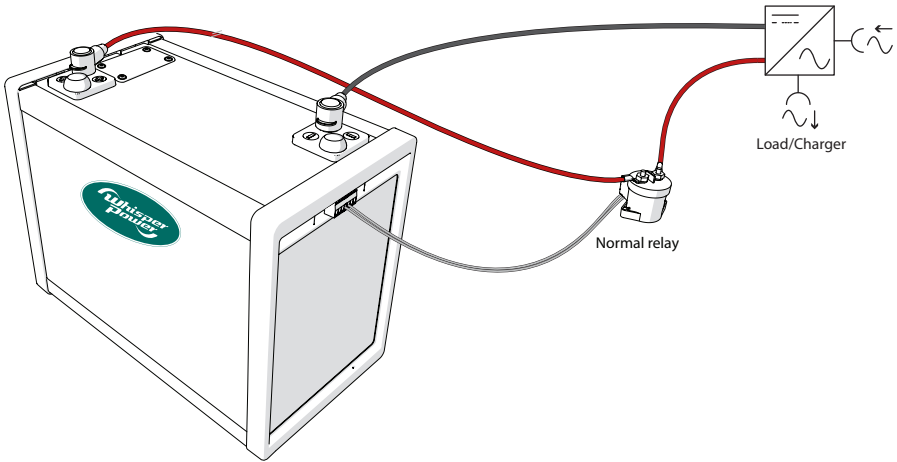


Figure 7. Connect a normal relay as Battery Disconnect device.

4.5.3. Using the WP WIB (Battery Interface Box)

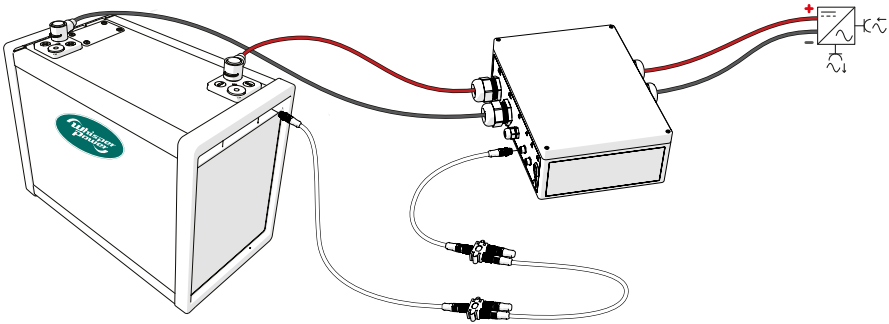


Figure 8. Connecting a Li-ion battery to the WP WIB

Consult the manual of the WP WIB for installation instructions.

4.5.4. Using the WP BCI-C1 (Battery Communication Interface) with a normal relay

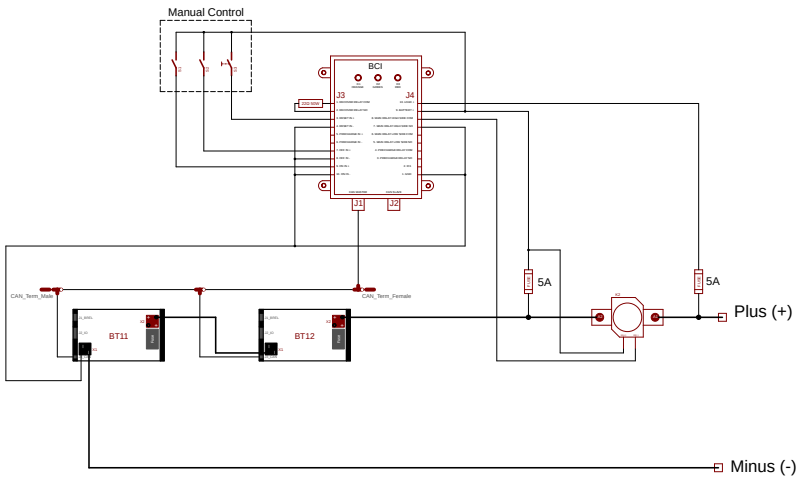


Figure 9. Connecting a Li-ion battery to the WP BCI-C1

Consult the manual of the WP BCI-C1 for installation instructions.

4.6. Connecting the Li-ion battery to the load/charger

4.6.1. Connecting a single Li-ion battery to the load/charger with a bi-stable relay

Warning! Ensure you have completed all the previous steps described in chapter 4.5 before connecting the battery to the load/charger.

1. Slide the terminal covers over the connection wires.
2. Connect the + terminal of the battery to the - or A terminal of the relay (Figure 10).
3. Connect the load or charger to the + or B terminal of the relay.
4. Connect the - terminal of the battery. Do not connect the - terminal first as this may lead to short circuits (Figure 10).
5. Ensure both contacts are tightened to 20Nm.
6. Place the terminal covers over the terminals (Figure 11).
7. Press the reset button for 10-15 seconds after connecting the bi-stable relay to Con1 output.(the reset button is located under the fuse cover). The bi-stable relay contacts will be turned off and on, this is to make sure that the bi-stable relay is ON

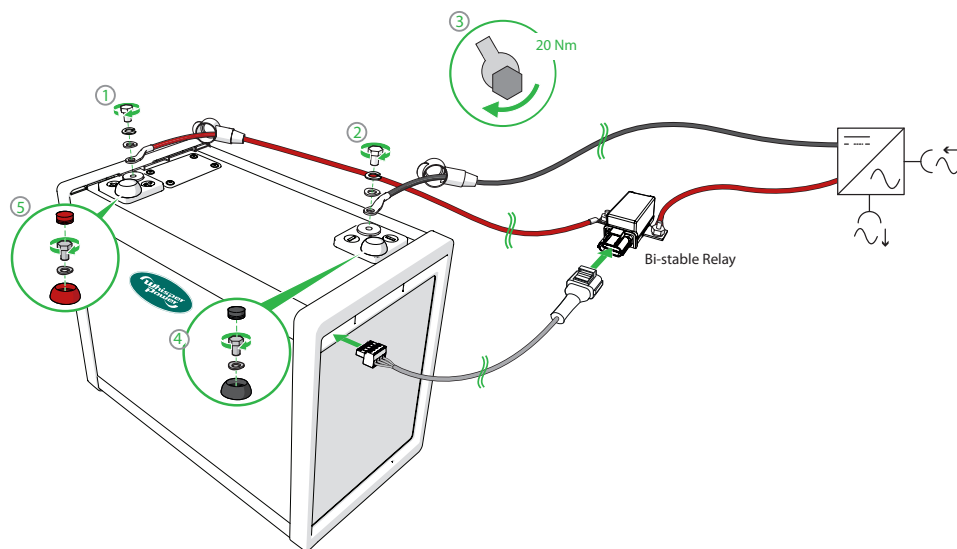


Figure 10. Connecting the battery to the load

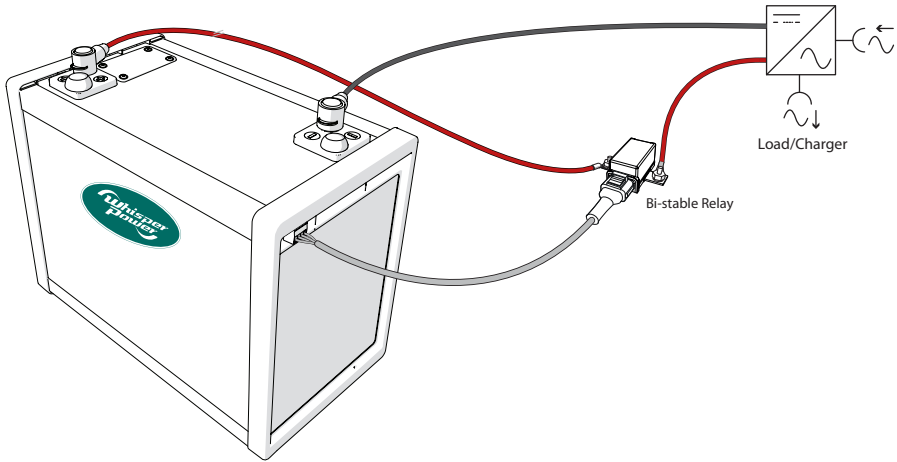


Figure 11. Securing the terminal covers

4.6.2. Connecting a single Li-ion battery to the load/charger with a normal relay



Warning! Ensure you have completed all the previous steps described in chapter 4.5 before connecting the battery to the load/charger.

1. Slide the terminal covers over the connection wires.

1. Connect the + terminal of the battery to the - or A1 terminal of the relay (Figure 12).

2. Connect the load or charger to the + or A2 terminal of the relay.

3. Connect the - terminal of the battery. Do not connect the - terminal first as this may lead to short circuits (Figure 12).

4. Ensure both contacts are tightened to 20Nm.

Place the terminal covers over the terminals (Figure 13)

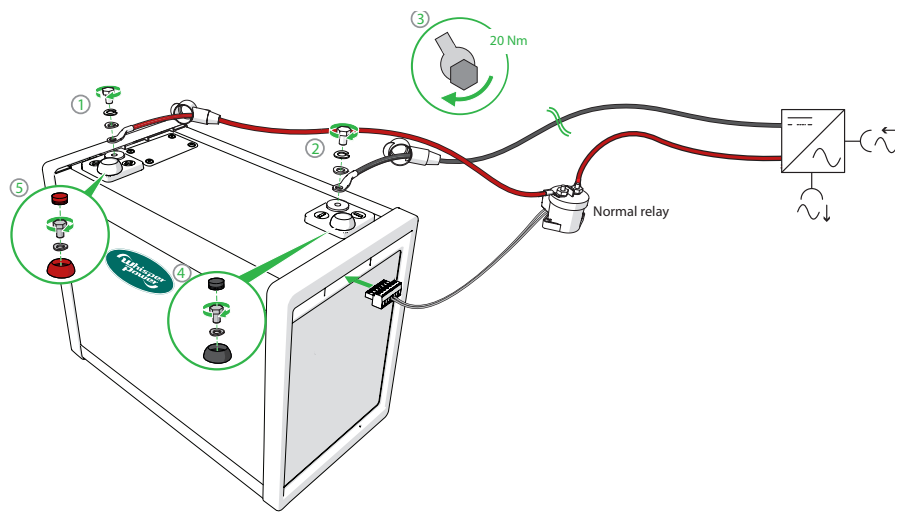


Figure 12. Securing the terminal covers.

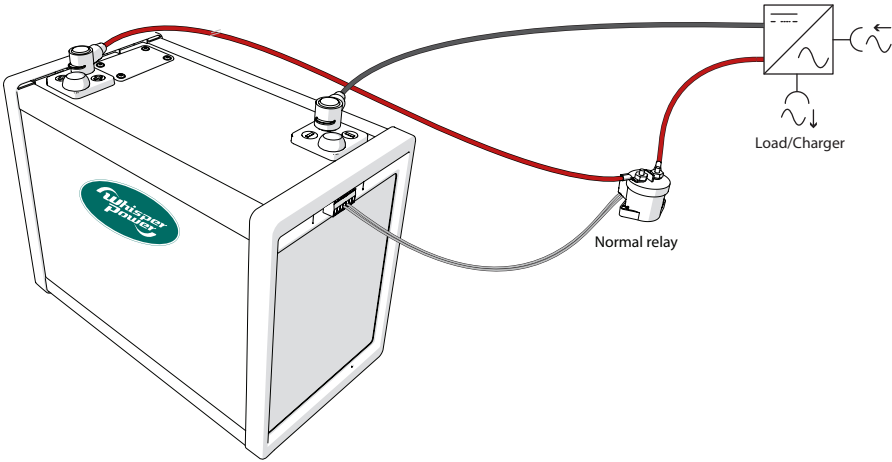


Figure 13. Connecting the battery to the load

4.6.3. Connecting Li-ion batteries in series.

- ⚠ **Caution!** Before connecting 2 or more Li-ion batteries, the Li-ion batteries must be charged to 100% SoC.
- ⚠ **Caution!** For more than 4 Li-ion batteries in series connection consult Whisper Power or your dealer.
- ⚠ **Caution!** Depending on the installation a precharge circuit is needed. For further information consult Whisper Power or your dealer.

When using Li-ion batteries in series configuration CAN balancing is required (see paragraph 4.7.4.). The CAN power cable is necessary for CAN balancing.

In installations with more than 2 batteries in series the CAN power cable should be powered from an external 24V power supply.

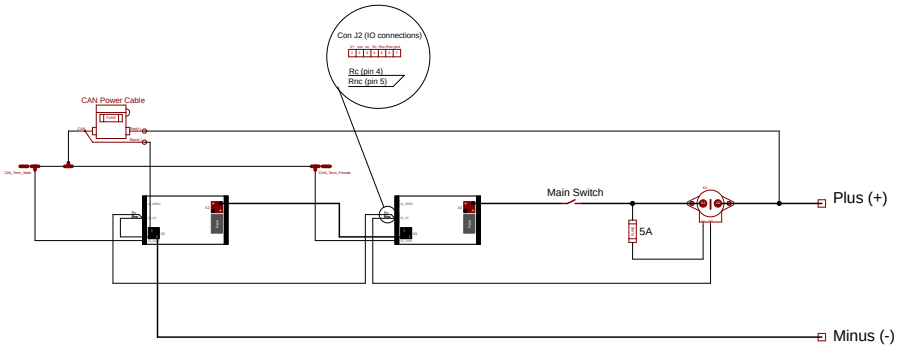


Figure 14. Batteries connected in series with CAN power cable and disconnecting device

4.6.4. Connecting Li-ion batteries in parallel

- ⚠ **Caution!** Before connecting 2 or more Li-ion batteries, the Li-ion batteries must be charged to 100% SoC.
- ⚠ **Caution!** For more than 4 Li-ion batteries in parallel connection consult Whisper Power or your dealer.
- ⚠ **Caution!** Depending on the installation a precharge circuit is needed. For further information consult Whisper Power or your dealer.

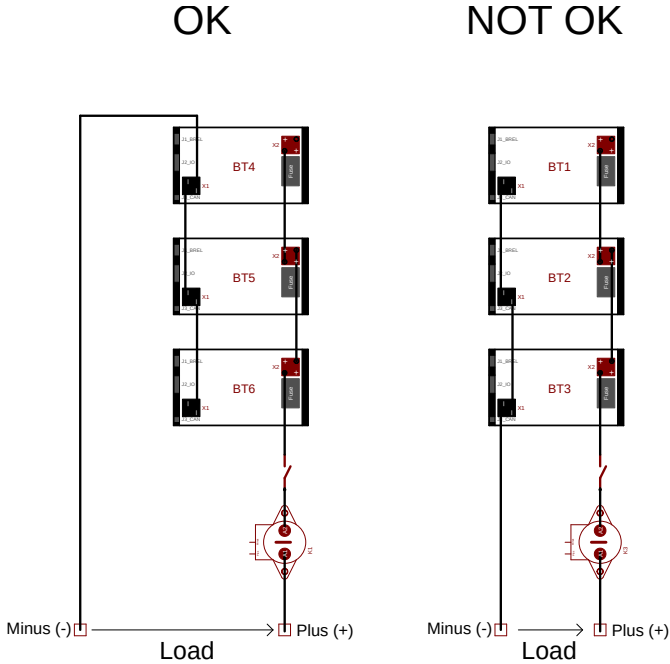


Figure 15. Three Li-ion batteries in parallel with external relay

OK: Equally divided battery current.
All batteries contribute equally to the current into the load.

NOT OK: Current not equally divided.
Batteries closest to load will have the highest contribution to the current into the load.
Whereas batteries further away from load will have lesser current contribution.
Wear and tear will be higher on the Li-ion battery close to the load.

When using Li-ion batteries in parallel configuration CAN balancing is not required.

4.6.5. Connecting Li-ion batteries in series and parallel

⚠ Caution! Before connecting 2 or more Li-ion batteries, the Li-ion batteries must be charged to 100% SoC.

⚠ Caution! For more than 4 Li-ion batteries in series and parallel connection consult Whisper Power or your dealer.

⚠ Caution! Depending on the installation a precharge circuit is needed. For further information consult Whisper Power or your dealer.

When using Li-ion batteries in series and parallel configuration CAN balancing is required (see paragraph 4.7.4). The CAN power cable is necessary for CAN balancing. In installations with more than 2 batteries in series the CAN power cable should be powered from an external 24V power supply.

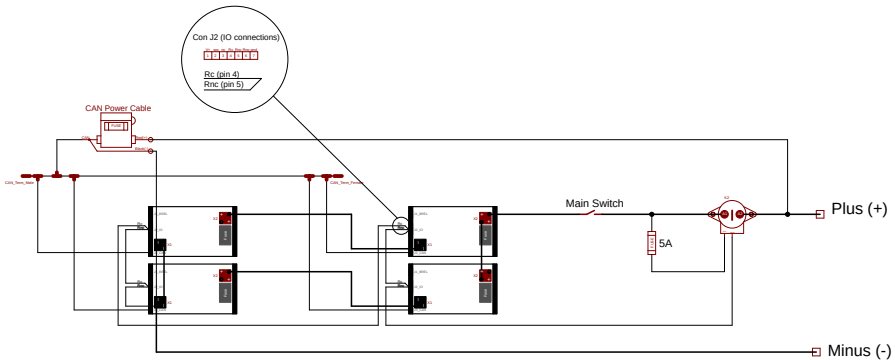


Figure 16. Four Li-ion batteries in a series - parallel connection with external relay

4.7. CANopen interface

The CANopen interface of the Li-ion battery must be used for CAN balancing and can be used for monitoring purposes.

The Li-ion battery can be monitored using the Battery Monitor software and the Touch Display Screen. (see paragraph 2.8.2)

To use the Battery Monitoring Software, the CAN bus of the Li-ion battery (CON 3) needs to be connected by means of CAN-to-USB interface to the computer on which the monitoring software and the usb drivers are installed.

More information about the CANopen bus can be found at the CiA website: www.can-cia.org.

4.7.1. CAN Bus network topology

The CAN Bus must be used in a bus network topology. Do not use a ring- or a star topology.
The maximum CAN bus legnth is limited because the Li-ion battery has a fixed bitrate of 250kbps.

In Table 6 is an overview of these restrictions.

Bit rate	Bus length (L)	Max. stub length (S)	Accumulated stub length
250 kbps	250 m	11 m	55 m

Table 6. CAN bus speed

4.7.2. Termination Resistors

The CAN bus requires termination at the two ends of the bus. The USB-to-CAN interface may be connected in anywhere to the CAN bus.

Use termination resistors at the end nodes to prevent reflections on the line. The value of this resistor should be +/- 120 ohms.

CAN bus power

Due to the galvanic separation between the BMS and the Li-ion battery's CAN interface an external power supply is needed on the CAN bus.

The CAN bus can be powered through Con 2 (I/O Connection 7) (figure 17) or the CAN power cable. (figure 18)

This situation may occur when a USB-to CAN interface is directly connected to the Li-ion battery (figure 17).

1. Connect Pin 1 of Con2 to the + terminal of the Li-ion battery.
2. Connect Pin 7 of Con2 to the - terminal of the Li-ion battery.

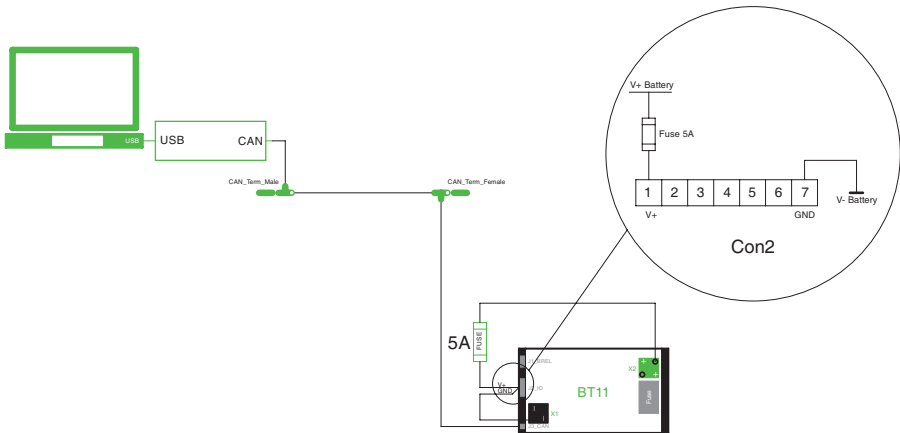


Figure 17. Use Con2 to power the CAN bus

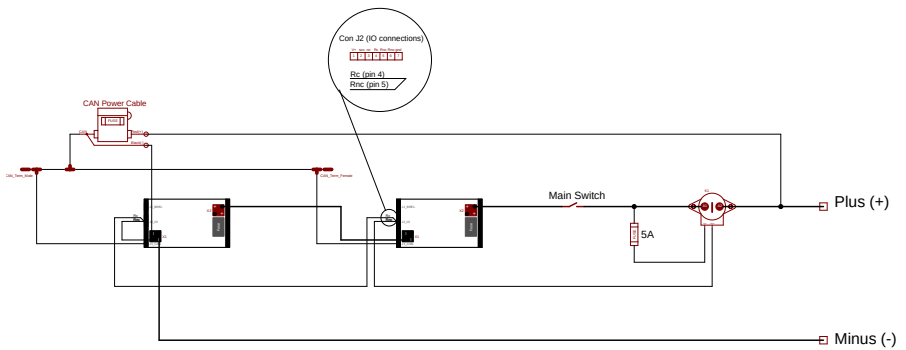


Figure 18. Use of CAN power cable to power the CAN bus

4.7.3. CAN balancing

When the Li-ion battery is connected in a series configuration CAN balancing is required. CAN balancing makes sure that all batteries are balanced properly. For this it is necessary that the batteries must communicate with each other. Therefore the CAN bus is used.




CAN balancing works with WP BCI-C1/WP WIB and without WP BCI-C1/WP WIB up to 8 batteries.

Disconnecting the Li-ion battery






1. Turn off any device or charger the Li-ion battery is connected to.
2. Disconnect the negative wire from the - terminal of the Li-ion battery.
3. Disconnect the positive wire from the + terminal of the Li-ion battery.

5. Battery use

5.1. General information

-  **Warning!** Always use a Battery Disconnect device.
-  **Caution!** In case of an undervoltage shutdown, charge immediately.
-  **Warning!** Follow the safety guidelines and measures of chapter 3

5.2. Charging

-  **Warning!** Never charge the Li-ion battery with a charging current larger than 1C.
-  **Warning!** Stop charging in case the Li-ion battery switches into alarm mode. (the protection relay will disengage)
-  **Caution!** Charge before use
-  **Caution!** Disconnect the charger from the Li-ion battery if it is not used for a long time.
-  **Caution!** To preserve the lifespan of the Li-ion battery, use a charger approved by Whisper Power.

1. Connect the charger to the Li-ion battery as described in paragraph 4.6.
2. Charge the Li-ion battery in case of an under-voltage shutdown or if the state of charge drops below 20% to preserve the lifespan of the Li-ion battery.

5.2.1. Charging rate

Whisper Power Li-ion battery can be charged in approximately 1 hour. Displayed in Table 7 are the charge times for the Li-ion battery at different charge currents. Always use the indicated charge current and end of charge voltage during charging.

Charging rate		
	Time	Change current
Maximum	1 hour	1C (160A)
Endurance lifecycle	3 hours	C3 (53.3A)

Table 7. Charging rates at different charge currents

5.2.2. Charging method

Whisper Power recommends using the following charging method.

Charge Profile Whisper Power Batteries

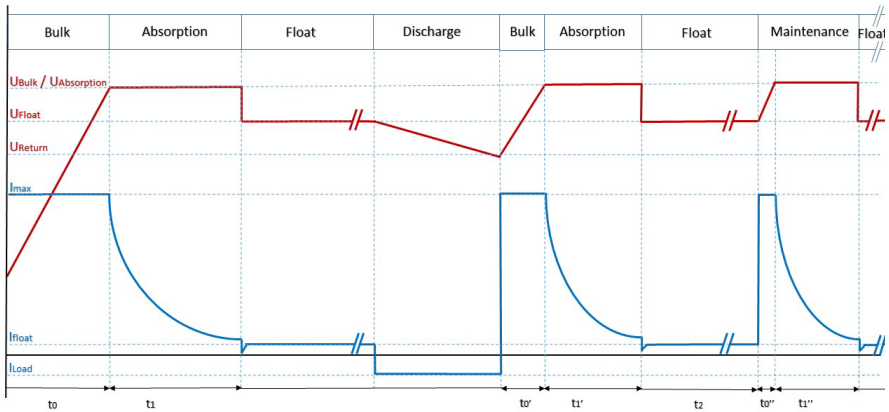


Figure 19. Charge curve

Bulk phase

In this phase the batteries are charged with a constant current up to the end of charge voltage (Ubulk). If Ubulk is reached the charger will automatically switch to absorption phase. The maximum charge current (Imax) for Whisper Power batteries is 1C, however for endurance cycle life Whisper Power suggests to limit the current to C3 (1C = nominal battery capacity, C3 = 1/3 of nominal capacity). On some chargers the maximum charger active time (t0) can be programmed. Whisper Power suggests setting t0 to: $t_0 = 2 \cdot (BTcap / Chcur)$
Example: Battery capacity = 160Ah, Charger = 80A, Set to to a maximum of $2 \cdot (160/80) = 4$ hours.

Bulk Phase			
	Typical	Min	Max
Imax	-	-	1C (160 A)
t0	Depends on the battery SoC	-	$2 \cdot (BTcap / Chcur)$

Table 8. Bulk Phase

Absorption phase

In this phase the charge voltage must be maintained at UAbsorption to fully charge the Li-ion battery and set the State of Charge (SoC) counter to 100%. See Table 7. This phase is finished when the SoC is indicating 100%.

Absorption Phase			
	Typical	Min	Max
UAbsorption	14.4V DC	14.3V DC	14.6V DC
t1	20 minutes	10 minutes	1 hour

Table 9. Absorption Phase

Float phase

In this phase the charge voltage is set to UFloat. The charger will supply the load, if any.

Float Phase			
	Typical	Min	Max
UFloat	13.8V DC	13.6V DC	14V DC

Table 10. Float Phase

Discharge phase

In this phase the Li-ion battery is discharged. As soon as the Li-ion battery voltage drops below UReturn for longer than 5 seconds the charging process must be repeated.

Discharge Phase			
	Typical	Min	Max
UFloat	13.5V DC	13.4V DC	13.6V DC

Table 11. Discharge Phase

Maintenance phase

Every t2 hours the batteries require a maintenance charge to fully charge the Li-ion battery and set the State of Charge (SoC) counter to 100%. Without this phase the Li-ion battery SoC can be inaccurate.

Maintenance Phase		
	Typical	Max
t3	13 weeks	26 weeks

Table 12. Maintenance phase

5.2.3. Battery balancing

The Li-ion battery is automatically balanced during the absorption phase (see paragraph 5.2.2).

During the batteries lifespan, the cells within the Li-ion battery may be unbalanced due to high discharge currents and short float charge periods. This may result in a loss of capacity and unbalanced cells. Cells may be equalized by means of the following procedure:

Apply a constant voltage of 14.4V and a current of between 1A and 2A to manually equalize the Li-ion battery.

5.2.4. Reading out the battery's State of Charge (SoC)

The Li-ion battery's State of Charge can be read out either by using the BM01, Touch Display, CAN network, or by the analogue output (see further instructions below).

1. Connect Pin1 of Con2 to the Li-ion battery's + pole.
2. Connect Pin 7 of Con2 to ground.
3. Determine the voltage at Pin 2 of CON2 (see Figure 20).
The analog SoC output ranges from 0 to 10 volt, in which 0V corresponds with 0% SoC and 10V corresponds with 100% SoC.
The SoC is an indication. Charging currents smaller than 100mA are not used in the SoC calculation.
4. Perform a complete charge cycle to the Li-ion battery through if the SoC indication does not provide an accurate measurement. This will recalibrate the SoC.

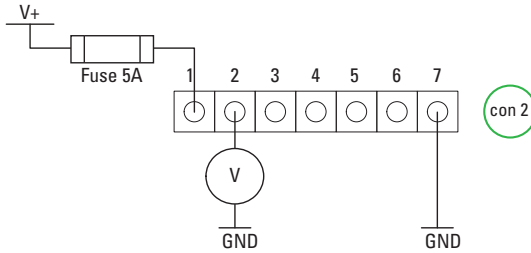


Figure 20. Determining the batteries SoC

5.3. Battery Monitoring Software

Battery monitoring software offers the possibility to continuously monitor a number of the Li-ion battery properties through sensors within the Li-ion battery. It also enables one to download a complete recording of the Li-ion battery's properties over time.

The Battery Monitoring software and the hardware are not included with the Li-ion battery. An overview of these products is given in paragraph 2.8.2.

5.3.1. Battery History Recording

The battery history can be downloaded with the Battery Monitor software. This recording can only be accessed by a reseller or Whisper Power for evaluation.

6. Inspection, cleaning and maintenance

6.1. General information



Warning! Never attempt to open or dismantle the Li-ion battery! The inside of the Li-ion battery does not contain serviceable parts.

1. Disconnect the Li-ion battery from all loads and charging devices before performing cleaning and maintenance activities (see paragraph 4.7.5).
2. Remove the fuse or dummy fuse before cleaning and maintenance activities (see paragraph 4.3.2).
3. Place the enclosed protective caps over the terminals before cleaning and maintenance activities to avoid the risk of contacting the terminals.

6.2. Inspection

1. Inspect for loose and/or damaged wiring and contacts, cracks, deformations, leakage or damage of any other kind. If damage to the Li-ion battery is found, it must be replaced. Do not attempt to charge or use a damaged Li-ion battery. Do not touch the liquid from a ruptured Li-ion battery.
2. Observe and note the run time that a new, fully-charged Li-ion battery provides for powering your product. Use this new Li-ion battery run time as a basis to compare run times for older batteries. The run time of the Li-ion battery will vary depending on the products' configuration and the application it is used for.
3. Routinely check the Li-ion battery's charge status. Lithium Iron Phosphate batteries continue to slowly self-discharge (1-2% per month) when not in use or whilst in storage.
4. Carefully monitor batteries that are approaching the end of their estimated life.
5. Consider replacing the Li-ion battery with a new one if you note either of the following conditions:
 - The Li-ion battery run time drops below about 80% of the original run time.
 - The Li-ion battery charge time increases significantly.

6.3. Cleaning

If necessary, clean the Li-ion battery with a soft, dry cloth. Never use liquids, solvents, or abrasives to clean the Li-ion battery.

7. Storage

Follow the storage instructions in this manual to optimize the lifespan of the Li-ion battery during storage. If these instructions are not followed and the Li-ion battery has no charge remaining when it is checked, consider it to be damaged. Do not attempt to recharge or use it. Replace it with a new Li-ion battery.

See chapter 2.4 for storage temperature conditions.

The self-discharge of the Li-ion battery is 1-2% per month.

1. Charge the Li-ion battery to 100% of its capacity before storage.
2. Disconnect the Li-ion battery from all loads and, if present, the charging device
3. Remove the fuse from the Li-ion battery during storage. (See paragraph 4.3.2)
4. Place the terminal covers over the Li-ion battery's terminals during storage.
5. Charge the Li-ion battery to 100% of its capacity every year.

8. Transportation

8.1. General

Always check all applicable local, national, and international regulations before transporting a Lithium Iron Phosphate battery.

Transporting an end-of-life, damaged, or recalled Li-ion battery may, in certain cases, be specifically limited or prohibited.

The transport of the Li-ion battery falls under hazard class UN3480, class 9. For transport over water, air and land, the Li-ion battery falls within packaging group PI965 Section II.



Use Class 9 Miscellaneous Dangerous Goods and UN Identification labels for transportation of lithium ion batteries which are assigned Class 9. Refer to relevant transportation documents. Lithium batteries and lithium ion cells are regulated in the U.S. in accordance with Part 49 of the Code of Federal Regulations, (49 CFR Sections 105-180) of the U.S. Hazardous Materials Regulations.

Visit www.iata.org for the complete transport regulations and packing instructions for this product.

The relevant information for Li-ion batteries can be found under "Programs" > "Cargo" > "Dangerous goods (HAZMAT)".

9. Disposal and recycling

9.1. General information

Always discharge the Li-ion battery before disposal. Use electrical tape or other approved covering over the Li-ion battery connection points to prevent short circuits.

Battery recycling is encouraged. Dispose of the Li-ion battery in accordance with local, state and federal laws and regulations. Batteries may be returned to the manufacturer.

USA & Canada:

Lithium Iron Phosphate batteries are subject to disposal and recycling regulations that vary by country and region. Always check and follow your applicable regulations before disposing of any Li-ion battery. Contact Rechargeable Battery Recycling Corporation (www.rbcc.org) for U.S.A. and Canada, or your local Li-ion battery recycling organization.

EC

Waste must be disposed of in accordance with relevant EC Directives and national, regional and local environmental control regulations. For disposal within the EC, the appropriate code according to the European Waste Catalogue (EWC) should be used.

Other

Many countries prohibit the disposal of waste electronic equipment in standard waste receptacles.

10. Troubleshooting

Problem	Possible reason	Solution
The capacity of the Li-ion battery has decreased	The cells within the batteries are not properly balanced or the Li-ion battery is worn out. .	Perform one full charge cycle to balance the cells.
The Li-ion battery cannot be charged / discharged	The fuse of the Li-ion battery is not installed	Install the fuse; follow the procedures described in paragraph 4.3.2
	The fuse in the Li-ion battery is broken.	Disconnect all loads and chargers, check and correct for short circuits and defects. Then replace the fuse; follow the procedures described in paragraph 4.3.2
	The Li-ion battery has been deeply discharged. The BMS is now in "fault condition".	Disconnect all loads and connect a charger to the Li-ion battery. Then press the reset button for at least 10-15 seconds to resolve the "fault condition"(see paragraph 2.7.).
	The Li-ion battery has been overcharged. The BMS is now in "fault condition".	Disconnect the charger from the Li-ion battery and press the reset button for at least 10-15 seconds to resolve the "fault condition" (see paragraph 2.7.).
	The Li-ion battery has overheated. The BMS is now in "fault condition".	Disconnect the charger and all loads and wait for the Li-ion battery to cool down. Then press the reset button for at least 10-15 seconds to resolve the "fault condition" (see paragraph 2.7.).

Table 13. Troubleshooting

11. Warranty and liability

11.1 Upon delivery the customer is obliged to immediately verify whether the products have been damaged during transport. In the event that any such damage has arisen, the customer must notify Whisper Power thereof as soon as possible, in any event no later than three (3) days of delivery, by means of accurate, written statement, stating the damage and where possible a photograph. Failure to inspect the products and inform Whisper Power within the stated time or the use of the products at any time shall be conclusive evidence that Whisper Power has satisfactorily tendered delivery.

11.2 In the event that the customer demonstrates that any of the delivered products do not conform to the agreement, Whisper Power (at its option, upon having received those products returned by the customer) has the option to either repair or replace such products by new products, or to refund the invoice value, exclusive of any dispatch costs.

11.3 Whisper Power grants a three year limited warranty for damages caused by manufacturing defects starting at the time of delivery. Damages caused by manufacturing defects do not include damage resulting from (a) general wear and tear, (b) short circuit, (c) overcharging, (d) deep discharging, (e) overheating of Whisper Power products (f) installation of the Whisper Power product by persons unskilled to work with electro-technical devices or components, (g) any other wrongful use contrary to the Whisper Power's user manual or the safety instruction, (h) any use contrary to the product specifications of that product; (i) any acts of force majeure.

11.4 Except as specified in the clause 11.3 Whisper Power makes no warranty, whether express or implied, including without limitation any implied warranty of merchantability and fitness for a particular purpose or any warranty arising from any course of dealing, course of performance or usage of trade and specifically disclaims any representation or warranty that the product will meet customer's requirements, perform any specific function or achieve a desired result other than expressly stated by Whisper Power in writing.

11.5 Any liability to the customer in any case ceases to apply in the event that the customer fails to notify Whisper Power of the existence of the defect within ten (10) days of having discovered the defect, in writing, in order to enable Whisper Power to investigate the damage. Some of Whisper Power's products electronically store usage data, including charging/discharging data, in order to enable Whisper Power to analyse such data retroactively when investigating damage.

11.6 Any liability of Whisper Power for damage suffered by the customer is in any case limited to the invoice amount of the relevant products, unless such damage has been caused by gross negligence or willful misconduct of Whisper Power.

Whisper Power can never be held liable for (a) damage caused by any of the circumstances mentioned in clause 11.3, leading to damage to the Whisper Power products or to any other device located near those products, or (b) consequential damage or (c) loss of profits or goodwill.

11.7 To the extent that a court determines that the limitation of liability as meant in clause 11.6 cannot be invoked against a particular claim for damages by the customer, Whisper Power's liability for loss of property, damage to property, and bodily injury (including death) caused by the application of those particular Whisper Power products shall in any event be limited to the amount actually paid out by Whisper Power's insurance company to Whisper Power in accordance with the insurance cover of that insurance policy for that particular type of damage. Whisper Power has taken out insurance against certain risks, as described in the respective insurance policies. These policies contain a usual limitation of insurance payment to be paid out to Whisper Power if, and to the extent that, the event is a covered event.

Appendix I. Declaration of Conformity



Generating Confidence

EC Declaration of Conformity

Product Number/Name/Description:

**WP-ION (Lithium Ion Battery) 12V / 160Ah / 2122Wh
(Energy / Traction Battery)**

The undersigned hereby declares, on behalf of *WhisperPower BV, Kelvinlaan 82, 9207 JB Drachten, The Netherlands*, that the above- referenced product, to which this declaration relates, is in conformity with the provisions of:

- Council Directive 2006/66/EC, Environmental EU Compliance
- Council Directive 2014/30/EU (December 15, 2004) on Electromagnetic Compatibility

European standards used:

- EN 61000- 6- 3 (2007) + A1 (2011), EN 55016- 2- 3 (2010) + A1 (2010) + C1 (2013), EMC (Emission) Compliance
- EN 61000- 6- 2 (2005) + AC (2005), EN 61000- 4- 2 (2009), EN 61000- 4- 3 (2006) + A1 (2008) + A2 (2010), EN 61000- 4- 4 (2012), EN 61000- 4- 5 (2007), EN 61000- 4- 6 (2009), EMI (Immunity) Compliance
- IEC 62133, Safety IEC Compliance
- IEC 61960 [ed2.0], Performance IEC Compliance

The Technical Construction File required by this Directive is maintained at the corporate headquarters of WhisperPower BV, Kelvinlaan 82, 9207 JB Drachten, The Netherlands.

Signed by:

Dr. M. Favot

CTO, Drachten

Date: Sept 20th 2017

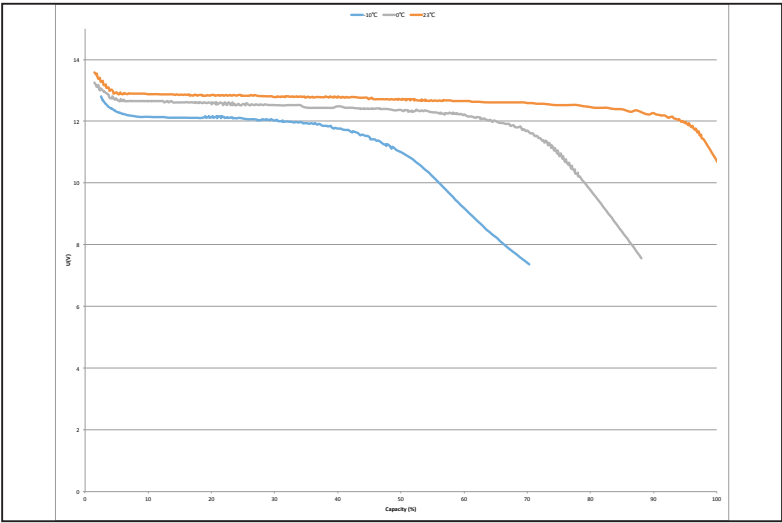
WhisperPower BV
Kelvinlaan 82
9207 JB Drachten
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KvK: 01120025

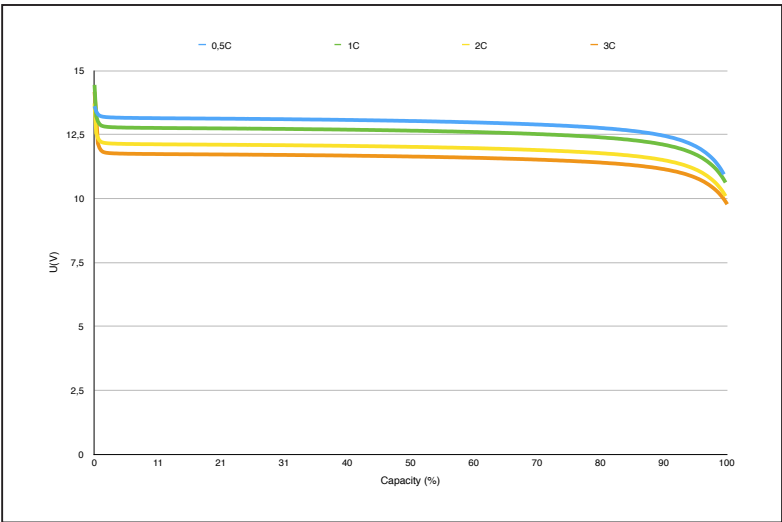
whisperpower.com

Appendix II. Performance Graphs

Temperature performance



Load performance



Appendix III. Conductor requirements

Subject

Use appropriate wire for the connection wires to ensure no overheating or unnecessary losses occur. Consult the SAE-J378 or ISO 10133:2012 standards to determine the appropriate wire properties. Use appropriate fuses matching the wires and load.

The below information is a summary extracted from the ISO10133:2012, reading the ISO ISO10133:2012 is recommended.

Conductor requirements 12V d.c. system at 30 °C ambient temperature

Allowable maximum current, in amperes, for single conductors at insulation temperature ratings. With a maximum voltage drop of 3%.

S is the conductor cross-sectional area, in square millimeters

I is the load current, in amperes

L is the length, in meters, of conductor from the positive power source to the electrical device and back to the negative source connection.

Conductors at insulation temperature 105 °C:

S / L	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	75	100
0,75	16	8	5	4	3	3	2	2	2	2	1	1	1	1	0	0	0	0	0	0
1	22	11	7	5	4	4	3	3	2	2	1	1	1	1	1	1	0	0	0	0
1,5	33	16	11	8	7	5	5	4	4	3	2	2	1	1	1	1	1	1	0	0
2,5	45	27	18	14	11	9	8	7	6	5	4	3	2	2	2	1	1	1	1	1
4	55	44	29	22	18	15	13	11	10	9	6	4	4	3	3	2	2	2	1	1
6	75	66	44	33	26	22	19	16	15	13	9	7	5	4	4	3	3	3	2	1
10	120	110	73	55	44	37	31	27	24	22	15	11	9	7	6	5	5	4	3	2
16	170	170	117	88	70	59	50	44	39	35	23	18	14	12	10	9	8	7	5	4
25	200	200	183	137	110	91	78	69	61	55	37	27	22	18	16	14	12	11	7	5
35	240	240	240	192	154	128	110	96	85	77	51	38	31	26	22	19	17	15	10	8
50	325	325	325	274	220	183	157	137	122	110	73	55	44	37	31	27	24	22	15	11
70	375	375	375	375	307	256	220	192	171	154	102	77	61	51	44	38	34	31	20	15
95	430	430	430	430	417	348	298	261	232	209	139	104	83	70	60	52	46	42	28	21
120	520	520	520	520	520	439	376	329	293	263	176	132	105	88	75	66	59	53	35	26
150	560	560	560	560	560	549	470	412	366	329	220	165	132	110	94	82	73	66	44	33

Conductors at insulation temperature 85 - 90 °C:

S / L	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	75	100
0,75	16	8	5	4	3	3	2	2	2	2	1	1	1	1	0	0	0	0	0	0
1	22	11	7	5	4	4	3	3	2	2	1	1	1	1	1	1	0	0	0	0
1,5	30	16	11	8	7	5	5	4	4	3	2	2	1	1	1	1	1	1	0	0
2,5	40	27	18	14	11	9	8	7	6	5	4	3	2	2	2	1	1	1	1	1
4	50	44	29	22	18	15	13	11	10	9	6	4	4	3	3	2	2	2	1	1
6	70	66	44	33	26	22	19	16	15	13	9	7	5	4	4	3	3	3	2	1
10	100	100	73	55	44	37	31	27	24	22	15	11	9	7	6	5	5	4	3	2
16	150	150	117	88	70	59	50	44	39	35	23	18	14	12	10	9	8	7	5	4
25	185	185	183	137	110	91	78	69	61	55	37	27	22	18	16	14	12	11	7	5
35	225	225	225	192	154	128	110	96	85	77	51	38	31	26	22	19	17	15	10	8
50	300	300	300	274	220	183	157	137	122	110	73	55	44	37	31	27	24	22	15	11
70	360	360	360	360	307	256	220	192	171	154	102	77	61	51	44	38	34	31	20	15
95	410	410	410	410	410	348	298	261	232	209	139	104	83	70	60	52	46	42	28	21
120	480	480	480	480	480	439	376	329	293	263	176	132	105	88	75	66	59	53	35	26
150	520	520	520	520	520	520	470	412	366	329	220	165	132	110	94	82	73	66	44	33

Conductors at insulation temperature 70 °C:

S / L	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	75	100
0,75	16	8	5	4	3	3	2	2	2	2	1	1	1	1	0	0	0	0	0	0
1	20	11	7	5	4	4	3	3	2	2	1	1	1	1	1	1	0	0	0	0
1,5	25	16	11	8	7	5	5	4	4	3	2	2	1	1	1	1	1	1	0	0
2,5	35	27	18	14	11	9	8	7	6	5	4	3	2	2	2	1	1	1	1	1
4	45	44	29	22	18	15	13	11	10	9	6	4	4	3	3	2	2	2	1	1
6	60	60	44	33	26	22	19	16	15	13	9	7	5	4	4	3	3	3	2	1
10	90	90	73	55	44	37	31	27	24	22	15	11	9	7	6	5	5	4	3	2
16	130	130	117	88	70	59	50	44	39	35	23	18	14	12	10	9	8	7	5	4
25	170	170	170	137	110	91	78	69	61	55	37	27	22	18	16	14	12	11	7	5
35	210	210	210	192	154	128	110	96	85	77	51	38	31	26	22	19	17	15	10	8
50	270	270	270	270	220	183	157	137	122	110	73	55	44	37	31	27	24	22	15	11
70	330	330	330	330	307	256	220	192	171	154	102	77	61	51	44	38	34	31	20	15
95	390	390	390	390	390	348	298	261	232	209	139	104	83	70	60	52	46	42	28	21
120	450	450	450	450	450	439	376	329	293	263	176	132	105	88	75	66	59	53	35	26
150	475	475	475	475	475	475	470	412	366	329	220	165	132	110	94	82	73	66	44	33

Conductor requirements 48V d.c. system at 30 °C ambient temperature

Allowable maximum current, in amperes, for single conductors at insulation temperature ratings. With a maximum voltage drop of 3%.

- S is the conductor cross-sectional area, in square millimeters
- I is the load current, in amperes
- L is the length, in meters, of conductor from the positive power source to the electrical device and back to the negative source connection.

Conductors at insulation temperature 105 °C:

S / L	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	75	100
0,75	12	8	5	4	3	3	2	2	2	2	1	1	1	1	0	0	0	0	0	0
1	18	11	7	5	4	4	3	3	2	2	1	1	1	1	1	1	0	0	0	0
1,5	21	16	11	8	7	5	5	4	4	3	2	2	1	1	1	1	1	1	0	0
2,5	30	27	18	14	11	9	8	7	6	5	4	3	2	2	2	1	1	1	1	1
4	40	40	29	22	18	15	13	11	10	9	6	4	4	3	3	2	2	2	1	1
6	50	50	44	33	26	22	19	16	15	13	9	7	5	4	4	3	3	3	2	1
10	70	70	70	55	44	37	31	27	24	22	15	11	9	7	6	5	5	4	3	2
16	100	100	100	88	70	59	50	44	39	35	23	18	14	12	10	9	8	7	5	4
25	140	140	140	137	110	91	78	69	61	55	37	27	22	18	16	14	12	11	7	5
35	185	185	185	185	154	128	110	96	85	77	51	38	31	26	22	19	17	15	10	8
50	230	230	230	230	220	183	157	137	122	110	73	55	44	37	31	27	24	22	15	11
70	285	285	285	285	285	256	220	192	171	154	102	77	61	51	44	38	34	31	20	15
95	330	330	330	330	330	330	298	261	232	209	139	104	83	70	60	52	46	42	28	21
120	400	400	400	400	400	400	376	329	293	263	176	132	105	88	75	66	59	53	35	26
150	430	430	430	430	430	430	430	412	366	329	220	165	132	110	94	82	73	66	44	33

Conductors at insulation temperature 85 - 90 °C:

S / L	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	75	100
0,75	10	8	5	4	3	3	2	2	2	2	1	1	1	1	0	0	0	0	0	0
1	14	11	7	5	4	4	3	3	2	2	1	1	1	1	1	1	0	0	0	0
1,5	18	16	11	8	7	5	5	4	4	3	2	2	1	1	1	1	1	1	0	0
2,5	25	25	18	14	11	9	8	7	6	5	4	3	2	2	2	1	1	1	1	1
4	35	35	29	22	18	15	13	11	10	9	6	4	4	3	3	2	2	2	1	1
6	45	45	44	33	26	22	19	16	15	13	9	7	5	4	4	3	3	3	2	1
10	65	65	65	55	44	37	31	27	24	22	15	11	9	7	6	5	5	4	3	2
16	90	90	90	88	70	59	50	44	39	35	23	18	14	12	10	9	8	7	5	4
25	120	120	120	120	110	91	78	69	61	55	37	27	22	18	16	14	12	11	7	5
35	160	160	160	160	154	128	110	96	85	77	51	38	31	26	22	19	17	15	10	8
50	210	210	210	210	210	183	157	137	122	110	73	55	44	37	31	27	24	22	15	11
70	265	265	265	265	265	256	220	192	171	154	102	77	61	51	44	38	34	31	20	15
95	310	310	310	310	310	310	298	261	232	209	139	104	83	70	60	52	46	42	28	21
120	360	360	360	360	360	360	360	329	293	263	176	132	105	88	75	66	59	53	35	26
150	380	380	380	380	380	380	380	380	366	329	220	165	132	110	94	82	73	66	44	33

Conductors at insulation temperature 70 °C:

S / L	1	2	3	4	5	6	7	8	9	10	15	20	25	30	35	40	45	50	75	100
0,75	6	6	5	4	3	3	2	2	2	2	1	1	1	1	0	0	0	0	0	0
1	8	8	7	5	4	4	3	3	2	2	1	1	1	1	1	1	0	0	0	0
1,5	12	12	11	8	7	5	5	4	4	3	2	2	1	1	1	1	1	1	0	0
2,5	17	17	17	14	11	9	8	7	6	5	4	3	2	2	2	1	1	1	1	1
4	22	22	22	22	18	15	13	11	10	9	6	4	4	3	3	2	2	2	1	1
6	29	29	29	29	26	22	19	16	15	13	9	7	5	4	4	3	3	3	2	1
10	40	40	40	40	40	37	31	27	24	22	15	11	9	7	6	5	5	4	3	2
16	54	54	54	54	54	54	50	44	39	35	23	18	14	12	10	9	8	7	5	4
25	71	71	71	71	71	71	71	69	61	55	37	27	22	18	16	14	12	11	7	5
35	87	87	87	87	87	87	87	87	85	77	51	38	31	26	22	19	17	15	10	8
50	105	105	105	105	105	105	105	105	105	110	73	55	44	37	31	27	24	22	15	11
70	135	135	135	135	135	135	135	135	135	135	102	77	61	51	44	38	34	31	20	15
95	165	165	165	165	165	165	165	165	165	165	139	104	83	70	60	52	46	42	28	21
120	190	190	190	190	190	190	190	190	190	190	176	132	105	88	75	66	59	53	35	26
150	220	220	220	220	220	220	220	220	220	220	220	165	132	110	94	82	73	66	44	33

Derating of conductors in ambient temperatures of 60 °C
For conductors in 60 °C ambient, the maximum current rating in the above tables shall be derated by the factors below.

Temperature rating of conductor insulation, °C	Multiply maximum current from Table by:
70	0,75
85 – 90	0,82
105	0,86
125	0,89
200	1

Table 14. Derating of conductors



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