SUPER B
lithium batteries

Charging Manual

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CHARGING MANUAL
SUPER B ENERGY BATTERIES

Charging Manual Super B Energy Batteries

This document describes how to charge a Super B Lithium Iron Phosphate energy battery or batteries. It is meant for chargers that can be set with a charging profile to meet the Super B battery charge specification. This document can also be used to verify if a charger with a nonadjustable charge profile can be used to charge Super B batteries.

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1. Charging

⚠ **Warning!** Never overcharge the Li-ion battery, this will permanently damage the Li-ion battery. Always use a charger which automatically halts the charging process when the Li-ion battery is full.

⚠ **Warning!** Stop the charging process if the Li-ion battery gets too hot during charging (>55-60°C).

⚠ **Warning!** Never charge a Li-ion battery with a charging current larger than specified in the manual as this will damage the Li-ion battery.

⚠ **Caution!** Disconnect the charger from the mains and the Li-ion battery if it is not used for a long time. Note that the CAN network draws current when active.

⚠ **Caution!** To preserve the lifespan of the Li-ion battery use a suitable charger or a charger approved by Super B. The use of other chargers, such as lead-acid chargers can shorten the lifespan of the Li-ion battery. AGM / GEL chargers may be used if the charge voltages and duration of the different charge states don't exceed charge specification of the Li-ion battery.

Connect the charger to the Li-ion battery as described in the battery manual.

Charge the Li-ion battery whenever the state of charge drops below 20% to preserve the lifespan of the Li-ion battery.

If the state of charge drops below 20%, always keep the voltage of the Li-ion battery above 10 V.

1.1. Charging rate

Super B batteries that are capable to be charge with 1C can be charged from empty (0 % SoC) to full (100% Soc) in just over an hour. 1C indicates 1 times the capacity of the Li-ion battery so a 100Ah battery which can be charged with 1C may be charged with 100 A. Displayed in Table 1 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.

	Time	Charge current (A)	Typical end of charge voltage
Maximum	70-80 minutes	1C	14.4V
Endurance Lifecycle	3 hours + ~20 min	C3	14.4V

Table 1. Charging rate Super B lithium batteries

The maximum charge current for Super B lithium batteries is 1C. However for endurance

cycle life Super B suggests to limit the current to C3. (1C = nominal battery capacity, C3 = 1/3 of nominal battery capacity).

1.2. Charging method

Super B recommends using the charging method called: "Constant Current Constant Voltage" (CCCV). The CV part of charging is also used to balance the cells of the Li-ion battery, and therefore prolonging the lifespan of the Li-ion battery.

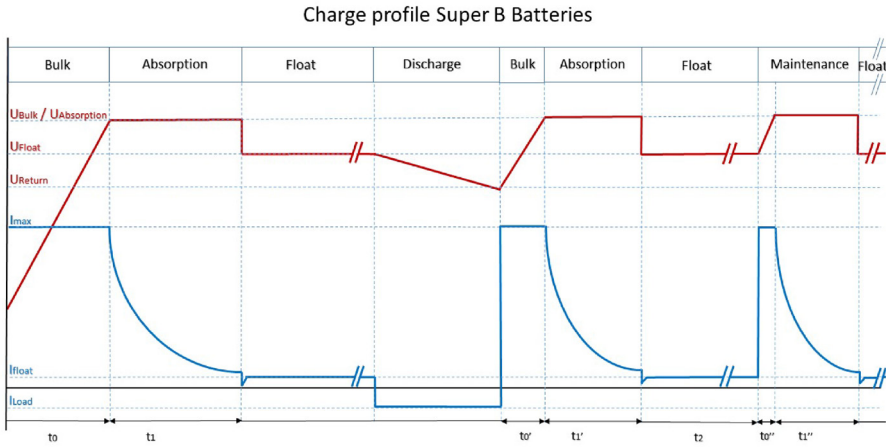

Figure 1. Charge profile Super B Batteries

2. Charge phases

The charging process consists of the following phases:

- Bulk phase
- Absorption phase
- Float phase
- Maintenance phase, this is optional and depends if the Li-ion battery is not charged regularly at 100% (and if the used charger is capable of)

Each charge phase will be described in more detail on the next pages.

2.1. Bulk phase

In this phase (CC part of CCCV) the Li-ion batteries are charged with a constant current up to the end of charge voltage ($U_{absorption}$). When $U_{absorption}$ is reached, the charger switch to the absorption phase.

On some chargers the time t_0 can be programmed. This is a safety precaution that stops the charger if the bulk phase is taking too long. Time t_0 depends on the charge current and the Li-ion battery capacity. If this option is available t_0 can be calculated and set using this formula :

$$t_0 = \frac{C_{bat}}{I_{ch}} * 1.2$$

With :

- t_0 : the bulk time in hour,
- C_{bat} : the battery nominal capacity in Ah,
- I_{ch} : the charging current of the charger in Amps.

The factor 1.2 is due to the Li-ion battery having more capacity than its rating and current measurement inaccuracy of the charger.

If, during charging, there is also power consumption this should be taken into account because the charge current will be less.

Parameter	Min	Typical	Max
$U_{absorption}$ (12V)	14.3V	14.4V	14.6V
$U_{absorption}$ (24V)	28.6V	28.8V	29.2V
$U_{absorption}$ (48V)	57.2V	57.6V	58.4V
I_{ch} (A)	-	C3	-
t_0	See formula above		

Table 2. Bulk Phase

Below an example with empty Li-ion batteries charged with a 12A charger. The bulk phase duration takes longer with higher nominal capacity:

Battery	C_{bat}	I_{ch} (A)	t_0 < (in hours)
EPSILON 12V90Ah	90 Ah	12	9 h 00 min
NOMADA 12V105Ah	105 Ah	12	10 h 30 min
NOMIA 12V160Ah	160 Ah	12	16 h 00 min
NOMIA 12V210Ah	210 Ah-	12	21 h 00 min-

Table 3. Bulk Phase Example 12A Charger

To lower the bulk phase duration, the use of a charger with more current is necessary. For instance, same example with a 24A charger:

Battery	C_{bat}	I_{ch} (A)	t_0 < (in hours)
EPSILON 12V90Ah	90 Ah	24	4 h 30 min
NOMADA 12V105Ah	105 Ah	24	5 h 15 min
NOMIA 12V160Ah	160 Ah	24	8 h 00 min
NOMIA 12V210Ah	210 Ah-	24	10 h 30 min-

Table 4. Bulk Phase Example 24A Charger

2.2. Absorption phase

In this phase (CV part of CCCV) the charge voltage is kept constant at $U_{absorption}$ to fully charge the Li-ion battery and equalize the battery cells.
The charger must supply a current low enough to balance the cells. The balancing current is max. 2A for the Nomia and max. 0.8A for the Nomada.

The duration of the absorption phase may vary depending on the age and state of health of the Li-ion battery. When the absorption time t_1 is over, the charger switch to the float phase.

Parameter	Min	Typical	Max
$U_{absorption}$ (12V)	14.3V	14.4V	14.6V
$U_{absorption}$ (24V)	28.6V	28.8V	29.2V
$U_{absorption}$ (48V)	57.2V	57.6V	58.4V
t_1	10 minutes	30 minutes	1 hour

Table 5. Absorption Phase

2.3. Float phase

In this phase the Li-ion battery is not charged any longer. The charger's output voltage is set to U_{float}. If there are devices on that take power from the Li-ion battery the charger will aid the battery or power all devices. Not all chargers have a float phase.

Parameter	Min	Typical	Max
U_{float} (12V)	13.6V	13.8V	13.9V
U_{float} (24V)	27.6V	27.6V	27.8V
U_{float} (48V)	54.4V	55.2V	55.6V

Table 6. Float Phase

2.4. Discharge during float phase

During the float phase, the charger will supply the load. However, if this load is higher than the charger current, the battery will also need to supply partially the load. In this case, if the battery voltage drops below U_{return}, then the charging process will be repeated. A new bulk phase (t_0') followed by an absorption phase (t_1') will start again.

Parameter	Min	Typical	Max
U_{return} (12V)	-	12.8V	-
U_{return} (24V)	-	25.6V	-
U_{return} (48V)	-	51.2V	-

Table 7. Discharge Phase

2.5. Optional maintenance phase

If supported by the charger, every t_2 the charger can do a maintenance charge to make sure that the Li-ion batteries are kept fully charged.
A new bulk phase (t_0'') followed by an absorption phase (t_1'') will start again.

Parameter	Min	Typical	Max
t_2	-	7 days or 10 cycles*	20 days or 20 cycles*

Table 8. Maintenance Phase
*Whichever comes first

3. Storage description

In storage, the Li-ion battery has to be disconnected from all loads (CAN included) and chargers. In this state, the battery self-discharge is below 3% a month.

⚠ **Warning!** Please follow the storage guidelines for each Super B Li-ion battery, which are available in their respective user manual.

3.1. Maintenance in storage

The battery should be charged every 3 months.

Parameter	Min	Typical	Max
t_2	-	3 months	12 months

Table 9. Maintenance in storage

3.2. End of storage

At the end of a storage period and before using the Li-ion battery again, the battery needs to be fully charged.

⚠ **Warning!** When used in a system, all Li-ion batteries need to be charged at 100% SoC State of Charge) before installation.

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