SPECIFICATION FOR SMART VH MODULE

Product Manager : P. Prenleloup

Project Manager : A. Juan

Quality Assurance Manager : F. Zaninotto

SUCCESSIVES RELEASES

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GLOSSARY

SPECIFICATION FOR SMART VH MODULE

CONTENTS

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1 SCOPE

This specification applies to a Nickel-Metal Hydride rechargeable battery of 10, 20, 30 Ni-MH cells in serial connection which SAFT designation is "Smart VH Module".

When capacity requirement is higher than the basic Smart VH Module configuration, the Smart VH Module is intended for easy additional parallel assembly. It can also be configured for alternate discharging (one battery activated in a group of batteries). It is important to note that each individual Smart VH Module will not be in position to deliver more than its designed power (25A or 50A depending on chosen option).

It is provided already assembled in an internal configuration delivering the required voltage, and cannot be assembled in serial configuration to increase its voltage (in case of such need, please consult SAFT).

2 GENERAL ELECTRICAL CHARACTERISTICS

All the figures listed in the following tables are based on fresh battery within two months after date code (see § “Marking”).

Please see examples of the performances that can be obtained on a battery in annex 2.

SPECIFICATION FOR SMART VH MODULE

In case of a request outside the above range, please contact SAFT.

Electrical characteristics		VH Module with VH D			VHF		
Configuration		10S	20S	30S	10S	20S	30S
Nominal voltage (V)		12	24	36	12	24	36
Typical capacity at C drain rate after full charge at 3A / + 20°C (Ah)		9	9	9	14,5	14,5	14,5
Specific energy (Wh/kg)		50	55	56	56	62	64
Energy density (Wh/dm3)		81	101	110	102	120	128
Continuous power at 80 % depth of discharge 25A (W)	25A version	255	510	765	265	530	795
1min pulse power at 80 % depth of discharge 50A (W)	50A version	NC	NC	NC	455	910	1365
Mechanical characteristics							
Height (mm)		99	159	219	129	219	309
Length (mm)		178	178	178	178	178	178
Width (mm)		73,5	73,5	73,5	73,5	73,5	73,5
Weight (kg)		2,1	3,8	5,6	3,1	5,6	8,1
Volume (dm3)		1,3	2,1	2,9	1,7	2,9	4,0
Operating conditions							
Operating temperature range (°C) (+5 to + 40)		normal conditions					
(-20°C to + 65°C)		Extended conditions with reduced performance					
Transport and storage temperature range (°C)		+ 5 to + 25					
Typical charge time							
95 % of capacity (h)			3			5	
balancing time to 100% of capacity typical use (h)			5			5	
balancing time to 100% of capacity after long storage (h)			48			48	
Maximum discharge current (Version 25A / Version 50A)			25 / 50 (1 min)			25 / 50 (1min)	
Maximum one shot full discharge current (A) (Version 25A / Version 50A)			25 / 40			25 / 45	
Maximum peak current (A) (Version 25A / Version 50A)			80 (0,1s) / 120 (0,1s) 50 (0,5s) / 80 (0,5s) 30 (5s) / 55 (5s)			80 (0,1s) / 120 (0,1s) 50 (0,5s) / 80 (0,5s) 30 (5s) / 55 (5s)	

3 HOW TO ORDER A MODULE WITH CUSTOMISED PARAMETERS

Reference : 80x xxx [X X X X]

Standard versions

25 A versions

10 VHD	**803 860**
20 VHD	**803 870**
30 VHD	**803 880**
10 VHF	**803 920**
20 VHF	**803 930**
30 VHF	**803 940**

50 A versions

10 VHD	**804 580**
20 VHD	**804 590**
30 VHD	**804 600**
10 VHF	**804 610**
20 VHF	**804 620**
30 VHF	**804 630**

Options

Timer

4 h *(standard)*	**A**
24 h	**B**
85 h	**C**
12 h	**D**

Priority

On *(standard)*	**N**
Off	**F**

Regen Alarm

Off *(standard)*	**F**
On	**N**

Pre Alarm

10 % *(standard)*	**A**
0 %	**B**
25 %	**C**
50 %	**D**

Ordering Examples

803 930 ANFA 20 VHF Smart VHmodule with 25A circuit,
4 h Timer, Priority On, Regen Alarm Off, 10 % Pre Alarm threshold

804 600 ANFA 30 VHD Smart VHmodule with 50A circuit,
4 h Timer, Priority On, Regen Alarm Off, 10 % Pre Alarm threshold

803 870 BNFB 20 VHD Smart VHmodule with 25A circuit,
24 h Timer, Priority On, Regen Alarm Off, 0 % Pre Alarm threshold

804 610 AFNC 10 VHF Smart VHmodule with 50A circuit,
4 h Timer, Priority Off, Regen Alarm On, 25 % Pre Alarm threshold

For detailed explanations, see § “customised parameters”.

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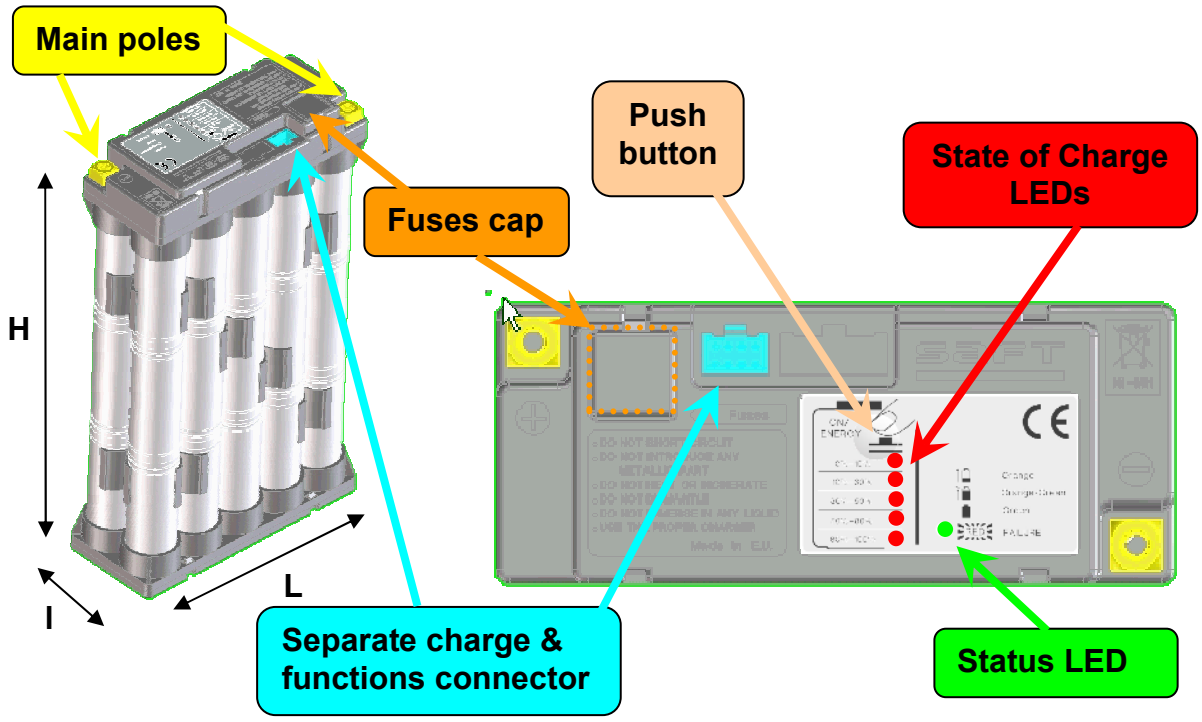
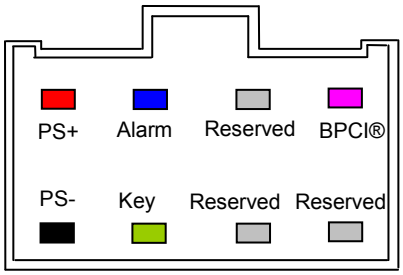
4 GENERAL MECHANICAL SMART VH MODULE SPECIFICATION

SMART VH MODULE DRAWING



Separate charge & functions connector :



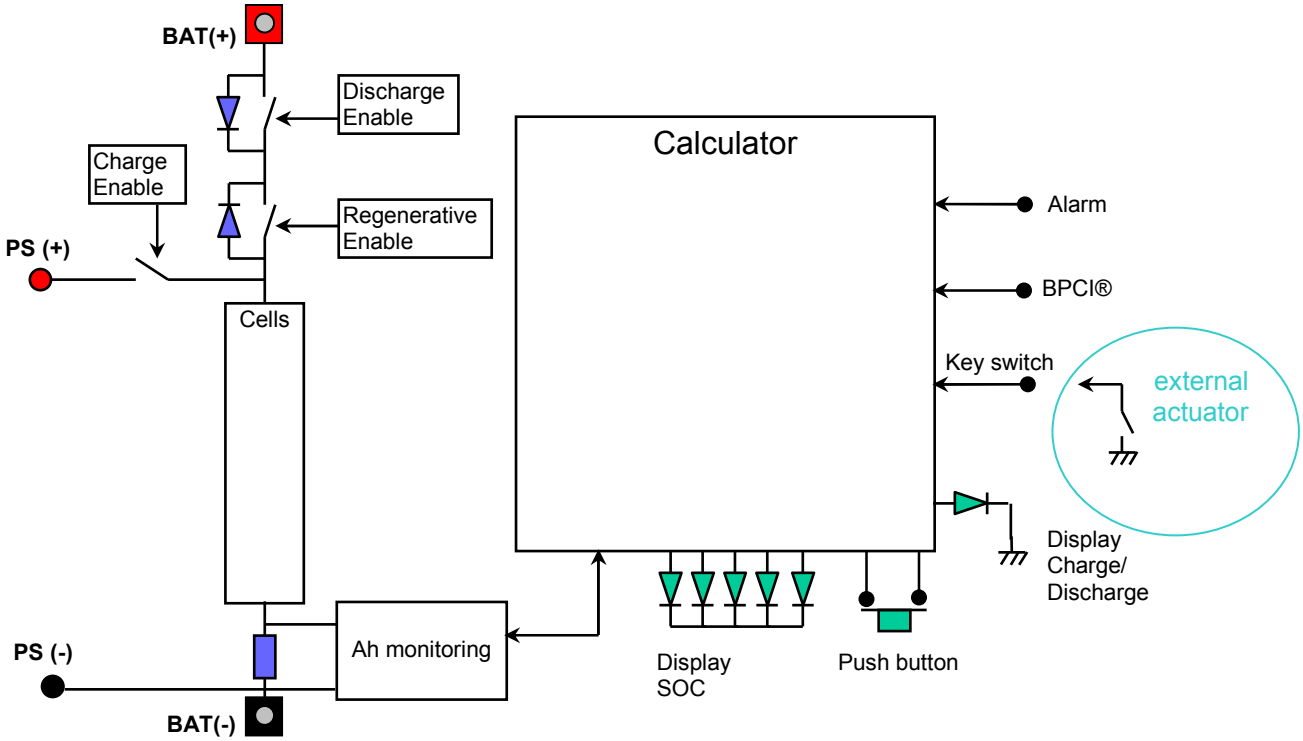
Outputs:

Discharge terminal type: M8 screw terminal (M8 screw L<12mm needed to fix the wire's ring tab)
Separate charge & functions connector : HIROSE 547-0085-8-MDF6-8DP-3.5DSA

Components:

Fuse : charge : 15A/ 32V for 10 or 20 cells or
15A/ 58V for 30 cells (replaceable using a flat screwdriver)
Fuse : discharge : 30A/ 32V for 10 or 20 cells or
30A/ 58V for 30 cells (replaceable using a flat screwdriver)

The associated electrical schematic is described below:



5 SAFETY PRECAUTIONS

This paragraph will describe actions that will damage battery, in order that during the design stage of the complete battery they can be taken in consideration. SAFT policy is to assist the customer at the earliest possible stage of design, in order to help to answer to the main questions that can have to be taken into account.

Study this safety information carefully. Additionally, a Material Safety Data Sheet is available upon request.

Battery related accidents can easily be avoided by awareness and understanding of the hazards involved and by handling the batteries accordingly.

NEVER

- Immerse the battery or pour water on the battery.
- Expose the battery to fire.
- Reverse charging of the battery
- Open battery outside of authorized network, disassemble the battery blocks or cells (be aware that alkaline electrolyte is contained inside, and electrolyte exposure can be harmful).
- Operate the battery with a non authorized Power Supply.
- Short-circuit the battery (eg. introducing a metallic part in the connector)
- Discharge the battery out of range conditions (eg current over the max current)
- Have a high temperature source around the battery (may activate the safety protections at cell and battery level)

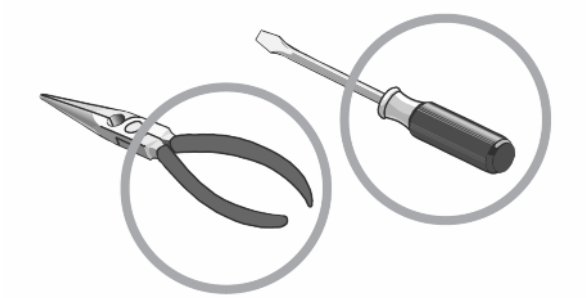
Warnings

- If any leakage of electrolyte occurs, stop using the battery immediately. Electrolyte is corrosive to some metals and may cause minor damage to concrete.
- If electrolyte comes in contact with your skin or clothes, wash immediately with soap and water.
- If electrolyte comes in contact with your eyes, wash thoroughly with water and immediately consult a doctor.

Electrical Hazards

With the typical connection on a 36V battery, the main battery poles and the charge poles can operate normally over 50 volts during charge. Bodily contact with 50-60 volts may cause a mild shock.
Batteries are capable of delivering short circuit currents of more than one hundred amperes.

- Do not wear rings, watches, bracelets, etc. when working on batteries. Short-circuit currents through these objects can cause serious burns or injuries.
- Use only tools with insulated handles.



Only authorized and trained personnel should install batteries.

6 STORAGE

It is strongly recommended to leave the Smart VH Module on its Constant Current Power Supply when unused, every time it is possible This will allow to benefit the maximum capacity available when using the Smart VH Module.
SAFT recommends to store the Smart VH Module within a temperature range of +5°C to +25°C in a 65 ± 5% relative humidity atmosphere, plugged on an active CCPS.
In case it is not possible to leave it on its CCPS, **it is mandatory to store the Smart VH Module in a complete charged state and at cool temperature**. After a 28 days storage at +20° ± 2°C, or 7 days storage at +40°C ± 2°C the Smart VH module, shall retain minimum 65% of its initial capacity. In both cases, the Smart VH Module shall recover full initial capacity after a complete cycle.

6.1 Storage recommendations

- Store the batteries in a dry, clean and cool area.
- Do not expose to excessive heat or direct sunlight.
- The batteries should be stored in the charged state:
  Before storing the battery for a long period of time, it is recommended to fully charge the battery, using the CCPS, for a minimum of 24 hours.

In case the battery was installed on its application, make sure the drained current when in storage is lower than 100mA during the power saving mode timer duration, otherwise the battery needs to be electrically disconnected.

6.2 Extended temperature conditions:

- An extended storage between +25°C/+35°C and 65% relative humidity is permitted for up to 2 months (cf § 2).
- An extended storage between +35°C/+60°C and 65% relative humidity is permitted for up to 3 weeks (cf § 2).

6.3 Long term storage (3 months and more):

After 3 months storage at room temperature or 1.5 months at 35°C, the Smart VH Module shall recover 100% of its minimum capacity (after 5 charge / discharge cycles). Bypassing this reactivating operation can mean that recovering maximum performances can take a longer time with normal use cycles.

For more than 3 months storage it is **mandatory** to completely recharge the Smart VH module, every 6 months or less. In that case, when using the Smart VH Module for the first time and in order to restore the initial performance, it is recommended to full cycle the Smart VH Module (up to 5 cycles). In these conditions, the Smart VH Module shall recover 95% of its initial capacity, even after 12 months storage unconnected @25°C.

7 TRANSPORTATION

Packing cases

Make use of original packing cases if possible. Batteries may also be placed in heavy cardboard boxes and strapped to pallets.

Shipping to various sites

Pack the material for each site individually or pack each battery in separate boxes or on separate pallets. Make sure every part required for the installation is included and clearly marked and labeled. Make a final check that all required components are included before shipping.

8 HOW TO USE THE BATTERY?

8.1 Unpacking and inspection

Inspect the shipment and make sure all items on the packing list have been received. Report any shortages to the shipping company as well as to Saft.
Check the packing material for damages. If there is any sign of damage, open the packing cases immediately and inspect the equipment. Report any irregularities to the shipping company as well as to Saft.
While unpacking, check that all required components are inside the boxes. Report any damages or shortages.
Make sure that the user notice is not thrown away with discarded packaging material.
Do not handle the batteries by pulling on the main poles or plastic flanges, this may damage the connections. To handle the batteries easily and securely, handle the cells sticks directly.
Make use of original packing cases if re-packing.

Note: Prior to installation, always check the open circuit voltage (OCV). The Smart VH Module can arrive with an OCV of 0V (energy saving mode, no LED illuminated). After pressing the push button it will show the Gas Gauge LEDs giving its State Of Charge. In the standard configuration, it should also show the status LED illuminated “green”, plus its internal electrochemistry voltage on the main poles (other configuration, see chapter “Customized parameters”).

Smart VH Modules are shipped partially charged and need to be charged before use, see chapter “Charging the battery”.

8.2 Installation & First use

Step 1
Install the CCPS dedicated to charge the Smart VH Module. Check that the voltage printed on the label corresponds to the nominal voltage of the battery, and that the mains voltage corresponds to your grid voltage.

Step 2
Install the Smart VH Module arranging the CCPS cord so it is accessible to connect it to the module, but not too close so thermal emission from the CCPS will not be transferred to the battery. Connect the CCPS to the Smart VH Module. Connect the CCPS to the mains. The Smart VH Module status LED illuminates in orange.

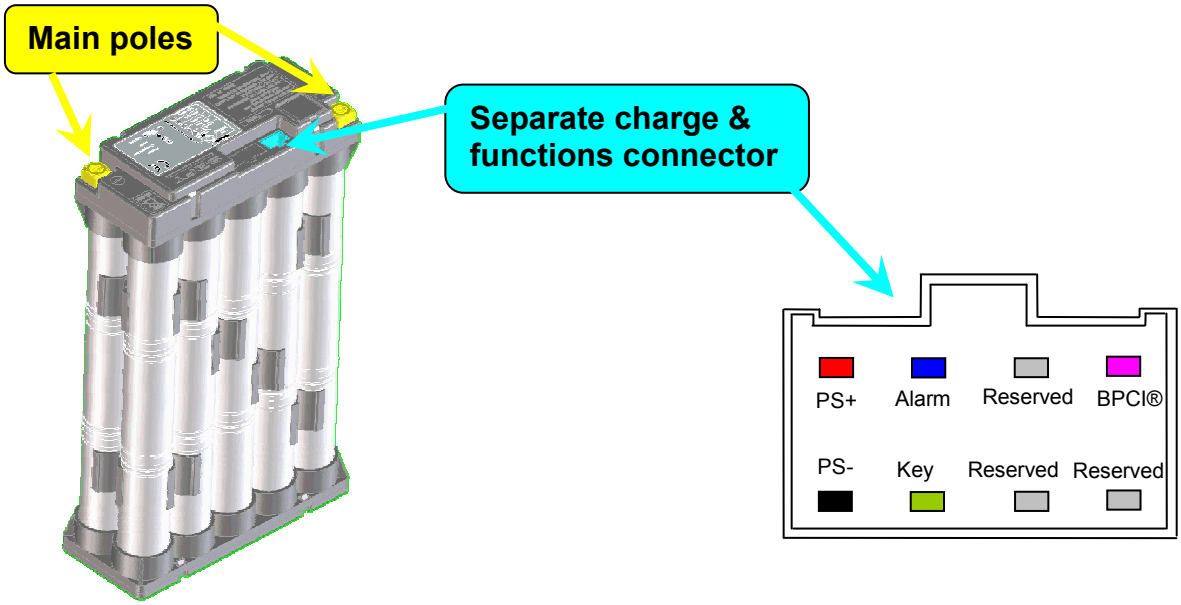
Step 3
Leave the battery on charge until the status LED illuminates to “green”. It can last more than 48h for the first complete charge.

Step 4
Unplug the CCPS from the mains, then unplug the Smart VH Module. Check the LEDs shown by the Smart VH Module. If you press the push button the 5 Gas Gauge LEDs should be illuminated red.

Step 5
Connect the Smart VH Module main poles to your application (draining less than the maximum current available for the Smart VH Module version you have). Battery should provide the required current to the application.

Step 6
The Smart VH Module can now be installed in its final configuration on your application. Refer to the following chapters about the different possibilities for integrating the Smart VH Module in your global circuitry.

9 CONNECTING A SMART VH MODULE



A Smart VH Module can be connected in several different ways. Impact on the application will be detailed in the next chapters.

9.1 Connecting through main poles only

This is the easiest way to connect a Smart VH Module, which is recommended for example when the interface to the charger or the application is done by the same plug (that can be linked to the application OR to the charger, but not both at the same time).

Using this type of connexion allows using the Smart VH Modules in parallel through the main poles only, in both charge and discharging situation.

In such connexion mode, the battery is activated by pressing the push button or when it is connected to the charger, and remains activated as described in chapter “How to activate the battery”.

9.2 Connecting through main poles AND the separate charge & functions connector

This mode is necessary in 3 main situations (that can also be combined):

- Access to the push button is not available when the battery is installed inside the application (eg. in a closed box). It is then necessary to be in position to activate (or deactivate) the battery from the application. In such case the Key Switch pin should be connected to the ground (PS-) through an external actuator accessible from the final application (see chapter “Role of the Key Switch”).

- Application requires that charge & discharge should be done simultaneously, with the application not able to accept the CCPS Open Circuit Voltage (1.5*Vnom) without damages. Connecting the CCPS to the separate Separate charge & functions connectors then allows to use the battery as a buffer and limit the voltage seen by the application in charge to 1.3*Vnom (see chapter “Charging the battery”).

- Application requires some communication or interface with the Smart VH Module, whatever in a easy way (I/O pins: alarm & key switch) or through a calculator (digital pins: BPCI® though ASCII or HEXA mode).

See chapter “Grouping several Smart VH Modules” in case you are in such case to get details about the wiring conditions.

10 CHARGING THE BATTERY

10.1 Charge control principle:

The charging process has four phases:
- Initialization
- Fast charge to charge the battery rapidly to state of charge higher than 90%
- Balancing charge to balance all the cells in the battery
- Trickle charge to maintain fully charged a battery connecting to a power supply

As temperature increase is detrimental to life duration of the cell (due to MH alloy corrosion), and in order to ensure a good compromise between capacity and life

duration, the Smart VH Module is charged by using a special algorithm that optimizes the temperature rise of the battery.

After a long period of storage the balancing charge phase will increase. Therefore it will be longer to get the GREEN charge LED displayed.

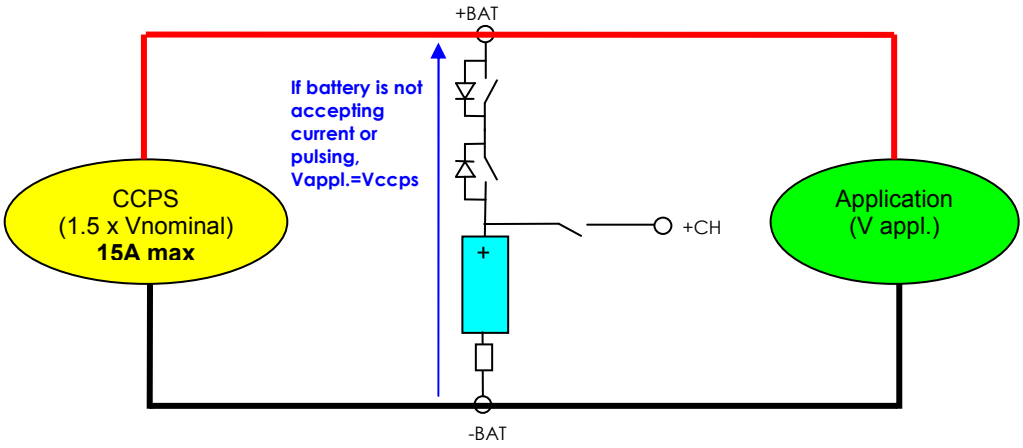
Very important note: The Smart VH Module is not protected against reverse connection of the power supply; this will definitively damage the Battery Protection and Communication Circuit (BPCI®) in the smart VH Module.

To obtain the best performance of the battery, the charge shall be made:

- Not near a heat generator or under the sunlight.
- Not near a cold generator.
- Not in a high humidity atmosphere or under the rain.
- In room temperature between 15 to 30°C.
- To obtain better charge efficiency, it is recommended not to charge the battery directly after discharge, to avoid to start to charge the battery above 30°C.

10.2 Charging by main poles

There is an impact of the Power Supply positioning for the application when the battery is managing the incoming current in charge mode:



If the charge is done through the main poles (15A max), the application will see the Open Circuit Voltage of the Power Supply when battery is pulsing to limit the charge current. MAKE SURE YOUR APPLICATION CAN ACCEPT IT WITHOUT DAMAGES.

Note: In fact, the output voltage could fluctuate between open circuit voltage of the power supply (typically 1.5 x Vnom) and battery voltage in charge (typically 1.23 x Vnom). The frequency of the variation will depend on charge status of the battery.

Note : The Key Switch must be on the “ON” position, otherwise the charge through main poles is not possible.

When charging through mains poles, the charge rate depends on State Of Charge (SOC).

- If SOC < 80%, the charging current is the current delivered by the CCPS or the application (regenerative mode) for 4 minutes, the battery is in regenerative charge. (see chapter “Regenerative charge” for details)
- If 80% < SOC < 85%, the charging current is the current delivered by the CCPS or the application (regenerative mode) for 1 minute, the battery is in limited regenerative charge. (see chapter “Regenerative charge” for details)

After these 3 plus 1 minutes, the current is regulated to 3A by the charge control circuit of the battery, the battery is in fast charge.

- If SOC > 85%, the current is immediately regulated to 3A by the charge control circuit of the battery, the battery is in fast charge.

During Fast charge:

- when the SOC reaches 96% or if a DT/Dt detection occurs, the battery goes in Balancing charge. If DT/Dt occurs, the SOC is set to 98%.
- if temperature reaches 50°C, the charge current is stopped and the charge goes back to Initialization phase.

Balancing charge duration increases upon previous storage time. During battery assembly, the Balancing time is set to 48h.
The Balancing can be completed with several partial Balancing charges.

After Balancing charge, the battery goes in Trickle charge. At this status, the battery is fully charge and fully balanced.

Note: If charge current delivered by charger is lower than 3A, the charge controller cannot regulate the charge current at 3A, so the charge will be made at charger current and the charging time will be longer.

Note: If the “Regenerative alarm” option has been validated during assembly of the battery, the “pre alarm” pin on Separate charge and functions connector is active (Ground) when

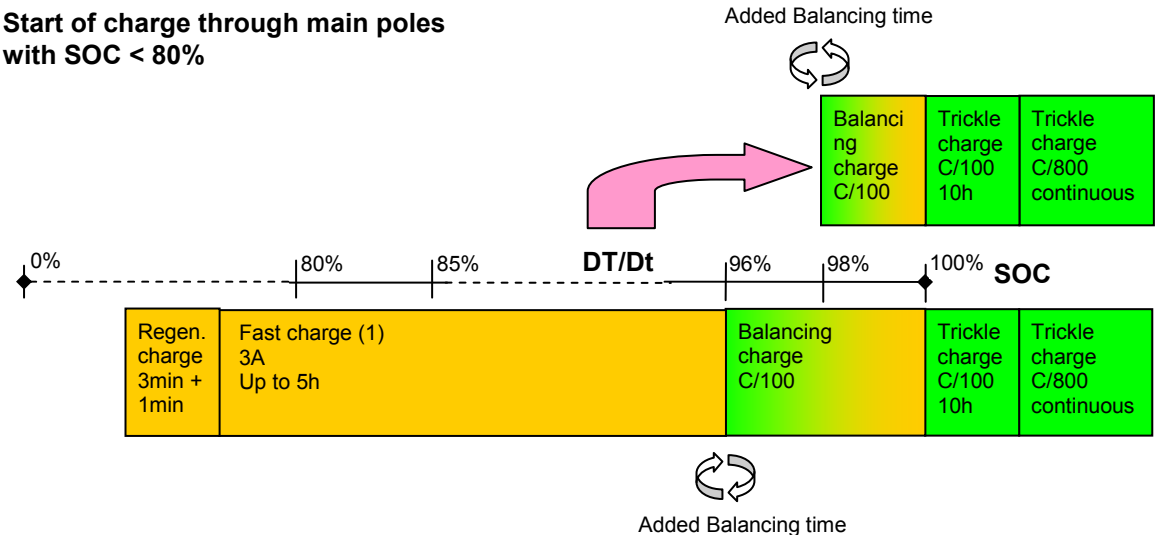
- SOC < 10% (see chapter “Customized parameters”) or

- SOC > 80% or
- T battery > 45°C or
- Regenerative time > 3minutes,

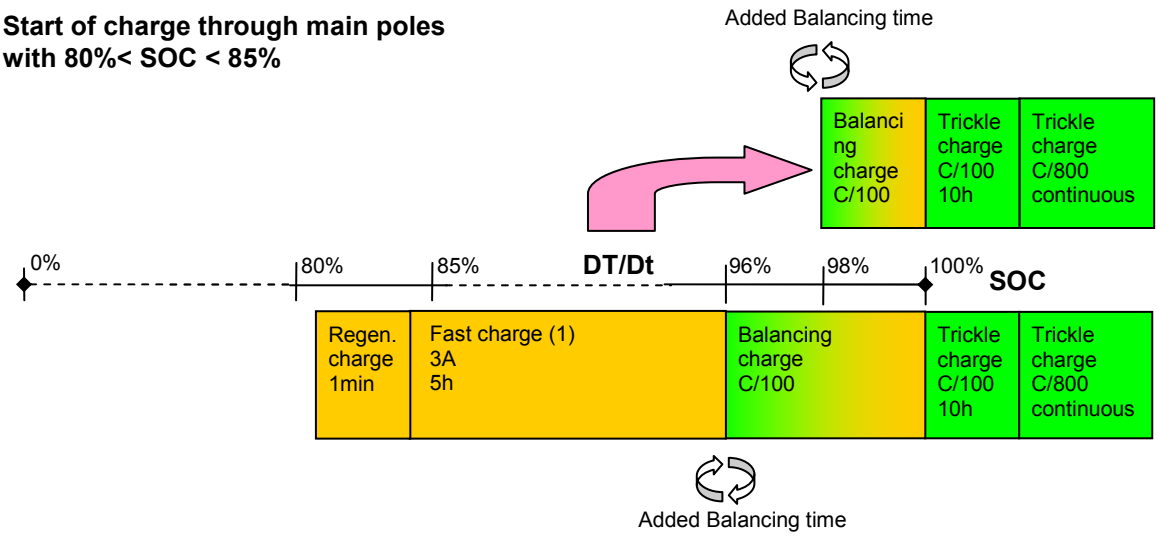
otherwise it is not active (Open collector).

The following diagrams describe the different charge process's depending of SOC status at beginning of charge:

Start of charge through main poles with SOC < 80%



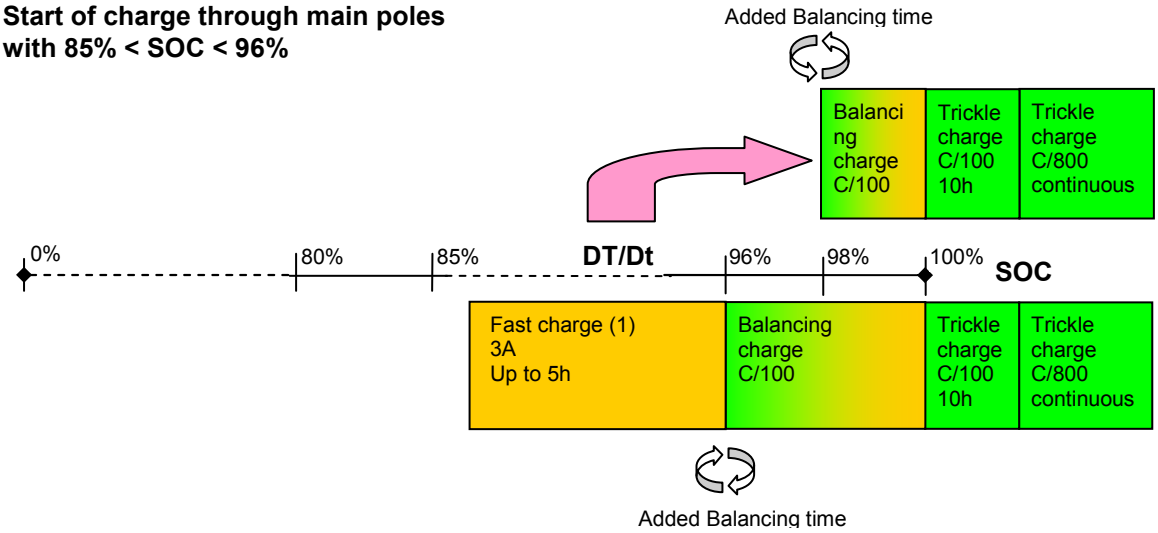
Start of charge through main poles with 80%< SOC < 85%



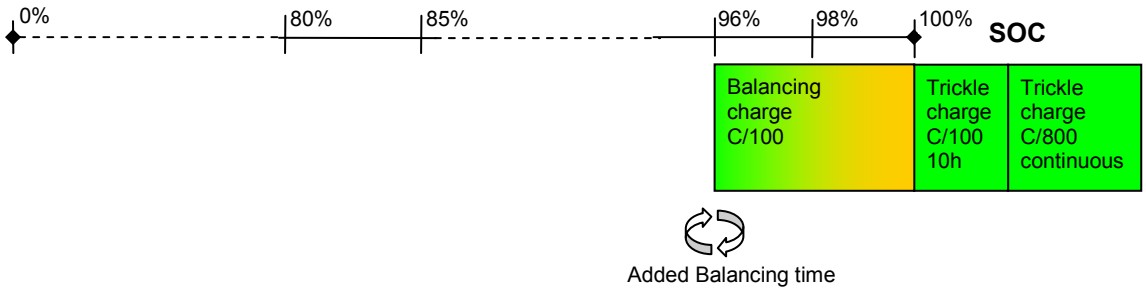
Note (1) in diagrams: If the battery is connected to a charger after a sleep mode period, the fast charge begins by a Initialization phase with charging current at 0A for

several minutes. During this Initialization phase, the charge control circuit checks the temperature and the temperature slope of the battery. If the temperature is out of the range 0°C ~ 40°C or the temperature slope is too high, the charge control circuit postpones the fast charge of the battery until temperature is right.

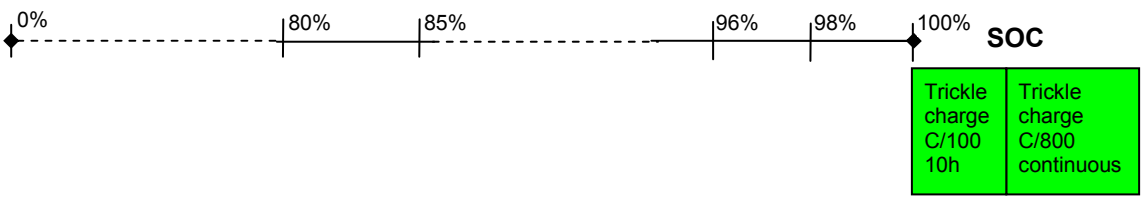
Start of charge through main poles with 85% < SOC < 96%



Start of charge through main poles with 96% ≤ SOC < 100%



Start of charge through main poles with SOC = 100%



10.3 Charging through main poles while application drains current.

Getting into the Charge mode is a result of the global current (keeping restriction on Separate charge & functions connector) as seen by the Smart VH Module. For example, the charge can be performed when the battery is connected both to an application which is draining a current from the battery and a Power Supply. In such case, the charge current considered by the battery is the difference between the incoming current (provided by the Power Supply) and the drained current (drained by the application). The charge duration then depends on the global charge current (if lower than 3A).

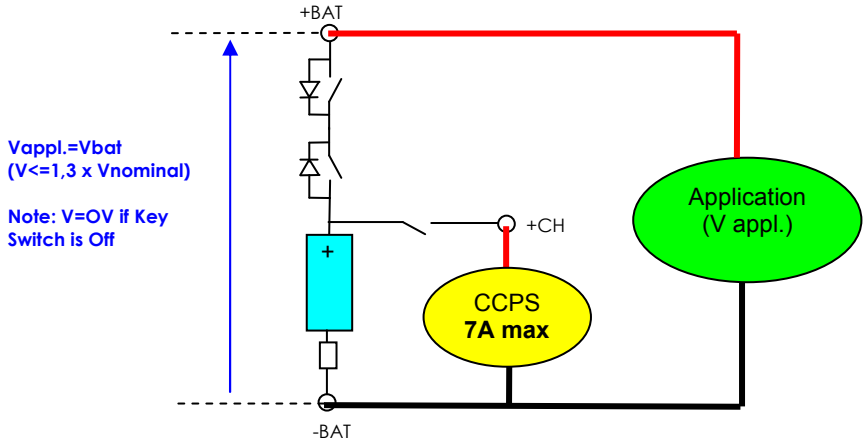
Example1: CCPS current = 3A and application current = 1A
First, the battery is fast charged at 2A constant until SOC = 96% and the application is supplied at battery voltage.
When SOC = 96%, the battery goes in Balancing charge and the application is supplied at CCPS voltage except during Balancing pulse at same voltage as fast charge.

Example2: CCPS current = 6A and application current = 2A
First, the battery is fast charged at 3A regulated until SOC = 96% and the application is supplied by voltage which oscillates between battery voltage and CCPS voltage with period of 1s.
When SOC = 96%, the battery goes in Balancing charge and the application is supplied at CCPS voltage except during Balancing pulse at same voltage as fast charge.

Note: In fact, the output voltage could fluctuate between open circuit voltage of the power supply (typically 1.5 x Vnom) and battery voltage in charge (typically 1.23 x Vnom). The frequency of the variation will depend on charge status of the battery.

Example3: CCPS current = 3A and application current = 4A
The battery is discharged at 1A

10.4 Charging by Separate charge & functions connector



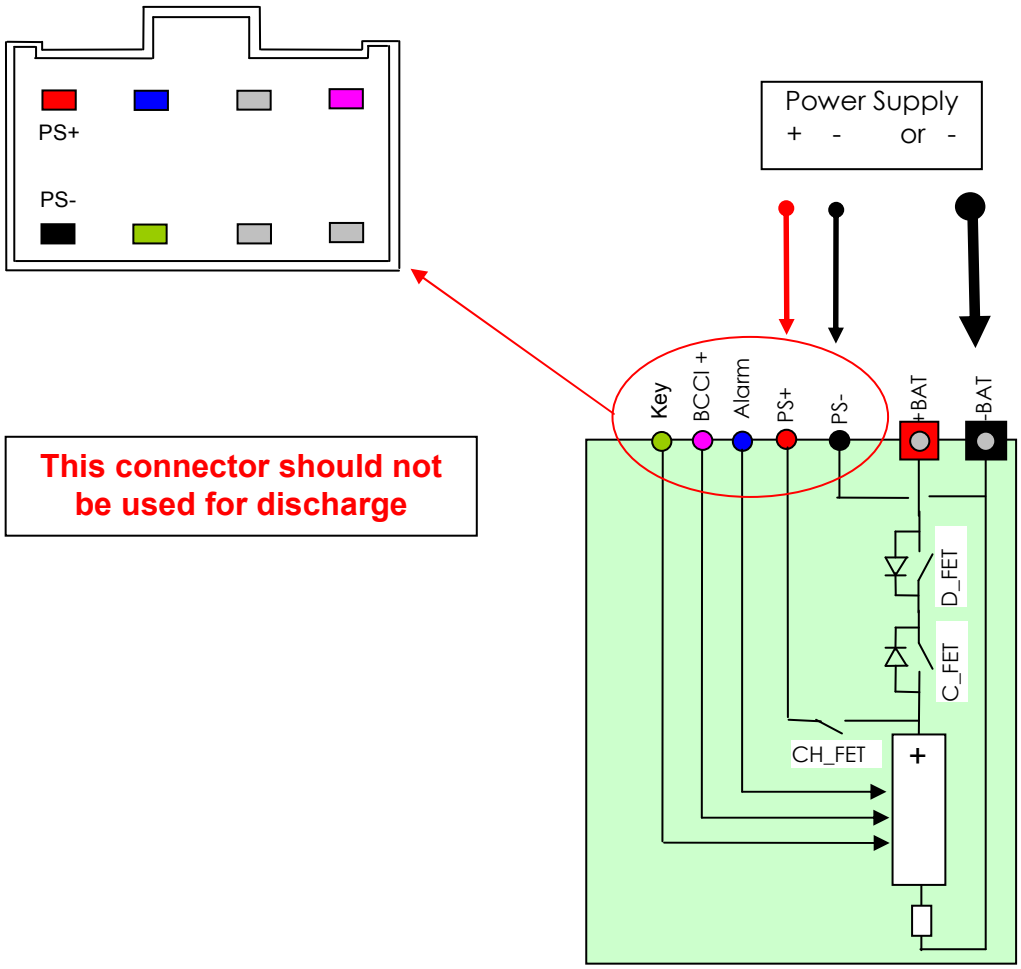
If charge is done through charge pins (7A max) and Key Switch is ON, the application will see Battery Voltage when battery is pulsing the charge current.

One of the main interests of this configuration is that the battery acts as a buffer and the application is protected from Power Supply higher Open Circuit Voltage.

Note: In fact, the output voltage could fluctuate between battery voltage without charge (typically 1.18 x Vnom). and battery voltage in charge (typically 1.23 x Vnom). The frequency of the variation will depend on charge status of the battery.

Note: if Key Switch is OFF, the application is not powered (0V).

The Smart VH Module Separate charge & Functions connector has the following characteristics:



The charge through Separate charge & functions connector is similar to charge through main poles, except there is no regenerative charge mode.

That means if SOC < 96%, the current is immediately regulated to 3A by the charge control circuit of the battery, the battery is in Fast charge.

During Fast charge:

- when the SOC reaches 96% or if a DT/Dt detection occurs, the battery goes in Balancing charge. If DT/Dt occurs, the SOC is set to 98%.
- if temperature reaches 50°C, the charge current is stopped and the charge goes back to Initialization phase.

Balancing charge duration increases upon previous storage time. During battery assembly, the Balancing time is set to 48h.

The Balancing can be completed with several partial Balancing charges.

After Balancing charge, the battery goes in Trickle charge. At this status, the battery is fully charge and fully balanced.

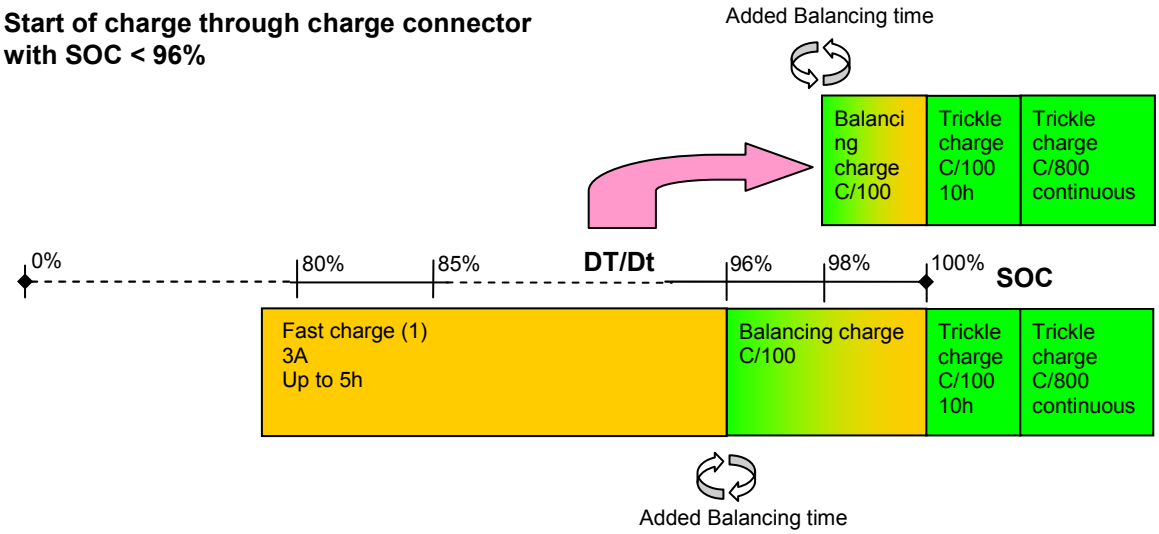
Note: If charge current delivered by charger is lower than 3A, the charge controller cannot regulate the charge current at 3A, so the charge will be made at charger current and the charging time will be longer.

Note: If the “Regenerative alarm” option has been validated during assembly of the battery, the “pre alarm” pin on Separate charge and functions connector is active (Ground) when

- SOC < 10% (see chapter “Customized parameters”) or
- SOC > 80% or
- T battery > 45°C or
- Regenerative time > 3minutes,

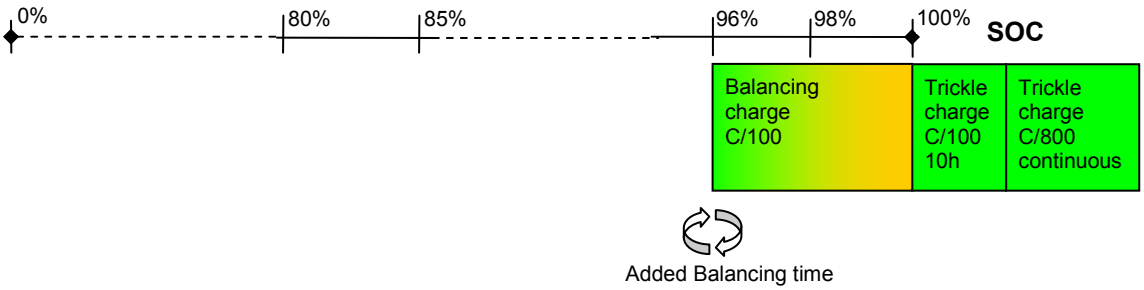
otherwise it is not active (Open collector).

The following diagrams describe the different charge process’s depending of SOC status at beginning of charge:

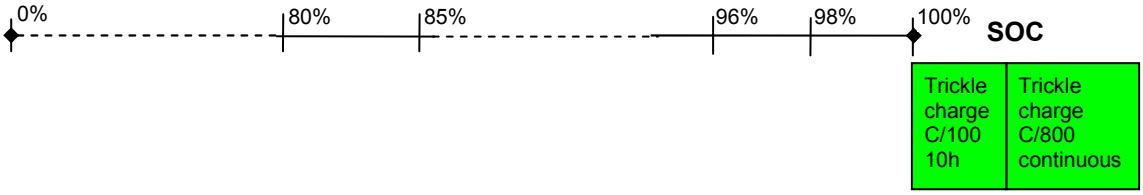


Note (1) in diagrams: If the battery is connected to a charger after a sleep mode period, the fast charge begins by a Initialization phase with charging current at 0A for several minutes. During this Initialization phase, the charge control circuit checks the temperature and the temperature slope of the battery. If the temperature is out of the range 0°C ~ 40°C or the temperature slope is too high, the charge control circuit postpones the fast charge of the battery until temperature is right.

Start of charge through main poles with 96% ≤ SOC < 100%



Start of charge through main poles with SOC = 100%



10.5 Charging through Separate charge & functions connector while application drains current.

As for charge through main poles, getting into the Charge mode is a result of the global current with some restrictions on Separate charge & functions connector as seen by the Smart VH Module.

Example1: CCPS current = 3A and application current = 1A

First, the battery is fast charged at 2A constant until SOC = 96% and the application is supplied at battery voltage.

At SOC = 96%, the battery oscillate between fast charge and Balancing charge to stay at SOC = 96%. The application is supplied at voltage which oscillates between battery voltage in charge and battery voltage not in charge (Balancing).

When application stops to drain current to the battery, the battery goes in Balancing charge and then trickle charge.

Example2: CCPS current = 6A and application current = 2A

First, the battery is fast charged at 3A regulated until SOC = 96% and the application is supplied by battery voltage which oscillates between battery in charge and battery not in charge with period of 1s.
When SOC = 96%, the battery goes in Balancing charge and the application is supplied at battery voltage except during Balancing pulse at same voltage as fast charge.

Example3: CCPS current = 3A and application current = 4A
The battery is discharged at 4A until SOC = 96%. Below SOC = 96%, the battery is discharged at 1A

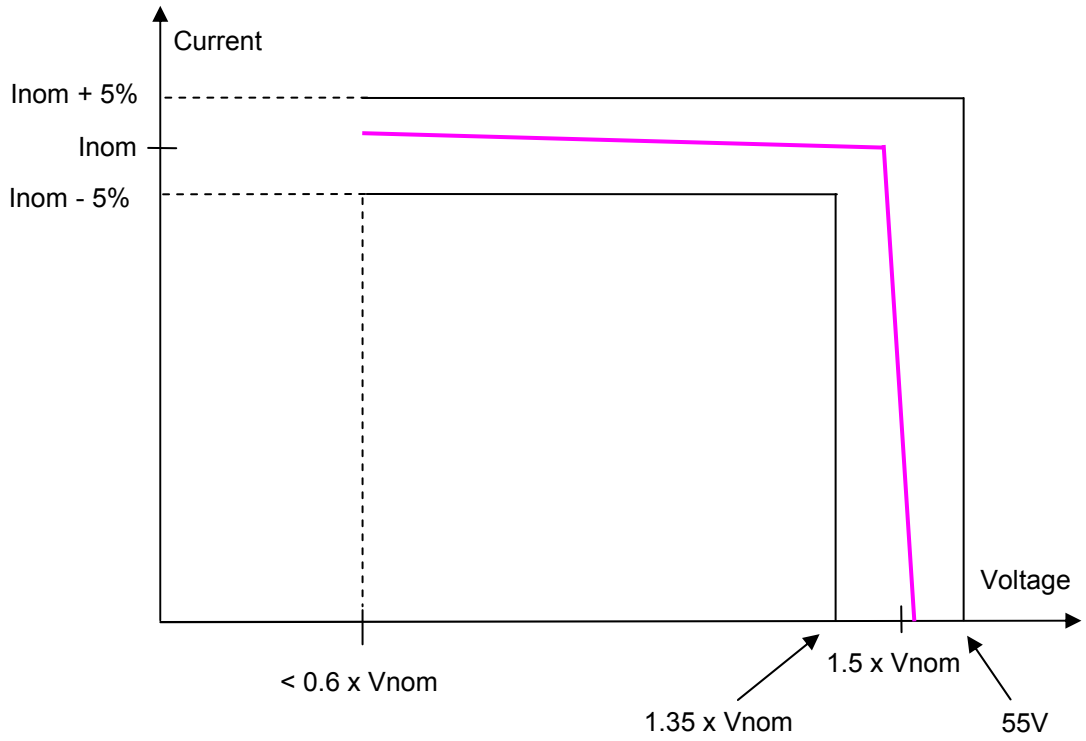
10.6 Associated Constant Current Power Supply (CCPS):

The Smart VH Module includes a charge control circuit that enables to use a current regulated power supply as a charger. It monitors the different parameters of the battery like voltage and temperature and a switch to control the input of current into the battery.

It should be used with a constant current power supply with following characteristics :

- Output current: from 0A to 7A max on Separate charge & functions connector, or 15A max on main poles
- Output voltage: 1.5V x Vnom recommended (55V max.). For other values, please consult SAFT.

In case of use of a Power Supply having different characteristics, please consult SAFT.



10.7 Charge Status indicator:

Then different status of the charge controller is known by looking at the LED display:

Orange	**Initialization phase / Fast charge**: ➢ Check first that Voltage > 0.8V/cell, Temperature in [5°C;40°C] and Slope of temperature not too high. ➢ If temperature > 50°C , charge duration will be longer ➢ Self adapting to memorized status of the battery
Orange / Green	**Balancing charge** battery is already operational ➢ More than 95% of capacity is reached. ➢ Current is reduced to perform the balancing of all the cells within the battery, depending on their measured status
Green	**Trickle charge** ➢ Balancing has been completed, battery will provide its full capacity ➢ Battery should be leaved in this status until next use
Flashing red	**Defect** , no charge ➢ Check the charge fuse first

	➢ Contact your reseller or have a look to our FAQ list to see which maintenance actions could be realized

During the charge phases, the Gas Gauge LEDs are indicating the current State Of Charge except when the status LED is green (Trickle mode).

11 DISCHARGE

11.1 How to activate the battery?

If battery is not activated (status LED Off), there is no voltage on main poles and the status LED is Off.
If battery is activated (status LED On), there is voltage on main poles and the status LED is On.

Move Key Switch from “OFF” to “ON” activates the battery. See Chapter “Role of the Key switch”.
If the Key Switch is “ON”, the battery can be Off because of a long period without current drain (current < 100mA in charge or discharge) from the battery. In this case, the battery can be activated by pushing the gas gauge button or sending data on communication bus BPCI®.

Note: If Key Switch is “OFF”

- sending data communication does not activate battery
- pushing gas gauge button activates gas gauge LED but does not activate the battery

11.2 Discharge connection

For discharging the Smart VH module, use the 2 discharge plots described in chapter “General Mechanical Smart VH Module Specification”.

Note: for 50A option, some protections are requested to protect either the battery or the application (external specific fuse), so please contact SAFT before connecting.

11.3 Discharge management principle:

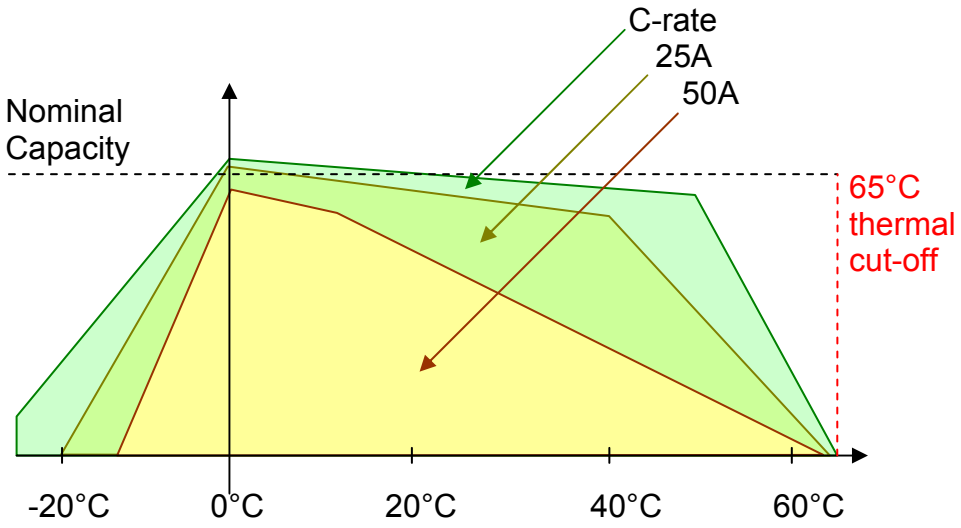
It is recommended to start to use the battery when the battery temperature is the 0°C ~ 40°C range.

It is possible to start the discharge until 50°C occasionally; however, as temperature is detrimental to life duration, life service will be reduced proportionnaly.

Moreover, when the Smart VH Module temperature raises the threshold of 65°C, the discharge current is stopped by the discharge control system.
The system is reset when the temperature decreases to 55°C

Note : In case of 65°C cut off, the status led will turn off, and the gas gauge indicator will still indicate the real battery state of charge when pushing the button. The battery is not empty and will be able to discharge again as soon as the temperature will reach 55°C.

The Smart VH Module includes a discharge controller that stops automatically the discharge (main poles voltage is then 0 V) and prevent from deep discharge (during use). In such case, the Gas Gauge level is set to 0%.
This discharge controller also isolates the battery from the application when the detected current in very low for a long period (sleeping mode, to avoid slow discharge through the leakage current that might remain when the application is not used).



This diagram shows the available capacity for a complete discharge at the mentioned current. It has been realized in an oven equipped with temperature regulation, on a 50A Smart VH Module at initial cycling state and not inserted in a casing. Those performances might vary depending on thermal environment for a Smart VH Module inserted in the application and should therefore be evaluated on the final configuration.

The maximum continuous current allowed and the acceptable peaks are mentioned in chapter “General technical characteristics”.

Note: In case a current over the maximum allowed current (according the option 25A or 50A) is drained from the battery, there might be some irreversible damages.

11.4 Regenerative charge

In discharge mode, the Smart VH Module is able to accept current coming trough the main poles. This function allows to recover energy from a motor or a reversible device powered by the Smart VH Module.

The regenerative current coming from main poles is fully accepted by the Smart VH Module during 3 minutes if :

- State of Charge < 80%
- Temperature < 45°C

Then the current is accepted during 1 minute if:

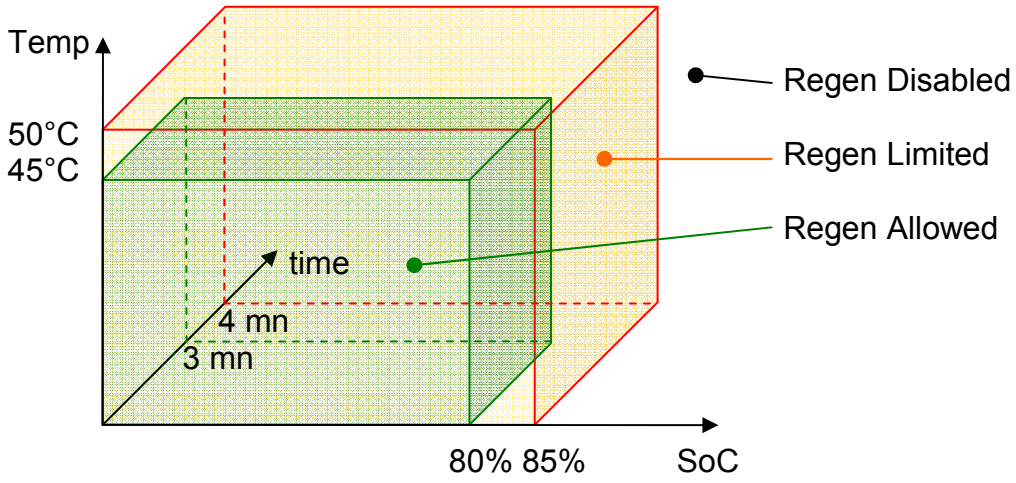
- State of Charge between 80% and 85%
- Temperature between 45°C and 50°C
- More than 3 minutes of regenerative current without interruption

During this minute, the Smart VH Module is in “Regen Limited” mode, and the Pre-alarm signal is activated (see note below).

The Smart VH Module will refuse regenerative current if:

- State of Charge > 85%
- Temperature > 50°C
- More than 1 minute of regenerative current without interruption in “Regen Limited” mode

Under these conditions, the Smart VH Module is in “Regen Disabled” mode, and the Pre-alarm signal remains activated (see note below). In that case the battery goes immediately in charging mode (limitation of the current by pulses coming from the regenerative source or complete disconnection).



Note: If the "Regenerative alarm" option has been validated during assembly of the battery, the "pre alarm" pin on Separate charge and functions connector is active (Ground) when:

- SOC < 10% (see chapter "Customized parameters") or
- SOC > 80% or
- T battery > 45°C or
- Regenerative time > 3 minutes,

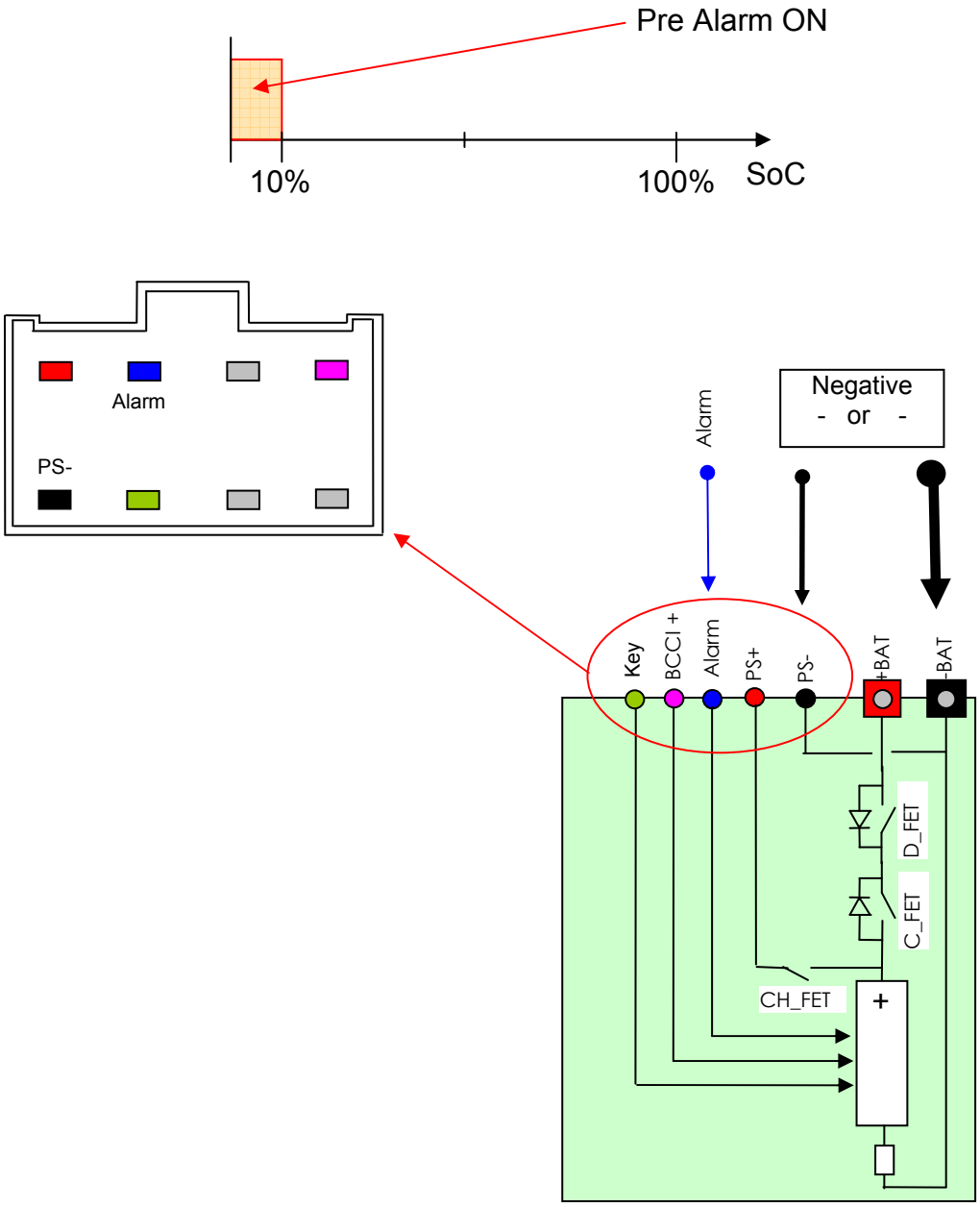
otherwise it is not active (Open collector).

11.5 Pre alarm

11.5.1 Pre-alarm without regenerative alarm option

This function can provide the end of discharge information through the connector, in order to use this information in order to launch a proper application shutdown. This information is available on the "Alarm" pin of the Separate charge and functions connector, and will be sending its signal when the battery is down to around 10% of its total energy (see chapter "Customized parameters").

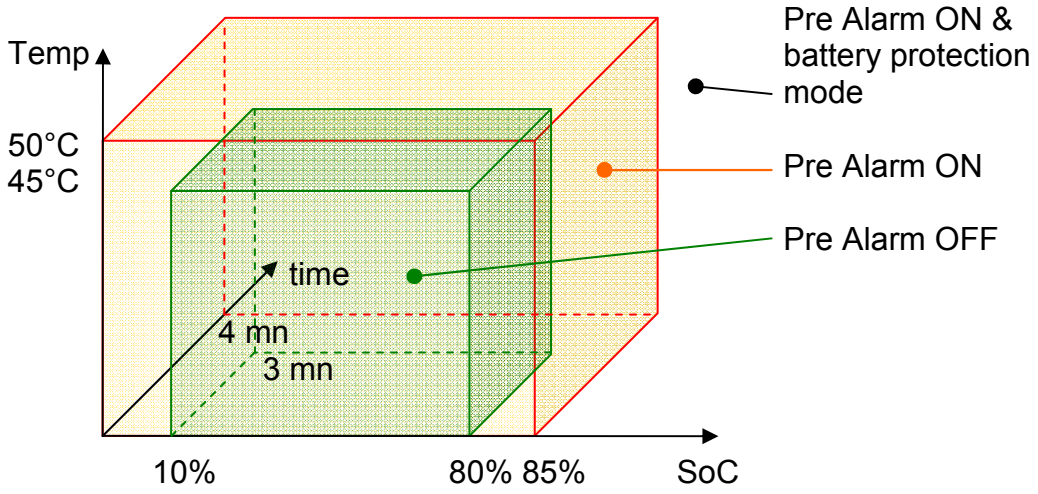
The application can then stop its operation before seeing the battery self disconnecting when completely empty.



11.5.2 Pre-alarm with regenerative alarm option

In addition to the end of discharge information, the Pre Alarm is able to provide regenerative charge “Limited” or “Disabled” information.

In this case, the “Pre Alarm” pin on Separate charge and functions connector is active (Ground) when SOC < 10% (see chapter “Customized parameters”) or SOC > 80% or T battery > 45°C or Regenerative time > 3 minutes otherwise it is not active (Open collector).



Note: The “Regenerative alarm” option is validated upon request during assembly of the battery, this option cannot be selected or not by the end-user (see chapter “Customized parameters”).

11.6 Display

Green	**Discharge** ➢ If the discharge current is higher than 100mA, the gas gauge leds are enlightened ➢ When the PreAlarm signal on User connector is ON, the battery is close to end of discharge cut-off
Orange	**Regenerative charge** ➢ Battery sees a charge current upper than 100mA ➢ When the PreAlarm signal on User connector is ON, the battery is close to regenerative charge limit (*) ➢ When the regenerative charge is not allowed, the battery switches to Charge mode and may pulse the incoming current

(*) : only when the regenerative alarm option is selected

12 POWER SAVING MODES

12.1 Stand by mode

In this mode, the battery self consumption is reduced and the main poles are in an Open Circuit situation, but the communication with the application is instantaneously available.

To bring the battery to discharge mode, press the Gas Gauge push button.

It is also possible to bring the battery to discharge mode by using the Key Switch pin on the separate charge and functions connector (in the standard Smart VH Module, you need to unground this pin - if it was already ungrounded, you need to ground & unground this pin).

12.2 Low power mode

In this mode, the battery self consumption is reduced more than in Stand By mode and the main poles are in an Open Circuit situation, and a request for communication will bring the battery to Stand by mode (battery not allowed to discharge – eg. empty or over temperature - or OFF position of the Key Switch) or discharge mode (other cases).

When delivered, the Smart VH Module will be operating in this mode, which allows assembly operations with a minimal risk in case of accidental short circuit, as the main poles are disconnected from the cell voltage.

12.3 Status LED display in Power Saving modes

No led 	**Sleep** ➢ Battery current stayed lower than 100mA for a long time ➢ Sleep mode will never be reached if current is higher than 200mA ➢ Press gas gauge button or connect a charger to wake up the battery

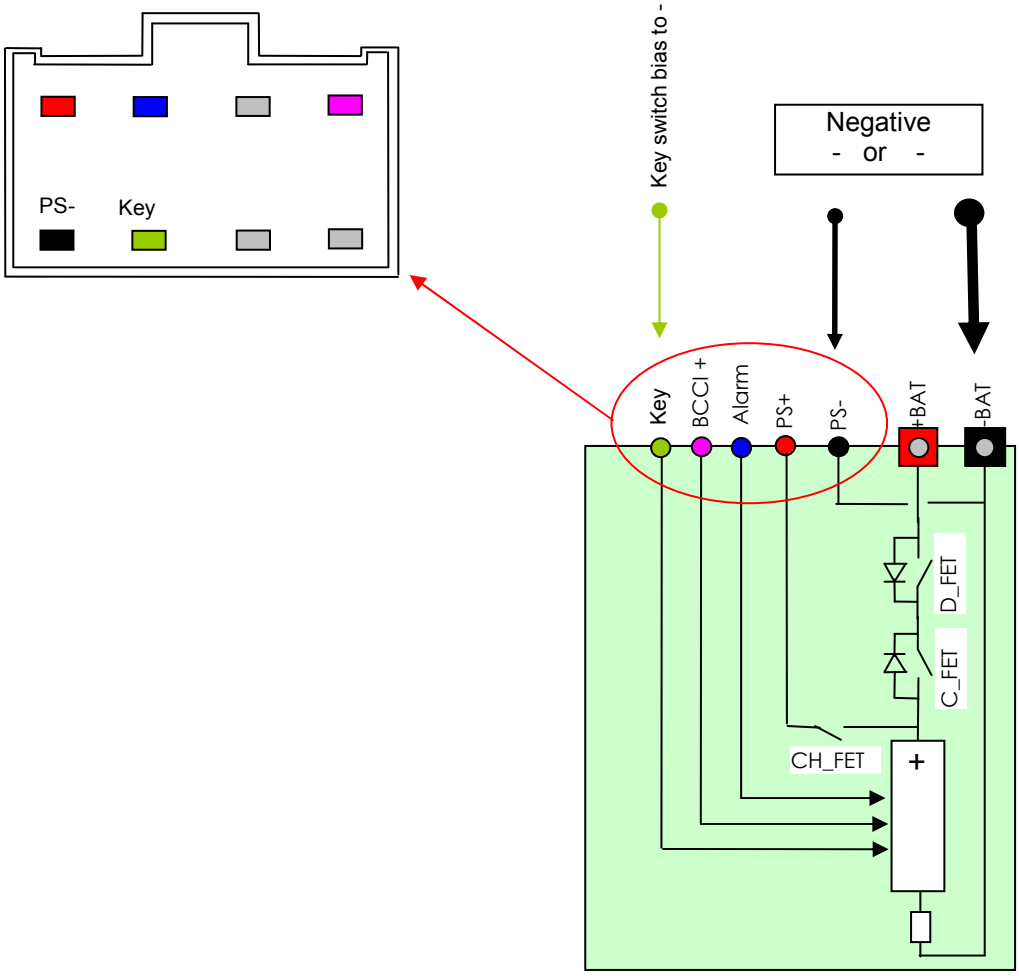
13 ROLE OF THE KEY SWITCH

The Key Switch allows controlling the battery's main poles. In case is in the "off" position, the battery is isolated from the application. This can be seen by looking to the status LED (which is not illuminated when the battery is isolated from the application).

Therefore it is important to notice that the battery will not be charged if the Power Supply is connected to the main poles AND the Key Switch is on the “off” position.

If it is important to charge the battery whatever the Key Switch position, please connect the Power Supply to the charge pins (7A max).

In the annex pages, you will find an overview of the changes between the different operating modes existing for the battery, depending on the fact that you are using or not the Key Switch.



In case of Priority ON configuration (see chapter “Priority ON / Priority OFF” for detail), when pushing the “Push button” the Key Switch pin becomes an output that follows the push button. The Key Switch pin is pull-up to +3.3V through 100KΩ if the gas gauge push button is released and pull-down to 0V through 1KΩ if gas gauge push button is pressed.

14 DEFECT MODE

14.1 Description

The defect mode indicates that a major issue has been detected by the Smart VH Module.

In this case, the electronics immediately disconnects the battery (main poles and charge pins on Separate charge & functions connector) and displays a defect signal on the status led for one minute.

Identified cases are the following:

- Short circuit protection

A current upper than 150A detected.

- Invalid temperature measurement

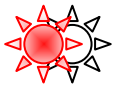
Temperature measured outside of -30°C / +80°C range.

- Over temperature detection

Hardware thermal cut-off (70°C) toggled.

Some defects are not permanent (short-circuit, over temperature). If the issue is solved, the Smart VH Module can be reactivated by pushing the gas gauge button.

14.2 Display

Flashing red 	**Defect**, battery disconnected ➢ Defect detected (see Defect Mode Description) ➢ Contact your reseller or have a look to our FAQ list to see which maintenance actions could be realized

15 INTEGRATED PROTECTIONS

The Smart VH Module is protected against failure of charger by internal protections (at both software and hardware levels). Those protections are active whenever the charge is done through the Separate charge & functions connector, or through the main poles.

Very important note: The Smart VH Module is not protected against reverse connection of the power supply; this will definitively damage the Battery Protection and Communication Circuit (BPCI®) in the smart VH Module.

Smart VH Module is also protected against charge (if charged through the Separate charge & functions connector) or discharge over-current by some fuses (except for the discharge fuse in the 50A configuration, that needs to be installed externally). Those fuses that can be supplied by SAFT on request.

16 GAS GAUGE

16.1 Principle

The capacity measurement is based on coulomb counter through a sense resistor.

The circuit integrates a self-discharge calculation based on time and temperature.

The full charged capacity level (LastMeasuredDischarge) is updated during calibration cycle (see below).

16.2 Display

It is possible to display the Nominal Available Capacity on 5 LED's, the display being activated by pressing the push button. The display will also be automatically active in discharge mode and in charge mode (with unsigned global current over 100mA).

The display corresponds to:

Display	1 led blinking	1 led	2 led	3 led	4 led	5 led
Capacity	Empty	0% < < 10%	10% < < 30%	30% < < 50%	50% < < 80%	80% < < 100%

Note: When waking up a Smart VH Module after a long storage, the gas gauge level update may take some seconds as the self discharge calculation is performed.

16.3 Procedure to calibrate the gas gauge.

During use, the real available capacity of the cells decreases because of cycling and ageing process. To keep the accuracy of the gas gauge, it is necessary to regularly update the full discharge capacity of the battery.

Two signs indicate that calibration is necessary:

- The gas gauge display goes suddenly from two Led's On or more to one Led flashing.
- The data register "Relative SOC" goes suddenly from value greater than 10% to 0.

The following sketch describes a method to do this calibration.

- Conditions of the test:
  - Temperature of battery greater than 10°C during calibration
  - No period of rest between trickle charge and discharge or during discharge.
  - No partial charge during calibration cycle
- First do a full charge of the batteries until status LED becomes Green.
- Do a full discharge until stop of discharge by the battery. A simple way to do a full discharge at a current of ~4Amps is to connect low voltage halogen lamps on the main poles:
  - A 12V / 50W lamp to discharge a 12V battery.
  - Two 12V / 50W lamps connected in series to discharge a 24V battery.
  - Three 12V / 50W lamps connected in series to discharge a 36V battery.

If the capacity decreasing is greater than 5% since the last calibration, it will be necessary to do several calibration cycles to do the calibration completely.
A way to know if the capacity decreasing is greater than 5% is to read the "LastMeasuredDischarge" register before and after the calibration cycle.
A variation of the "LastMeasuredDischarge" register equals to 5% of the value in "Designcapacity" register means, at least a new calibration cycle is necessary.

Numeric example:
Suppose "DesignCapacity" register = 14500mAh and before calibration cycle, "LastMeasuredDischarge" register = 14700mAh.
After first calibration, if "LastMeasuredDischarge" register = 13975mAh, as 13975 equals 14700 – 14500 x 5%, that means the calibration process is not complete.
After second calibration, if "LastMeasuredDischarge" register = 13550mAh, as 13550 is greater than 13975 – 14500 x 5%, that means the calibration process is finished and the value: 13550mAh in "LastMeasuredDischarge" register represents the new real capacity of the battery.

17 COMMUNICATION

17.1 Data acquisition

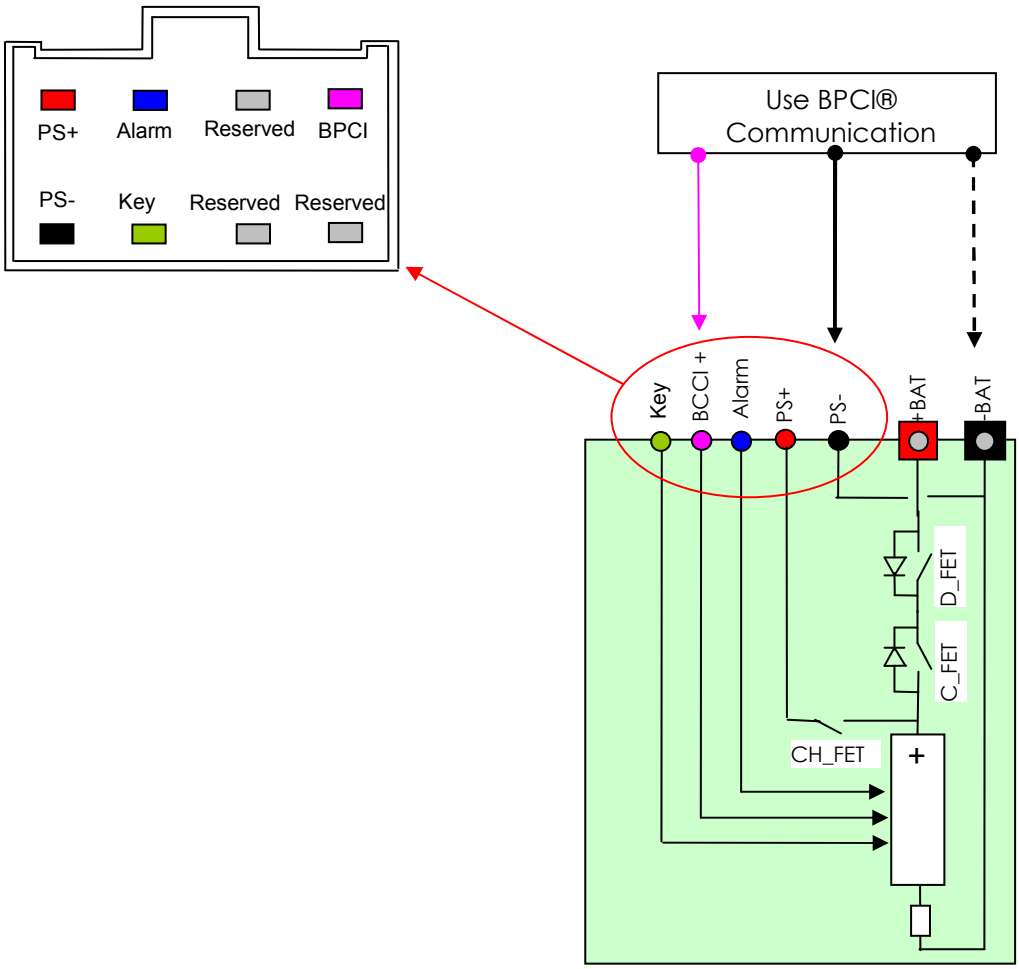
It is possible to collect the data through 1 wire Battery Protection & Communication Interface (BPCI®) bus available on the connector (see “§ Connecting a Smart VH module”).

17.2 Wiring diagram of single Smart VH Module

Connection is done through Separate charge & functions connector.

When starting a communication in case of Smart VH Module in sleeping mode, the module wakes up automatically and goes back to operating mode.

Note: when the battery is in sleep mode, this first message will wake up the battery and could be not understood by the battery so it could be necessary to repeat it to have an answer.



17.3 Description of the BPCI® Bus

BPCI® Bus is a Single Wire bus interfacing a peripheral with Saft Smart Module with BPCI® (Battery Protection and Communication Interface). It can be used to retrieve data from the battery or to send commands to the battery.

The bus is accessible on the user connector on the module (PIN 7). The logic level voltages are 0 and 3.3V. A pull up to Vcc (3.3V) is necessary on the peripheral. A 10kOhms pull-up resistor is recommended.

The data format is similar to RS232 format configured as followed:

- Speed 9600bits/s
- Eight data bits
- No parity bit
- One stop bit

- No flux control

17.4 Accessible data

All data requests are composed of 1 byte sent to the battery. The battery sends back the requested data within 10ms after the request reception.

Two data format are supported, Hexadecimal and ASCII. If a data is requested by its Hex code, the battery sends back an hexadecimal data. If a data is requested by an ASCII code (i.e. a character) the battery sends back the description of the data followed by a text coded data (string format).

When receiving commands, the battery does not send back any data.

Hex	ASCII	Description	Access	Hex Format	ASCII Format
0x41	"A"	Battery Reference	Read	String (10)	String (10)
0x42	"B"	Serial Number	Read	String (10)	String (10)
0x43	"C"	Serial Number (Para)	Read	String (14)	String (14)
0x44	"D"	Software Version	Read	String (4)	String (4)
0x45	"E"	Configuration	Read	String (12)	String (12)
0x00	"Z"	Sleep	Command	-	-
0x01	"H"	Push Button	Command	-	-
0x10	"a"	Design Capacity	Read	Ah (2 Bytes)	String (6)
0x11	"b"	Last Measured Disch	Read	Ah (2 Bytes)	String (6)
0x12	"c"	Remaining Capacity	Read	Ah (2 Bytes)	String (6)
0x13	"d"	Flags Status 1	Read	Bit flags	String (8)
0x14	"e"	Flags Status 2	Read	Bit flags	String (8)
0x15	"f"	Flags Status 3	Read	Bit flags	String (8)
0x16	"g"	Flags Status 4	Read	Bit flags	String (8)
0x17	"h"	Flags Status 5	Read	Bit flags	String (8)
0x18	"i"	Flags Status 6	Read	Bit flags	String (8)
0x19	"j"	Default Status	Read	Bit flags	String (8)
0x1A	"k"	State of Health	Read	% (1 byte)	String (3)
0x1B	"l"	Relative SOC	Read	% (1 byte)	String (3)
0x1C	"m"	Absolute SOC	Read	% (1 byte)	String (3)
0x1D	"n"	Battery Current	Read	mA (2 Bytes)	String (6)
0x1E	"o"	Battery Voltage	Read	mV (2 Bytes)	String (6)
0x1F	"p"	Battery Temperature	Read	°C (1 Byte)	String (3)
0x20	"q"	Balancing Time	Read	h (1 Byte)	String (3)

Examples:

If contents of Flags Status1 is : 00001000
Peripheral to battery: 0x13 => Battery to peripheral: 0x08
Peripheral to battery: “d” => Battery to peripheral: “Flags Status 1” “00001000”
If content of Battery Current is : 3025mA
Peripheral to battery: 0x1D => Battery to peripheral: 0x0B0xD1
Peripheral to battery: “n” => Battery to peripheral: “Battery Current” “+03025”

If content of Software Version is : 004C
Peripheral to battery: 0x44 => Battery to peripheral: 0x000x000x040x0C
Peripheral to battery: “D” => Battery to peripheral: “Software Version” “004C”

Peripheral to battery: “H”
Battery to peripheral: *N/A* – Battery displays SOC (push button action)

17.5 Description of data

Battery Reference
This read-only string returns an ASCII character string where the first byte is the number of characters available. The maximum number of characters is 10.

Serial Number
This read-only string returns an ASCII character string where the first byte is the number of characters available. The maximum number of characters is 10.

Serial Number (Parallel)
This read-only string returns an ASCII character string where the first byte is the number of characters available. The maximum number of characters is 14.

Software Version
This read-only string returns an ASCII character string where the first byte is the number of characters available. The maximum number of characters is 4.

Configuration
This read-only string returns an ASCII character string where the first byte is the number of characters available. The maximum number of characters is 12.

Design Capacity
This read represents the value of DesignCapacity register for a complete battery.

Initialize at manufacturing process and no update during life of battery
Units: Ah
Range: 0 to 6553.5Ah
Granularity: 0.1Ah

Last Measured Discharge
This read represents the value of LastMeasuredDischarge register for a complete battery
Initialize at manufacturing process and update during life of battery after a complete valid charge – discharge cycle
Units: Ah
Range: 0 to 6553.5Ah
Granularity: 0.1Ah

Remaining Capacity
This read represents the value of RemainingCapacityNow register for a complete battery
Initialize at manufacturing process and update during use of battery
Units: Ah
Range: 0 to 6553.5Ah
Granularity: 0.1Ah

Flags Status 1
This read-only register returns an unsigned integer representing the internal Status1 register of BPCI®.

	(MSB) 7	6	5	4	3	2	1	(LSB) 0
FlagsStatus1	DTDt	TMAX	FATIM	VMAX	INCHA	FACHA	TOPCHA	TRICHA

DTDt : DT/DtDetection
Set to 1 if a DT/Dt detection occurs in charge and reset when charger is disconnected.
TMAX : TmaxDetection
Set to 1 if a Tmax detection occurs in charge and reset when charger is disconnected.
SOC : StateOf ChargeDetection
Set to 1 if the SOC detection occurs in charge and reset when charger is disconnected.
VMAX: VmaxDetection
Set to 1 if a Vmax detection occurs in charge and reset when charger is disconnected.
INCHA: InitialCharge

Set to 1 if the charge is in Initialization phase mode

FACHA: FastCharge

Set to 1 if the charge is in fast charge mode

TOPCHA: BalancingCharge

Set to 1 if the charge is in Balancing charge mode

TRICHA: TrickleCharge

Set to 1 if the charge is in trickle charge mode

Flags Status 2

This read-only register returns an unsigned integer representing the internal Status2 register of BPCI®.

	(MSB) 7	6	5	4	3	2	1	(LSB) 0
FlagsStatus2	OTB	Reserved	OTM	DVD	VLLD	Reserved	VALDIS	FULCHA

OTB: OverTemperatureBattery

Set to 1 if one TCELL is above θd (typically 60°C) and reset when TCELL is below θrd
(typically 50°C)

OTM: OverTemperatureMos

Set to 1 if one TMOS is above θMos (typically 120°C) and reset when TMOS is below θrMos (typically 100°C)

DVD: DvDetection

Set to 1 if one DV (battery unbalanced) voltage is detected and reset when DV disappears

VLLD: VllDetection

Set to 1 if one VLL (low voltage level) is detected and reset when VLL disappears

VALDIS: ValidDischarge

Set to 1 if the discharge is valid to update Last Measured Discharge on full discharge at end of Balancing charge.

FULCHA: FullyCharge

Set to 1 if the battery is fully charged (typically when Relative SOC >= 98%)

Flags Status 3

This read-only register returns an unsigned integer representing the internal Status3 register of BPCI®.

	(MSB) 7	6	5	4	3	2	1	(LSB) 0
FlagsStatus3	PRALM	DIS_ON	DISCON	EMPTY	REGDIS	REGLIM	REGEN	DISMOD

DISMOD: DischargeMode
Set to 1 if BPCI® is in Discharge mode
REGEN: FullRegenerativeEnable
Set to 1 if mode regenerative is fully allowed (typically when RMC ≤ LMD * 80% and T ≤ 45°C)
REGLIM: RegenerativeLimited
Set to 1 if mode regenerative is limited (typically when LMD * 80% < RMC ≤ LMD * 85% or 45°C < T < 50°C)
REGDIS: RegenerativeDisable
Set to 1 if mode regenerative is forbidden (typically when RMC > LMD * 85% ot T ≥ 50°C)
EMPTY: EmptyBattery
Set to 1 if parameter “Empty” is activated after a DV or a VLL detection, reset when RMC > LMD * 10% on regenerative charge or at start of fast charge mode.
DISCON: DischargeControl
Follows status of Discharge MOSFET
DIS_ON: DischargeOn
Follows status of “DIS_ON” I/O on user connector
PRALM: PreAlarm
Follows status of “Pre-alarm” signal (typically when RMC ≤ LMD * 10%)

Flags Status 4

This read-only register returns an unsigned integer representing the internal Status4 register of BPCI®.

	(MSB) 7	6	5	4	3	2	1	(LSB) 0
FlagsStatus4	CHDET	BTCDET	Reserved	Reserved	Reserved	REGCON	CHACON	Reserved

CHACON: ChargeControl
Follows status of Charge MOSFET
REGCON: RegenControl
Follows status of Regenerative Charge MOSFET
BTCDET: Chargedetect on BATC
Follows status of Charger detection signal on +BAT
CHDET: Chargedetect on CH
Follows status of Charger detection signal on +PS/+CH on user connector

Flags Status 5

This read-only register returns an unsigned integer representing the internal Status5 register of BPCI®.

	(MSB) 7	6	5	4	3	2	1	(LSB) 0
FlagsStatus5	BP_DEP	LED_RED	LED_GRN	LED_90	LED_75	LED_40	LED_20	LED_05

LED_05: Led 0_10%ChargeStop
Follows status of “Led_05”
LED_20: Led 10_30%ChargeStop
Follows status of “Led_20”
LED_40: Led 30_50%ChargeStop
Follows status of “Led_40”
LED_75: Led 50_80%ChargeStop
Follows status of “Led_75”
LED_90: Led 80_100%ChargeStop
Follows status of “Led_90”
LED_GRN: Status led (bicolor)
Follows status of green led
LED_RED: Status led (bicolor)
Follows status of red led
BP_DEP: Push button status
Follows status of push button

Flags Status 6 (reserved for future use)

Default Status
This read-only unsigned integer word returns the DefaultStatus register of the battery.

	(MSB) 7	6	5	4	3	2	1	(LSB) 0
DefaultStatus	Reserv.	Reserv	Reserv	Reserv	CHSTOP	NTCNOK	Reserv	Reserv

NTCNOK: NTCNotOK
Set to 1 if NTCCell1 or NTCCELL2 = 0 or ∞ and if NTCMos = 0
CHSTOP: ChargeStop
Set to 1 by “Cha_Stop” signal

SOH
This read-only unsigned integer word returns the StateOfHealth register of the battery from 0 to 100.
Units: %
Range 0 to 100

Note : this register is not yet implemented.

Relative SOC

This read returns the value of Relative State of Charge from 0 to 100.
Relative SOC = Remaining Capacity / Last Measured Discharge * 100
Units: %
Range 0 to 100

Absolute SOC
This read returns the value of Absolute State of Charge from 0 to 100.
Absolute SOC = Remaining Capacity / Design Capacity * 100
Units: %
Range 0 to 100

Battery Voltage
This read-only word returns the voltage of the battery.
Units: mV
Range: 0 to 65535mV
Granularity: 5mV

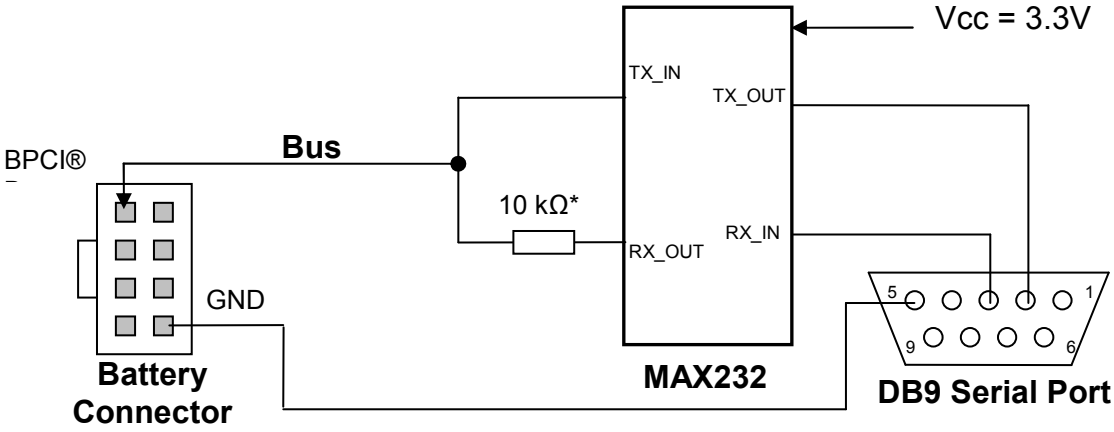
Battery Temperature
This read-only word returns the internal temperature of the battery.
Units: °C
Range: -127°C to +127°C
Granularity: 1°C

Battery Current
This read-only word returns the instantaneous current or average current of the battery.
Units: mA
Range for instantaneous current:
-5000mA (discharge) to +15000mA (charge / regenerative)
Granularity for instantaneous current:
5mA
Range for average current measured on 30s:
-32000mA to -5000mA (discharge) and +15000mA to +32000 mA (charge)
Granularity for average current:
400mA

Balancing Time
This read-only word returns the time needed in Balancing mode to balance the cells within the battery and get the full capacity.
Units: h
Range: 0h to 72h
Granularity: 1h

17.6 Connection of the battery to a computer:

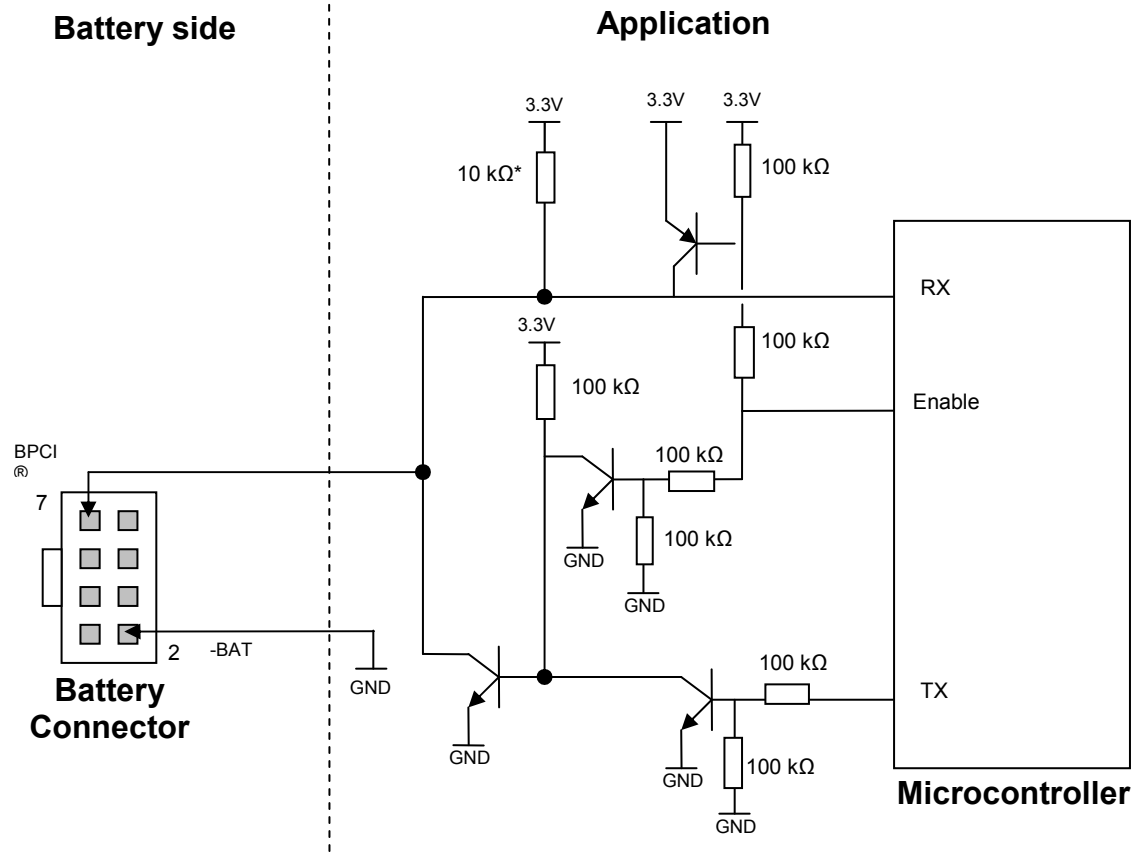
The connection will require a conversion of the signal of the bus towards a serial connection (RS232 type) in order to connect the bus to a computer serial port.
The following schematic gives the principle of communication interface between BPCI® Bus and RS232 port of personal computer. A complete schematic is given in annex.



* : when RX_Out is at high, this resistor is the bus pull-up, adjustable.

17.7 Connection of the battery to a microcontroller:

The following schematic the principle of communication between BPCI® Bus and the UART of a microcontroller



* : this resistor is the bus pull-up, adjustable

The UART of the microcontroller must be configured with: 9600 bauds, 8 data bits, no parity, 1 stop bit.

The Enable allows when one writes on the bus to remove the echo (not to receive on RX what is sent by TX) by hardware. The Enable is thus in a low state when the microcontroller writes on the bus, at the high state if not (what also allows a traditional use of the UART if the RX/TX signals are used directly on microcontroller IO).
The remove of echo can also be done by software on some microcontroller.

18 CONSUMPTION

The consumption of the Smart VH Module electronics has been designed in order to allow the battery to provide the maximal energy to the application. In order to reduce its own consumption, several modes have been integrated.

18.1 Active mode (charge or discharge)

In this mode, the status LED is enlightened.
The consumption of the BPCI® in this mode is less than 20 mA depending on LED display. The turn Key Switch is on ON position and the push button has been pushed or the communication has been active or a charger is connected or has been disconnected.
If the turn key stays on ON position, with discharge current less than 200mA for 4 hours, with no charger connected for 4 hours, with no push button action for 4 hours and with no communication for 4 hours, the battery will go in sleeping mode. This timer parameter can be customised (see § “Customised parameters” below).

18.2 Stand by mode (Data transmission)

The consumption of the BPCI® in this mode is less than 1mA. The turn Key Switch is on OFF position. The push button has just been pushed or the communication bus is active.
Turn the key on ON position or connect the charger will put the battery in active mode.
Stop pushing button action and stop communication will put the battery in sleep mode.

18.3 Sleeping mode (Low power)

The consumption of the BPCI® in this mode is less than 150 µA. The turn Key Switch is on OFF position or has been on ON position for more than 4 hours, no charger has been connected for 4 hours,the push button has not been pushed for 4 hours, the communication bus is not active for 4 hours. This timer parameter can be customised (see § “Customised parameters” below).
A push button action or a communication will put the battery in stand-by mode.
Turn the key on ON position or connect a charger will put the battery in active mode.

19 CUSTOMIZED PARAMETERS (AT ORDER)

19.1 Priority ON / Priority OFF

There are 2 possible configurations, that will allow to have the battery or group of batteries active when the Key Switch signal is ungrounded (this is the “Priority ON” configuration), or to have it inactive when the Key Switch signal is ungrounded (this is the “Priority OFF” configuration). The choice between the configuration is done during assembly by programming as shown in the following table:

Mode Programmed during asembly	Smart VH Module Status	"Key switch" Separate charge and functions pin Status (value depending on the Key position)
Priority ON	Sleeping	Grounded
Priority ON	Ready for discharge	Ungrounded
Priority OFF	Ready for discharge	Grounded
Priority OFF	Sleeping	Ungrounded

The standard Smart VH Modules configuration is "Priority ON" (this is the status when it is not connected to any harness on the Separate charge and functions connector).

In case the Smart VH Module is configured in "Priority OFF" mode, you need to ground this pin (if it was already grounded, you need to unground & ground this pin).

19.2 Timer for automatic sleep mode

The time to go automatically from active mode to sleep mode is a parameter adjustable during assembly of the battery.
Initially, the time is 4 hours. It can be customised to 12, 24, and 85 hours on the production line*.
Note: The automatic switching in sleep mode can not be disabled.

Note : In application, where this automatic sleep mode is critical, it is strongly recommended that the application manages battery wake up with key switch.
In application where drain current can be low or close to 200mA for a long period, it is strongly recommended to use key switch to manage wake up of the battery.
Especially in configuration with several batteries in parallel with low drain current, each battery must deliver more than 200mA to avoid going to sleeping mode automatically. As the current is not necessary balanced, it is possible to have less than 200mA on some batteries and more than 200mA on others. So it is strongly recommended to use key switch to manage wake up of battery from application.

* : On request, it can be programmed from 20 minutes to 85 hours by step of 20 minutes.

19.3 Pre alarm capacity

Before end of discharge disconnection, the battery is able to provide a pre alarm information. This signal is available on separate charge and function connector (see § “connecting a smart module”).
The state of charge level for this pre alarm can be customised when ordering a Smart VH module (see § “how to order a Smart VH Module”).

19.4 Regen alarm

Is some limit cases, the battery is not able to accept any regenerating charge : the battery is able to provide a pre alarm information before this limit point is reached. This signal is available on separate charge and function connector (see § “connecting a smart module”) on the same pin than the pre-alarm capacity alarm.

Note :
If the user wants only to have a pre alarm capacity indication, the regen alarm parameter should be set to “OFF” at order. (see § “how to order a Smart VH Module”).
If the user wants only to have a regen alarm indication, the pre alarm parameter capacity level should be set to “0%” at order. (see § “how to order a Smart VH Module”).

20 GROUPING SEVERAL SMART VH MODULES

The Smart VH Module is designed in order to provide easy grouping possibilities to extend the battery system energy. It allows to provide a simple management of the connected application (e.g.: provide the possibility to have a On/Off switch on a control wire, regardless the power the Smart VH Module is providing) even if communication abilities are not existing at the application level.

Note :
The capacity is multiplied by the number of mosule but the user has to take into account that the maximum current allowed by the system is always 25 or 50A.

When connecting several modules in parallel, it is recommended to have equivalent state of charge for all of them to avoid peak currents.

20.1 Wiring diagram in case of series association

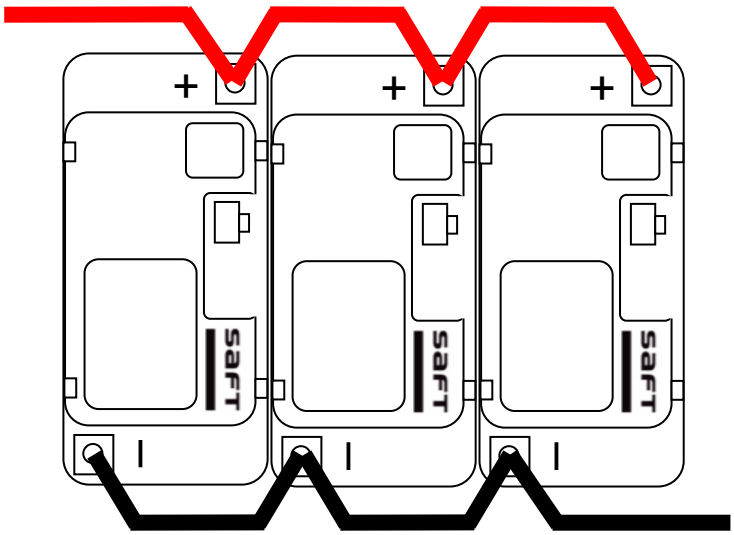
Connecting Smart VH Modules in series can definitively damage the Battery Protection and Communication Circuit (BPCI®) in the smart VH Module. For any application requiring such assembly, please contact SAFT.

20.2 Wiring diagram in case of parallel association

Connection for power is done by simply connecting all of the main poles together; i.e.: All plus poles connected together & all minus poles connected together.

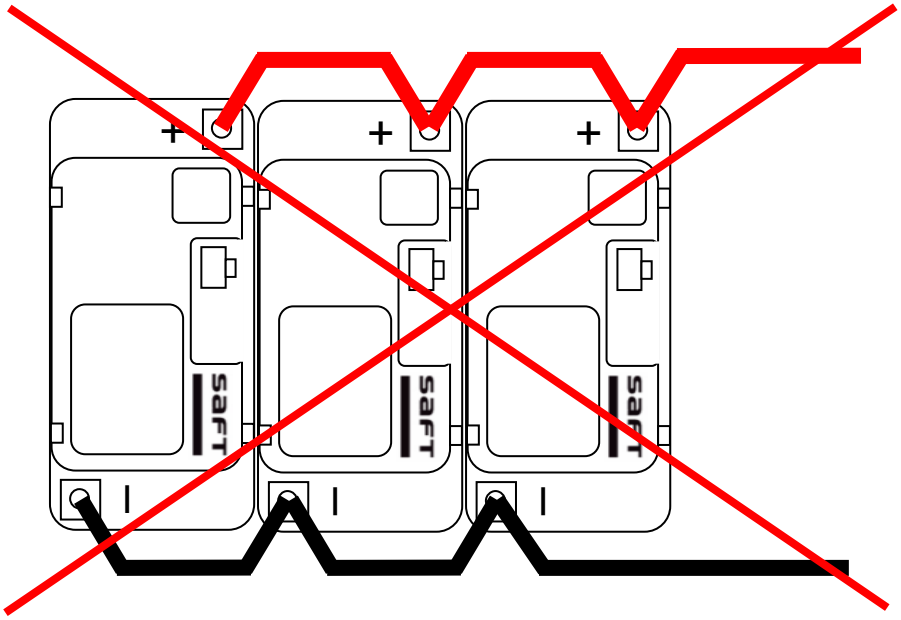
Proper connection to balance the current:

OK

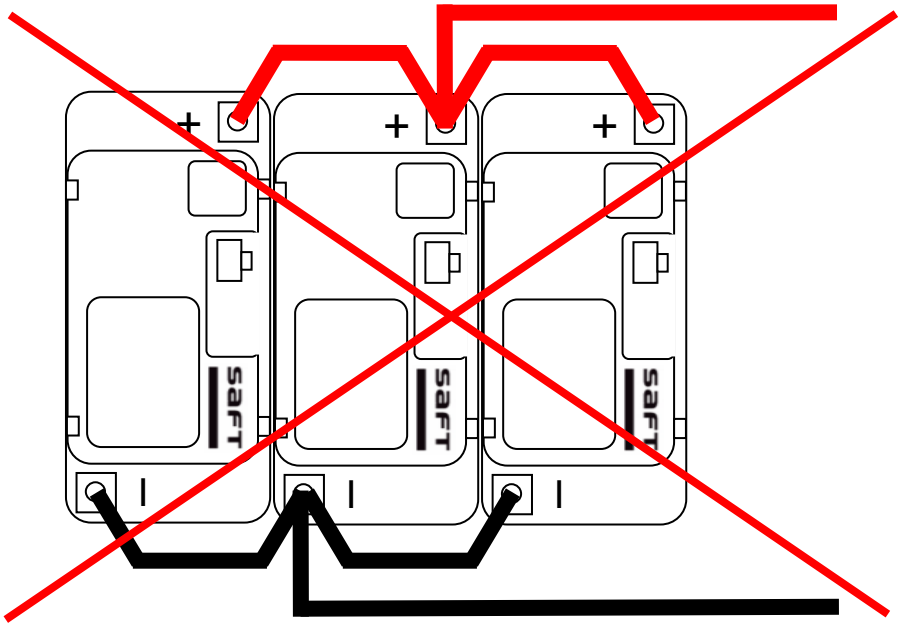


Improper connection to balance the current:

NOK



NOK



Very important note:
Connecting plus pole of a first battery to minus pole of a second battery and minus pole of the first battery to plus pole of the second battery will definitively damage the Battery Protection and Communication Circuit (BPCI®) in the smart VH Module.

Connection for charge can be done though main poles connected in parallel.
Note: to properly manage the charge current, the charge current delivered by the power supply must be lower than 15A.

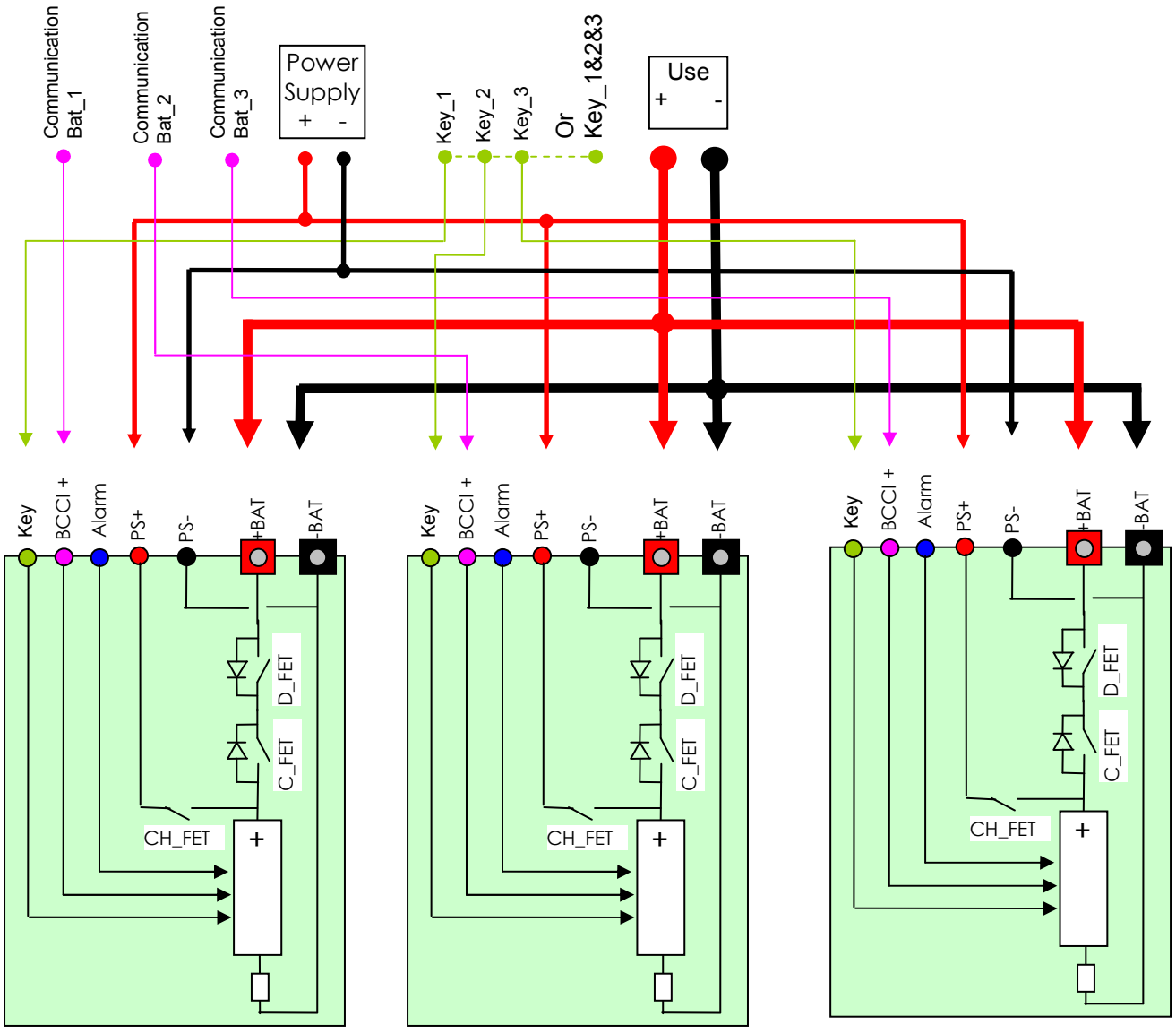
Connection for charge can also be done through separate charge and functions connector pins connected in parallel, in this case, the charge current must be lower than 7A.

Connection for key switch is done through the Separate charge & functions connector.
Use in parallel : If all the key signals are connected in parallel, the batteries main poles are enabled or disabled at the same time.
Alternate use : If the key signals are separated, the batteries main poles can be enabled or disabled separately. It allows to use or check the modules separately.

Connection for communication is done through Separate charge & functions connectors.

Note: The BPCI® communication bus can not be connected in parallel, they must be managed by the application separately.

The wiring of such battery group will then be as follows (from 1 to n batteries, all configured with the same Priority type):



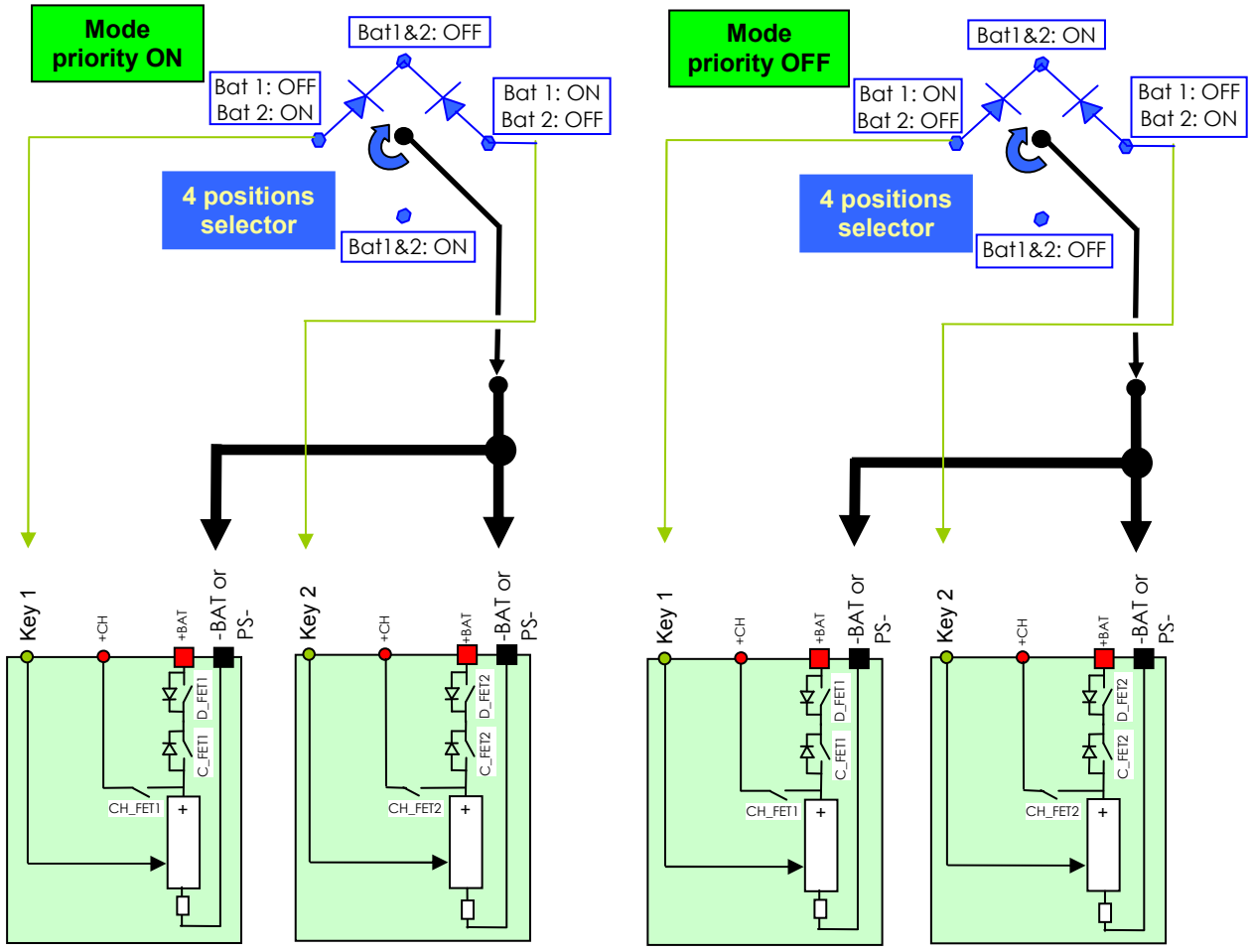
It is necessary to separate the BPCI® buses, and connect them to different communication ports on the application.

If the Key Switch pins from the different batteries are connected together, all the batteries are activated when the gas gauge push button of only one battery is pressed and released.

Note: The above function is valid only if the batteries are configured in "Priority ON" mode.

20.3 Wiring diagram in case of 2 Smart VH Modules association

It is possible to control such configuration by using a simple multi-position selector, connecting the “Key switch” pins as described below:



In this configuration (each Smart VH Module being left on the “Priority ON” configuration, the end user can activate battery 1, battery 2 or both batteries, or deactivate both batteries. Note that the battery number corresponds to the battery position into the harness (which is installed in a fixed configuration inside the application).

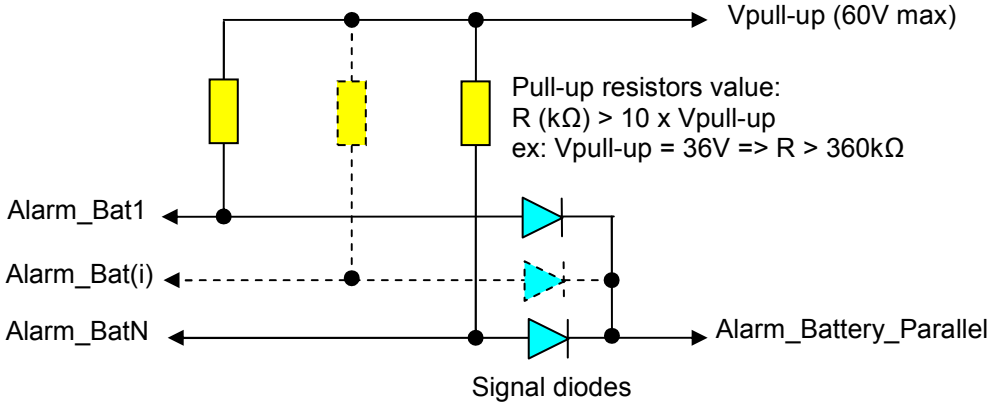
In “priority OFF” mode, if the user does not want to use both batteries at the same time, the 4 positions switch can be replaced by a 3 positions switch and the diodes can be removed.

20.4 Wiring diagram of Pre-alarm signal in case of more than 2 batteries parallel association

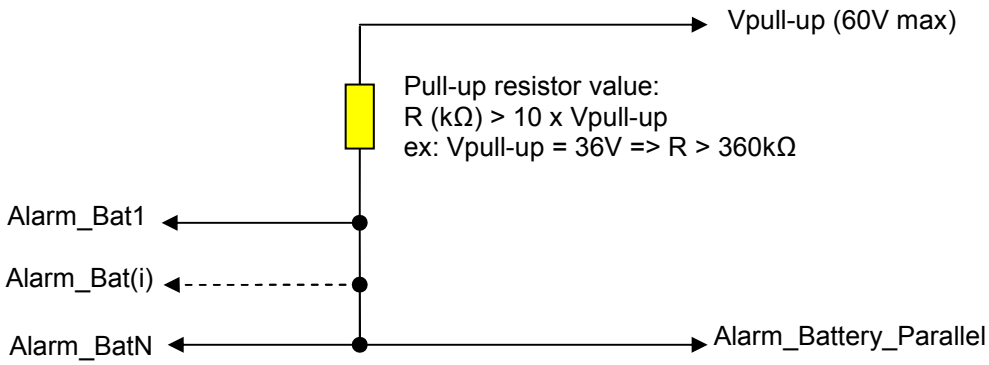
The pre-alarm signal on Separate charge & functions connector is an open collector signal through 2.2kΩ resistor.

The following schematic is an AND topology, that means the output pre alarm signal will be active (low level) if all the input pre alarm signal are active (low level). The schematic is mainly use when all the batteries are connected and all discharged in parallel at the same time.

Note: The battery voltage Vbat may be used as Vpull-up.



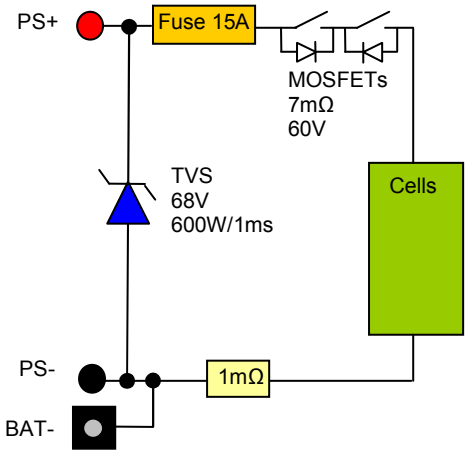
The following schematic is an OR topology, that means the output pre alarm signal will be active (low level) if only one input pre alarm signal is active (low level). The schematic is mainly use when the batteries are connected in parallel and discharged one by one or not in parallel at the same time.

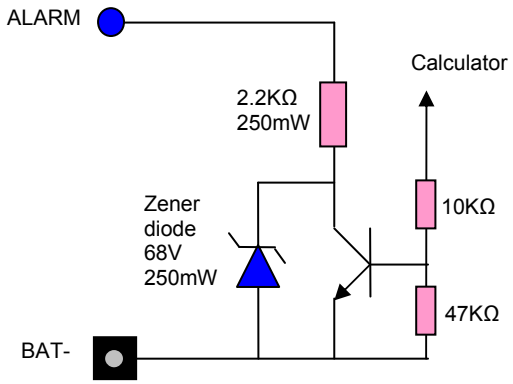
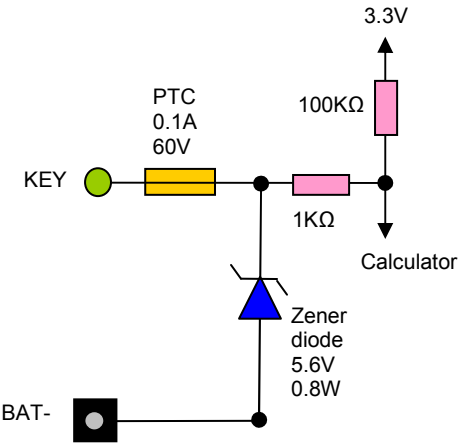


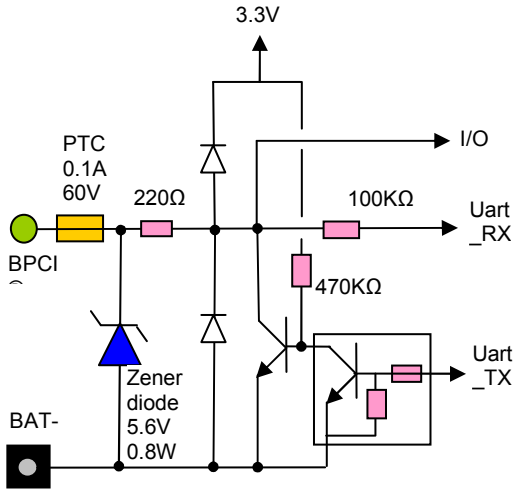
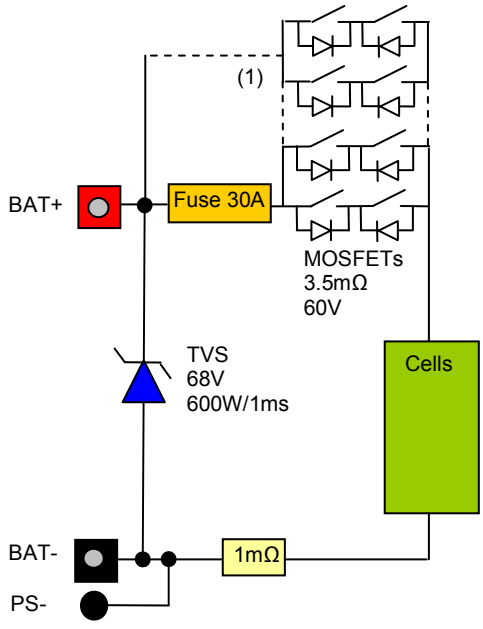
21 HARDWARE INTERFACE

21.1 Interface of battery signals

The following diagrams describe the interface of each signal of the battery.

Pin out	Signal	Interface schematics	Comments
1 2	PS+ PS-		TVS protects BPCI® against short time over voltage (<1s). Long time over voltage (>1s) will blow the TVS and damage definitively the BPCI®

3	Pre_ALARM		External pull_up must limit input current: Vpull-up < 60V and R pull-up (KΩ) > 10 x Vpull-up => Vlow < 0.5V Vhigh = Vpull-up
4	KEY_Switch		On application side, the Key Switch is a switch open or close to BAT-
5	Reserved		No connection on this pin on application side
6	Reserved		No connection on this pin on application side

7	BPCI®_Bus		An external pull-up to 3.3V on the application side is necessary. Recommended Pull-up resistor is 10 KΩ
8	Reserved		No connection on this pin on application side
	BAT+ BAT-		TVS protects BPCI® against short time over voltage (<1s). Long time over voltage (>1s) will blow the TVS and damage definitively the BPCI® (1) In version 50A, more MOSFETs are mounted and the fuse 30A is strapped. A fuse 50A must be mounted on application side.

22 MAINTENANCE

This mode is used in the case of maintenance (SAFT can provide an optional maintenance tool, please consult us to get more information if interested) or wish to get information from the Smart VH Module.

It can provide communication between a computer and the Smart VH Module, using a standard COM port and a serial console software (like HyperTerminal for example). See § “Communication” for details.

In this case, the application may not be connected to the Separate charge and functions connector, leaving it available for such non usual operations (Note: the Separate charge and functions connector is not intended to be inserted & removed more than 100 times, and should be manipulated with care).

23 MECHANICAL

23.1 How to position your SMART VH Module?

23.1.1 Mechanical position

The Smart VH Module can be set up vertically or horizontally.

Its plastics part should not be blocked in rotation (1° freedom in rotation should be allowed).

It is optimized to be fanned.

23.1.2 Sealed container

The Smart VH Module cannot be put in a sealed container without a system allowing air to go out from the container, especially during charge as Hydrogen generation may occur.

A system like a Gore-Tex component or a vent can be added on the box to satisfy this point.

23.2 Vibrations

Test description:

Cycle description:

- 0-7 Hz : 0 g²/Hz
- 7 Hz : 0.1 g²/Hz
- 7 - 10 Hz : from 0.1 to 0.8 g²/Hz
- 10 - 14 Hz : 0.8 g²/Hz
- 14 - 60 Hz : from 0.8 to 0.1 g²/Hz
- 60 - 100 Hz : 0.1 g²/Hz
- 100 Hz : 0 g²/Hz

Duration : 2,5 heures / axis.

Criteria:
No voltage cut during the test and battery still functional after all.

Result:
OK

23.3 Shocks

Test description:
* Vertical axis: 3 shocks 1/2 sinus of 25g and 20 ms in 2 directions
* Biggest side axis: 3 shocks 1/2 sinus of 30g and 3,3 ms in 2 directions

Criteria:
Battery is still functional, no break.

Result:
OK

23.4 Drop

The SMART Module is not designed for such constraint. An aluminum casing is available as an option for such a request. Please consult Saft for details.

23.5 Water tightness

The Smart VH Module is IP and cannot support water projections.
It should be put in a bag or a container.

23.6 Environmental conditions

23.6.1 Hot

Test description:
Storage of a fully charged battery at +70°C storage during 72 hours

Criteria:
Battery is still functional, no break.

Result:
OK.

23.6.2 Cold

Test description:
Storage of a fully charged battery at -40°C storage during 72 hours

Criteria:
Battery is still functional.

Result:
OK.

23.6.3 Humidity

Test description:
Storage of a fully charged battery 21 days at +50°C and 93 %

Criteria:
Battery is still functional.

Result:
OK.

23.6.4 Salt fog

The Smart VH Module is not designed for such constraint. Please consult Saft for such applications.

23.6.5 Variation of temperature

Test description:
Following IEC 68-2-14:
15 cycles from -20°C to + 55°C, maintained during 90 min and return to -20°C @ 3°C / sec

Criteria:
Battery is still functional.

Result:
OK.

24 CYCLE LIFE

SPECIFICATION FOR SMART VH MODULE

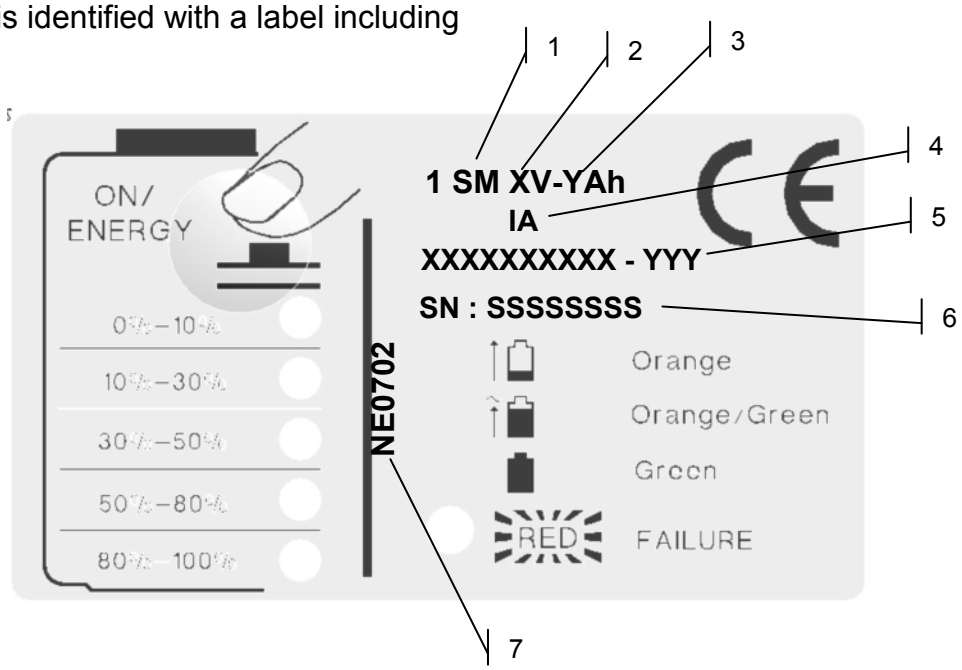
The cycle life of a rechargeable Smart VH Module depends on various parameters such as charge rate, discharge rate, depth of discharge, overcharge, temperature, period of rest between charge and discharge, storage...

The service life of a NiMH battery is warranted 2 years (or 500 cycles) at 20°C ambient temperature, in normal conditions. During this service life, the performance of the battery should remain at a level over 70% of its initial performances.

The Saft warranty specification is available upon request.

25 MARKING

The battery is identified with a label including



1. Product designation : 1 SM = 1 Smart Module
2. Product voltage :12, 24 or 36 volts
3. Product capacity : 9 or 14.5 Ah
4. Circuit max continuous current : 25A or 50A
5. Product P/N : 10 digits, with 3 digits for revision .
6. Serial number : Unique
7. Product manufacturing date code: NE YY WW
   - NE : Manufacturing plant (Nersac, France)
   - YY : Year (07 = 2007, …)
   - WW : Week (23 = Week #23)

Smart VH Module service life starts at this date.

26 QUALITY

1.1 Standard safety

Smart VH Module has been developed to satisfy IEC 61951-2 following our quality system according to ISO 9001 issue 2000 standard.

1.2 CEM approval

Smart VH Module is compliant with :
EN 55014-1 / EN55014-2 / EN61000-6-2 / EN61000-6-3.

1.3 MSDS

Please refer to “Safety Data Sheet Secondary Nickel-Metal Hydride Sealed Cells”. Please contact Saft to get the updated document if needed.

27 FAQ

27.1 How to change the fuses?

In case the fuses are blown it is possible to change them by removing the cover with a screwdriver and then to remove the broken fuses.

Be carefull to use correct fuse as a replacement:

- For 20 and 20 cells batteries, you can use a 32V rated ATO fuse @15A for charge and @30A for discharge, with above specification.
- For 30 cells batteries, please use a 58V rated fuses, @15A for charge and @30A for discharge, with above specification.

27.2 Smart VH Module Failures

Sleep mode (Status LED and gas gauge LEDs OFF):

Major Failure on discharge path if there is nominal voltage between +BAT and –BAT and if battery can deliver current. Stop immediately to use the smart VH module. This failure can happen after having connecting the charge power supply in the reverse way between +BAT and -BAT.

Major Failure on charge path if there is nominal voltage between PS+ and PS- on 8 pins Separate charge and functions connector. Stop immediately to use the smart VH module. This failure can happen after having connecting the charge power supply in the reverse way between PS+ and PS-

Failure if nothing happens when connecting the charging power supply after having checked output voltage of the power supply is 1.5 x battery nominal voltage (+/- 5%).

Failure if nothing happens when activating the Key Switch after having checked Key Switch connection on 8 pin Separate charge and functions connector.

Failure if nothing happens when trying to communicate through BPCI® bus after having checked data connection on 8 pin Separate charge and functions connector.

Failure if nothing happens when pushing the gas gauge button

Discharge mode (Status LED ON):

Failure if discharge is not possible on battery not too hot and not empty (gas gauge indicator > 0%) after having checked discharge fuse and Key Switch if used.

Failure if discharge current is not stopped by the battery at end of discharge.

Charge mode (Status LED ON and charge power supply connected):

Failure if status Led always stays yellow or state of charge indicator does not increase after having checked charge fuse if charge done through PS+ or discharge fuse if charge done through +BAT.

Failure if charge power supply delivers continuously current to the battery during Balancing and trickle charge. During these phases, current must be pulsed: On for some minutes and Off for less than one hour in Balancing phase or Off for some hours in trickle phase.

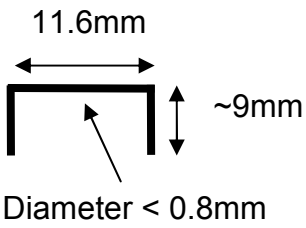
Gas gauge:

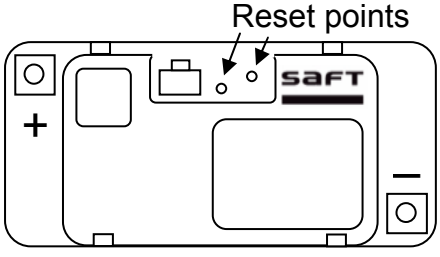
Failure if gas gauge Led's always Off when pushing button
Failure if gas gauge Led's always On when no action on push button and no current goes in or out the battery.

Defect mode:

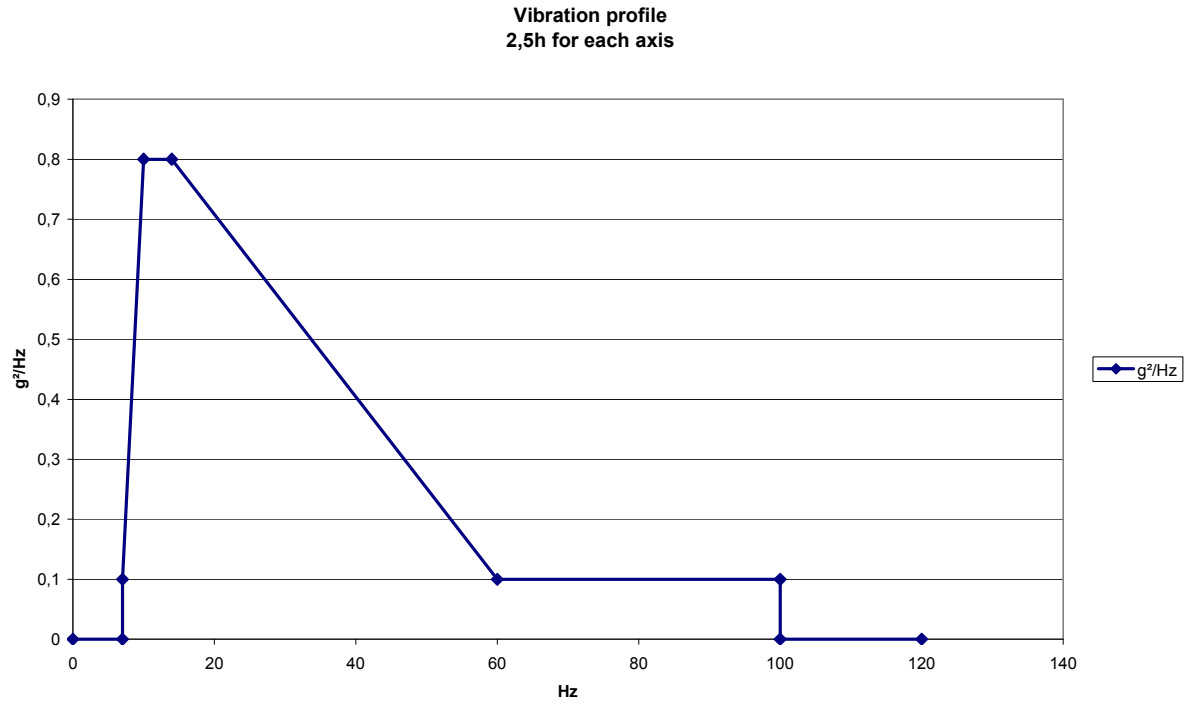
Failure if battery goes again in defect mode after pushing gas gauge button.

In case microcontroller seems blocked, it is possible to reset it by making a strap between the two small holes close to 8 pin Separate charge and functions connector with the special reset tool:





ANNEX 1 : VIBRATION PROFILE

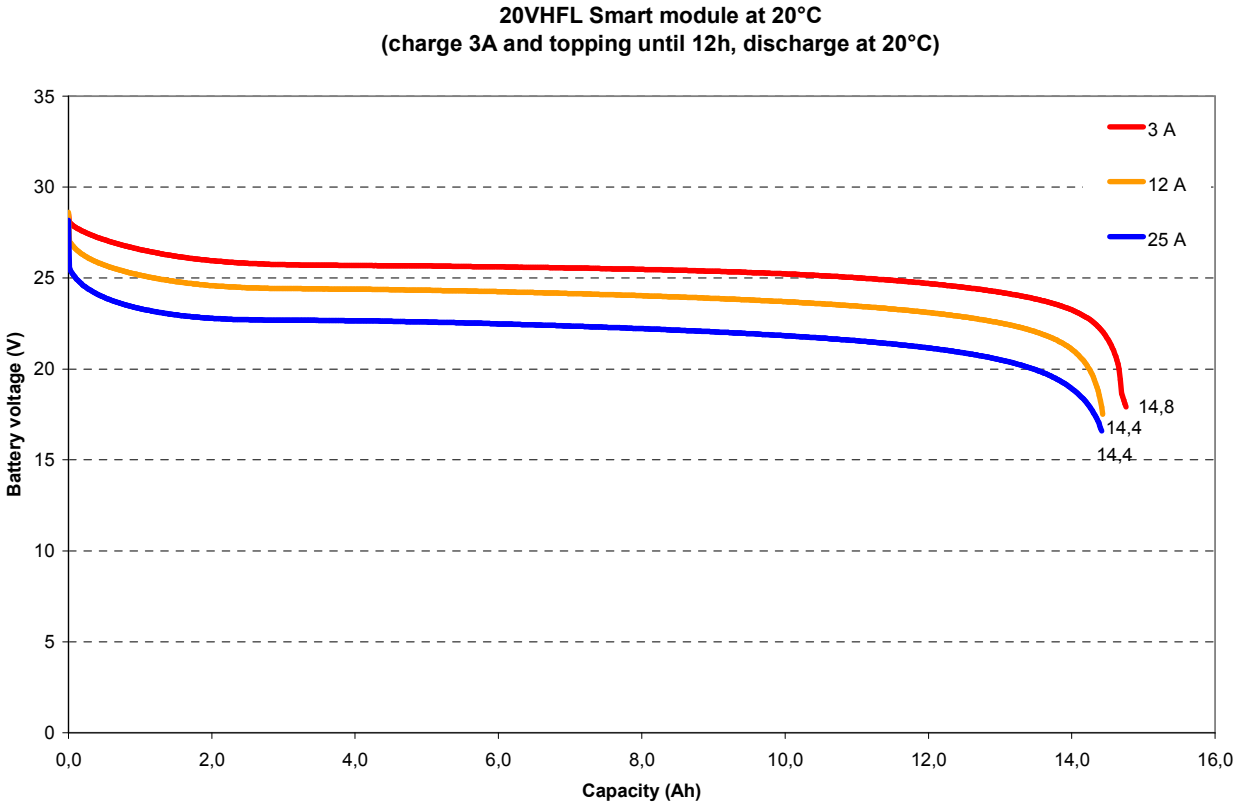


ANNEX 2: CURVES

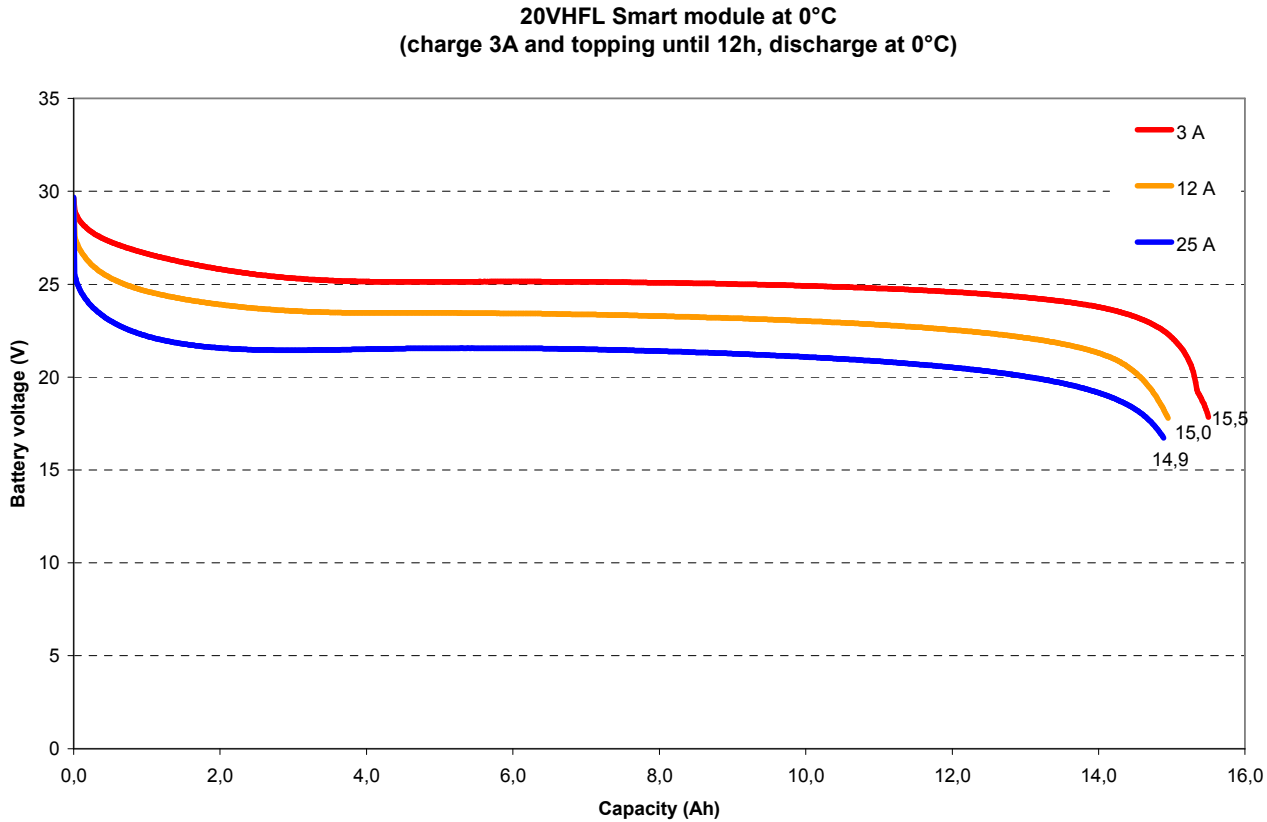
In this chapter, you will find several curves of performances on both 20 VHF and 20 VHD full options fresh Smart VH Module (including charge management, discharge management and gas gauge).

NOTA :Those curves are shown as example only and are not contractual.

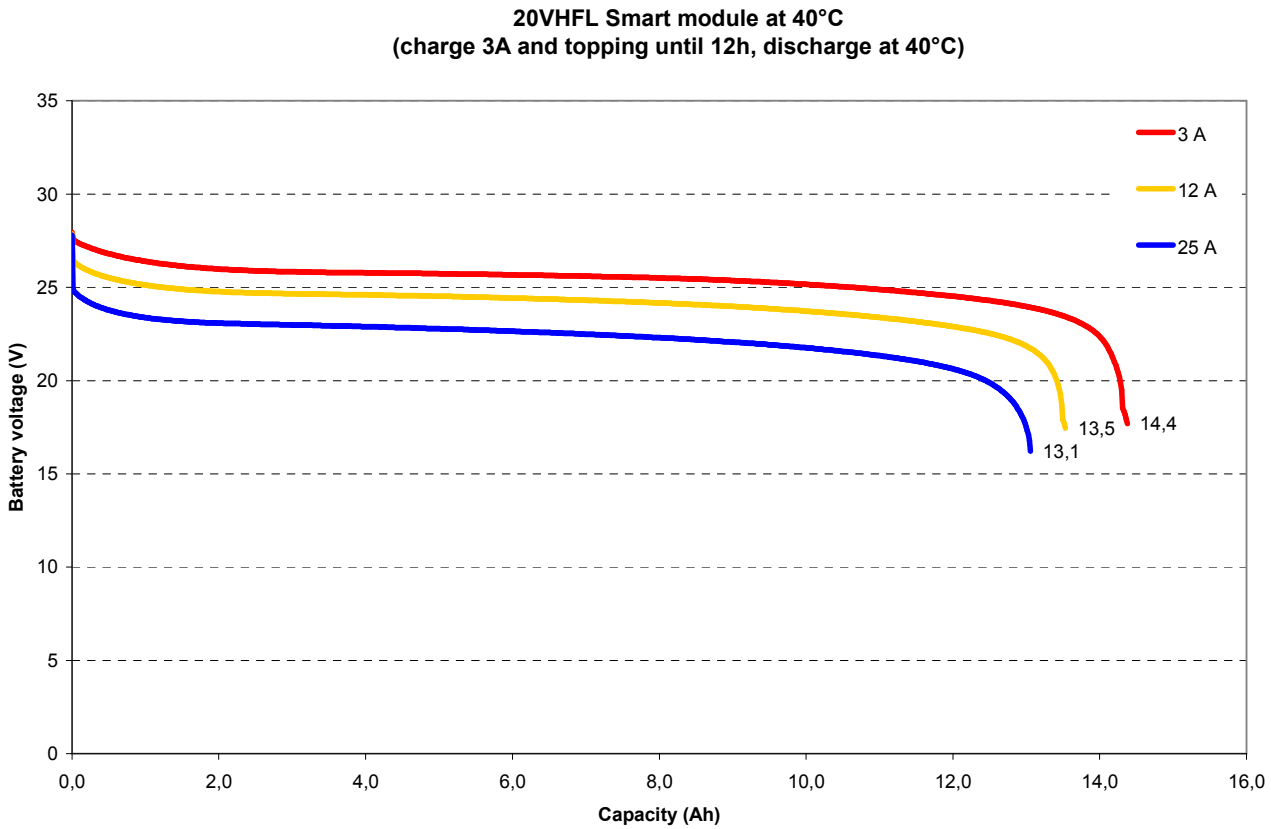
SMART VH MODULE (20 VHF, full options) : Discharge at different rates after standard charge at 20°C



SMART VH MODULE (20 VHF, full options) : Discharge at different rates after standard charge at 0°C



SMART VH MODULE (20 VHF, full options) : Discharge at different rates after standard charge at 40°C



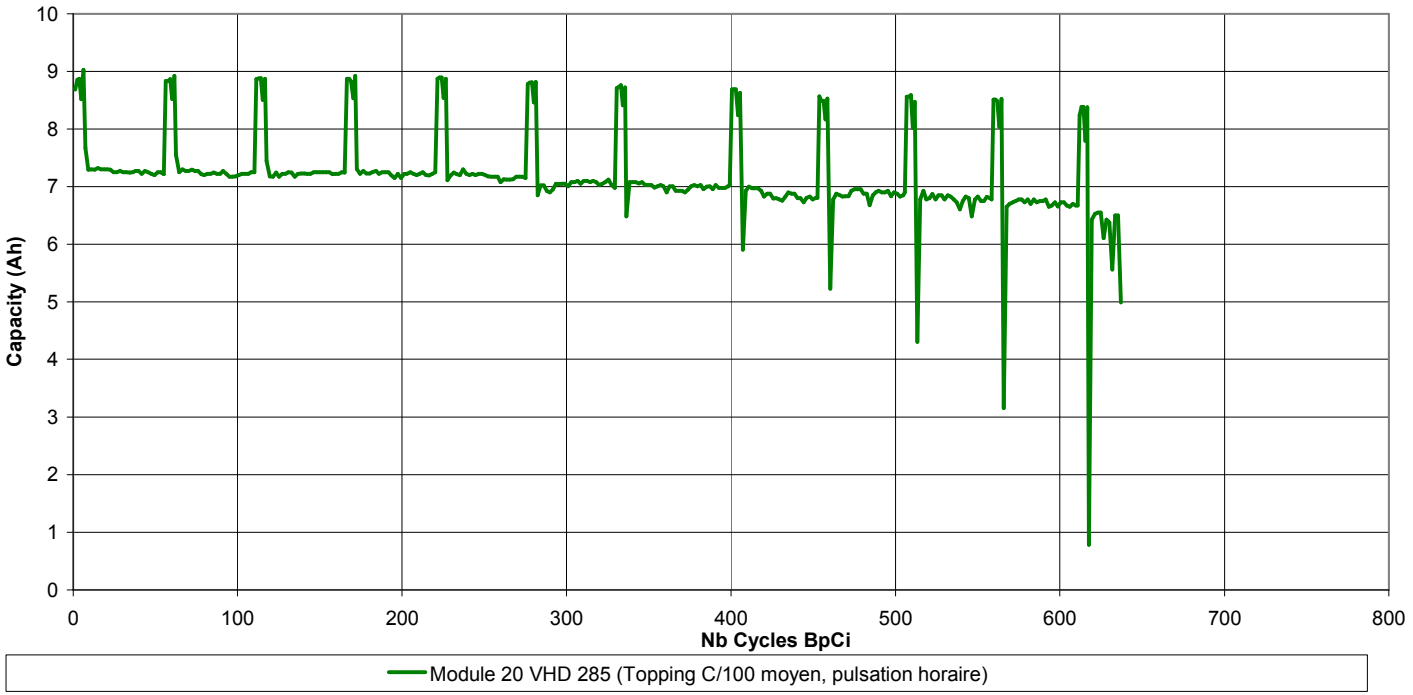
SMART VH MODULE (20 VHD285, full options) : cycling test

06_062

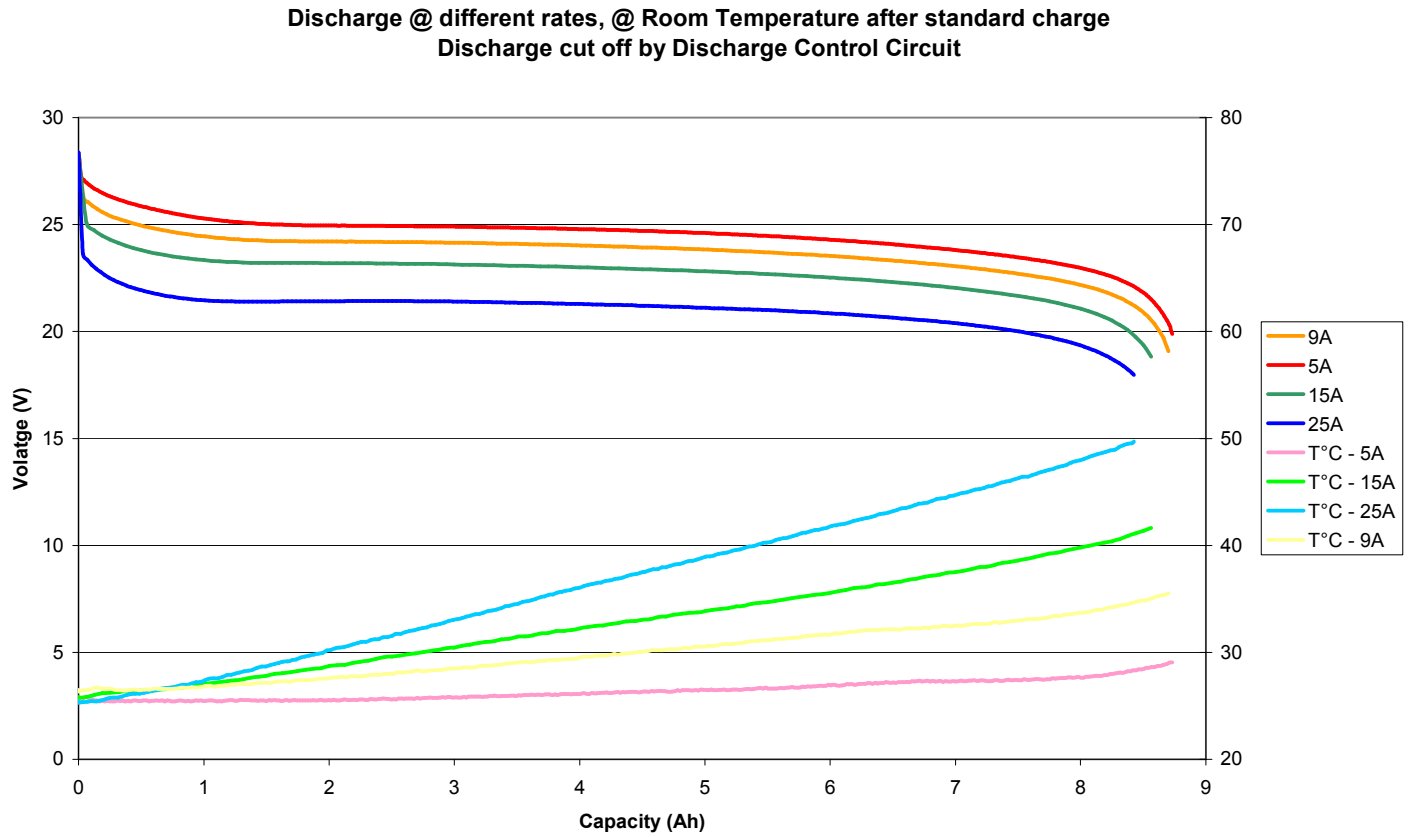
MODULES 20 VHD (285)

MES. DE CAPA.(6 CYCLES) : CHA. 12h MAX / CHARG. DEC. A 3A, R=0(CY. 1,2,3,5), R=24h(CY.4)
CHA. 12h MAX / CHARG, DEC.A 30A, R=0
CYCLA.(X2): CHA. 12h MAX /CHAR., DEC.2h 3A, CHA.1.5h 3A, DEC.3A(BMS)

CAPACITY change

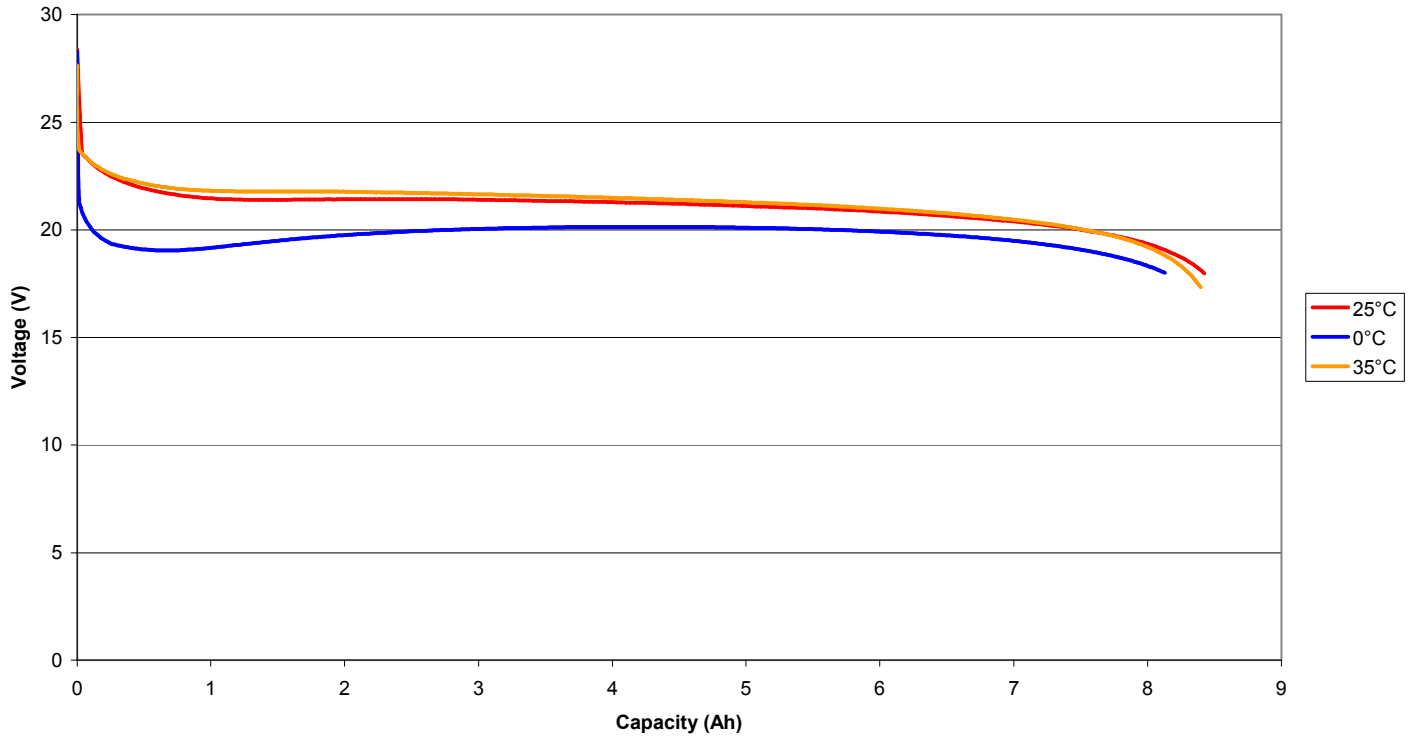


SMART VH MODULE (20 VHD, full options) : Discharge at different rates after standard charge at RT

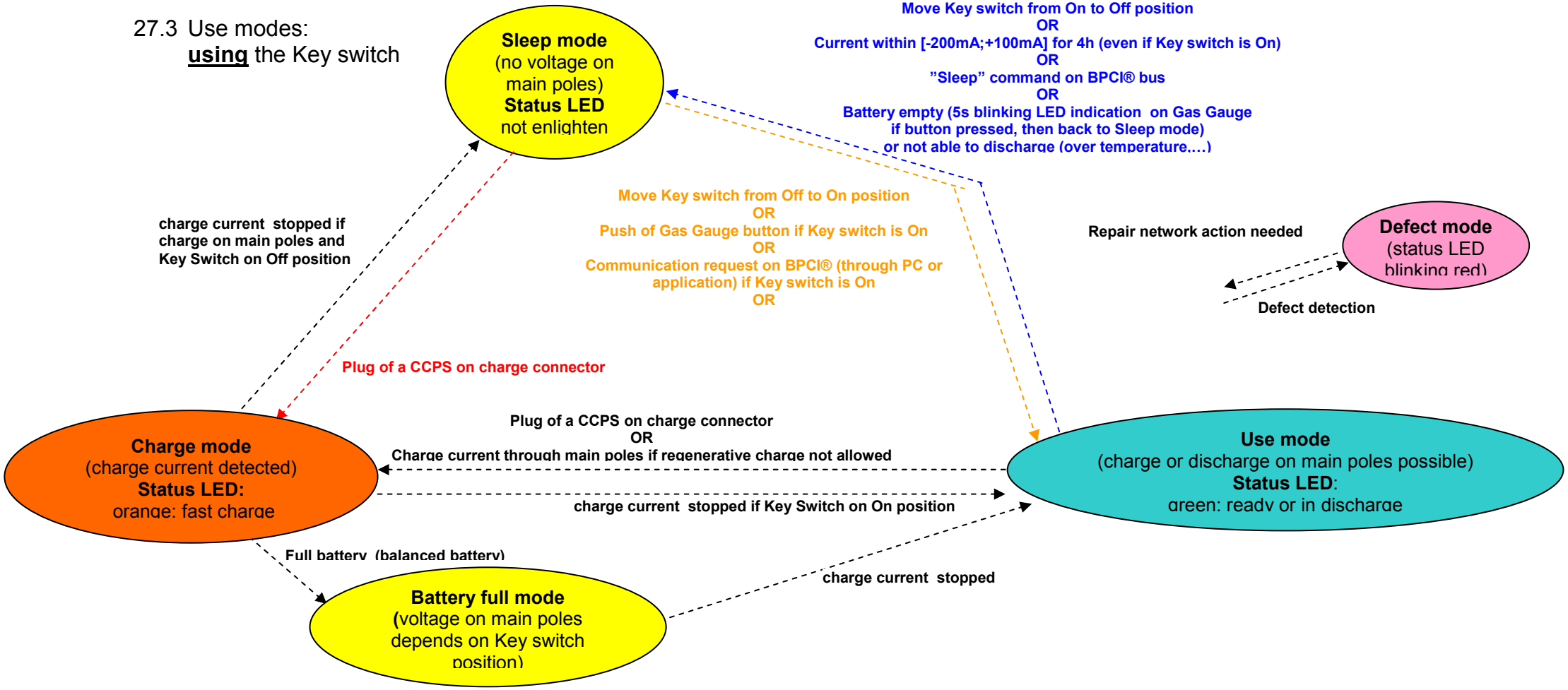


SMART VH MODULE (20 VHD, full options) : Discharge at 25A at Different Temperature , after Standard Charge

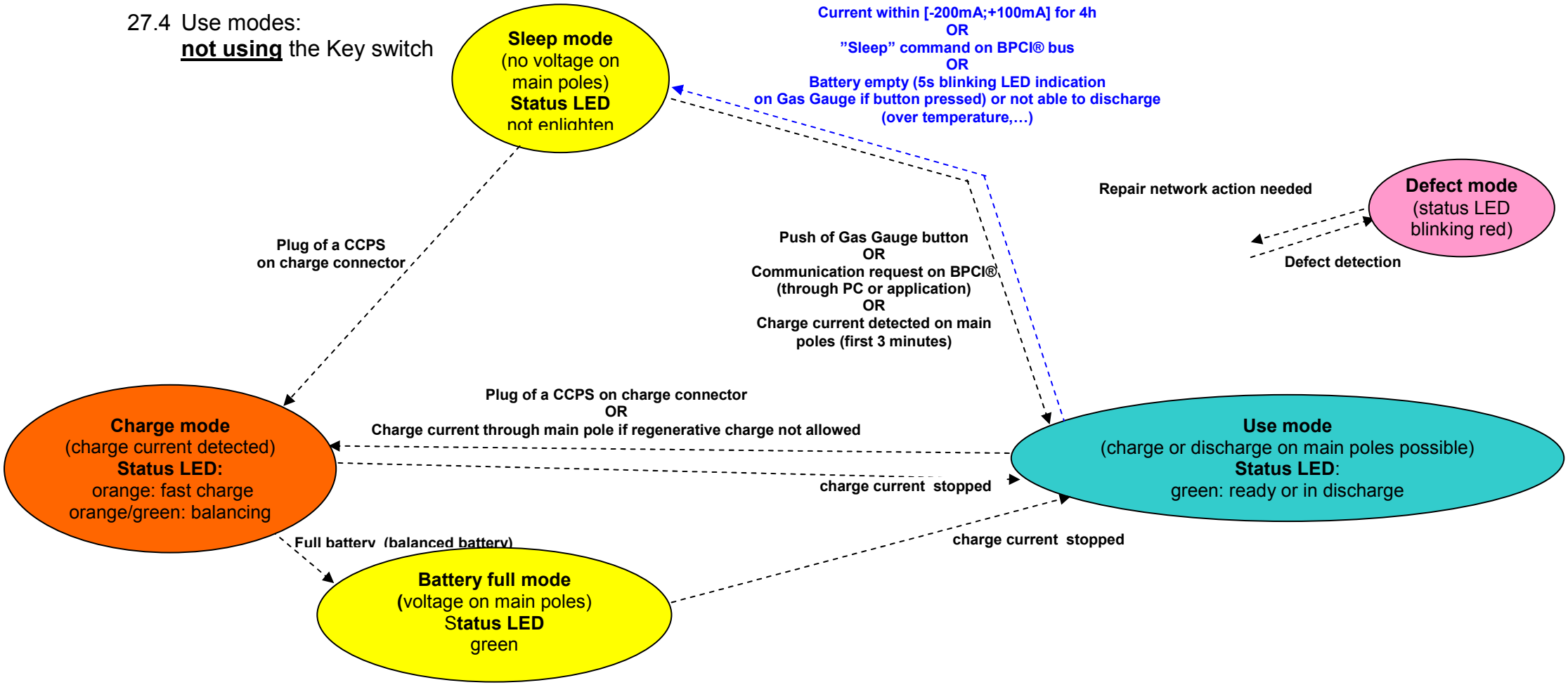
Discharge @ 25A, @ different temperatures, after standard charge
Discharge cut off by Discharge Control Circuit



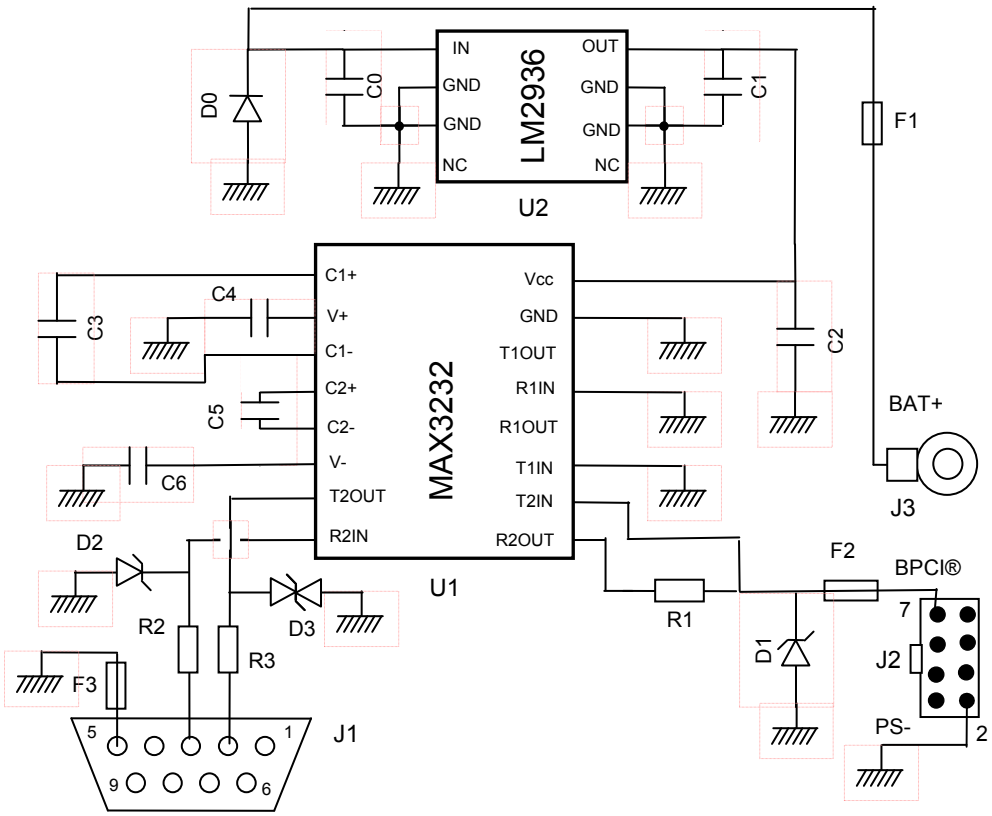
27.3 Use modes:
using the Key switch



27.4 Use modes:
not using the Key switch



ANNEX: BPCI®_Bus to RS232 adaptor



Index	Type	Value	Unit	Characteristics	Qté
R1	Resistor	10	kOhm	1.4W	1
R2*, R3*	Resistor	1	kOhm	1.4W	2
C0	Ceramic capacitor	100	nF	100V	1
C1	Electrolytic capacitor	10	uF	16V	1
C2	Ceramic capacitor	10	nF	50V	1
C3, C4, C5, C6	Ceramic capacitor	100	nF	50V	6
F1*, F2*, F3*	Polyswitch	50	mA	MF-MSMF010 (Bourns) ou PFMF.010.2 (Schurter)	2
D0*	Diode	1	A	S1B ou S1D (Fairchild ou Vishay)	1
D1*	Zener diode	5.6	V	BZD27C5V6 (Philips)	1
D2*	Zener diode	5.6	V	BZX84C5V6 (Philips)	1
D3*	TVS diode bidirectional	10	V	SMAJ10CA (ST ou Vishay)	1
U2	Régulateur	3,3	V	LM2936HVBMA-3.3 (National)	1
U1	Transceiver RS232			MAX3232CSE (Maxim)	1
J1	Connector			Sub_D DB9 sortie femelle	1
J2	Connector + Contacts	MDF6-8DS-3.5C MDF6-2022 SC		Separate charge and functions - 8 points	1 2
J3	Round Tab				1

(*) optional protection components

End of document.