



SMART.IC3

Programming and use manual



	Date	Notes
Issue 1.0	15/04/2018	Official documentation

Introduction

This manual is addressed to technical staff for the installation of SMART.IC3 system.

Please note that it is compulsory following the below indications:

- Read this whole document before starting the installation
- Keep a copy of this document nearby the product.



READ THIS MANUAL BEFORE PERFORMING ANY OPERATION

Before starting any operation, it is mandatory reading this installation manual.

The guarantee of good functioning and the full performance of the monitoring system strictly depend on the proper application of all the instructions contained in this manual.

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1 Description of the product's features

Smart.IC3 is a device designed for the monitoring and control of lead batteries. Its main features are:

- Measurement of instantaneous battery data including voltage, current, available Ah, and temperature. An indication of the available Ah is provided by the LEDs on the panel (§2.3).
- Built-in RTC (Real Time Clock) to build a log of collected the data complete with date and time
- Storage of historical data: it is possible checking the batteries' past activity from a PC using the SmartViewII software, or from WEB or APP (only for products equipped with GSM). The collected data can be shown grouped by working cycle, or gathered by day. For each working cycle, data are displayed both in figures and graphics
- Data downloading on a PC: all the data are sent to the SmartViewII PC program thanks to the connection established through a USB cable
- Statistical analysis. SmartViewII's many functions able to provide statistics in order to check the correct use of the battery and its charge, and to report any anomaly
- Web monitoring: any Internet browser can access WEB application Smart.Lift. It gathers and processes data from Smart.IC3 devices and sends reports relevant to the whole devices' fleet. The WEB application Smart.Lift allows performing deep analysis and planning maintenance activities.
- App monitoring: Smart.Lift App is available for both Apple and Android. It shows the main data relevant to the batteries of the devices' fleet - including any anomaly.
- Analysis of battery efficiency based on the analysis of the data relevant to the functioning gathered during the last weeks.

2 Logics of operation

2.1 Working cycle

A **working cycle** is a sequence including a **discharging phase followed by a charging one**.

A **discharging phase** is a time interval, during which the battery current is negative or zero.

A **charging phase** is an interval, in which the battery current is positive or zero.

Every time a discharging phase is followed by a charging phase, the working-cycle counter is increased.

There is not always a full correspondence between working cycles and cycles counter: a cycle's change is forced in case of power failure or long inactivity after a charge. Another exception occurs when the Opportunity charge option is set (see §2.5 Opportunity charge).

The switch from the discharging to the charging phase takes place after 2 minutes of charging in order to avoid that the presence of a braking-charge recovery device abnormally increases the number of counted cycles. In this case, we talk about energy *recovered during the discharge*: this quantity is counted and displayed as "Recovered Capacity".

During the discharging stage, the "Discharged Capacity" is counted. In addition, two situations which may arise in case of excessive discharge are highlighted: the "**Underdischarge Time**", which indicates when the voltage is below the set "Underdischarge Voltage" (see §3.3), and the "Discharged Capacity Under AhBS", which indicates the capacity used below the threshold of (100-AhBS)% of the nominal battery capacity. During the discharging stage, the "Self-discharged Capacity" and the "Recovered Capacity" are also counted.

Within the charging stage there are a *First Stage, that is*, the charge before reaching the configured "Voltage Threshold 2nd Stage; a *Second Stage, that is*, the charge following the attainment of the "Voltage Threshold 2nd Stage"; and the *Overcharge*, which corresponds to any excess charge over the hypothetical attainment of 109% of the nominal capacity

The screenshot shows the 'OnLine - SmartIC IV3' interface. At the top, there are tabs for Monitor, Info, Recorder, Old Data, OLD Data Info, Diagram, Temperature, Daily, Programming, Associations, and Averages. The 'Info' tab is active, displaying various battery parameters:

- SN: B18IN999994
- CUS: B18IN999994
- RET: (empty)
- USE: (empty)
- BAT: (empty)
- FLT: (empty)
- Rated Voltage (V): 24
- Rated Capacity (Ah): 300
- Charge Controlled By SmartIC: No
- Cycle Number: **13** (highlighted in yellow)
- Warning: **Ah alignment not performed !!!** (highlighted in yellow)

Below this, there are sections for Discharge Data and Charge Data:

- Discharge Data:** Discharge Start: 21/09/18 17:05:52. Discharge Time: 0:00 (hh:mm). Underdischarge Time: 0:00 (hh:mm). Pause Time in Discharge: 0:00 (hh:mm). Number of Discharges: 0. Capacity at Cycle Start: 0 (Ah), 0.0 (%). Discharged Capacity: 0 (Ah), 0.0 (%). Capacity Discharged Under AhBS: 0 (Ah), 0.0 (%). Self discharged Capacity: 0 (Ah), 0.0 (%). Recovered Capacity: 0 (Ah), 0.0 (%). Capacity at Discharge End: 0 (Ah), 0.0 (%).
- Charge Data:** Start Of Charging: 21/09/18 17:05:58. Stages Time: 1st: 0:00, 2nd: 0:00 (hh:mm). Total Charging Time: 0:00 (hh:mm). Pause Time in Charging: 0:00 (hh:mm). Number of Recharges: 0. Capacity at the Start of Charging: 0 (Ah), 0.0 (%). Reinstated Capacity 1st Stage: 0 (Ah), 0.0 (%). Reinstated Capacity 2nd Stage: 0 (Ah), 0.0 (%). Total Reinstated Capacity: 0 (Ah), 0.0 (%). Recharge Increase: 0.0 (%). Total Input Capacity: 0 (Ah), 0.0 (%). Equalization: 0:00 (hh:mm). Capacity in Overcharging: 0 (Ah), 0.0 (%). Overcharging Time: 0:00 (hh:mm). Capacity at End of Cycle: 30 (Ah), 10.0 (%). Maximum Voltage: 0.00 (Volts), 0.00 (V/cv). Maximum Current: 0.0 (A), 0.0 (%). Current at the End of Charging: 0.0 (A), 0.0 (%). SmartIC Maximum Temperature: Internal: 0.0, External: 0.0 (°C).

At the bottom, there are three status sections:

- Failures:** Includes Safety Timer 1st Stage, Safety Ah, Low Battery Efficiency, Low Level Of Battery Electrolyte, Overtemperature, 2nd Stage, Wrong Programming/Relay Failure, Battery Discharged Under AhBS, EEPROM/RTC Failure, and External temperature probe fault (checked).
- Status SmartCB:** Includes Outside Mains Connected, Outside Battery Charger Connected, Forks Lock (checked), Low Battery, Overtemperature, Scheduling, and Anti opportunity charging.
- Charging Status:** Includes End of Charging Ah, Charge 1st Stage, Charge 2nd Stage, Pause, Overcharging, End of Charging Time, Equalizing Charge, Equalizing Charge Pause, Floating Charge, and Incompleted Charge (checked).

SmartViewII: TAB Info OLD

2.2 Anomalies

The SmartIC3 provides information about any anomaly found in the cycle. This information is shown in different platform as described in the table below.

Anomalies	Description	LED Anom.	Smart View	WEB	WEB super user	Mobile APP
Safety Timer 1st Stage	While charging, the battery voltage did not reach the "Voltage Threshold 2nd Stage" by the "Safety Timer 1st Stage" (see §3.3)		x		x	
Safety Timer 2nd Stage	While charging during the 2nd Stage, the battery charge did not reach the nominal capacity by the "Voltage Threshold 2nd Stage" (see §3.3)		x		x	
Safety Ah	While charging, the battery reached 110% of the nominal capacity before reaching the 2nd Stage	x	x	x	x	x
Battery Discharged Under AhBS	While discharging, the battery capacity dropped below the "Battery discharged threshold (AhBS)" (see §3.3)	x	x	x	x	x
Low Battery Efficiency	The battery has been in an under-discharging state for a time \geq "Under-Discharge check" time when the remaining battery capacity is \geq (Nominal capacity - Battery discharged threshold) (see §3.3) (°)		x		x	
Low Level Of Battery Electrolyte	The electrolyte level sensor indicates the electrolyte under the minimum level (*)	x	x	x	x	x
Opportunity charge	A possible misuse for opportunity charge is detected (too many charge/discharge in a few time)	x		x	x	x
Over-temperature or generic fault	The temperature has reached the programmed threshold	x	x		x	
Wrong Programming/Relay Failure	By selecting SmartCB (see §3.3) a charging current is present even though the "Charge Relay" is open		x		x	
EEPROM/RTC Failure	A failure in the memory of the SmartIC device or RTC was detected		x		x	

(°)The "Low Battery Efficiency" anomaly must not be confused with the Battery Efficiency indication provided by SmartService, which is evaluated over a long operational period of the battery and not on single cycles.

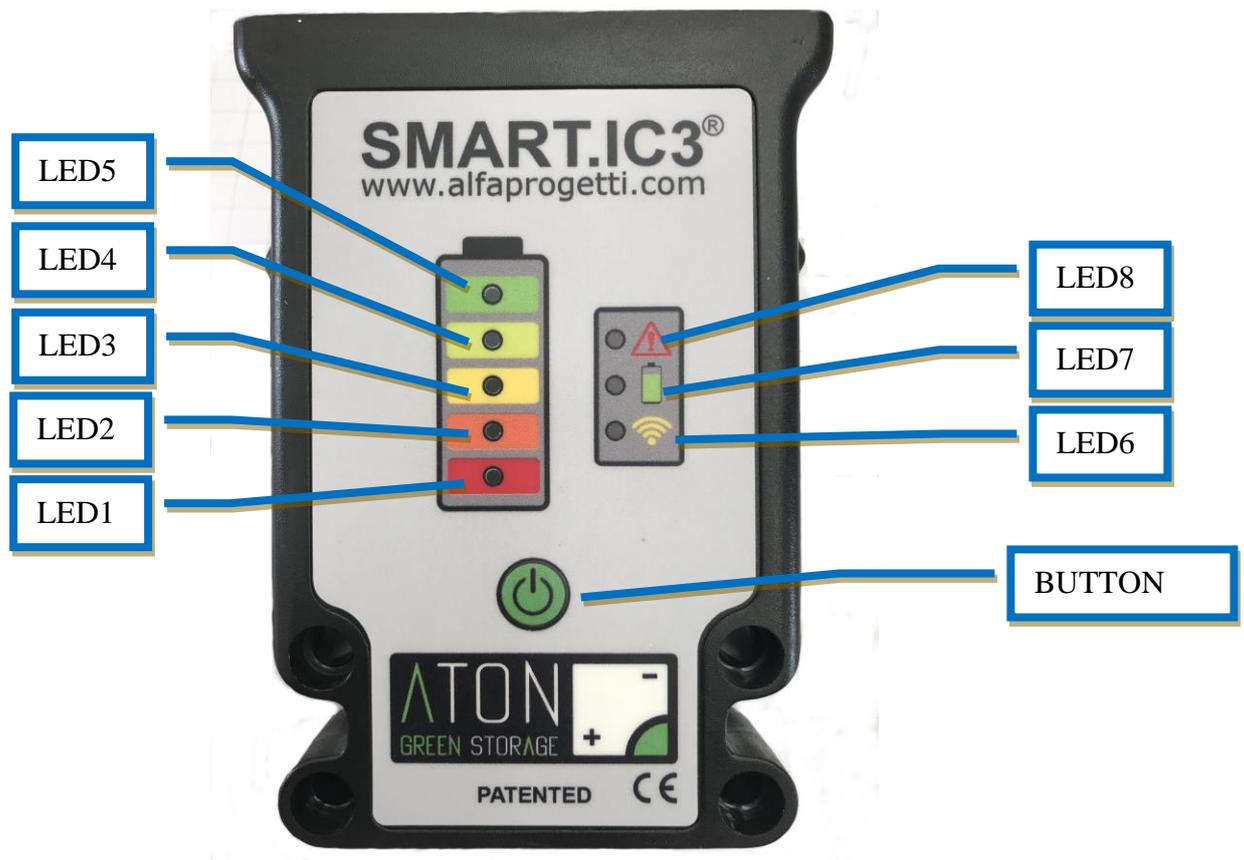
(*)The "Low Level Of Battery Electrolyte" anomaly is indicated by activating the LED anomaly and is reported on SmartView Info TAB for the whole time it is active. However, the anomaly is stored in the Old Data Info TAB.

NOTE: The "Low Level Of Battery Electrolyte" anomaly status appears after the sensor has detected the anomaly for 3 consecutive minutes. The anomaly is deactivated when the sensor detects no anomalies for 10 consecutive seconds. Given that some sensors provide a delayed signal, the actual timing of activation and deactivation of the anomaly depends on the used sensor.

2.3 LED Signals

The LEDs on the unit provide useful information, including the indication of the battery charge and some possible anomalies. LEDs can indicate the following conditions:

LED 1 flashing	Battery capacity 20% lower than of the nominal battery's capacity
LED 1 ON	Battery capacity between 20% and 40% of the battery
LED 1 and 2 ON	Battery capacity between 40% and 60% of the battery
LEDs 1-3 ON	Battery capacity between 60% and 80% of the battery
LEDs 1-4 ON	Battery capacity between 80% and 95% of the battery
LEDs 1-5 ON	Battery capacity not lower than 95% of the battery
Periodic shut OFF of LEDs 5 to Led 1	Discharge current
Periodic turning ON of LEDs 1 to Led 5	Charge current
Led 2 flashing	Forks lock activated due to over temperature, see §2.6
Led 3 flashing	Forks lock activated due to anti-opportunity charge, see §2.6
Led 4 flashing	Forklift Lock activated due to scheduling, see §2.6
Led 5 flashing	Forks Lock activated due to low battery charge, see §2.6
Led 6 (COMUNICATION) flashing	GPRS Communication
Led 7 (2nd STAGE THRESHOLD)	It turns ON when the battery voltage is higher than the "Voltage Threshold 2nd Stage", see §3.3
Led 8 (ALARM) flashing	Auto-start stage
Led 8 (ALARM) ON	Anomaly detected in the current cycle



2.4 Estimate of completed recharge

Thanks to the above-described features, Smart.IC3 can accurately indicate the battery's capacity.

There are two different ways to determine the attainment of a full charge.

According to the first one, the battery is considered as charged after the duration of the charge subsequent to the attainment of the "Threshold Voltage 2nd Stage" has reached the "Safety Timer 2nd Stage" (see §3.3).

According to the second one, the charge is considered as completed when the reintegrated capacity added to the capacity already in the battery when the charge started equals the nominal capacity.

The Default setting provides to choose the Ah method (see §3.3).

NOTE:

The alignment (see §4 Alignment) only occurs after having performed a full time-charge.

2.5 Opportunity charge

The term "Opportunity charge" describes the type of use due to which the battery is repeatedly charged and discharged for short periods and small capacity (as it happens for instance with the AGVs - Automatic Guided Vehicle). In such situations, too many working cycles could cause a rapid depletion of memory and largely illegible data. In such cases, by setting "Opportunity charge" on while programming (§3.3), it is possible reducing the daily number of cycles: when this mode is on, a new cycle is generated only in case of a discharge after the sum of the times of the cycle's charge has exceeded one hour.

2.6 Lock functions

The Smart.IC3 device provides some functions based on the measurement of the battery's physical quantities to inhibit the operation of the forklift and/or lock the forks through the NO (Normally Open) contact of a relay.

Such functions require that the relay contact is wired to a circuit of the forklift that can limit functionalities (for example, the circuit that stops operation when the operator is not seated).

Temperature: if, after a charging stage, the battery's temperature exceeds the set value (see §3.3), the relay's NO contact is opened. The contact automatically closes when temperature lowers by 2° compared to the set threshold.

NOTE: this function requires the installation of an external temperature probe and the setting of the temperature's threshold.

Anti-opportunity charge: after being charged, if the percentage of Ah in the battery is higher than the one set in Anti-opportunity charge (see §3.3), the forklift is enabled for standard use (the NO contact is closed). On the contrary, if the battery capacity drops below the set percentage, use is disallowed (the NO contact remains open). By setting the parameter to 0% (as a default), the function is disabled.

Forks Lock: when discharging, standard operation is allowed (NO contact is closed) until the battery level drops below the (100-Forks Lock)%.

On the contrary, when the capacity drops below this threshold, standard use is not allowed (NO contact is left open).

NOTE: In order to avoid disrupting manoeuvres during a period of intensive use, the lock occurs 30 seconds after the last manoeuvre. The default value of the parameter "Forks Lock" is 80%.

Moreover, the device provides the following lock function to prevent the use of the forklift outside working hours.

The screenshot shows a window titled "POWER SAVING" with a close button (X) in the top right corner. Inside the window is a "Scheduler" section with the heading "Cheapest hours". Below this heading is a table with two columns for start and end times for each day of the week. The start time for Monday is highlighted in blue. At the bottom of the window are "OK" and "Cancel" buttons.

Day	Start Time	End Time
Monday	23:59	23:59
Tuesday	10:00	23:59
Wednesday	16:40	2:39
Thursday	23:59	0:00
Friday	23:59	21:20
Saturday	5:00	21:20
Sunday	0:00	2:39

Forklift Lock: it is possible setting the time (start and end) of the forklift's lock for each day of the week. If the two times coincide, the forklift does not lock. The "Lock Timeout" parameter indicates the downtime before the lock is operational.

2.7 Use of the button

- If -during the discharge phase- the "Forks Lock" mode is reached, by pushing on the button an additional bonus of usable capacity equal to 4% of the nominal capacity is ensured
- If -during a working cycle- the different power points are blocked due to "Anti-opportunity Charge", by pressing on the button it is possible disabling the lock for that cycle
- The repeated pressing of the button within 6 minutes from the feeding forces the amount of Ah in the battery with a 20% increase of the nominal capacity every time the button is pressed (note: it does not perform the alignment). This feature is useful if the "Forks Lock" function is selected in order to allow normal use of the forklift after the installation of Smart.IC2 V3 before the alignment charge is performed.

3 Programming

Once installed, Smart.IC3 needs to get some information in order to properly work.

To this purpose, it is necessary connecting it via USB to a PC equipped with the SmartViewII program for Windows.

NOTE: in case a S3 GPRS device is being programmed, it is possible performing via WEB the below actions by connecting to the Smart.Lift portal and inserting one's own access data.

3.1 Preparation

- Connect the USB micro-cable to the PC's USB port
- Launch SmartViewII
- Insert level 2 Password (Level 1 Password (for user): BETA
Level 2 Password (for the installer): ALFA)

NOTE: Level 1 password only allows viewing the stored data; it does not allow modifying the device's settings.

The above passwords are default's and can be changed any time by pressing the Connection button.

3.2 Date and time setting

- Select the "Programming" TAB
- Press the "Set clock"¹ button
- Select the "Monitor" TAB and check the date and time

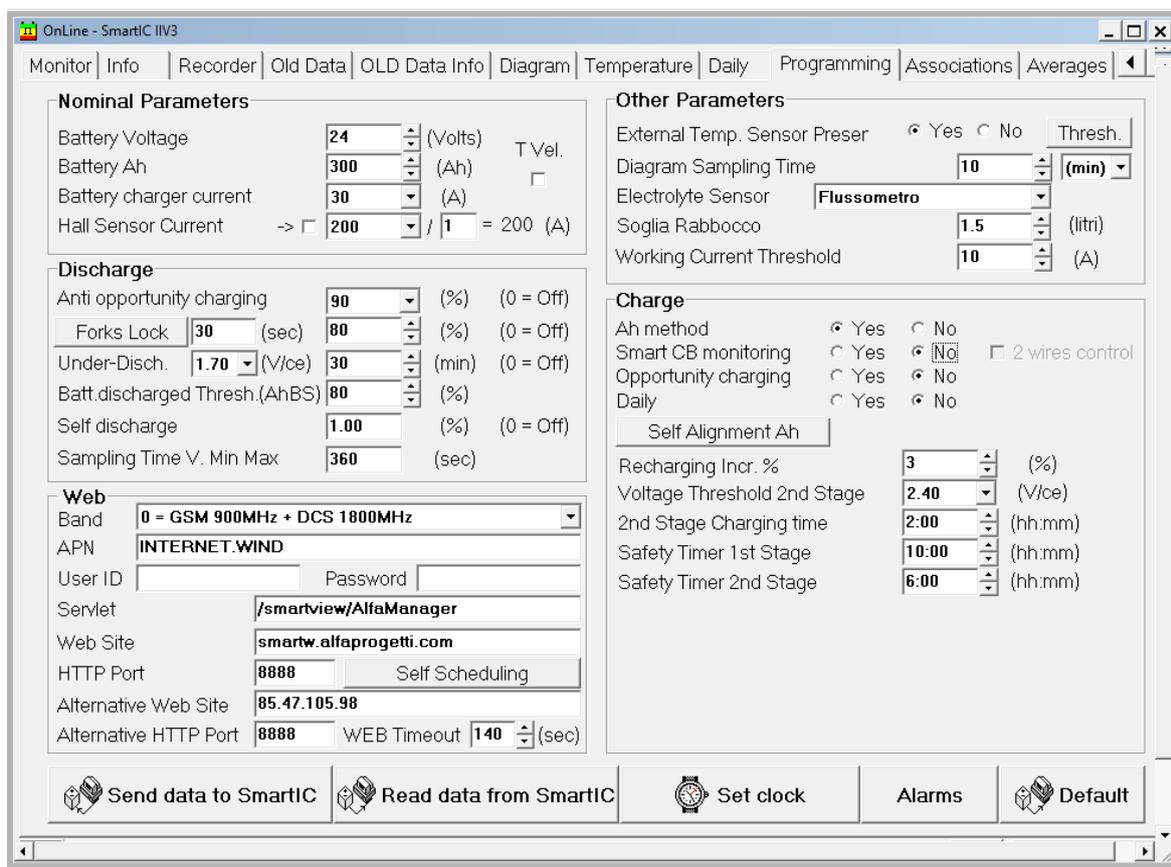
NOTE: if the date and time set in a S3 GPRS device are different from the current ones, Smart.lift web application will automatically update them.

3.3 Programming of operating parameters

The operating parameters allow Smart.IC3 to correctly function during its standard operation. Therefore, they must be filled-in carefully.

NOTE: the operation parameters can be set also before installing the device on the battery.

¹ The process transfers the PC's date and time to Smart.ON: check that the PC data are correctly set
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SmartViewII: programming of operation parameters

- Select the “Programming” TAB
- Fill the following fields:
 - o Battery voltage; Battery Ah
 - o Battery charger Current
 - o Ext. Temp. sensor present (if present)
 - o Electrolyte sensor (if present)

The following table shows a complete list of all the parameters that can be set on the device:

Battery Voltage	Nominal voltage of the battery
Battery Ah	Nominal capacity of the battery
Battery charger current	Nominal current of the battery charger
Hall <u>S</u> ensor Current	Nominal value of the current sensor
Diagram sampling time	Voltage and current log sampling times for graphs (1, .., 127 min / 1, .., 127 sec); (default: 6 min) NOTE: If expressed in seconds, the duration of cycles will be one hour at most
External Temp. Sensor Present	External temperature sensor selection
Electrolyte Sensor	Input and operation of electrolyte level sensor selection
Operation current threshold	Current threshold above which the operation time is counted (default 10A)
Anti-opportunity charge	Forks lock setting for anti-opportunity charge. See §2.6
Forklift Lock	Forks lock setting for low battery charge. See §2.6
Forklift Lock	Forklift Lock schedule setup button. See §2.6
Under-Discharge	If the voltage is below the specified value (V/el) for the specified time (minutes), the capacity is forced to (100-AhBS)% of the nominal capacity Ah Battery if greater than said value (default: 1.70 V/el, 30 minutes)

Battery-discharged threshold (AhBS)	If discharged below (100-AhBS)% of the nominal capacity, the battery is indicated as discharged (default 80%)
Self-discharge	Self-discharged capacity every 24 hours (default: 1%)
Ah method	Charging mode selection: capacity (Yes) or time (No) (default: YES)
Smart CB monitoring	Battery charger selection: SmartCB/SmartEnergy
Opportunity charge	Select the scheduled counting of working cycles (default: No)
Self-alignment Ah	Access button to set the Self alignment parameters
Recharging Incr. %	Percentage of energy dissipated during charging stage
Voltage Threshold 2nd Stage	Gas-production voltage threshold. It determines the transition from the first to the second charging stage and related counts (default: 2.40 V/el)
2nd Stage Charging time	Time after exceeding the Voltage Threshold 2nd Stage to end the charge for timed recharges and in the alignment cycle (default: 2:00 hours)
Safety time 1st Stage	If the voltage has not reached the Voltage Threshold 2nd Stage within this time period, an alarm is generated (default: 10:00 hours)
Safety timer 2nd Stage	If the capacity has not reached the nominal value within this time period starting from the achievement of the Voltage Threshold 2nd Stage, an alarm is generated (default: 6:00 hours)
Auto-start	Auto-start time selection (only available when SmartCB is selected)
Setup	Button to select the daily autostart schedule if the energy savings function is enabled (only available when SmartCB is selected)
Band	GPRS module operating band
APN	APN Code of the GPRS network chosen
User ID	User ID of the GPRS network chosen
Password	Password of the GPRS network chosen
Servlet	WEB application
Web Site	WEB application address
HTTP Port	GPRS Gateway
Self-scheduling	Access button to set the Auto Scheduling parameters
Alternative Web Site	WEB application alternative address
Alternative HTTP Port	Alternative GPRS Gateway
WEB Timeout	Auto disconnect time on no GPRS link

NOTE: The "Self-alignment Ah function" automatically corrects the indication representing the charge available in the battery (Ah). The configurable parameters indicate the threshold, beyond which the correction is performed, the maximum possible alignment, and the number of samples on which the "Self-Alignment" is based. The "Self-Alignment" is allowed only if the alignment has already been performed (see §4 Alignment).

Default parameters:

Alignment Threshold	10%
Max Alignment	10%
Num. of Samples	8

The screenshot shows a software window titled "SELF ALIGNMENT" with a standard Windows-style title bar (minimize, maximize, close buttons). The window is divided into two main sections: "Self Alignment Programming" and "SOC".

Self Alignment Programming

Alignment Thresh.	10	(% Ah Nom)
Max Alignment	10	(% Ah Nom)
Num. of Samples	8	
t0	1.96	(V/cel)
t100	2.18	(V/cel)
Disch. time window	3	(min/10)
Rechar. time window	12	(min/10)
Delta Ah	10	(% Ah Nom)
Delta V/cel	4	(mV/cel)

SOC

0

Date/Time	00/00/00 00:00:00	
Cycle	65535	
Ah	65535	(Ah)
Cell voltage	3.05	(V/cel)
Delta soc	-1	(%Ah Nom)

At the bottom of the window, there are two buttons: "OK" (with a green checkmark icon) and "Cancel" (with a red X icon).

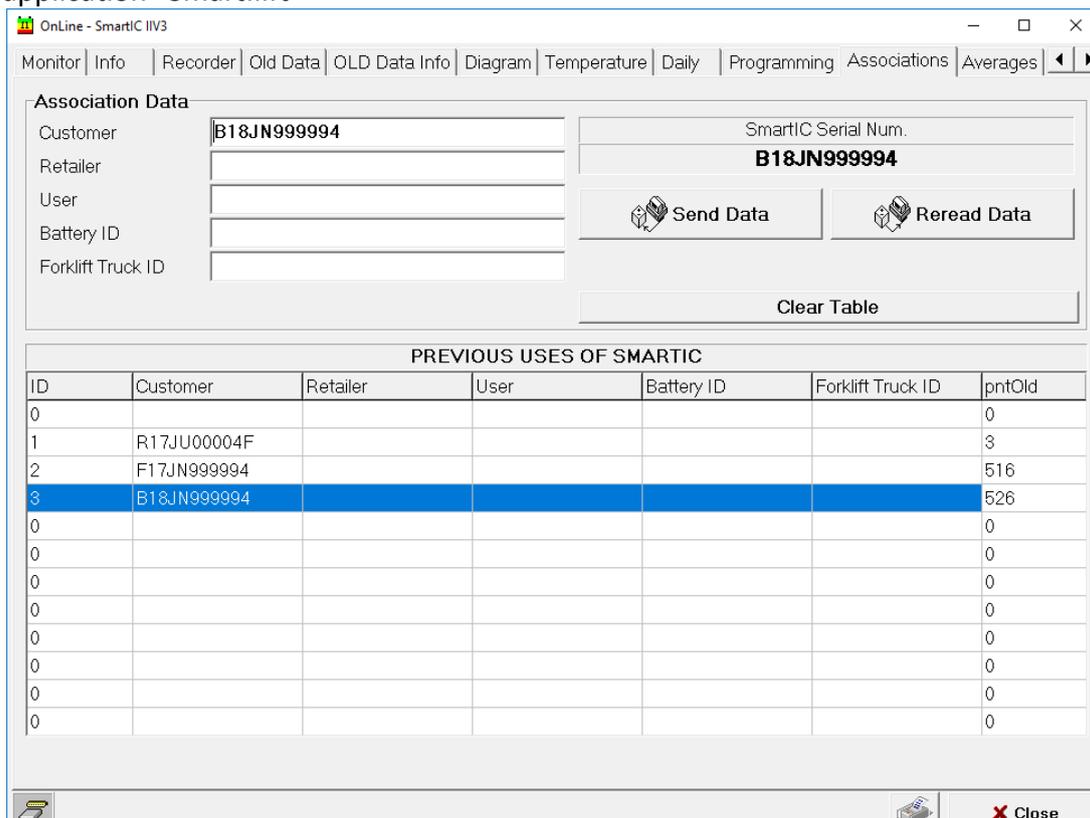
Press the "Send data to SmartIC" button to make the changes effective.

3.4 Programming of associations

Associations are mnemonic parameters, to which working cycles and diagrams collected by Smart.IC3 during standard operation refer. Every time cycles and diagrams are downloaded onto a PC, they can be identified and selected thanks to the association's parameters.

NOTES:

- Associations' parameters are optional and it is not compulsory inserting them. In case they are filled-in, it is necessary to carefully choose both names and codes and to avoid using the same parameters for different devices.
- Associations' parameters are not used if Smart.IC3's data are accessed through WEB application "Smart.lift"



SmartViewII: programming of associations

- Select "Associations" TAB
- Fill in the following fields:

Customer	Text identifying customer
Retailer	Text identifying dealer
User	Text identifying user
Battery ID	Text identifying battery serial number
Forklift Truck ID	Text identifying forklift truck serial number

Press the "Send Data" button and check that the table below shows a new line displaying the inserted parameters.

NOTE: the programming of associations can be performed also before installing the device on the battery.

4 Alignment

In order to make Smart.IC3 fully operational and to allow it collecting and supplying all the data, it is necessary supplying information on the battery's state of charge. This action is called ALIGNMENT and must be performed only once, after having connected the device to the battery. During the standard operation, the Smart.IC3 device keeps aligned by measuring and counting the inbound and outbound charge of the battery.

The alignment procedure involves the execution of a traditional full charge, that is:

- The battery voltage reaches the value indicated in the configured "Voltage Threshold 2nd Stage" parameter (default: 2.4V/eI)
- The charge continues after reaching this voltage for a period not shorter than that established with the configured "2nd Stage Charging Time" parameter (default: 2 hours).

After the alignment procedure is finished, all the LEDs are lit in the Battery mimic panel to indicate that the battery is fully charged.

It is advised to perform the alignment procedure when the battery is not fully charged.

IMPORTANT: it is usually very simple performing the alignment process; it is actually enough recharging the battery with a conventional battery charger. However, sometimes the recharge according to the above-mentioned conditions is not performed due to many causes, among which:

- The battery is already charged and the battery charger performs a too-short charge
- The battery voltage does not reach the set "Voltage Threshold 2nd Stage" (this happens, for instance, for gel battery chargers)
- The battery charger has a particular charging curve.

In such cases, it is possible changing the "Voltage Threshold 2nd Stage" and/or "2nd Stage Charging Time" parameters by reducing their values in order to ease the alignment achievement. However, it is advisable not to deviate much from the default values as to avoid providing Smart.IC3 any incorrect information about the battery's real status

NOTE: as long as the Smart.IC3 is not aligned

- The red LED indicating low battery flashes (unless the battery's capacity has been forced using the procedure described at §2.7)
- With SmartView:
 - In the TAB Monitor, the battery-charge status is replaced by the message "Ah Alignment not performed"
 - In the OLD Data info TAB the graphic representation of the cycle is replaced by the message "Ah Alignment not performed!!!"
 - There are no other references to the battery charge.

Even when Smart.IC3 is not aligned, all parameters measured during the cycle (voltages, currents, temperatures, date, and time) and the graphs are logged.

NOTE: The alignment procedure must be repeated every time Smart.IC3 is disconnected from the power supply for more than 1 min.

5 Specifications

The tables below shows some useful technical features:

STORABLE DATA:

Storable working cycles	400
Storable graph data	12,000 samples (equal to 50 days with sampling every 6 minutes)
Storable daily data	The unit stores the working data relevant to the previous 30 days

FIELD OF OPERATION:

Current size T200	batteries from 100 to 340Ah
Current size T400	batteries from 350Ah to 740Ah
Current size T800	batteries from 750 to 1500Ah

ELECTRICAL SPECIFICATIONS

Supply Min/max	18V - 144V
Average power consumption	S3 < 1.5W; S3GPRS < 2W
Protection from internal breakdown	Fuse on the power input
Contact Relay	2A @ 30Vdc (Vmax = 50Vdc/Vac)
Operating temperature	-20°C to +50°C

PHYSICAL SPECIFICATIONS

Size (external dimensions)	100mm x 60mm x 142mm
Overall antenna connector (min)	60mm
Weight	350g
Degree of protection	IP 42