UNIVERSAL CHARGER

Firmware User Manual

www.seven-segments.com

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1. Introduction

Aim of this document is to create a reference for the UNIVERSAL CHARGER calibration and usage.

This manual is divided in three main sections:

1. Menu structure
2. First power ON
3. On-the-field usage

The user interface is very simple and all the operations can be done via a 4 keys keyboard. The messages for the user are displayed in the 16 characters by 2 lines LCD display.

In this manual the four keys are represented in this way:

+	is the UP/+ key
-	is the DOWN/- key
OK	is the NEXT/OK key
BRK	is the BREAK key

This is the representation for the display (16x2) characters:

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.seven-segments.
www.          .com
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To have more detail about the Universal Charger please refer to the following documents:

1. Universal Charger – Firmware User Manual (this document)
2. Universal Charger – Technical Description
3. Universal Charger – General Manager SW
4. Universal Charger – Display SW

2. Universal Charger menu structure

The Universal charger (or shortly "the charger") user interface structure is based on the concept of the "Battery pack profiles". A battery pack profile (or shortly "a profile") is the the bundle of all the characteristics that defines a particular battery pack: for example the chemistry, the number of cells, the pack capacity and so on.

The charger user interfaces is devoted to manage the battery profiles. Up to 12 different, user defined, battery profiles can be stored and managed inside the charger, allowing the user for an easy and fast charge and discharge of up to 12 different battery solution.

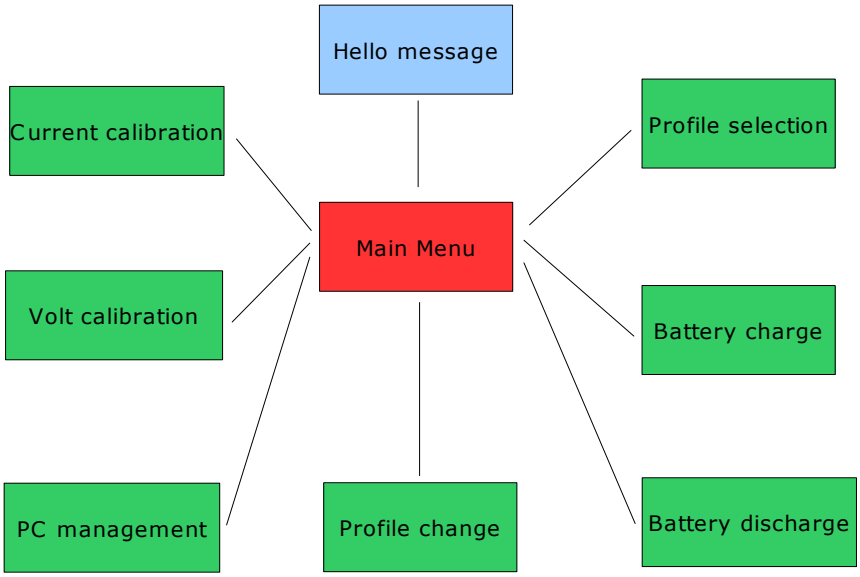
A profile, within the charger can be selected from the list of the 12: once selected all the successive actions are performed on this profile. The three actions that the user can perform on the selected profile is the charge (battery pack charge) the discharge (battery pack discharge) or modify (profile modify).

The remaining functions are not directly related to the profiles management but are relevant to the complete charger: The PC management allows the user to read and write all the profiles and the general charger settings. The PC (via serial port) can manage all the parameters inside the charger, included the "advanced" ones that are not editable directly via the charger.

Important: The editing of the "advanced parameters" (with the **Universal Charger – General Manager SW**.) is intended **only** for expert users: wrong values on these parameters can bring to the battery pack or charger damage. The "normal" users can charge and discharge safely the battery packs without the need to change the "advanced parameters".

The last function is the charger calibration (for voltage and current) for an easy adapting to the user hardware, without external programs or firmware recompilations.

The Universal Charger menu structure is detailed in the following table:



3. Universal Charger first power ON

At the first power ON (after the microcontroller programming) the charger will display (for a few instants) the following message:

Initializing...	-	No action.
	+	No action.
	OK	No action.

Important: do not remove the power supply during the internal state initializing. The power loss in this phase could cause the internal variable corruption with a wrong charger functionning. In this case the microcontroller should be re-programmed or the charger forced to a new initialization using the PC program that allows the editing of the "advanced parameters".

After the first power ON the user must calibrate the charger in order to correctly read the volt and ampere during the charge/discharge process. Please note that using a non-calibrated charger will potentially damage the battery packs connected to the charger.

Please go to the calibration function description for more details.

Note. The internal (non-volatile) settings can be reloaded to its default values using the PC program that allows the editing of the "advanced parameters" - the **Universal Charger – General Manager SW**.

4. Universal Charger on-the-field usage

The charger usage can be explained using the messages displayed and/or the keys that can be used to make the different choices:

Important:

BRK	Pressing (at any moment) the "break" key will force the charger to restart from the "hello" menu, giving an effective reset to the microcontroller. Use this feature as "emergency stop" or to break an unwanted action.

"Hello" message

The first message (together a short sound from the speaker, the "hello beep") that appear on the display is the "hello" message:

.seven-segments. www. .com	+ - OK	The charger will start showing the "hello" message on the display. The user can abort this visualization pressing any key. Pressing any key during the "hello" message will abort an eventual suspended action. During a charge or discharge a particular flag is stored within the charger to "remember" in case of power loss (or user "break") the last performed action: at the end of the "hello message" displaying the charger reads this flag and try to complete the suspended action. If the user hit any key, this process is skipped and the charger goes to the main menu.

Note: The user can customize this message using the PC program that allows the editing of the "advanced parameters".

Note: The user can customize the frequency of the "hello" beep (and of all the other sounds produced at the end of charge and discharge processes) using the PC program that allows the editing of the "advanced parameters" - the **Universal Charger – General Manager SW**.

Main menu

The first message (together a short sound from the speaker, the "hello beep") that appear on the display is the "hello" message:

Task select: **Profile select**	-	No action
	+	Go to the next function of the menu.
	OK	Go to the selection of the battery profile. The user can select from a list of 12 different profiles. The names of the profiles are automatically generated. The user can select a profile for charge, discharge or editing.

Task select: **Batt. charge**	-	Go to the previous function of the menu.
	+	Go to the next function of the menu.
	OK	Go to the charge of the battery pack using the profile previously selected.

Task select: **Batt. discharge**	-	Go to the previous function of the menu.
	+	Go to the next function of the menu.
	OK	Go to the discharge of the battery pack using the profile previously selected.

Task select: Profile change	-	Go to the previous function of the menu.
	+	Go to the next function of the menu.
	OK	Go to the editing of the selected profile.

Task select: PC management	-	Go to the previous function of the menu.
	+	Go to the next function of the menu.
	OK	Go to the serial communication with PC for charger and profiles general management.

Task select: Volt calibr.	-	Go to the previous function of the menu.
	+	Go to the next function of the menu.
	OK	Go to the calibration of the charger. This function helps the user to easily calibrate the charger for accurate voltage reading.

Task select: Ampere calibr.	-	Go to the previous function of the menu.
	+	No action.
	OK	Go to the calibration of the charger. This function helps the user to easily calibrate the charger for accurate current reading.

Profile selection

The profile selection is a function that allows the user for viewing all the profiles stared in the charger and to select a particular profile for battery charging, discharging or to edit the profile itself.

Pack# 1:LiPo x 2 K 2000C 1.0D 4.0	-	Display the previous battery profile. The first profile is the number 1.
	+	Display the next battery profile. The last profile is the number 12.
	OK	Select the displayed battery profile. The user must select the profile for charge, discharge or editing.

This name is automatically generated by the charger when the user edit the battery profile. The meaning of the automatic generated name is the following:

String	Values	Meaning
Pack# 1	1 .. 12	Display the number of the battery profile, from 1 to 12
LiPo	NiCd, NiMh, LiPo, SLA	Display the type (chemistry) of the battery
x 2	1 .. 19	Display the number of batteries in series within the pack. For the batteries that allows to be parallelized (LiPo and SLA) this is the number of series elements. For the LiPo convention that marks the packs with XSYP this is the X value. Example: for a 7.4V LiPo battery pack marked: 2S1P 2000mAh, 1C/10C the right value to be displayed in this field is "2".
K 2000	100 .. 25500	Display the pack capacity expressed in mAh. For the batteries that allows to be parallelized (LiPo and SLA) this is the capacity of series elements. Example: for a 7.4V LiPo battery pack marked: 2S1P 2000mAh, 1C/10C the right value to be displayed in this field is "2000".
C 1.0	0.1 .. 25.5	Display the charge current for the battery profile, expressed as multiplier for the capacity. In this case the multiplier 1.0 will be applied to the value of 2000 (capacity) giving a charge current of 2.0 Ampere. Example: for a 7.4V LiPo battery pack marked: 2S1P 2000mAh, 1C/10C the **maximum** value displayed in this field can be "C 1.0".

		Important: please read carefully the battery instruction before setting of this value. Very few batteries allows to be charged at a rate greater than 1C.
D 4.0	0.1 .. 25.5	Display the discharge current for the battery profile, expressed as multiplier for the capacity. In this case the multiplier 4.0 will be applied to the value of 2000 (capacity) giving a discharge current of 8.0 Ampere. Example: for a 7.4V LiPo battery pack marked: 2S1P 2000mAh, 1C/10C the **maximum** value displayed in this field can be "D10.0". **Important: please read carefully the battery instruction before setting of this value. Setting a value greater than the maximum allowed can cause battery overheating and/or damage.**

Note: The charger has an internal parameter that limit the maximum charge current delivered to a battery pack. The maximum charge current depends on power supply used, on type of mosfet, on heat sink connected and is different for the different hardware implementations. It is user responsibility to set an appropriate value for this parameter. The default value limit the charge current to **5 Ampere**, but the user can customize this value using the PC program that allows the editing of the "advanced parameters" - the **Universal Charger – General Manager SW**.

Note: The charger has an internal parameter that limit the maximum discharge current sunk from a battery pack. The maximum discharge current depends on type of mosfet, on heat sink connected and is different for the different hardware implementations. It is user responsibility to set an appropriate value for this parameter. The default value limit the charge current to **20 Ampere**, but the user can customize this value using the PC program that allows the editing of the "advanced parameters" - the **Universal Charger – General Manager SW**.

Battery charge

The "battery charge" function charges and monitor the progress of the battery pack charge. When the charger start this operation switches ON the fan cooler in order to dissipate the heat generated by the mosfets.

The first step is the autocalibration of the current pickup, done during the display of this message:

Initializing...	-	No action.
	+	No action.
	OK	No action.

After a few seconds the charge process will start

Chrg.LiPo 5.49A 12.345V 2690mAh	-	No action.
	+	No action.
	OK	Terminates the charging process.

The meaning of the displayed fields is the following:

String	Values	Meaning
Chrg	-	"Charge" of the battery pack.
LiPo	NiCd, NiMh, LiPo, SLA	Display the type (chemistry) of the battery: NiCd: **Ni**ckel **Ca**dmium NiMh: **Ni**ckel **M**etal **h**ydride LiPo: **Li**thium **Po**lymer SLA: **S**ealed **L**ead **A**cid
5.49A	0.0 ... 65.53	Display the actual charge current, in Ampere, with a resolution of 0.01 Ampere (10mA).
12.345V	0.000 ... 65.535	Display the actual battery pack voltage, in Volt, with a resolution of 0.001 Volt (1mV).

2690mAh	0 .. 65535	Display the actual battery charged capacity, in mAh, with a resolution of 1mAh.

Note: The charger has an internal parameter that limit the maximum charge current delivered to a battery pack. The maximum charge current depends on power supply used, on type of mosfet, on heat sink connected and is different for the different hardware implementations. It is user responsibility to set an appropriate value for this parameter. The default value limit the charge current to **5 Ampere**, but the user can customize this value using the PC program that allows the editing of the "advanced parameters" - the **Universal Charger – General Manager SW**.

At the end of the charge process the speaker will produce 3 "beep" and the display will look in this way:

Chrg.End! . 0A 12.345V 2690mAh	-	No action.
	+	No action.
	OK	Switch off the fan cooler and return to the main menu.

On the display will remain the battery voltage and the total amount of capacity charged. The fan remains ON during this phase, allowing for an efficient heatsink cooling. Pressing the "OK" key the charger will return to the main menu.

The charge will finish at the reaching of one of these conditions: (the displayed message is always the same)

Type of finish	Battery type	Remarks
Standard	NiMh and NiCd	This charge is performed always at costant current. The charger, after an initial inhibition period, records the peak voltage of the battery pack and compare this value to the actual battery pack voltage. This value is often named "Delta peak". If the delta peak becomes greater than a defined value, the charge ends. The initial inhibition period is fixed by default at **5 minutes**. The delta peak is fixed by default at **5mV/cell** for NiMh and **10mv/cell** for NiCd. These values can be modified (for each profile) using the PC program that allows the editing of the "advanced parameters".

	LiPo and SLA	The charger in a first phase will force a costant current into the battery pack until the reaching of a predefined threshold (**4.200V/cell** for LiPo and **2.500V/cell** for SLA): after this point the charge is at costant voltage (the threshold one), changing the current flowing inside the battery pack. When the current is below a fixed percentage (by default at **5%**) of the initial current the charge process ends. These values can be modified (for each profile) using the PC program that allows the editing of the "advanced parameters".
Timeout	All types	The charger has an internal setting that stops the charge process after a charged capacity of **120%** with respect to the nominal battery capacity. Example: for a 2000mAh battery the timeout will expire after 2400mAh of charged capacity. This value can be modified (for each profile) using the PC program that allows the editing of the "advanced parameters".
Error	All types	The charger cannot reach the current set by the user, for this will abort the charge. The reason of this error can be: 1. Battery removed or not present 2. Current too high for the hardware
User break	All types	The user, pressing the "OK" key will stops the charge.

Note: The charger store the "charge in progress" flag in a specific non volatile variable. In case of power loss the pending action will remains stored, and at the power return the charger (after the "hello message") will try to continue the charge. The user can abort this process pressing a key during the displaying of the "hello message".

Battery discharge

The "battery discharge" function charges and monitor the progress of the battery pack discharge. When the charger start this operation switches ON the fan cooler in order to dissipate the heat generated by the mosfets.

The first step is the autocalibration of the current pickup, done during the display of this message:

Initializing...	-	No action.
	+	No action.
	OK	No action.

After a few seconds the discharge process will start

Dsch.LiPo 5.49A 12.345V 2690mAh	-	No action.
	+	No action.
	OK	Terminates the discharging process.

The meaning of the displayed fields is the following:

String	Values	Meaning
Dsch.	-	"Discharge" of the battery pack.
LiPo	NiCd, NiMh, LiPo, SLA	Display the type (chemistry) of the battery
5.49A	0.0 ... 65.53	Display the actual discharge current, in Ampere, with a resolution of 0.01 Ampere (10mA).
12.345V	0.000 ... 65.535	Display the actual battery pack voltage, in Volt, with a resolution of 0.001 Volt (1mV).
2690mAh	0 .. 65535	Display the actual battery discharged capacity, in mAh, with a resolution of 1mAh.

Note: The charger has an internal parameter that limit the maximum discharge current sunk from a battery pack. The maximum discharge current depends on type of mosfet, on heat sink connected and is different for the different hardware implementations. It is user responsibility to set an appropriate value for this parameter. The default value limit the discharge current to **20 Ampere**, but the user can customize this value using the PC program that allows the editing of the "advanced parameters" - the **Universal Charger – General Manager SW**.

At the end of the discharge process the speaker will produce 3 "beep" and the display will look in this way:

Dsch.End! . 0A 12.345V 2690mAh	-	No action.
	+	No action.
	OK	Switch off the fan cooler and return to the main menu.

On the display will remain the battery voltage and the total amount of capacity discharged. The fan remains ON during this phase, allowing for an efficient heatsink cooling. Pressing the "OK" key the charger will return to the main menu.

The discharge is performed always at costant current and will finish at the reaching of one of these conditions: (the displayed message is always the same)

Type of finish	Battery type	Remarks
Standard	All types	The discharge will stops at the reaching of a "cutoff" threshold, different for each battery chemistry. NiCd: **800mV/cell** NiMh: **1000mV/cell** LiPo: **3000mV/cell** SLA: **2000mV/cell** These values can be modified (for each profile) using the PC program that allows the editing of the "advanced parameters".
Error	All types	The charger cannot reach the current set by the user, for this will abort the discharge. The reason of this error can be that

		the current is too high for the hardware.
User break	All types	The user, pressing the "OK" key will stops the charge.

Note: The charger store the "discharge in progress" flag in a specific non volatile variable. In case of power loss the pending action will remains stored, and at the power return the charger (after the "hello message") will try to continue the discharge. The user can abort this process pressing a key during the displaying of the "hello message".

Profile change

The profile change is a function that allows the user for editing the "standard parameters" of the selected profile.

Battery type selection: The type of batteries are the following:

0 - NiCd: **Ni**ckel **Ca**dmium
1 - NiMh: **Ni**ckel **M**etal **h**ydride
2 - LiPo: **Li**thium **Po**lymer
3 - SLA: **S**ealed **L**ead **A**cid

Chemistry: NiMh Battery type	-	Display the previous battery type.
	+	Display the next battery type.
	OK	Confirm the displayed choice for battery type and go to the next parameter setting

Note: it is very important to set the correct battery type because the differents chemistries have a different charging and discharging methodology that, in case of wrong setting, can damage the batteries and/or the charger.

Battery pack capacity: allow the change of the pack capacity. For the batteries that allows to be parallelized (LiPo and SLA) this is the capacity of series elements, for NiCd and NiMh is the capacity of the single cell.

Example: for a 7.4V LiPo battery pack marked:
2S1P 2000mAh, 1C/10C
the right value to be put in this field is "2000".

Usually for SLA batteries this is the capacity printed on the battery package.

Capacity: 2000 mAh per cell	-	Decrease the cell capacity at multiples of 100mAh. The minimum selectable capacity is 100mAh.
	+	Increase the cell capacity at multiples of 100mAh. The maximum selectable capacity is 25500mAh.
	OK	Confirm the displayed choice for battery type and go to the next parameter setting

The pack capacity is used by the charger to calculate:

1. the charge and discharge current, multiplying the charge and discharge rate (from 0.1 to 25.5) by the capacity.
2. the timeout value for charge completion. After a charged capacity of 120%, the charge will stops.

Number of cells: Display the number of batteries in series within the pack. For the batteries that allows to be parallelized (LiPo and SLA) this is the number of series elements. For the LiPo convention that marks the packs with XSYP this is the X value.

Example: for a 7.4V LiPo battery pack marked:
2S1P 2000mAh, 1C/10C
the right value to be put in this field is "2".

Cells: 2 Number of cells	-	Decrease the number of cells (or series elements). The minimum selectable number of cells is 1.
	+	Increase the number of cells (or series elements). The maximum selectable number of cells is 19.
	OK	Confirm the displayed choice for battery type and go to the next parameter setting

Note: the user can calculate the number of cells in a pack looking at the "nominal pack voltage", divided by the cell typical voltage. The typical cell voltage is the following:

NiCd and NiMh: 1.2 V/cell
LiPo: 3.7 V/cell
SLA: 2 V/cell

Example:
A 12V SLA battery is composed by 12/2=6 series elements.

Charge current: the user sets indirectly the charge current via a rate multiplier (from 0.1 to 25.5) that is multiplied by the capacity in order to get the effective current.

Charge: 1.0 mult. for capac.	-	Decrease the charge current. The minimum value is 0.1. This value must be multiplied by the capacity in order to get the effective current value.
	+	Increase the charge current. The maximum value is 25.5. This value must be multiplied by the capacity in order to get the effective current value.
	OK	Confirm the displayed choice for battery type and go to the next parameter setting

Important: please read carefully the battery instruction before setting of this value. Very few batteries allows to be charged at a rate greater than 1C.

Note: The charger has an internal parameter that limit the maximum charge current delivered to a battery pack. The maximum charge current depends on power supply used, on type of mosfet, on heat sink connected and is different for the different hardware implementations. It is user responsibility to set an appropriate value for this parameter. The default value limit the charge current to **5 Ampere**, but the user can customize this value using the PC program that allows the editing of the "advanced parameters" - the **Universal Charger – General Manager SW**.

Example: for a LiPo pack with capacity 2000mAh, the manufacturer specify a value of 1C in charge and 10C in discharge. These two last values are exactly the (maximum) values that can be put in the charge and discharge current fields: These values shall produce a curent of 2000x1.0=2A in charge and 2000x10.0=20A in discharge.

Note: the rate multiplier can be intended as the inverse of the hours needed to pass the selected capacity to the battery pack. If we specify a charge rate of 1.0 the selected capacity shall be passed to battery in 1 hour, if we specify a charge rate of 2.0 the same capacity shall be passed in 1/2 of one hour (30 minutes).

Discharge current: the user sets indirectly the discharge current via a rate multiplier (from 0.1 to 25.5) that is multiplied by the capacity in order to get the effective current.

Discharge: 4.0 mult. for capac.	-	Decrease the discharge current. The minimum value is 0.1. This value must be multiplied by the capacity in order to get the effective current value.
	+	Increase the discharge current. The maximum value is 25.5. This value must be multiplied by the capacity in order to get the effective current value.
	OK	Confirm the displayed choice for battery type and go to the next parameter setting

Important: please read carefully the battery instruction before setting of this value. Setting a value greater than the maximum allowed can cause battery overheating and/or damage.

Note: The charger has an internal parameter that limit the maximum discharge current that can be sunk from a battery pack. The maximum discharge current depends on type of mosfet, on heat sink connected and is different for the different hardware implementations. It is user responsibility to set an appropriate value for this parameter. The default value limit the charge current to **20 Ampere**, but the user can customize this value using the PC program that allows the editing of the "advanced parameters" - the **Universal Charger – General Manager SW**.

Example: for a LiPo pack with capacity 2000mAh, the manufacturer specify a value of 1C in charge and 10C in discharge. These two last values are exactly the (maximum) values that can be put in the charge and discharge current fields: These values shall produce a curent of 2000x1.0=2A in charge and 2000x10.0=20A in discharge.

Note: the rate multiplier can be intended as the inverse of the hours needed to sink the selected capacity to the battery pack. If we specify a discharge rate of 10.0 the selected capacity shall be discharged from battery in 1/10 of an hour (6 minutes).

PC management

This function allows the PC to control the charger via a serial link. The user can link the PC program (that allows the editing of the "advanced parameters") to the charger only when the charger is displaying this message.

The setting parameters for the COM port are 9600,N,8,1.

PC serial link..	-	Return to the main menu.
	+	Return to the main menu.
	OK	Return to the main menu.

Note. This function is useful ONLY for the editing of the charger parameters. The PC program that displays the charge and discharge curves do not need to enter in this function.

Note. The complete interfacing protocol with the charger shall be detailed in the "Universal Charger – technical description" document, in order to allow the open source community to develop different programs for graphics, statistics and control of the charger.

Volt calibration

This function allows the user to calibrate the charger for accurate voltage readings. For the calibration the user need a battery pack and an accurate tester for voltage reading. Please follow these steps:

1. Connect the battery pack to the charger
2. Connect the tester to the battery pack to read the overall pack voltage and be sure that the voltage is stable. Be sure that the tester is well functionning and the batteries are OK.
3. Select the "Volt calibration" function: at this point the display will show the battery pack voltage.
4. Compare the value displayed on the tester (reference) and the value displayed on the charger.
5. If the value displayed on the charger is **lower** than the value on the tester, press the "+" key until the two values are equal.
6. If the value displayed on the charger is **greater** than the value on the tester, press the "-" key until the two values are equal.

-	Decrease the voltage reading on the charger.
+	Increase the voltage reading on the charger.
OK	Return to the main menu.

Note: this process can be a bit long if the two voltages are very different. In this case the user can choose between these two solution:

1. Be patient and continue the process, using the "autorepeat" function that is enabled pressing a key for more than 1 second.
2. Start the PC management program (**Universal Charger – General Manager SW**) that allows the editing of the "advanced parameters" and sets the value of the two resistors that sets the voltage scale of the charger (R5 and R6). Once performed this operation, the voltage calibration is very quick, because must compensate only the resistors tolerance. The default are R6 = 12 KOhm and R5 = 47 Kohm.

Ampere calibration

This function allows the user to calibrate the charger for accurate current readings. For the calibration the user need an accurate tester capable to read a current of 2A, and a power supply capable to source at least 2A . Please follow these steps:

1. Connect the tester to the charger in order to read the current that flows out from the charger. The tester red cable must be connected to the tester "10A" or similar input and to the charger red wires. The tester black cable must be connected to the tester "GND" or similar input and to the charger black cables.
2. Set the tester to read the current, full scale greater than 2A and be sure that the tester is well functionning and the batteries are OK.
3. Select the "Ampere calibration" function: at this point the display will show the 2A test current that comes out from the charger.
4. Compare the value displayed on the tester (reference) and the value displayed on the charger.
5. If the value displayed on the charger is **lower** than the value on the tester, press the "+" key until the two values are equal.
6. If the value displayed on the charger is **greater** than the value on the tester, press the "-" key until the two values are equal.

2.00A .015V	-	Decrease the ampere reading on the charger.
	+	Increase the ampere reading on the charger.
	OK	Return to the main menu.

Note: this process can be a bit long if the two voltages are very different. In this case the user can choose between these two solution:

1. Be patient and continue the process, using the "autorepeat" function that is enabled pressing a key for more than 1 second.
2. Start the PC management program (**Universal Charger – General Manager SW**) that allows the editing of the "advanced parameters" and sets the value of the current pick-up sensitivity. Once performed this operation, the calibration is very quick, because must compensate only

the current pick-up tolerances. The default is 25000 uV/Ampere (nominal for LTS-25NP).