ADVANCED CHARGER

User Manual

www.seven-segments.com

Table of contents

1. Introduction

Aim of this document is to create a complete reference for the ADVANCED CHARGER usage, functionning and structure in order to help new developments starting from this design.

This manual is divided in three main sections:

1. Advanced Charger description and reference
2. PC protocol (RS232 interface)
3. Advanced Charger usage

2. Advanced charger general description

The ADVANCED CHARGER is a “general purpose” charger based on a PIC microcontroller. This charger is completely dependent from the PIC firmware for all the functions, and the hardware outside the microcontroller is minimal. The charger blocks are the following:

- RS232 interface, based on a 5 volts RS232 transceiver, that connects directly the charger to a personal computer
- A linear regulator for 5V power supply
- A mosfet based linear charge/discharge circuit
- Two separated feedback for battery current and voltage
- Display, keys and acoustic buzzer on a separated board

The charge/discharge circuit is based on a P-channel mosfet for the battery charge and N-channel mosfet for discharge. The general principle is very simple: The PIC microcontroller controls the Mosfets gate voltage in order to sink or source a fixed current from/to the batteries. The feedback is a powerful current to voltage converter that use the Hall effect for non-invasive current measurement, in order to have no series components in the current flow, extending the range of current measurement and control. The other feedback, the battery voltage, is used for end-of-charge or end-of-discharge detection. The gate voltage is controlled using a PWM signal, filtered and referenced to the ground for N-channels or to the power supply for P-channels. The high-current path has a very few active or passive components: The charge currents flow from the power supply to the battery trough a schottky diode and two (parallelized) P-channel mosfets, and the discharge current flows from the battery positive to the battery negative trough the N-channel mosfets. This solutions has the advantage to reduce the power loss on these circuits and to charge and discharge a very high currents also starting from a very-low (12V minimum) power supply. The schottky diode allow the user to connect the battery pack and the power supply in any order, and if the power supply is removed the battery pack does not flows current through the charger.
The charger has the following capabilities for the charge/discharge management:

Charge process

The charge is performed using a costant current source with a user-defined current intensity. The range for the current can be choose between 0.1 and 9.9 ampere. The lower limit is due to the current to voltage trasducer that is configurated for the high discharge currents measurement and has some limitations on the low currents. The upper limits depends on the two P-channel mosfet internal resistance. The charge continues until the PIC microcontroller detects a fall in the battery pack voltage of few millivolts (user defined) with respect the maximum voltage reached in the charge process. A timeout for safe operations is defined.

Discharge process

The discharge is performed using a costant current source with a user-defined current intensity. The range for the current can be choose between 1 and 30 ampere. The lower limit is due to the current to voltage trasducer that is configurated for the high discharge currents measurement and has some limitations on the low currents. The upper limits depends on the N-channel power dissipation and in the cooler circuit for these two transistors. Pratically a Pentium processor cooler with fan with two N-channel TO-247 transistors can reach about 300W of power dissipation or about 40A from a 7.2V battery pack: I have limited this current to 30A because the cooler is really too hot and dangerous at 40A and all the test on the batteries that I found on the specialized magazines was performed at 30A (mean battery voltage, run time…). The discharge continues until the PIC microcontroller detects the crossing of user-defined threshold voltage.

The advanced charger is used without a PC connected for normal operations: the PC connection will be useful only for charge/discharge diagram and for battery profiles management.

Interface description

The main interfaces of the basic charger are below listed:

Hardware interfaces

Connectors	Name	Description
J10-1	DC SUPPLY +	Power supply: connect to a 12V to 16V power supply.
J10-2	DC SUPPLY -	Power supply return.
J11	BATTERY +	Connection to the positive pole of the battery for the voltage reading. The connection has two separated cables in order to have no voltage loss during the battery voltage measurement. These wires should be at least 2.5sqmm in order to allow the 30A continuous current flow.
J10	BATTERY -	Connection to the negative pole of the battery for the voltage reading. The connection has two separated cables in order to have no voltage loss during the battery voltage measurement. These wires should be at least 2.5sqmm in order to allow the 30A continuous current flow.
J2 (PANEL)	SERIAL PORT	J4 pin 3 is the RS232 TX wire, and should be connected to the pin 3 of DEM9P connector; J4 pin 2 is the RS232 RX wire, and should be connected to the pin 2 of DEM9P connector. The ground should be connected to the DEM9P connector pin 5. This definition is for a very-basic null modem cable for two PC connection with a 2 and 3 pins twisted. (female to female cable)
J14	FAN COOLER	Fan cooler connector.
S1-S4 (PANEL)	SWITCHES	This connector has 4 switches for operational selection. The switches have a microcontroller internal pull-up and closes to 0V the input signal when activated. (see the table for switches assignment)
J99 (PANEL)	BUZZER	Piezo buzzer resonant on 2KHz

Keys interface

Connectors	Name	Description
S4	UP/+	This key allow the increase of the selected parameter or the rolling up of the menu
S3	DOWN/-	This key allow the decrease of the selected parameter or the rolling down of the menu
S2	NEXT/OK	This key allow the selection of next parameter or the selection of a sub-menu
S1	BREAK	This key break the current operation and return to main menu

Serial interface

Connectors	Name	Description
J2 pin 3	TX	RS232 TX signal for trasmission. The serial port parameters are 9600 baud, no parity, 1 stop bit.
J2 pin 2	RX	RS232 RX signal for reception. The serial port parameters are 9600 baud, no parity, 1 stop bit.

Software interface

The software interface has two separated functions:

1. During the charge or discharge process the user can monitor the values coming from the serial port (graphics plotting)
2. The user can upload/download the battery profiles via serial interface

The data coming from the serial interface during the charge or discharge process is below listed:

Number	Name	Remarks
0	0x55	Start of frame
1	0x55	“
2	0x55	“
3	0x55	“
4	0x55	“
5	0x55	“
6	CURRH	Current value MSB
7	CURRL	Current value LSB
8	VOLTH	Battery voltage MSB
9	VOLTL	Battery voltage LSB
10	MAHU	Capacity charged/discharged MSB
11	MAHX	
12	MAHH	
13	MAHL	Capacity charged/discharged LSB
14	MIN	Minutes in charge/discharge
15	SEC	Seconds in charge/discharge

The bytes comes from the interface at 9600 baud,N,8,1. The characters are sent every 5 msec and the overall frame is sent every (16*5) 80msec.
The scale factors are the following:

Current=(CURRH*256+CURRL)/327.68 (in Ampere)
Voltage=(VOLTH*256+VOLTL)/4.9368 (in mV)
Capacity=(MAHU*256+MAHX+MAHH/256+MAHL/65536)/3.6 (in mAh)

The data for eeprom modify has the following format:

Store Address:

Byte	Format	Remarks
1	10XX.HHHH	
2	11XX.LLLL	Store the address HHHH.LLLL in the memory pointer.

The charge answer will be the data contained in the addressed cell (one byte).

Store Data:

Byte	Format	Remarks
1	0DDD.DDDD	Store the data (ASCII) DDD.DDDD in the cell addressed by the memory pointer.

The memory pointer after the store data will be increased and will wrap around at the location 0xE0, restarting from 0x0.

The internal EEPROM memory contains 7 different battery charge/discharge profiles. The profile contains all the parameters for a complete battery pack characterization. The parameters are in ASCII format andare below listed:

Address	Name	Remarks
0x0	CELL	Number of cells: ‘1’..’7’ Example:’6’ means a battery pack of 6 cells.
0x1-0x2	CAPACITY	Single cell capacity: ‘00’..’99’. The value is multiplied by 100 in order to obtain the real capacity in mAh. Example: ‘24’ means a battery pack of 2400mAh.
0x3-0x4	CUTOFF	Single cell cutoff voltage: ‘00’..’99’. The value is multiplied by 10 in order to obtain the single cell cutoff voltage in mV. Example: ‘70’ means a cutoff of 700mV per cell, with a total cutoff of (6x700) 4.2V. We suggest 700mV for NiCd and 800mV for NiMh.
0x5-0x6	DPEAK	Single cell delta peak voltage: ‘00’..’99’. The value is the single cell delta peak in mV. Example: ‘15’ means a delta peak of 15 mV per cell, with a total delta peak of (6x15) 90mV. We suggest 15mV for NiCd and 5mV for NiMh.

0x7-0x8	CHARGE	Charge current : '00'..'99'. The value is divided by 10 in order to obtain the charge current in A. Example: '24' means a charge current of 2.4A.
0x9-0xA	DISCHARGE	Discharge current : '00'..'99'. The value is the discharge current in A. Example: '20' means a discharge current of 20A.
0xB	INHIBIT	Inhibit time for delta peak after start of charge. This value '0'..'9' is expressed in minutes. Example:'3' means a inhibit a 3 minutes delta peak inhibt after start of charge. We suggest 3 min for NiCd and 5 min for NiMh.
0xC	TIMEOUT	Value for timeout: '0'..'9'. This value is multiplied by 10 and is added 100 in order to obtain the percentage of capacity for timeout. Example: '20' means a timeout capacity of 120% of nominal capacity, the charge will stop for timeout after (2400*120/100) 2880mAh. We suggest 120% for NiCd and 110% for NiMh.
0xD-0xF	SPARE	Spare locations
0x10-0x1F	NAME	Holds the name of the profile (16 chars)

The profiles address are the following:

Profile 1 -> 0x0-0x1F
Profile 2 -> 0x20-0x3F
Profile 3 -> 0x40-0x5F
Profile 4 -> 0x60-0x7F
Profile 5 -> 0x80-0x9F
Profile 6 -> 0xA0-0xBF
Profile 7 -> 0xC0-0xDF

3. Advanced charger usage

The ADVANCED charger usage is very simple and all the operations can be done via a 3 keys keyboard (the 4-th key is the “break” or restart key). The messages for the user are displayed in the 16 characters by 2 lines LCD display.

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

1. Power up the charger with a 12V to 16V DC power supply.
2. Will be displayed the “hello” message.

The “hello” message will disappear in about 10 seconds or if the user press a key (except BREAK/ESC that restart the system)

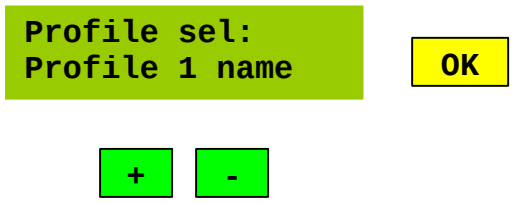
Pressing a key or waiting for 10 seconds the charger will go in the main menu, for function selection or parameters setting. If the user don’t press a key the charger will check if the previous action (charge,discharge or cycle) was suspended and in case of a pending action the charger will restart the interrupted task with same parameters. The action is suspended if the power supply is removed, if the charger software locks or if the user press the BREAK key. If the user press a key during the “hello” message displaying, the charger will discard the suspended action and go to the main menu.

The BREAK key pressed in any moment will restart the system starting from the hello message and the above described procedure.

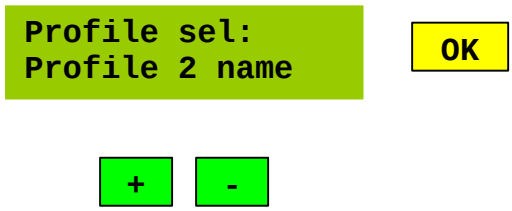
3. Main menu

Task select: Profile Select	**OK**	Go to the battery “profile” selection: the “profile” is the set of parameters used for batteries charging and discharging. In practice the user should have a profile for each type of battery pack.
+ **-**		
Task select: Batt. Charge	**OK**	Start the battery charging with a set of parameters selected during the “profile select” task.
+ **-**		
Task select: Batt. Discharge	**OK**	Start the battery discharging with a set of parameters selected during the “profile select” task.
+ **-**		
Task select: Batt. Cycle	**OK**	The battery “cycle” is composed by a discharge (like the previous task) followed by a charge.
+ **-**		
Task select: Set Parameters	**OK**	The user can modify all the parameters of the selected “profile”. The changes are stored in permanent memory and are mantained if the user switch off the charger.
+ **-**		
Task select: PC Management	**OK**	This mode allow the user to store/recall the “profiles” within the charger, managing a small “profiles” database in the PC mass memory.
+ **-**		
Task select: Power Supply	**OK**	This mode transform the charger in a power supply with voltage setting and maximum current limiting.

4. Profile Select

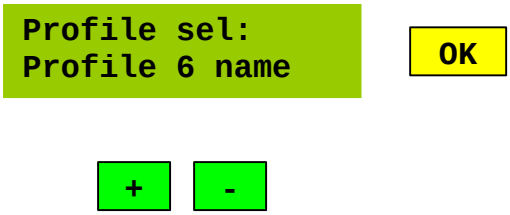


Pressing OK the user select a particular “profile”. The profile name should contains all the necessary info for particular profile identification. After the selection the charger will return to main menu.

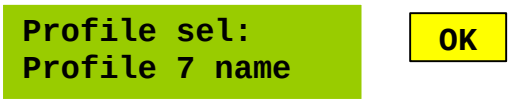


Profile 2 selection.

...



Profile 6 selection.

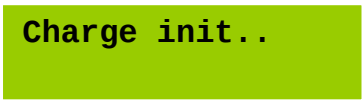


Profile 7 selection.

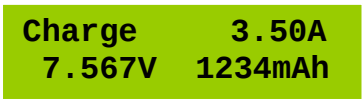
The default naming used in the charger is the following:

Example: 6x2400 NiMh 2420
Where 6 is the number of cells, 2400 is the cell capacity, NiMh is the cell technology, 24 is the charge current (2.4A) and 20 is the discharge current (20A).

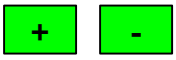
5. Battery charge



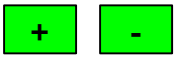
The charger self-calibrate the charger block for about 6 seconds. The user shall connect the battery pack to the charger before the charge init phase.



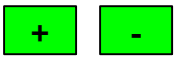
The values displayed in charge are the effective current (3.50A) the battery pack voltage (7.567V) and a third, user selectable field. The user can select the charged capacity…

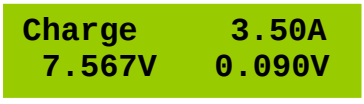


…the charge elapsed time in minutes and seconds…

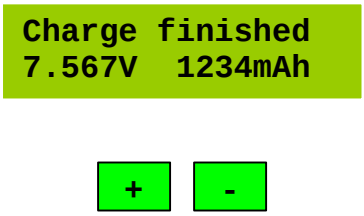


…the battery pack peak voltage…

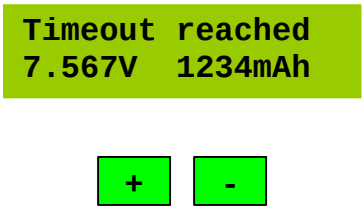




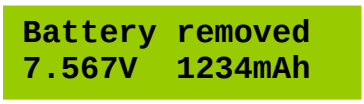
…the delta peak voltage for battery end of charge detection. The user can switch between these 4 display modes during the charge or after the charge end.



The charge can finish for delta peak detection: in this case the message displayed is shown and the user can display the total capacity, the charge total time, the battery peak or the delta peak. The charger produces a small beep for end-of-charge.



The charge can finish for timeout if the capacity charged is over the selected threshold. The charger produces a small beep for end-of-charge. The OK key will return to main menu.



The charge can finish if the user remove the battery pack: in this case the message displayed is shown. The charger produces a small beep for end-of-charge.

6. Battery discharge

Discharge init..

The charger self-calibrate the discharger block for about 6 seconds. The user shall connect the battery pack to the charger before the discharge init phase.

Discharge 20.00A
7.567V 34mAh

+ **-**

The values displayed in discharge are the effective current (20.00A) the battery pack voltage (7.567V) and a third, user selectable field. The user can select the discharged capacity…

Discharge 20.00A
7.567V 0:34

+ **-**

…the discharge elapsed time in minutes and seconds…

Discharge 20.00A
7.567V 9.787V

+ **-**

…the battery pack peak voltage (starting value)…

Discharge 20.00A
7.567V 4.200V

…the cut-off voltage for battery end of discharge detection. The user can switch between these 4 display modes during the discharge or after the discharge end.

Discharge end
7.567V 1234mAh

OK

+ **-**

The charge can finish for cut-off voltage reaching: in this case the message displayed is shown and the user can display the total capacity, the discharge total time, the battery peak or the cut-off voltage. The charger produces a small beep for end-of-discharge.

7. Battery cycle

The battery cycle is a simple “battery discharge” followed by a “battery charge” task. All the parameters and display applicable to the “battery cycle” are the same of “battery discharge” and “battery charge”. The only difference is that the charger does not stop the discharge phase and wait for user acknowledge but goes directly to the charge process.

8. Set parameters

Cells: 7
Number of cells

OK

The cells number can be changed between 1 and 7 cells using the + and – keys. The OK key save the actual value and goes to the next parameter.

+ -

Capacity: 3300
mAh per cell

OK

The single cell capacity is selectable from 0 to 9900 mAh in step of 100 mAh. This parameter is used by the charger for charge timeout detection.

+ -

Cut off: 700
mV per cell

OK

The cell cut-off voltage is selectable from 0 to 990 mV. This parameter is used by the charger for end of discharge detection.

+ -

Delta Peak: 15
mV per cell

OK

The cell delta peak voltage is selectable from 0 to 99 mV. This parameter is used by the charger for end of charge detection.

+ -

Charge: 3.5
Current in A

OK

The charge current is selectable form 0.1 to 9.9 Ampere with steps of 0.1A.

+ -

Discharge: 15
Current in A

OK

The discharge current is selectable from 1 to 39 Ampere with steps of 1A.

+ -

Inhibit: 6
In minutes

OK

After the start of charge the delta peak is inhibited for a number of minutes from 0 to 9.

+ **-**

Timeout: 120
% of Capacity

OK

The timeout is user selectable from 100% to 190% of the cell nominal capacity.

+ **-**

Name:
6x2400 NiCd 2420

OK

The name can be changed character by character and the OK key pass to the next character. At the end of the string (16 chars) the user ends the parameters set phase.

+ **-**

Return
to main menu

OK

The OK key finish this phase and return to main menu.

When the user select a “profile” and enters in the “Set parameters” submenu all the changes to the existing values will be applied to the “profile” and are permanently stored in the charger.

9. PC Management

Eeprom updating	**OK**	The user can start the routine for internal Eeprom updating via PC program. The commands are described in the relevant chapter. The user can exit pressing OK, and the charger return to main menu.

See the software reference for details on PC profiles management.

Power supply

```
Current calib..
```

The charger self-calibrate the voltage regulator block for about 6 seconds.

```
Volt: 9.9V
 9.878V -  3.45A
```

OK

The user with + and – keys can modify the output voltage. The effective output voltage is displayed with the current erogated to the load. There is a 5A fixed limitation on the current. OK will return to the main menu.

+ -