

**This document is a draft version. It is uncompleted and can contain mistakes. Please wait for official release before use.**

# Cheali Charger v1.00

## Manual / User Guide



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# 1 Introduction

This manual explains how Cheali Charger works, not how to flash your charger. For flashing information, go to <https://github.com/stawel/cheali-charger/tree/master/docs>

This project is an alternative firmware for a variety of LiPo chargers:

- Atmega32 CPU
  - G.T. POWER A6-10 200W
  - IMAX B6 Charger/Discharger 1-6 Cells (clone, original)
  - AC/DC Dual Power B6AC 80W RC Balance Charger/Discharger
  - Turnigy A-6-10 200W Balance charger & discharger
  - Turnigy Accucel-6 50W 5A Balancer/Charger w/ Accessories
  - Turnigy Accucel-8 150W 7A Balancer/Charger
  - Turnigy MEGA 400Wx2 Battery Charger/Discharger (800W)
  - ... many more
- Nuvoton NuMicro M0517LBN CPU
  - IMAX B6 Charger/Discharger 1-6 Cells
- Unsupported
  - Turnigy Accucel-6 80W Balancer/Charger - Based on an older, uncommon CPU. See #106

**Don't use it if You don't need to (not everything is implemented yet).**

**The first thing to do after flashing your charger is to calibrate it. Read § “Calibration”.**

## 2 Main functions

Cheali Charger works with the battery's types listed below:

- Li-ion, LiPo, LiPo-4.30V, LiPo-4.35V, LiFe
  - charging
  - fast charging
  - charging + balancing
  - discharging
  - balancing
  - storage
  - storage + balancing
- NiCd and NiMH
  - charging, method: “-dV/dt” or/and “dT/dt” (with external temperature sensor)
  - discharging
  - cycling
- NiZn
  - charging
  - fast charging
  - charging + balancing
  - discharging
  - balancing
- Pb: **not well tested!**
  - Charging
  - discharging

Cheali Charger has also advanced functions:

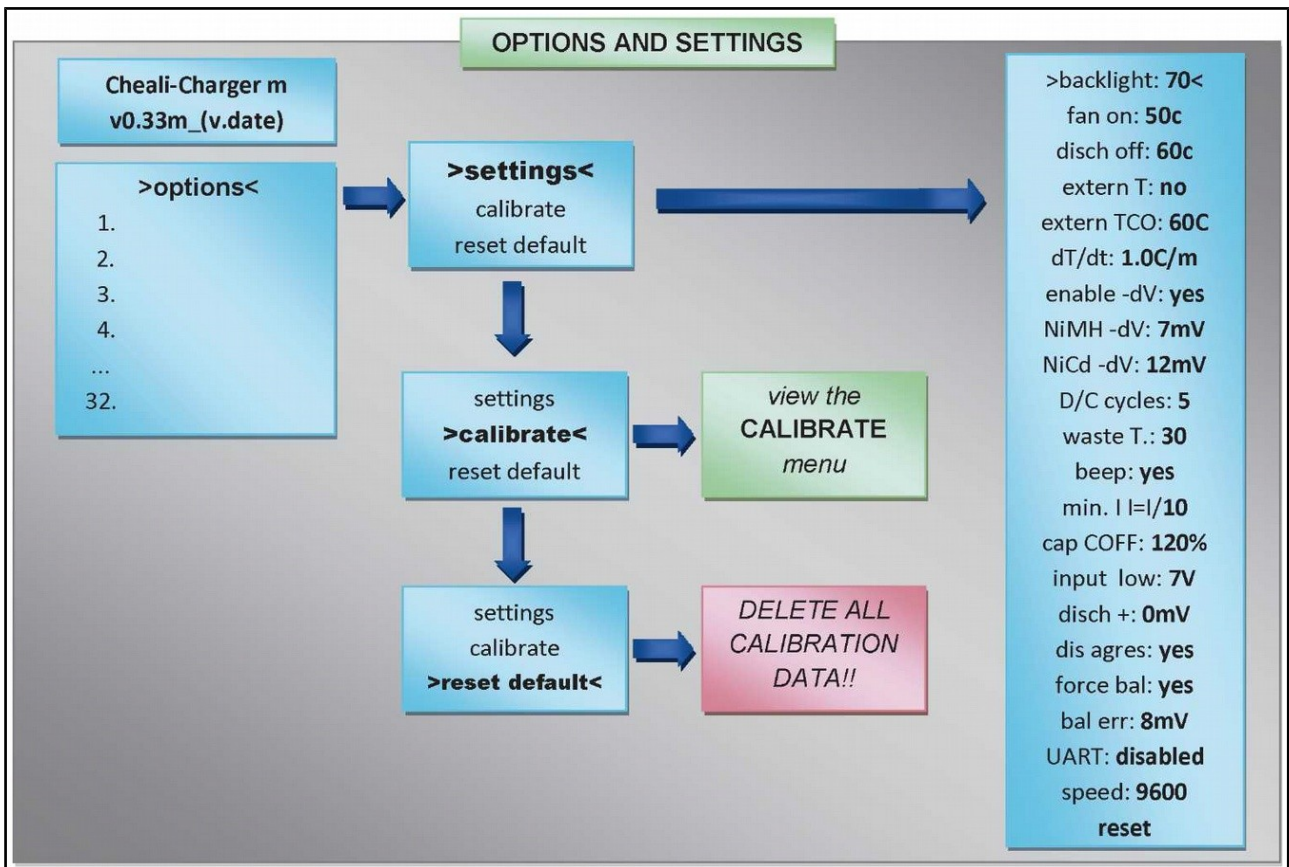
- Internal resistance display
  - single cell resistance
  - whole battery resistance
  - battery leads resistance
- Internal and external temperature monitoring
- Over-charge and over-discharge monitoring
- Input voltage monitoring
- Memory for 30 batteries
- LogView support
- **CALIBRATION**

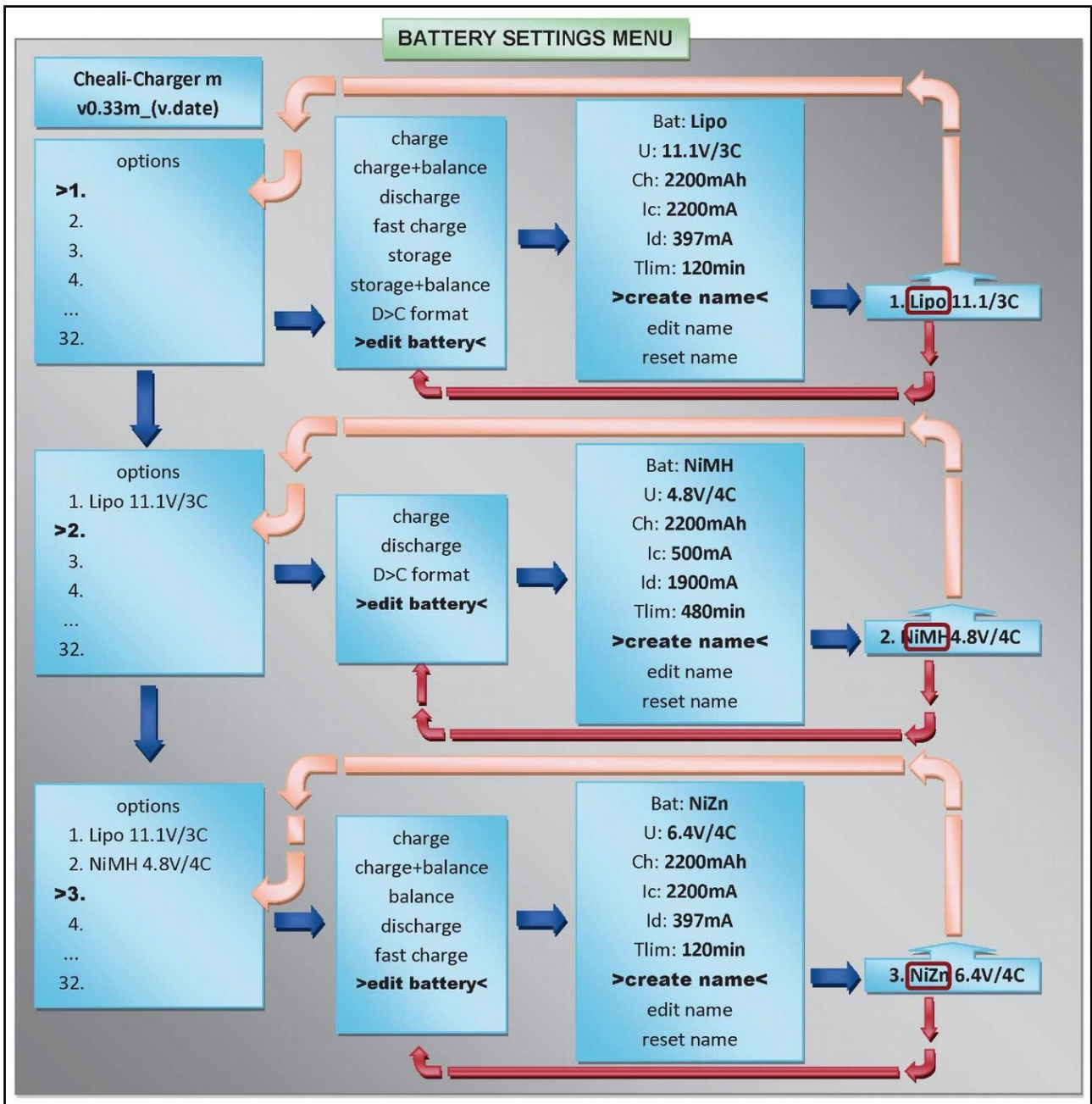
**The first thing to do after flashing your charger is to calibrate it. Read § “Calibration”.**

### 3 Software structure

The software structure of Cheali charger looks like the diagram below. To navigate, use the four buttons of the front panel of your charger:

- “Batt type / Stop” or “Stop / Escape”: Stop the running program (charging, discharging...) or exit the menu one level above.
- “Dec” or “-”: move up in the navigation menu or reduce a value.
- “Inc” or “+”: move down in the navigation menu or reduce a value.
- “Start/Enter” or “Enter/Start”: validate a value or enter the menu one level below. Long push (3 seconds) will start the selected charging program.





## 4 Calibration

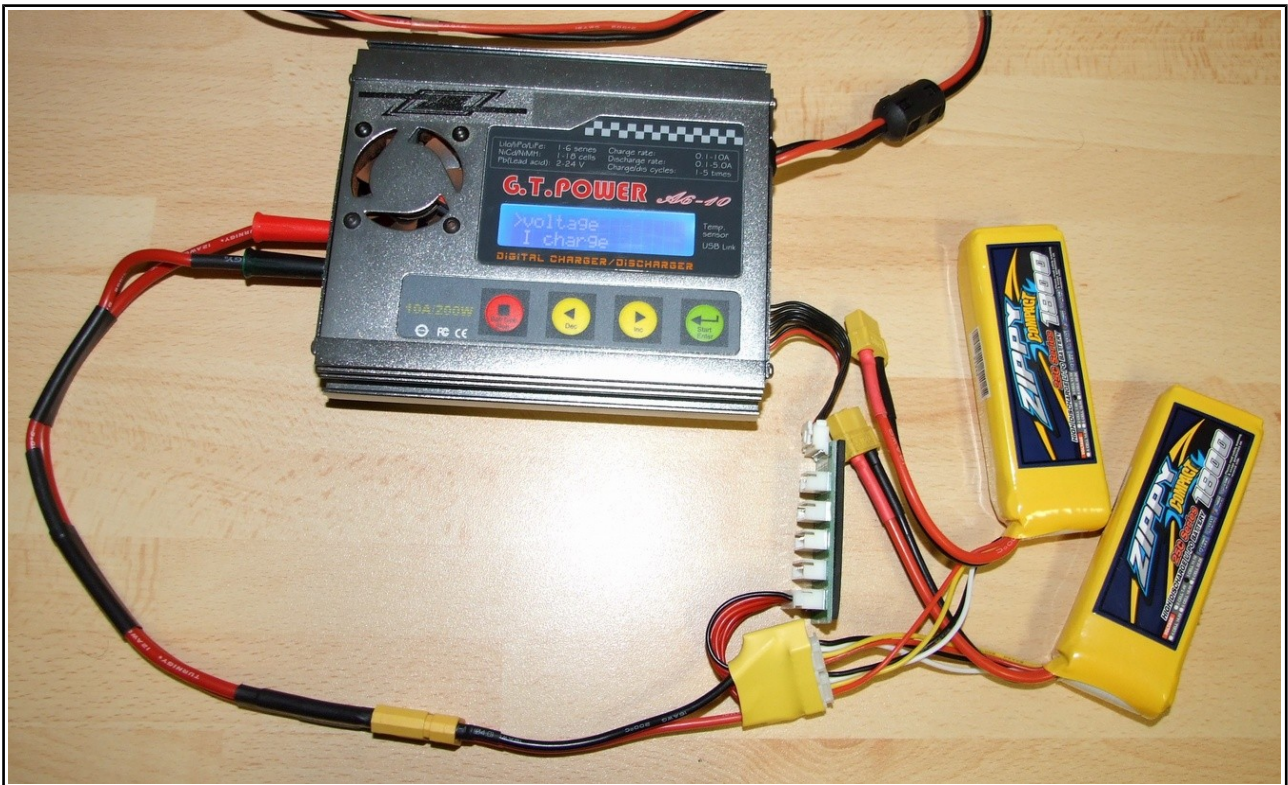
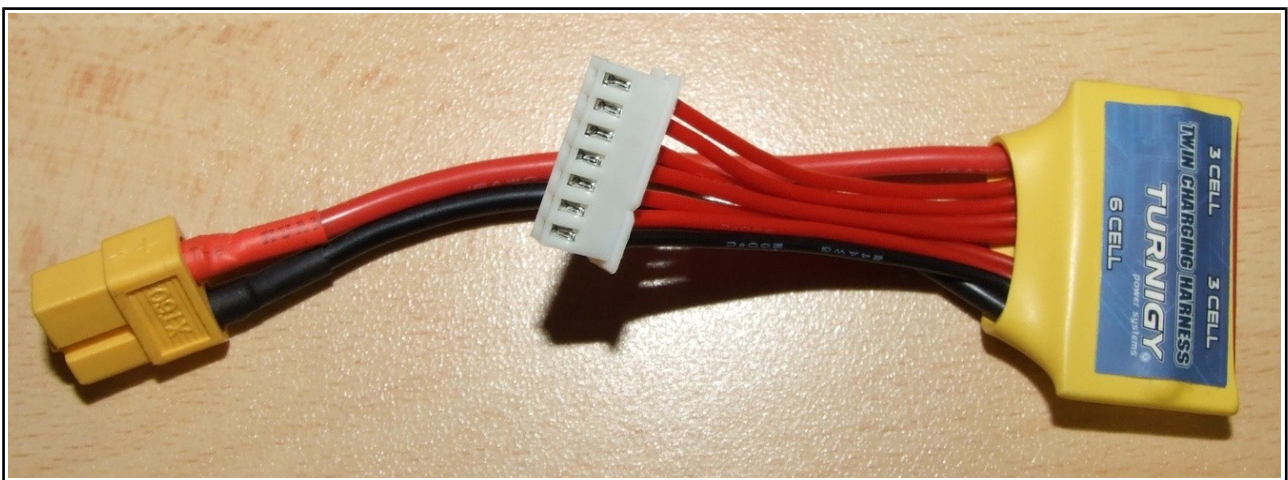
If you have just flashed your charger, go to "options"->"reset default". You will have a "clean" installation. If you only want to recalibrate your charger, don't reset it or you will erase all your personal parameters.

Connect a NOT fully charged LiPo battery to the main leads and the balance port.

If you don't own a battery with a balance connector, just connect a regular one (~4V) to the main leads and the balance port first two pins (pin "0" <--> Bat-, pin "1" <--> Bat+).

If you don't have a 6S battery, maybe you could use a coupling cable for dual 3S charging (see picture below).

Of course, if you only use 3S or 4S batteries, just calibrate the charger for 3S or 4S (**never use uncalibrated ports**)



go to: "options"->"calibrate":

## 4.1. Voltage calibration

- go to "voltage"
- use a voltmeter to measure voltage off all cells and the power supply voltage ( $V_{in}$ ) and set voltage on  $V_{in}$ ,  $V_{b1}$ ,  $V_{b2}$ ,...,  $V_{b6}$ .

*Note: Only  $V_{b1}$  is mandatory. Battery main leads and balance port must be connected. You need to change at least one value (this will copy  $V_{1-6}$  voltage to  $V_{bat}$ )*

## 4.2. Charging and discharging current calibration

**WARNING: Your battery must be not fully charged or discharged and must accept a 1000mA charging and discharging current.**

**WARNING: During the current calibration, there is no circuit protection. If the values are higher than the charger performance limits, or set incorrectly, it can lead to irreparable damage to the charger.**

### 4.2.1 Charge current calibration

- disconnect balance port
- connect your amperemeter in series with the main leads of the battery. Use the 10A(20A) input
- go to "I charge"
- go to: "50mA" (100mA on some versions)
- press "start" button (current flow should be visible on amperemeter)
- press "Inc", "Dec" buttons until the amperemeter measures 50mA (100mA on some versions)
- press "start" button to save the setting
  
- go to: "1000mA"
- press "start" button
- press "Inc", "Dec" buttons until the amperemeter shows 1000mA
- press "start" button to save the setting

### 4.2.2 Discharge current calibration

- go to "I discharge"
- repeat the same steps as before (you will see "minus" sign on your amperemeter).



### 4.3. Temperature probes (external / internal) calibration

When needed, you can calibrate the external (or internal) temperature probe.

- go to "temp extern" (or "temp intern")
- set two calibration points

**PUT "HITS AND TIPS" ABOUT THERMAL CALIBRATION**

Done.

If you have any problems with calibration, go to "options"->"reset default" and try again.

## 5 Charging a battery

Many chargers have charging menu organized like this: battery technology (LiPo, NiMH...) --> charging/discharging/balancing...program --> choose program parameters (number of cells, current...)

This scheme could lead to mistake and could be dangerous for your battery, charger, and house. Furthermore, most people always use the same parameters for one kind of battery. For example, you have a 3S 1000mA LiPo battery and you always charge it at LiPo/3S/2000mA for a charge in half an hour.

Cheali Charger works with another scheme: batteries memories.

1. You create a batterie type in one of the 30 memories allowed.
2. You set its technology (LiPo, NiCd...)
3. You set its number of cells
4. You set its charge and discharge currents

Have a look at §3 “Software structure” for diagrams.

## 6 Charging programs' details

### 6.1. Li-ion, LiPo, LiPo-4.30V, LiPo-4.35V, LiFe

#### 6.1.1 Charging

You must connect the main lead to the charger.

It is not necessary to connect the balance lead but highly recommended because, when the balance port is connected, the charger works with a more accurate voltage reading and controls the voltage of each cells.

(v1.99: If balance port is not connected the charger will beep at you but you can still long-press the "start" button to start charging)

#### Charging strategy:

- 1<sup>st</sup> phase: constant current CC (can be set in [battery]->"edit battery"->"Ic:"). Voltage rises up to charged battery final voltage.
- 2<sup>nd</sup> phase: constant voltage CV (can be set in [battery]->"edit battery"->"Vc:"). When final voltage is reached, charger switches from constant current to constant voltage and decreases current down to Imin (by default it's set 1/10 "Ic", but can be set in [battery]->"edit battery"->"min Ic" when advanced menus are enabled (when "options"->"settings"->"menus: advanced"))

Notes:

- *The charger makes a break between these two phases (goes down with current to 0A for a few seconds) to measure the battery's internal resistance.*
- *There is no balancing when “charging” program is used. You have to use “charging+balance” program.*

**Stop criteria:**

- Optimistic (everything works well until the battery is fully charged): charging current goes down to "min Ic".
- Others criteria:

Criteria	Displayed string	Where to set
(normal) battery's capacity limit reached	"capacity cutoff"	[battery]->"edit battery"->"Cap:"
(normal) time limit reached	"time limit"	[battery]->"edit battery"->"time:"
(error?) external temperature (temperature probe) too high, if enabled	"ext.temp.cutoff"	[battery]->"edit battery"->"extrn TCO:"
(error) internal temperature is greater than "disch off" + 5°C (discharge cutoff temperature + 5°C) -- assuming the charger has an internal temperature probe (200W chargers, Nuvoton)	"int.temp.cutoff"	"options"->"settings"->"disch off"
<ul style="list-style-type: none"> <li>• (error) battery disconnected (output voltage too high)</li> </ul>	"battery disc."	
<ul style="list-style-type: none"> <li>• (error) output current higher than Ic +1A (short circuit)</li> </ul>	"HW failure"	
<ul style="list-style-type: none"> <li>• (error) balance port disconnected (when connected at start)</li> </ul>	"balancer disc."	
(error) input voltage (power supply voltage) too low	"input V to low"	"options"->"settings"->"input low:"

## 6.1.2 Fast charging

You must connect the main lead to the charger.

It is not necessary to connect the balance lead but highly recommended because, when the balance port is connected, the charger works with a more accurate voltage reading and controls the voltage of each cells.

It's not working like it should on v1.99 (currently it works exactly like "charging"). Need to be fixed.

V1,99: we can change it to "Charger stops as soon as the final voltage is reached." (this would probably make more sens now, since now we can set "min Ic" for the "charging" program)

### **Fast charging strategy:**

The “fast charging” strategy is the same as the “charging” strategy but the stop current is set  $I_c/5$ .

### **Stop criteria:**

The “fast charging” stop criteria are the same as the “charging” criteria but the stop current is set  $I_c/5$ .

## 6.1.3 Charging + balancing

You must connect the main lead and the balance lead to the charger.

### **Charging and balancing strategy:**

1<sup>st</sup> phase: same strategy as the “charging” program

2<sup>nd</sup> phase: same strategy as the “balancing” program (discharging individual cells)

### **Stop criteria:**

The stop criteria are the same as the "charging" program + voltage difference between cell's must be lower than the cells voltage difference (can be set in "[battery]->"edit battery"->"bal. Err:").

*Note: Charging current can go below "min Ic", when balancing is still running.*

## 6.1.4 Discharging

You must connect the main lead to the charger.

It is not necessary to connect the balance lead but it is highly recommended (charger beeps if balance lead is not connected)

### Discharging strategy:

- 1<sup>st</sup> phase: constant current CC (can be set in [battery]->"edit battery"->"Id:"). Voltage decreases to discharged battery final voltage (can be set in "[battery]->"edit battery"->"Vd:")
- Optional 2<sup>nd</sup> phase: constant voltage CV (can be set in [battery]->"edit battery"->"Vc:"). You have to enable this option in "[battery]->"edit battery"->"adapt dis:" (enabled = set to "Yes")  
When final voltage is reached, charger switches from constant current to constant voltage and decreases current down to Imin (by default it's set 1/10 "Ic", but can be set in [battery]->"edit battery"->"min Ic" when advanced menus are enabled (when "options" → "settings"->"menus: advanced"))

(v1.99) we discharge the battery with constant current only, if the voltage goes below "[battery]->"edit battery"->"Vd:" per cell we stop discharging.

(\*) if however the option "[battery]->"edit battery"->"adapt dis:" is enabled (set to "Yes") we also discharge the battery with constant voltage (cell voltage stays at "[battery]->"edit battery"->"Vd:", and we decrease the discharge current until we reach "[battery]->"edit battery"->"min Id:"

### Stop criteria:

- Optimistic (everything works well until the battery is fully discharged):
  - With 2<sup>nd</sup> phase disabled: discharged battery final voltage "Vd" is reached.
  - With 2<sup>nd</sup> phase enabled: discharged battery final voltage "Vd" is reached and discharging current goes down to "min Id".

Others criteria:

- ??? To Be Completed ???

## 6.1.5 Balancing

You must connect the main lead and the balance lead to the charger.

### **Balancing strategy and stop criteria:**

Each cell is discharged individually until the voltage balancing error become lower than "bal. Err" (can be set at [battery]->"edit battery"->"bal. err:")

(v1.99 implementation)

1. we "select" a cell with the "minimum cell voltage"
2. we "mark" a cell as "balancing needed" (discharging needed) if its voltage is greater than the "minimum cell voltage" + [battery]->"edit battery"->"bal. Err:"
3. we discharge cells "marked" as "balancing needed"
4. if a cell voltage goes below "minimum cell voltage", "unmark" it
5. repeat 3-5 until all cells are unmarked

## 6.1.6 Storage

You must connect the main lead to the charger.

It is not necessary to connect the balance lead but it is highly recommended (charger beeps if balance lead is not connected)

### **Balancing strategy and stop criteria:**

- If voltage per cell is lower than [battery]->"edit battery" → "Vs:", the charger runs the "charging" program,
- otherwise the charger runs the "discharging" program with "[battery]->"edit battery"->"adapt dis:" enabled.
- The end voltage is set to [battery]->"edit battery"->"Vs:" (per cell).

## 6.1.7 Storage + balancing

You must connect the main lead and the balance lead to the charger.

### **Balancing strategy and stop criteria:**

- If voltage per cell is lower than [battery]->"edit battery"->"Vs:", the charger runs the "charging+balancing" program,
- otherwise the charger runs the "discharging" program with "[battery]->"edit battery"->"adapt dis:" enabled AND balancing enabled.
- The end voltage is set to [battery]->"edit battery"->"Vs:" (per cell).

## 6.2. NiCd and NiMH

### 6.2.1 Charging

Cheali-charger uses the  $\Delta V$  method and the  $dT/dt$  method (if external temperature probe is enabled) to determine when a battery is fully charged. In order for these methods to be effective, **the charge current must be higher than 0.5C. Make sure your battery is suitable for high current charging.**

#### Charging with small current

If the charging current is too small (for example 0.1C) it is very likely that Cheali-charger will not be able to determine the end of charge. In this case you should set an appropriate charging time limit (can be set at edit battery->Tlim:) and capacity cut-off limit (see §7 [GS007]).

#### Chargers using Atmel atmega32 CPU

In the  $\Delta V$  method, we try to measure a voltage drop of about -5mV (per cell) on output. The atmega32 ADC resolution is not enough accurate for the  $\Delta V$  method to work. Cheali-charger is trying to enhance the ADC resolution by using a method called 'Oversampling and Decimation'. This method requires a noisy signal at input. For this reason, on atmega32 based chargers, it is recommended to enable artificial noise in settings (adc noise: yes).

For more information, have a look at:

[https://github.com/stawel/cheali-charger/blob/master/docs/nimh\\_nicd\\_charging.md](https://github.com/stawel/cheali-charger/blob/master/docs/nimh_nicd_charging.md)

[https://github.com/stawel/cheali-charger/blob/master/docs/artificial\\_adc\\_noise.md](https://github.com/stawel/cheali-charger/blob/master/docs/artificial_adc_noise.md)

#### Chargers using Nuvoton M0517 CPU

The measurement is sufficiently accurate; artificial noise is not required.

### 6.2.2 Discharging

To Be Completed

### 6.2.3 Cycling

To Be Completed

## **6.3. NiZn**

### **6.3.1 Charging**

To Be Completed

### **6.3.2 Fast charging**

To Be Completed

### **6.3.3 Charging + balancing**

To Be Completed

### **6.3.4 Discharging**

To Be Completed

### **6.3.5 Balancing**

To Be Completed



## **6.4. Pb**

### **6.4.1 Charging**

To Be Completed

### **6.4.2 Discharging**

To Be Completed


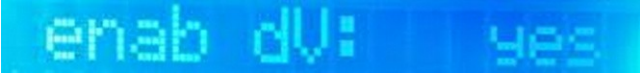
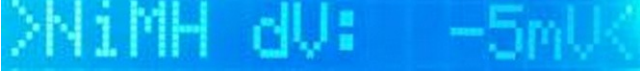



## 7 Settings

### 7.1. General settings [GSxxx]

Column Id	Name	Description	Charger type
[GS001]	backlight: X	LCD backlight	200W/400W
[GS002]	fan on: X°C	Turn on cooling fan when charger internal temperature is higher than X°C	200W/400W
[GS003]	disch off: X°C	Pause discharging when charger internal temperature is higher than X°C	200W/400W, M0517 see (7.1-1)
[GS004]	extrn T: yes/no	Enable/disable external temperature probe. Used in: "extrn TCO:", "dT/dt:"	All
[GS005]	extrn TCO: X°C	External temperature cut-off. Stop program when ext. temp. is higher than X°C. See also: "extrn T:"	All
[GS006]	beep: yes/no	Enable/disable sound	All
[GS007]	cap COff: X%	Capacity cut-off. Stop charging/discharging when charge reaches X% of batteries capacity	All
[GS008]	input low: XV	Stop program when input voltage (power supply voltage) is lower than X	All
[GS009]	reset	Reset all settings to default	All

(7.1-1) chargers with Nuvoton-M0517 CPU don't have a dedicated internal temperature probe. Cheali Charger uses the CPU's temperature.

## 7.2. NiMH and NiCd specific settings [NSxxx]

Column Id	Name	Description	Charger type
[NS001]	dT/dt: X°C/m	 Stop charging when external temperature increases more than X°C per minute. See also: "extrn T:"	All
[NS002]	enab dV: yes/no	 Enable ΔV method to determine end of charging for NiMH and NiCd. <b>Should be always "yes"!</b>	All
[NS003]	NiMH dV: XmV	 ΔV value for NiMH (per cell), see also: "enab dV:"	All
[NS004]	NiCd dV: XmV	 ΔV value for NiCd (per cell), see also: "enab dV:"	All
[NS005]	D/C cycles: N	 Number of discharges/charges when cycling (formatting) battery.	All
[NS006]	D/C rest: time	 Rest time between discharge and charge during cycling in minutes	All
[NS007]	adc noise: yes/no	Add noise to batteries main-leads input connector. See §6.2.1	atmega32 based chargers.

### 7.3. LiXX, NiZn, Pb specific settings [LSxxx]

Column Id	Name	Description	Affected batteries
[LS001]	min Iout: I/X	Stop charging (discharging) when current is lower than $I_c/X$ ( $I_d/X$ ), see (7.3-1 and 7.3-2)	All See (7.3-3)
[LS002]	min Iout: YmA	Minimum allowed output current, see (7.3-4)	All
[LS003]	o.charge: XmV	Over-charge LiXX battery, for lipo endV = 4.20V + X mV (per cell)	LiXX See (7.3-5)
[LS004]	o.disch: XmV	Over-discharge LiXX battery, for lipo endV = 3.00V + X mV (per cell)	LiXX See (7.3-5)
[LS005]	dis agres: yes/no	Aggressive discharging: off: stop discharging immediately after battery reaches endV on: when battery reaches endV, go down with the discharge current, see "min Iout: I/X" and (7.3-2)	All
[LS006]	force bal: yes/no	Force user to connect balance port before starting any program	LiXX See (7.3-5)
[LS007]	bal. err: XmV	Acceptable voltage error between cells when balancing	LiXX see (7.3-5)

(7.3-1) minimum allowed charge current is equal:  $=\max(\text{"min Iout: } I_c/X", \text{"min Iout: } YmA")$   
 where:  $I_c$  - is batteries charge current ("edit battery"->" $I_c$ :")

(7.3-2) minimum allowed discharge current is equal:  $=\max(\text{"min Iout: } I_d/X", \text{"min Iout: } YmA")$   
 where:  $I_d$  - is batteries discharge current ("edit battery"->" $I_d$ :")  
 "dis agres:" should be set to: yes

(7.3-3) affects: charge/discharge of LiXX, Pb, NiZn and discharge of NiMH, NiCd

(7.3-4) the chargers design doesn't allow to deliver less current than a certain value, (current




measuring op-amp is not "rail-to-rail")

You can measure this value in "option"->"calibrate"->"I charge"->"100mA":

- press "inc","dec" until measured current is the lowest possible but bigger than 0mA.
- press "stop" to exit (don't save this setting!)

(7.3-5) LiXX := LiPo, LiFe, LiLo, L430, L435

## 7.4. UART settings [USxxx]

Column Id	Name	Description	Charger type
[US001]	UART:	 enable UART, should be "disabled" or "normal"	All
[US002]	speed:	 UART speed	All
[US003]	UART inp:	 UART input: temp: temperature connector pin7: M0517 pin 7 (charger needs modification)	M0517

## 8 Batteries types and voltage limits

Battery type	V idle	V charge	V discharge	V storage	V valid empty
NiCd	1.200	1.800	0.850	0	0.850
NiMH	1.200	1.800	1.000	0	1.000
Pb	2.000	2.450	1.750	0	1.900
LiFe	3.300	3.600	2.000	3.300	3.000
LiLo	3.600	4.100	2.500	3.750	3.500
LiPo	3.700	4.200	3.000	3.850	3.209
Li430	3.700	4.300	3.000	3.850	3.209
Li435	3.700	4.350	3.000	3.850	3.209
NiZn	1.600	1.900	1.300	1.600	1.400

# 9 UART functions

To Be Completed