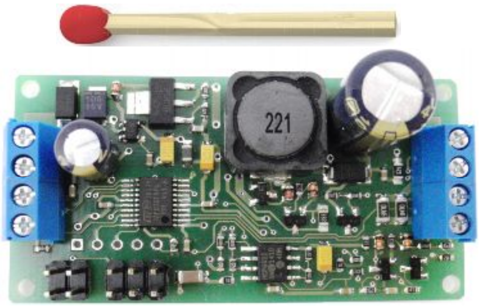
AMEX

Research
Development of Electronics
Prototyping
Microcontroller education systems

Model No.: NHC-01

Smart Charger Module for NiMH Battery Packs

(Rev. 2.0)



DESCRIPTION

The NHC-01 is a professional, processor-controlled charger module for NiMH battery pack for AA and AAA cells (1000…2800 mAh) intended to build into mobile devices, mobile educational robots and other apparatus. It has the possibility to set different charge currents and number of cells. This charger module can charge 2..8 pcs series NiMH battery.

Because of small dimensions of the NHC-01 (60 mm x 30 mm x 17 mm) it is ideally suited to build into many devices (for OEM and DIY) which normally require inconvenient and frequent removing of battery cells from battery holder and moving them to an external charger. The possibility of building the NHC-01 charger module into different devices is very unique, practical and economical solution for many users and designers in the field of electronics and robotics.

The NHC-01 charger module requires only external power supply (AC/DC adapter or other power supply source; (230VAC/9..18VDC, 1.5A). The charger module employs several algorithms to detect the end of the charge. They ensure high reliability and make the battery to be fully charged without the risk of overheating and overcharging. Configuring the charger is very simple and boils down to proper setting of jumpers build into the charger.

Indication of current work mode is signaled by a LED diode. It is also possible to connect an optional NTC thermistor to measure temperature of the battery cells. The thermistor ensures the most accurate detection of the end of charge at higher charge currents.

FEATURES: Smart DC Charger Module for OEM and DIY

Basic NHC-01 parameters:

- Charging current: 125 mA, 250 mA, 500 mA, 1000 mA
- Cell capacity: 1000..2800 mAh (cells are connected in series)
- Number of cells: 2, 3, 4, 5, 6, 7, 8 (2.4V – 9.6V)
- Power supply voltage: 9..18 VDC (from external power supply : 230V AC/9..18 VDC, 1.5A)
- Small dimension (LxWxH): 60 mm x 30 mm x 17 mm
- Ambient operation temperature: 0°C to +40°C
- Ambient operation relative humidity: 20% to 85%
- Applications: excellent for building in battery charging function inside your device or build your own battery pack charger

Examples of use:

- mobile robots
- measurement instruments
- mobile devices

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NiMH battery charging methods

Basically, charging of NiMH cells is performed by injecting constant current for a given period of time. The higher the current the shorter the charging time. Additionally, the charger monitors voltage across the cells and as an option their temperature. Depending on the charging current value the cells voltage may change differently. Proper detection of NiMh cells voltage is very important at higher charging currents (0.5..1C; C – cell capacity). The NHC-01 uses different end-of-charge detection algorithms depending on charging current.

To assure reliable charging, NiMH chargers must include electronic filtering to compensate for noise and voltage fluctuations induced by the battery and the charger. NHC-01 smart charger module achieves this by combining NDV (Negative Delta V), voltage plateau, delta temperature (dT/dt), temperature threshold and time-out timers into the full-charge detection algorithm. These "or-gates" utilize whatever comes first depending on battery condition.

Standard charging with current 0,1C (also called "overnight charging")

This charging method is the simplest and basically does not require any precise measurement circuits. Charging is performed by forcing constant current with a value of 0.1C for 14..16 hours. This method was very common in NiCd battery chargers (it is also used to charge NiMH batteries). Because of low charge current there is almost no risk of overheating and overcharging even though the battery will not be disconnected from the charger for much longer time. However, the big disadvantage of the method is quite long charging time which is unacceptable in many cases.

When low charging currents are selected (125 mA and 250 mA) the –dV detection is extremely difficult or not possible at all, because the voltage drop value is incredibly low. The only way to detect the end of charging is to measure voltage across the cells pack (the cells are connected in series). Additionally, charging time is counted by a timer. When time expires the charging process is stopped even though the required voltage across the cells pack is not yet reached (too low voltage may indicate battery worn-out or damage)

Fast charging

In order to fast charge a NiMH cell high current with a value of 0,5..1C is used. NHC-01 charger module uses current of 1A to charge AA cells and 0.5A for AAA ones. High charging current shortens the entire process to 1..3 hours. However, this approach requires precise detection of cells voltage changes and optionally cells temperature because high charging current can easily cause overcharging and overheating that can destroy the cells and even lead to explosion as a consequence.

When fast charge is used, the cell voltage initially rises and when the cell is almost fully charged the voltage value is stabilized for a short time (see Fig. 1). Then the voltage starts to drop slightly ("-delta-V" algorithm) . At the same time the temperature of the cell starts to rise rapidly (typically 0.8..1.5°C per minute – it is used in "delta-T" or "dT" algorithm). The voltage drop is very low and it is typically in the range of 5 to 10 mV per cell (depending on the charging current).

The above phenomenon is a sign that the cell is fully charged. However, to detect such low voltage drop is very difficult task because of external noise, power supply voltage fluctuations and errors introduced by measurement circuits. The voltage drop is very low relative to high cell voltage which makes its detection even more difficult. Because of that, it is recommended to use a temperature sensor attached to the cell. NHC-01 has an additional connector to install NTC 10kΩ thermistor ($B_{25/85}$=3691 K). Thermistor installation is described further.

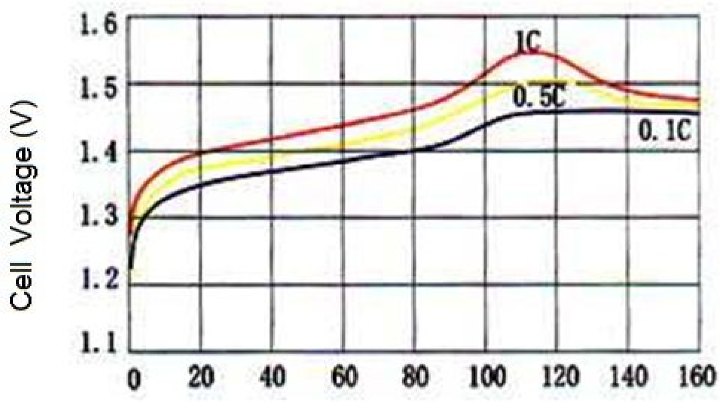


Fig. 1. An example of cell voltage waveform at different charging currents

The –delta-V (or –dV for short) is precisely and reliably detected by the NHC-01 thanks to the use of proper analog and digital filtering and precise measurements of the cells voltage. Digital filtering allows to reject false –dV which can occur due to sudden changes in the power supply voltage value and noise that can be present in the battery wires.

Overcharge protection

Under normal conditions (fast charging) charging process is stopped when –dV reaches 8 mV per cell or dT reaches about 0.8...1.5 C/minute. However it may happen that –dV or dT are not detected.
In such case there must be some other ways to detect the end of the charging. The charger constantly measures the voltage across cells packet. If the voltage reaches about 1.7V per cell the charging is stopped. When the thermistor is used and appropriate dT value is not detected the charging is also stopped when the temperature reaches 55°C. Additionally, a timer is employed to count charging time. The timer has the highest priority in deciding of stopping the charging. When the time expires the charger turns off the current regardless of –dV, dT and overall voltage across cells pack.

Short circuit and overload protection

NHC-01 has built-in output overload and short circuit protection. The protection is activated when charging current exceeds 1.5 A. Then the charging is turned off for 2 seconds. After this time the charging is turned on again (it is a “hiccup” mode protection). When the overload or short circuit is detected again the cycle repeats. As long as the failure condition is detected the timer is frozen.

<u>It should be noted that the protection is usable only for the charger output itself. It does not protect the charged battery against short circuit which can cause very large currents to flow through the battery.</u>

Work mode indicator

NHC-01 can work in several modes which can be signaled by LED diode indicator. The LED does not require current limiting resistor as it is built into the charger PCB and it has value of 330 Ω. The LED supply voltage is 3.3V (typ.).

Four work modes are defined:

- no charging (LED is off)
- charging (LED lights continuously)
- short circuit or overcharge (LED blinks fast with a frequency of about 3 Hz)
- end of charging (LED blinks slowly with a frequency of about 0.5 Hz)

The LED diode signal can also be used to connect to external circuits for example microcontrollers, processors etc.

Table 1. NHC-01 charging methods

Charging current	Charging mode	Full charge detection methods used	Max. charging time	Max. cell voltage (note 2)
125 mA	standard (for AAA cells)	timer, max. voltage across cells packet, max. cell temperature (note 1)	16 h	1,55 V
250 mA	standard (for AA cells)	timer, max. voltage across cells packet, max. cell temperature (note 1)	16 h	1,55 V
500 mA	fast (for AAA cells)	timer, max. voltage across cells packet, max. cell temperature, dT, -dV (note 1)	3 h	1,7 V
1000 mA	fast (for AA cells)	timer, max. voltage across cells packet, max. cell temperature, dT, -dV (note 1)	3 h	1,7 V

NOTES:

1) **Maximum cell temperature and dT method are used only when thermistor is used. The thermistor is detected automatically when the charging process starts. The thermistor is not required but is highly recommended when high charging currents are used (500 mA and 1000 mA)**
2) **Maximum voltage across cells pack is equal to number of cells multiplied by max. cell voltage**

It is recommended to use a proprietary battery packs made of selected NiMH cells.
The selection among others is based on a choice of NiMH cells with similar internal resistance. It guarantees similar voltage values across the cells during charging. Internal cells resistances have different values among different manufacturers. It makes different voltages to appear across cells pack in the final charging phase. The voltage across cells pack also depends on charging current.

Powering the NHC-01

It is best to use stabilized external power supply source with output current higher than 1A. The use of non-stabilized power supply is not recommended as its output voltage depends on load current and may exceed the allowable power supply voltage range accepted by the charger. Non-stabilized power supply output voltage contains ripple that may substantially disturb charging process. The minimum value of power supply voltage required depends on the number of cells selected (see Table 3).

Table 2. NHC-01 parameters

Parameter	min	typ.	max	unit
Power supply voltage (note 5)	9		18	**V**
quiescent current (note 1)		22	32	**mA**
charging current (note 4)	125		1000	**mA**
charging current deviation	-6		+6	**%**
output voltage for LED diode (note 2)	3		3,3	**V**
overload/short circuit protection threshold		1.5		**A**
number of cells	2		8	**pcs.**
required thermistor resistance (note 3)		10		**kΩ**

NOTES:

1) Power supply current drawn by NHC-01 without cells pack
2) LED output is equipped with internal built-in current limiting resistor (330 Ω)
3) Thermistor is optional but it is recommended when 500 mA or 1000 mA charging currents are used.
4) Charging current is set by jumpers and can have the following values: 125 mA, 250 mA, 500 mA and 1000 mA (see charger installation description)
5) The actual power supply voltage value depends on number of cells chosen (see charger installation chapter)

Typical installation of the NHC-01

Figure 2 shows typical installation of the NHC-01 charger module (see notes below the picture). If the charger module is to be built into mobile robot for example the use may want to mount a two-position switch (ON/OFF-Charge) and a socket for power supply (AC/DC adapter) – see Fig. 3.

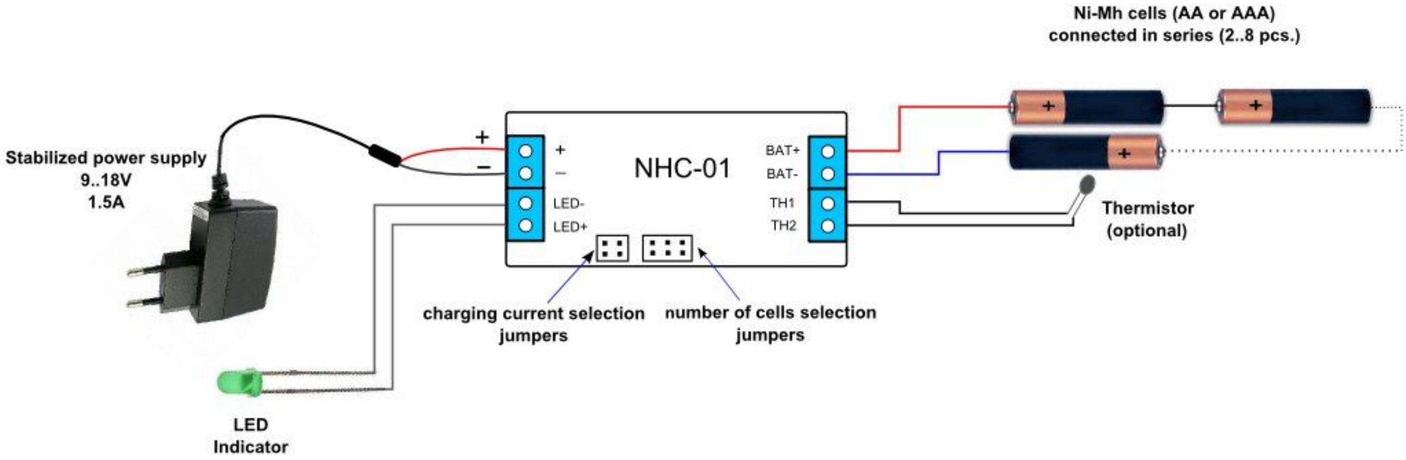
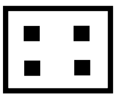


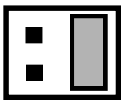
Fig. 2. Typical installation of the NHC-01. Thermistor should be placed inside the cells packet (between two cells and must strictly adhere to one of the cells). LED diode should be visible to the user (for example on the panel of the device

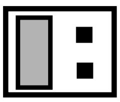
Precautions

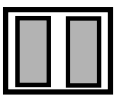
- *Jumpers should be set before powering up the charger. When charging takes place, changing jumpers setting will have no effect.*
- *Ambient temperature should* ***not*** *be higher than +40° C when using the charger module.*
- *Use short wires with proper cross-section to connect battery to the charger. Too long or too thin wires will add unwanted voltage drop which can cause charging process stop prematurely.* ***Total resistance of battery wires should not be higher than 0.05 Ω.***
- *Remove the AC/DC power before connecting or disconnecting the battery pack.*
- *Some components in the charger module may become hot when charging current is set to 1000 mA. It is absolutely normal and should not arouse a concern.*

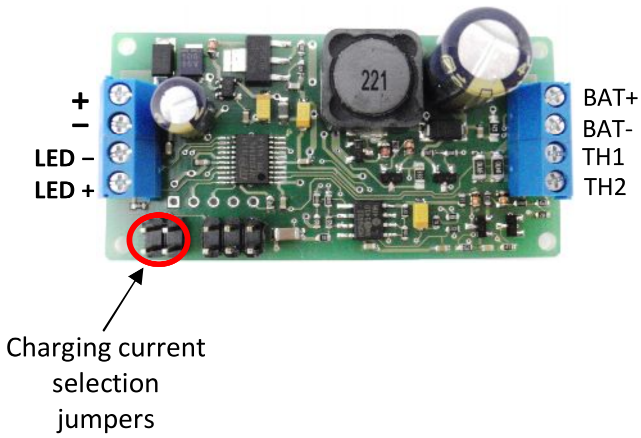
Charging current jumpers setting:
(NHC-01 top view as shown below)


125 mA

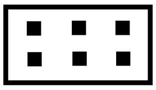

250 mA


500 mA

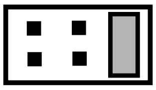

1000 mA



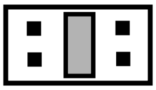
Number of cells jumpers setting:
(NHC-01 top view as shown below)



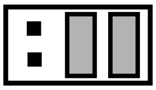
2 cells



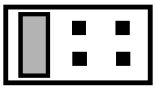
3 cells



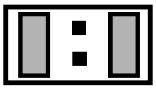
4 cells



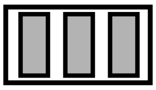
5 cells



6 cells



7 cells



8 cells

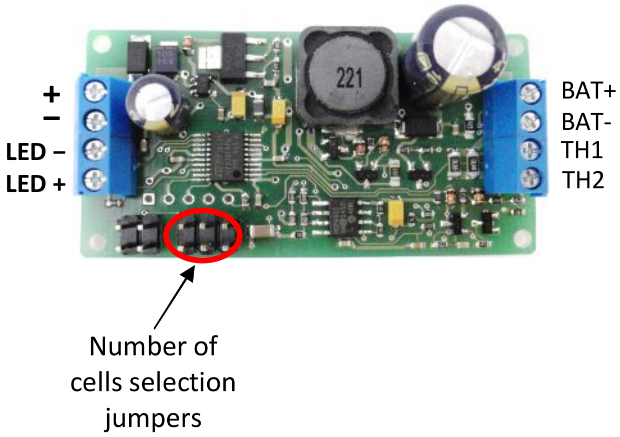


Table 3. Minimum power supply voltage vs. number of cells

Number of cells	Minimum power supply voltage of the NHC-01 charger
2	9 V
3	9 V
4	10 V
5	11 V
6	12 V (see note below)
7	15 V
8	17 V

Note: some NiMH cells may require higher voltage (min. 13 V)

Final remarks concerning NHC-01 charger module usage

Before charging the battery the user should set appropriate number of cells and charging current. Incorrect selection of the number of cells can cause overcharging or undercharging. Thermistor is an optional component and when it is used it must strictly adhere to one of the cells (it should adhere to the cell which is in the middle of the pack at best)

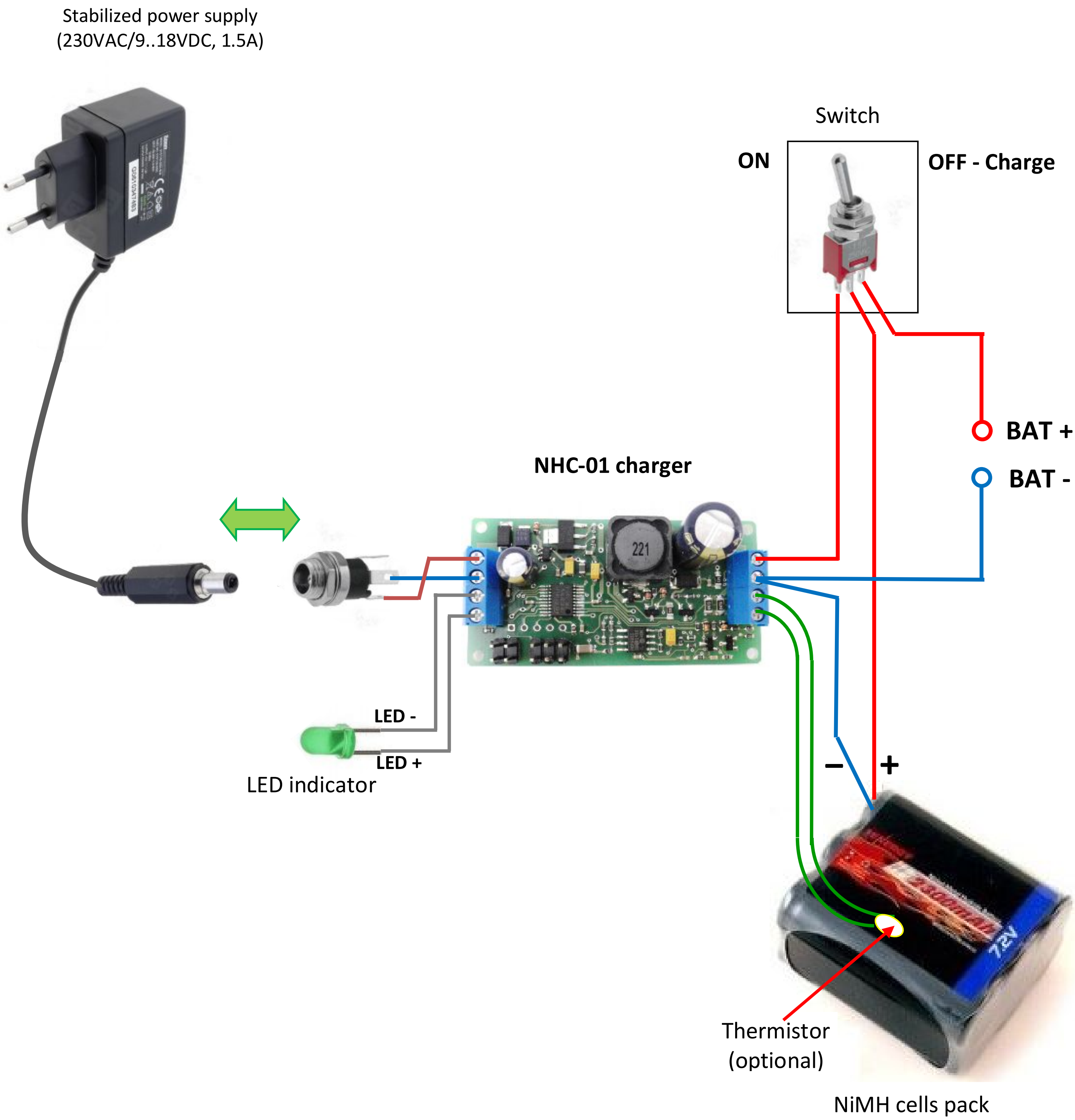


Fig. 3. Schematic diagram of the NHC-01 equipped with external power supply, power supply voltage connector, NiMH battery pack, thermistor, LED diode and a switch

If the two-position switch is in **ON** position (Fig. 3) then the battery voltage is present across BAT+ and BAT- terminals. When the switch is in **OFF** position (charge) then charging will start when power supply is connected to the power supply connector. When charging is finished (it is indicated by slowly blinking LED) <u>it is necessary to disconnect the power supply from the charger</u>. The power can be drawn from the battery when the switch is **ON** position.

Example of using NHC-01 charger for charging NiMH battery pack