1.2V NiMH cell charger.

Background

Each Nickel Metal Hydride (NiMH) cell is different.
Many NiMH battery chargers connect two or more cells in series so that they can be charged from a higher voltage. For this to be successful, there is the assumption that each cell is identical and needs to receive the same amount of charge. In practice, this is rarely the case and can lead to one cell being overcharged while others are undercharged.
The situation is even worse when 10 NiMH cells are connected in series to form a 12V battery. After a few charges, the battery will not be able to hold its full charge and in extreme cases, the terminal voltage will become less than 12V as one or more cells become reverse polarised. This results from discharged cells in the battery passing a large current when in use.

This charger treats each cell individually and so is able to ensure that each cell becomes fully charged.

Charging NiMH cells.

A NiMH cell, irrespective of capacity, has a nominal terminal voltage of **1.2V.**
A NiMH cell should be considered as **fully discharged** if its terminal voltage is **0.9V.**
Discharging a cell more than this can cause damage to the cell.
It is not necessary to fully discharge NiMH cells before recharging.
For long life, NiMH cells should be charged at 0.1C, where C is the capacity of the cell in milliAmp Hours (mAH). This will take up to 15 hours.
When charging at 0.1C, the cell will be **charged** when the cell's terminal voltage is **1.45V.**

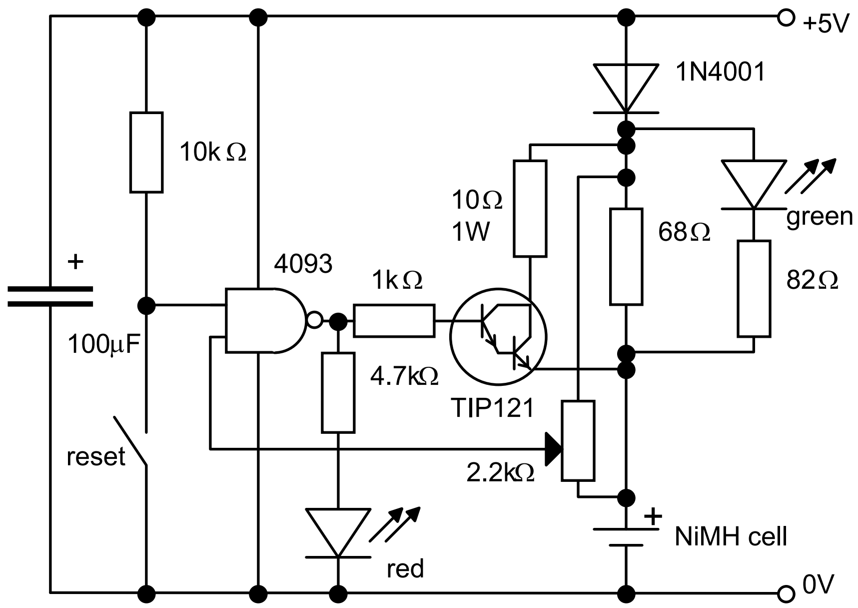
Quick charging (0.3C) and fast charging (1C) result in much shorter charging times (4 hours) and (1hour) but can easily result in damage to the cells from excess temperature (>45 - 50°C) if not properly monitored.

Once a cell is fully charged, it can be continuously trickle charged at 0.01C 0.03C without incurring any damage.

Specification

Charges 2000mAH to 2500mAH NiMH cells individually.
Operates from a 5V supply. (E.g. a USB port.)
End terminal voltage is 1.45V
Maximum charging current 0.25A
Short circuit protected (0.45A)
Trickle charge current ~50mA
A red LED indicates that the cell is charging at ~0.25A.
A green LED indicates that a cell is connected and trickle charging.

Circuit diagram



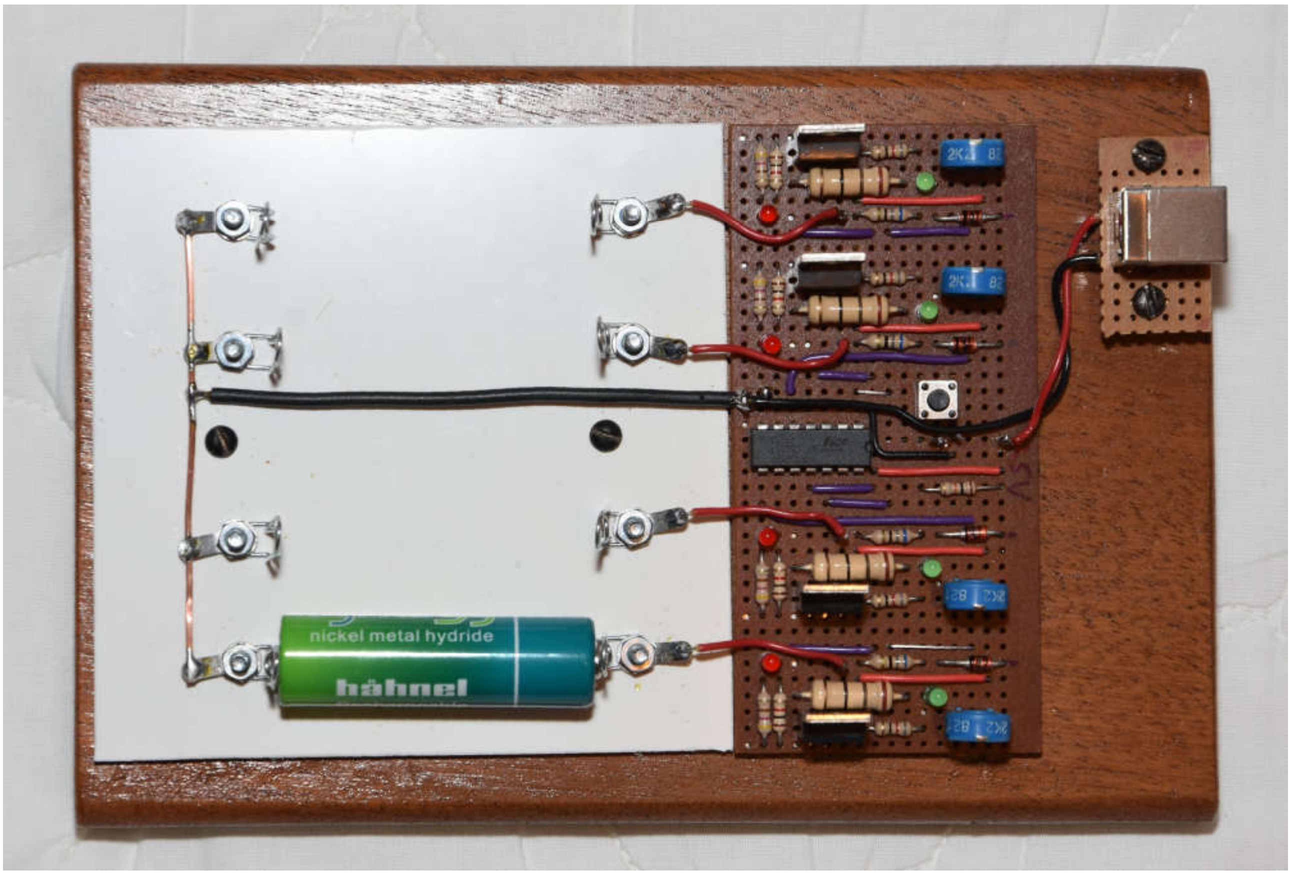
How it works

The diagram above shows the circuit for charging one 2400mAh cell. Since there are four Schmitt NAND gates in a 4093 IC, four of these can be constructed with just one IC.
The 1N4001 isolates the charging circuit from any others operating from the same 5V supply. (Any of the 1N400x family are suitable.)
The 68Ω resistor and the green LED/82Ω resistor provide the trickle charge current.
The green LED will light whenever there is a cell connected to the circuit.
The NAND gate has Schmitt trigger inputs. When operating from a 5V supply, the upper switching level is typically 2.9V and the lower switching level is typically 1.9V (TI data sheet). (The actual values do not matter in this circuit.)
If the wiper of the 2.2kΩ preset pot. is less than the upper switching level, then the output of the NAND gate will be ~5V. This will switch on the red LED and the TIP122 darlington pair transistor which allows current to flow through the 10Ω resistor. This supplies the main charging current for the cell.
As the cell charges, the voltage across the cell increases until the voltage at the wiper of the 2.2kΩ preset pot. exceedes the upper switching level of the NAND gate input. The output of the NAND gate will go low, the red LED and the TIP122 will switch off and the cell will continue to trickle charge.
(The TIP122 can be substituted for any darlington pair transistor with a collector current greater than ~500mA.)

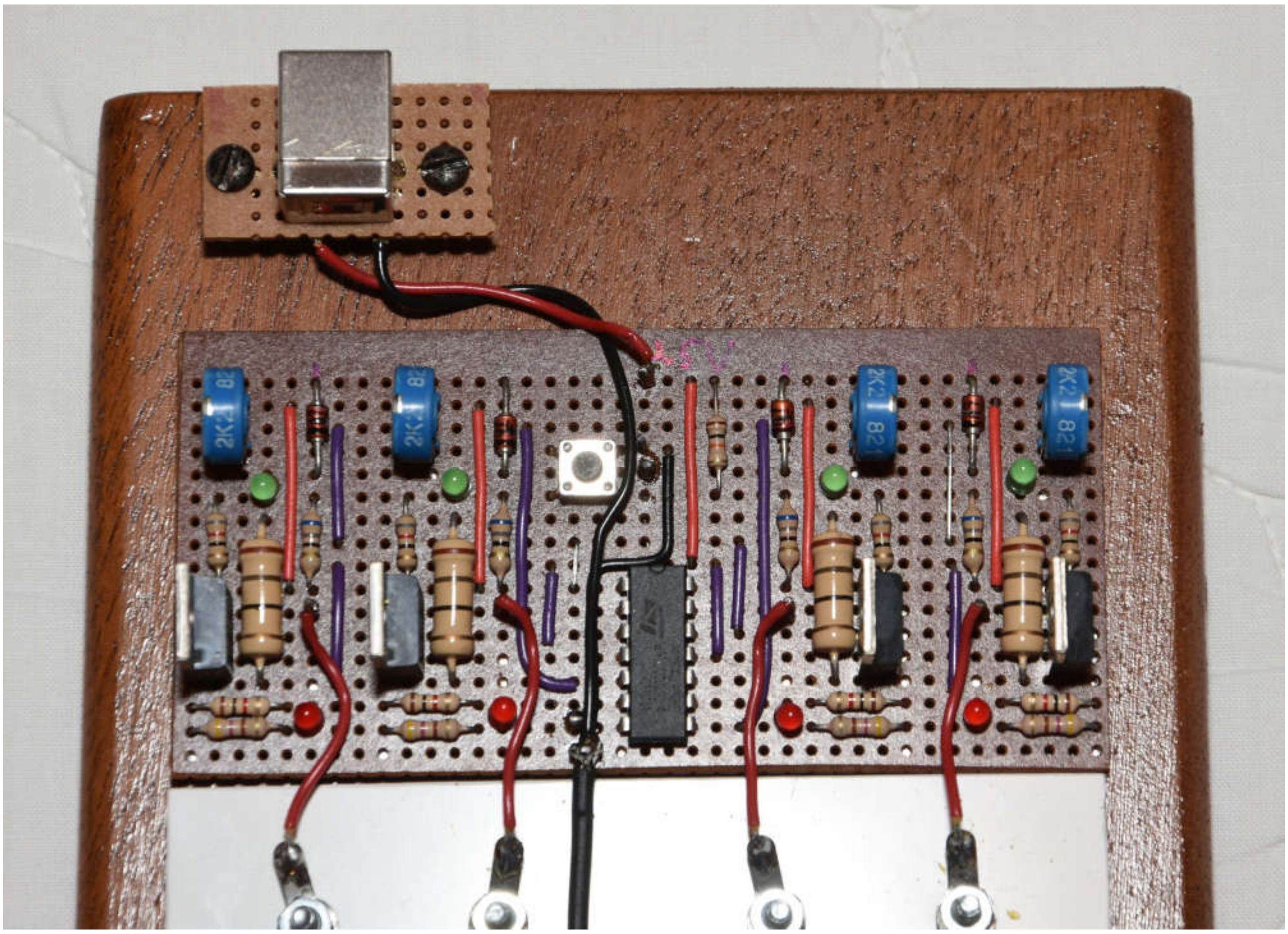
When most cells are initially connected to the circuit, the voltage at the wiper of the 2.2kΩ pot. will not be below the lower switching level of the NAND gate. Charging is started by pressing the reset switch, which forces the output of the NAND gate to ~5V so switching on the main charging current.
(The overall value of the 2.2kΩ pot. is not critical - these were available. Most values greater than 1kΩ should work well.)
If the red LED lights when a cell is first connected, then either it is very discharged or damaged and should be inspected for short circuits.

Calibration.

After construction and testing, the 2.2kΩ pot. needs to be set so that the main charging current switches off when the voltage across the cell is 1.45V.
This can be achieved by placing an almost charged NiMH cell in the circuit and adjusting the 2.2kΩ pot. so that the red LED switches off when there is 1.45V across the cell.
Keeping the reset switch pressed, will keep the main charging current passing and can be useful when making the adjustments.
Once the 2.2kΩ pot. is set, no further adjustment is necessary.



The terminals for the cell holders were made from bent 22.5mm paper clips, bolted onto a sheet of plastic.



The reset switch is above and slightly to the left of the 4093 IC.