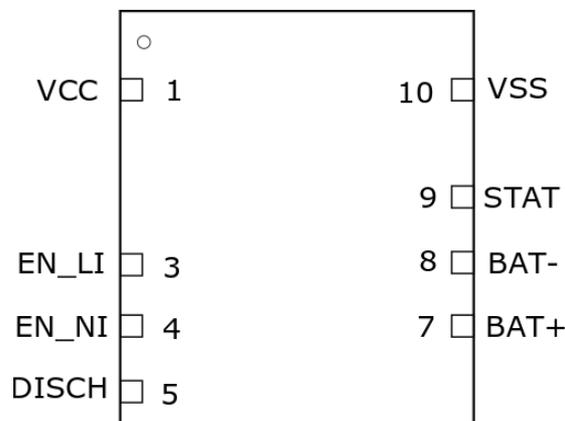


Carest Charging module for rechargeable battery ACM1801C

The charging module is designed for charging and discharging single-cell lithium-ion (LiON) batteries and nickel-metal hydride (NiMH) batteries.



Pic.1 Schematic view ACM1801C.

Table 1. Contact overview ACM1801C:

PIN		Input/Output	Description
NAME	NUMBER		
VCC	1	Input	Supply voltage. Connects directly to the positive terminal of the charge source.
EN_LI	3	Input	Switch on the charging of the Li-Ion battery.
EN_NI	4	Input	Switch on the charging of the NiMH battery.
DISCH	5	Input	Switch on of the discharge of the battery.
BAT+	7	Input	Positive battery terminal.
BAT-	8	Input	Negative battery terminal.
STAT	9	Output	Charge status output.
VSS	10	Input	GND Connects directly to the negative terminal of the charge source.

Table 2. Absolute maximum ratings.

Supply Voltage, VCC	-0.3...+25V
Inputs voltage range EN_LI, EN_NI, DISCH, BAT+, BAT-	0.3...6V

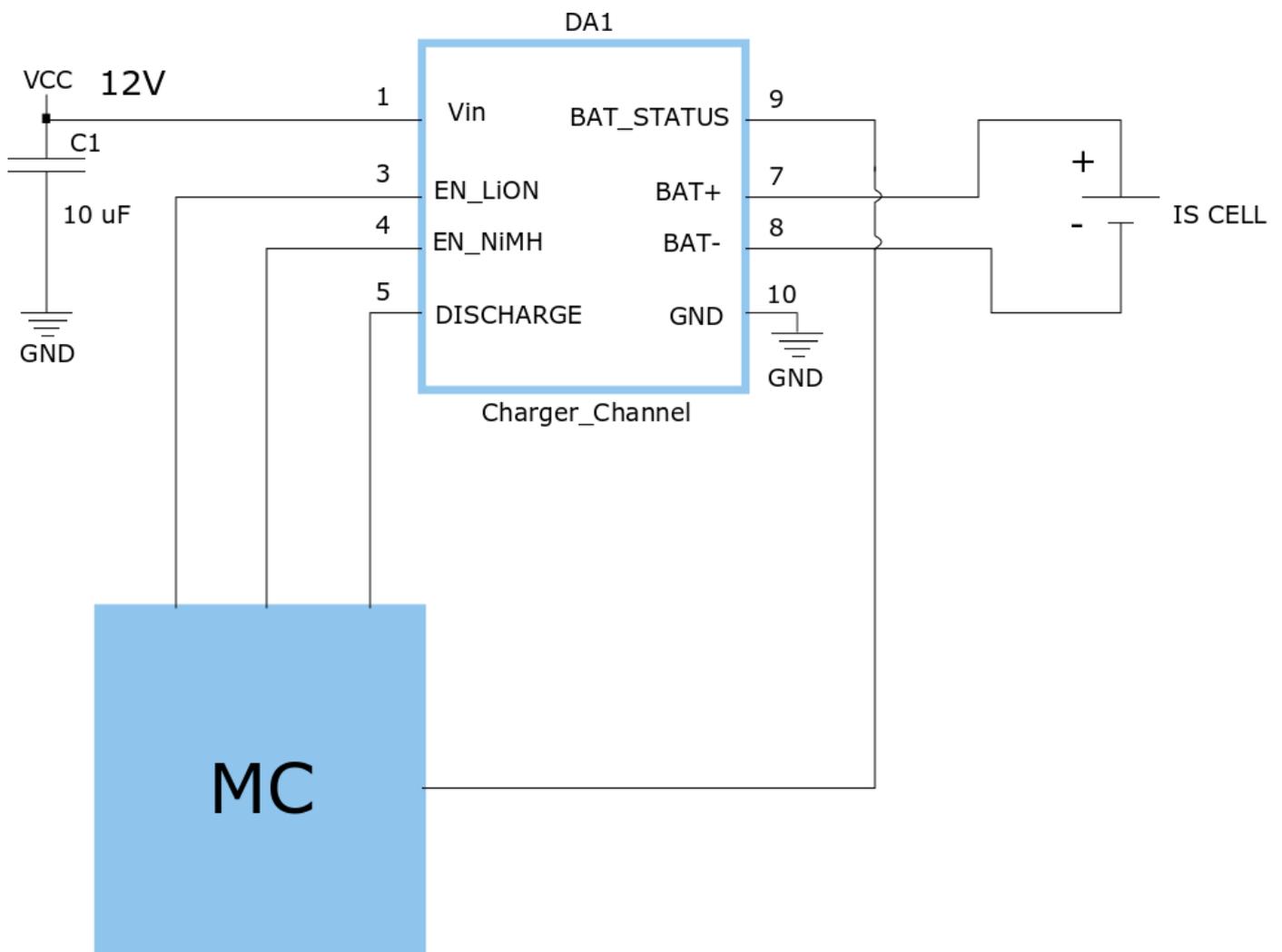
Table 3. Recommended operating conditions.

Supply voltage, VCC	12...24V
Input voltage range EN_LI, EN_NI, DISCH	3.3...5V
Input voltage range BAT+, BAT-	0...4.2V

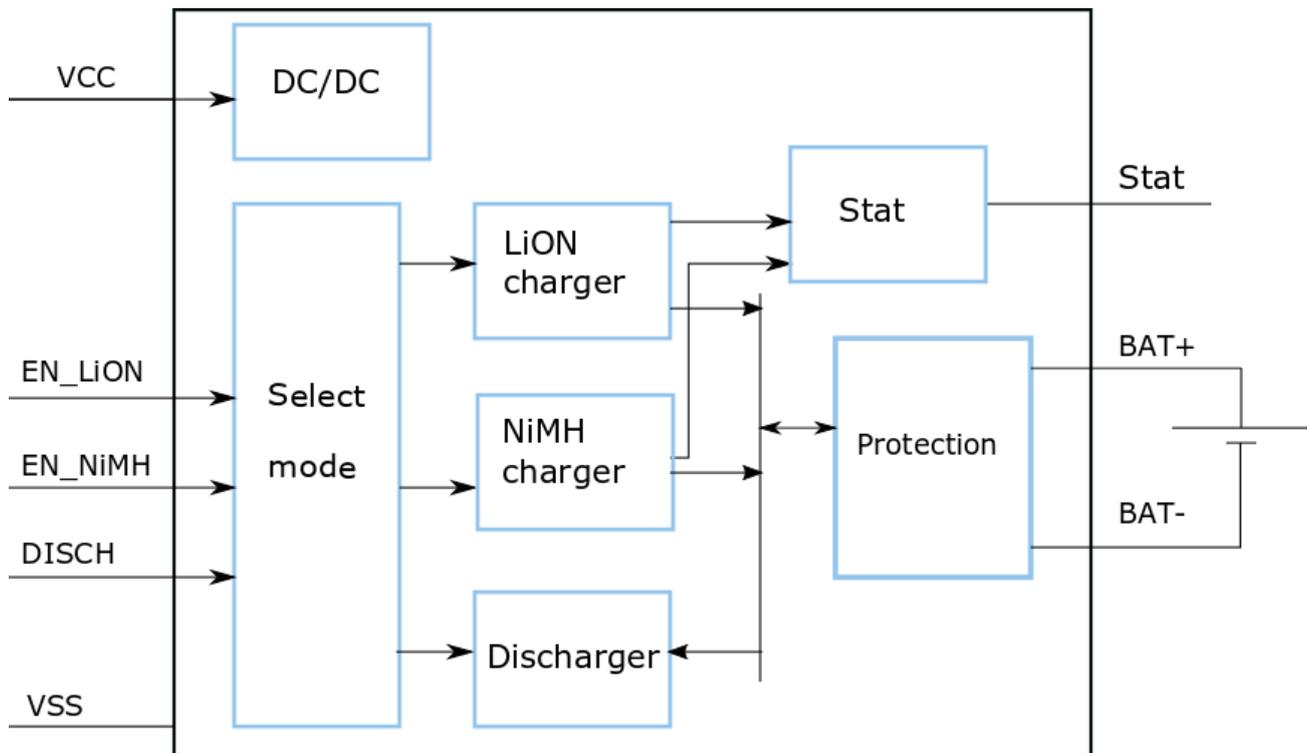
Table 4. Electrical Characteristics.

	Minimum	Maximum	Units
Output current when charging Li, NiMH	0	0.5	A
Output current in En_li operation mode, supply of external circuit.	0	0.5	A
Input current, I_{in} , (Vcc=12V)	0	0.25	A
Input current EN	-	0.45	mA
Input current Disch	-	0.3	mA
Output current status, Li Ni	-	40	mA
	-	20	mA
Current consumption when off	-	0.2	mA
Current consumption in Li-Ion mode	-	7.5	mA
Current consumption in NiMH mode	-	1.5	mA
Current consumption in charging mode	-	0.5	mA
ΔV for NiMH	3		mV
Temperature mode	-40	+85°C	°C

	Minimum	Maximum	Units
Input voltage EN_Li, EN_NI - low	0	0.6	V
Input voltage EN_Li, EN_NI - High	2	5	V
Output Voltage when charging in progress Li-Ion, BAT+	4	4.2	V
Output Voltage when charging in progress NiMH, BAT+	0	1.7	V
Output Voltage, Status, low level (logical 0)	0	1	V
Output Voltage, Status, High level (logical 1)	3	4.7	V



Pic.2. Connection scheme.



Pic.3. Main circuit nodes scheme ACM1801C.

Operation description ACM1801C

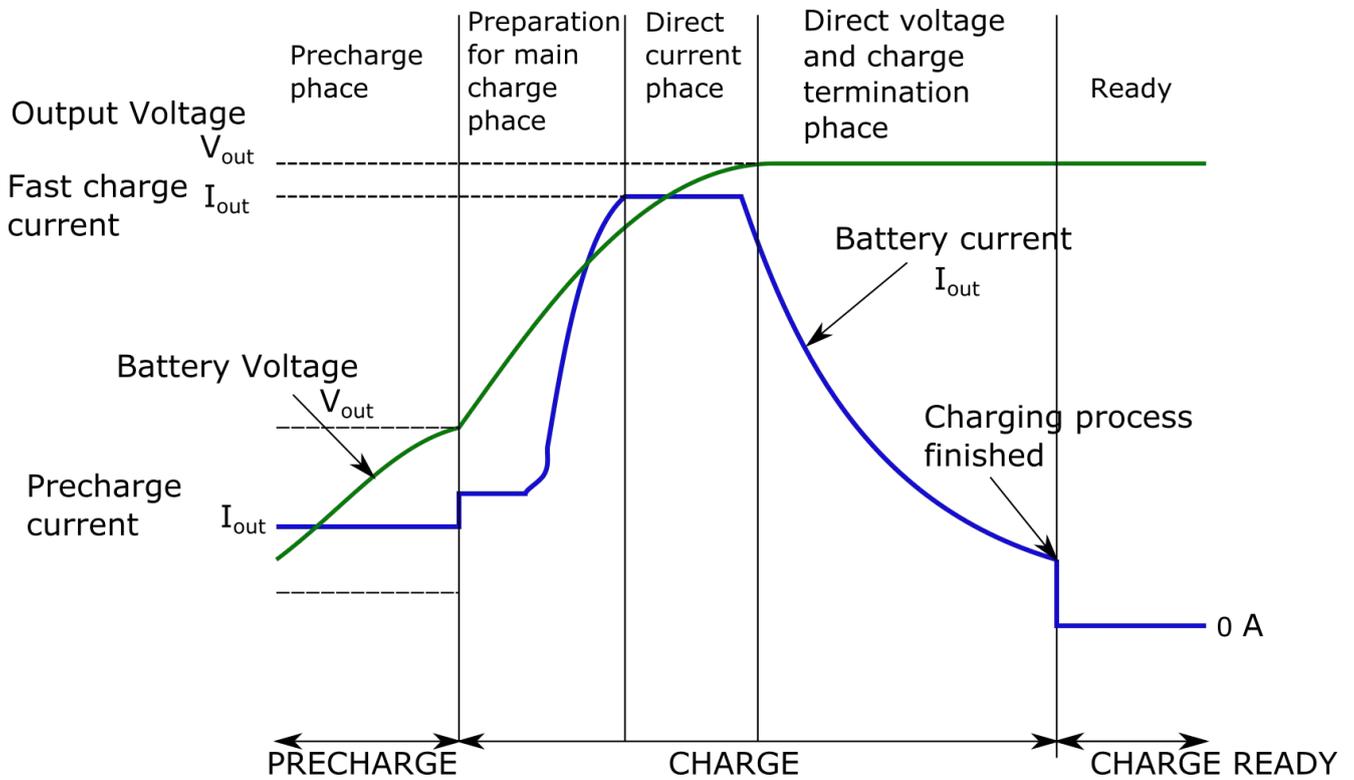
Charge of Li-Ion Battery

ACM1801C contains a charging unit for one Li-Ion or Li-Pol battery cell (then simply Li-Ion). The ACM1801C device can be used not only to charge batteries but also to power an external circuit (external voltage should be set to 4V). The charging process of the Li-Ion batteries divided into several steps. On each step of the charging the voltage outputs and inputs are monitored and controlled. If the supply voltage gets lower than 3.3V, the charge circuit enter in low consumption mode, the charging at this moment stops. The charging cycle starts if the supply voltage is correct, as well as the battery is present and in good condition.

The charging device has two main charging phases: precharge and main charge. The charging unit protected against exceeding battery voltage, temperature and short circuit. The precharging process takes place at the minimum current, until the moment the voltage of the battery is not within the permissible limits for the next stage of the charge. The precharging process allows the use the full capacity of the battery.

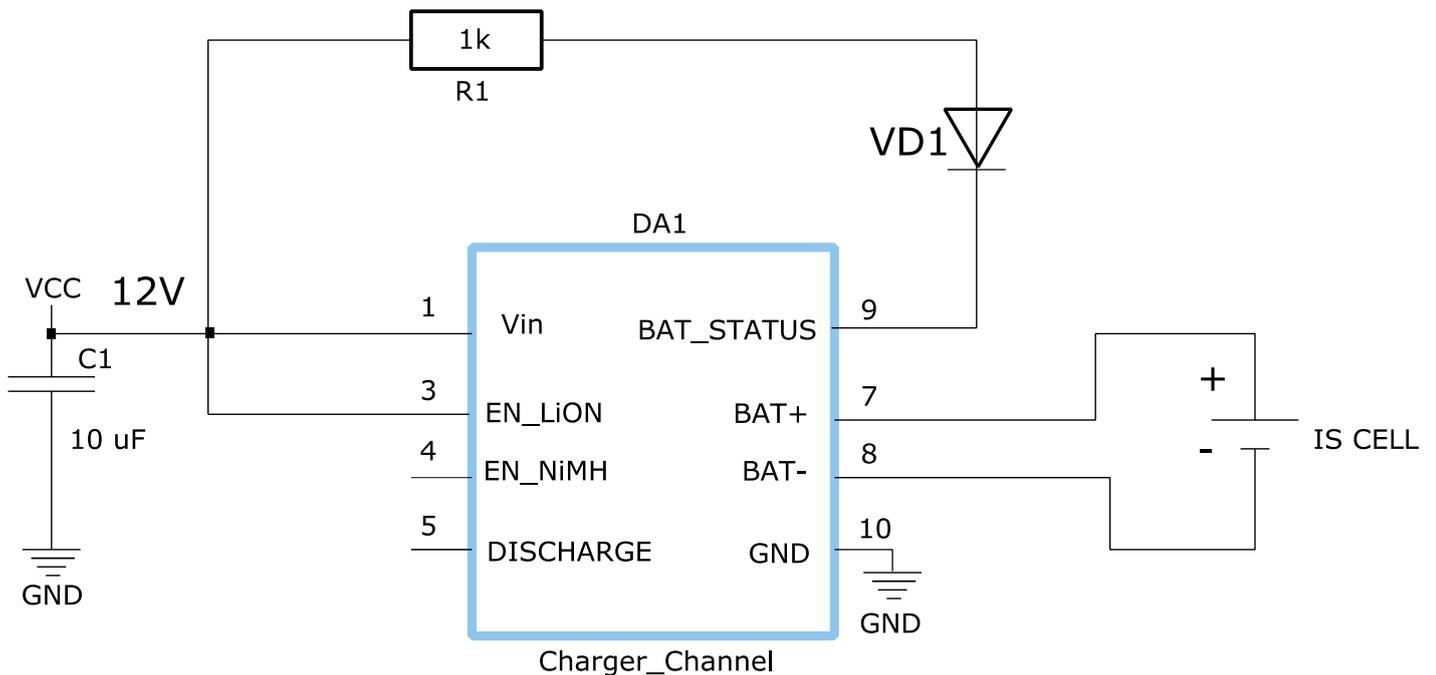
The main charge process divided into 3 stages: preparation, charge by direct current and charge by direct voltage, thus allowing reaching full charge fast and safely. When on preparation stage the nominal current value is raised until the nominal value as well as the voltage. From this point forward the current is being limited and the voltage is slowly dropping, at the end of the charge it reaches the minimum value. Which signals that it is the end of the charging process.

The precharge is limited by a timer to 30 min. The main charge is limited by a timer to 10 hours. If the timeout of 30 min or 10 hours is due then the charging process stops.



Pic.4 Charge profile of the Li-Ion battery.

To indicate the end of the charge the status output is used (BAT_STATUS). For this a LED needs to be connected to this output.



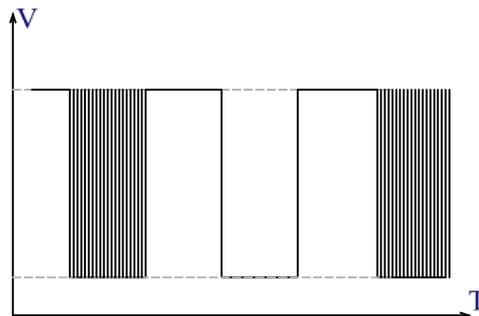
Pic 5. Use of STAT output for charge status.

Charge of NiMH battery

ACM1801C implements an impulse charge algorithm. It is important to note that before turning on the charging module (EN_Ni in high state), the battery must be inserted.

The ACM1801C has several charging phases for NiMH batteries: "Precharge", "Fast charge", "Final charge" and "Saving".

When the battery is inserted, located by the device and its supply voltage is in the correct threshold, the ACM1801C goes into "Precharge" mode and starts testing the battery. This allows to prevent the "Fast charge" of old depleted batteries. The precharge process is set for a low speed charge until the cell reaches 1V. ACM1801C precharges the battery while regulating the voltage descend with a sensitive resistor up to 113mV. The device charges in impulse mode, the voltage is supplied to the battery 25% of all the time. All the other time the battery is disconnected from the power supply and it's voltage is measured. The STAT output while in "Precharge" signals the current charge state with a rectangular voltage, with 1Hz frequency. If the voltage of the cell is higher than 1V during 30 minutes then the ACM1801C goes into the "Error" state. If the ACM1801C is in "Precharge" state and is detected that the battery charge is higher than 1,75V then the device determines that the cell was extracted or is defective and enters in "Error" state. On the pic.6 is presented the operation chart of the switching on the internal generator.



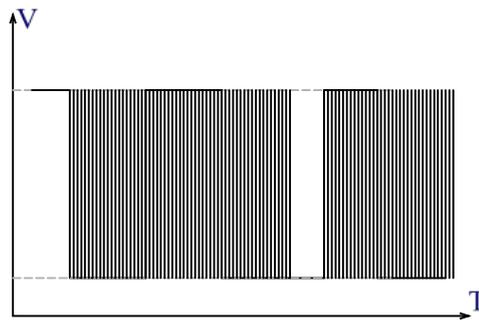
Pic.6. Operation mode "Precharge".

After this the ACM1801C switches to "Fast charge", which includes testing the battery to exclude charging by mistake an alkaline element or NiMH elements that are worn out or damaged. Fast charging continues as long as all battery health criteria are met. The fast charge ends on $-\Delta V$ method (negative delta voltage) - the voltage on the battery gets decreased when the battery charge is full. When the device is in "Fast charge" mode it regulates the voltage on the measurement resistor up to 113 mV.

On the STAT output is set a high voltage. In "Fast charge" mode the device tests the battery every 31 sec. by checking the external voltage from the battery with it's internal resistance and voltage. This measurements are compared with the previous values. The maximum cell voltage while charging is saved. If the cell voltage falls more than 3 mV ($V-\Delta V$) from it's maximum value, then the "Fast charge" is finalized and it switches to "Final charge" mode.

ACM1801C also switches to "Final charge" mode if the battery voltage doesn't go over the maximum value for 16 minutes. The voltage of a separate battery is compared with a charged battery

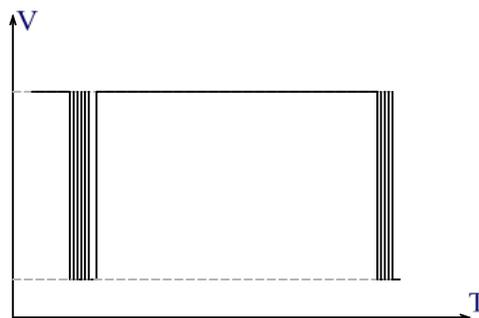
voltage. The difference is compared with the impedance threshold. If the difference is higher than the threshold value then the cell impedance is considered to be too high to charge and the ACM1801C switches to “Error” status. As an additional protection from overcharging ACM1801C ends “Fast charge” mode and switches to “Final charge” after 2,5 hours. If at anytime in “Fast charge” the voltage on the battery goes over 1,75V, the ACM1801C determines that the cell is either overcharged or was extracted and switches to “Error” status. On pic.7 is presented the operation chart of the internal generator in “Fast charge” mode.



Pic.7 “Fast charge” operation mode.

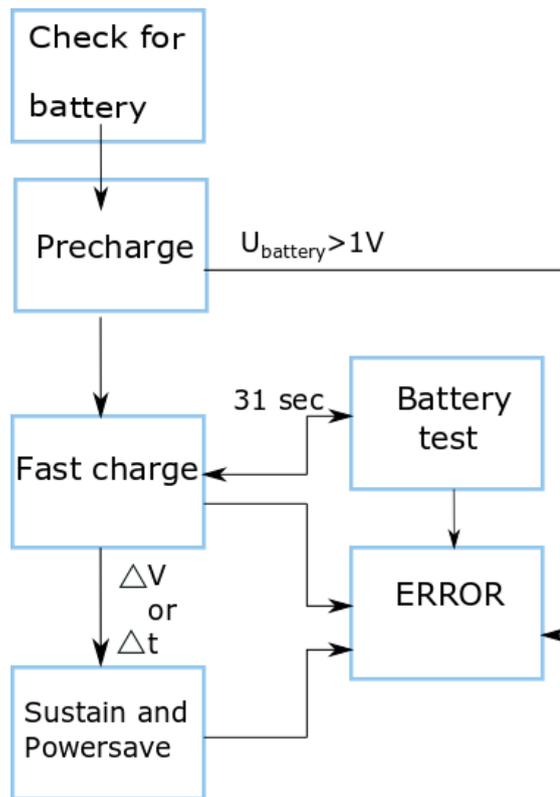
For a full charge the “Final charge” phase is used. In this state the ACM1801C charges the battery with impulses with 25% of the speed of “Fast charge”. While charging the ACM1801C monitors the charge and the maximum battery voltage. If an error occurs while charging the ACM1801C switches to “Error” state and the charging process stops.

STAT output is off. The cell charge is maintained for an indefinite period by continuing to charge the battery by impulses with a duty-cycle of 1.56% of the total charge time. On pic.9 is presented with an operation chart of the internal generator.



Pic. 9 Operation mode “Powersave”

In “Error” state, charging is switched off to avoid ruining the battery, on the STAT output a 4 Hz signal is given.



Pic.10 NiMH charging algorithm.

Discharge module

The discharge module is designed ONLY for NiMH batteries. The use of this device for the discharge of LiON Batteries of more than 250mA is forbidden. The discharge power shouldn't exceed 2W. The simultaneous charge and discharge is forbidden. The NiMh charge can be regulated by supplying voltage to the DISCH pin, the parameters are provided in the table5.

Table 5. NiMH battery discharge

Voltage, V	Discharge current, mA
0	0
1	120
2	250
3.3	430
5	650

Status

STATUS allows the indication of the current charge and battery state.

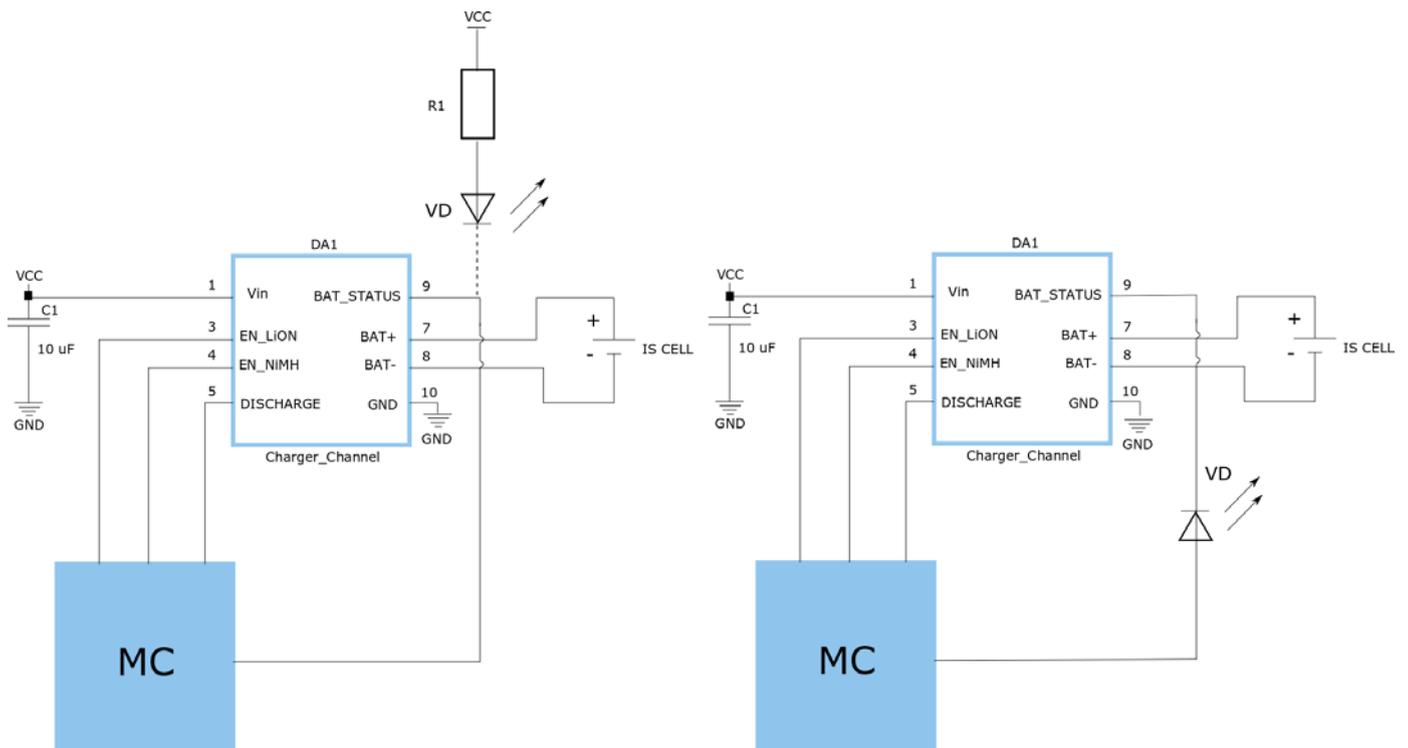
Table 6. Statusin NiMH charge mode

	Charge status				
	No battery	Precharge	Fast charge	Sustain, powersave	Error
StatPIN	Log 0	Charge with 1Hz frequency (50% charge)	Log 1	Log 0	Charge with 4Hz frequency (50% charge)

Table 7. Statusin LI charge mode an external pull-up is required

	Charge status				
	No battery	Precharge	Fast charge	Sustain, powersave	Error
StatPIN	Log 1	Log 0	Log 0	Log 1	Log 1

Connection diagram



Pic. 11 Connection status "STAT" to LED

DC/DC switching regulator

The module has an integrated DC/DC step-down converters, which allow to lower the supply voltage. The DC/DC converter allow the module to work in the range of voltage inputs 12 to 24V, which provide the necessary current to the charging circuit.

Protection

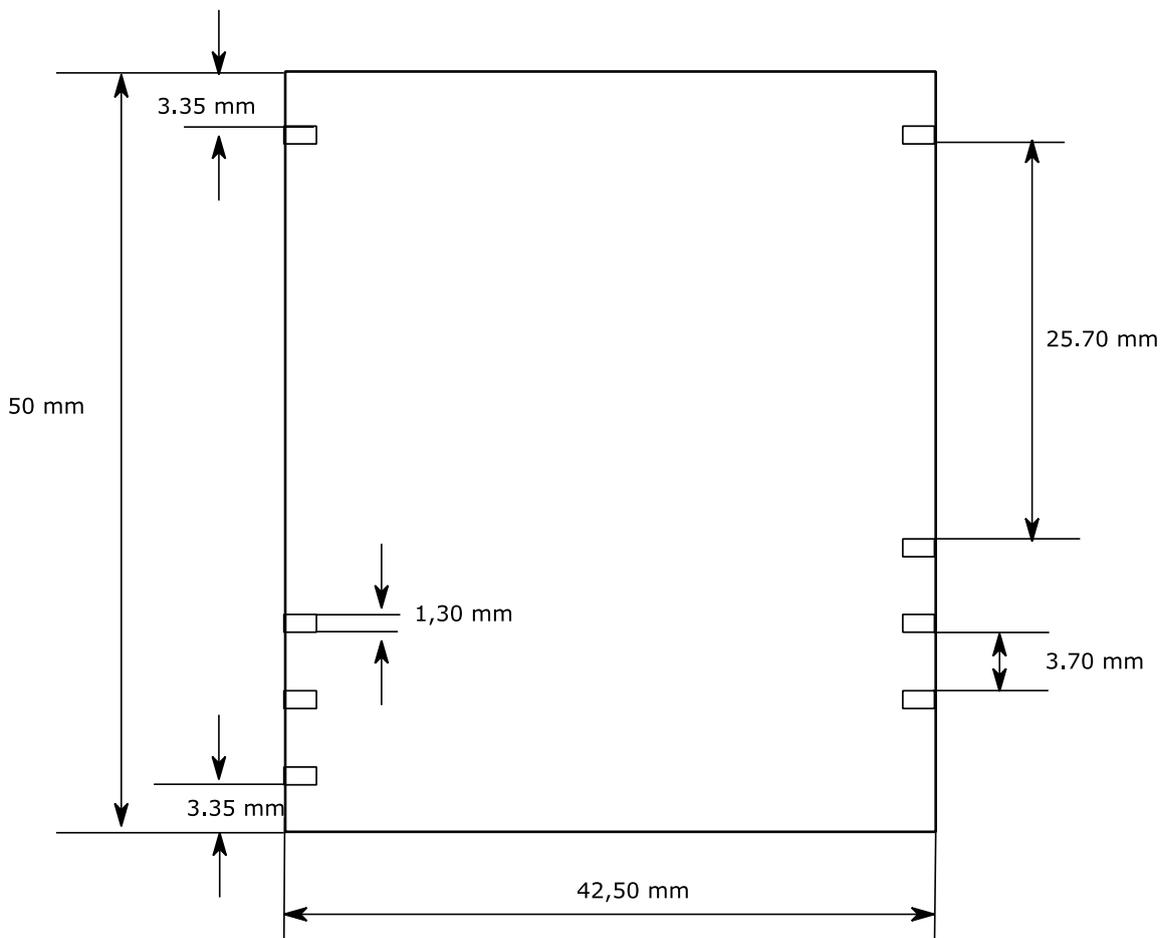
ACM1801C has implemented a battery protection from reverse polarity. If the battery is connected incorrectly then the current loss is less than 1uA.

Short circuit current while Li-Ion is operational (EN-Li - High Logical level) - not more than 130mA.

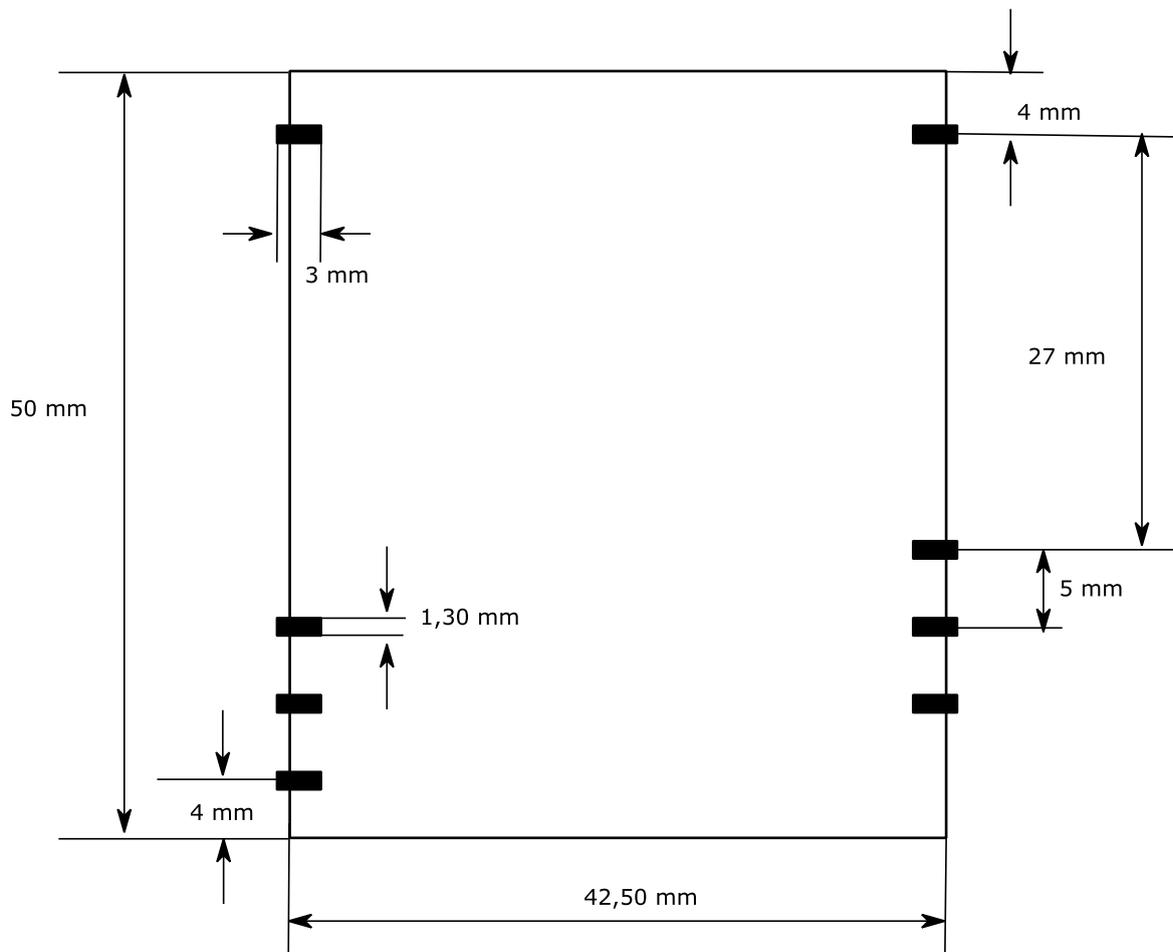
Short circuit current while NiMH is operation (EN_NI - High Logical level) - not more than 1A during 0,5 sec. (impulse detection of battery failure).

Attention! The simultaneous charge of Li-Ion and NiMH is forbidden.

Dimensions and mounting seat.



Pic. 12 Overall dimensions of the ACM1801C module.



Pic. 13 Recommended mounting seat for ACM1801C module.