Single Lithium Cell Charger

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Using the BQ24002 from Texas Instruments it is possible to build a simple and small charger module for single lithium-ion (Li-ion) cells. The device is available in a SSOP20 package and so does not require heroic assembly and soldering skills.

Individual cells are becoming available from the main catalogue suppliers, but a much cheaper option is to rescue cells from defunct notebook batteries. In most cases only a couple of cells are faulty and the others can still look forward to a long and useful life. A single cell is ideal for any equipment that needs a 3.3 V power supply, and will generally give a good operating life. The charger circuit requires a 5 V input, which can readily be obtained from a USB port or from any 5 V power supply.

The charge process begins with a trickle charge current. When the cell terminal voltage is sufficiently high the charger switches to a higher constant charge current. Charging is terminated when the cell voltage reaches a preset limit (the 'final voltage'). The charger described here is suitable for cells with a final voltage of 4.1 V or 4.2 V, configured using jumper JP1: pin 9 is taken to ground to select 4.1 V or to V_{CC} to select 4.2 V.

It is important **never** to exceed the maximum permissible cell voltage: if in doubt, **consult the manufacturer's specifications for the definitive value**.

The charge current is determined and monitored by input shunt resistor R1. A value of 0.1 Ω gives a charge current I_L of 1 A: the general formula is $I_L = 0.1\ \text{V} / \text{R1}$. In this example, the input voltage should be no greater than 5.3 V to ensure that the maximum allowable power dissipation of the IC is not exceeded. With a charge current of 0.5 A (R1 = 0.2 Ω), the maximum allowable input voltage is 7.6 V.

The circuit offers a charge time limit and cell temperature monitoring. The charge time limit is set using JP2. If the jumper is not fitted charging will always stop within three hours, even if the cell has not reached its final voltage. If the jumper is fitted to pull pin 13 to V_{CC} (the supply voltage) the time limit is four and a half hours, and if pin 13 is pulled to ground the time limit is six hours. If the final voltage is reached early, charging will of course cease before expiry of the time limit. The LEDs allow the charge process to be monitored. Red LED D1 lights during charging and flashes to indicate that a fault has been detected. When the cell is more than 90 % charged the red LED is extinguished and the green LED lights.

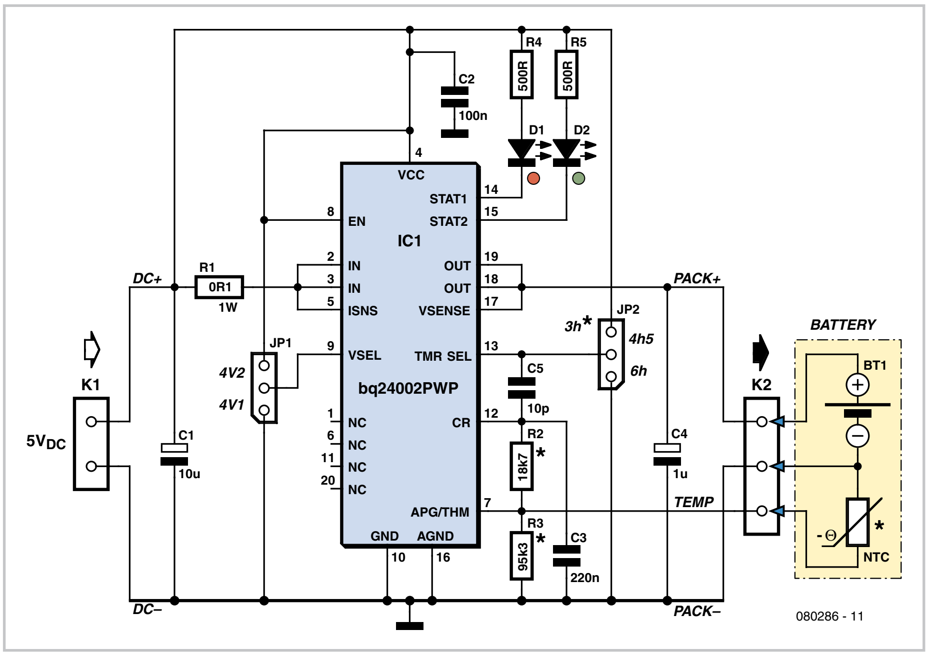
Pin 7 (APG/THM) is the input to a window comparator with a lower threshold of 0.56 V and an upper threshold of 1.5 V. If the voltage on this pin is over 1.5 V or below 0.56 V the IC regards this as a fault and aborts the charging process. Charging can only occur if the voltage on the pin lies between the two thresholds. The window comparator can be used either to monitor the IC's supply voltage or to monitor the temperature of the lithium cell. In the circuit shown we have used the input in a temperature monitoring configuration: the voltage on pin 7 is determined by a voltage divider comprising R2, R3 and an NTC thermistor, which is arranged to sense the temperature of the lithium cell and which is wired in parallel with R3 via connector K2. Pin 12 (CR) carries a reference voltage of 2.85 V; so that charging is possible under normal conditions the thermistor and the voltage divider of which it forms a part must be dimensioned so that the voltage on pin 7 lies within the comparator's voltage window when the cell is running at a safe temperature. The values shown for R2 and R3 will allow charging as long as the resistance of the thermistor lies between 4.8 kΩ (upper temperature limit) and 26.6 kΩ (lower temperature limit). Using a typical 10 kΩ thermistor (such as the Vishay 2381 640 63103) this means that charging will occur as long as the cell temperature is between approximately 5 °C and approximately 43 °C. A 12 kΩ thermistor from the same series gives an upper limit of 48 °C: this is the arrangement used in Texas Instruments' evaluation module [1].

Formulae are given in the datasheet [2] to help with the calculation of component values in the voltage divider. Alternatively, the TempSense Designer software [3] can be used: it offers a graphical user interface and a number of other features.

(080286)

Characteristics

- Designed for a single Li-ion cell
- Suitable for all lithium chemistry cells with a final voltage of 4.1 V or 4.2 V (lithium-cobalt, lithium-manganese and lithium-polymer)
- Configurable 4.1 V or 4.2 V final voltage
- Input voltage from 4.5 V to 10 V (depending on charge current)
- Charge current up to 1.2 A
- Charge current configurable via shunt resistor
- Linear regulator topology
- Precharge function for deeply-discharged cells
- Charge status indicated by two LEDs
- Two package options: SSOP20 or QFN



Internet Links

[1] http://focus.ti.com/lit/ug/sluu113/sluu113.pdf

[2] http://focus.ti.com/lit/ds/slus462e/slus462e.pdf

[3] http://focus.ti.com/docs/prod/folders/print/bq24002.html