



VARTA

Secondary Lithium Ion Cells

Advanced Product Information

Charging information and hints

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1 Preface

This Advanced Product Information describes typical charging characteristics of the VARTA secondary lithium ion single cell batteries, and gives application oriented information and hints to design an appropriate charging circuit. In any case, the latest version of the associated VARTA secondary lithium ion cell data sheet that documents the maximum charge conditions and the 'Handling, Precautions and Prohibitions for Varta secondary lithium ion batteries' must be observed in any design process. The documents are available at www.varta-microbattery.com.

2 Charging Method

The optimal charging method for VARTA secondary lithium ion batteries is to apply constant current and constant voltage, same as the method used today for charging lithium-ion batteries.

Constant current is applied at the beginning of a typical full-charge cycle, when the battery voltage is low. When the battery voltage rises to a specified limit, the charger switches to constant voltage and continues in that mode until the charging current declines to the cell specific minimum charge current, or until the max charge time is reached. Under both conditions, the battery will be fully charged.

The maximum charge voltage is limited to 4.2 V and should be controlled within tolerances of ± 50 mV.

For standard charging, the initial charging current is limited to C/2. In this case, charging must be cut-off after 5 hours. For rapid charge, the initially used current is limited to 1C. In this case charging must be cut-off after 3 hours.

In any case, charging must be cut-off when the minimum charge current is reached as specified within the VARTA secondary lithium ion cell data sheet.

Beside current and voltage limits, ambient temperature conditions should be considered for proper charging. Typically charging of Lithium Polymer systems is allowed between 0°C and 45°C. For exact values, please consult the cell associated technical data sheet.

3 Phases of Charging

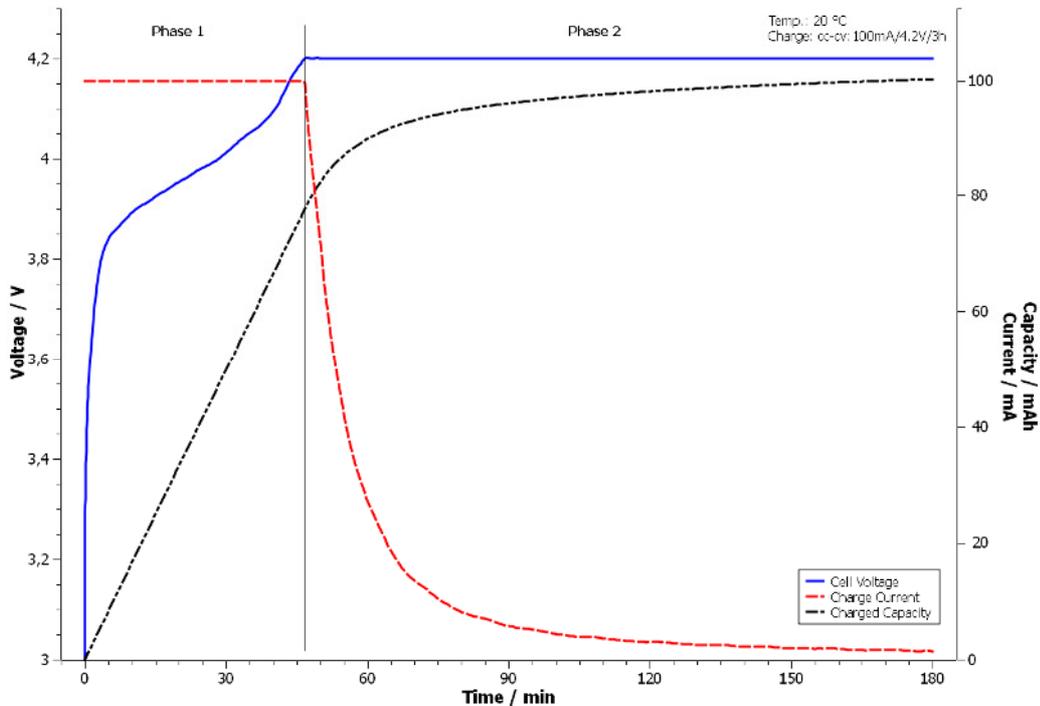


Figure 1. illustrates the different phases during a rapid charge cycle.

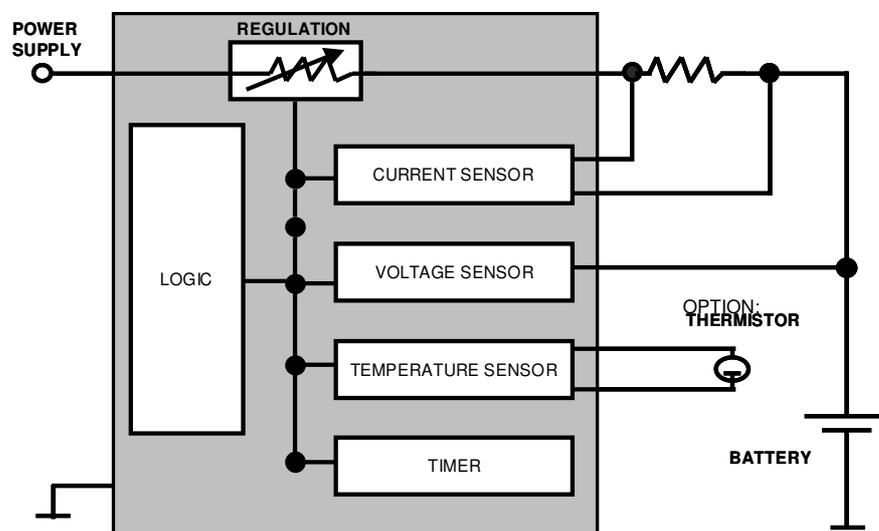
For instance the battery is a 100 mAh VARTA secondary lithium ion cell (CP 1654 A2), discharged down to 3.0 V. So the battery is empty.

In phase 1, the maximum charge current of 1C is applied until the voltage level of 4.2 V is reached. It shows how the discharged battery is rapidly charged by the maximum current of 1C = 100 mA. The Voltage level of 4.2 V is reached after approximately 45 minutes. The 'Charged Capacity' line shows that approximately 70% of the capacity is reached at this point in time.

When the max charge voltage of 4.2 V is reached, phase 2 of charging starts. Now the voltage is controlled and the current is floating. During the constant-voltage phase, current drops exponentially due to the sum of battery resistance and any resistance in series with the battery (much like charging a capacitor through a resistor). When the minimum charge current is reached (in this case 2 mA (0.02 C)), charging is completed and the cell has reached 100% capacity.

4 Suitable charging IC

The semiconductor industries offer a broad range of charging ICs and application notes with implementation hints to support electronic hardware engineers to design the appropriate charging circuit for their devices. Figure 2 gives a building block for the main functions of such a charging IC.



The key elements of such charging IC are:

- current sensor
- voltage sensor
- timer
- temperature sensor
- logic and regulator block

Based on the sensor inputs, the logic controls the regulator block and ensures that neither voltage limits nor current limits are exceeded. The same is done with the timer info. The temperature sensor is connected with a thermistor (PTC/NTC). Thus the charging IC is able to ensure proper charging within the specified temperature limits. The charging IC can be configured to meet the cell specific limits.

The following charging IC's are investigated by VARTA Microbattery and found suitable to charge secondary lithium ion cells:

- Linear Technology Type LTC 1731x
- MAXIM Type i.e. 1898, 1925, 1926
- TEXAS Instruments Type BQ 2054, 2057, 24010, 24012, 24013

Of course, other available charging ICs may be used too. In any case, the latest version of the cell associated VARTA secondary lithium ion Data Sheet and the 'Handling, Precautions and Prohibitions for VARTA secondary lithium ion cells' must be observed in any design process.

5 Miscellaneous

An often asked question is if the charge time can be reduced by increasing the initial charge current.

Increasing the charge current does not shorten the charging time by much. Although the maximum charge voltage is reached faster with higher charge current, the charging at constant voltage to reach 100 % charging takes longer. So the phase one of the charging as shown in figure 1 is shorter, but the overall effect with regards to charge time is very low. Beside this, the negative effect is shorter battery life and lower cycle time when using higher charge currents.

In some cases design engineers want to use existing charging circuits which are initially designed for Li-Ion batteries, maximum charge voltage of 4.1 V.

In general VARTA secondary lithium ion cells can be charged with a maximum voltage of 4.1 V. While this 'softer' charging will have a positive impact to the life time and cycle life, the maximum chargeable capacity will be limited to approximately 90 % compared to the capacity chargeable at 4.2 V. In any case, all other charge limits (max/min current, time and temperature) must be observed.

6 Approval

All batteries have to be validated to confirm that they meet the required performance in the application. It is the responsibility of the customer to validate this in the application environment and to confirm this to the supplier by signing and returning customer specific drawing or battery delivery specification before ordering the battery to be used in the application. Latest when ordering the battery it is assumed that technical validation is passed and battery approved for production.

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