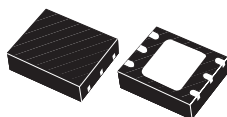


## 800 mA standalone linear Li-Ion battery charger with thermal regulation



DFN6 (3 x 3 mm)

### Features

- Programmable charge current up to 800 mA
- No external MOSFET, sense resistors or blocking diode are required
- Complete linear charger for single-cell Li-Ion batteries
- Constant current/constant voltage operation with thermal regulation to maximize charge rate without risk of overheating
- Two charge status output pins
- Charge single-cell Li-Ion batteries directly from USB port
- Preset 4.2 V charge voltage with 1% accuracy
- Charge current monitor for gas gauge
- Automatic recharge
- Undervoltage lockout
- C/10 charge termination
- 25  $\mu$ A supply current in shutdown mode
- Low battery voltage detection for pre-charge setting
- Soft-start feature limits inrush current
- DFN6 (3 x 3 mm) package (to improve power dissipation)

### Applications

- Cellular phones
- PDAs
- Bluetooth® applications
- Battery-powered devices

### Description

The **STBC08** is a constant current/constant voltage charger for single-cell Li-Ion batteries.

Neither external sense resistor nor blocking diode are required. The **STBC08** is designed to work within USB power specifications. An internal block regulates the current when the junction temperature increases, to protect the device when it operates in high power or high ambient temperature conditions. The charge voltage is fixed at 4.2 V, and current limitation can be programmed using a single resistor connected between PROG pin and GND. The charge cycle is automatically terminated when the current, which flows to the battery, is 1/10 of the programmed value. If the external adapter is removed, the **STBC08** turns off and a 2  $\mu$ A current can flow from the battery to the device.

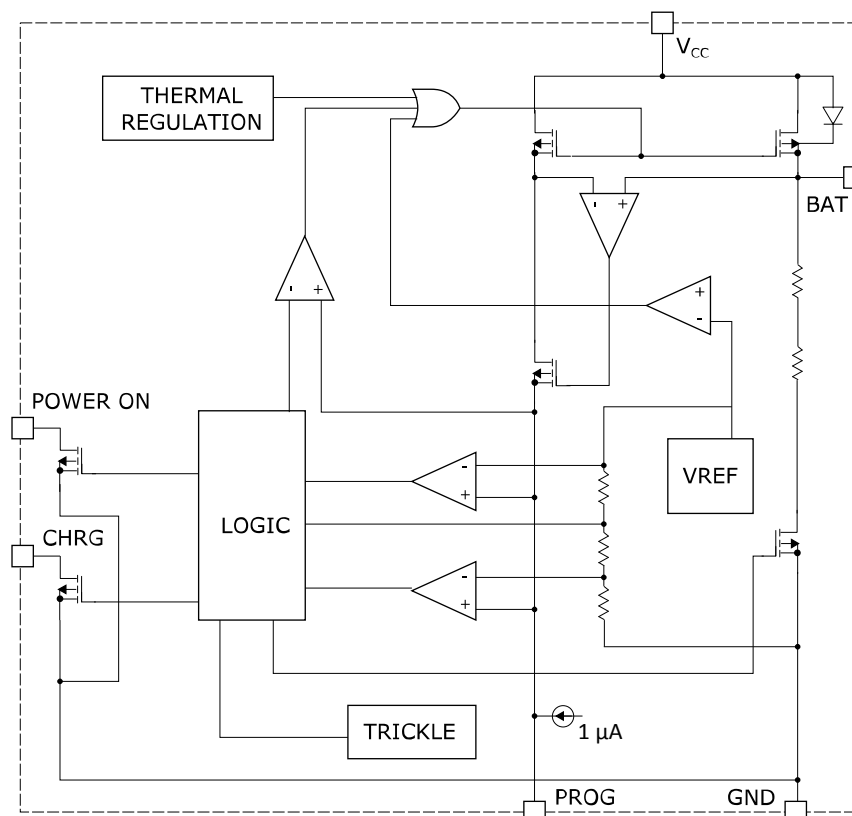
The device can be in shutdown mode, reducing the supply current to 25  $\mu$ A.

The device also has a charge current monitor, undervoltage lockout, automatic recharge. The charge termination and input voltage presence are indicated by two separated status pins.

| Maturity status link   |                  |
|------------------------|------------------|
| <a href="#">STBC08</a> |                  |
| Device summary         |                  |
| Order code             | STBC08PMR        |
| Package                | DFN6 (3 x 3 mm)  |
| Packaging              | 4500 pieces/reel |

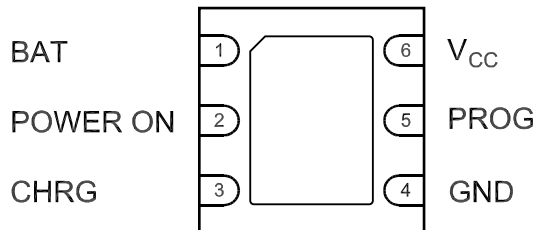
# 1 Application diagram

Figure 1. Block diagram



## 2 Pin configuration

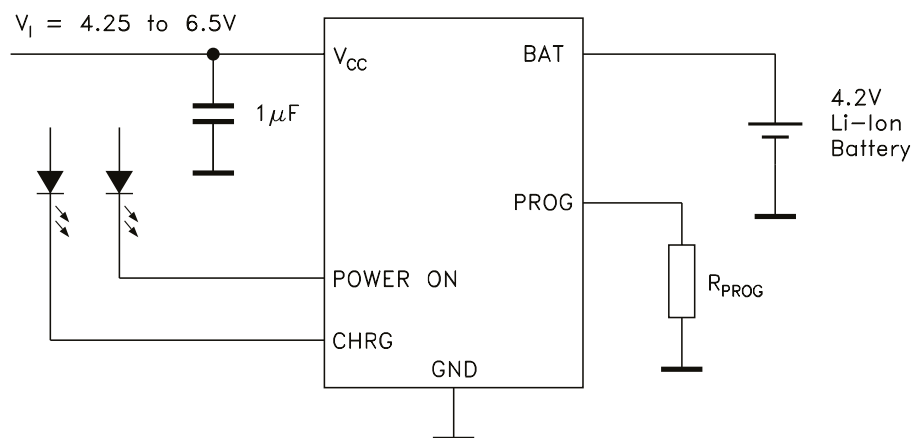
**Figure 2. Pin connection (top view)**



**Table 1. Pin description**

| Pin | Symbol      | Notes                                                                                                                                                                                                                   |
|-----|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | BAT         | This pin provides an accurate output voltage of 4.2 V and the charge current to the battery. Only 2 $\mu$ A reverse current can flow to the device when it is in shutdown mode.                                         |
| 2   | POWER ON    | Open drain. When the STBC08 detects an undervoltage lockout condition or when the external adapter provides an input voltage higher than 7.2 V or less than the battery voltage, POWER ON goes to high impedance state. |
| 3   | CHRG        | Open drain. This pin goes to low impedance when the STBC08 is in pre-charge or charge mode.                                                                                                                             |
| 4   | GND         | Ground pin.                                                                                                                                                                                                             |
| 5   | PROG        | Charge current program, charge current monitor and shutdown pin. The current limitation is programmed using $R_{PROG}$ tolerance of 1% between PROG pin and GND.                                                        |
| 6   | $V_{CC}$    | Input supply voltage. The input range goes from 4.25 to 6.5 V.<br>If $V_{CC} < V_{BAT} + 30$ mV the device enters shutdown mode and the sinked $I_{BAT}$ is less than 2 $\mu$ A.                                        |
| 7   | Exposed pad | Connected to GND or left floating.                                                                                                                                                                                      |

**Figure 3. Application circuit**



### 3 Maximum ratings

**Table 2. Absolute maximum ratings**

| Symbol         | Parameter                            | Value                         | Unit        |
|----------------|--------------------------------------|-------------------------------|-------------|
| $V_{CC}$       | Input supply voltage                 | From - 0.3 to 10              | V           |
| $V_{BAT}$      | Battery pin voltage                  | From - 0.3 to 7               | V           |
| $V_{PROG}$     | PROG pin voltage                     | From - 0.3 to $V_{CC} + 0.3$  | V           |
| $V_{CHRG}$     | CHRG pin voltage                     | From - 0.3 to 7               | V           |
| $V_{POWER-ON}$ | POWER ON pin voltage                 | From - 0.3 to 7               | V           |
| $V_{LV}$       | TEMP, LED1, LED2, ISET               | From - 0.3 to $V_{REF} + 0.3$ | V           |
| $I_{BAT}$      | BAT pin current                      | 800                           | mA          |
| $I_{PROG}$     | PROG pin current                     | 800                           | $\mu A$     |
|                | BAT short-circuit duration           | Continuous                    |             |
| $P_D$          | Power dissipation                    | Internally limited            | mW          |
| $T_J$          | Maximum junction temperature         | 125                           | $^{\circ}C$ |
| $T_{STG}$      | Storage temperature range            | - 65 to 125                   | $^{\circ}C$ |
| $T_{OP}$       | Operating junction temperature range | - 40 to 85                    | $^{\circ}C$ |

**Table 3. Thermal data**

| Symbol       | Parameter                           | Value | Unit          |
|--------------|-------------------------------------|-------|---------------|
| $R_{th(JA)}$ | Thermal resistance junction-ambient | 105.7 | $^{\circ}C/W$ |

## 4 Electrical characteristics

$V_{CC} = 5\text{ V}$ ,  $C_I = 1\text{ }\mu\text{F}$ ,  $T_J = -40\text{ }^\circ\text{C}$  to  $85\text{ }^\circ\text{C}$  unless otherwise specified.

**Table 4. Electrical characteristics**

| Symbol     | Parameter                                                                        | Test conditions                                                                              | Min.                     | Typ.    | Max.    | Unit          |
|------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------|---------|---------|---------------|
| $V_{CC}$   | Supply voltage                                                                   |                                                                                              | 4.25                     |         | 6.5     | V             |
| $I_{CC}$   | Supply current <sup>(1)</sup>                                                    | Charge mode, $R_{PROG} = 10\text{ k}\Omega$                                                  |                          | 150     | 500     | $\mu\text{A}$ |
|            |                                                                                  | Standby mode (charge ended)                                                                  |                          | 150     | 300     |               |
|            |                                                                                  | Shutdown mode                                                                                | $R_{PROG}$ not connected | 21      | 40      |               |
|            |                                                                                  |                                                                                              | $V_{CC} < V_{BAT}$       | 17      | 50      |               |
|            |                                                                                  |                                                                                              | $V_{CC} < V_{UV}$        | 17      | 40      |               |
| $V_{BAT}$  | Termination output voltage                                                       | $V_{CC} = 4.3\text{ V}$ to $6.5\text{ V}$                                                    | 4.158                    | 4.2     | 4.242   | V             |
| $I_{BAT}$  | BAT pin current                                                                  | Current mode<br>$R_{PROG} = 10\text{ k}\Omega$                                               | 90                       | 100     | 110     | mA            |
|            |                                                                                  | Current mode<br>$R_{PROG} = 2\text{ k}\Omega$                                                | 465                      | 500     | 535     | mA            |
|            |                                                                                  | Standby mode<br>$V_{BAT} = 4.2\text{ V}$                                                     | 0                        | -2.5    | -6      | $\mu\text{A}$ |
|            |                                                                                  | Shutdown mode ( $R_{PROG} =$<br>not connected) $T_J = 25\text{ }^\circ\text{C}$              |                          | $\pm 1$ | $\pm 2$ |               |
|            |                                                                                  | Sleep mode, $V_{CC} = 0\text{ V}$ ,<br>$T_J = 25\text{ }^\circ\text{C}$                      |                          | $\pm 1$ | $\pm 2$ |               |
| $I_{PRE}$  | Pre-charge current                                                               | $V_{BAT} < 2.8\text{ V}$<br>$R_{PROG} = 2\text{ k}\Omega$ , $T_J = 25\text{ }^\circ\text{C}$ | 20                       | 45      | 70      | mA            |
| $V_{PRE}$  | Pre-charge threshold                                                             | $R_{PROG} = 10\text{ k}\Omega$ , $V_{BAT}$<br>falling                                        | 2.8                      | 2.9     | 3.0     | V             |
|            |                                                                                  | Hysteresis $R_{PROG} = 10\text{ k}\Omega$                                                    | 70                       | 100     | 130     | mV            |
| $V_{UV}$   | $V_{CC}$ undervoltage<br>lockout                                                 | $V_{CC}$ low to high<br>$R_{PROG} = 10\text{ k}\Omega$                                       | 3.65                     | 3.80    | 3.95    | V             |
|            |                                                                                  | Hysteresis $R_{PROG} = 10\text{ k}\Omega$                                                    | 50                       | 180     | 300     | mV            |
| $V_{MSD}$  | Manual shutdown<br>threshold                                                     | PROG pin rising                                                                              | 1.15                     | 1.21    | 1.30    | V             |
|            |                                                                                  | PROG pin falling                                                                             | 0.85                     | 0.95    | 1.05    |               |
| $V_{ASD}$  | $V_{CC}$ - $V_{BAT}$ lockout<br>threshold                                        | $V_{CC}$ low to high<br>$T_J = 25\text{ }^\circ\text{C}$<br>$R_{PROG} = 10\text{ k}\Omega$   | 50                       | 85      | 120     | mV            |
|            |                                                                                  | $V_{CC}$ high to low $T = 25\text{ }^\circ\text{C}$<br>$R_{PROG} = 10\text{ k}\Omega$        | 5                        | 30      | 50      |               |
| $I_{TERM}$ | C/10 termination<br>current threshold<br>( $I_{BAT}/I_{BATC10}$ ) <sup>(2)</sup> | $R_{PROG} = 10\text{ k}\Omega$                                                               |                          | 10      |         | $\mu\text{A}$ |
|            |                                                                                  | $R_{PROG} = 2\text{ k}\Omega$                                                                |                          | 10      |         |               |

| Symbol                     | Parameter                                                | Test conditions                                                                    |  | Min. | Typ. | Max. | Unit             |
|----------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------|--|------|------|------|------------------|
| $V_{\text{PROG}}$          | PROG pin voltage                                         | Current mode<br>$R_{\text{PROG}} = 10 \text{ k}\Omega$                             |  | 0.93 | 1.0  | 1.07 | V                |
| $V_{\text{CHRG}}$          | CHRG pin pull-down voltage                               | $I_{\text{CHRG}} = 5 \text{ mA}$                                                   |  |      | 0.35 | 0.6  | V                |
| $I_{\text{POWER\_ON}}$     | POWER ON pin leakage current                             | Pull-up                                                                            |  |      | 1    |      | $\mu\text{A}$    |
|                            | POWER ON pin pull-down voltage                           | $I_{\text{POWER\_ON}} = 5 \text{ mA}$                                              |  |      | 0.35 | 0.6  | V                |
| $\Delta V_{\text{RECHRG}}$ | Recharge battery threshold voltage                       | Battery voltage $T_J = 25^\circ\text{C}$<br>$R_{\text{PROG}} = 10 \text{ k}\Omega$ |  |      | 200  |      | mV               |
| $T_{\text{LIM}}$           | Junction temperature in constant temperature mode        |                                                                                    |  |      | 120  |      | $^\circ\text{C}$ |
| $R_{\text{ON}}$            | PowerFET on-resistance (between $V_{\text{CC}}$ and BAT) |                                                                                    |  |      | 600  |      | $\text{m}\Omega$ |
| $t_{\text{SS}}$            | Soft-start time                                          | $I_{\text{BAT}} = 0$ to $I_{\text{BAT}} = 1000 \text{ V} / R_{\text{PROG}}$        |  |      | 100  |      | $\mu\text{s}$    |
| $T_{\text{RECHARGE}}$      | Recharge comparator filter time <sup>(3)</sup>           | $V_{\text{BAT}}$ high to low                                                       |  | 0.75 | 2    | 4.5  | ms               |
| $t_{\text{TERM}}$          | Termination comparator filter time <sup>(3)</sup>        | $I_{\text{BAT}}$ falling below $I_{\text{CHG}}/10$                                 |  | 400  | 1000 | 2500 | $\mu\text{s}$    |
| $I_{\text{PROG}}$          | PROG pin pull-up current                                 |                                                                                    |  |      | 1    |      | $\mu\text{A}$    |

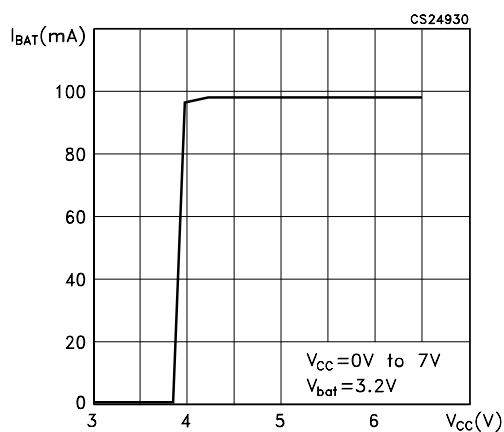
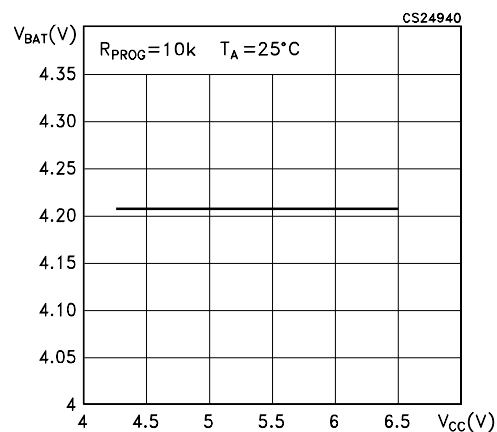
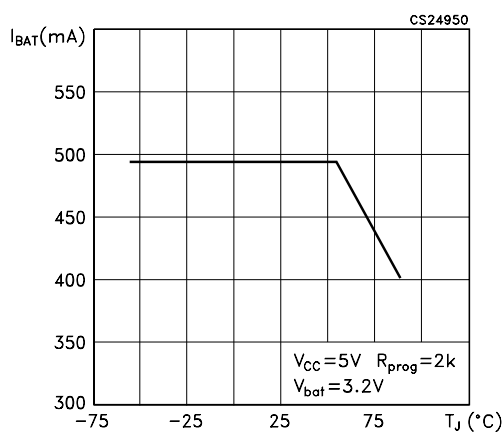
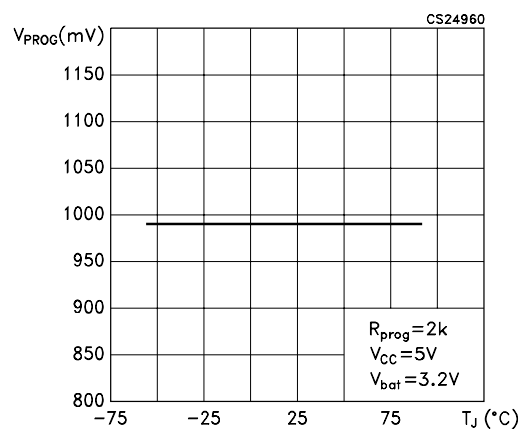
1. Supply current includes PROG pin current but it doesn't include any current delivered to the battery through  $V_{\text{BAT}}$  pin

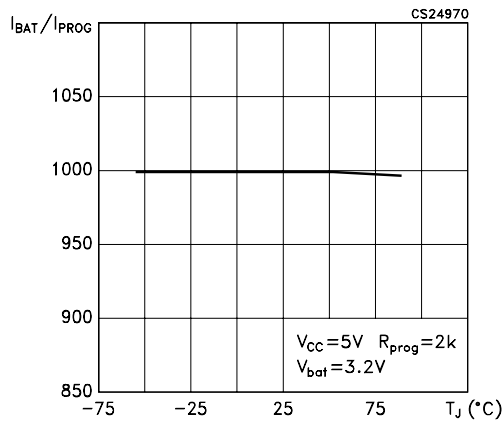
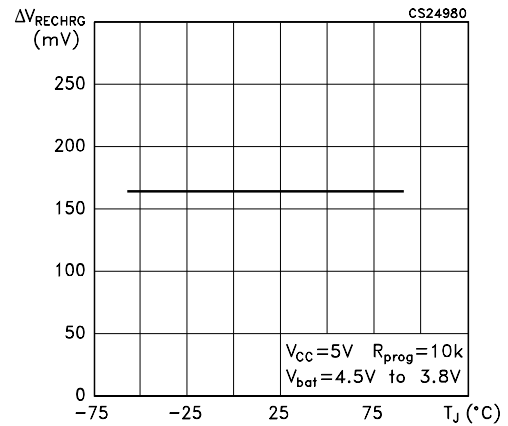
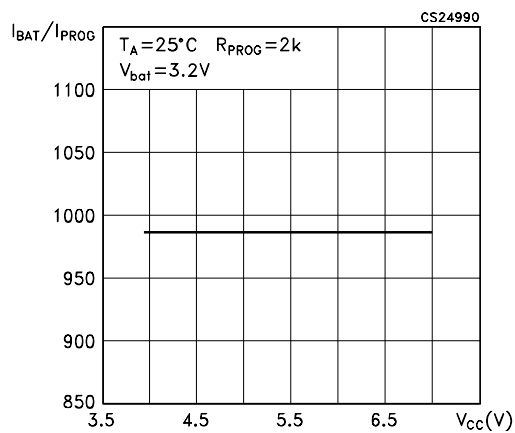
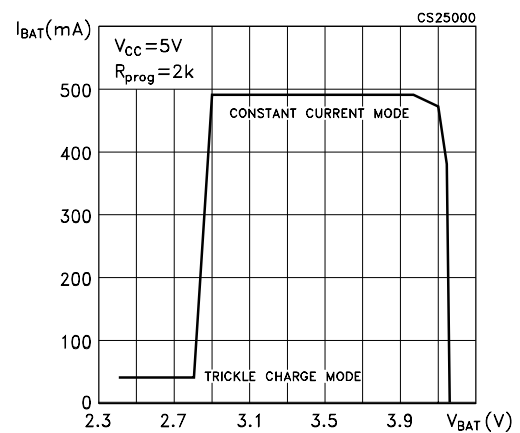
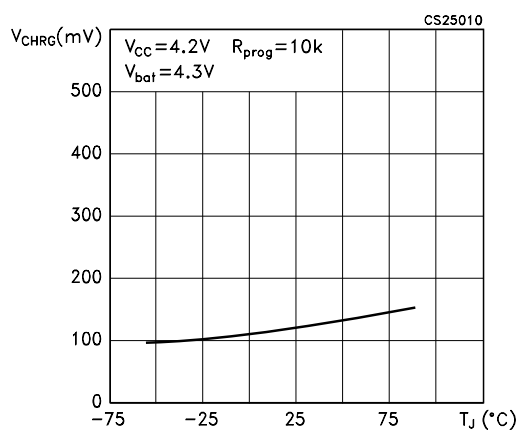
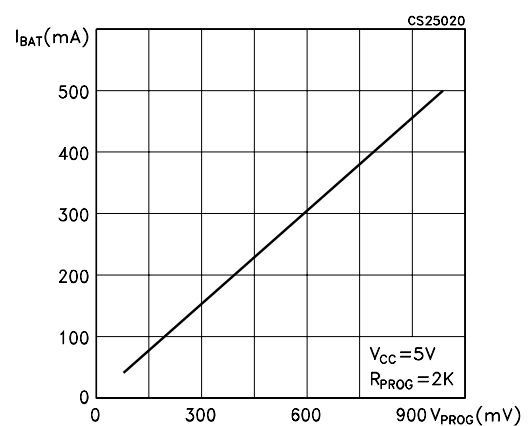
2.  $I_{\text{TERM}}$  is indicated as a fraction of measured full charge current with indicated PROG resistor.

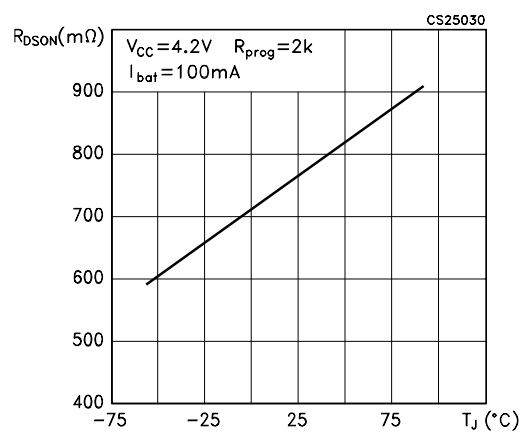
3. Guaranteed by design.

**Note:** The STBC08 has been tested using a battery simulator and an output capacitor value of  $4.7 \mu\text{F}$ .

## 5 Typical performance characteristics

**Figure 4.  $I_{BAT}$  vs. supply voltage**

**Figure 5.  $V_{BAT}$  vs.  $V_{CC}$** 

**Figure 6.  $I_{BAT}$  vs. temperature**

**Figure 7.  $V_{PROG}$  vs. temperature**


**Figure 8.  $I_{BAT} / I_{PROG}$  vs. temperature**

**Figure 9. Recharge battery threshold voltage vs. temperature**

**Figure 10.  $I_{BAT} / I_{PROG}$  vs.  $V_{CC}$** 

**Figure 11.  $I_{BAT}$  vs.  $V_{BAT}$** 

**Figure 12.  $V_{CHRG}$  vs. temperature (CHRG pin output low voltage)**

**Figure 13.  $I_{BAT}$  vs.  $V_{PROG}$** 


**Figure 14. Power FET on-resistance**


## 6 Application information

The STBC08 uses an internal P-channel MOSFET to work in constant current and constant voltage method. It provides up to 800 mA with a final regulated output voltage of 4.2 V  $\pm$ 1% in full temperature range. Neither blocking diode nor sensing resistor are required. The USB port can be used as a power supply voltage.

### 6.1 Charge cycle

A charge cycle begins when the voltage at the  $V_{CC}$  pin rises above UVLO threshold level,  $R_{PROG}$  program resistor of 1% is connected between PROG pin and GND pin and when a battery is connected to the charger output. If the battery voltage is below 2.9 V, the charger enters trickle charge mode. In this condition, the device supplies 1/10<sup>th</sup> of the programmed charge current to keep the battery voltage in a safe level otherwise the life of a battery reduces. If BAT pin voltage is higher than 2.9 V the charger goes to constant current mode. When BAT pin voltage is close to the final float voltage (4.2 V) the device goes to constant voltage mode and the charge current begins decreasing. The charge cycle is over when the current drops 1/10<sup>th</sup> of the programmed value.

### 6.2 $V_{CC}$ pin

Input supply voltage is used to supply the device in the range from 4.25 V to 6.5 V voltage. A bypass capacitor of 1  $\mu$ F is recommended. When  $V_{CC}$  value drops below 30 mV of BAT pin voltage, the device goes to shutdown mode, dropping  $I_{BAT}$  less than 2  $\mu$ A.

### 6.3 POWER ON pin

POWER ON pin is an open drain flag indicating  $V_{CC}$  presence,  $V_{UVLO} < V_{CC} < 7.2$  V and  $V_{CC} > V_{BAT}$ . While in high impedance, it indicates that  $V_{CC} < V_{UVLO}$ ,  $V_{CC} > 7.2$  V or  $V_{CC} < V_{BAT}$ . In high impedance status  $V_{CC}$  does not start the charge cycle.

### 6.4 CHRГ pin

CHRG pin is an open drain flag indicating the status of the charge. When the pin is in low-state, the device charges the battery. If the pin is in high impedance state the charge is over.

**Table 5. Flag status values for CHRG pin**

| POWER ON         | CHRG             | Description                                                                                                                       |
|------------------|------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| 0                | 0                | Pre-charge mode (trickle charge mode) or charge mode. $V_{CC}$ is higher than $V_{UVLO}$ and $R_{PROG}$ is connected to PROG pin. |
| 0                | 1 <sup>(1)</sup> | Standby mode (charge completed) or shutdown mode ( $R_{PROG}$ not connected).                                                     |
| 1 <sup>(1)</sup> | 1 <sup>(1)</sup> | Supply is not sufficient.                                                                                                         |

1. Output pin in high impedance (external pull-up needed).

### 6.5 PROG pin

Charge current program, charge current monitor and shutdown pin. The charge current is programmed by connecting a resistor of 1%,  $R_{PROG}$  to ground. When the device charges in constant current, the voltage value of this pin is 1.0 V. In other conditions, the voltage on this pin can measure the charge current thanks to the following formula:

$$I_{BAT} = \left( \frac{V_{PROG}}{R_{PROG}} \right) \times 1000 \quad (1)$$

PROG pin shuts down the device; disconnecting the program resistor from ground, the current of 1  $\mu$ A flows to pull PROG pin high.

If the value of this pin is 1.21 V (shutdown threshold voltage), the device enters shutdown mode and the input supply current drops to 25  $\mu$ A. Driving this pin to voltage beyond 2.4 V, a current of 35  $\mu$ A flows to the device from PROG pin.

## 6.6 Programming charge current

$R_{PROG}$  resistor sets the charge current value. The battery charge current is 1000 times the PROG pin current value. The program resistor and the charge current are calculated according to the following equation:

$$R_{PROG} = 1000 \times \frac{V_{PROG}}{I_{BAT}} \quad (2)$$

The charge current out of BAT pin can be monitored by PROG pin voltage as per below equation:

$$I_{BAT} = \left( \frac{V_{PROG}}{R_{PROG}} \right) \times 1000 \quad (3)$$

## 6.7 BAT pin

The charge current output pin provides the battery with charge current and regulates the final float voltage to 4.2 V. An internal resistor is a feedback loop, which compares  $V_O$  with the reference.

## 6.8 Charge termination

A charge cycle is terminated when the final float voltage is reached while the charge current falls 1/10<sup>th</sup> of the programmed value. The charge is over when PROG pin voltage falls below 100 mV for a time longer than  $t_{TERM}$  (~1 ms). The charge current is latched off, the device is in standby mode and the input supply current drops to 200  $\mu$ A.

## 6.9 Soft-start

When a charge cycle starts, an internal soft-start circuit minimizes the inrush current. At starting phase, the charge current ramps from zero to full scale in 100  $\mu$ s.

## 6.10 Thermal regulation

An internal thermal feedback loop reduces the output current if the die temperature rises above a present value of approximately 120 °C. This feature protects the device from the excessive temperature and allows the user to push the limits of the power handling the capability of a given circuit board without damaging the device.

## 6.11 Power dissipation

A good thermal PC board layout should be used to maximize the available output current. The thermal path for the heat generated by IC is from the die to the copper lead frame through the package leads and exposed pad to the PC board copper.

The PC board copper is the heat sink. Footprint copper pads should be as wider as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feed-through vias to inner or backside copper layers are also useful to improve the overall thermal performance of the device. Other heat sources on the board, not related to the device, have to be considered when a PC board layout is designed because they affect the overall temperature rise and the maximum output current.

## 6.12 Stability considerations

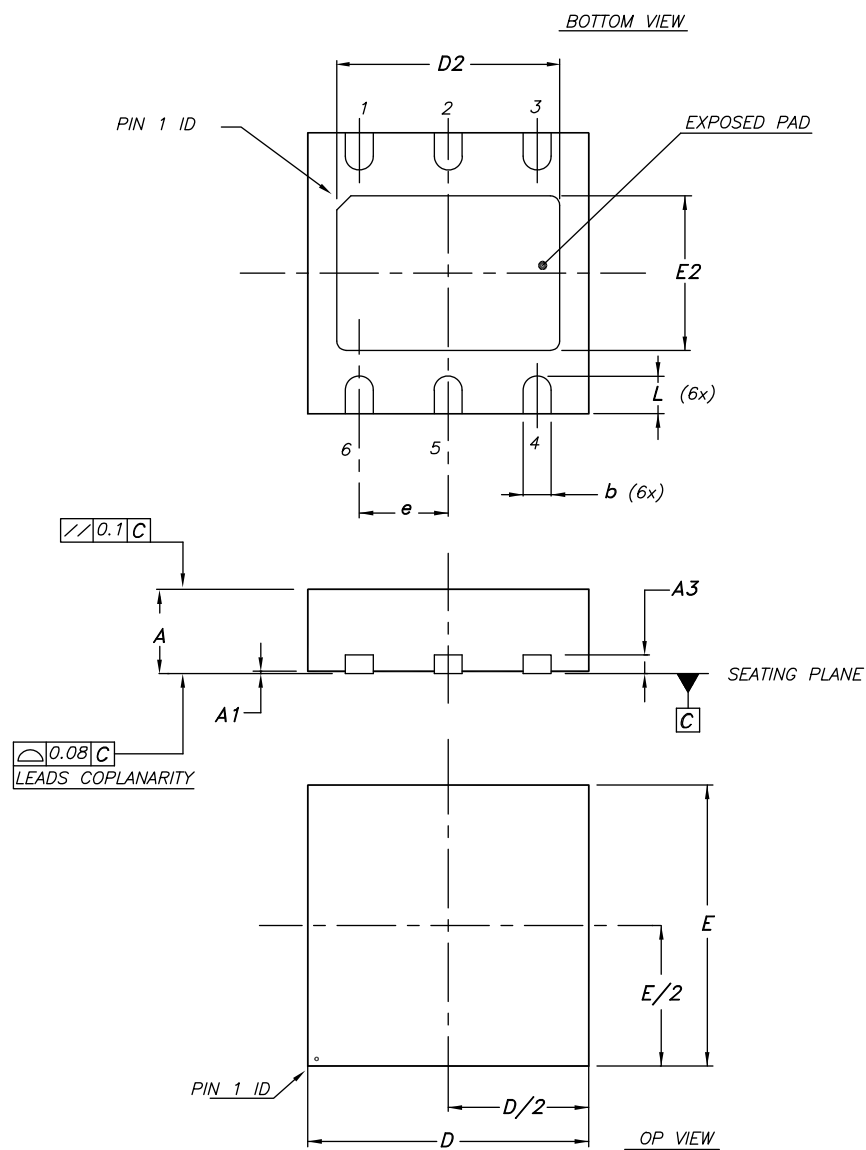
The STBC08 contains two control loops: the constant voltage and the constant current. The constant voltage loop is stable without any compensation when a battery is connected with low impedance leads. Excessive lead length, however, may add enough parasitic series inductance to require 1  $\mu$ F bypass capacitor from BAT to GND. Furthermore, a 4.7  $\mu$ F capacitor with a series resistor (0.2  $\Omega$  to 1  $\Omega$ ) from BAT to GND is required to keep ripple voltage low when the battery is disconnected.

## 7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK®** packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK® is an ST trademark.

### 7.1 DFN6 (3 x 3 mm) package information

**Figure 15. DFN6 (3 x 3 mm) package outline**

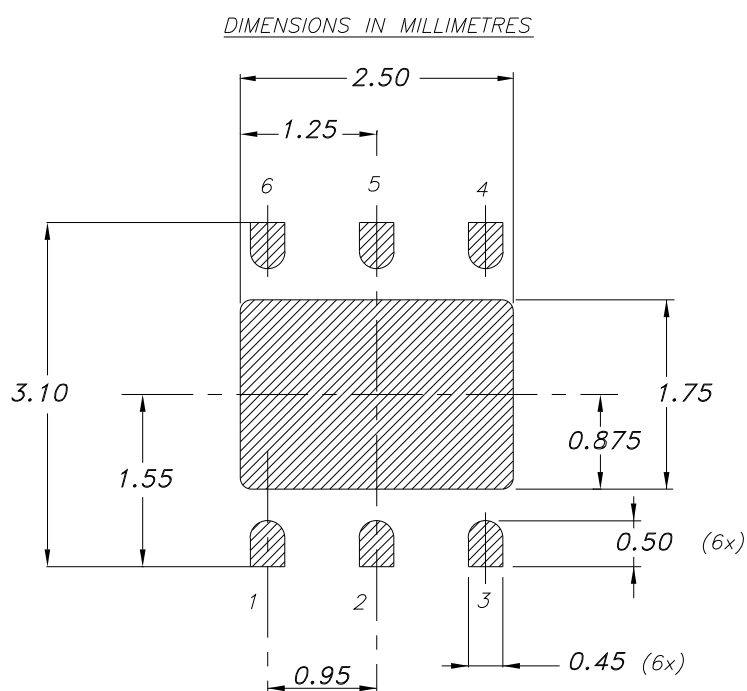


7946637\_C

**Table 6. DFN6 (3 x 3 mm) package mechanical data**

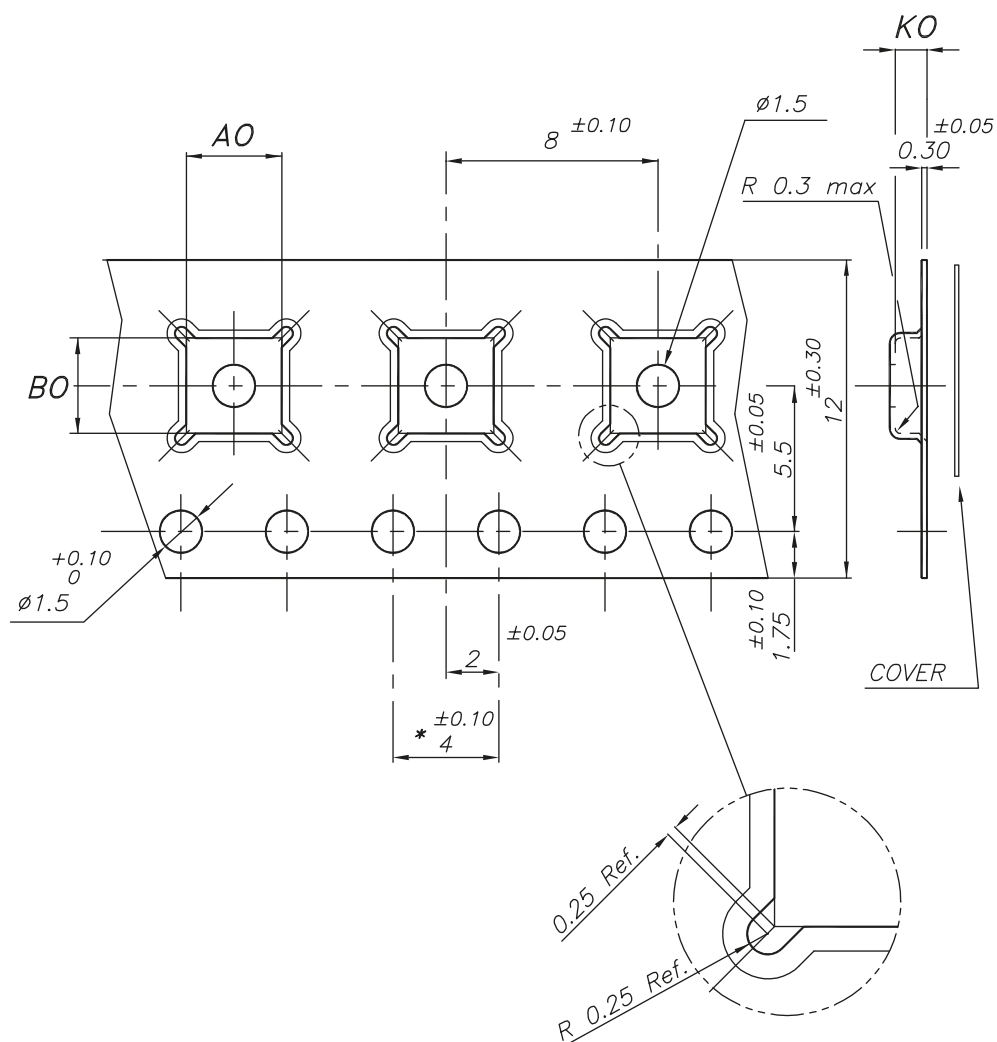
| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A    | 0.80 |      | 1    |
| A1   | 0    | 0.02 | 0.05 |
| A3   |      | 0.20 |      |
| b    | 0.23 |      | 0.45 |
| D    | 2.90 | 3    | 3.10 |
| D2   | 2.23 |      | 2.50 |
| E    | 2.90 | 3    | 3.10 |
| E2   | 1.50 |      | 1.75 |
|      |      | 0.95 |      |
| L    | 0.30 | 0.40 | 0.50 |

**Figure 16. DFN6 (3 x 3 mm) recommended footprint**



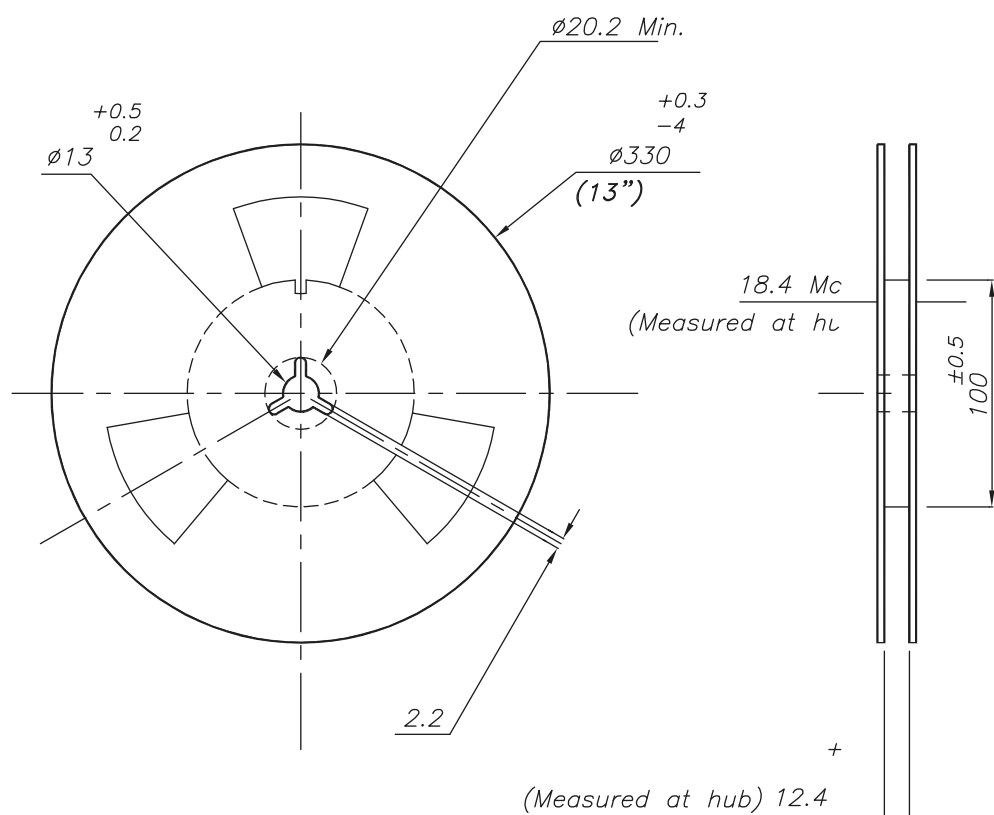
## 7.2 DFN6 (3 x 3 mm) packing information

Figure 17. DFN6 (3 x 3 mm) tape outline



\*  
— 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE  $\pm 0.20$

7875978\_N

**Figure 18. DFN6 (3 x 3 mm) reel outline**


7875978\_N

**Table 7. DFN6 (3 x 3 mm) tape and reel mechanical data**

| Dim. | mm   |      |      |
|------|------|------|------|
|      | Min. | Typ. | Max. |
| A0   | 3.20 | 3.30 | 3.40 |
| B0   | 3.20 | 3.30 | 3.40 |
| K0   | 1    | 1.10 | 1.20 |

## Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes                                                                                                               |
|-------------|----------|-----------------------------------------------------------------------------------------------------------------------|
| 04-Sep-2006 | 1        | Initial release.                                                                                                      |
| 29-May-2014 | 2        | Added exposed pad pin to Table 2.<br>Updated $I_{TERM}$ parameter in Table 5.<br>Modified Table 6. Minortext changes. |
| 17-Jul-2017 | 3        | Updated Table 5.                                                                                                      |
| 28-Nov-2018 | 4        | Updated $V_{BAT}$ value in <a href="#">Table 2. Absolute maximum ratings</a> .                                        |

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