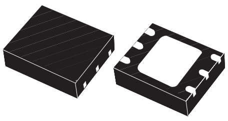
STBC08

Datasheet

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



DFN6 (3 x 3 mm)

Maturity status link
STBC08

Device summary	
Order code	STBC08PMR
Package	DFN6 (3 x 3 mm)
Packaging	4500 pieces/reel

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 μA 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.

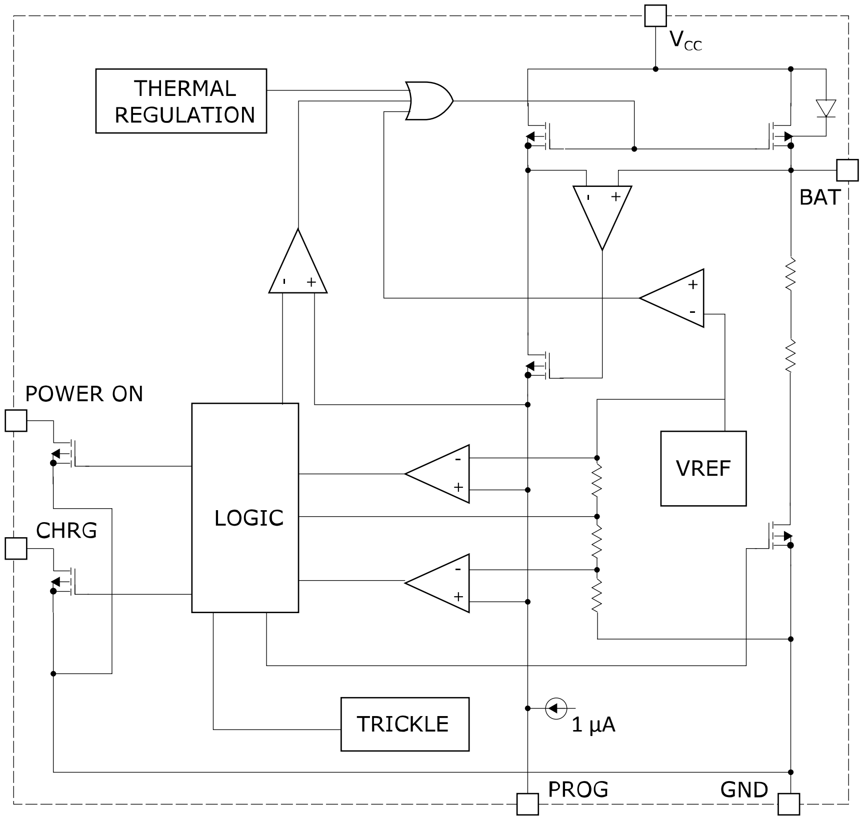
Neither external sense resistor nor blocking diode are required. The STBC08 is designed to work within USB power specifications. An internal block regulates the current when the junction temperature increases, to protect the device when it operates in high power or high ambient temperature conditions. 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 μA current can flow from the battery to the device.

The device can be in shutdown mode, reducing the supply current to 25 μA.

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.

1 Application diagram

Figure 1. Block diagram



2 Pin configuration

Figure 2. Pin connection (top view)

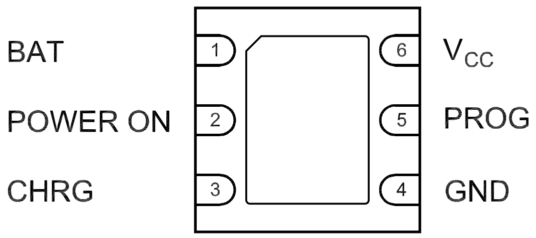
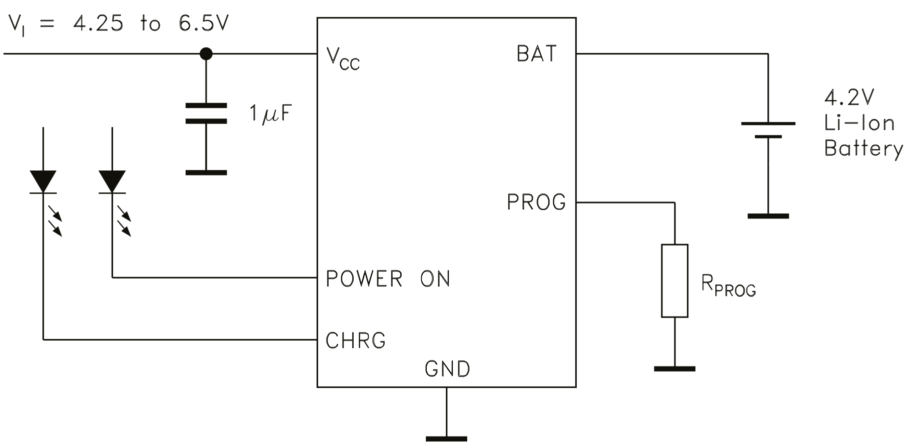


Table 1. Pin description

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 µA 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. If $V_{CC} < V_{BAT}$ + 30 mV the device enters shutdown mode and the sinked I_{BAT} is less than 2 µA.
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	µA
	BAT short-circuit duration	Continuous	
P_D	Power dissipation	Internally limited	mW
T_J	Maximum junction temperature	125	°C
T_{STG}	Storage temperature range	– 65 to 125	°C
T_{OP}	Operating junction temperature range	– 40 to 85	°C

Table 3. Thermal data

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

4 Electrical characteristics

V_{CC} = 5 V, C_I = 1 µF, T_J = - 40 °C to 85 °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 [1]	Charge mode, R_{PROG} =10 kΩ			150	500	µA
		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 V to 6.5 V		4.158	4.2	4.242	V
I_{BAT}	BAT pin current	Current mode R_{PROG} = 10 kΩ		90	100	110	mA
		Current mode R_{PROG} = 2 kΩ		465	500	535	mA
		Standby mode V_{BAT} = 4.2 V		0	-2.5	-6	µA
		Shutdown mode (R_{PROG} = not connected) T_J = 25 °C			±1	±2	
		Sleep mode, V_{CC} = 0 V, T_J = 25 °C			±1	±2	
I_{PRE}	Pre-charge current	V_{BAT} < 2.8 V R_{PROG} = 2 kΩ, T_J = 25 °C		20	45	70	mA
V_{PRE}	Pre-charge threshold	R_{PROG} = 10 kΩ, V_{BAT} falling		2.8	2.9	3.0	V
		Hysteresis R_{PROG} =10 kΩ		70	100	130	mV
V_{UV}	V_{CC} undervoltage lockout	V_{CC} low to high R_{PROG} = 10 kΩ		3.65	3.80	3.95	V
		Hysteresis R_{PROG} =10 kΩ		50	180	300	mV
V_{MSD}	Manual shutdown 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 threshold	V_{CC} low to high T_J = 25 °C R_{PROG} = 10 kΩ		50	85	120	mV
		V_{CC} high to low T = 25 °C R_{PROG} = 10 kΩ		5	30	50	
I_{TERM}	C/10 termination current threshold (I_{BAT}/I_{BATC10}) [2]	R_{PROG} = 10 kΩ			10		µA
		R_{PROG} = 2 kΩ			10		

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_{PROG}	PROG pin voltage	Current mode R_{PROG} = 10 kΩ	0.93	1.0	1.07	V
V_{CHRG}	CHRG pinpull-down voltage	I_{CHRG} = 5 mA		0.35	0.6	V
I_{POWER_ON}	POWER ON pin leakage current	Pull-up		1		µA
	POWER ON pin pull-down voltage	I_{POWER_ON} = 5 mA		0.35	0.6	V
ΔV_{RECHRG}	Recharge battery threshold voltage	Battery voltage T_J = 25 °C R_{PROG} = 10 kΩ		200		mV
T_{LIM}	Junction temperature in constant temperature mode			120		°C
R_{ON}	PowerFET on-resistance (between V_{CC} and BAT)			600		mΩ
t_{SS}	Soft-start time	I_{BAT} = 0 to I_{BAT} = 1000 V / R_{PROG}		100		µs
$T_{RECHARGE}$	Recharge comparator filter time (3)	V_{BAT} highto low	0.75	2	4.5	ms
t_{TERM}	Termination comparatorfilter time (3)	I_{BAT} fallingbelow I_{CHG}/10	400	1000	2500	µs
I_{PROG}	PROG pin pull-up current			1		µA

1. *Supply current includes PROG pin current but it doesn't include any current delivered to the battery through V_{BAT} pin*
2. *I_{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 µF.*

5 Typical performance characteristics

Figure 4. I_{BAT} vs. supply voltage

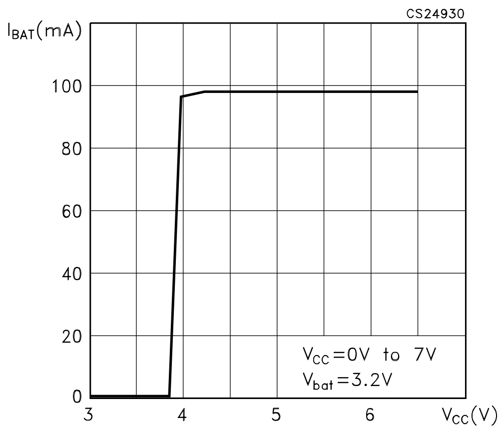


Figure 5. V_{BAT} vs. V_{CC}

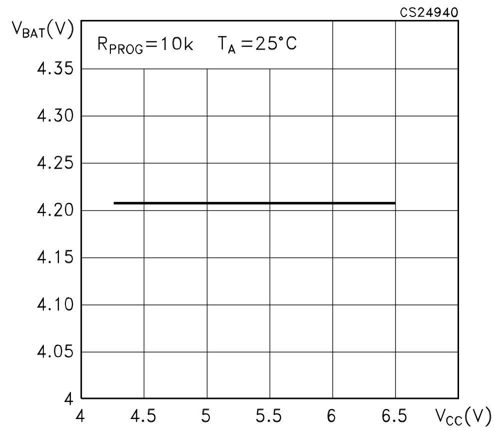


Figure 6. I_{BAT} vs. temperature

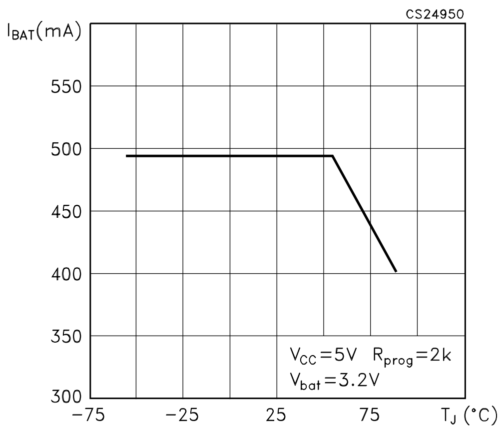


Figure 7. V_{PROG} vs. temperature

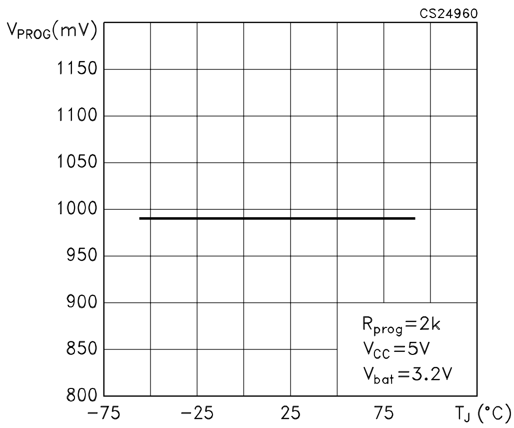


Figure 8. I_{BAT} / I_{PROG} **vs. temperature**

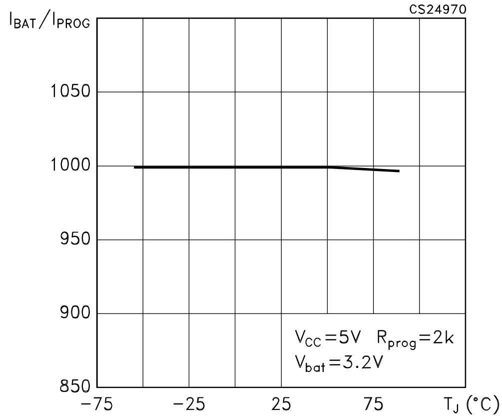


Figure 9. Recharge battery threshold voltage vs. temperature

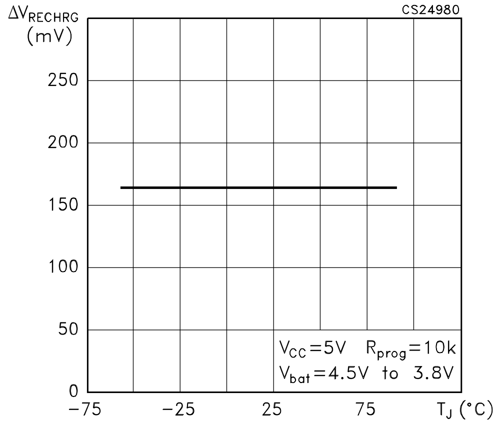


Figure 10. I_{BAT} / I_{PROG} **vs.** V_{CC}

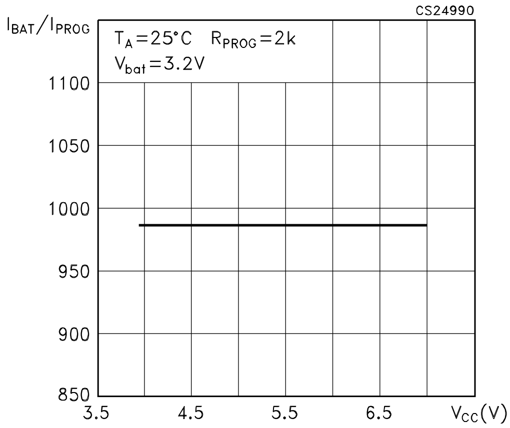


Figure 11. I_{BAT} **vs.** V_{BAT}

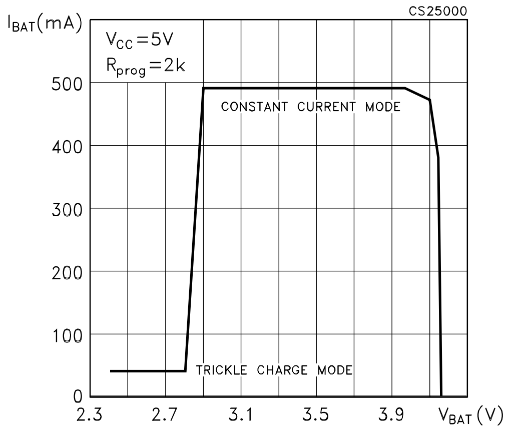


Figure 12. V_{CHRG} **vs. temperature (CHRG pin output low voltage)**

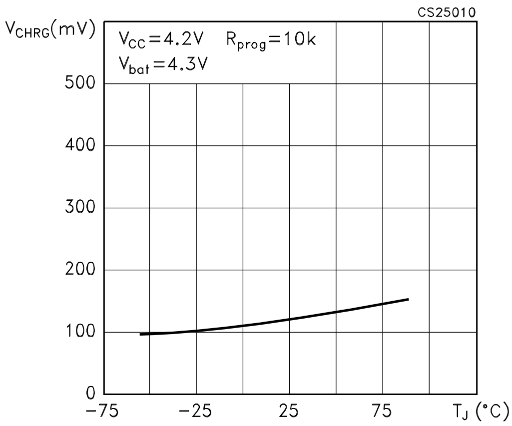


Figure 13. I_{BAT} **vs.** V_{PROG}

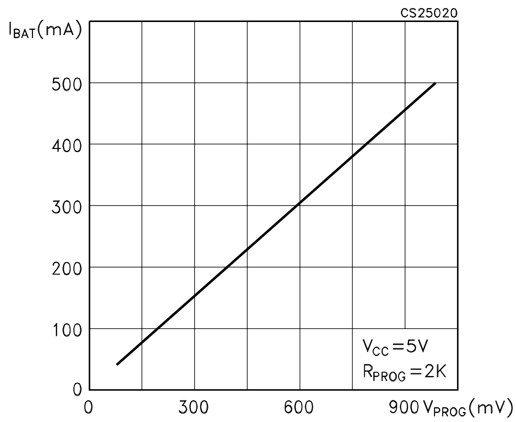
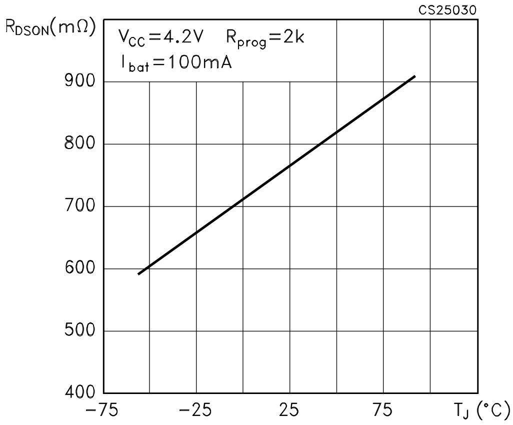


Figure 14. Power FET on-resistance



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 ±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 $1/10^{th}$ 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 $1/10^{th}$ 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 µF 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 µA.

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 CHRG 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 (1)	Standby mode (charge completed) or shutdown mode (R_{PROG} not connected).
1 (1)	1 (1)	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 µA 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 µA. Driving this pin to voltage beyond 2.4 V, a current of 35 µA 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 1/10th ofthe 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 µA.

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 µs.

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 µF bypass capacitor from BAT to GND. Furthermore, a 4.7 µF capacitor with a series resistor (0.2 Ω to 1 Ω) 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. ECOPACK® is an ST trademark.

7.1 DFN6 (3 x 3 mm) package information

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

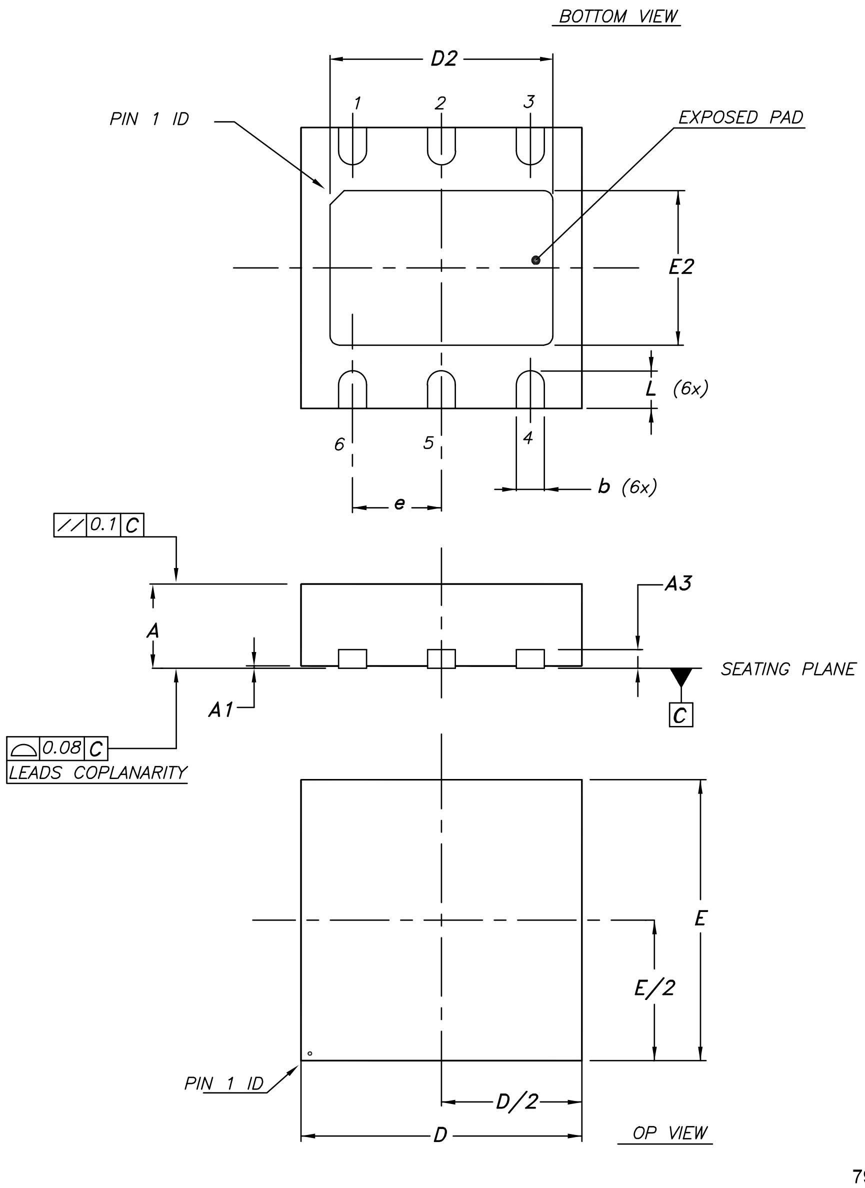
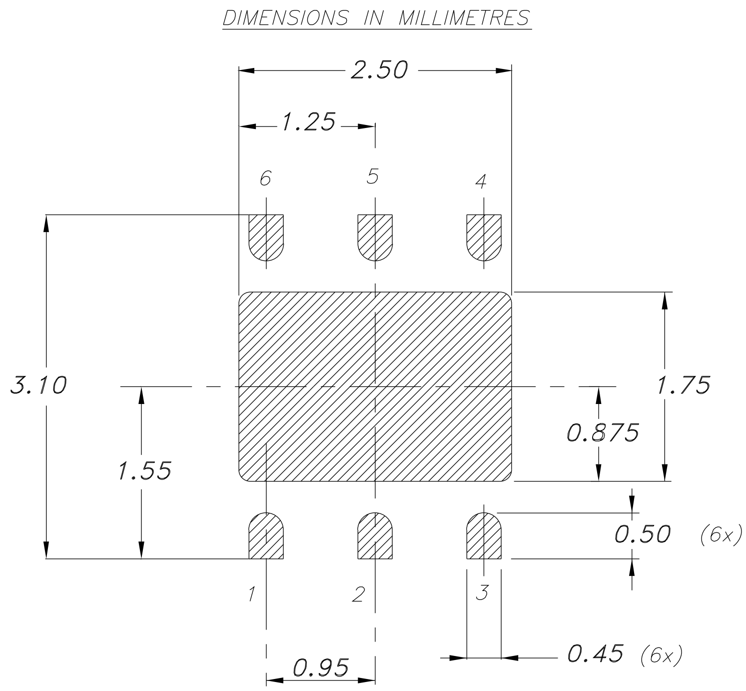


Table 6. **DFN6 (3 x 3 mm) package mechanical data**

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**

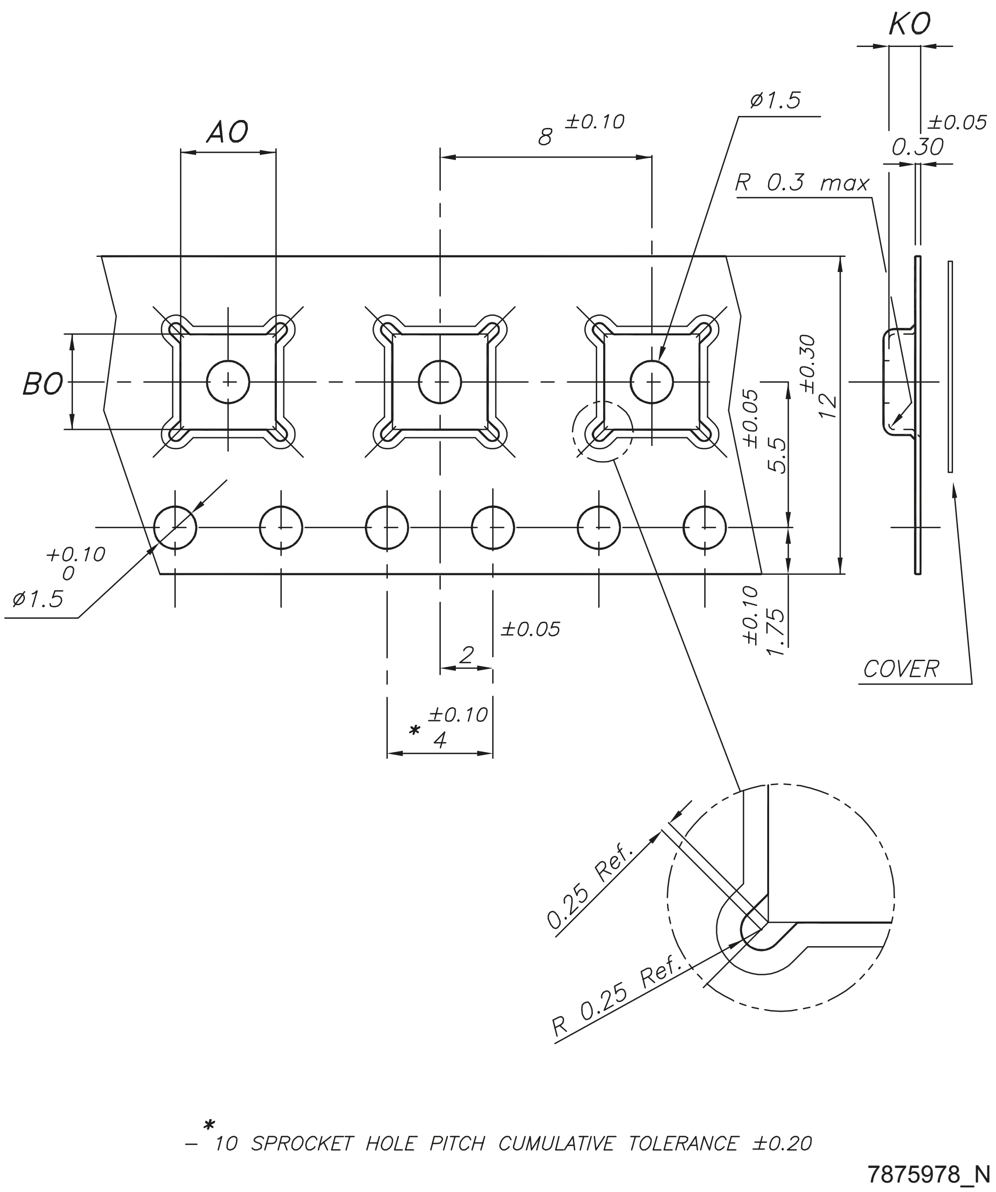


Figure 18. DFN6 (3 x 3 mm) reel outline

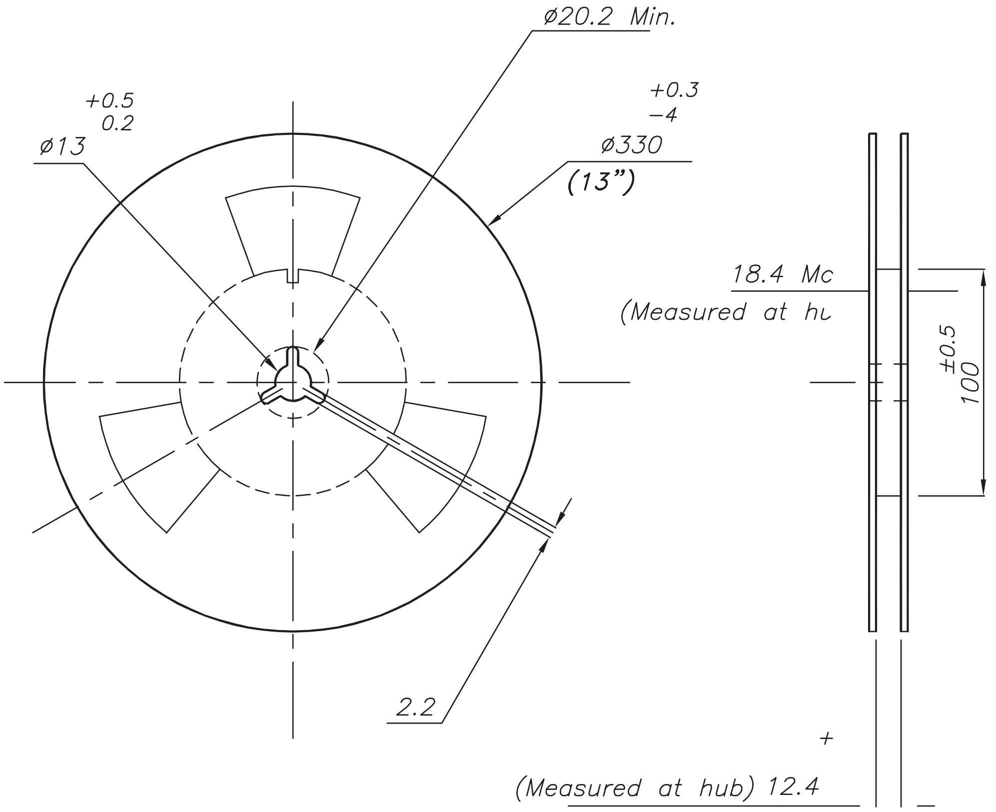


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Table 7. DFN6 (3 x 3 mm) tape and reel mechanical data

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. Updated I_{TERM} parameter in Table 5. Modified Table 6. Minortext changes.
17-Jul-2017	3	Updated Table 5.
28-Nov-2018	4	Updated V_{BAT} value in Table 2. Absolute maximum ratings.

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