Programmable Multi-Chemistry Fast-Charge Management IC

Check for Samples: bq2000T

FEATURES

- **Safe Management of Fast Charge for NiCd, NiMH, or Li-Ion Battery Packs**
- **High-Frequency Switching Controller for Efficient and Simple Charger Design**
- **Pre-Charge Qualification for Detecting Shorted, Damaged, or Overheated Cells**
- **Fast-Charge Termination by ΔT/Δt for Nickel Chemistries, Minimum Current for Li-Ion Chemistries, Maximum Temperature, and Maximum Charge Time**
- **Selectable Top-Off Mode for Achieving Maximum Capacity in NiMH Batteries**
- **Programmable Trickle-Charge Mode for Reviving Deeply Discharged Batteries and for Postcharge Maintenance**
- **Built-in Battery Removal and Insertion Detection**
- **Sleep Mode for Low Power Consumption**

APPLICATIONS

- **Multi-Chemistry Charger**
- **Nickel Charger**
- **High-Power, Multi-Cell Charger**

GENERAL DESCRIPTION

The bq2000T is a programmable, monolithic IC for fast-charge management of nickel cadmium (NiCd), nickel metal-hydride (NiMH), or lithium-ion (Li-Ion) batteries in single- or multi-chemistry applications. The bq2000T chooses the proper battery chemistry (either nickel or lithium) and proceeds with the optimal charging and termination algorithms. This process eliminates undesirable, undercharged, or overcharged conditions, and allows accurate and safe termination of fast charge.

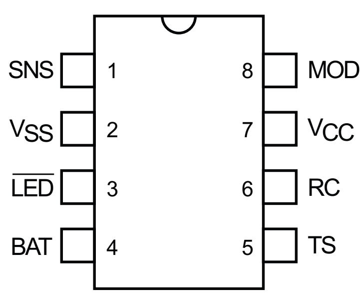
Depending on the chemistry, the bq2000T provides a number of charge termination criteria:

- Rate of temperature rise (ΔT/Δt) (for NiCd and NiMH)
- Minimum charge current (for Li-Ion)
- Maximum temperature
- Maximum charge time

For safety, the bq2000T inhibits fast charge until the battery voltage and temperature are within user-defined limits. If the battery voltage is below the low-voltage threshold, the bq2000T uses trickle-charge to condition the battery. For NiMH batteries, the bq2000T provides an optional top-off charge to maximize the battery capacity.

The integrated high-speed comparator allows the bq2000T to be the basis for a complete, high-efficiency battery charger circuit for both nickel-based and lithium-based chemistries.

8-Pin DIP or Narrow SOIC or TSSOP



Pin Names

SNS	Current-sense input
V_{SS}	System ground
$\overline{LED}$	Charge-status output
BAT	Battery-voltage input
TS	Temperature-sense input
RC	Timer-program input
V_{CC}	Supply-voltage input
MOD	Modulation-control output

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

PIN DESCRIPTIONS

SNS **Current-sense input**

Enables the bq2000T to sense the battery current via the voltage developed on this pin by an external sense-resistor connected in series with the battery pack

V_{SS} **System ground**

Connect to the battery's negative terminal

$\overline{\text{LED}}$ **Charge-status output**

Open-drain output that indicates the charging status by turning on, turning off, or flashing an external LED, driven through a resistor.

BAT **Battery-voltage input**

Battery-voltage sense input. A simple resistive divider, across the battery terminals, generates this input.

TS **Temperature-sense input**

Input for an external battery-temperature monitoring circuit. An external resistive divider network with a negative temperature-coefficient thermistor sets the lower and upper temperature thresholds.

RC **Timer-program input**

Used to program the maximum fast charge-time, maximum top-off charge-time, hold-off period, trickle charge rate, and to disable or enable top-off charge. A capacitor from V_{CC} and a resistor to ground connect to this pin.

V_{CC} **Supply-voltage input**

Recommended bypassing is 10 µF + 0.1 µF to 0.22 µF of decoupling capacitance near the pin.

MOD **Modulation-control output**

Push-pull output that controls the charging current to the battery. MOD switches high to enable charging current to flow and low to inhibit charging-current flow.

FUNCTIONAL DESCRIPTION

The bq2000T is a versatile, multi-chemistry battery charge control device. See Figure 1 for a functional block diagram and Figure 2 for a state diagram.

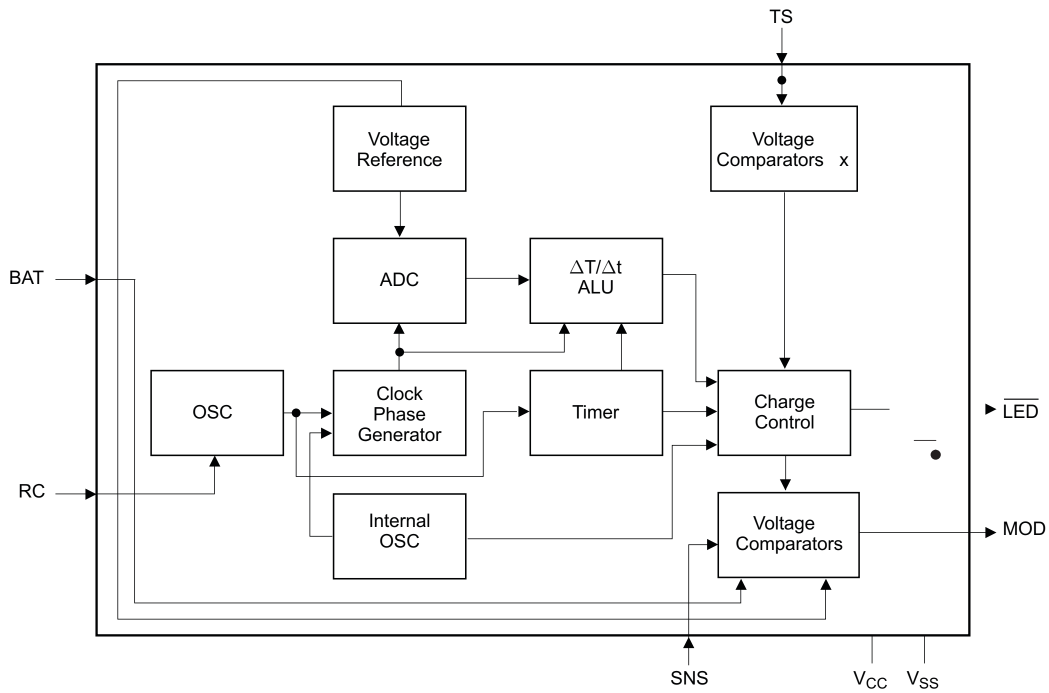
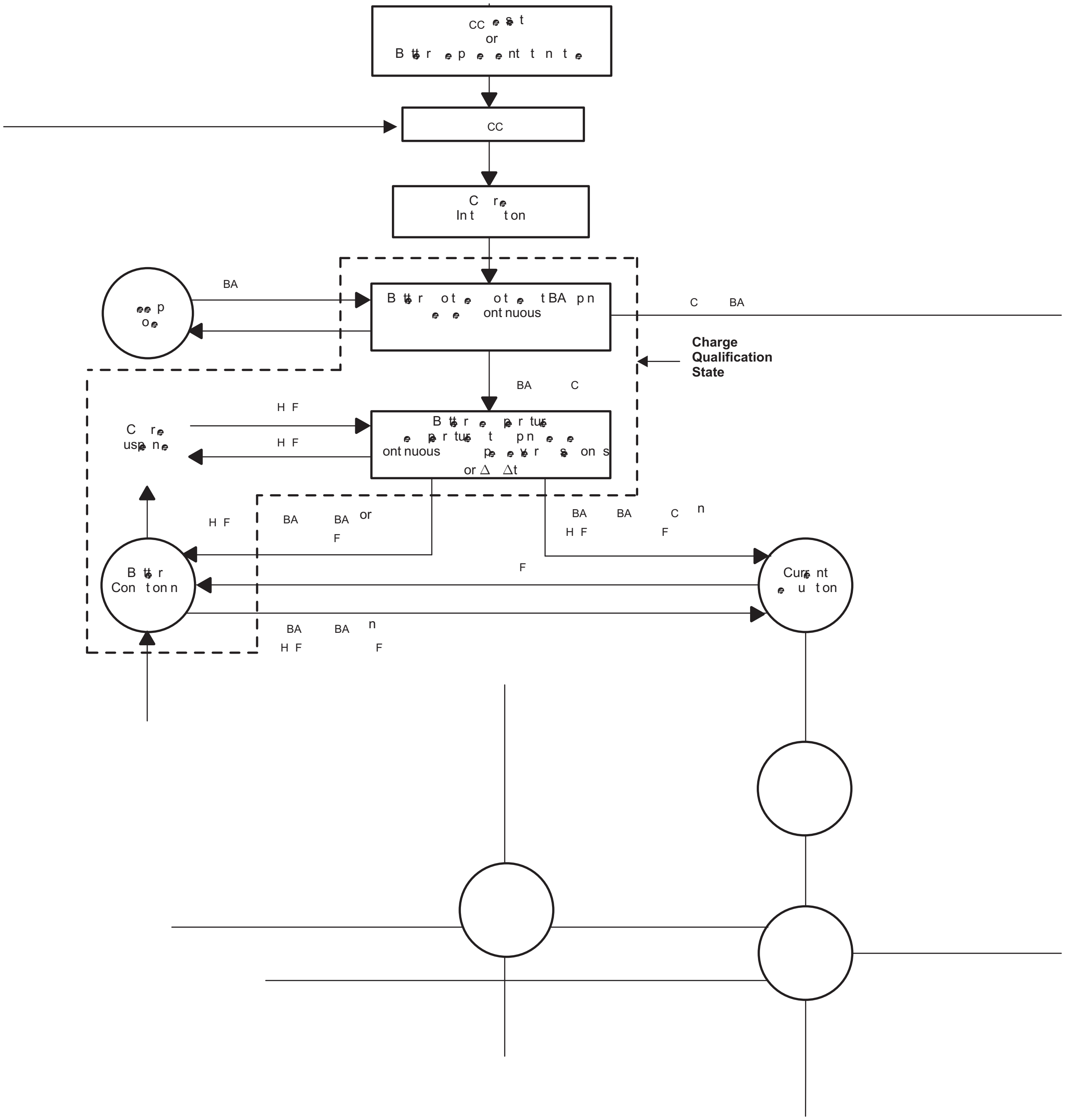


Figure 1. Functional Block Diagram



NOTE: If $V_{TS} < V_{TCO}$ at any time, may only return to Trickle Maintenance Charge state and not to Top-Off.

Figure 2. State Diagram

ABSOLUTE MAXIMUM RATINGS(1)

		VALUE	UNIT
V_{CC}	V_{CC} relative to V_{SS}	–0.3 to 7	V
V_T	DC voltage applied on any pin, relative to V_{SS}	–0.3 to V_{CC}	V
T_{OPR}	Operating ambient temperature	–20 to 70	°C
T_{STG}	Storage temperature	–40 to 125	°C
T_{SOLDER}	Soldering temperature (10 s max)	260	°C

(1) Permanent device damage may occur if Absolute Maximum Ratings are exceeded. Functional operation should be limited to the Recommended DC Operating Conditions detailed in this data sheet. Exposure to conditions beyond the operational limits for extended periods of time may affect device reliability.

DC THRESHOLDS(1)

$T_A = T_{OPR}$; V_{CC} = 5 V ± 20% (unless otherwise specified)

PARAMETER		TEST CONDITIONS	TYPICAL	TOLERANCE	UNIT
V_{TCO}	Temperature cutoff	Voltage at the TS pin	0.225 × V_{CC}	±5%	V
V_{HTF}	High-temperature fault	Voltage at the TS pin	0.25 × V_{CC}	±5%	V
V_{LTF}	Low-temperature fault	Voltage at the TS pin	0.5 × V_{CC}	±5%	V
V_{MCV}	Maximum cell voltage	Voltage at the BAT pin	2.00	±0.75%	V
V_{LBAT}	Minimum cell voltage	Voltage at the BAT pin	950	±5%	mV
V_{THERM}	TS input change for ΔT/Δt detection	Voltage at the TS pin	-V_{CC}/161	±25%	V/min
V_{SNSHI}	High threshold at SNS	Voltage at the SNS pin	50	±10	mV
V_{SNSLO}	Low threshold at SNS	Voltage at the SNS pin	–50	±10	mV
V_{SLP}	Sleep-mode input threshold	Voltage at the BAT pin	V_{CC}–1	±0.5	V
V_{RCH}	Recharge threshold	Voltage at the BAT pin	V_{MCV}–0.1	±0.02	V

(1) All voltages are relative to V_{SS} except as noted.

RECOMMENDED DC OPERATING CONDITIONS

over operating free-air temperature range (unless otherwise noted)

		TEST CONDITIONS	MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		4	5	6	V
I_{CC}	Supply current	Exclusive of external loads		0.5	1	mA
I_{CCS}	Sleep current	$V_{BAT} = V_{SLP}$			5	µA
V_{TS}	Thermistor input	V_{TS} < 0.5 V prohibited	0.5		V_{CC}	V
V_{OH}	Output high	MOD, I_{OH} = 10 mA	V_{CC}–0.4			V
V_{OL}	Output low	MOD, $\overline{LED}$, I_{OL} = 10 mA			0.2	V
I_{OZ}	High-impedance leakage current	$\overline{LED}$			5	µA
I eTj /F2 2 7 Tf 10.4 282.6 Td (V)Tj ET BT /F2 teT /F2 0 rg 535.4f 100 Tz 0 0 0 rg 533.4 270.4 T2f 100 Tz 0 0 0 rg 2i5.4f 1.2 Td (V)Tj ED						

0 Td (threshold)Tj 30.89 0 Td (at)Tj233 0 Td (V 0 rg 2480 Tdd (V)Tj (der8.7 1.4 d (V)Tj capaci248.5 3F2 7 Tf 100

Initiation and Charge Qualification

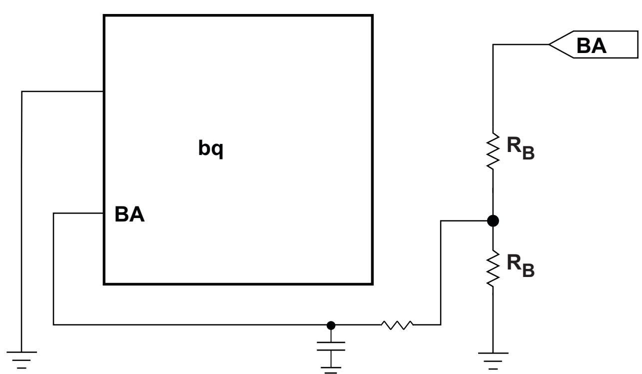
The bq2000T initiates a charge cycle when it detects

- Application of power to V_{CC}
- Battery replacement
- Exit from sleep mode
- Capacity depletion (Li-Ion only)

Immediately following initiation, the IC enters a charge-qualification mode. The bq2000T charge qualification is based on battery voltage and temperature. If the voltage on the BAT pin is less than the internal threshold, V_{LBAT}, the bq2000T enters the battery conditioning state. This condition indicates the possibility of a defective or shorted battery pack. In an attempt to revive a fully depleted pack, the bq2000T enables the MOD pin to trickle-charge at a rate of once every 1.0s. As explained in the section "Top-Off and Pulse-Trickle Maintenance Charge," the trickle pulse-width is user-selectable and is set by the value of the resistance connected between the RC pin and V_{SS}.

During charge qualification, the $\overline{\text{LED}}$ pin blinks at a 1-Hz rate, indicating the pending status of the charger.

Once battery



Lithium-Ion Batteries

The bq2000T uses a two-phase fast-charge algorithm for Li-Ion batteries (Figure 4). In phase one, the bq2000T regulates constant current until V_{BAT} rises to V_{MCV}. Once V_{BAT} = V_{MCV}, the device identifies the cell as a Li-ion, and changes the termination method from ΔT/Δt to minimum current. The bq2000T then moves to phase two, regulates the battery with constant voltage of V_{MCV}, and terminates when the charging current falls below the I_{MIN} threshold or the timer expires (whichever happens first). A new charge cycle is started if the cell voltage falls below the V_{RCH} threshold.

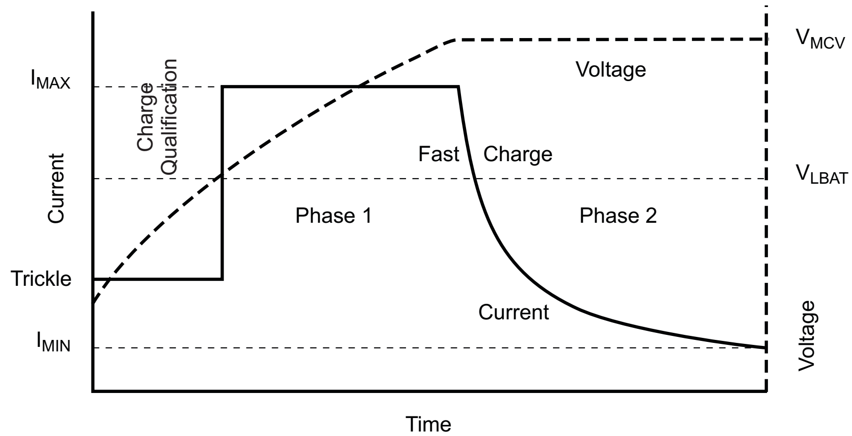


Figure 4. Lithium-Ion Charge Algorithm

During the current-regulation phase, the bq2000T monitors charge time, battery temperature, and battery voltage for adherence to the termination criteria. During the final constant-voltage stage, in addition to the charge time and temperature, it monitors the charge current as a termination criterion. There is no post-charge maintenance mode for Li-Ion batteries.

Table 1 summarizes the charging process for both Nickel and Li-Ion batteries.

Table 1. Charge Algorithm

BATTERY CHEMISTRY	CHARGE ALGORITHM
NiCd or NiMH (V_{BAT} < V_{MCV} always)	1. Charge qualification terminSLUS13e 2. Trickle charge, if required 3. Fast charge (constant current) 4. Fast charge termination (rate of temperature rise, maximum charge time = 1 MTO) 5. Top-off (optional) 6. Trickle charge
Li-Ion (V_{BAT} ≤6.	1. Charge qualification 2. Trickle charge, if required 3. Fast charge (constant current)

chargeCopyrigh”

FAST CHARGE TERMINATION

Initial Hold-Off Period

The bq2000T incorporates a user programmable hold-off period to avoid premature fast charge termination that can occur with brand new nickel cells at the very beginning of fast charge. The values of the external resistor and capacitor connected to the RC pin set the initial hold-off period. During this period, the bq2000T avoids early termination due to an initial rise in the battery temperature by disabling the rate of temperature rise (ΔT/Δt) feature. This period is fixed at the programmed value of the maximum charge time (MTO) divided by 32.

$$o\ d\ o\ \ \ per\ od - \frac{M}{\ } \quad (1)$$

Maximum Charge Time (NiCd, NiMH, and Li-Ion)

The bq2000T sets the maximum charge-time through the RC pin. With the proper selection of external resistor and capacitor values, various time-out values may be achieved. If the timer expires while still in constant-current charging, the bq2000T assumes a Nickel chemistry and proceeds to top-off charge (if top-off is enabled) or trickle maintenance charge. Figure 5 shows a typical connection.

Figure 5. Typical Connection for the RC Input

The following equation shows the relationship between the R_{MTO} and C_{MTO} values and the maximum charge time (MTO) for the bq2000T:

$$MTO = R_{MTO} \times C_{MTO} \times 35{,}988 \quad (2)$$

MTO is measured in minutes, R_{MTO} in ohms, and C_{MTO} in farads. (**Note:** R_{MTO} and C_{MTO} values also determine other features of the device. See Table 4 and Table 5 for details.)

If, during fast charge, $V_{TS} > V_{LTF}$, then the timer is paused and the IC enters battery conditioning charge until $V_{TS} < V_{LTF}$. Since the IC is in the battery conditioning state, the $\overline{LED}$ flashes at the 1 Hz rate. Once $V_{TS} < V_{LTF}$, fast charge restarts and the timer resumes from where it left off with no change in total fast charge time.

For Li-Ion cells, when the battery reaches the constant-voltage phase of fast charge, the bq2000T adds an additional MTO of time to whatever time was left over from the constant current fast charge timer. Thus, the pack could spend longer than 1 MTO in constant-voltage fast charge, but is always limited to 1 MTO in constant-current fast charge. This feature provides the additional charge time required for Li-Ion cells.

For Nickel cells, if top-off is enabled, the timer is reset on the completion of fast charge before beginning top-off charge.

Maximum Temperature (NiCd, NiMH, Li-Ion)

A negative-coefficient thermistor, referenced to V_{SS} and placed in thermal contact with the battery, may be used as a temperature-sensing device. Figure 6 shows a typical temperature-sensing circuit.

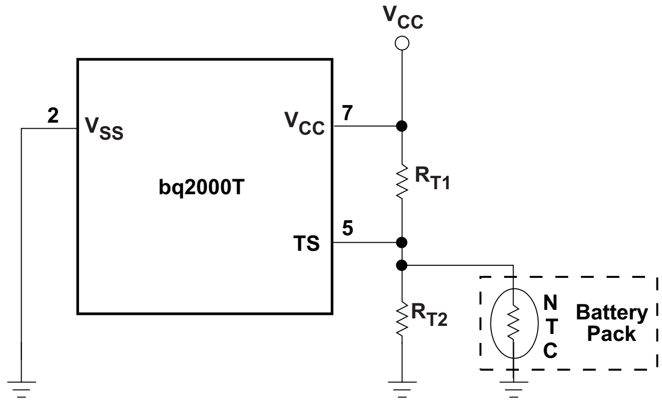


Figure 6. Temperature Monitoring Configuration

During fast charge, the bq2000T compares the battery temperature to an internal high-temperature cutoff threshold, V_{TCO}, and a low-temperature threshold, V_{LTF}. During fast charge only, the V_{HTF} fault comparator is disabled. When the voltage at the TS pin is lower than V_{TCO}, the bq2000T terminates fast charge, moves to the charge suspended state, and turns off the $\overline{LED}$. When V_{TS} rises above V_{HTF}, the bq2000T resumes charging in the trickle maintenance charge state, per Figure 2. In fast charge (either constant current or constant voltage fast charge), when the voltage on the TS pin is higher than V_{LTF}, the charger enters the battery conditioning state, as described in the previous section. Fast charge is resumed when V_{TS} is less than V_{LTF}.

Rate of Temperature Rise (NiCd, NiMH)

The bq2000T uses a rate of temperature rise ($\Delta T/\Delta t$) scheme to terminate fast charge for NiCd and NiMH batteries. During fast charge, it samples the TS pin voltage every 8 seconds and compares it to the value measured 2 samples earlier. This feature terminates fast charge if this voltage declines at a rate of $V_{CC}/161$ (V/min). Figure 6 shows a typical connection diagram. In preparation for sampling the TS pin voltage, the bq2000T briefly turns off most circuits (the MOD and RC pins both go low) in order to get the cleanest possible, noise-free measurement. While the monitoring of the TS pin voltage is continuous, the sampling of the TS pin voltage with the internal ADC only occurs during the constant current regulation phase of fast charge. If the cell voltage reaches V_{MCV}, the pack is assumed to be Li-Ion and the TS pin voltage sampling is disabled, as $\Delta T/\Delta t$ is not a termination criterion for Lithium cells.

Minimum Current (Li-Ion Only)

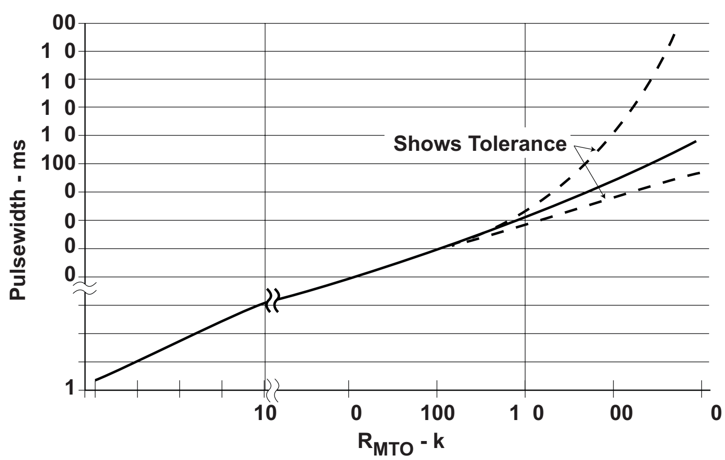
The bq2000T monitors the charging current during the voltage-regulation phase of Li-Ion batteries. Fast charge is terminated when the current is tapered off to 7% of the maximum charging current. Note that this threshold is different for the bq2000.

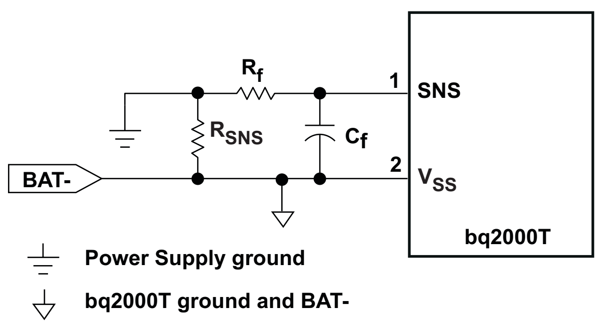
Once constant-current fast charge has ended, the bq2000T either measures the value of the C_{MTO} capacitor (in the case of Nickel batteries) and then proceeds to either top-off or trickle maintenance charge or simply completes the constant-voltage stage of fast charge (in the case of a Li-Ion cell).

Top-Off and Pulse-Trickle Maintenance Charge

An optional top-off charge is available for NiCd or NiMH batteries. Top-off may be desirable on batteries that have a tendency to terminate charge before reaching full capacity. To enable this option, the capacitance value of C_{MTO} connected between the RC pin and V_{CC} (Figure 5) should be greater than 0.13 µF , and the value of the resistor connected to this pin should be less than 250 kΩ . To disable top-off, the capacitance value should be less than 0.07 µF. The tolerance of the capacitor needs to be taken into account in component selection.

Once top-off is started, the timer is reset and top-off proceeds until the timer expires, V1999





$$I_{MAX} = \frac{0.05}{R_{SNS}}$$

$$\text{Hysteresis (V)} = V_{CC} \times \frac{C_{HYS}}{(C_{HYS} + C_f)}$$

Being a hysteretic controller, the switching frequency of the bq2000T is determined by the values of several of the external circuit components. The components that affect the switching frequency are: input voltage, R_{SNS} value, inductor value, hysteresis capacitor value (C_{HYS}), and the value of the filter on the current sense signal (R_f and C_f values). R_f and C_f have the most impact on the switching frequency and are also the components that are easiest to change to adjust the frequency, as they do not affect anything else in the circuit (besides, of course, the cleanliness and quality of the current sense signal being fed to the bq2000T). In general, increasing the input voltage and/or inductor value or decreasing C_{HYS} and/or the $R_f \times C_f$ filter corner frequency increases the switching frequency. Figure 9 and Figure 10 show empirical data on the variation in switching frequency based on adjusting R_f and C_f. This data was taken with an input voltage of 12 V, inductor value of 220 µH, R_{SNS} value of 50 mΩ, and C_{HYS} value of 4.7 pF. Typical switching frequencies for the bq2000T are between 100 and 200 kHz, though it is possible to achieve switching frequencies in excess of 300 kHz.

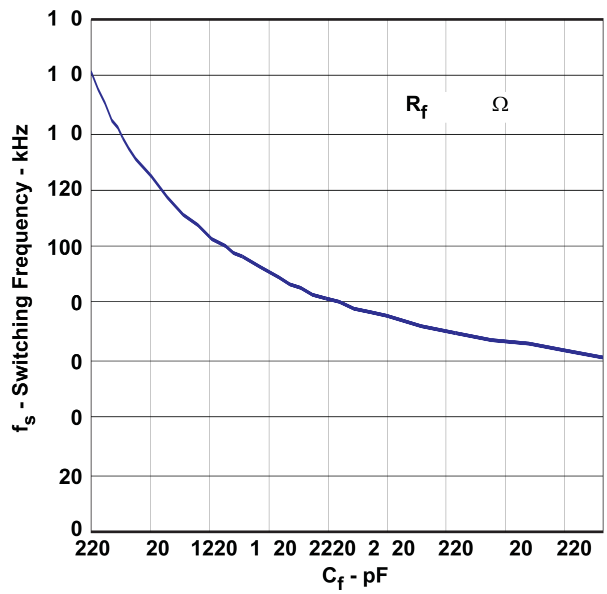


Figure 9. Switching Frequency vs Capacitance

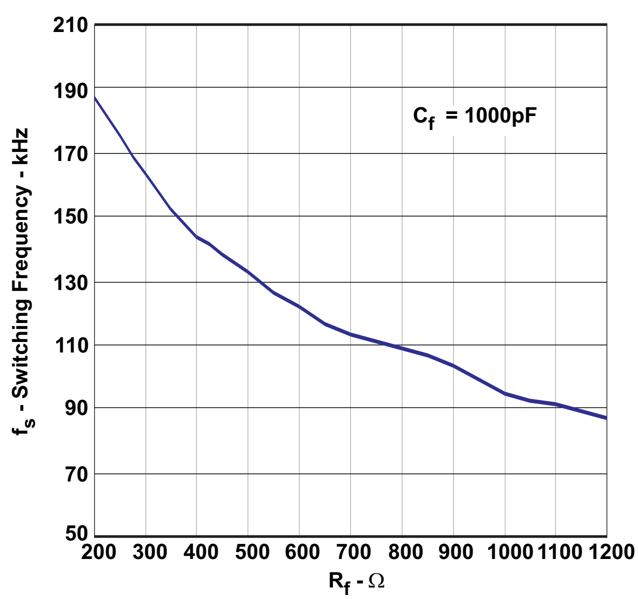


Figure 10. Switching Frequency vs Resistance

BATTERY VOLTAGE INPUT

As shown in Figure 3, a resistor voltage-divider between the battery pack's positive terminal and V_{SS} scales the battery voltage measured at the BAT pin.

For Li-Ion battery packs, the resistor values R_{B1} and R_{B2} are calculated by the following equation:

$$\frac{B}{B} \left(\times \frac{}{} \right) - \qquad (5)$$

where N is the number of cells in series and V_{CELL} is the manufacturer-specified charging voltage. R_{B1} + R_{B2} should be at least 200 kΩ and no more than 1 MΩ.

A NiCd or NiMH battery pack consisting of N series cells may benefit by the selection of the R_{B1} value to be N–1 times larger than the R_{B2} value. This sets the per cell regulation voltage (V_{CELL}) equal to V_{MCV}. It is critical that V_{CELL} be set high enough that the nickel pack not reach voltage regulation, thus allowing proper termination by ΔT/Δt. The typical V_{CELL} setting for a nickel pack is between 1.7 V and 2 V.

In a mixed-chemistry design, a common voltage-divider is used as long as the maximum charge voltage of the nickel-based pack is below that of the Li-Ion pack. Otherwise, different scaling is required. See Figure 11 for an example.

Figure 11. Single-Cell Li-Ion, 3-Cell NiCd/NiMH 1-A Charger

Table 5. Summary of Li-Ion Charging Characteristics

PARAMETER	VALUE(1)
Maximum cell voltage (V_{MCV})	2 V
Minimum pre-charge qualification voltage (V_{LBAT})	950 mV
High-temperature cutoff voltage (V_{TCO})	0.225 × V_{CC}
High-temperature fault voltage (V_{HTF})	0.25 × V_{CC}
Low-temperature fault voltage (V_{LTF})	0.5 × V_{CC}
bq2000T fast-charge maximum time out (MTO)	2 × R_{MTO} × C_{MTO} × 35,988 (See Maximum Charge Time section for full explanation)
Fast-charge charging current (I_{MAX})	0.05/R_{SNS}
Hold-off period	MTO/32
Minimum current (for fast-charge termination)	I_{MAX}/14
Trickle-charge frequency (before fast charge only)	1 Hz
Trickle-charge pulse-width (before fast charge only)	See Figure 7

(1) See the DC Thresholds Specification for details.

Charge Status Display

The charge status is indicated by open-drain output $\overline{LED}$. Table 6 summarizes the display output of the bq2000T. A temperature fault or timer expiring changes the charge state immediately (according to Figure 2) and thus changes the $\overline{LED}$ status immediately and accordingly.

Table 6. Charge Status Display

bq2000T CHARGE STATE	$\overline{LED}$ STATUS
Charge qualification (including battery conditioning and charge suspended)	1-Hz flash
Fast charge (current and voltage regulation)	Low
Top-off charge	High impedance
Trickle maintenance charge (after fast charge)	
Charge complete	
Battery absent	
Sleep mode	

Sleep Mode

The bq2000T features a sleep mode for low power consumption. This mode is enabled when the voltage at the BAT pin is above the low-power-mode threshold, V_{SLP}. During sleep mode, the bq2000T shuts down all unnecessary internal circuits, drives the $\overline{LED}$ output to high-impedance state, and drives the MOD pin low. Restoring BAT below the V_{MCV} threshold initiates the IC and starts a fast-charge cycle. Normally, the bq2000T only enters sleep mode when there is no battery connected on the output and the charger is idling with nothing to charge. In addition, V_{IN} needs to be high enough such that when V_{IN} is present on the output, V_{BAT} would be greater than V_{SLP}. In sleep mode, the output voltage decays to V_{MCV} at which point the bq2000T turns on and pulses the MOD pin several times. With no battery connected, the output rises to near V_{IN} at which point the bq2000T re-enters sleep mode. During sleep mode, the RC pin is at V_{SS} potential. A typical sleep mode waveform is shown in Figure 18.

TYPICAL CHARACTERISTICS

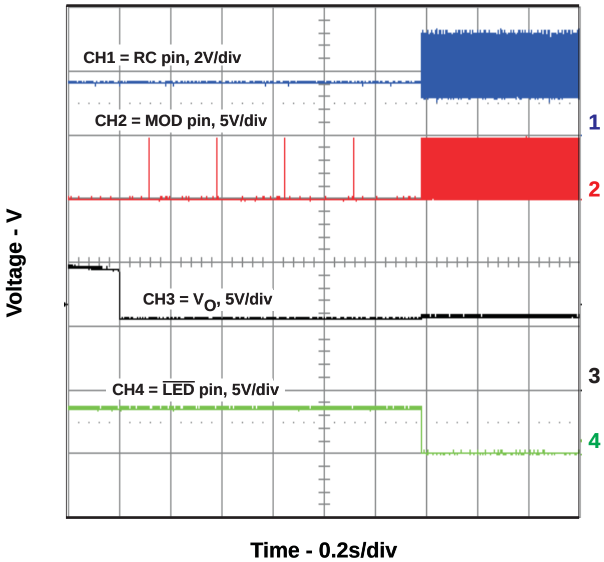


Figure 12. bq2000T Start-up on Battery Insertion

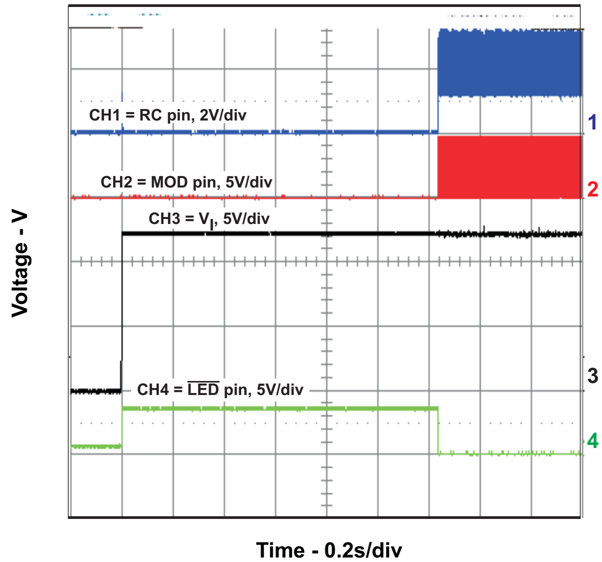


Figure 13. bq2000T Start-up on Vin

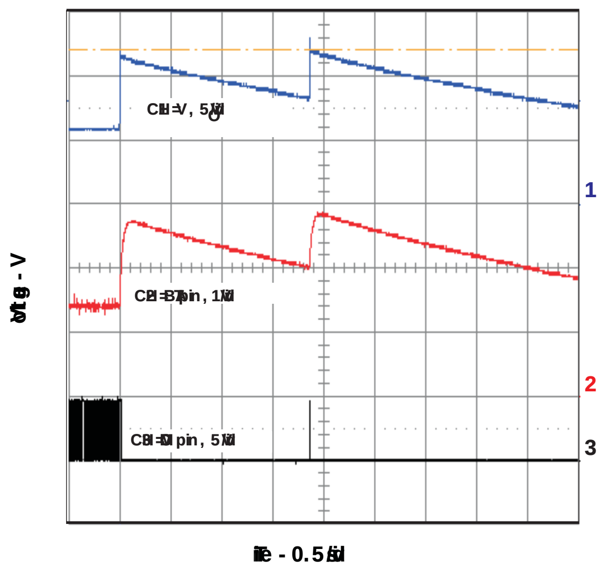


Figure 14. Battery Removal During Fast Charge

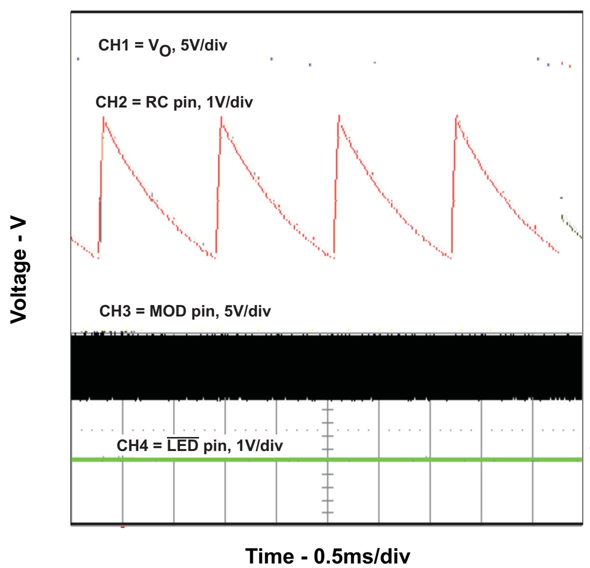


Figure 15. bq2000T in Fast Charge

TYPICAL CHARACTERISTICS (continued)

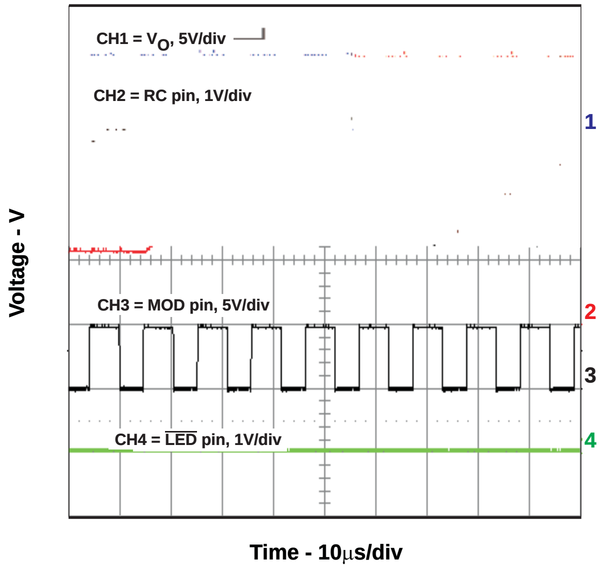


Figure 16. bq2000T in Fast Charge

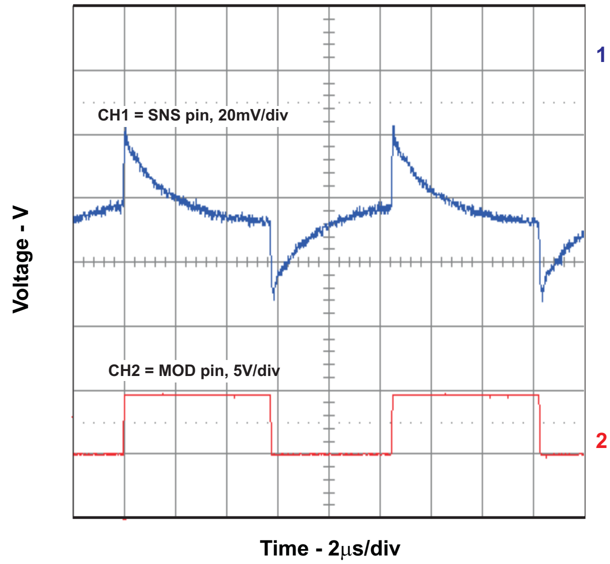


Figure 17. bq2000T Fast Charge SNS and MOD Waveforms

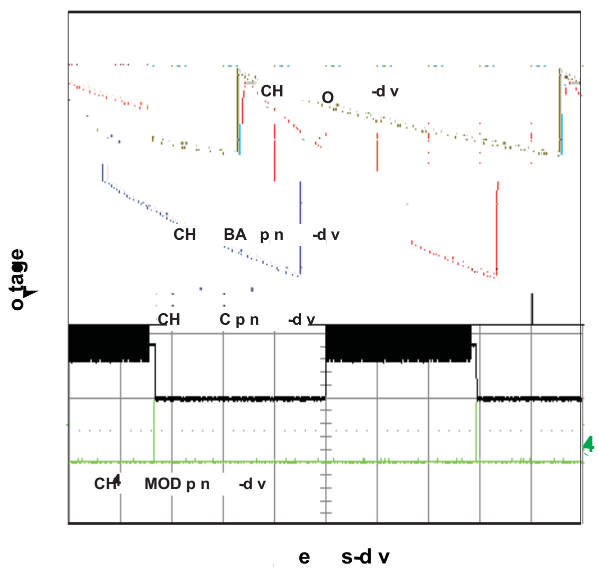


Figure 18. bq2000T Cycling In and Out of Sleep Mode (No battery present)

REVISION HISTORY

Changes from Original (January 1999) to Revision 1 — Page

- Changed the device status From: Preliminary To: Final 1
- Added state diagram 4
- Changed minimum current termination From: 14% To: 7% 9
- Changed capacitor value for enabling top-off From: 0.13 µF To: 0.26 µF 9
- Changed Figure 11 13
- Changed V_{TCO} 14
- Changed V_{HTF} 14
- Changed V_{LTF} 14

Changes from Revision 1 (May 1999) to Revision 2 — Page

- Changed minimum current (for fast-charge termination) From: $I_{MAX}/7$ To: $I_{MAX}/14$ 15

Changes from Revision 2 (February 2000) to Revision 3 — Page

- Changed ordering information 1
- Changed Figure 1 - connection added between TS and ADC and connection deleted between BAT and ADC 3
- Changed Figure 2 - battery temperature From: (checked at all times) To: (sampled every 16 seconds for ΔT/Δt) 4

Changes from Revision 3 (February 2001) to Revision 4 — Page

- Changed resistor value From: 15 kΩ To: 250Td (-)Tj 5.7 0 Td /F21 9 Tf 16 0 TD Preliminary To: Final(û)Tj /F2 9 Tf 6 0 Td (t......... 0 Td (............)Tj

PACKAGING INFORMATION

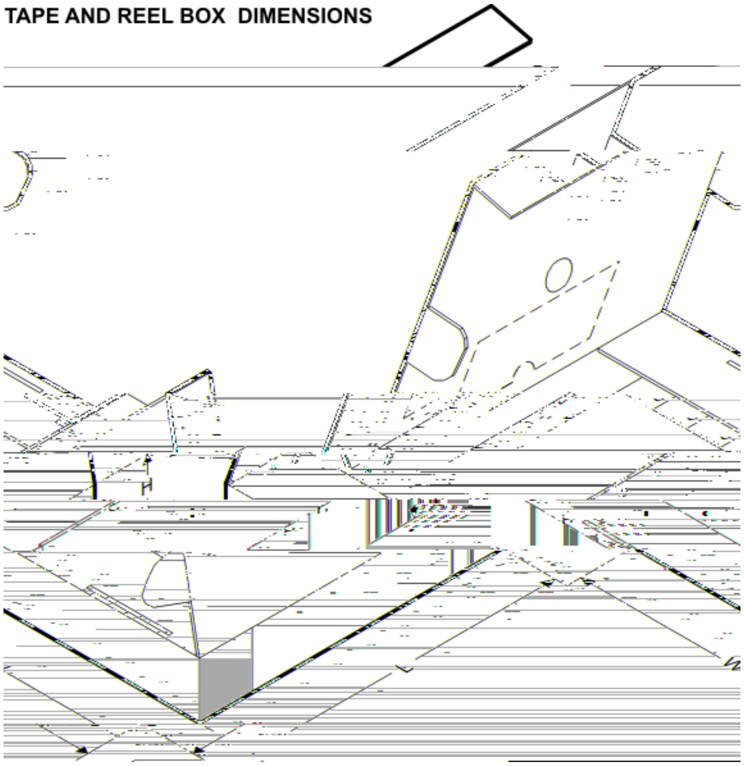
Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
BQ2000TPN-B5	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2000TPW	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ2000TPWG4	ACTIVE	TSSOP	PW	8	150	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ2000TPWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ2000TPWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ2000TSN-B5	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2000TSN-B5G4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2000TSN-B5TR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2000TSN-B5TRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

TAPE AND REEL INFORMATION

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ2000TPWR	TSSOP	PW	8	2000	367.0	367.0	35.0
BQ2000TSN-B5TR	SOIC	D	8	2500	367.0	367.0	35.0

[redacted]

Example
Pad Geometry
(See Note C)

Example
Solder Mask Opening
(See Note E)

C. Publication IPC-7351 is recommended for alternate [redacted]

D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.

[redacted] and around signal pads.

[redacted]

IMPORTANT NOTICE

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		