

## NiCd/NiMH Fast-Charge Management ICs

### Features

- Fast charge of nickel cadmium or nickel-metal hydride batteries
- Direct LED output displays charge status
- Fast-charge termination by rate of rise of temperature, maximum voltage, maximum temperature, and maximum time
- Internal band-gap voltage reference
- Optional top-off charge (bq2002T only)
- Selectable pulse-trickle charge rates (bq2002T only)
- Low-power mode
- 8-pin 300-mil DIP or 150-mil SOIC

### General Description

The bq2002D/T Fast-Charge IC are low-cost CMOS battery-charge controllers able to provide reliable charge termination for both NiCd and NiMH battery applications. Controlling a current-limited or constant-current supply allows the bq2002D/T to be the basis for a cost-effective stand-alone or system-integrated charger. The bq2002D/T integrates fast charge with optional top-off and pulsed-trickle control in a single IC for charging one or more NiCd or NiMH battery cells.

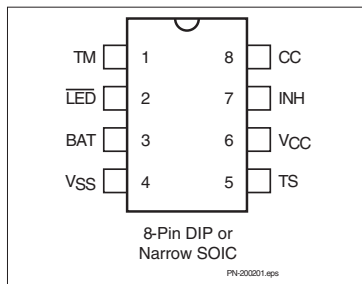
Fast charge is initiated on application of the charging supply or battery replacement. For safety, fast charge is inhibited if the battery temperature and voltage are outside configured limits.

Fast charge is terminated by any of the following:

- Rate of temperature rise
- Maximum voltage
- Maximum temperature
- Maximum time

After fast charge, the bq2002T optionally tops-off and pulse-trickles the battery per the pre-configured limits. Fast charge may be inhibited using the INH pin. The bq2002D/T may be placed in low-standby-power mode to reduce system power consumption.

### Pin Connections



### Pin Names

TM	Timer mode select input	TS	Temperature sense input
LED	Charging status output	V <sub>CC</sub>	Supply voltage input
BAT	Battery voltage input	INH	Charge inhibit input
V <sub>SS</sub>	System ground	CC	Charge control output

### bq2002D/T Selection Guide

Part No.	TCO	HTF	LTF	Fast Charge	Time-Out	Top-Off	Maintenance
bq2002D	0.225 * V <sub>CC</sub>	0.25 * V <sub>CC</sub>	None	C/4	440 min	None	None
				1C	110 min	None	None
				2C	55 min	None	None
bq2002T	0.225 * V <sub>CC</sub>	0.25 * V <sub>CC</sub>	0.4 * V <sub>CC</sub>	C/4	320 min	C/64	C/256
				1C	80 min	C/16	C/256
				2C	40 min	None	C/128

# bq2002D/T

## Pin Descriptions

<b>TM</b>	<b>Timer mode input</b>	A three-level input that controls the settings for the fast charge safety timer, voltage termination mode, top-off, pulse-trickle, and voltage hold-off time.
<b>LED</b>	<b>Charging output status</b>	Open-drain output that indicates the charging status.
<b>BAT</b>	<b>Battery input voltage</b>	The battery voltage sense input. The input to this pin is created by a high-impedance resistor divider network connected between the positive and negative terminals of the battery.
<b>VSS</b>	<b>System ground</b>	
<b>TS</b>	<b>Temperature sense input</b>	Input for an external battery temperature monitoring thermistor.
<b>VCC</b>	<b>Supply voltage input</b>	5.0V ±20% power input.
<b>INH</b>	<b>Charge inhibit input</b>	When high, INH suspends the fast charge in progress. When returned low, the IC re-

sumes operation at the point where initially suspended.

## CC Charge control output

An open-drain output used to control the charging current to the battery. CC switching to high impedance (Z) enables charging current to flow, and low to inhibit charging current. CC is modulated to provide top-off, if enabled, and pulse trickle.

## Functional Description

Figures 2 and 3 show state diagrams of bq2002D/T and Figure 4 shows the block diagram of the bq2002D/T.

### Battery Voltage and Temperature Measurements

Battery voltage and temperature are monitored for maximum allowable values. The voltage presented on the battery sense input, BAT, should represent a single-cell potential for the battery under charge. A resistor-divider ratio of

$$\frac{RB1}{RB2} = N - 1$$

is recommended to maintain the battery voltage within the valid range, where N is the number of cells, RB1 is the resistor connected to the positive battery terminal, and RB2 is the resistor connected to the negative battery terminal. See Figure 1.

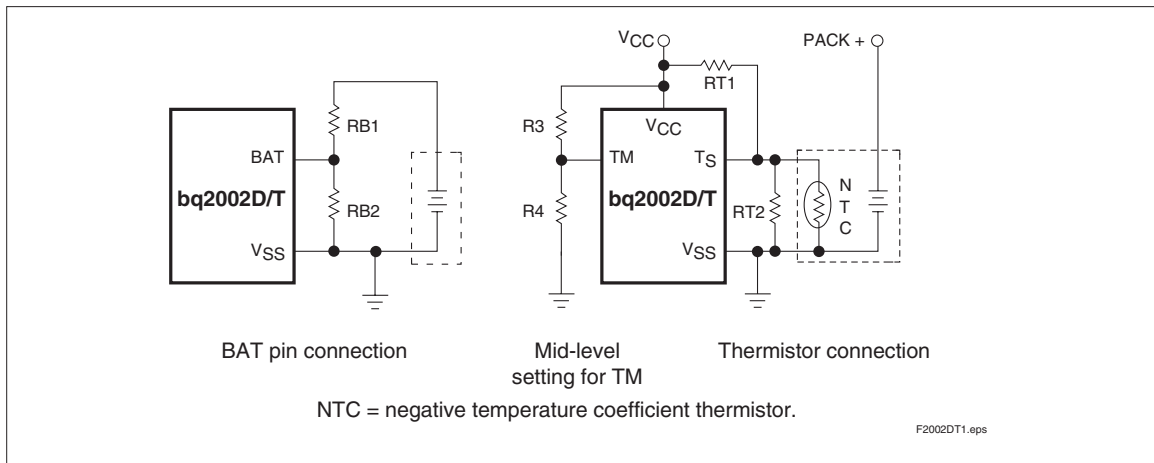


Figure 1. Voltage and Temperature Monitoring and TM Pin Configuration

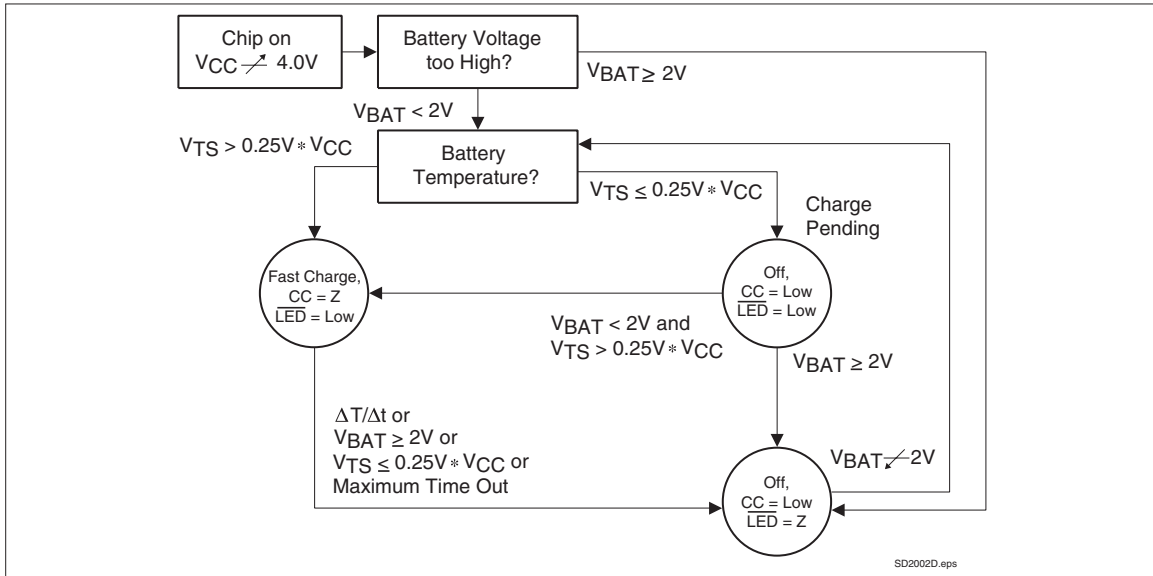


Figure 2. bq2002D State Diagram

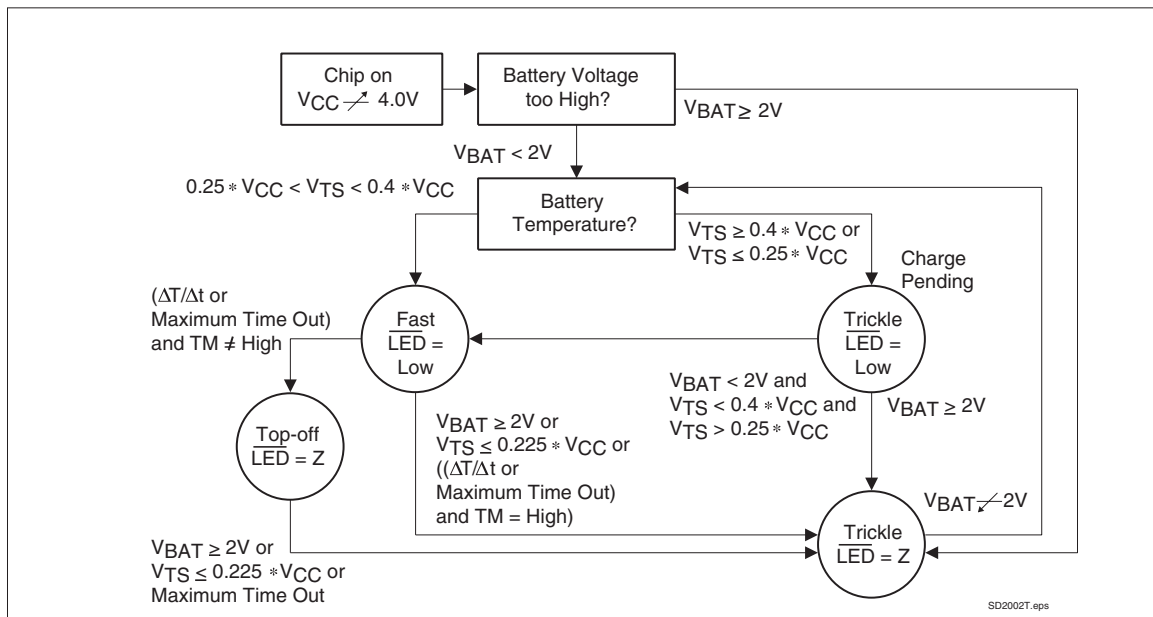


Figure 3. bq2002T State Diagram

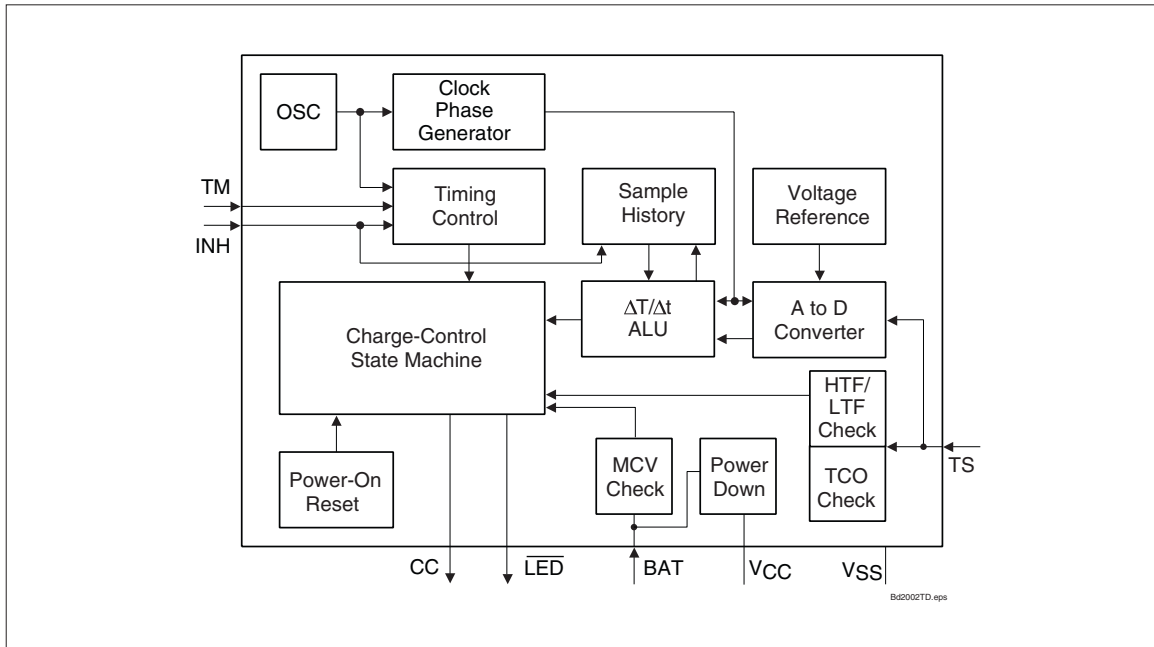


Figure 4. Block Diagram

**Note:** This resistor-divider network input impedance to end-to-end should be at least 200kΩ and less than 1 MΩ.

A ground-referenced negative temperature coefficient thermistor placed in proximity to the battery may be used as a low-cost temperature-to-voltage transducer. The temperature sense voltage input at TS is developed using a resistor-thermistor network between V<sub>CC</sub> and V<sub>SS</sub>. See Figure 1.

### Starting A Charge Cycle

Either of two events starts a charge cycle (see Figure 5):

1. Application of power to V<sub>CC</sub> or
2. Voltage at the BAT pin falling through the maximum cell voltage where

$$V_{MCV} = 2V \pm 5\%$$

If the battery is within the configured temperature and voltage limits, the IC begins fast charge. The valid battery voltage range is  $V_{BAT} < V_{MCV}$ . The valid temperature range is  $V_{HTF} < V_{TS} < V_{LTF}$  for the bq2002T and  $V_{HTF} < V_{TS}$  for the bq2002D where

$$V_{LTF} = 0.4 * V_{CC} \pm 5\%$$

$$V_{HTF} = 0.25 * V_{CC} \pm 5\% \text{ (bq2002T only)}$$

If the battery voltage or temperature is outside of these limits, the IC pulse-trickle charges until the temperature falls within the allowed fast charge range or a new charge cycle is started.

Fast charge continues until termination by one or more of the four possible termination conditions:

- Rate of temperature rise
- Maximum voltage
- Maximum temperature
- Maximum time

### T/ t Termination

The bq2002D/T samples at the voltage at the TS pin every 19s and compares it to the value measured three samples earlier. If the voltage has fallen 25.6mV or more, fast charge is terminated. The  $\Delta T/\Delta t$  termination test is valid only when  $V_{TCO} < V_{TS} < V_{LTF}$  for the bq2002T and  $V_{TCO} < V_{TS}$  for the bq2002D.

### Temperature Sampling

A sample is taken by averaging together 16 measurements taken 57μs apart. The resulting sample period (18.18ms) filters out harmonics around 55Hz. This tech-

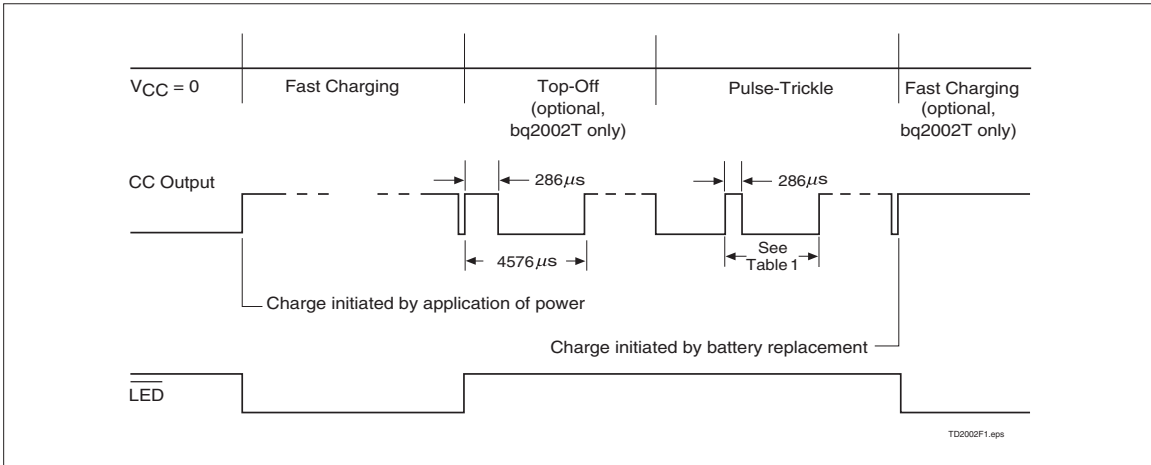


Figure 5. Charge Cycle Phases

nique minimizes the effect of any AC line ripple that may feed through the power supply from either 50Hz or 60Hz AC sources. Tolerance on all timing is  $\pm 20\%$ .

**Maximum Voltage, Temperature, and Time**

Any time the voltage on the BAT pin exceeds the maximum cell voltage,  $V_{MCV}$ , fast charge or optional top-off charge is terminated.

Maximum temperature termination occurs anytime the voltage on the TS pin falls below the temperature cut-off threshold  $V_{TCO}$  where

$$V_{TCO} = 0.225 * V_{CC} \pm 5\%$$

Maximum charge time is configured using the TM pin. Time settings are available for corresponding charge rates of C/4, 1C, and 2C. Maximum time-out termination is enforced on the fast-charge phase, then reset, and

Table 1. Fast-Charge Safety Time/Top-Off Table

Part No.	Corresponding Fast-Charge Rate	TM	Typical Fast-Charge and Top-Off Time Limits (minutes)	Top-Off Rate	Pulse-Trickle Rate	Pulse-Trickle Period (ms)
bq2002D	C/4	Mid	440	None	None	None
	1C	Low	110	None	None	None
	2C	High	55	None	None	None
bq2002T	C/4	Mid	320	C/64	C/256	18.3
	1C	Low	80	C/16	C/256	73.1
	2C	High	40	None	C/128	73.1

**Notes:** Typical conditions = 25°C,  $V_{CC} = 5.0V$   
 Mid =  $0.5 * V_{CC} \pm 0.5V$   
 Tolerance on all timing is  $\pm 20\%$

## bq2002D/T

---

enforced again on the top-off phase, if selected (bq2002T only). There is no time limit on the trickle-charge phase.

### Top-off Charge—bq2002T Only

An optional top-off charge phase may be selected to follow fast charge termination for 1C and C/4 rates. This phase may be necessary on NiMH or other battery chemistries that have a tendency to terminate charge prior to reaching full capacity. With top-off enabled, charging continues at a reduced rate after fast-charge termination for a period of time selected by the TM pin. (See Table 1.) During top-off, the CC pin is modulated at a duty cycle of 286 $\mu$ s active for every 4290 $\mu$ s inactive. This modulation results in an average rate 1/16th that of the fast charge rate. Maximum voltage, time, and temperature are the only termination methods enabled during top-off.

### Pulse-Trickle Charge—bq2002T Only

Pulse-trickle is used to compensate for self-discharge while the battery is idle in the charger. The battery is pulse-trickle charged by driving the CC pin active for a period of 286 $\mu$ s for every 72.9ms of inactivity for 1C and 2C selections, and 286 $\mu$ s for every 17.9ms of inactivity for C/4 selection. This results in a trickle rate of C/256 for the top-off enabled mode and C/128 otherwise.

### TM Pin

The TM pin is a three-level pin used to select the charge timer, top-off, voltage termination mode, trickle rate, and voltage hold-off period options. Table 1 describes the states selected by the TM pin. The mid-level selection input is developed by a resistor divider between  $V_{CC}$  and ground that fixes the voltage on TM at  $V_{CC}/2 \pm 0.5V$ . See Figure 5.

### Charge Status Indication

In the fast charge and charge pending states, and whenever the inhibit pin is active, the  $\overline{LED}$  pin goes low. The  $\overline{LED}$  pin is driven to the high-Z state for all other conditions. Figure 3 outlines the state of the  $\overline{LED}$  pin during charge.

### Charge Inhibit

Fast charge and top-off may be inhibited by using the INH pin. When high, INH suspends all fast charge and top-off activity and the internal charge timer. INH freezes the current state of  $\overline{LED}$  until inhibit is removed. Temperature monitoring is not affected by the INH pin. During charge inhibit, the bq2002D/T continues to pulse-trickle charge the battery per the TM selection. When INH returns low, charge control and the charge timer resume from the point where INH became active. The  $V_{TS}$  sample history is cleared by INH.

### Low-Power Mode

The IC enters a low-power state when  $V_{BAT}$  is driven above the power-down threshold ( $V_{PD}$ ) where

$$V_{PD} = V_{CC} - (1V \pm 0.5V)$$

Both the CC pin and the  $\overline{LED}$  pin are driven to the high-Z state. The operating current is reduced to less than 1 $\mu$ A in this mode. When  $V_{BAT}$  returns to a value below  $V_{PD}$ , the IC pulse-trickle charges until the next new charge cycle begins.

## Absolute Maximum Ratings

Symbol	Parameter	Minimum	Maximum	Unit	Notes
V <sub>CC</sub>	V <sub>CC</sub> relative to V <sub>SS</sub>	-0.3	+7.0	V	
V <sub>T</sub>	DC voltage applied on any pin excluding V <sub>CC</sub> relative to V <sub>SS</sub>	-0.3	+7.0	V	
T <sub>OPR</sub>	Operating ambient temperature	0	+70	°C	Commercial
T <sub>STG</sub>	Storage temperature	-40	+85	°C	
T <sub>SOLDER</sub>	Soldering temperature	-	+260	°C	10s max.
T <sub>BIAS</sub>	Temperature under bias	-40	+85	°C	

**Note:** 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 (T<sub>A</sub> = 0 to 70°C; V<sub>CC</sub> ±20%)

Symbol	Parameter	Rating	Tolerance	Unit	Notes
V <sub>TCO</sub>	Temperature cutoff	0.225 * V <sub>CC</sub>	±5%	V	V <sub>TS</sub> ≤ V <sub>TCO</sub> terminates fast charge and top-off
V <sub>HTF</sub>	High-temperature fault	0.25 * V <sub>CC</sub>	±5%	V	V <sub>TS</sub> ≤ V <sub>HTF</sub> inhibits fast charge start
V <sub>LTF</sub>	Low-temperature fault	0.4 * V <sub>CC</sub>	±5%	V	V <sub>TS</sub> ≥ V <sub>LTF</sub> inhibits fast charge start (bq2002T only)
V <sub>MCV</sub>	Maximum cell voltage	2	±5%	V	V <sub>BAT</sub> ≥ V <sub>MCV</sub> inhibits/terminates fast charge

## bq2002D/T

### Recommended DC Operating Conditions (T<sub>A</sub> = 0 to 70°C)

Symbol	Condition	Minimum	Typical	Maximum	Unit	Notes
V <sub>CC</sub>	Supply voltage	4.0	5.0	6.0	V	
V <sub>BAT</sub>	Battery input	0	-	V <sub>CC</sub>	V	
V <sub>TS</sub>	Thermistor input	0.5	-	V <sub>CC</sub>	V	V <sub>TS</sub> < 0.5V prohibited
V <sub>IH</sub>	Logic input high	0.5	-	-	V	INH
	Logic input high	V <sub>CC</sub> - 0.5	-	-	V	TM
V <sub>IM</sub>	Logic input mid	$\frac{V_{CC}}{2} - 0.5$	-	$\frac{V_{CC}}{2} + 0.5$	V	TM
V <sub>IL</sub>	Logic input low	-	-	0.1	V	INH
	Logic input low	-	-	0.5	V	TM
V <sub>OL</sub>	Logic output low	-	-	0.8	V	$\overline{\text{LED}}$ , CC, I <sub>OL</sub> = 10mA
V <sub>PD</sub>	Power down	V <sub>CC</sub> - 1.5	-	V <sub>CC</sub> - 0.5	V	V <sub>BAT</sub> ≥ V <sub>PD</sub> max. powers down bq2002D/T; V <sub>BAT</sub> < V <sub>PD</sub> min. = normal operation.
I <sub>CC</sub>	Supply current	-	-	500	μA	Outputs unloaded, V <sub>CC</sub> = 5.1V
I <sub>SB</sub>	Standby current	-	-	1	μA	V <sub>CC</sub> = 5.1V, V <sub>BAT</sub> = V <sub>PD</sub>
I <sub>OL</sub>	$\overline{\text{LED}}$ , CC sink	10	-	-	mA	@V <sub>OL</sub> = V <sub>SS</sub> + 0.8V
I <sub>L</sub>	Input leakage	-	-	±1	μA	INH, CC, V = V <sub>SS</sub> to V <sub>CC</sub>
I <sub>OZ</sub>	Output leakage in high-Z state	-5	-	-	μA	$\overline{\text{LED}}$ , CC

**Note:** All voltages relative to V<sub>SS</sub>.



## Impedance

Symbol	Parameter	Minimum	Typical	Maximum	Unit
R <sub>BAT</sub>	Battery input impedance	50	-	-	MΩ
R <sub>TS</sub>	TS input impedance	50	-	-	MΩ

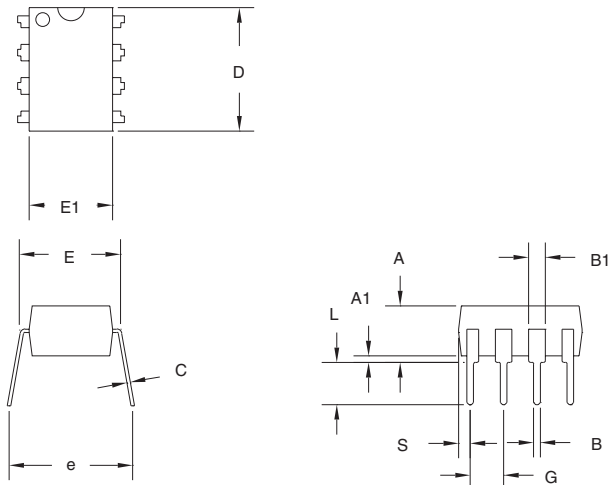
## Timing (T<sub>A</sub> = 0 to +70°C; V<sub>CC</sub> ±10%)

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Notes
d <sub>FCV</sub>	Time-base variation	-20	-	20	%	

**Note:** Typical is at T<sub>A</sub> = 25°C, V<sub>CC</sub> = 5.0V.

# bq2002D/T

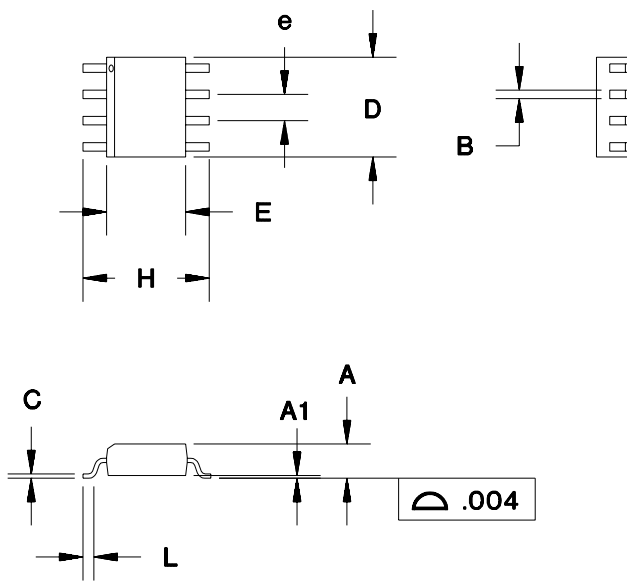
## 8-Pin DIP (PN)



## 8-Pin PN (0.300" DIP)

Dimension	Inches		Millimeters	
	Min.	Max.	Min.	Max.
A	0.160	0.180	4.06	4.57
A1	0.015	0.040	0.38	1.02
B	0.015	0.022	0.38	0.56
B1	0.055	0.065	1.40	1.65
C	0.008	0.013	0.20	0.33
D	0.350	0.380	8.89	9.65
E	0.300	0.325	7.62	8.26
E1	0.230	0.280	5.84	7.11
e	0.300	0.370	7.62	9.40
G	0.090	0.110	2.29	2.79
L	0.115	0.150	2.92	3.81
S	0.020	0.040	0.51	1.02

## 8-Pin SOIC Narrow (SN)



## 8-Pin SN (0.150" SOIC)

Dimension	Inches		Millimeters	
	Min.	Max.	Min.	Max.
A	0.060	0.070	1.52	1.78
A1	0.004	0.010	0.10	0.25
B	0.013	0.020	0.33	0.51
C	0.007	0.010	0.18	0.25
D	0.185	0.200	4.70	5.08
E	0.150	0.160	3.81	4.06
e	0.045	0.055	1.14	1.40
H	0.225	0.245	5.72	6.22
L	0.015	0.035	0.38	0.89

# bq2002D/T

---

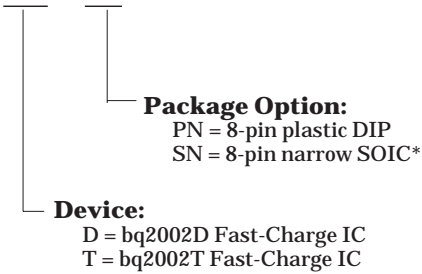
## Data Sheet Revision History

Change No.	Page No.	Description	Nature of Change
1	3	Was: Table 1 gave the bq2002D/T Operational Summary. Is: Figure 2 gives the bq2002D/T Operational Summary.	Changed table to figure.
1	5	Added top-off values.	Added column and values.
2	All	Revised and expanded this data sheet	
3	All	Revised and included bq2002D	Addition of device
4		Specified package information for the bq2002D	
5	1, 5	Corrected transposed rows in Selection Guide Table and made Table 1 consistent with Selection Guide.	

**Notes:** Change 1 = Sept. 1996 B changes from Aug. 1994.

## Ordering Information

bq2002



\* bq2002D is only available in the 8-pin narrow SOIC package

**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
BQ2002DSN	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002DSNG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002DSNTR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002DSNTRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002TPN	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2002TPNE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2002TSN	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002TSNG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002TSNTR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002TSNTRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

<sup>(1)</sup> 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.

<sup>(2)</sup> 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.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

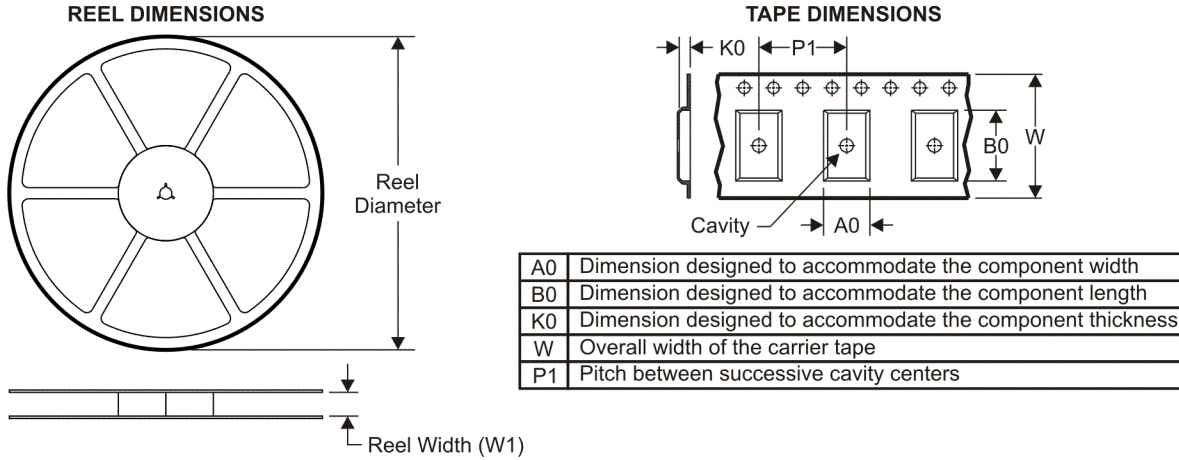
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

<sup>(3)</sup> MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

**TAPE AND REEL INFORMATION**



**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
BQ2002DSNTR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
BQ2002TSNTR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ2002DSNTR	SOIC	D	8	2500	340.5	338.1	20.6
BQ2002TSNTR	SOIC	D	8	2500	340.5	338.1	20.6

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
RF/IF and ZigBee® Solutions	<a href="http://www.ti.com/lprf">www.ti.com/lprf</a>

### Applications

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Broadband	<a href="http://www.ti.com/broadband">www.ti.com/broadband</a>
Digital Control	<a href="http://www.ti.com/digitalcontrol">www.ti.com/digitalcontrol</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Military	<a href="http://www.ti.com/military">www.ti.com/military</a>
Optical Networking	<a href="http://www.ti.com/opticalnetwork">www.ti.com/opticalnetwork</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Telephony	<a href="http://www.ti.com/telephony">www.ti.com/telephony</a>
Video & Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>
Wireless	<a href="http://www.ti.com/wireless">www.ti.com/wireless</a>

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2008, Texas Instruments Incorporated