UNITRODE

bq2004E/H

Fast-Charge ICs

Features

- ➤ Fast charge and conditioning of nickel cadmium or nickel-metal hydride batteries
- ➤ Hysteretic PWM switch-mode current regulation or gated control of an external regulator
- ➤ Easily integrated into systems or used as a stand-alone charger
- ➤ Pre-charge qualification of temperature and voltage
- ➤ Configurable, direct LED outputs display battery and charge status
- ➤ Fast-charge termination by Δ temperature/Δ time, peak volume detection, -ΔV, maximum voltage, maximum temperature, and maximum time
- ➤ Optional top-off charge and pulsed current maintenance charging
- ➤ Logic-level controlled low-power mode (< 5µA standby current)

General Description

The bq2004E and bq2004H Fast Charge ICs provide comprehensive fast charge control functions together with high-speed switching power control circuitry on a monolithic CMOS device.

Integration of closed-loop current control circuitry allows the bq2004 to be the basis of a cost-effective solution for stand-alone and system-integrated chargers for batteries of one or more cells.

Switch-activated discharge-before-charge allows bq2004E/H-based chargers to support battery conditioning and capacity determination.

High-efficiency power conversion is accomplished using the bq2004E/H as a hysteretic PWM controller for switch-mode regulation of the charging current. The bq2004E/H may alternatively be used to gate an externally regulated charging current.

Fast charge may begin on application of the charging supply, replacement of the battery, or switch depression. For safety, fast charge is inhibited unless/until the battery temperature and voltage are within configured limits.

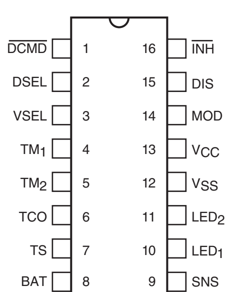
Temperature, voltage, and time are monitored throughout fast charge. Fast charge is terminated by any of the following:

- ■ Rate of temperature rise (ΔT/Δt)
- ■ Peak voltage detection (PVD)
- ■ Negative delta voltage (-ΔV)
- ■ Maximum voltage
- ■ Maximum temperature
- ■ Maximum time

After fast charge, optional top-off and pulsed current maintenance phases with appropriate display mode selections are available.

The bq2004H differs from the bq2004E only in that fast charge, hold-off, and top-off time units have been scaled up by a factor of two, and the bq2004H provides different display selections. Timing differences between the two ICs are illustrated in Table 1. Display differences are shown in Table 2.

Pin Connections



16-Pin Narrow DIP
or Narrow SOIC

PN2004E01.eps

Pin Names

$\overline{DCMD}$	Discharge command	SNS	Sense resistor input
DSEL	Display select	LED_1	Charge status output 1
VSEL	Voltage termination select	LED_2	Charge status output 2
TM_1	Timer mode select 1	V_{SS}	System ground
TM_2	Timer mode select 2	V_{CC}	5.0V ±10% power
TCO	Temperature cutoff	MOD	Charge current control
TS	Temperature sense	DIS	Discharge control output
BAT	Battery voltage	$\overline{INH}$	Charge inhibit input

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Pin Descriptions

$\overline{DCMD}$ **Discharge-before-charge control input**

The $\overline{DCMD}$ input controls the conditions that enable discharge-before-charge. $\overline{DCMD}$ is pulled up internally. A negative-going pulse on $\overline{DCMD}$ initiates a discharge to end-of-discharge voltage (EDV) on the BAT pin, followed by a new charge cycle start. Tying $\overline{DCMD}$ to ground enables automatic discharge-before-charge on every new charge cycle start.

DSEL **Display select input**

This three-state input configures the charge status display mode of the LED_1 and LED_2 outputs and can be used to disable top-off and pulsed-trickle. See Table 2.

VSEL **Voltage termination select input**

This three-state input controls the voltage-termination technique used by the bq2004E/H. When high, PVD is active. When floating, $-\Delta V$ is used. When pulled low, both PVD and $-\Delta V$ are disabled.

TM_1–TM_2 **Timer mode inputs**

TM_1 and TM_2 are three-state inputs that configure the fast charge safety timer, voltage termination hold-off time, "top-off", and trickle charge control. See Table 1.

TCO **Temperature cut-off threshold input**

Input to set maximum allowable battery temperature. If the potential between TS and SNS is less than the voltage at the TCO input, then fast charge or top-off charge is terminated.

TS **Temperature sense input**

Input, referenced to SNS, for an external thermister monitoring battery temperature.

BAT **Battery voltage input**

BAT is the battery voltage sense input, referenced to SNS. This is created by a high-impedance resistor-divider network connected between the positive and the negative terminals of the battery.

SNS **Charging current sense input**

SNS controls the switching of MOD based on an external sense resistor in the current path of the battery. SNS is the reference potential for both the TS and BAT pins. If SNS is connected to V_{SS}, then MOD switches high at the beginning of charge and low at the end of charge.

LED_1–LED_2 **Charge status outputs**

Push-pull outputs indicating charging status. See Table 2.

V_{SS} **Ground**

V_{CC} **V_{CC} supply input**

5.0V, ±10% power input.

MOD **Charge current control output**

MOD is a push-pull output that is used to control the charging current to the battery. MOD switches high to enable charging current to flow and low to inhibit charging current flow.

DIS **Discharge control output**

Push-pull output used to control an external transistor to discharge the battery before charging.

$\overline{INH}$ **Charge inhibit input**

When low, the bq2004E/H suspends all charge actions, drives all outputs to high impedance, and assumes a low-power operational state. When transitioning from low to high, a new charge cycle is started.

Functional Description

Figure 2 shows a block diagram and Figure 3 shows a state diagram of the bq2004E/H.

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 two-cell potential for the battery under charge. A resistor-divider ratio of:

$$\frac{RB1}{RB2} = \frac{N}{2} - 1$$

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.

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

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_{CC} and V_{SS}. See Figure 1. Both the BAT and TS inputs are referenced to SNS, so the signals used inside the IC are:

$$V_{BAT} - V_{SNS} = V_{CELL}$$

and

$$V_{TS} - V_{SNS} = V_{TEMP}$$

Discharge-Before-Charge

The $\overline{DCMD}$ input is used to command discharge-before-charge via the DIS output. Once activated, DIS becomes active (high) until V_{CELL} falls below V_{EDV}, at which time DIS goes low and a new fast charge cycle begins.

The $\overline{DCMD}$ input is internally pulled up to V_{CC} (its inactive state). Leaving the input unconnected, therefore, results in disabling discharge-before-charge. A negative going pulse on $\overline{DCMD}$ initiates discharge-before-charge at any time regardless of the current state of the bq2004. If $\overline{DCMD}$ is tied to V_{SS}, discharge-before-charge will be the first step in all newly started charge cycles.

Starting A Charge Cycle

A new charge cycle is started by:

1. Application of V_{CC} power.
2. V_{CELL} falling through the maximum cell voltage, V_{MCV} where:

$$V_{MCV} = 0.8 * V_{CC} \pm 30mV$$

3. A transition on the $\overline{INH}$ input from low to high.

If $\overline{DCMD}$ is tied low, a discharge-before-charge will be executed as the first step of the new charge cycle. Otherwise, pre-charge qualification testing will be the first step.

The battery must be within the configured temperature and voltage limits before fast charging begins.

The valid battery voltage range is $V_{EDV} < V_{BAT} < V_{MCV}$ where:

$$V_{EDV} = 0.4 * V_{CC} \pm 30mV$$

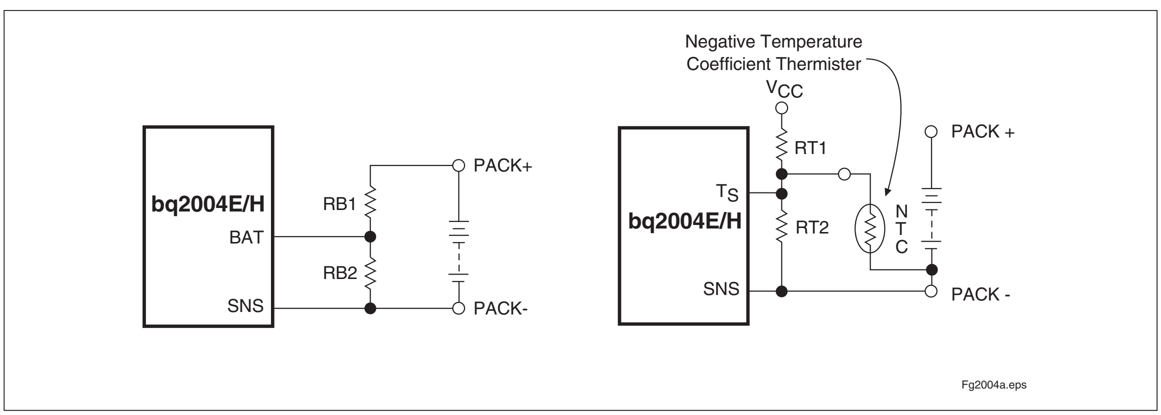


Figure 1. Voltage and Temperature Monitoring

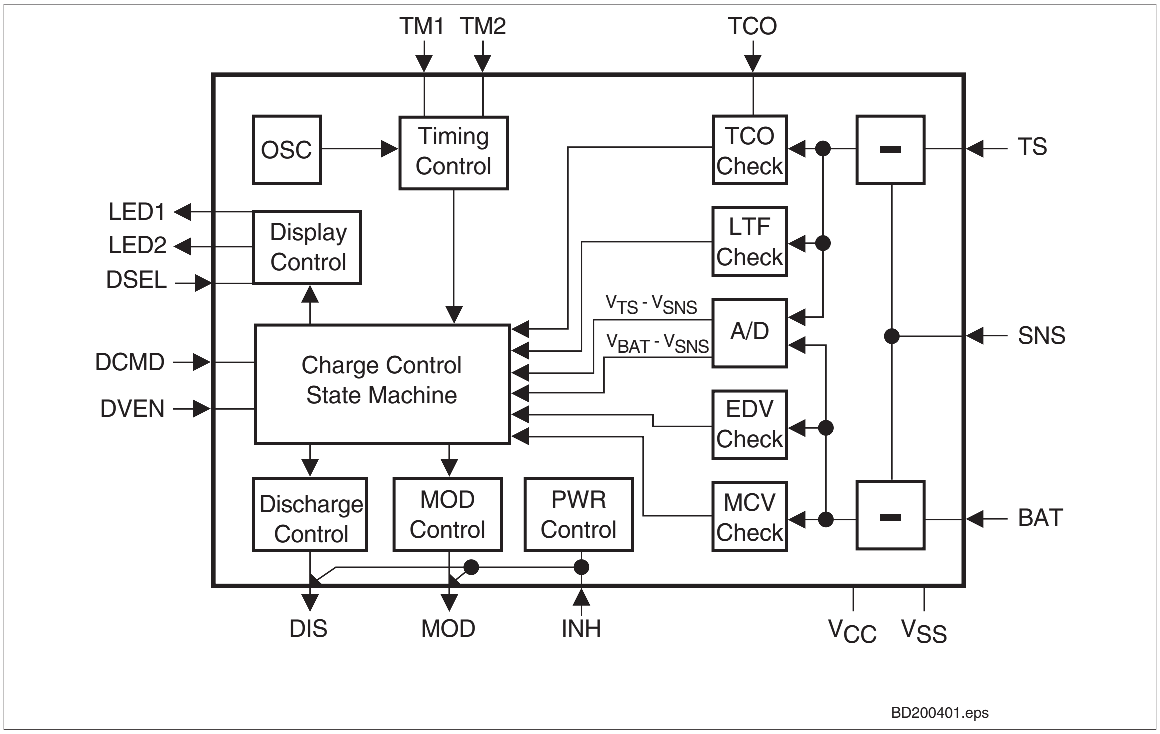


Figure 2. Block Diagram

The valid temperature range is $V_{HTF} < V_{TEMP} < V_{LTF}$, where:

$$V_{LTF} = 0.4 * V_{CC} \pm 30mV$$

$$V_{HTF} = [(1/3 * V_{LTF}) + (2/3 * V_{TCO})] \pm 30mV$$

V_{TCO} is the voltage presented at the TCO input pin, and is configured by the user with a resistor divider between V_{CC} and ground. The allowed range is 0.2 to 0.4 ∗ V_{CC}.

If the temperature of the battery is out of range, or the voltage is too low, the chip enters the charge pending state and waits for both conditions to fall within their allowed limits. During the charge-pending mode, the IC first applies a top-off charge to the battery.

The top-off charge, at the rate of 1/8 of the fast charge, continues until the fast-charge conditions are met or the top-off time-out period is exceeded. The IC then trickle charges until the fast-charge conditions are met. There is no time limit on the charge pending state; the charger remains in this state as long as the voltage or temperature conditons are outside of the allowed limits. If the voltage is too high, the chip goes to the battery absent state and waits until a new charge cycle is started.

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

- Delta temperature/delta time (ΔT/Δt)
- Peak voltage detection (PVD)
- Negative delta voltage (-ΔV)
- Maximum voltage
- Maximum temperature
- Maximum time

PVD and -ΔV Termination

The bq2004E/H samples the voltage at the BAT pin once every 34s. When -ΔV termination is selected, if V_{CELL} is lower than any previously measured value by 12mV ±4mV (6mV/cell), fast charge is terminated. When PVD termination is selected, if V_{CELL} is lower than any previously measured value by 6mV ±2mV (3mV/cell), fast charge is terminated. The PVD and -ΔV tests are valid in the range $0.4 * V_{CC} < V_{CELL} < 0.8 * V_{CC}$.

VSEL Input	Voltage Termination
Low	Disabled
Float	-ΔV
High	PVD

Voltage Sampling

Each sample is an average of voltage measurements. The IC takes 32 measurements in PVD mode and 16 measurements in -ΔV mode. The resulting sample periods (9.17ms and 18.18ms, respectively) filter out harmonics centered around 55Hz and 109Hz. This technique 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 ±16%.

Temperature and Voltage Termination Hold-off

A hold-off period occurs at the start of fast charging. During the hold-off period, -ΔV and ΔT/Δt termination are disabled. The MOD pin is enabled at a duty cycle of 260µs active for every 1820µs inactive. This modulation results in an average rate 1/8th that of the fast charge rate. This avoids premature termination on the voltage spikes sometimes produced by older batteries when fast-charge current is first applied. Maximum voltage and maximum temperature terminations are not affected by the hold-off period.

ΔT/Δt Termination

The bq2004E/H samples at the voltage at the TS pin every 34s, and compares it to the value measured two samples earlier. If V_{TEMP} has fallen 16mV ±4mV or more, fast charge is terminated. The ΔT/Δt termination test is valid only when $V_{TCO} < V_{TEMP} < V_{LTF}$.

Temperature Sampling

Each sample is an average of 16 voltage measurements. The resulting sample period (18.18ms) filters out harmonics around 55Hz. This technique 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 ±16%.

Maximum Voltage, Temperature, and Time

Anytime V_{CELL} rises above V_{MCV}, the LEDs go off and current flow into the battery ceases immediately. If V_{CELL} then falls back below V_{MCV} before t_{MCV} = 1.5s ±0.5s, the chip transitions to the Charge Complete state (maximum voltage termination). If V_{CELL} remains above V_{MCV} at the expiration of t_{MCV}, the bq2004E/H transitions to the Battery Absent state (battery removal). See Figure 3.

Maximum temperature termination occurs anytime V_{TEMP} falls below the temperature cutoff threshold V_{TCO}. Charge will also be terminated if V_{TEMP} rises above the low temperature fault threshold, V_{LTF}, after fast charge begins.

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

Corresponding Fast-Charge Rate		TM1	TM2	Typical Fast-Charge Safety Time (min)		Typical PVD, -ΔV Hold-Off Time (s)		Top-Off Rate		Pulse-Trickle Rate	Pulse-Trickle Period (Hz)	
2004E	2004H			2004E	2004H	2004E	2004H	2004E	2004H		2004E	2004H
C/4	C/8	Low	Low	325	650	137	273	Disabled		Disabled	Disabled	
C/2	C/4	Float	Low	154	325	546	546	Disabled		C/512	15	30
1C	C/2	High	Low	77	154	273	546	Disabled		C/512	7.5	15
2C	1C	Low	Float	39	77	137	273	Disabled		C/512	3.75	7.5
4C	2C	Float	Float	19	39	68	137	Disabled		C/512	1.88	3.75
C/2	C/4	High	Float	154	325	546	546	C/16	C/32	C/512	15	30
1C	C/2	Low	High	77	154	273	546	C/8	C/16	C/512	7.5	15
2C	1C	Float	High	39	77	137	273	C/4	C/18	C/512	3.75	7.5
4C	2C	High	High	19	39	68	137	C/2	C/4	C/512	1.88	3.75

Note: Typical conditions = 25°C, V_{CC} = 5.0V.

Table 2. bq2004E/H LED Output Summary

Mode 1 bq2004E	Charge Action State	LED_1	LED_2
DSEL = V_{SS}	Battery absent	Low	Low
	Fast charge pending or a discharge-before-charge in progress	High	High
	Fast charging	Low	High
	Fast charge complete, top-off, and/or trickle	High	Low
Mode 1 bq2004H	**Charge Action State**	**LED_1**	**LED_2**
DSEL = V_{SS}	Battery absent	Low	Low
	Discharge-before-charge in progress	High	High
	Fast charge pending	Low	$\frac{1}{8}$ second high $\frac{1}{8}$ second low
	Fast charging	Low	High
	Fast charge complete, top-off, and/or trickle	High	Low
Mode 2 bq2004E	**Charge Action State (See note)**	**LED_1**	**LED_2**
DSEL = Floating	Battery absent	Low	Low
	Fast charge pending or discharge-before-charge in progress	High	High
	Fast charging	Low	High
	Fast charge complete, top-off, and/or trickle	High	Low
Mode 2 bq2004H	**Charge Action State (See note)**	**LED_1**	**LED_2**
DSEL = Floating	Battery absent	Low	Low
	Discharge-before-charge in progress	High	High
	Fast charge pending	Low	$\frac{1}{8}$ second high $\frac{1}{8}$ second low
	Fast charging	Low	High
	Fast charge complete, top-off, and/or trickle	High	Low
Mode 3 bq2004E/H	**Charge Action State**	**LED_1**	**LED_2**
DSEL = V_{CC}	Battery absent	Low	Low
	Fast charge pending or discharge-before-charge in progress	Low	$\frac{1}{8}$ second high $\frac{1}{8}$ second low
	Fast charging	Low	High
	Fast charge complete, top-off, and/or trickle	High	Low

Note: Pulse trickle is inhibited in Mode 2.

Maximum charge time is configured using the TM pin. Time settings are available for corresponding charge rates of C/4, C/2, 1C, and 2C. Maximum time-out termination is enforced on the fast-charge phase, then reset, and enforced again on the top-off phase, if selected. There is no time limit on the trickle-charge phase.

Top-off Charge

An optional top-off charge phase may be selected to follow fast charge termination for the C/2 through 4C 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 equal to 0.235∗ the fast-charge safety time (See Table 1.) During top-off, the MOD pin is enabled at a duty cycle of 260µs active for every 1820µs inactive. This modulation results in an average rate 1/8th that of the fast charge rate. Maximum voltage, time, and temperature are the only termination methods enabled during top-off.

Pulse-Trickle Charge

Pulse-trickle charging may be configured to follow the fast charge and optional top-off charge phases to compensate for self-discharge of the battery while it is idle in the charger.

In the pulse-trickle mode, MOD is active for 260µs of a period specified by the settings of TM1 and TM2. See Table 1. The resulting trickle-charge rate is C/512. Both pulse trickle and top-off may be disabled by tying TM1 and TM2 to V_{SS} or by selecting Mode 2 in the display.

Charge Status Indication

Charge status is indicated by the LED_1 and LED_2 outputs. The state of these outputs in the various charge cycle phases is given in Table 2 and illustrated in Figure 3.

In all cases, if V_{CELL} exceeds the voltage at the MCV pin, both LED_1 and LED_2 outputs are held low regardless of other conditions. Both can be used to directly drive an LED.

Charge Current Control

The bq2004E/H controls charge current through the MOD output pin. The current control circuitry is designed to support implementation of a constant-current switching regulator or to gate an externally regulated current source.

When used in switch mode configuration, the nominal regulated current is:

$$I_{REG} = 0.225V/R_{SNS}$$

Charge current is monitored at the SNS input by the voltage drop across a sense resistor, R_{SNS}, between the low side of the battery pack and ground. R_{SNS} is sized to provide the desired fast charge current.

If the voltage at the SNS pin is less than V_{SNSLO}, the MOD output is switched high to pass charge current to the battery.

When the SNS voltage is greater than V_{SNSHI}, the MOD output is switched low—shutting off charging current to the battery.

$$V_{SNSLO} = 0.04 * V_{CC} \pm 25mV$$

$$V_{SNSHI} = 0.05 * V_{CC} \pm 25mV$$

When used to gate an externally regulated current source, the SNS pin is connected to V_{SS}, and no sense resistor is required.

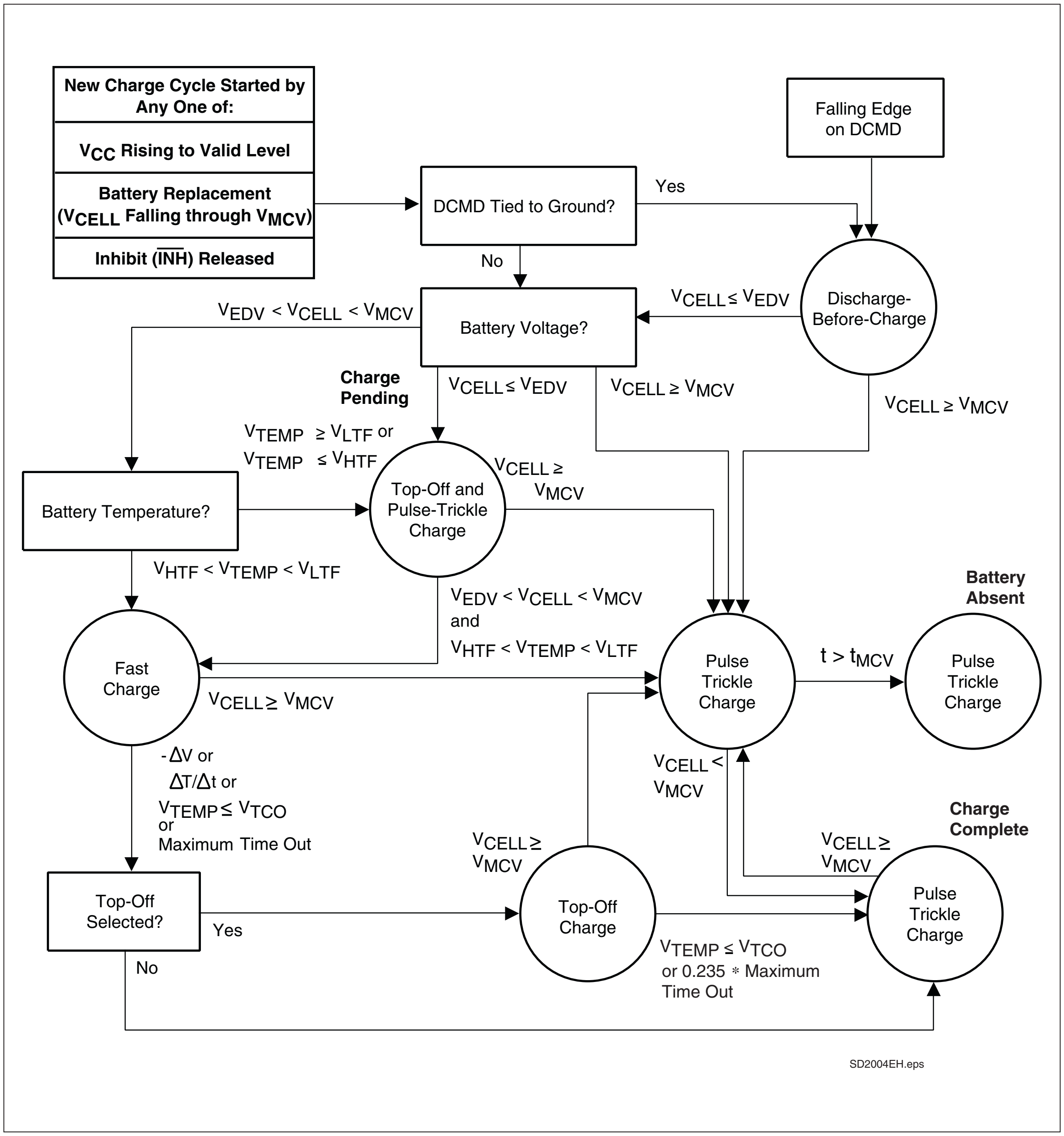


Figure 3. Charge Algorithm State Diagram

Absolute Maximum Ratings

Symbol	Parameter	Minimum	Maximum	Unit	Notes
V_{CC}	V_{CC} relative to V_{SS}	-0.3	+7.0	V	
V_T	DC voltage applied on any pin excluding V_{CC} relative to V_{SS}	-0.3	+7.0	V	
T_{OPR}	Operating ambient temperature	-20	+70	°C	Commercial
T_{STG}	Storage temperature	-55	+125	°C	
T_{SOLDER}	Soldering temperature	-	+260	°C	10 sec max.
T_{BIAS}	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 ($T_A = T_{OPR}$; V_{CC} ±10%)

Symbol	Parameter	Rating	Tolerance	Unit	Notes
V_{SNSHI}	High threshold at SNS resulting in MOD = Low	$0.05 * V_{CC}$	±0.025	V	
V_{SNSLO}	Low threshold at SNS resulting in MOD = High	$0.04 * V_{CC}$	±0.025	V	
V_{LTF}	Low-temperature fault	$0.4 * V_{CC}$	±0.030	V	$V_{TEMP} \geq V_{LTF}$ inhibits/terminates charge
V_{HTF}	High-temperature fault	$(1/3 * V_{LTF}) + (2/3 * V_{TCO})$	±0.030	V	$V_{TEMP} \leq V_{HTF}$ inhibits charge
V_{EDV}	End-of-discharge voltage	$0.4 * V_{CC}$	±0.030	V	$V_{CELL} < V_{EDV}$ inhibits fast charge
V_{MCV}	Maximum cell voltage	$0.8 * V_{CC}$	±0.030	V	$V_{CELL} > V_{MCV}$ inhibits/terminates charge
V_{THERM}	TS input change for $\Delta T/\Delta t$ detection	-16	±4	mV	V_{CC} = 5V, T_A = 25°C
$-\Delta V$	BAT input change for $-\Delta V$ detection	-12	±4	mV	V_{CC} = 5V, T_A = 25°C
PVD	BAT input change for PVD detection	-6	±2	mV	V_{CC} = 5V, T_A = 25°C

Recommended DC Operating Conditions ($T_A = T_{OPR}$)

Symbol	Condition	Minimum	Typical	Maximum	Unit	Notes
V_{CC}	Supply voltage	4.5	5.0	5.5	V	
V_{BAT}	Battery input	0	-	V_{CC}	V	
V_{CELL}	BAT voltage potential	0	-	V_{CC}	V	V_{BAT} - V_{SNS}
V_{TS}	Thermistor input	0	-	V_{CC}	V	
V_{TEMP}	TS voltage potential	0	-	V_{CC}	V	V_{TS} - V_{SNS}
V_{TCO}	Temperature cutoff	$0.2 * V_{CC}$	-	$0.4 * V_{CC}$	V	Valid $\Delta T/\Delta t$ range
V_{IH}	Logic input high	2.0	-	-	V	$\overline{DCMD}$, $\overline{INH}$
	Logic input high	V_{CC} - 0.3	-	-	V	TM_1, TM_2, DSEL, VSEL
V_{IL}	Logic input low	-	-	0.8	V	$\overline{DCMD}$, $\overline{INH}$
	Logic input low	-	-	0.3	V	TM_1, TM_2, DSEL, VSEL
V_{OH}	Logic output high	V_{CC} - 0.8	-	-	V	DIS, MOD, LED_1, LED_2, $I_{OH} \leq -10mA$
V_{OL}	Logic output low	-	-	0.8	V	DIS, MOD, LED_1, LED_2, $I_{OL} \leq 10mA$
I_{CC}	Supply current	-	1	3	mA	Outputs unloaded
I_{SB}	Standby current	-	-	1	µA	$\overline{INH}$ = V_{IL}
I_{OH}	DIS, LED_1, LED_2, MOD source	-10	-	-	mA	@V_{OH} = V_{CC} - 0.8V
I_{OL}	DIS, LED_1, LED_2, MOD sink	10	-	-	mA	@V_{OL} = V_{SS} + 0.8V
I_L	Input leakage	-	-	±1	µA	$\overline{INH}$, BAT, V = V_{SS} to V_{CC}
	Input leakage	50	-	400	µA	$\overline{DCMD}$, V = V_{SS} to V_{CC}
I_{IL}	Logic input low source	-	-	70	µA	TM_1, TM_2, DSEL, VSEL, V = V_{SS} to V_{SS} + 0.3V
I_{IH}	Logic input high source	-70	-	-	µA	TM_1, TM_2, DSEL, VSEL, V = V_{CC} - 0.3V to V_{CC}
I_{IZ}	Tri-state	-2	-	2	µA	TM_1, TM_2, DSEL, and VSEL should be left disconnected (floating) for Z logic input state

Note: All voltages relative to V_{SS} except as noted.

Impedance

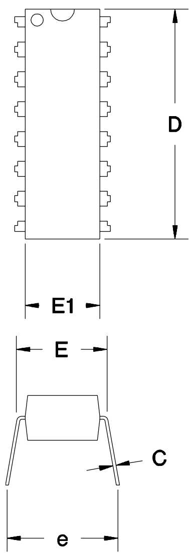
Symbol	Parameter	Minimum	Typical	Maximum	Unit
R_{BAT}	Battery input impedance	50	-	-	MΩ
R_{TS}	TS input impedance	50	-	-	MΩ
R_{TCO}	TCO input impedance	50	-	-	MΩ
R_{SNS}	SNS input impedance	50	-	-	MΩ

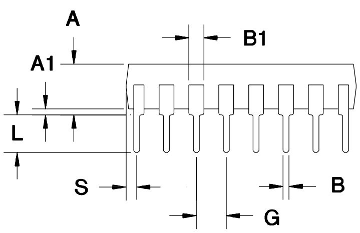
Timing (TA = 0 to +70°C; VCC ±10%)

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Notes
t_{PW}	Pulse width for $\overline{DCMD}$ and $\overline{INH}$ pulse command	1	-	-	µs	Pulse start for charge or discharge before charge
d_{FCV}	Time base variation	-16	-	16	%	V_{CC} = 4.75V to 5.25V
f_{REG}	MOD output regulation frequency	-	-	300	kHz	
t_{MCV}	Maximum voltage termination time limit	1	-	2	s	Time limit to distinguish battery removed from charge complete.

Note: Typical is at T_A = 25°C, V_{CC} = 5.0V.

16-Pin DIP Narrow (PN)

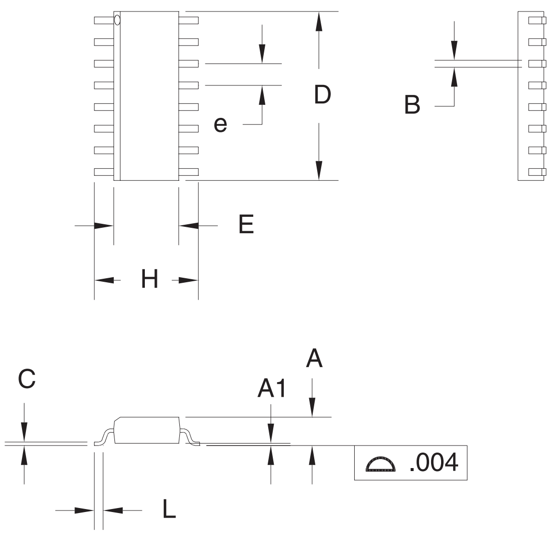




16-Pin PN (0.300" DIP)

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	0.740	0.770	18.80	19.56
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

16-Pin SOIC Narrow (SN)



16-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	0.385	0.400	9.78	10.16
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

Data Sheet Revision History

Change No.	Page No.	Description	Nature of Change
1	All	Combined bq2004E and bq2004H, revised and expanded format of this data sheet	Clarification
2	7	Separated bq2004E and bq2004H in Table 2, LED Output Summary	Clarification
3	5	Description of charge-pending state	Clarification
4			
5	9	Corrected V_{SNSLO} tolerance	Was: ±0.010 Is: ±0.025

Note: Change 1 = Oct. 1997 B changes from Sept. 1996 (bq2004E), Feb. 1997 (bq2004H).
Change 2 = Feb. 1998 C changes from Oct. 1997 B.
Change 3 = Dec. 1998 D changes from Feb. 1998 C.
Change 4 = June 1999 E changes from Dec. 1998 D.
Change 5 = Apr. 2005 F changes from June 1999 E.

Ordering Information

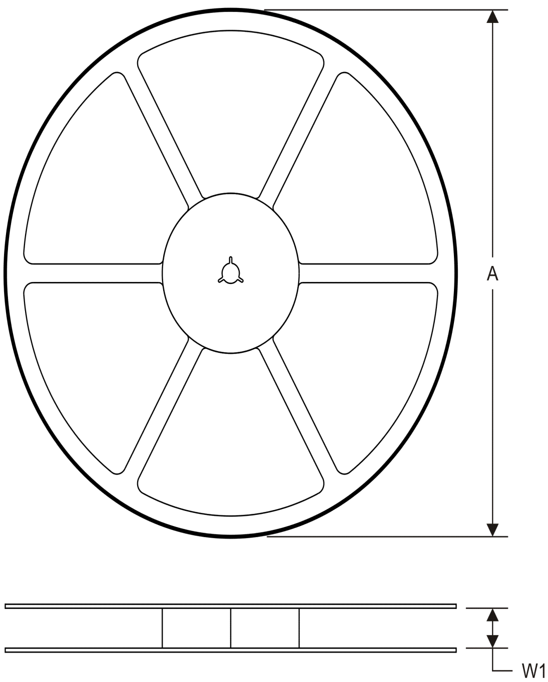
bq2004 _

Package Option:
PN = 16-pin narrow plastic DIP
SN = 16-pin narrow SOIC

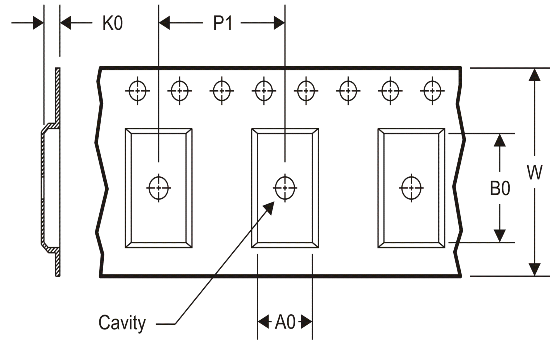
Device:
E = bq2004E Fast-Charge IC
H= bq2004H Fast-Charge IC

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



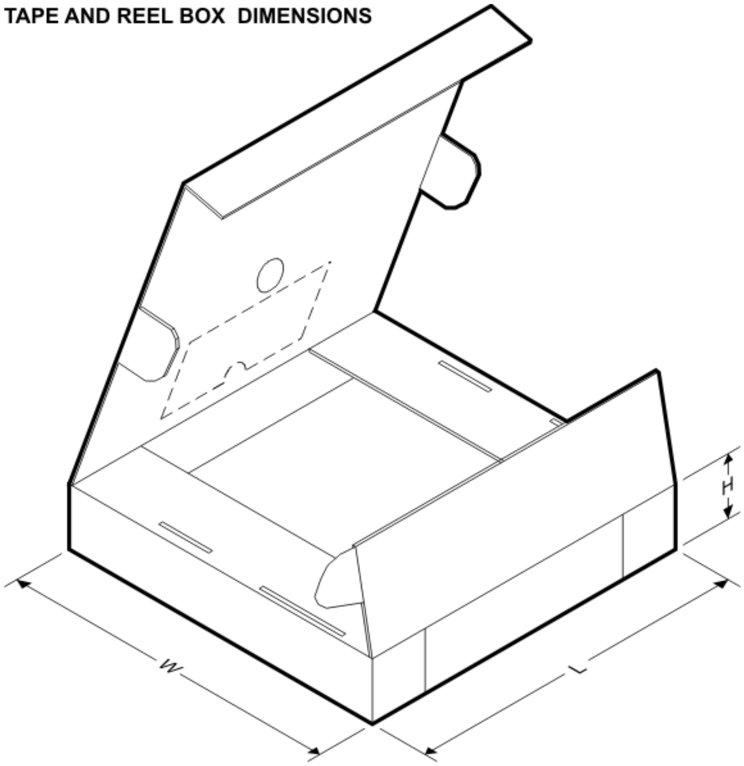
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*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
BQ2004ESNTR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
BQ2004HSNTR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ2004ESNTR	SOIC	D	16	2500	367.0	367.0	38.0
BQ2004HSNTR	SOIC	D	16	2500	367.0	367.0	38.0

IMPORTANT NOTICE

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