Fea e

- 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
- Direct LED outputs display battery and charge status
- Fast-charge termination by Δ temperature/Δ time, -ΔV, maximum voltage, maximum temperature, and maximum time
- Optional top-off charge

Gene al De c i i n

The bq2003 Fast Charge IC provides 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 bq2003 to be the basis of a cost-effective solution for stand-alone and system-integrated chargers for batteries of one or mo[(F)67.7(a-36-363.0TJ0 Te Tc -16-0.00lc)ellsIntegrati266-500.4(of)-500.4(c)Surrent

Pin Descriptions

CCMD, DCMD — **Charge initiation and discharge-before-charge control inputs**

Functional Description

Figure 3 shows a state diagram and Figure 4 shows a block diagram of the bq2003.

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 bat-

Discharge-Before-Charge

The 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. See Table 1 for the conditions that initiate discharge-before-charge. Discharge-before-charge is qualified by the same voltage and temperature conditions that qualify a new charge cycle start (see below). If a discharge is initiated but the pack voltage or temperature is out of range, the chip enters the charge pending mode and trickle charges the battery until the voltage and temperature qualification conditions are met, and then starts to discharge.

Starting A Charge Cycle

The stimulus required to start a new charge cycle is determined by the configuration of the CCMD and DCMD inputs. If CCMD and DCMD are both pulled up or pulled down, then a new charge cycle is started by (see Figure 2):

1. V_{CC} rising above 4.5V

2. V_{CELL} falling through the maximum cell voltage, V_{MCV}. V_{MCV} is the voltage presented at the MCV input pin, and is configured by the user with a resistor divider between V_{CC} and ground. The al-

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 five possible termination conditions:

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

-ΔV Te mina i n

If the DVEN input is high, the bq2003 samples the voltage at the BAT pin once every 34s. If V_{CELL} is lower than any previously measured value by 12mV ±4mV, fast charge is terminated. The -ΔV test is valid in the range $V_{MCV} - (0.2 * V_{CC}) < V_{CELL} < V_{MCV}$.

[redacted]

Each sample is an average of 16 voltage measurements [redacted] mizes the effect of any AC line ripple that may feed [redacted]

V l age Te mina i n H ld- ff

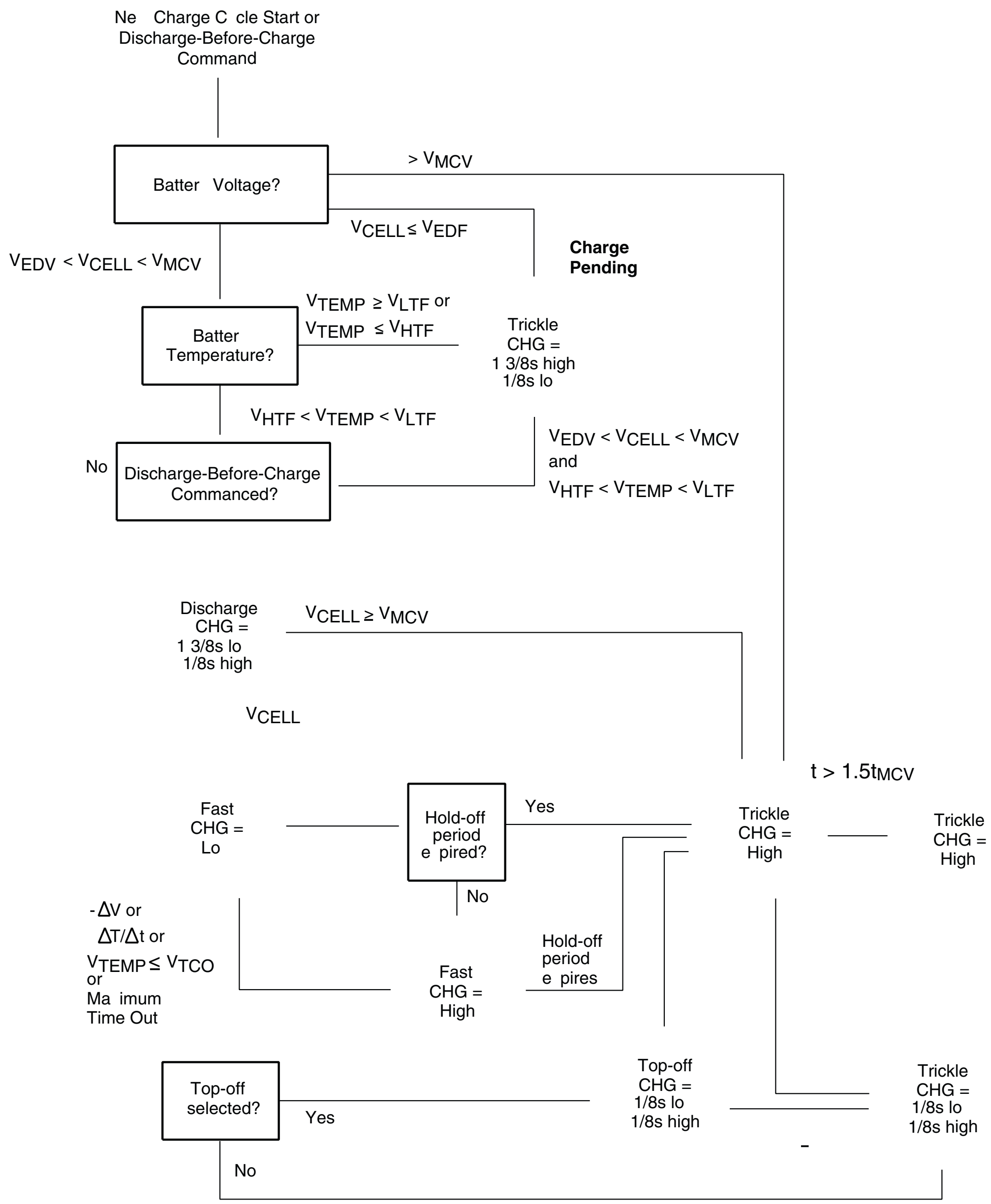
A hold-off period occurs at the start of fast charging. During the hold-off period, -ΔV termination is disabled. This avoids premature termination on the voltage spikes sometimes produced by older batteries when fast-charge current is first applied. ΔT/Δt, maximum voltage and maximum temperature terminations are not affected by the hold-off period.

ΔT/Δ Te mina i n

The bq2003 samples 9.9n

taken on the new battery is compared to ones taken before the original battery was removed and any that may have been taken while no battery was present. If the IC is configured for $\Delta T/\Delta t$ termination, this may result in a premature fast-charge termination on the newly inserted battery.

Maximum temperature termination occurs anytime the voltage on the TS pin falls below the temperature cut-off threshold $V_{TCO.}$ Charge is also terminated if V_{TEMP}


Ne Charge C cle Start or Discharge-Before-Charge Command
Batter Voltage?
> VMCV
VCELL ≤ VEDF
Charge Pending
VEDV < VCELL < VMCV
Batter Temperature?
VTEMP ≥ VLTF or VTEMP ≤ VHTF
Trickle CHG = 1 3/8s high 1/8s lo
VHTF < VTEMP < VLTF
No
Discharge-Before-Charge Commanced?
VEDV < VCELL < VMCV and VHTF < VTEMP < VLTF
Discharge CHG = 1 3/8s lo 1/8s high
VCELL ≥ VMCV
VCELL
t > 1.5tMCV
Fast CHG = Lo
Hold-off period e pired?
Yes
Trickle CHG = High
Trickle CHG = High
No
-ΔV or ΔT/Δt or VTEMP ≤ VTCO or Ma imum Time Out
Fast CHG = High
Hold-off period e pires
Top-off selected?
Yes
Top-off CHG = 1/8s lo 1/8s high
Trickle CHG = 1/8s lo 1/8s high
No

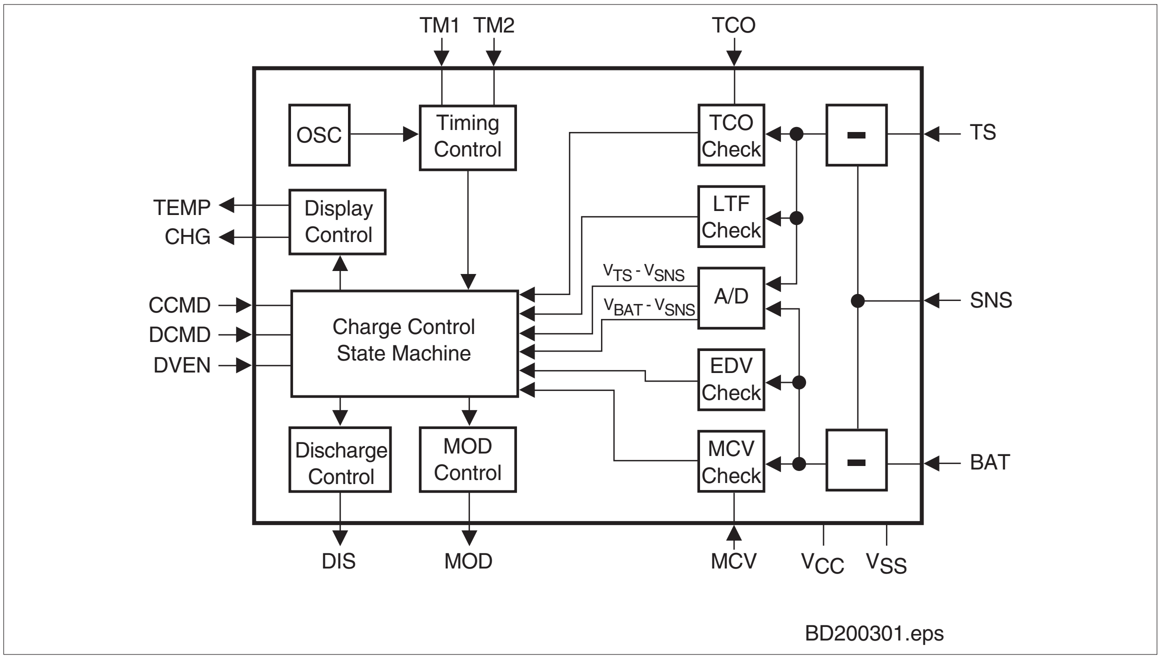


Fig e 4. Bl ck Diag am

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	0	+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 ($T_A = T_{OPR}$; $V_{CC} \pm 10\%$)

Symbol	Parameter	Rating	Tolerance	Unit	Notes
V_{SNSHI}	High threshold at SNS resulting in MOD = Low	$0.05 * V_{CC}$	±0.025	V	Tolerance is common mode deviation.
V_{SNSLO}	Low threshold at SNS resulting in MOD = High	$0.044 * V_{CC}$	±0.025	V	Tolerance is common mode deviation.
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	$(1/8 * V_{LTF}) + (7/8 * V_{TCO})$	±0.030	V	$V_{TEMP} \leq V_{HTF}$ inhibits fast charge
V_{EDV}	End-of-discharge voltage	$0.2 * V_{CC}$	±0.030	V	$V_{CELL} < V_{EDV}$ inhibits fast 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

Rec mmended DC O e a ing C ndi i n (T$_A$ = 0 . +70 C)

S mb l	Pa ame e	Minim m	T ical	Ma im m	Uni	N e
V_{CC}	Supply voltage	4.5	5.0	5.5	V	
V_{BAT}						

Im edance

S mb l	Pa ame. e	Minim m	T ical	Ma im m	Uni.
R_{BAT}	Battery input impedance	50	-	-	MΩ
R_{MCV}	MCV input impedance	50	-	-	MΩ
R_{TCO}	TCO input impedance	50	-	-	MΩ
R_{SNS}	SNS input impedance	50	-	-	MΩ
R_{TS}	TS input impedance	50	-	-	MΩ

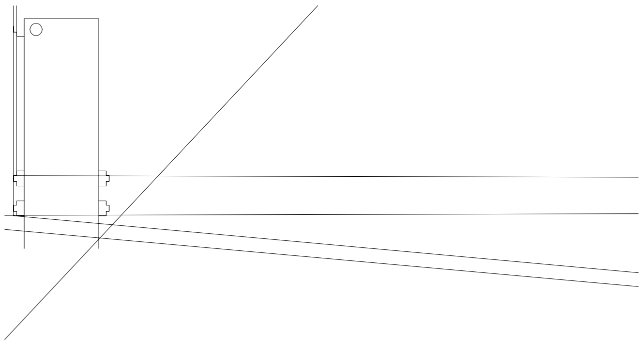
Timing (T$_A$ = 0 . +70 C; V$_{CC}$ ±10%)

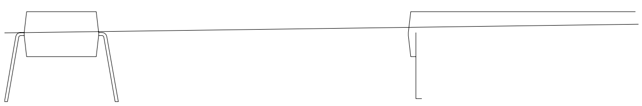
S mb l	Pa ame. e	Minim m	T ical	Ma im m	Uni.	N . e
t_{PW}	Pulse width for CCMD, DCMD pulse commands	1	-	-	µs	Pulse start for charge or discharge-before-charge
d_{FCV}	Time base variation	-16	-	16	%	V_{CC} = 4.5V to 5.5V
f_{REG}	MOD output regulation frequency	-	-	300	kHz	
t_{MCV}	Maximum voltage termination time limit	200	250	300	ms	Time limit to distinguish battery removed from charge complete

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

b 2003

PN: 16-Pin DIP Na





Da a Shee Re i i n Hi

Change N .	Page N .	De c i i n	Na e f Change
5	2	Changed block diagram	Changed diagram.
5	8	Added top-off values to Table 2.	Added values.
6	All	Revised and expanded format of this data sheet	Clarification
7	9	T_{OPR}	Deleted industrial temperature range.
8	3	Corrected Table 1	Correction
8	5, 7	Corrected and expanded the explanation for maximum voltage conditions	Clarification

Notes: Changes 1–4: Please refer to the *1997 D , B* .
Change 5 = Sept. 1996 F changes from Oct. 1993 E.
Change 6 = Oct. 1997 G changes from Sept. 1996 F.
Change 7 = June 1999 H changes from Oct. 1997 G.
Change 8 = Oct. 1999 I changes from June 1999 H.

O de ing Inf ma i n

b 2003 __

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

Device:
bq2003 Fast-Charge IC

PACKAGING INFORMATION

Orderable Device	Status [(1)]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [(2)]	Lead/Ball Finish	MSL Peak Temp [(3)]
BQ2003PN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2003PN-N	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2003PNE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2003S	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2003S-N	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2003S-NG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2003S-NTR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2003S-NTRG4	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2003SG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2003STR	ACTIVE	SOIC	DW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2003STRG4	ACTIVE	SOIC	DW	16	2000	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.
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)

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

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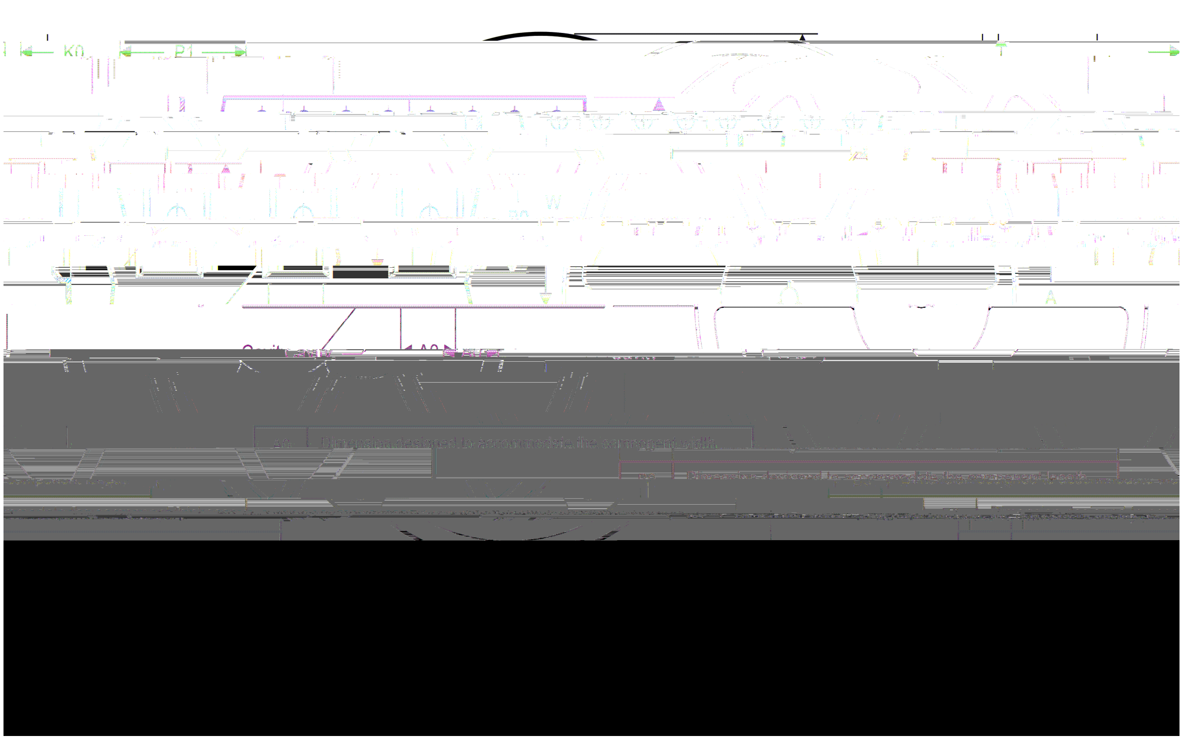
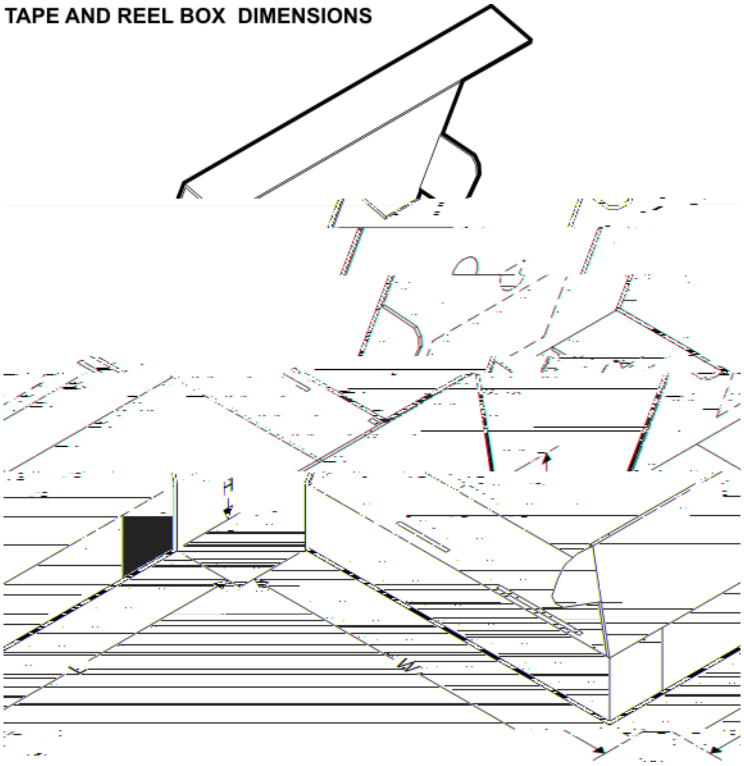
REEL DIMENSIONS **TAPE DIMENSIONS**



*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
BQ2003S-NTR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1
BQ2003STR	SOIC	DW	16	2000	330.0	16.4	10.75	10.7	2.7	12.0	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)
BQ2003S-NTR	SOIC	DW	16	2000	367.0	367.0	38.0
BQ2003STR	SOIC	DW	16	2000	367.0	367.0	38.0

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