UNITRODE

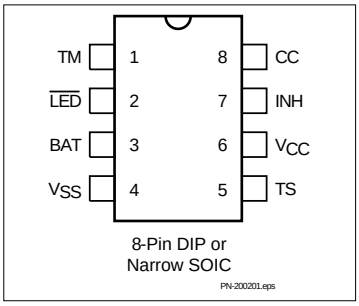
bq2002E/G

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 -ΔV, maximum voltage, maximum temperature, and maximum time
- Internal band-gap voltage reference
- Optional top-off charge
- Selectable pulse trickle charge rates
- Low-power mode
- 8-pin 300-mil DIP or 150-mil SOIC

Pin Connections



General Description

The bq2002E and bq2002G Fast-Charge ICs are low-cost CMOS battery-charge controllers providing reliable charge termination for both NiCd and NiMH battery applications. Controlling a current-limited or constant-current supply allows the bq2002E/G to be the basis for a cost-effective stand-alone or system-integrated charger. The bq2002E/G 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:

- Peak voltage detection (PVD)
- Negative delta voltage (-ΔV)
- Maximum voltage
- Maximum temperature
- Maximum time

After fast charge, the bq2002E/G optionally tops-off and pulse-trickles the battery per the pre-configured limits. Fast charge may be inhibited using the INH pin. The bq2002E/G may also be placed in low-standby-power mode to reduce system power consumption.

The bq2002E differs from the bq2002G only in that a slightly different set of fast-charge and top-off time limits is available. All differences between the two ICs are illustrated in Table 1.

Pin Names

TM	Timer mode select input	TS	Temperature sense input
$\overline{LED}$	Charging status output	V_{CC}	Supply voltage input
BAT	Battery voltage input	INH	Charge inhibit input
V_{SS}	System ground	CC	Charge control output

bq2002E/G Selection Guide

Part No.	LBAT	TCO	HTF	LTF	-ΔV	PVD	Fast Charge	t_{MTO}	Top-Off	Maintenance
bq2002E	0.175 * V_{CC}	0.5 * V_{CC}	0.6 * V_{CC}	None		✔	C/2	200	None	C/32
						✔	1C	80	C/16	C/32
					✔		2C	40	None	C/32
bq2002G	0.175 * V_{CC}	0.5 * V_{CC}	0.6 * V_{CC}	None		✔	C/2	160	None	C/32
						✔	1C	80	C/16	C/32
					✔		2C	40	None	C/32

Pin Descriptions

TM **Timer mode input**

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.

$\overline{\text{LED}}$ **Charging output status**

Open-drain output that indicates the charging status.

BAT **Battery input voltage**

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.

V_{SS} **System ground**

TS **Temperature sense input**

Input for an external battery temperature monitoring thermistor.

V_{CC} **Supply voltage input**

5.0V ±20% power input.

INH **Charge inhibit input**

When high, INH suspends the fast charge in progress. When returned low, the IC resumes 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

Figure 2 shows a state diagram and Figure 3 shows a block diagram of the bq2002E/G.

Battery Voltage and Temperature Measurements

Battery voltage and temperature are monitored for maximum allow

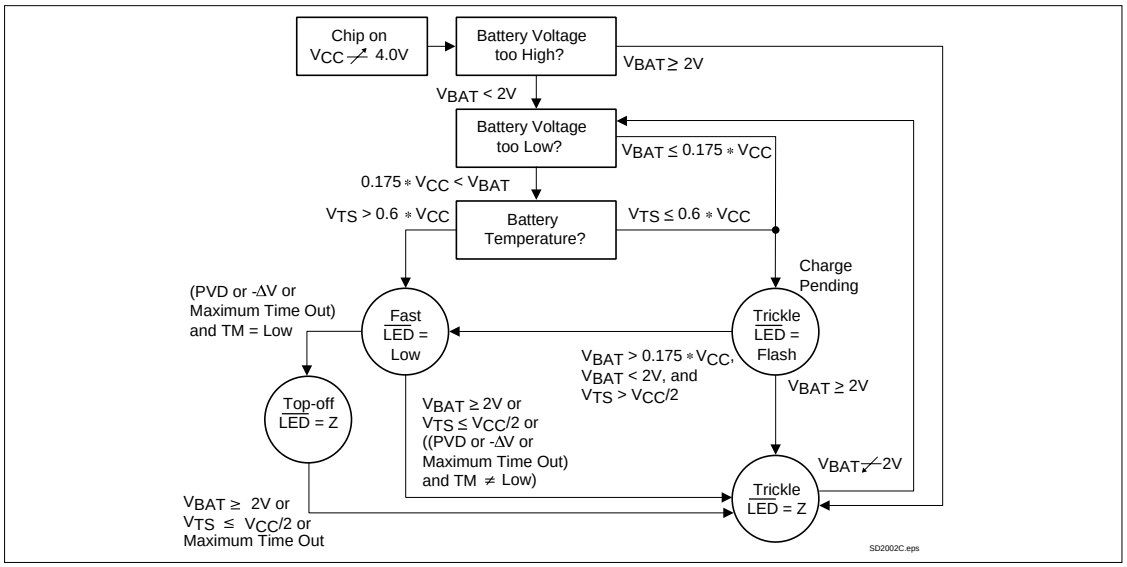


Figure 2. State Diagram

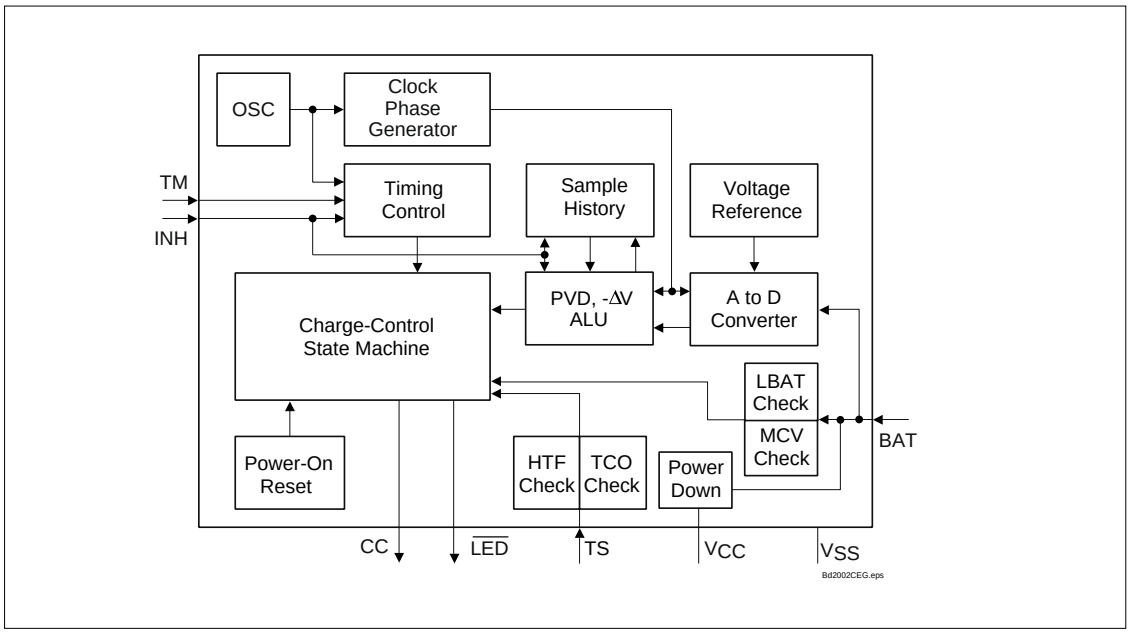


Figure 3. Block Diagram

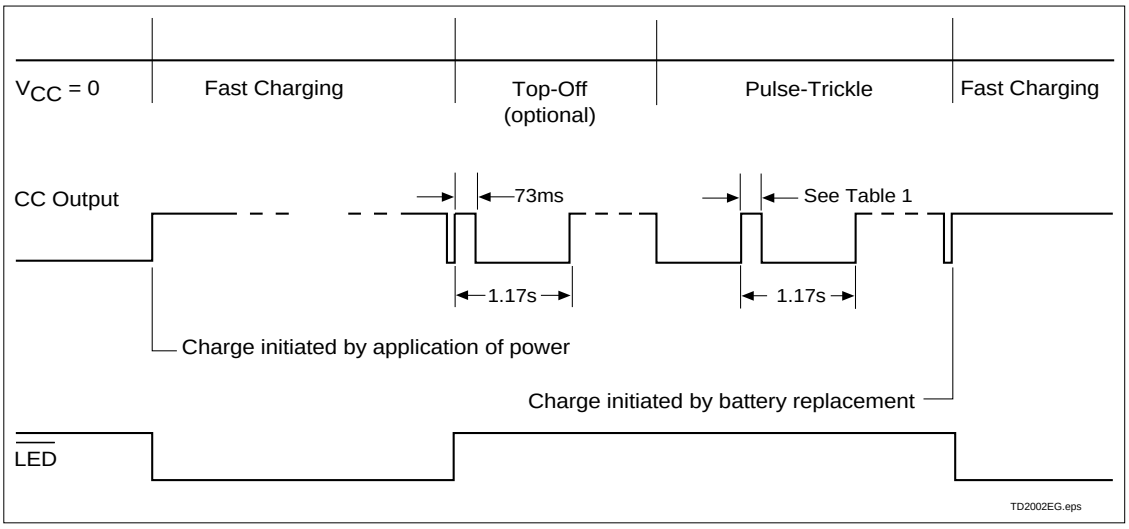


Figure 4. Charge Cycle Phases

A ground-referenced negative temperature coefficient thermistor placed near 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.

Starting A Charge Cycle

Either of two events starts a charge cycle (see Figure 4):

1. Application of power to V_{CC} or

2. Voltage at the BAT pin falling through the maximum cell voltage V_{MCV} 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 $V_{LBAT} < V_{BAT} < V_{MCV}$, where

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

Corresponding Fast-Charge Rate	TM	Termination	Typical Fast-Charge and Top-Off Time Limits (minutes)		Typical PVD and -ΔV Hold-Off Time (seconds)	Top-Off Rate	Pulse-Trickle Rate	Pulse-Trickle Width (ms)	Maximum Synchronized Sampling Period (seconds)
			bq2002E	bq2002G					
C/2	Mid	PVD	200	160	300	Disabled	C/32	73	18.7
1C	Low	PVD	80	80	150	C/16	C/32	37	18.7
2C	High	-ΔV	40	40	75	Disabled	C/32	18	9.4

Notes: Typical conditions = 25°C, V_{CC} = 5.0V
Mid = 0.5 * V_{CC} ±0.5V
Tolerance on all timing is ±12%.

$$V_{LBAT} = 0.175 * V_{CC} \pm 20\%$$

The valid temperature range is $V_{TS} > V_{HTF}$ where

$$V_{HTF} = 0.6 * V_{CC} \pm 5\%.$$

If the battery voltage or temperature is outside of these limits, the IC pulse-trickle charges until the next new charge cycle begins.

If $V_{MCV} < V_{BAT} < V_{PD}$ (see "Low-Power Mode") when a new battery is inserted, a delay of 0.35 to 0.9s is imposed before the new charge cycle begins.

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

- Peak voltage detection (PVD)
- Negative delta voltage (-ΔV)
- Maximum voltage
- Maximum temperature
- Maximum time

PVD and -ΔV Termination

There are two modes for voltage termination, depending on the state of TM. For -ΔV (TM = high), if V_{BAT} is lower than any previously measured value by 12mV ±3mV, fast charge is terminated. For PVD (TM = low or mid), a decrease of 2.5mV ±2.5mV terminates fast charge. The PVD and -ΔV tests are valid in the range $1V < V_{BAT} < 2V$.

Synchronized Voltage Sampling

Voltage sampling at the BAT pin for PVD and -ΔV termination may be synchronized to an external stimulus using the INH input. Low-high-low input pulses between 100ns and 3.5ms in width must be applied at the INH pin with a frequency greater than the "maximum synchronized sampling period" set by the state of the TM pin as shown in Table 1. Voltage is sampled on the falling edge of such pulses.

If the time between pulses is greater than the synchronizing period, voltage sampling "free-runs" at once every 17 seconds. A sample is taken by averaging together voltage measurements taken 57µs apart. The IC takes 32 measurements in PVD mode and 16 measurements in -ΔV mode. The resulting sample periods (9.17 and 18.18ms, respectively.4(n)-327.5(a)-28.3(s)-345.5(sha)-28.3D 0.038r T

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 4.

Charge Status Indication

A fast charge in progress is uniquely indicated when the $\overline{LED}$ pin goes low. The $\overline{LED}$ pin is driven to the high-Z state for all conditions other

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	-40	+85	°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 = 0 to 70°C; V_{CC} ±20%)

Symbol	Parameter	Rating	Tolerance	Unit	Notes
V_{TCO}	Temperature cutoff	0.5 * V_{CC}	±5%	V	$V_{TS} \le V_{TCO}$ inhibits/terminates fast charge and top-off
V_{HTFVO}	P R				

Recommended DC Operating Conditions (T_A = 0 to 70°C)

Symbol	Condition	Minimum	Typical	Maximum	Unit	Notes
V_{CC}	Supply voltage	4.0	5.0	6.0	V	
V_{DET}	-ΔV, PVD detect voltage	1	-	2	V	
V_{BAT}	Battery input	0	-	V_{CC}	V	
V_{TS}	Thermistor input	0.5	-	V_{CC}	V	V_{TS} < 0.5V prohibited
V_{IH}	Logic input high	0.5	-	-	V	INH
	Logic input high	V_{CC} - 0.5	-	-	V	TM
V_{IM}	Logic input mid	$\frac{V_{CC}}{2}$ - 0.5	-	$\frac{V_{CC}}{2}$ + 0.5	V	TM
V_{IL}	Logic input low	-	-	0.1	V	INH
	Logic input low	-	-	0.5	V	TM
V_{OL}	Logic output low	-	-	0.8	V	$\overline{LED}$, CC, I_{OL} = 10mA
V_{PD}	Power down	V_{CC} - 1.5	-	V_{CC} - 0.5	V	$V_{BAT} \geq V_{PD}$ max. powers down bq2002E/G; $V_{BAT} < V_{PD}$ min. = normal operation.
I_{CC}	Supply current	-	-	500	µA	Outputs unloaded, V_{CC} = 5.1V
I_{SB}	Standby current	-	-	1	µA	V_{CC} = 5.1V, $V_{BAT} = V_{PD}$
I_{OL}	$\overline{LED}$, CC sink	10	-	-	mA	@$V_{OL} = V_{SS}$ + 0.8V
I_L	Input leakage	-	-	±1	µA	INH, CC, V = V_{SS} to V_{CC}
I_{OZ}	Output leakage in high-Z state	-5	-	-	µA	$\overline{LED}$, CC

Note: All voltages relative to V_{SS}.

Impedance

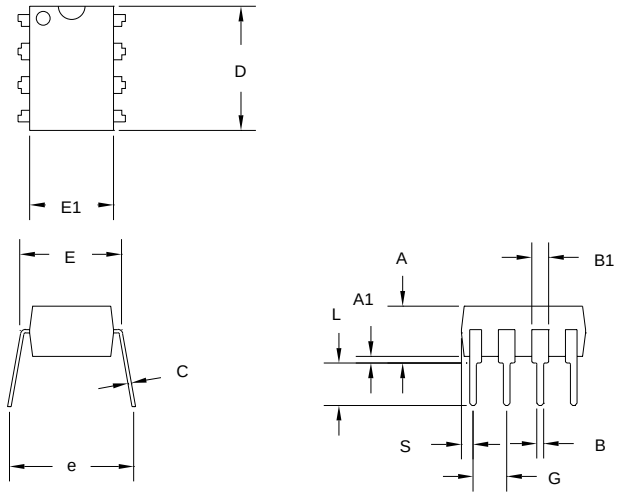
Symbol	Parameter	Minimum	Typical	Maximum	Unit
R_{BAT}	Battery input impedance	50	-	-	MΩ
R_{TS}	TS input impedance	50	-	-	MΩ

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

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Notes
d_{FCV}	Time base variation	-12	-	12	%	
t_{DLY}	Start-up delay	0.35	-	0.9	s	Starting from $V_{MCV} < V_{BAT} < V_{PD}$

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

8-Pin DIP (PN)

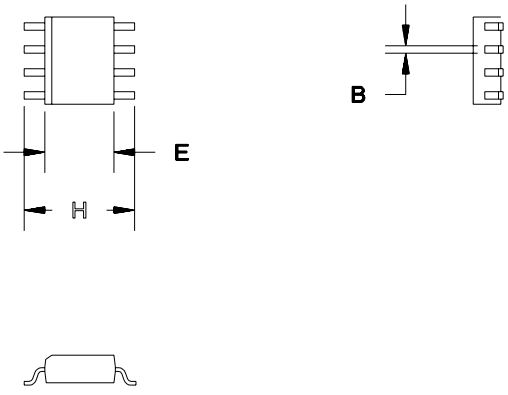


8-Pin PN (0.300" DIP)

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)DimensionInches MillimetersMin. Ma

C 0.007 0.010 0.18 0.25D 0.185 0.200 4.70 5.08E 0.150 0.160



PACKAGING INFORMATION

Orderable Device	Status [1]	Package Type	Package Drawing	Pins	Package Qty	Eco Plan [2]	Lead/Ball Finish	MSL Peak Temp [3]
BQ2002EPN	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2002EPNE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2002ESN	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002ESNG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002ESNTR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002ESNTRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002GPN	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2002GPNE4	ACTIVE	PDIP	P	8	50	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
BQ2002GSN	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002GSNG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002GSNTR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
BQ2002GSNTRG4	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 pse-tollows-278.0 (&)] Tfollows-278.0 (&)] Tfoll686 1 68.r1] Tfoll68valu

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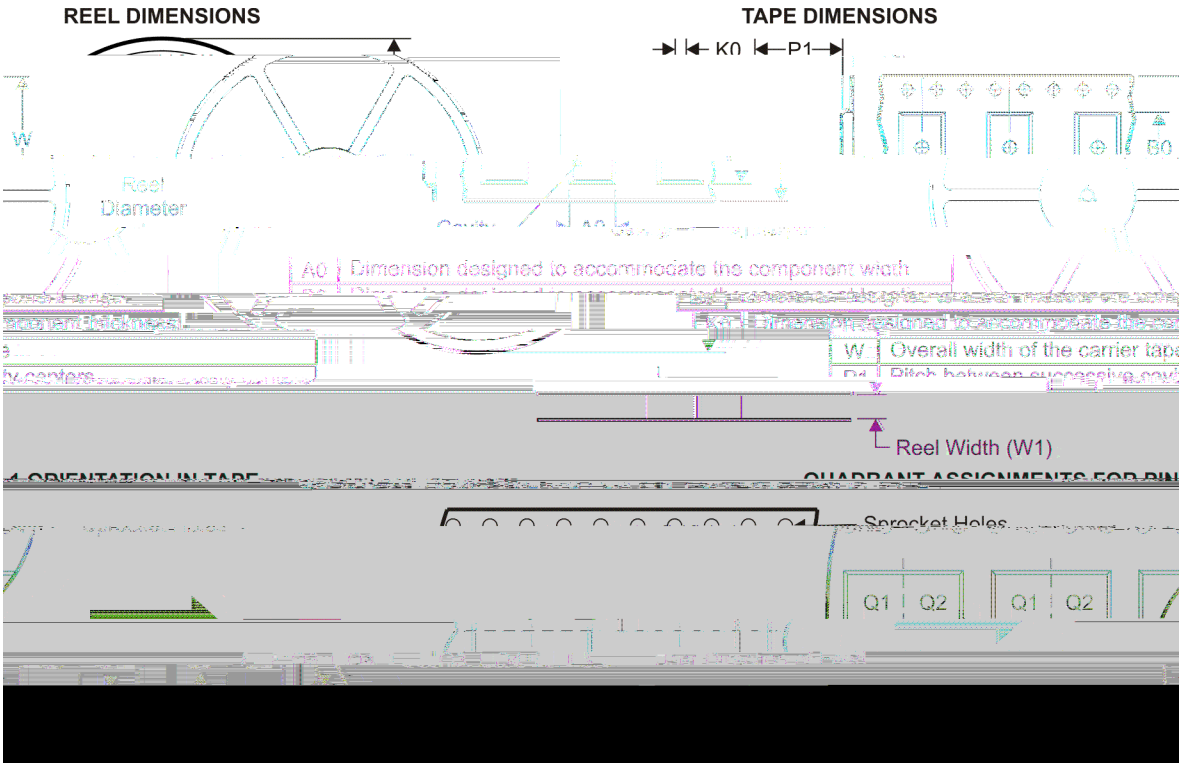
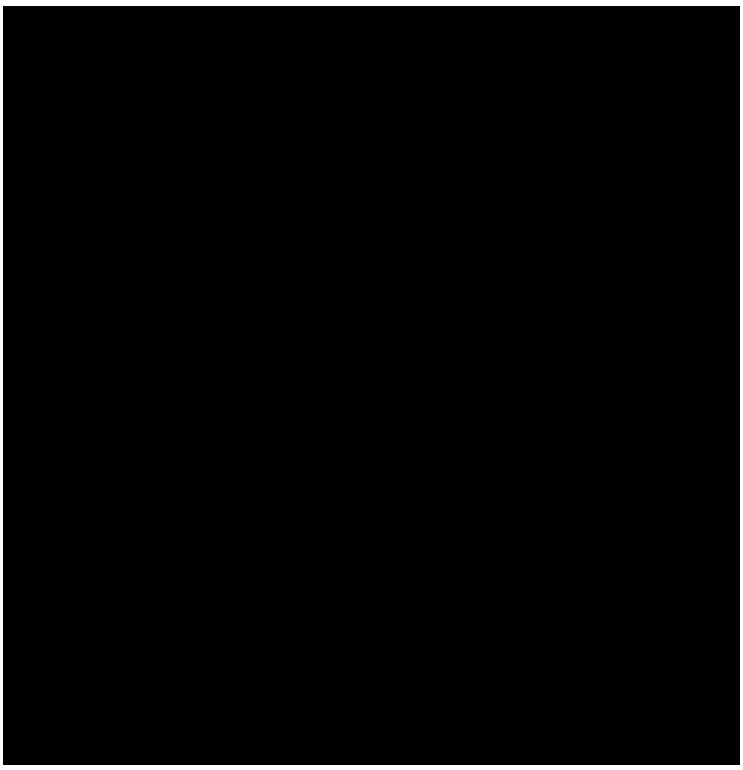


*All dimensions are nominal

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
BQ2002ESNTR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
BQ2002GSNTR	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ2002ESNTR	SOIC	D	8	2500	340.5	338.1	20.6
BQ2002GSNTR	SOIC	D	8	2500	340.5	338.1	20.6

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