BENCHMARQ

Preliminary **bq2056/T/V**

Low-Dropout Li-Ion Charge-Control IC With AutoComp™ Charge-Rate Compensation

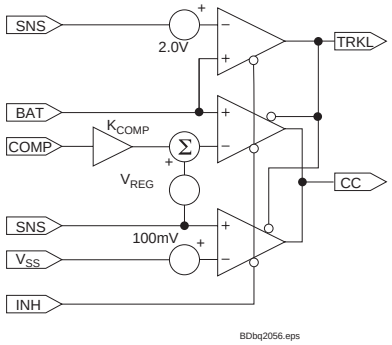
Features

- Significant reduction in charge time with AutoComp charge-rate compensation
- Ideal for low-dropout linear regulator design
- 1-cell, 2-cell, and programmable multicell versions
- Low-cost charger implementation with minimum number of external components
- Programmable current limit to accommodate any battery size
- Interface to external trickle charger for reviving deeply discharged batteries
- High-accuracy charge control
- Sleep mode for low power consumption
- Direct battery voltage sense without resistive dividers (bq2056 and bq2056T)

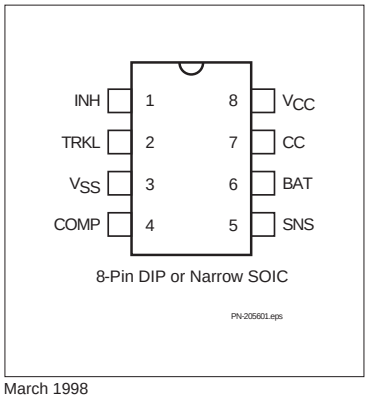
General Description

The bq2056 series ICs are low-cost precision linear charge-control devices for Li-Ion applications. With a minimum number of external components, the bq2056 is a complete low-dropout linear charger. The dropout voltage is typically less than 0.5V when the bq2056 is used with an external PNP transistor or P-channel FET. Features include proprietary automatic charge-rate compensation (AutoComp) and a trickle-charger interface output for reviving deeply discharged cells. The bq2056 supports a single-cell 4.1V pack and the 2056T supports a two-cell 8.2V pack. The bq2056V may be externally programmed for supporting other voltages. All versions feature a sleep mode for low-power applications.

Functional Block Diagram



Pin Connections



Pin Names

INH	Charge-inhibit input	SNS	Current sense input
TRKL	Trickle-charge interface output	BAT	Battery voltage input
		CC	Charge control output
V_{SS}	Ground	V_{CC}	Supply input
COMP	Charge-rate compensation input		

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Pin Descriptions:

INH **Charge-inhibit input**

When input to this pin is high, the bq2056 suspends the charge in progress and places the device in sleep mode. When input is low, the bq2056 resumes operation.

TRKL **Trickle-charge interface output**

This output is driven low if the battery voltage is less than an internal threshold level and INH is low. This open drain output can be used to enable an external trickle charger to revive a deeply discharged battery.

V_{SS} **Ground**

COMP **Charge-rate compensation input**

This input is used to set the charge-rate compensation level. The voltage regulation output may be programmed to vary as a function of the charge current delivered to the battery. This feature, called AutoComp, provides compensation for internal cell impedance during charge and therefore may be used to safely reduce charging time. Connecting this pin to V_{SS} disables the AutoComp feature.

SNS **Current sense input**

Battery current is sensed via the voltage developed on this pin by an external sense-resistor, connected in series with the negative terminal of the battery pack.

BAT **Battery voltage input**

This is the battery voltage sense input. This input is tied directly to the positive side of the battery pack on bq2056 and bq2056T versions. A simple resistive divider is required to generate this input for bq2056V.

CC **Charge-control output**

CC is an open-collector output that is used to control the charging current to the battery.

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

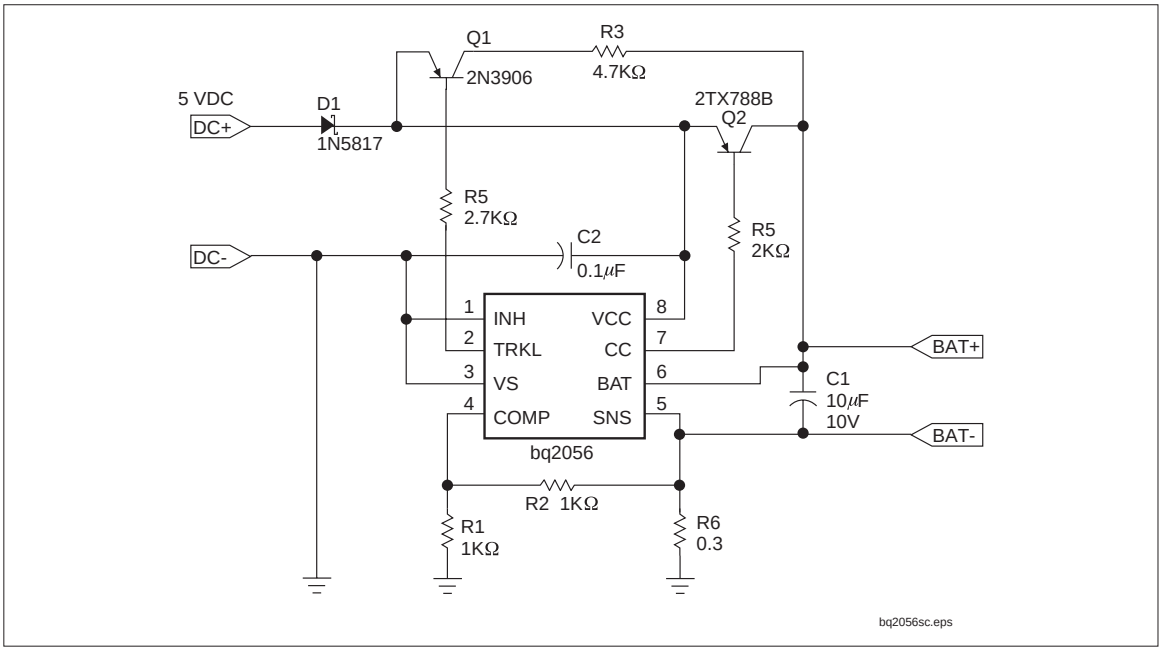


Figure 1. Low-Dropout Single-Cell Li-Ion Charger

Functional Description

The bq2056 supports a precision current- and voltage-limited charging system for Li-Ion applications. The no-load voltage regulation references (V_{REG}) for the bq2056 and bq2056T are maintained at 4.1V and 8.2V, respectively. The bq2056V provides variable regulation to accommodate a wide range of charge voltages and may be used to meet tighter tolerance requirements through external trimming. The functional block diagram for the bq2056 is on the first page of this data sheet, and Figure 1 illustrates a typical application.

Charge Algorithm

The bq2056 completes the charge cycle in two phases. A constant current phase replenishes approximately 70% of battery capacity, while an accurate voltage regulation phase completes the charge.

Figure 2 shows a typical charge algorithm for bq2056, including charge qualification, current regulation, and voltage regulation phases.

Charge Qualification

During charge qualification the bq2056 detects a low battery and reports this status on pin TRKL. Detection is accomplished by comparing pin BAT voltage to the internal threshold V_{MIN}. While pin BAT voltage is less than V_{MIN} and pin INH is low, the open-drain output TRKL is driven low and the voltage/current regulator is disabled (CC=high-z). In the bq2056V, low-voltage detection occurs when the voltage on pin BAT is less than or equal to V_{MIND}. As shown in Figure 1, TRKL enables an external trickle-charge circuit to bring the battery voltage up to V_{MIN} or V_{MIND}.

Current Regulation

The bq2056 provides current regulation while the pack voltage is below the voltage limit. Charge current feedback, applied through pin SNS, maintains regulation around a threshold of V_{SNS}. The following formula calculates the value of the sense-resistor connected in series with the negative terminal of the battery pack (Figure 3):

$$R_{SNS} = 0.1 / I_{MAX}$$

where I_{MAX} is the maximum charging current. I_{MAX} should not exceed 1A.

An external PNP or power P-FET may be used as the series pass element with control provided through output pin CC.

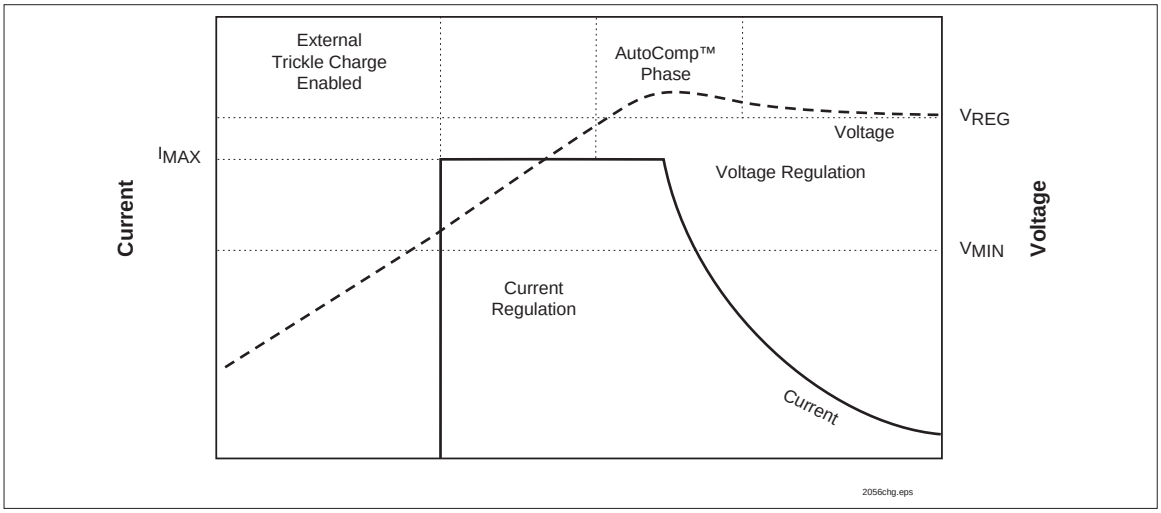


Figure 2. bq2056 Charge Algorithm

Voltage Regulation

Voltage regulation feedback is through pin BAT. This pin is connected directly to the pack in the bq2056 and bq2056T. This voltage is compared with the voltage regulation reference, V_{REG}. In the bq2056V, a resistive divider may be used to generate this input (Figure 4). In this case, the voltage presented on pin BAT is compared with the internal reference voltage V_{REF}. The resistor values R_{B1} and R_{B2} (Figure 4) are calculated based on the following equation:

$$\frac{R_{B1}}{R_{B2}} = \frac{N * V_{CELL}}{V_{REF}} - 1$$

where

N = Number of cells in series

V_{CELL} = Manufacturer-specified charge voltage

Automatic Charge-Rate Compensation (AutoComp) Feature

To reduce charging time, the bq2056 series uses the proprietary AutoComp technique to compensate safely for internal impedance of battery and any voltage drop in the charging and protection circuitry. This maximizes battery's capacity while reducing charging time. Compensation is through input pin COMP (Figure 5). A portion of the current sense voltage, presented through this pin, is scaled by a factor of K_{COMP} and summed with the regulation reference, V_{REG}. This process increases the output voltage to compensate for the battery's internal impedance.

For bq2056 and bq2056T, the voltage across the battery pack, V_{PAK}, is

$$V_{PAK} = V_{REG} + (K_{COMP} * \text{voltage on pin COMP})$$

For bq2056V, the compensation voltage is added to the product of the internal voltage reference, V_{REF}, and the gain of the external resistive divider between the battery pack and BAT input (Figure 4).

$$V_{PAK} = (V_{REF} * K_{DIV}) + (K_{COMP} * \text{voltage on pin COMP})$$

Sleep Mode

The charge function may be disabled through pin INH. When INH is driven high, internal current consumption is reduced, and pins CC and TRKL assumes a high-impedance output state.

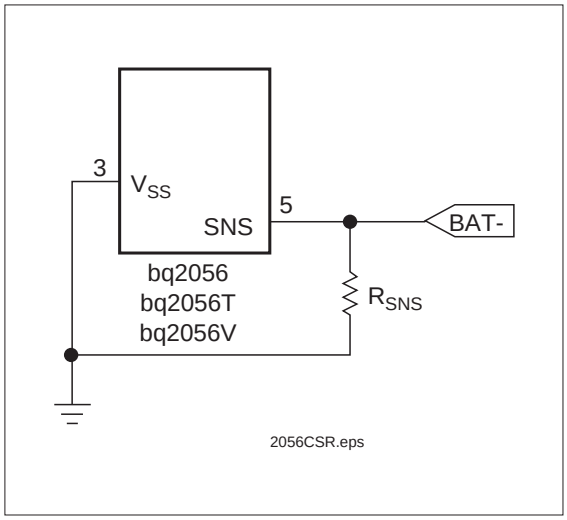


Figure 3. Current-Sensing Resistor

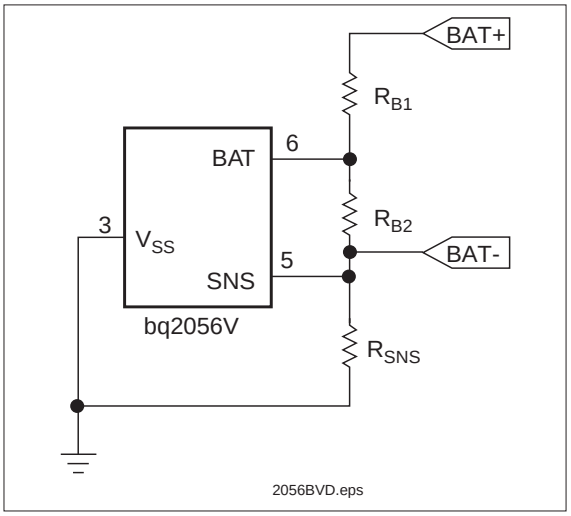


Figure 4. Battery Voltage Divider for bq2056V

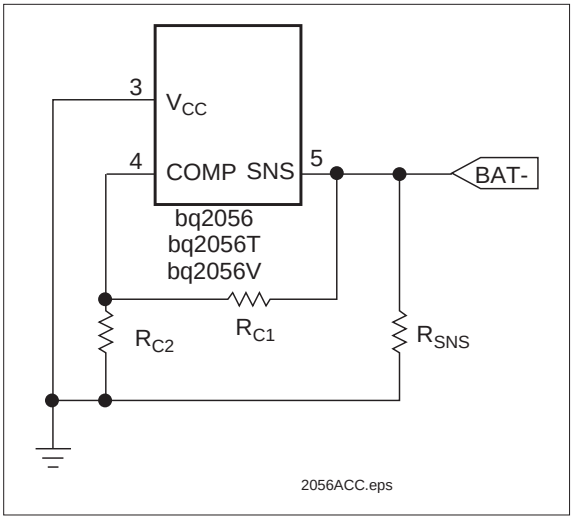


Figure 5. AutoComp Circuit

Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Units	Notes
V_{CC}	V_{CC} relative to V_{SS}	-0.3	+18	V	
V_T	DC voltage applied on any pin (excluding V_{CC}) relative to V_{SS}	-0.3	V_{CC}+0.3	V	
T_{OPR}	Operating ambient temperature	-20	70	°C	
T_{STG}	Storage temperature	-40	125	°C	
T_{SOLDER}	Soldering temperature	-	260	°C	10s max.
P_D	Power dissipation		300	mW	

DC Thresholds (T_A=25°C and V_{CC} = 5V unless otherwise specified)

Symbol	Parameter	Rating	Unit	Tolerance	Notes
V_{REG} (bq2056)	Voltage regulation reference	4.10	V	±0.7%	±0.5% variation over power supply and temperature range
V_{REG} (bq2056T)	Voltage regulation reference	8.20	V	±0.7%	±0.5% variation over power supply and temperature range
V_{REF} (bq2056V)	Voltage regulation reference	3.35	V	±0.7%	±0.5% variation over power supply and temperature range
V_{SNS}	Current regulation reference	100	mV	±15%	
V_{MIN} (bq2056)	Trickle-charge voltage reference	2.0	V	±15%	
V_{MIN} (bq2056T)	Trickle-charge voltage reference	4.0	V	±15%	
V_{MIND} (bq2056V)	Trickle-charge voltage reference	1.64	V	±15%	
K_{COMP}	AutoComp constant	2.0	-	±15%	

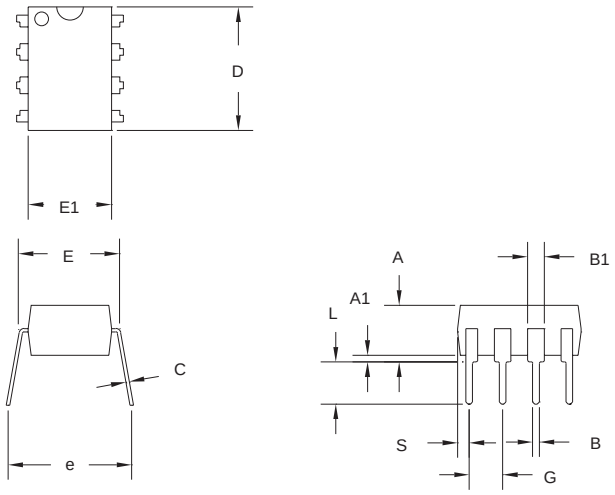
Recommended DC Operating Conditions (T_A=25°C)

Symbol	Parameter	Min	Typical	Max	Units	Notes
V_{CC}	Supply voltage relative to V_{SS}	5.0	-	17.0	V	
I_{CC}	Supply current	-	1	2	mA	INH = LOW
I_{CCS}	Sleep current	-	10	30	µA	INH = HIGH
V_{IL}	Input low	-	-	0.5	V	Pin INH
V_{IH}	Input high	2.0	-	-	V	Pin INH
V_{OL}	Output low	-	-	0.4	V	Pin TRKL, I_{OL} = 1mA
I_{OH}	Leakage current	-	-	1	µA	Pin TRKL
I_{SNK}	Sink current	-	-	40	mA	Pin CC

Impedance

Symbol	Parameter	Min	Typical	Max	Units	Notes
R_{BAT}	BAT pin input impedance	-	1	-	MΩ	
R_{SNS}	SNS pin input impedance	-	100	-	kΩ	
R_{COMP}	COMP pin input impedance	-	100	-	kΩ	

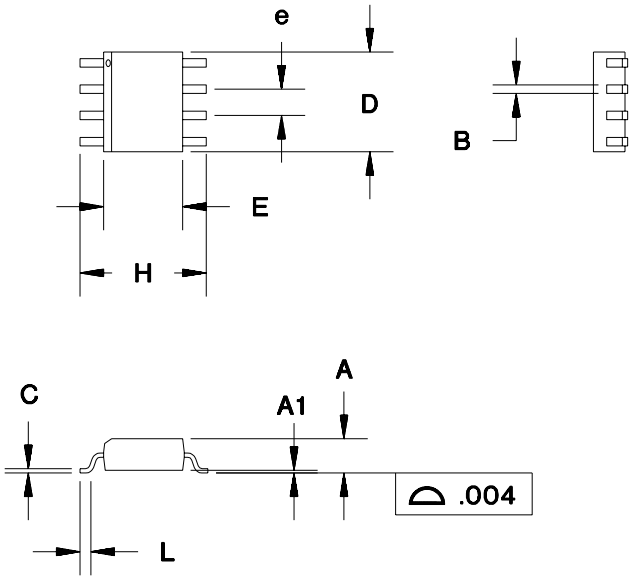
8-Pin DIP (PN)



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

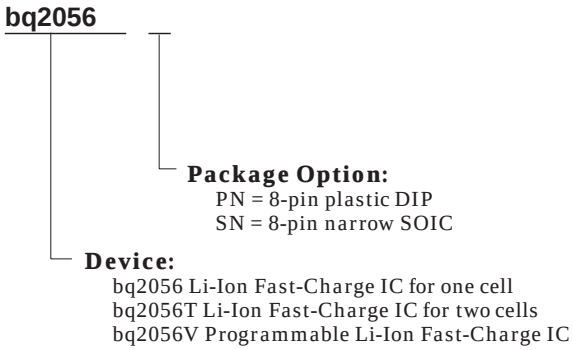
8-Pin SOIC Narrow (SN)

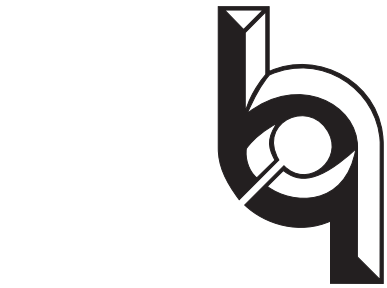


8-Pin SN (0.150" SOIC)

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

Ordering Information





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