bq2902

UNITRODE

Rechargeable Alkaline Charge/Discharge Controller IC

Features

- ➤ Safely charges two rechargeable alkaline batteries such as Renewal® from Rayovac®
- ➤ Terminates pulsed charge with maximum voltage limit
- ➤ Contains LED charge status output
- ➤ Features a pin-selectable low-battery cut-off
- ➤ Pre-charge qualification indicates fault condition
- ➤ Available in 8-pin 300-mil DIP or 150-mil SOIC

General Description

The bq2902 is a low-cost charger for rechargeable alkaline batteries such as Renewal® batteries from Rayovac®. The bq2902 combines sensitive, full-charge detection for two rechargeable alkaline cells, with a low-battery cut-off for overdischarge protection.

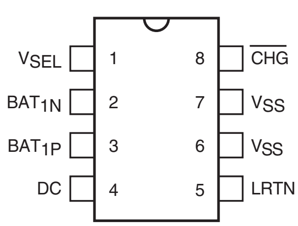
Designed for system integration into a two-cell system, the bq2902 can improve the service life of the rechargeable alkaline cells by properly managing the charge and discharge. The bq2902 requires a voltage limited current source to generate the proper charge pulses for the Renewal® cell. Each cell is individually monitored to ensure full charge without a damaging overcharge.

Charge completion is indicated when the average charge rate falls below approximately 3% of the fast charge rate. A status output is provided to indicate charge in progress, charge complete, or fault indication.

The bq2902 avoids over-depleting the battery by using the internal end-of-discharge control circuit. The bq2902 also eliminates the external power switching transistors needed to separately charge individual Renewal cells.

For safety, charging is inhibited if the per-cell voltage is greater than 3.0V during charge (closed-circuit voltage), or if the cell voltage is less than 0.4V (open-circuit voltage).

Pin Connections



8-Pin Narrow DIP or SOIC

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Pin Names

DC	Charging supply input	V_{SS}	Battery 2 negative input IC ground
$\overline{CHG}$	Battery status output	LRTN	System load return
BAT_{1P}	Battery 1 positive input	V_{SEL}	End-of-discharge voltage select input
BAT_{1N}	Battery 1 negative input		

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Pin Descriptions

DC **DC supply input**

This input is used to charge the rechargeable alkaline cells and power the bq2902 during charge. To charge the batteries, this input should be connected to a current-source limited to 300 mA. If the DC input current is greater than 300mA, the power dissipation limits of the package may be exceeded. The DC input should also be capable of supplying a minimum of 3.3V and should not exceed 5.5V.

$\overline{\text{CHG}}$ **Charge status**

This open-drain output is used to signify the battery charging status and is valid only when DC is applied.

V_{SEL} **End-of-discharge select input**

This three-level input selects the desired end-of-discharge cut-off voltage for the bq2902. V_{SEL} = BAT_{1P} selects an EDV of 1.10V. V_{SEL} floating selects EDV = 1.0V. V_{SEL} = V_{SS} selects EDV = 0.9.V

BAT_{1P} **Battery 1 positive input**

This input connects to the positive terminal of the battery designated BAT_1 (see Figure 3). This pin also provides power to the bq2902 when DC is not present.

BAT_{1N} **Battery 1 negative input**

This input connects to the negative terminal of the battery designated BAT_1 (see Figure 3).

V_{SS} **Battery 2 negative input/IC ground**

This input connects to the negative terminal of the battery designated BAT_2 (see Figure 3).

LRTN **Load return**

This open-drain pull-down output is typically used as a low-side switch. High-side load switching is also possible with the addition of an external P-FET.

Functional Description

Figure 1 is a block diagram outlining the major components of the bq2902.

Figure 2 illustrates the charge control and display status during a bq2902 cycle. Table 1 outlines the vari-

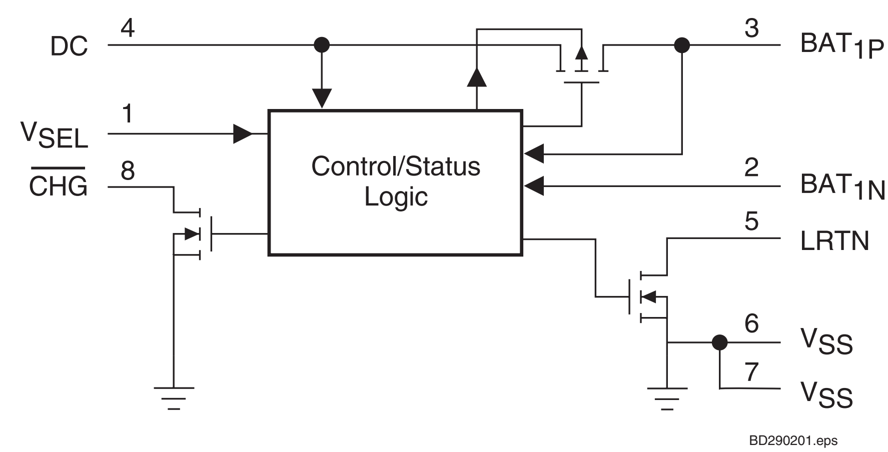


Figure 1. Functional Block Diagram

ous operational states and their associated conditions which are described in detail in the following section. Figure 3 is an application example.

Charge Initiation

The bq2902 always initiates and performs a charge cycle whenever a valid DC input is applied. A charge cycle consists of pulse charging the battery and then checking for a termination condition. The charging section explains charging in greater detail.

Charge Pre-Qualification

After DC is applied, the bq2902 checks the open-circuit voltage (V_{OCV}) of each cell for an undervoltage condition (V_{MIN} = 0.4V) and begins a charge cycle when the V_{OCV} of all cells is above V_{MIN}. If V_{OCV} of any cell is below V_{MIN}, the bq2902 enters a charge-pending mode and indicates a fault condition (see Table 1). The bq2902 remains in a charge-pending mode until V_{OCV} of each cell is above V_{MIN}.

Charge Termination

Once a charge cycle begins, the bq2902 terminates charge when the average charge rate falls below 3% of the maximum charge rate. The bq2902 also terminates charge when the closed-circuit voltage (V_{CCV}) of any cell exceeds 3.0V (V_{FLT}) during charge and indicates a fault condition on the $\overline{CHG}$ output (see Table 1).

Charge Re-Initiation

If DC remains valid, the bq2902 suspends all charge activity after full-charge termination. A charge cycle is re-initiated when all cell potentials fall below 1.4V. The rechargeable alkaline cells, unlike other rechargeable chemistries, do not require a maintenance charge to keep the cells in a fully charged state. The self-discharge rate for the Renewal cells is typically 4% per year at room temperature.

Charge Status Indication

Table 1 and Figure 2 outline the various charge action states and the associated BAT_{1P}, and $\overline{CHG}$ output states. The charge status output is designed to work with an LED indicator. In all cases, if DC is not present at the DC pin, or if the DC supply is less than the voltage at the BAT_{1P} pin, the CHG output is held in a high-impedance condition.

Charging

The bq2902 controls charging by periodically connecting the DC current-source to the battery stack, not to the individual battery cells. The charge current is pulsed from the internal clock at approximately a 80Hz rate on the BAT_{1P} pin.

The bq2902 pulse charges the battery for approximately 10ms of every 12.5ms, when conditions warrant. The bq2902 measures the open-circuit voltage (V_{OCV}) of each battery cell during the idle period. If a single-cell poten-

Table 1. bq2902 Operational Summary

Charge Action State	Conditions	BAT_{1P} Input	$\overline{CHG}$ Output
DC absent	$V_{DC} < V_{BAT1P}$	Low battery detection per V_{SEL}	Z
Charge initiation	DC applied	-	-
Charge pending/ fault	$V_{OCV} < 0.4V^1$ or $V_{CCV} > 3.0V^2$	-	⅔ sec = Low ⅔ sec = Z
Charge pulse	$V_{OCV} \leq$ 1.63V before pulse	Charge pulsed @ 80Hz per Figure 2	⅙ sec = Low ⅙ sec = Z
Pulse skip	V_{OCV} > 1.63V before pulse	Pulse skipped per Figure 2	⅙ sec = Low ⅙ sec = Z
Charge complete	Average charge rate falls below 3% of the fast charge rate	Charge complete	Low

Notes:
1. V_{OCV} = Open-circuit voltage of each cell between positive and negative leads.
2. V_{CCV} = Closed-circuit voltage.

tial of any battery is above the maximum open-circuit voltage (V_{MAX} = 1.63V ±3%), the following pulses are skipped until all cell potentials fall below the V_{MAX} limit. Charging is terminated when the average charge rate falls below approximately 3% of the maximum charge rate. Once charging is terminated, the internal charging FET remains off, and the $\overline{CHG}$ output becomes active per Table 1 and Figure 2. With DC applied, the internal discharge FET will always remain on.

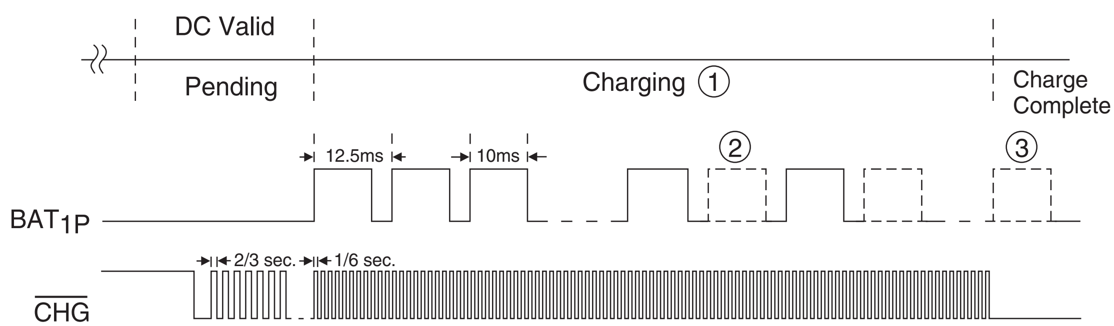
End-of-Discharge Control

When DC is not present or less than the voltage present on the BAT_{1P} pin, the bq2902 power is supplied by the voltage present at the BAT_{1P} pin. In this state, the batteries discharge down to the level determined by the V_{SEL} pin. The bq2902 monitors the cell voltage of the rechargeable alkaline cells.

If the voltage across any cell is below the voltage specified by the V_{SEL} input, the bq2902 disconnects the battery stack from the load by turning the internal discharge FET off. The discharge FET remains off until either the batteries are replaced or DC is reapplied, initiating a new charge cycle. After disconnecting the battery stack from the load, the standby current in the bq2902 is reduced to less than 1µA. The end-of-discharge voltage (V_{EDV}) is selectable by connecting the V_{SEL} pin as outlined in Table 2. Typically, higher discharge loads (>200mA) should use a lower discharge voltage cut-off to maximize battery capacity.

Table 2. bq2902 EDV Selections

End-of-Discharge Voltage	Pin Connection
1.10V	$V_{SEL} = BAT_{1P}$
1.00V	V_{SEL} = Z
0.90V	$V_{SEL} = V_{SS}$



Notes:
1. Charging: 0.4 < V_{OCV} ≤ 1.63V, V_{CCV} ≤ 3.0V.
2. Pulses skipped when V_{OCV} > 1.63V.
3. Charge complete when average charge falls below 3% of fast charge rate

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Figure 2. bq2902 Application Diagram

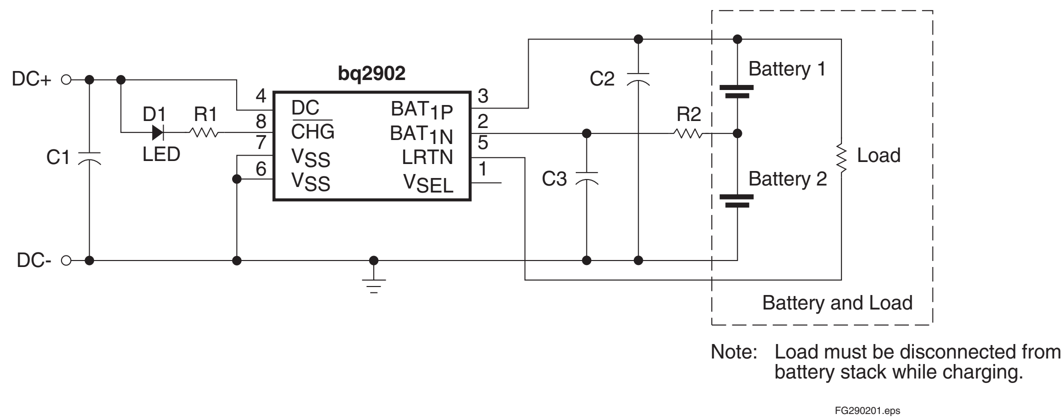


Figure 3. bq2902 Application Example, 1.0V EDV

Absolute Maximum Ratings

Symbol	Parameter	Minimum	Maximum	Unit	Notes
DC_{IN}	V_{DC} relative to GND	-0.3	7.0	V	
V_T	DC threshold voltage applied on any pin, excluding the DC pin, relative to GND	-0.3	7.0	V	
T_{OPR}	Operating ambient temperature	0	+70	°C	Commercial
		-40	+85	°C	Industrial
T_{STG}	Storage temperature	-40	+85	°C	
T_{SOLDER}	Soldering temperature	-	+260	°C	10 sec max.
I_{DC}	DC charging current	-	400	mA	
I_{LOAD}	Discharge current	-	500	mA	
I_{OL}	Output current	-	-	mA	$\overline{CHG}$

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 = 25°C; V_{DC} = 5.5V)

Symbol	Parameter	Rating	Tolerance	Unit	Notes
V_{MAX}	Maximum open-circuit voltage	1.63	±3%	V	$V_{OCV} > V_{MAX}$ inhibits/terminates charge pulses
V_{EDV}	End-of-discharge voltage	0.90	±5%	V	$V_{SEL} = BAT_{2N}$
		1.00	±5%	V	V_{SEL} = Z
		1.10	±5%	V	$V_{SEL} = BAT_{1P}$
V_{FLT}	Maximum open-circuit voltage	3.00	±5%	V	$V_{CCV} > V_{FLT}$ terminates charge, indicates fault
V_{MIN}	Minimum battery voltage	0.40	±5%	V	$V_{OCV} < V_{MIN}$ inhibits charge
V_{CE}	Charge enable	1.40	±5%	V	$V_{OCV} < V_{CE}$ on both cells re-initiates charge

Note: Each DC threshold parameter above has a temperature coefficient associated with it. To determine the coefficient for each parameter, use the following formula:

$$\text{Tempco} = \frac{\text{ParameterRating}}{1.63} * -0.5\text{mV/°C}$$

The tolerance for these temperature coefficients is 10%.

Timing $(T_A = T_{OPR})$

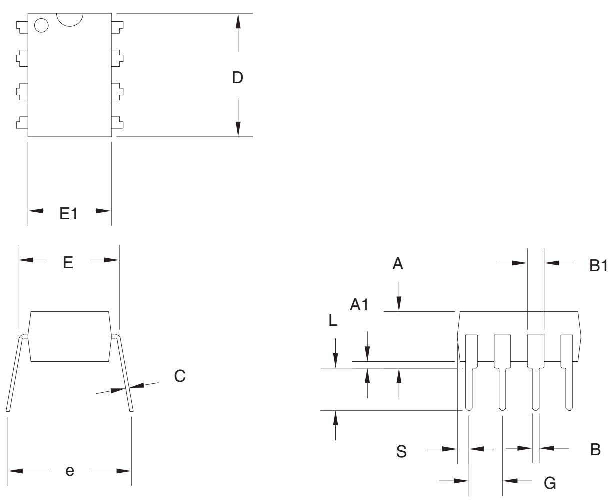
Symbol	Parameter	Minimum	Typical	Maximum	Unit	Notes
t_P	Pulse period	-	12.5	-	ms	See Figure 2
t_{PW}	Pulse width	-	10	-	ms	See Figure 2

Note: Typical is at T_A = 25°C.

DC Electrical Characteristics $(T_A = T_{OPR})$

Symbol	Parameter	Minimum	Typical	Maximum	Unit	Notes
V_{IH}	Logic input high	V_{BAT1P} - 0.1	-	V_{BAT1P}	V	V_{SEL}
V_{IL}	Logic input low	V_{SS}	-	V_{SS} + 0.1	V	V_{SEL}
V_{OL}	Logic output low	-	-	0.8	V	I_{OL} = 10mA
I_{OL}	Output current	10	-	-	mA	@$V_{OL} = V_{SS}$ + 0.8V
I_{CC}	Supply current	-	-	250	µA	Outputs unloaded, V_{DC} = 5.5V
I_{SB1}	Standby current	-	-	25	µA	V_{DC} = 0V, $V_{OCV} > V_{EDV}$
I_{SB2}	End-of-discharge standby current	-	-	1	µA	VDC = 0V
I_L	Input leakage	-	-	±1	µA	V_{SEL}
I_{OZ}	Output leakage in high-Z state	-5	-	-	µA	$\overline{CHG}$
R_{DSON}	On resistance	-	0.5	-	Ω	Discharge FET; V_{BAT1P} = 1.8V
I_{IL}	Logic input low	-	-	70	µA	V_{SEL}
I_{IH}	Logic input high	-70	-	-	µA	V_{SEL}
I_{IZ}	Logic input float	-2	-	2	µA	V_{SEL}
I_{DC}	DC charging current	-	-	300	mA	
V_{DC}	DC charging voltage	3.3	-	5.5	V	DC
I_{LOAD}	Discharge current	-	-	400	mA	
V_{OP}	Operating voltage	1.8	-	5.5	V	BAT_{1P}

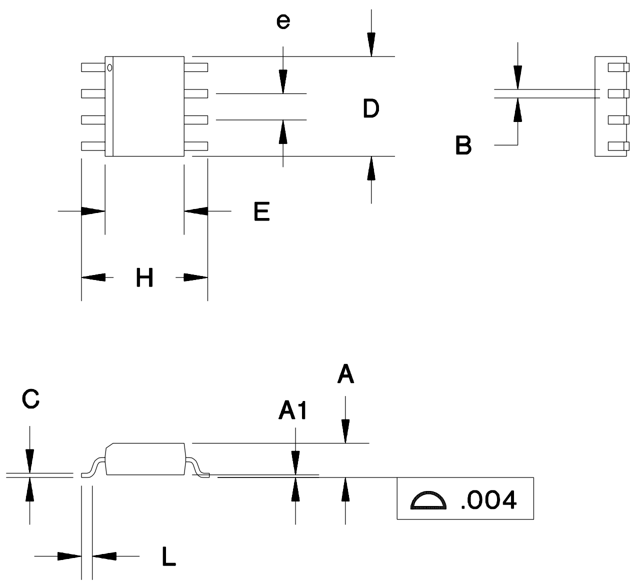
8-Pin DIP (PN)



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

Data Sheet Revision History

Change No.	Page No.	Description	Nature of Change
1	2	Figure 1. Functional Block Diagram	Updated block diagram

Notes: Change 1 = May 1999 C changes from Jan. 1997 B.

Ordering Information

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Package Option:
PN = 8-pin plastic DIP
SN = 8-pin narrow SOIC

Device:
bq2902 Rechargeable Alkaline
Charge/Discharge Controller IC

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