

# BQ25172: 800-mA Linear Battery Charger for 1- to 6-Cell NiMH Batteries

## 1 Features

- Input voltage up to 30-V tolerant
- Automatic Sleep Mode for low power consumption
  - 350-nA battery leakage current
  - 85- $\mu$ A input leakage current when charge disabled
- Supports 1- to 6-cell NiMH with intermittent-charging
- External resistor programmable operation
  - VSET to set NiMH series cell-count from 1s to 6s
  - ISET to set charge current from 10 mA to 800 mA
  - TMR to set charge safety timer duration from 4 hr to 22 hr
- High accuracy
  - $\pm 0.5\%$  charge voltage accuracy
  - $\pm 10\%$  charge current accuracy
- Charging features
  - NTC thermistor input to monitor battery temperature
  - Cold and hot temperature charging disabled
  - $V_{OUT\_OVP}$  reduced at cool temperatures
  - TS pin for charging function control
  - Open-drain output for status and fault indication
- Integrated fault protection
  - 18-V IN overvoltage protection
  - VSET based OUT overvoltage protection
  - 1000-mA overcurrent protection
  - 125°C thermal regulation; 150°C thermal shutdown protection
  - OUT short-circuit protection
  - VSET, ISET, TMR pins short/open protection

## 2 Applications

- [Fleet management, asset tracking](#)
- [Gas detector](#)
- [Electronic point of sales \(ePOS\)](#)
- [Beauty and grooming](#)
- [Electric toothbrush](#)
- [Pulse oximeter](#)
- [Blood glucose monitor](#)
- [Infrared thermometer](#)

## 3 Description

The BQ25172 is an integrated 800-mA linear charger for 1-cell to 6-cell NiMH batteries targeted at industrial and medical applications. The device has a single power output that charges the battery. The system load can be placed in parallel with the battery, as long as the average system load does not prevent the battery from being charged fully within the safety timer duration. When the system load is placed in parallel with the battery, the charge current is shared between the system and the battery.

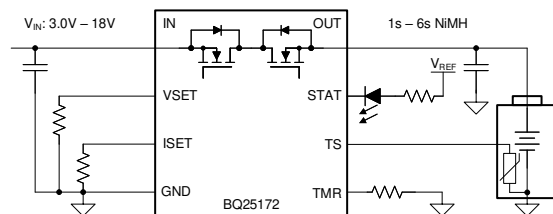
The device charges NiMH cells in constant current mode only and terminates the charge cycle when the programmable timer expires or the battery voltage exceeds the  $V_{OUT\_OVP}$  threshold. In all charge phases, an internal control loop monitors the IC junction temperature and reduces the charge current if an internal temperature threshold  $T_{REG}$  is exceeded.

The charger power stage and charge current sense functions are fully integrated. The charger function has high accuracy current, charge status display, and timer-based charge termination. The series cell-count, charge current, and charge timer are programmable through external resistors. Intermittent charging allows a NiMH battery to automatically recharge for a reduced timer duration once its voltage falls below the recharge threshold.

### Device Information

PART NUMBER <sup>(1)</sup>	PACKAGE	BODY SIZE (NOM)
BQ25172	WSON (8)	2.0 mm x 2.0 mm

- (1) For all available packages, see the orderable addendum at the end of the data sheet.



**Simplified Schematic**



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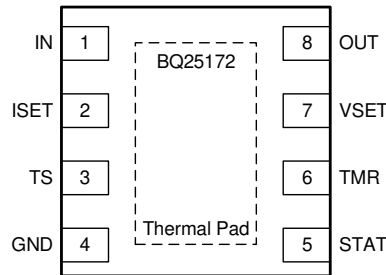
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## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
June 2022	*	Initial Release

## 5 Pin Configuration and Functions



**Figure 5-1. DSG Package WSON 8-Pin Top View**

**Table 5-1. Pin Functions**

PIN		I/O	DESCRIPTION
NAME	NUMBER		
IN	1	P	Input power, connected to external DC supply. Bypass IN with a $\geq 1\text{-}\mu\text{F}$ capacitor to GND, placed close to the IC.
ISET	2	I	Programs the device charge current. External resistor from ISET to GND defines charge current value. Expected range is 30 k $\Omega$ (10 mA) to 375 $\Omega$ (800 mA). $I_{\text{CHG}} = K_{\text{ISET}} / R_{\text{ISET}}$ .
TS	3	I	Temperature qualification voltage input. Connect a negative temperature coefficient (NTC) thermistor directly from TS to GND (AT103-2 recommended). Charge suspends when the TS pin voltage is out of range. $V_{\text{OUT\_OVP}}$ is reduced in cool region. If TS function is not needed, connect an external 10-k $\Omega$ resistor from this pin to GND. Pulling $V_{\text{TS}} < V_{\text{TS\_ENZ}}$ disables the charger.
GND	4	–	Ground pin
STAT	5	O	Open drain charge status indication output. Connect to the pullup rail via a 10-k $\Omega$ resistor. LOW indicates charge in progress. HIGH indicates charge complete or charge disabled. When a fault condition is detected, the STAT pin blinks at 1 Hz.
TMR	6	I	Connect to a pulldown resistor to program charge safety timer duration. Valid resistor range is 3.6 k $\Omega$ to 36 k $\Omega$ . Refer to <a href="#">Section 7.3.1.2</a> .
VSET	7	I	Programs the number of series NiMH cells. Valid resistor range is 3.6 k $\Omega$ to 62 k $\Omega$ . Recommend using a $\pm 1\%$ tolerance resistor with $< 200$ ppm/ $^{\circ}\text{C}$ temperature coefficient. Refer to <a href="#">Section 7.3.1.3</a> .
OUT	8	P	Battery connection. System load may be connected in parallel to the battery. Bypass OUT with a $\geq 1\text{-}\mu\text{F}$ capacitor to GND, placed close to the IC.
Thermal Pad	—	—	Exposed pad beneath the IC for heat dissipation. Solder thermal pad to the board with vias connecting to solid GND plane.

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
Voltage	IN	-0.3	30	V
Voltage	OUT	-0.3	13	V
Voltage	ISET, STAT, TMR, TS, VSET	-0.3	5.5	V
Output Sink Current	STAT		5	mA
Junction temperature, T <sub>J</sub>		-40	150	°C
Storage temperature, T <sub>stg</sub>		-65	150	°C

- (1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute maximum ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If briefly operating outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not sustain damage, but it may not be fully functional. Operating the device in this manner may affect device reliability, functionality, performance, and shorten the device lifetime.

### 6.2 ESD Ratings

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/ JEDEC JS-001, all pins <sup>(1)</sup>	±2500	V
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup>	±1500	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.  
 (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V <sub>IN</sub>	Input voltage	3.0		18	V
V <sub>OUT</sub>	Output voltage			10.5	V
I <sub>OUT</sub>	Output current			0.8	A
T <sub>J</sub>	Junction temperature	-40		125	°C
C <sub>IN</sub>	IN capacitor	1			μF
C <sub>OUT</sub>	OUT capacitor	1			μF
R <sub>TMR</sub>	TMR resistor	3.6		36	kΩ
R <sub>VSET</sub>	VSET resistor	3.6		62	kΩ
R <sub>TMR_VSET_TOL</sub>	Tolerance for TMR, and VSET resistors	-1		1	%
R <sub>TMR_VSET_TEMPCO</sub>	Temperature coefficient for TMR, and VSET resistors			200	ppm/°C
R <sub>ISET</sub>	ISET resistor	0.375		30	kΩ
R <sub>TS</sub>	TS thermistor resistor (recommend 103AT-2)		10		kΩ

## 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		BQ25172	UNIT
		DSG(WSON)	
		8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance (JEDEC <sup>(1)</sup> )	75.2	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	93.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	41.8	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	3.8	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	41.7	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	17.0	°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.5 Electrical Characteristics

3.0V < V<sub>IN</sub> < 18V and V<sub>IN</sub> > V<sub>OUT</sub> + V<sub>SLEEP</sub>, T<sub>J</sub> = -40°C to +125°C, and T<sub>J</sub> = 25°C for typical values (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>QUIESCENT CURRENTS</b>						
I <sub>Q_OUT</sub>	Quiescent output current (OUT)	OUT= 4.2V, IN floating or IN = 0V - 5V, Charge Disabled, T <sub>J</sub> = 25 °C		0.350	0.6	μA
		OUT= 4.2V, IN floating or IN = 0V - 5V, Charge Disabled, T <sub>J</sub> < 105 °C		0.350	0.8	μA
I <sub>Q_OUT</sub>	Quiescent output current (OUT)	OUT = 8.4V, IN floating or IN = 0V - 14V, Charge Disabled, T <sub>J</sub> = 25 °C		0.8	1.2	μA
		OUT = 8.4V, IN floating or IN = 0V - 14V, Charge Disabled, T <sub>J</sub> < 105 °C		0.8	1.5	μA
I <sub>SD_IN_TS</sub>	Shutdown input current (IN) with charge disabled via TS pin	IN = 5V, Charge Disabled (V <sub>TS</sub> < V <sub>TS_ENZ</sub> ), no battery		80	110	μA
I <sub>STANDBY_IN</sub>	Standby input current (IN) with charge terminated	IN = 5V, Charge Enabled, charge terminated		190		μA
I <sub>STANDBY_IN</sub>	Standby input current (IN) with charge terminated	IN = 14V, Charge Enabled, charge terminated		230		μA
I <sub>Q_IN</sub>	Quiescent input current (IN)	IN = 5V, OUT = 3.8V, Charge Enabled, I <sub>CHG</sub> = 0A		0.45	0.6	mA
I <sub>Q_IN</sub>	Quiescent input current (IN)	IN = 14V, OUT = 7.6V, Charge Enabled, I <sub>CHG</sub> = 0A		0.45	0.6	mA
<b>INPUT</b>						
V <sub>IN_OP</sub>	IN operating range		3.0		18	V
V <sub>IN_LOWV</sub>	IN voltage to start charging	IN rising	3.05	3.09	3.15	V
V <sub>IN_LOWV</sub>	IN voltage to stop charging	IN falling	2.80	2.95	3.10	V
V <sub>SLEEPZ</sub>	Exit sleep mode threshold	IN rising, V <sub>IN</sub> - V <sub>OUT</sub> , OUT = 4V	95	135	175	mV
V <sub>SLEEP</sub>	Sleep mode threshold hysteresis	IN falling, V <sub>IN</sub> - V <sub>OUT</sub> , OUT = 4V		80		mV
V <sub>IN_OV</sub>	VIN overvoltage rising threshold	IN rising	18.1	18.4	18.7	V
V <sub>IN_OVZ</sub>	VIN overvoltage falling threshold	IN falling		18.2		V
<b>CONFIGURATION PINS SHORT/OPEN PROTECTION</b>						
R <sub>ISET_SHORT</sub>	Resistor value considered short	R <sub>ISET</sub> below this at startup, charger does not initiate charge, power cycle or TS toggle to reset			350	Ω
R <sub>VSET_SHORT</sub>	Resistor value considered short	R <sub>VSET</sub> below this at startup, charger does not initiate charge, power cycle or toggle to reset			2.8	kΩ
R <sub>VSET_OPEN</sub>	Resistor value considered open	R <sub>VSET</sub> above this at startup, charger does not initiate charge, power cycle or toggle to reset	80			kΩ
R <sub>TMR_SHORT</sub>	Resistor value considered short	R <sub>TMR</sub> below this at startup, charger latches off, power cycle or TS toggle to reset			2.8	kΩ
R <sub>TMR_OPEN</sub>	Resistor value considered open	R <sub>TMR</sub> above this at startup, charger latches off, power cycle or TS toggle to reset	45			kΩ
<b>BATTERY CHARGER</b>						
I <sub>CHG_RANGE</sub>	Typical charge current regulation range		10		800	mA
K <sub>ISET</sub>	Charge current setting factor, I <sub>CHG</sub> = K <sub>ISET</sub> / R <sub>ISET</sub>	10mA < I <sub>CHG</sub> < 800mA	270	300	330	AΩ
I <sub>CHG_ACC</sub>	Charge current accuracy	R <sub>ISET</sub> = 375Ω, OUT = 3.8V	720	800	880	mA
		R <sub>ISET</sub> = 600Ω, OUT = 3.8V	450	500	550	mA
		R <sub>ISET</sub> = 3.0kΩ, OUT = 3.8V	90	100	110	mA
		R <sub>ISET</sub> = 30kΩ, OUT = 3.8V	9	10	11	mA

## 6.5 Electrical Characteristics (continued)

$3.0V < V_{IN} < 18V$  and  $V_{IN} > V_{OUT} + V_{SLEEP}$ ,  $T_J = -40^{\circ}C$  to  $+125^{\circ}C$ , and  $T_J = 25^{\circ}C$  for typical values (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{RECHG}$	Battery recharge threshold, per cell	OUT falling, VSET configured for 2-cell	1.305	1.330	1.355	V
$R_{ON}$	Charging path FET on-resistance	IOU = 400mA, $T_J = 25^{\circ}C$		845	1000	m $\Omega$
		IOU = 400mA, $T_J = -40 - 125^{\circ}C$		845	1450	m $\Omega$
<b>BATTERY CHARGER PROTECTION</b>						
$V_{OUT\_OVP}$	OUT overvoltage rising threshold, per cell	VOU rising, TS normal	1.65	1.70	1.75	V
$V_{OUT\_OVP}$	OUT overvoltage falling threshold, per cell	VOU falling, TS normal	1.40	1.45	1.50	V
$V_{OUT\_OVP\_TSCOO}$	OUT overvoltage rising threshold, per cell	VOU rising, TS in cool range	1.45	1.50	1.55	V
$V_{OUT\_OVP\_TSCOO}$	OUT overvoltage falling threshold, per cell	VOU falling, TS in cool range	1.30	1.35	1.40	V
$I_{OUT\_OCP}$	Output current limit threshold	IOU rising	0.9	1	1.1	A
<b>TEMPERATURE REGULATION AND TEMPERATURE SHUTDOWN</b>						
$T_{REG}$	Typical junction temperature regulation			125		$^{\circ}C$
$T_{SHUT}$	Thermal shutdown rising threshold	Temperature increasing		150		$^{\circ}C$
	Thermal shutdown falling threshold	Temperature decreasing		135		$^{\circ}C$
<b>BATTERY-PACK NTC MONITOR</b>						
$I_{TS\_BIAS}$	TS nominal bias current		36.5	38	39.5	$\mu$ A
$V_{COLD}$	Cold temperature threshold	TS pin voltage rising (approx. $0^{\circ}C$ )	0.99	1.04	1.09	V
	Cold temperature exit threshold	TS pin voltage falling (approx. $4^{\circ}C$ )	0.83	0.88	0.93	V
$V_{COOL}$	Cool temperature threshold; $V_{OUT\_OVP}$ reduced	TS pin voltage rising (approx. $10^{\circ}C$ )	650	680	710	mV
	Cool temperature exit threshold; $V_{OUT\_OVP}$ returns to normal	TS pin voltage falling (approx. $13^{\circ}C$ )	580	610	640	mV
$V_{HOT}$	Hot temperature threshold	TS pin voltage falling (approx. $45^{\circ}C$ )	176	188	200	mV
	Hot temperature exit threshold	TS pin voltage rising (approx. $40^{\circ}C$ )	208	220	232	mV
$V_{TS\_ENZ}$	Charge Disable threshold. Crossing this threshold shall shutdown IC	TS pin voltage falling	40	50	60	mV
$V_{TS\_EN}$	Charge Enable threshold. Crossing this threshold shall restart IC operation	TS pin voltage rising	65	75	85	mV
$V_{TS\_CLAMP}$	TS maximum voltage clamp	TS pin open-circuit (float)	2.3	2.6	2.9	V
<b>LOGIC OUTPUT PIN (STAT)</b>						
$V_{OL}$	Output low threshold level	Sink current = 5mA			0.4	V
$I_{OUT\_BIAS}$	High-level leakage current	Pull up rail 3.3V			1	$\mu$ A

## 6.6 Timing Requirements

		MIN	NOM	MAX	UNIT
<b>BATTERY CHARGER</b>					
$t_{TS\_DUTY\_ON}$	TS turn-on time during TS duty cycle mode		100		ms
$t_{TS\_DUTY\_OFF}$	TS turn-off time during TS duty cycle mode		2		s
$t_{OUT\_OCP\_DGL}$	Deglintch time for $I_{OUT\_OCP}$ , IOU rising		100		$\mu$ s
$t_{SAFETY}$	Charge safety timer accuracy, $R_{TMR} = 18k\Omega$	9.5	10	10.5	hr
$t_{INTERMITTENT}$	Commercial Intermittent charge safety timer (NiMH), as percentage of $t_{SAFETY}$		20		%

## 6.7 Typical Characteristics

$C_{IN} = 1 \mu F$ ,  $C_{OUT} = 1 \mu F$ ,  $V_{IN} = 5 V$ ,  $V_{OUT} = 3.8 V$ , Temperature = Ambient (unless otherwise specified)

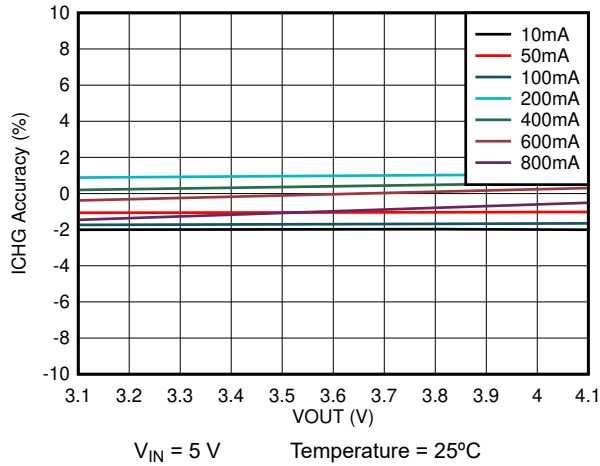


Figure 6-1. ICHG Accuracy vs. Output Voltage

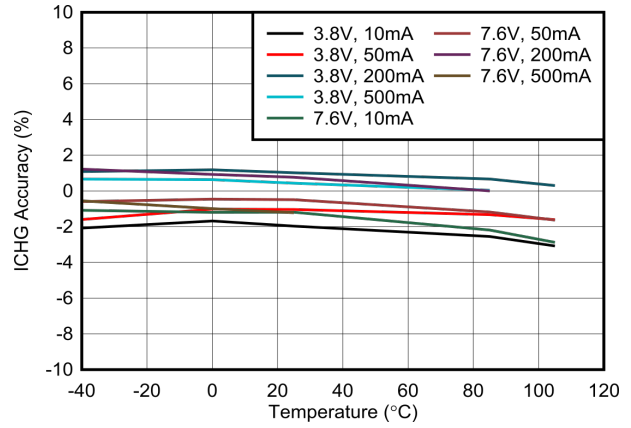


Figure 6-2. ICHG Accuracy vs. Temperature

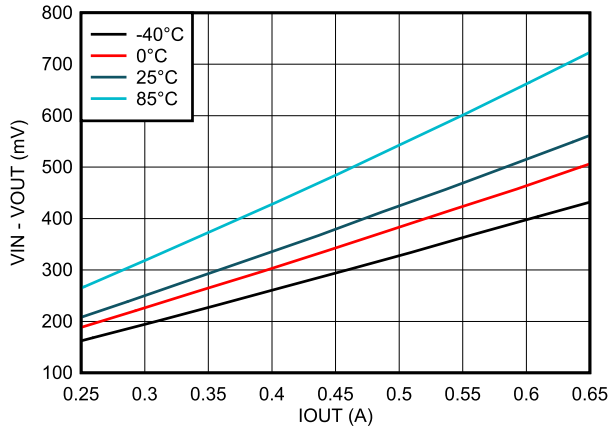


Figure 6-3. Dropout Voltage vs. Output Current

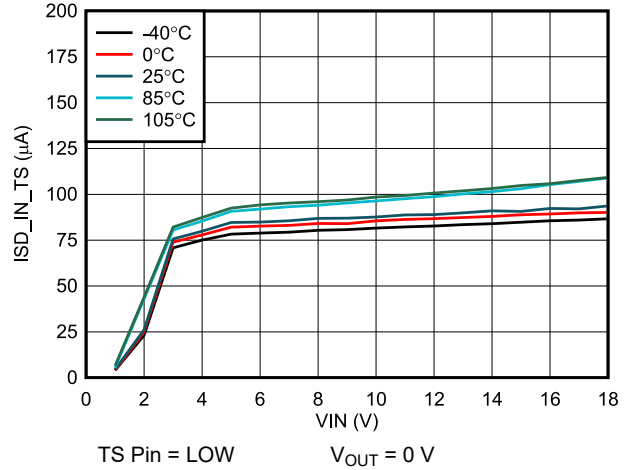


Figure 6-4. Input Shutdown Current vs. Input Voltage

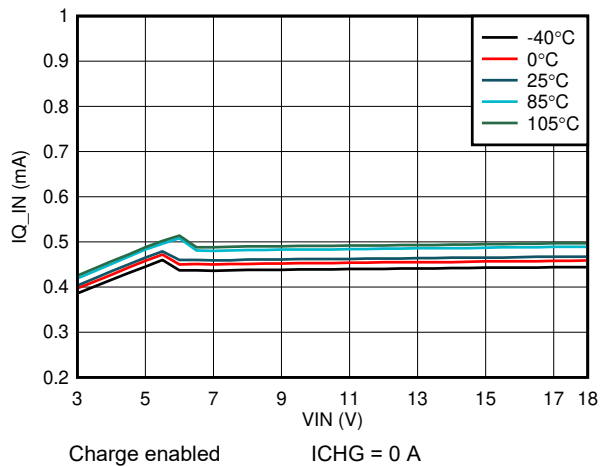


Figure 6-5. Input Quiescent Current vs. Input Voltage

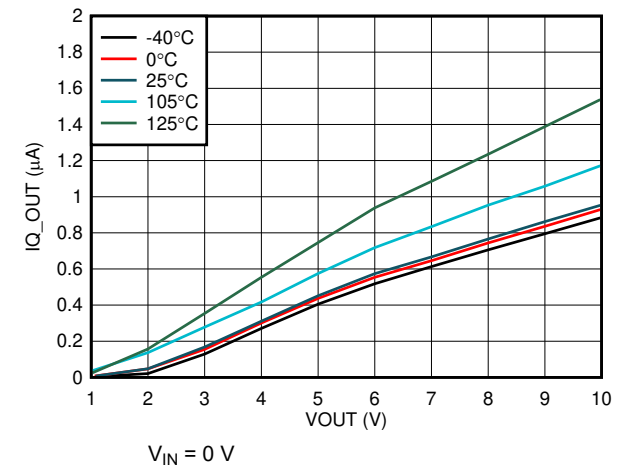


Figure 6-6. Output Quiescent Current vs. Output Voltage



## 7 Detailed Description

### 7.1 Overview

The BQ25172 is an integrated 800-mA linear charger for 1-cell to 6-cell NiMH battery applications. The device has a single power output that charges the battery. When the system load is placed in parallel with the battery, the input current is shared between the system and the battery.

The device charges a NiMH battery in constant current mode only and terminates the charge cycle when the programmable timer,  $t_{\text{SAFETY}}$ , expires or the battery voltage exceeds the  $V_{\text{OUT\_OVP}}$  threshold. An optional intermittent charging phase can be programmed to automatically recharge the NiMH battery for a reduced timer duration once its voltage falls below  $V_{\text{RECHG}}$ .

The charger includes flexibility in programming of the charge current, charge safety timer duration, and series cell-count. This charger is designed to work with a standard USB connection or dedicated charging adapter (DC output).

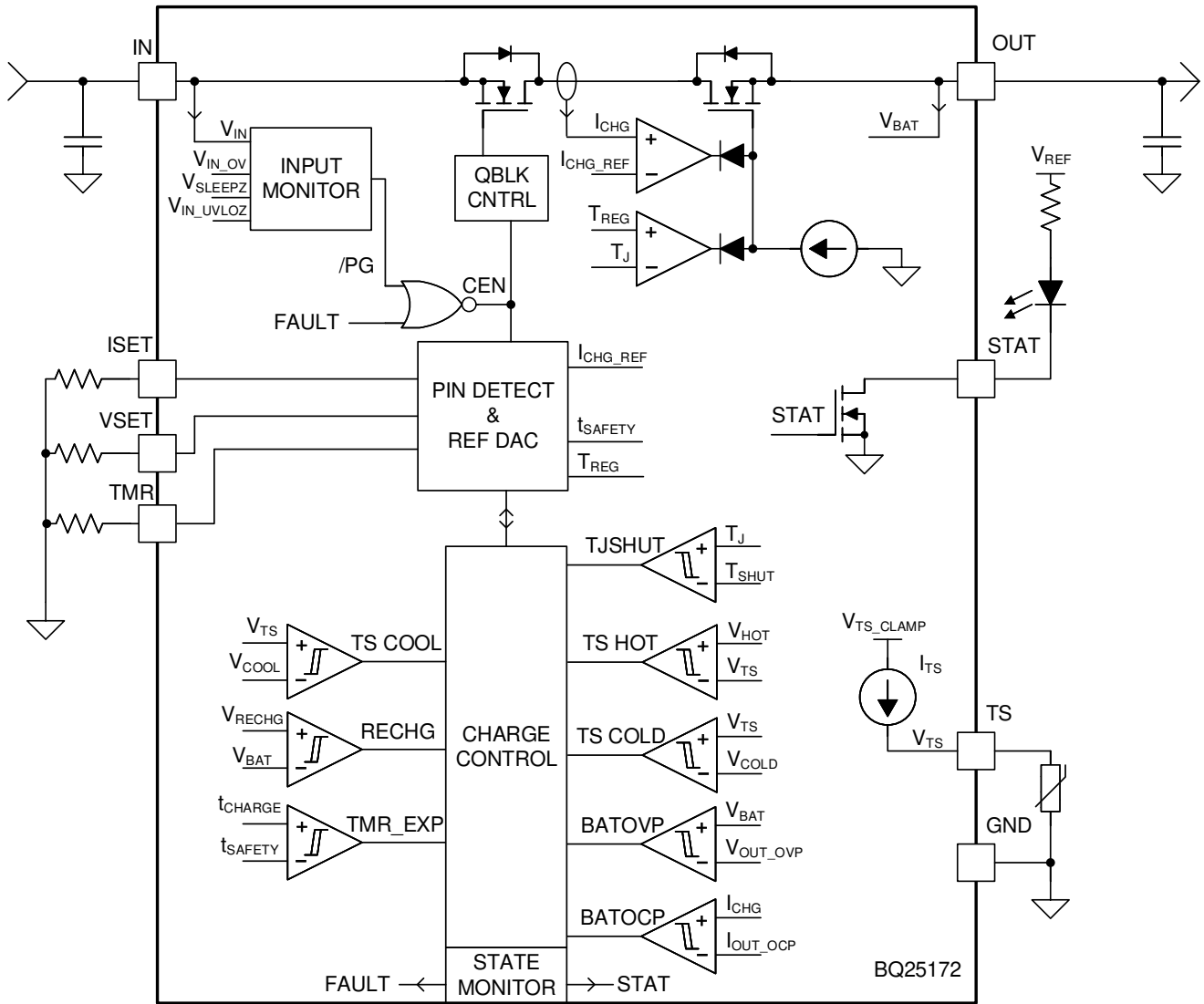
The charger also comes with a full set of safety features: battery temperature monitoring, overvoltage protection, charge safety timer, and configuration pin (VSET, ISET, TMR) short and open protection. Upon application of a valid input power source, the configuration pins are checked for short and open circuits. All of these features and more are described in detail in the following sections.

The charger is designed for a single path from the input to the output to charge the battery. Once the input adapter has been connected, the charge current is applied and the safety timer is started. The charge current is programmed using the ISET pin. The safety timer is programmed by the TMR pin.

Power dissipation in the IC is greatest at high charge currents and low battery voltages. If the IC temperature reaches  $T_{\text{REG}}$ , the IC enters thermal regulation, slows the timer clock by half, and reduces the charge current as needed to keep the temperature from rising any further.

Further details are described in [Section 7.3](#).

## 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 Device Power Up from Input Source

When an input source is plugged in and charge is enabled ( $V_{TS} > V_{TS\_EN}$ ), the device checks the input source voltage to turn on all the bias circuits. It detects and sets the charge current, safety timer length, and series cell-count before the linear regulator is started. The power-up sequence from input source is as listed:

1. ISET pin detection
2. TMR pin detection to select charge timer
3. VSET pin detection to select battery stack configuration
4. Charger power up

#### 7.3.1.1 ISET Pin Detection

After a valid VIN is plugged in and  $V_{TS} > V_{TS\_EN}$ , the device checks the resistor on the ISET pin for a short circuit ( $R_{ISET} < R_{ISET\_SHORT}$ ). If a short condition is detected, the charger remains in the FAULT state until the input or TS pin is toggled. If the ISET pin is open-circuit, the charger proceeds through pin detection and starts the charger with no charge current. The ISET pin is monitored while charging and changes in  $R_{ISET}$  while the charger is operating immediately translates to changes in charge current.

An external pull-down resistor ( $\pm 1\%$  or better is recommended to minimize charge current error) from the ISET pin to GND sets the charge current as:

$$I_{CHG} = \frac{K_{ISET}}{R_{ISET}} \tag{1}$$

where:

- $I_{CHG}$  is the desired charge current
- $K_{ISET}$  is a gain factor found in the electrical characteristics
- $R_{ISET}$  is the pull-down resistor from the ISET pin to GND

For charge currents below 50 mA, an extra RC circuit is recommended on ISET to achieve a more stable current signal. For greater accuracy at lower currents, part of the current-sensing FET is disabled to give better resolution.

#### 7.3.1.2 TMR Pin Detection

The TMR pin is used to program the safety timer using a  $\pm 1\%$  pull-down resistor. The available pull-down resistors and corresponding timer lengths are listed in the following table.

**Table 7-1. TMR Pin Resistor Value Table**

RESISTOR	CHARGE TIMER (HR)
> 45 kΩ	No charge (open-circuit)
36 kΩ	4 hr
27 kΩ	6 hr
24 kΩ	8 hr
18 kΩ	10 hr
15 kΩ	12 hr
11 kΩ	14 hr
8.2 kΩ	16 hr
6.2 kΩ	18 hr
4.7 kΩ	20 hr
3.6 kΩ	22 hr

**Table 7-1. TMR Pin Resistor Value Table (continued)**

RESISTOR	CHARGE TIMER (HR)
< 3.0 kΩ	No charge (short-circuit)

If either a short- or open-circuit condition is detected, the charger stops operation and remains in the FAULT state until the input or TS pin is toggled.

Once a value has been detected, it is latched in and the pin is not continuously monitored during operation. A change in this pin is not acknowledged by the IC until the input supply or TS pin is toggled.

### 7.3.1.3 VSET Pin Detection

The VSET pin is used to program the device cell configuration using a  $\pm 1\%$  pulldown resistor. The available pulldown resistors and corresponding cell configurations are listed in the following table.

**Table 7-2. VSET Pin Resistor Value Table**

RESISTOR	CELL COUNT
> 80 $\Omega$	No charge (open-circuit)
62 kΩ	1-cell
47 kΩ	1-cell + intermittent charge
36 kΩ	2-cell
27 kΩ	2-cell + intermittent charge
24 kΩ	3-cell
18 kΩ	3-cell + intermittent charge
15 kΩ	4-cell
11 kΩ	4-cell + intermittent charge
8.2 kΩ	5-cell
6.2 kΩ	5-cell + intermittent charge
4.7 kΩ	6-cell
3.6 kΩ	6-cell + intermittent charge
< 3.0 kΩ	No charge (short-circuit)

If either a short- or open-circuit condition is detected, the charger stops operation and remains in the FAULT state until the input or TS pin is toggled.

Once a valid resistor value has been detected, the corresponding cell configuration is latched in and the pin is not continuously monitored during operation. A change in this pin is not acknowledged by the IC until the input supply or TS pin is toggled.

### 7.3.1.4 Charger Power Up

After ISET, TMR, and VSET pin resistor values have been validated, the device proceeds to enable the charger. For more info see [Section 7.3.2.1](#).

## 7.3.2 Battery Charging Features

When charge is enabled ( $V_{TS} > V_{TS\_EN}$ ), the device automatically completes a charging cycle according to the settings on the ISET, TMR, and VSET pins. Charging is terminated when the charge safety timer expires or battery voltage exceeds  $V_{OUT\_OVP}$ .

### 7.3.2.1 NiMH Battery Charging Profile

The device charges NiMH batteries in constant current mode only. The charge current programmed by ISET is the only current applied over the charging cycle, as shown in [Figure 7-1](#). The charge termination method for the device is timer-based. The charge safety timer,  $t_{SAFETY}$ , sets the charging duration. Programming the charge safety timer is done with a pulldown resistor on the TMR pin.

Intermittent charging is designed to replenish the natural self-discharge of NiMH cells by restarting a short charge cycle (20% of  $t_{SAFETY}$ ) when the output voltage falls below the  $V_{RECHG}$  threshold. If the intermittent charging function is disabled and a full charge cycle has been completed (safety timer expired with  $V_{OUT}$  above  $V_{RECHG}$ ), the device does not start a new charge cycle automatically and requires input supply or TS pin toggle to initiate a new charge cycle.

If battery voltage is above  $V_{RECHG}$  at power up, the battery is considered full and the device does not charge. Once the battery voltage falls below  $V_{RECHG}$ , the device automatically begins charging. If the intermittent charging function is disabled, a single charge cycle is initiated with the safety timer duration programmed by the TMR pin. If intermittent charging is enabled, an intermittent charge cycle is initiated for 20% of the TMR programmed value.

When the charge timer (full-length or intermittent) expires, the battery voltage is checked again. If the battery voltage is below  $V_{RECHG}$ , a fault is reported through the STAT pin and further charging is prevented. If the charge timer expires with  $V_{OUT}$  above  $V_{RECHG}$ , the STAT pin indicates charge completed. In the case where the TS fault is within the cool threshold,  $V_{OUT\_OVP}$  is automatically reduced to  $V_{OUT\_OVP\_TSCOOL}$  voltage.

If the charger is in thermal regulation during charging, the actual charging current will be less than the programmed value. Termination by timer is still enabled, but the charging safety timer is counted at half the clock rate. For more information, refer to [Section 7.3.2.2](#).

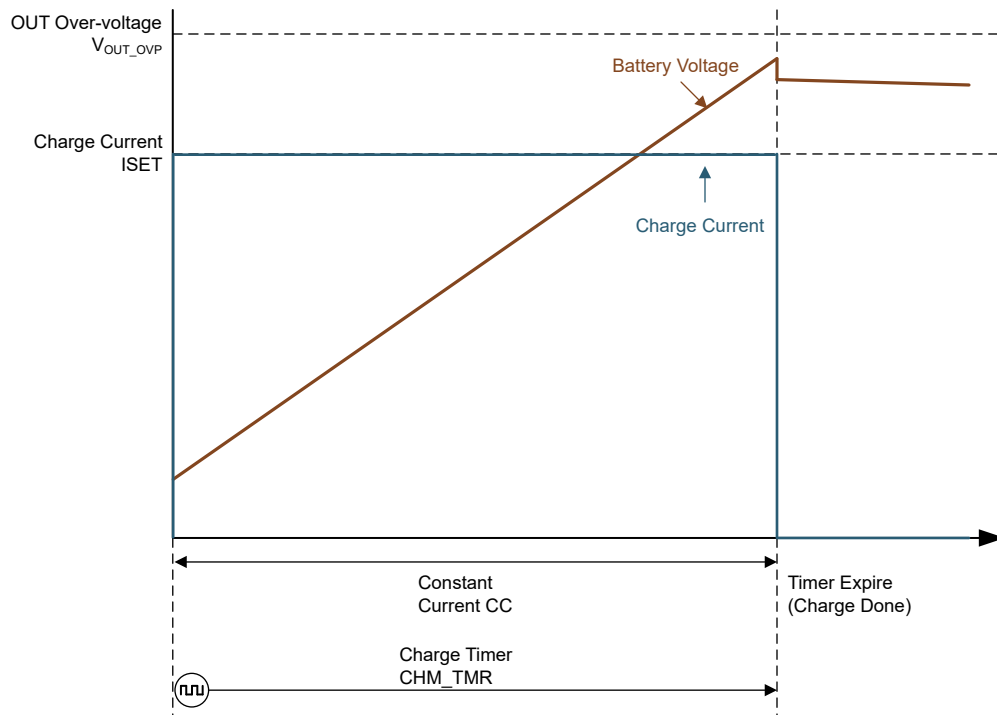
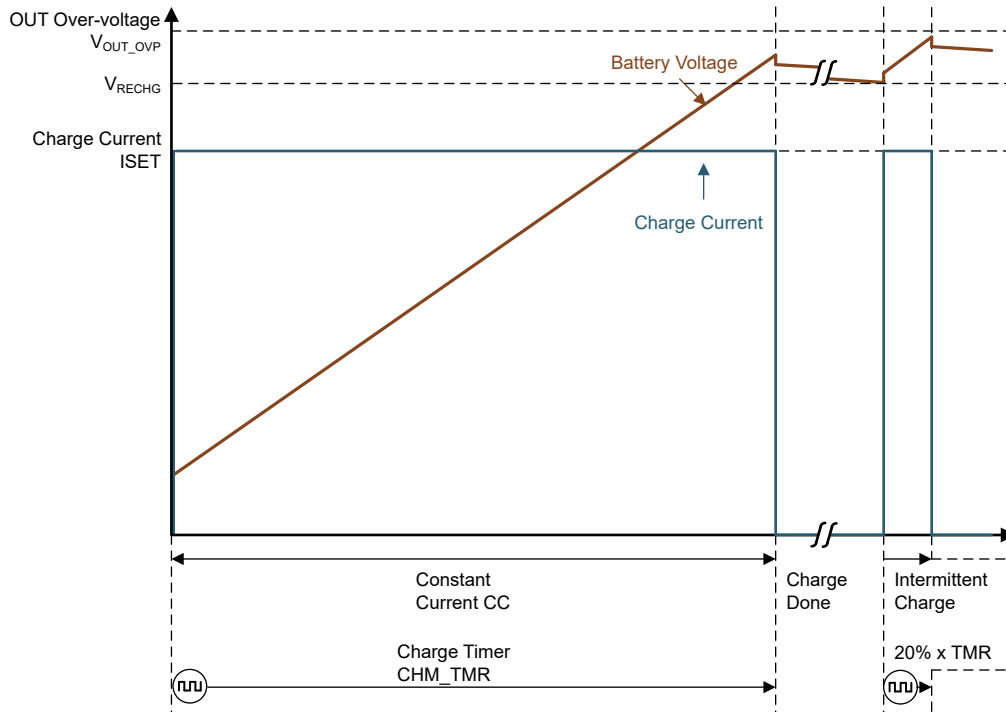


Figure 7-1. NiMH Battery Charging Profile with Intermittent Charging Disabled



**Figure 7-2. NiMH Battery Charging Profile with Intermittent Charging Enabled**

### 7.3.2.2 Charging Safety Timers

The device has built-in safety timers to prevent an extended charging cycle due to abnormal battery conditions. When the safety timer expires, the charge cycle ends.

During thermal regulation, the safety timer counts at half the clock rate as the actual charge current is likely to be below the  $I_{SET}$  setting. For example, if the charger is in thermal regulation throughout the whole charging cycle and the safety timer is 10 hours, then the timer will expire in 20 hours.

During faults which disable charging, such as  $V_{IN}$  OVP, BAT OVP, TSHUT, or TS faults, the timer is suspended. If the charging cycle is stopped and started again, the timer is reset (toggle of the TS pin restarts the timer).

The safety timer restarts counting when the charging cycle stops and restarts. This can occur as a result of the TS pin being toggled, the battery falling below the recharge threshold, or the input supply being toggled.

### 7.3.2.3 Battery Cold, Hot Temperature Qualification (TS Pin)

While charging, the device continuously monitors battery temperature by sensing the voltage at the TS pin. A negative temperature coefficient (NTC) thermistor should be connected between the TS and GND pins (recommend: 103AT-2). If temperature sensing is not required in the application, connect a fixed 10-k $\Omega$  resistor from the TS pin to GND to allow normal operation. Battery charging is allowed when the TS pin voltage falls between the  $V_{COLD}$  and  $V_{HOT}$  thresholds (typically 0°C to 45°C).

If the TS pin indicates battery temperature is outside this range, the device stops charging and enters the Standby state. Once battery temperature returns to normal conditions, charging resumes automatically.

In addition to battery temperature sensing, the TS pin can be used to disable the charger at any time by pulling TS voltage below  $V_{TS\_ENZ}$ . The device disables the charger and consumes  $I_{SD\_IN\_TS}$  from the input supply. In order to minimize quiescent current, the TS current source ( $I_{TS\_BIAS}$ ) is duty-cycled, with an on time of  $t_{TS\_DUTY\_ON}$  and an off time of  $t_{TS\_DUTY\_OFF}$ . After the TS pin pulldown is released, the device may take up to  $t_{TS\_DUTY\_OFF}$  to turn  $I_{TS\_BIAS}$  back on. After the source is turned on, the TS pin voltage goes above  $V_{TS\_EN}$  and reenables charger operation. The device treats this TS pin toggle as an input supply toggle, triggering a device power up from input source (see Section 7.3.1).

### 7.3.3 Status Outputs (STAT)

#### 7.3.3.1 Charging Status Indicator (STAT)

The device indicates the charging state on the open-drain STAT pin as listed in the following table. This pin can drive an LED.

**Table 7-3. STAT Pin States**

CHARGING STATE	STAT PIN STATE
Charge completed (TMR_EXP), charger in Sleep mode or charge disabled	High
Charge in progress (including intermittent charge active)	Low
Fault (VIN OVP, BAT OVP, BAT OCP, or VSET, ISET, TMR pin short or open)	Blink at 1 Hz

### 7.3.4 Protection Features

The device closely monitors input and output voltages, as well as internal FET current and temperature for safe linear regulator operation.

#### 7.3.4.1 Input Overvoltage Protection (VIN OVP)

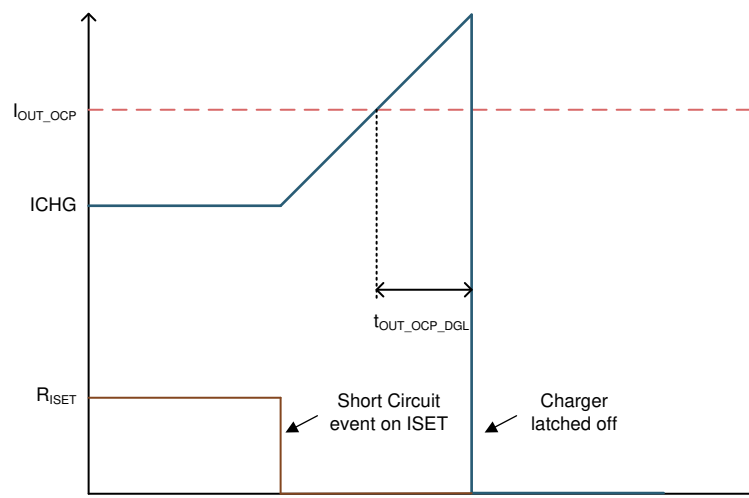
If the voltage at the IN pin exceeds  $V_{IN\_OV}$ , the device turns off, the safety timer suspends counting, and the device enters Standby mode. Once the IN voltage recovers to a normal level, the charge cycle and the safety timer automatically resume operation.

#### 7.3.4.2 Output Overvoltage Protection (BAT OVP)

If the voltage at the OUT pin exceeds  $V_{OUT\_OVP}$ , the device immediately stops charging, the safety timer suspends counting, and the device enters Standby mode. Once the OUT voltage recovers to a normal level, the charge cycle and the safety timer resume operation.

#### 7.3.4.3 Output Overcurrent Protection (BAT OCP)

During normal operation, the OUT current should be regulated to the ISET programmed value. However, if a short circuit occurs on the ISET pin, the OUT current may rise to an unintended level. If the current at the OUT pin exceeds  $I_{OUT\_OCP}$ , the device turns off after a deglitch,  $t_{OUT\_OCP\_DGL}$ , the safety timer resets the count, and the device remains latched off. An input supply or pin toggle is required to restart operation.



**Figure 7-3. Overcurrent Protection**

#### 7.3.4.4 Thermal Regulation and Thermal Shutdown (TREG and TSHUT)

The device monitors its internal junction temperature ( $T_J$ ) to avoid overheating and to limit the IC surface temperature. When the internal junction temperature exceeds the thermal regulation limit, the device automatically reduces the charge current to maintain the junction temperature at the thermal regulation limit (TREG). During thermal regulation, the safety timer runs at half the clock rate and the actual charging current is reduced below the programmed value on the ISET pin.

Additionally, the device has thermal shutdown to turn off the linear regulator when the IC junction temperature exceeds the TSHUT threshold. The charger resumes operation when the IC die temperature decreases below the TSHUT falling threshold.

### 7.4 Device Functional Modes

#### 7.4.1 Shutdown or Undervoltage Lockout (UVLO)

The device is in the shutdown state if the IN pin voltage is less than  $V_{IN\_LOWV}$ . The internal circuitry is powered down, all the pins are high impedance, and the device draws from the input supply. Once the IN voltage rises above the  $V_{IN\_LOWV}$  threshold, the IC enters Sleep mode or Active mode depending on the OUT pin voltage.

#### 7.4.2 Sleep Mode

The device is in Sleep mode when  $V_{IN\_LOWV} < V_{IN} < V_{OUT} + V_{SLEEPZ}$ . The device waits for the input voltage to rise above  $V_{OUT} + V_{SLEEPZ}$  to start operation.

#### 7.4.3 Active Mode

The device is powered up and charges the battery when the TS pin is above  $V_{TS\_ENZ}$  and the IN voltage ramps above both  $V_{IN\_LOWV}$  and  $V_{OUT} + V_{SLEEPZ}$ . The device draws  $I_{Q\_IN}$  from the supply to bias the internal circuitry. For details on the device power-up sequence, refer to [Section 7.3.1](#).

##### 7.4.3.1 Standby Mode

The device is in Standby mode if a valid input supply is present and charge is terminated or if a recoverable fault is detected. The internal circuitry is partially biased, and the device continues to monitor for either  $V_{OUT}$  to drop below  $V_{RECHG}$  or the recoverable fault to be removed.

#### 7.4.4 Fault Mode

The fault conditions are categorized into recoverable and nonrecoverable as follows:

- Recoverable, from which the device should automatically recover once the fault condition is removed:
  - VIN OVP
  - BAT OVP
  - TS HOT
  - TS COLD
- Nonrecoverable, requiring pin or input supply toggle to resume operation:
  - BAT OCP
  - ISET pin short detected
  - Charge timer expires with  $V_{OUT}$  below  $V_{RECHG}$



## 8 Application and Implementation

### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 8.1 Application Information

A typical application consists of the device configured as a standalone battery charger for a 1-cell to 6-cell NiMH battery. The charge voltage and number of cells is configured using a pull-down resistor on the VSET pin. The charge current is configured using a pull-down resistor on the ISET pin. A battery thermistor may be connected to the TS pin to allow the device to monitor battery temperature and control charging. Pulling the TS pin below  $V_{TS\_ENZ}$  disables the charging function. The safety timer is programmable through a pull-down resistor on the TMR pin. Faults are indicated through the STAT pin.

### 8.2 Typical Applications

#### 8.2.1 NiMH Charger Design Example

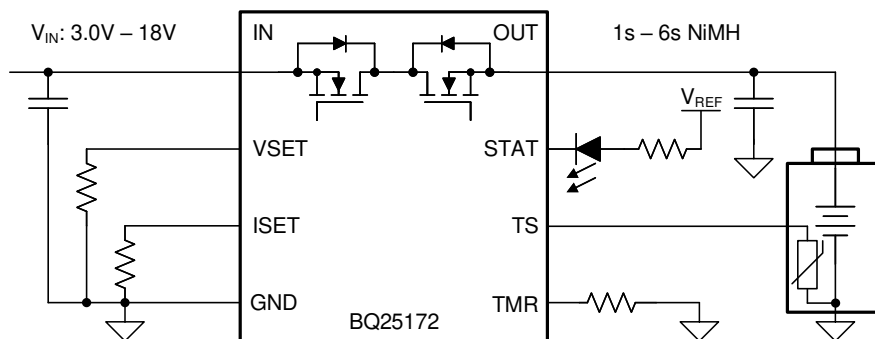


Figure 8-1. BQ25172 Simple Schematic

##### 8.2.1.1 Design Requirements

The design requirements include the following:

- Input supply up to 18 V
- Battery: 4-cell NiMH,  $R_{VSET} = 11 \text{ k}\Omega$
- Fast charge current:  $I_{CHG} = 30 \text{ mA}$
- Recharge voltage for intermittent cycles:  $V_{RECHG} = 1.33\text{V} \times 4 = 5.32 \text{ V}$
- Charge safety timer:  $R_{TMR} = 8.2 \text{ k}\Omega$ ,  $t_{SAFETY}: 16 \text{ hr}$
- TS – Battery temperature sense = 10-k $\Omega$  NTC (103AT-2)
- TS can be pulled low to disable charging

##### 8.2.1.2 Detailed Design Procedure

The regulation voltage is set via the VSET pin to 2s NiMH, the input voltage is 5 V and the charge current is programmed via the ISET pin to 500 mA.

$$R_{ISET} = [K_{ISET} / I_{CHG}]$$

from electrical characteristics table. . .  $K_{ISET} = 300 \text{ A}\Omega$

$$R_{ISET} = [300 \text{ A}\Omega / 0.5 \text{ A}] = 600 \Omega$$

Selecting the closest 1% resistor standard value, use a 604- $\Omega$  resistor between ISET and GND, for an expected  $I_{CHG}$  497 mA.

### 8.2.1.3 Application Curves

$C_{IN} = 1 \mu F$ ,  $C_{OUT} = 1 \mu F$ ,  $V_{IN} = 5 V$ ,  $V_{OUT} = 3.8 V$  (unless otherwise specified)



$R_{ISET} = 0.6 k\Omega$

**Figure 8-2. Power Up with Battery**



$R_{ISET} = 0.6 k\Omega$  OUT = open-circuit

**Figure 8-3. Power Up without Battery**



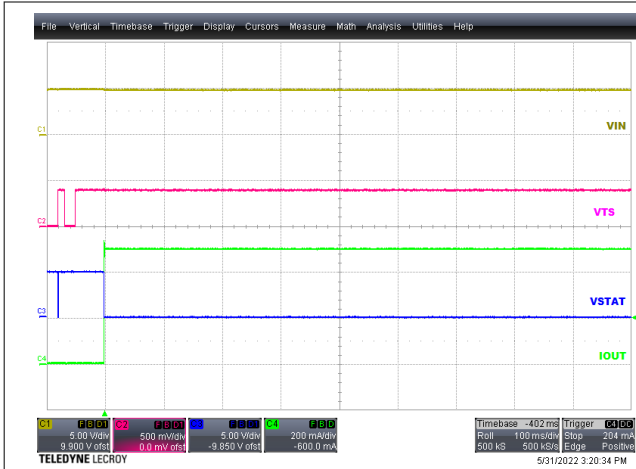
$V_{IN} = 5 V \rightarrow 0 V$

**Figure 8-4. Power Down with Battery**



TS pulled LOW

**Figure 8-5. Charge Disable**



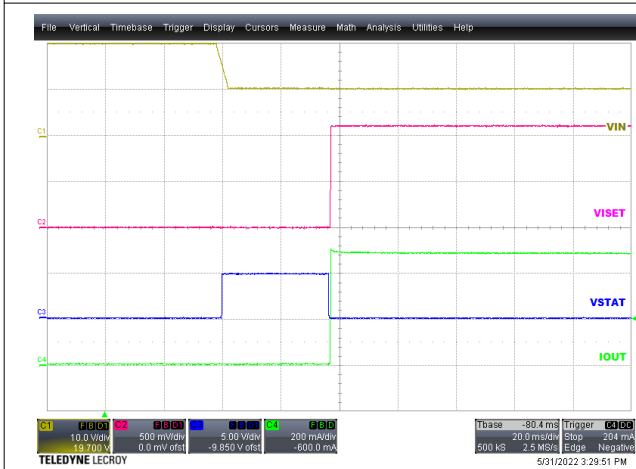
TS pin released

**Figure 8-6. Charge Enable**



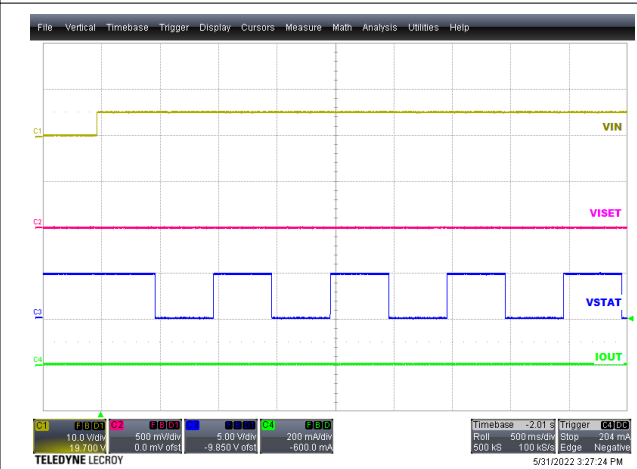
$V_{IN} = 5\text{ V} \rightarrow 10\text{ V}$

**Figure 8-7. Input OVP Response**



$V_{IN} = 20\text{ V} \rightarrow 10\text{ V}$

**Figure 8-8. Input OVP Recovery**



$I_{SET} = 0\ \Omega$

**Figure 8-9. ISET Short-Circuit Then Power Up**

## 9 Power Supply Recommendations

The device is designed to operate from an input voltage supply range between 3 V and 18 V (tolerant up to 30 V) and current capability of at least the maximum designed charge current. If located more than a few inches from the IN and GND pins, a larger capacitor is recommended.

## 10 Layout

### 10.1 Layout Guidelines

To obtain optimal performance, the decoupling capacitor from the IN pin to the GND pin and the output filter capacitor from the OUT pin to the GND pin should be placed as close as possible to the device, with short trace runs to both IN, OUT, and GND.

- All low current GND connections should be kept separate from the high current charge or discharge paths from the battery. Use a single-point ground technique incorporating both the small signal ground path and the power ground path.
- The high current charge paths into the IN pin and from the OUT pin must be sized appropriately for the maximum charge current in order to avoid voltage drops in these traces.

### 10.2 Layout Example

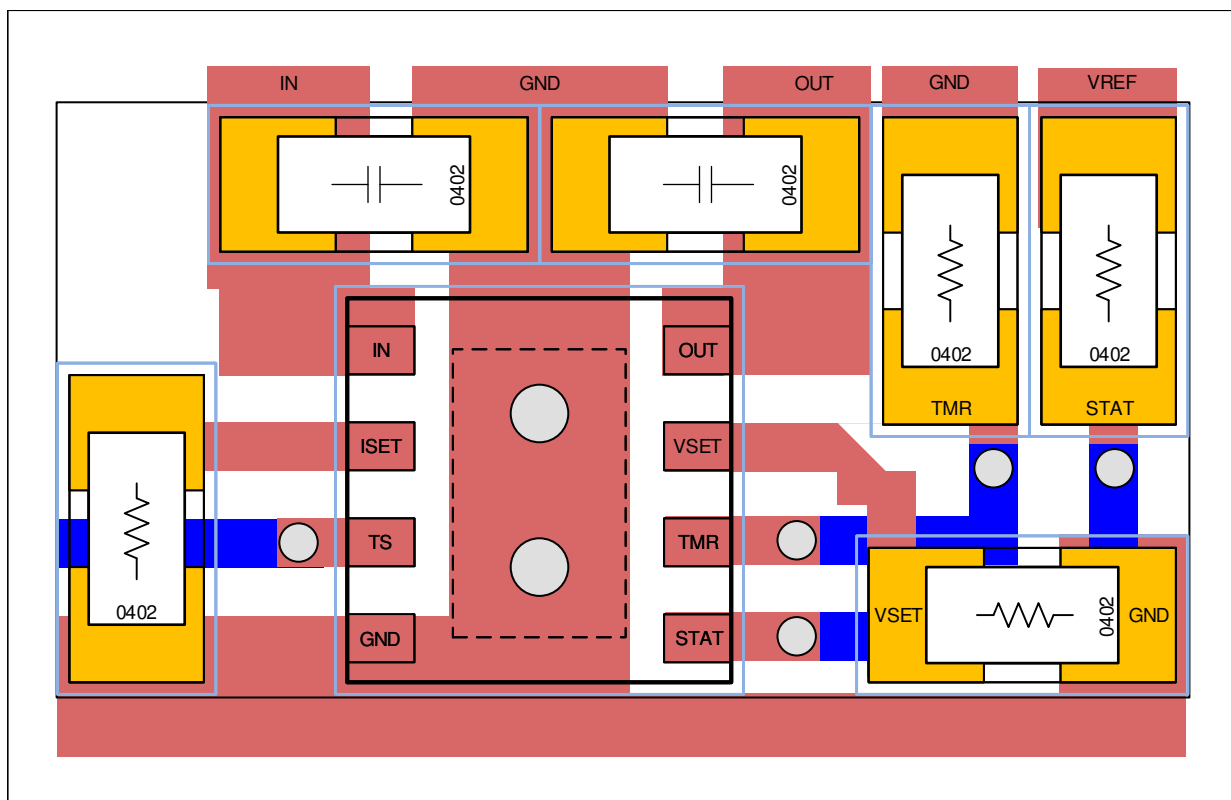


Figure 10-1. BQ25172 Layout Example

## 11 Device and Documentation Support

### 11.1 Device Support

#### 11.1.1 Third-Party Products Disclaimer

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#### 11.3 Support Resources

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#### 11.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

#### 11.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
BQ25172DSGR	ACTIVE	WSON	DSG	8	3000	RoHS & Green	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	B172	Samples

(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) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

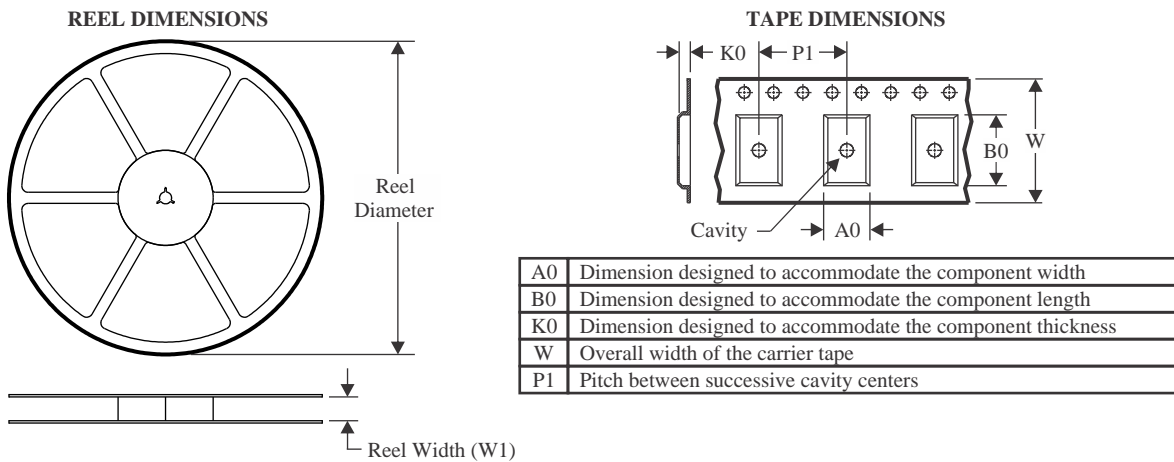
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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**TAPE AND REEL INFORMATION**

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**


\*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
BQ25172DSGR	WSO8	DSG	8	3000	180.0	8.4	2.3	2.3	1.15	4.0	8.0	Q2



**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ25172DSGR	WSON	DSG	8	3000	210.0	185.0	35.0

## GENERIC PACKAGE VIEW

**DSG 8**

**WSON - 0.8 mm max height**

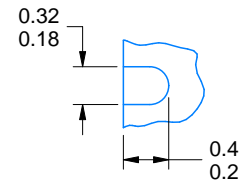
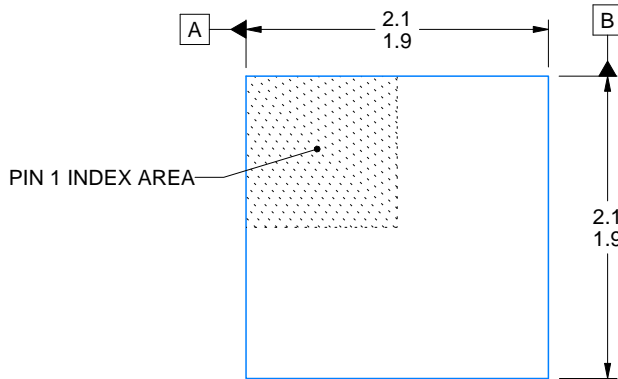
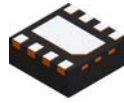
2 x 2, 0.5 mm pitch

PLASTIC SMALL OUTLINE - NO LEAD

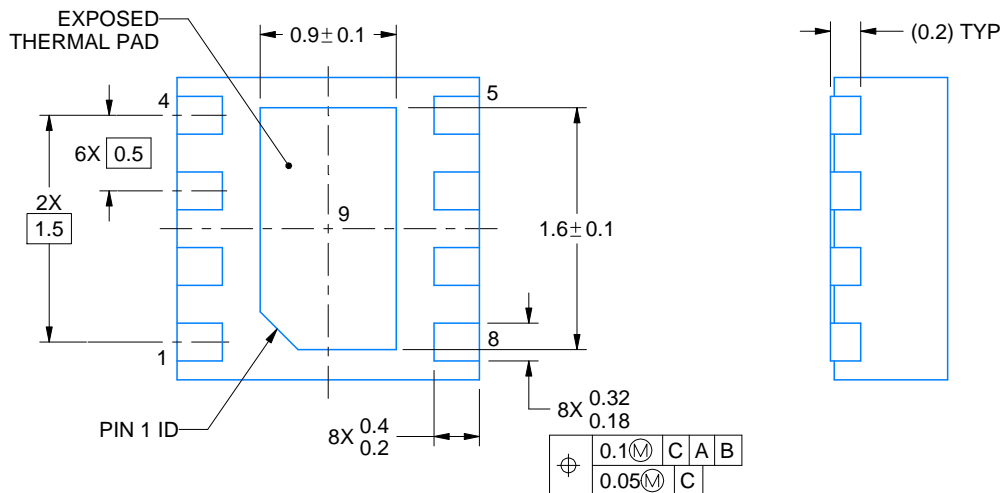
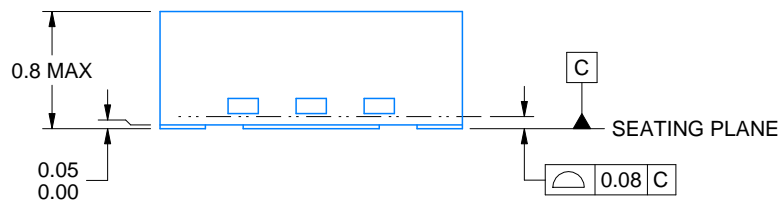
This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4224783/A



ALTERNATIVE TERMINAL SHAPE  
TYPICAL



4218900/D 04/2020

NOTES:

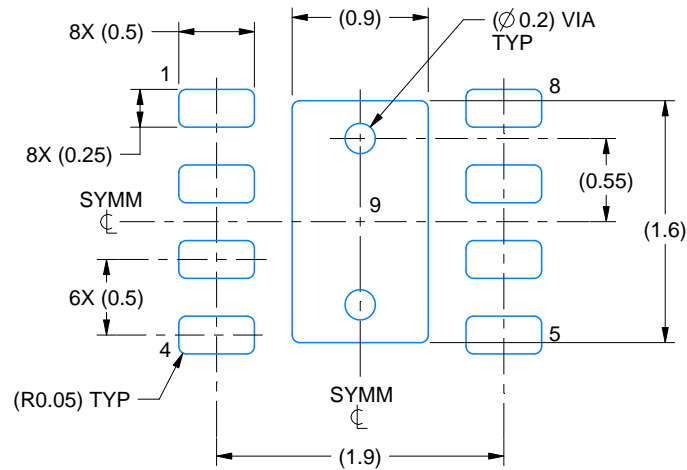
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

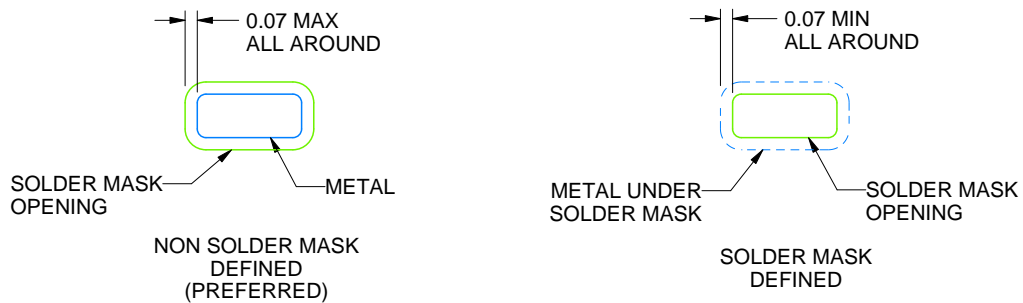
DSG0008A

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



LAND PATTERN EXAMPLE  
SCALE:20X



SOLDER MASK DETAILS

4218900/D 04/2020

NOTES: (continued)

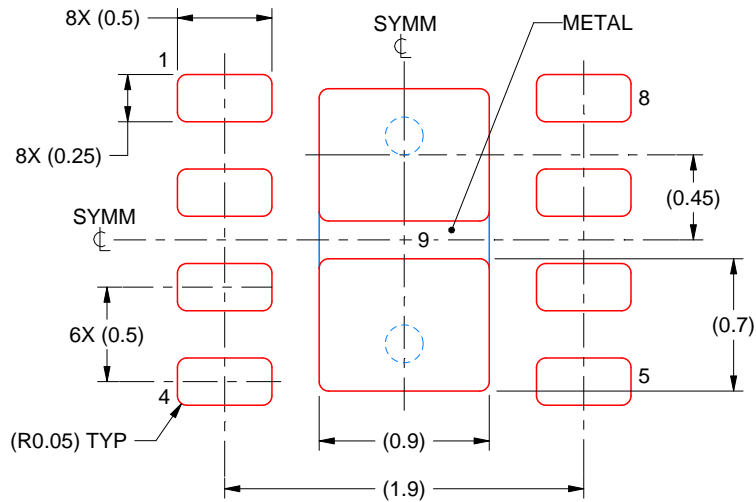
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

DSG0008A

WSON - 0.8 mm max height

PLASTIC SMALL OUTLINE - NO LEAD



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 9:  
87% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:25X

4218900/D 04/2020

NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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