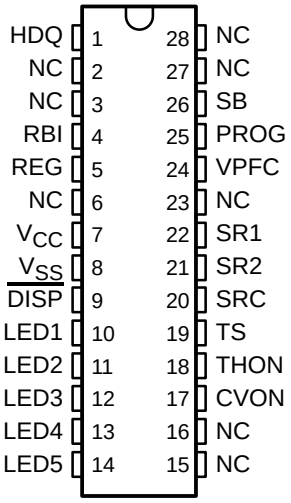
bq2016
GAS GAUGE IC FOR HIGH DISCHARGE RATES

SLUS475A – JANUARY 2001 – REVISED NOVEMBER 2002

TSSOP PACKAGE
(TOP VIEW)



NC — Do not connect

Range
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k or in-system installation maintains an accurate record of available ischarge activity of the battery, the IC monitors a voltage drop across th the cells of the battery. The bq2016 compensates for battery battery self-discharge to the charge counter to provide available- of operating conditions. The bq2016 works with NiCd or NiMH battery and that are designed for high discharge rate applications such as

reference of the battery pack. The bq2016 learns the true discharge atically updates the full-charge reference during the course of a aining capacity is reported as the ratio between the actual discharge bq2016 communicates available capacity using 5 LEDs or the 1-wire

Kb/s) allows an external processor to read and write the internal with the bq2016 is useful for pack testing or host processing of the registers include available battery capacity, voltage, temperature, maintains the register set in the event of pack voltage collapse due

ls in the pack. The REG output and an external FET provide a simple, wer to the circuit from the cells

OPTIO

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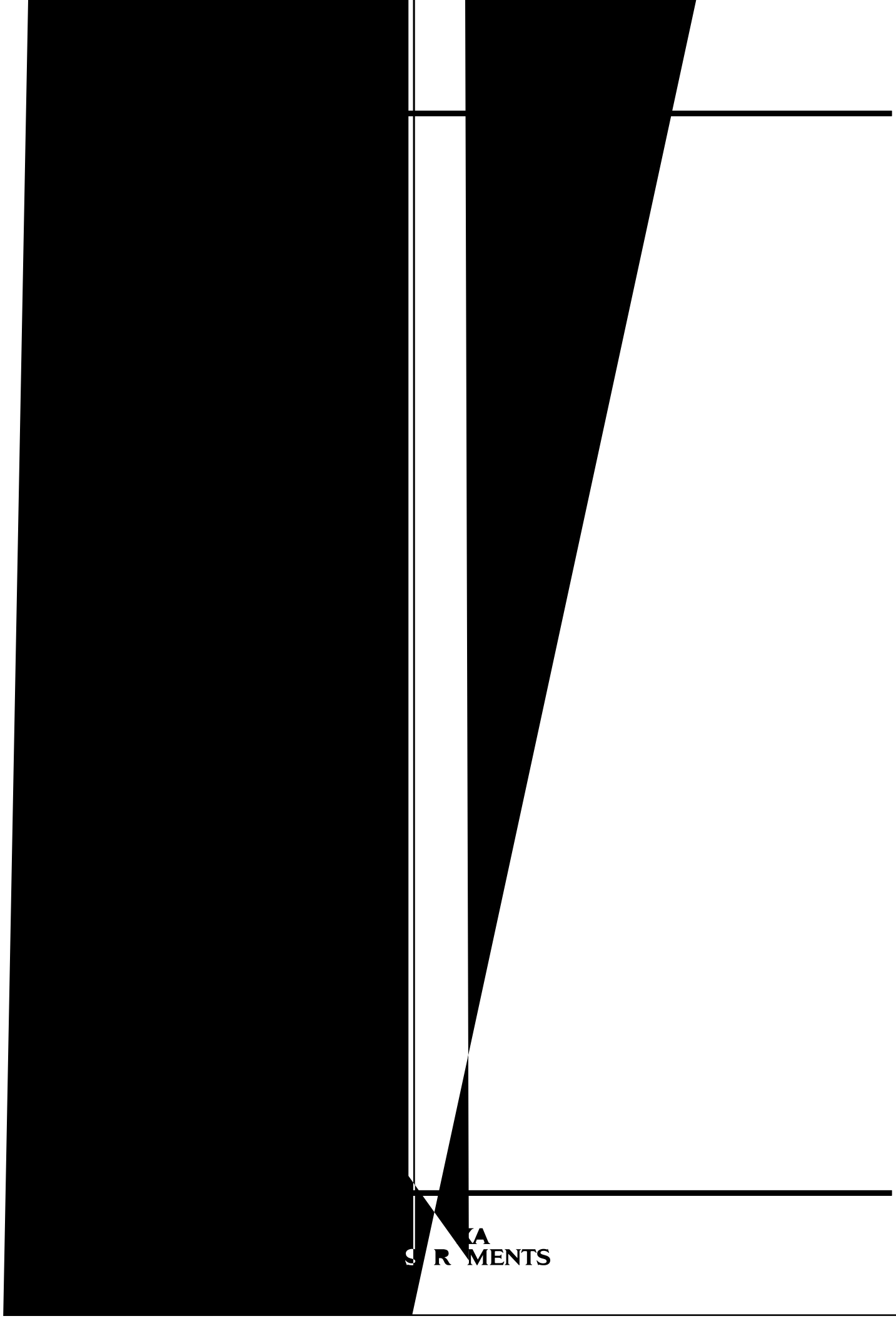
ond ailability, standard warranty, and use in critical applications of d d thereto appears at the end of this data sheet.

Terminal Functions

TERMINAL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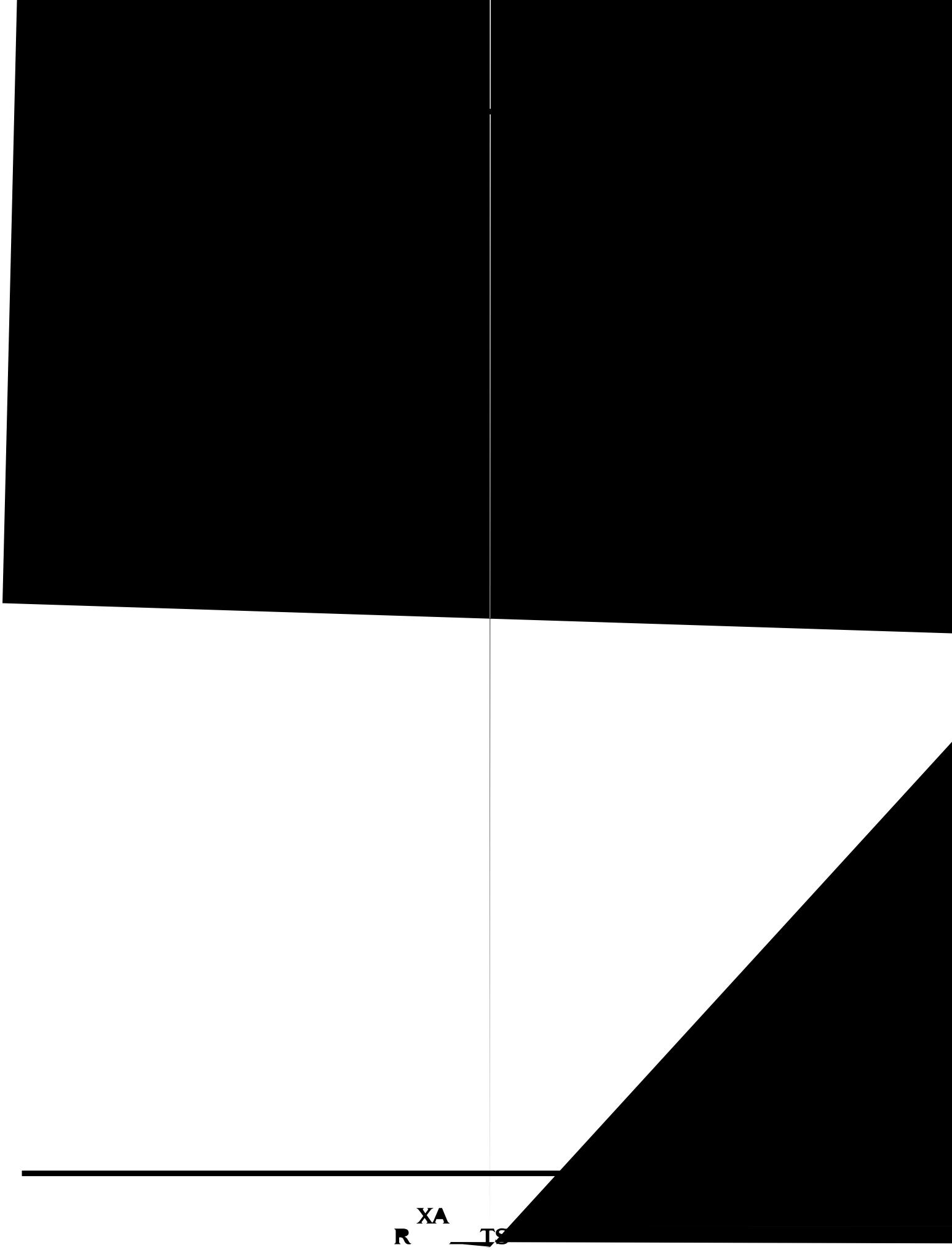

main gas gauge registers (continued)

NAC calibration

The bq2016 sets NAC to 85% of LMD when it detects a transition from fast-charge to a trickle charge provided that 85% ≥ NAC > 80% of LMD when the bq2016 detects the transition. For this determination, fast-charge detection (FCDT) corresponds to the FCDT value set by the PROG pin. Fast-charge detection occurs when the FCDT condition is met for 30s after the CHGS bit is set in FLGS1. Once fast-charge activity is qualified, a transition of the SRC signal below the FCDT threshold enables trickle-charge detection. The bq2016 verifies trickle charge by continuing to sample the SRC input for signals above the trickle-charge threshold and below the fast-charge threshold. This sampling can take up to 3 minutes. Once a trickle-charge is verified, the bq2016 adjusts NAC up to 85% of LMD if NAC was between 80% and 85% of LMD. If NAC was greater then 85% of LMD, NAC is unchanged upon transition detection.

last measured discharge (LMD)

Last measured discharge is the most recent measured discharge capacity of the battery. On initialization, the bq2016 sets LMD = PFC. When a valid charge is detected following a valid discharge, the bq2016 updates LMD with the current value in DCR. During subsequent discharges, the bq2016 updates LMD with the current value in DCR. (The DCR value represents the measured discharge capacity of the battery from full to the EDV threshold.) The bq2016 limits the adjustment of LMD down to 75% of its previous value. A qualified discharge is necessary for a capacity transfer from DCR to the LMD register. The LMD register also serves as the 100% reference threshold used by the display mode.

discharge count register (DCR)

The discharge count register (DCR) is used to update the last measured discharge register only if a complete battery discharge from full to empty occurs without any partial battery charges. In this way, the bq2016 adapts its capacity determination based on the actual conditions of discharge.

The DCR counts up during discharge independent of NAC and can continue to increase after NAC decrements to 0. Before NAC = 0 (empty battery), both discharge and self-discharge increment the DCR. After NAC = 0, only discharge increments the DCR. The DCR resets to 0 when the VDQ bit in the primary status flags register (FLAGS1) is set on charge. The bq2016 sets VDQ=1 on a fast charge-to-trickle detection if NAC is greater than 80% of LMD or when NAC=LMD. The DCR does not roll over but stops counting when it reaches ffffh. The DCR value becomes the new LMD value on the first valid charge after a discharge to EDV threshold if the bq2016 detects a qualified discharge. A valid charge is a minimum of one (maximum of two) NAC increments. A qualified

flag trickle The as if ent the DCT condition is me occu2s if

charge and discharge count counting (continued)

self-discharge estimation

The bq2016 continuously decrements NAC and increments DCR for self-discharge based on time and temperature. The self-discharge count rate is programmed to be a nominal 1/80 × NAC rate per day for NiCd and a nominal 1/60 × NAC for NiMH. This is the rate for a battery whose temperature is between 20°C–30°C. The self-discharge rate doubles every 10°C increase in temperature.

count compensations

The bq2016 compensates charge and discharge counting for temperature and rate before updating the NAC and/or DCR. The bq2016 compensates self-discharge estimation for temperature before updating the NAC or DCR.

charge compensations

The bq2016 compensates for charge efficiencies at a quick-charge and fast-charge rate at two different temperature thresholds. The bq2016 applies the NiCd or NiMH factors based on the VPFC setting. For charge compensation, quick charge is defined as a C/5 charge rate or less and fast charge is defined as a rate greater than C/5.

The charge-compensation factors are shown in Tables 4 and 5.

charge compensations

Table 4. Charge Compensation for NiCd

CHARGE TEMPERATURE	QUICK CHARGE (≤ C / 5) COMPENSATION	FAST CHARGE (> C / 5) COMPENSATION
<40C	0.80	0.95
≥ 40	0.75	0.90

Table 5. Charge Compensation for NiMH

CHARGE TEMPERATURE	QUICK CHARGE (≤ C / 5) COMPENSATION	FAST CHARGE (> C / 5) COMPENSATION
<40C	0.80	0.90
≥ 40	0.75	0.85

discharge compensation

The bq2016 corrects for the rate of discharge by adjusting an internal discharge-compensation factor. The

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initialization

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registers (continued)

MCV

The bq2016 sets the MCV bit when it detects that the maximum cell voltage threshold is being exceeded.

Bit =	Condition
0	Cell voltage is below the threshold.
1	Cell voltage is above the threshold.

CI

The bq2016 sets the CI bit on reset and when the CPI register exceeds 64.

Bit =	Condition
0	An LMD update has occurred.
1	The bq2016 has been reset or the CPI register exceeds 64.

VDQ

The bq2016 sets the VDQ bit when the present discharge cycle is considered valid for an LMD update.

Bit =	Condition
0	The present discharge cycle is not valid for an LMD update.
1	The present discharge cycle is valid for an LMD update.

Bit 2 is reserved.

EDV

The bq2016 sets the EDV bit when the battery voltage drops below the EDV threshold. The bit is latched and remains set until valid charge activity is detected.

Bit =	Condition
0	The battery voltage is greater than the EDV threshold.
1	The battery voltage is less than the EDV threshold.

OCE

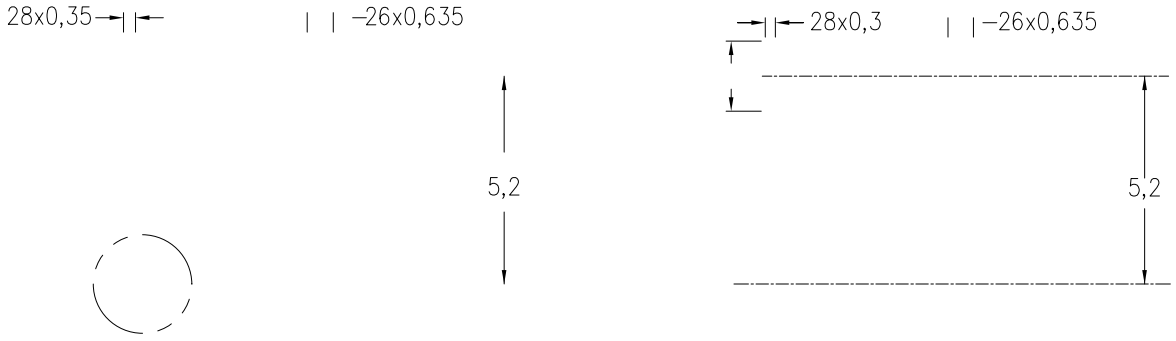
The bq2016 sets the OCE bit when an VFC offset calibration has been performed.

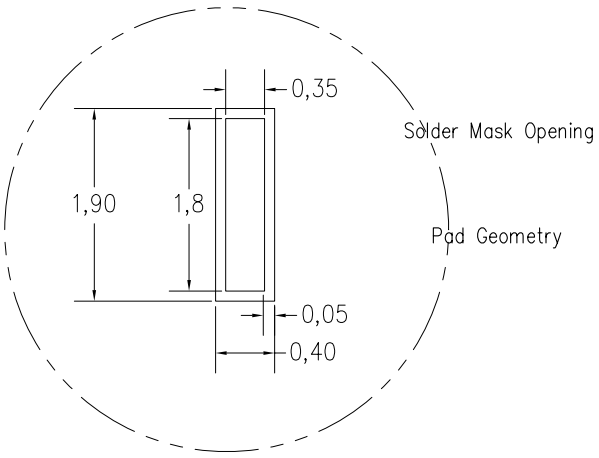
Bit =	Condition
0	Offset calibration not completed
1	Offset calibration completed

TEMP (0x02) – Temperature

The TEMP register contains the battery temperature as computed using the internal temperature sensor of the

DBQ (R–PDSO–G28)





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