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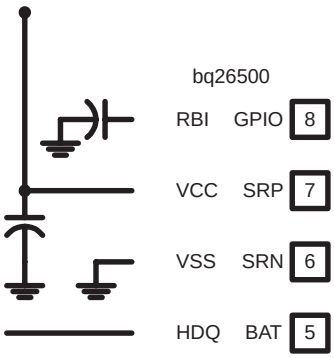

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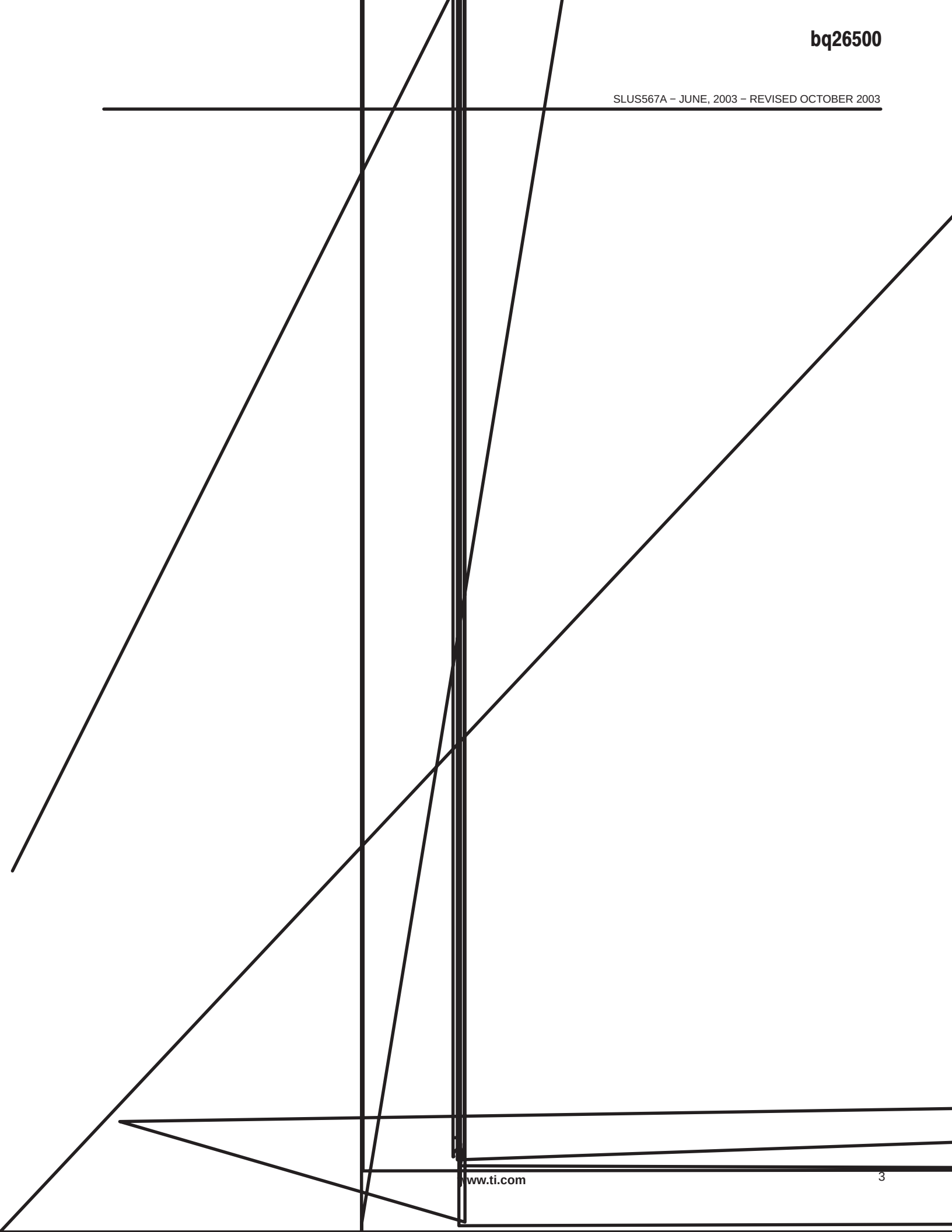
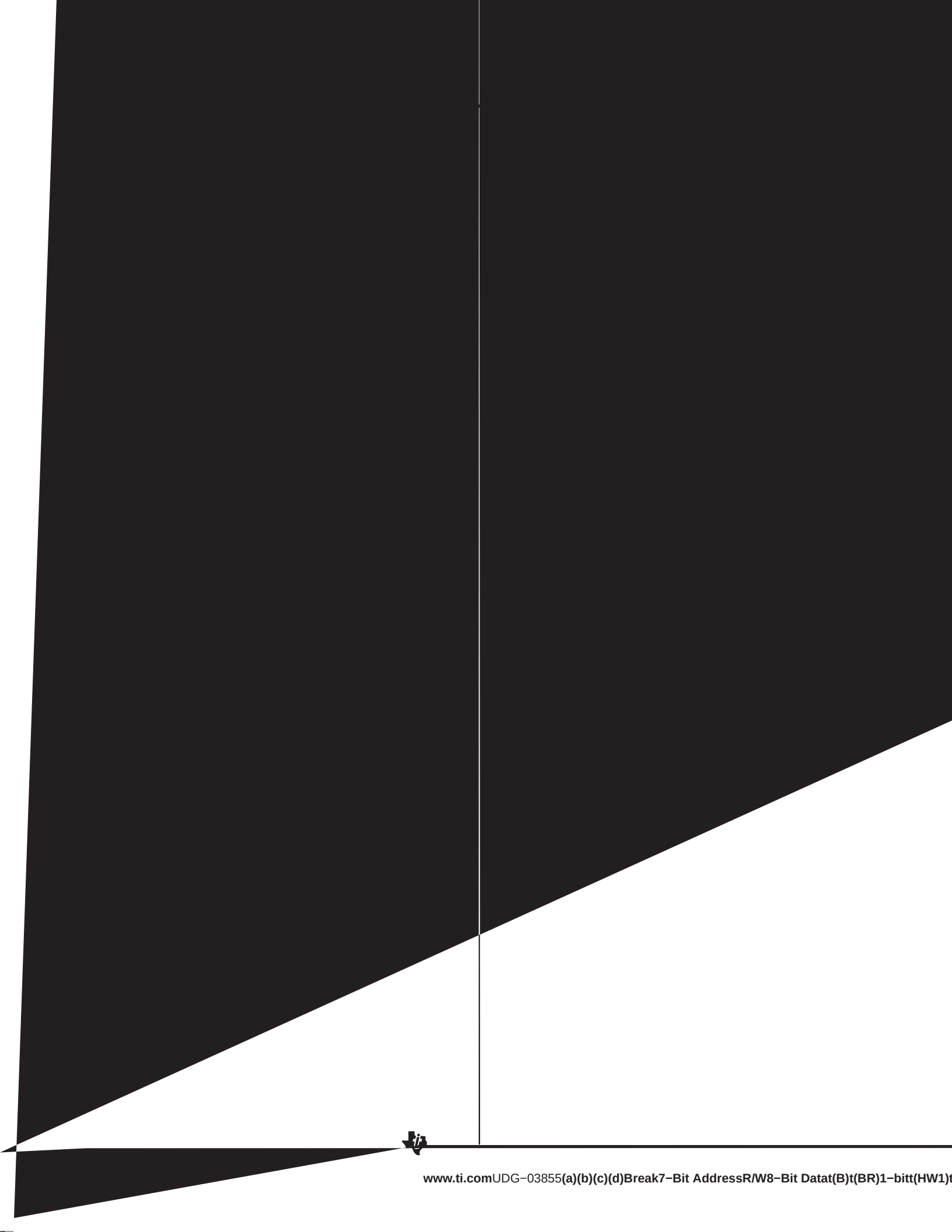




APPLICATION INFORMATION

FUNCTIONAL DESCRIPTION

The bq26500 determines battery capacity by monitoring the amount of charge input to or removed from a Li-Ion or Li-Pol battery. The bq26500 measures discharge and charge currents, monitors the battery for low voltage thresholds, and compensates for temperature and self-discharge rate. Current is measured across a small value series resistor between the negative terminal of the battery and the pack ground (see R_S in Figure 2). Available capacity is reported with a resolution of $0.003/R_S$(mAh). Time-to-empty (TTE) reporting in minutes at host-provided at-rate currents allow the requirements for host based calculations to be greatly reduced or eliminated; reading a single register pair provides useful and meaningful information to the application's end user.

Figure 2 shows a typical application circuit. Differential sense of the voltage across the current sense resistor, R_S, improves device performance, leading to an improvement in reported time-to-empty accuracy. In the typical application, the GPIO pin can be used as a general-purpose programmable I/O port. An internal pull-down on the HDQ line ensures that the device detects a logic "0" on the HDQ line and automatically enters the low power sleep mode when the system power is switched off or the pack is removed. A 100-kΩ pull-up to V_{CC} can be added to the HDQ line to disable this feature. The bq26500 can operate directly from a single Li-Ion or Li-Pol cell.

Measurements

As shown in the Figure 3, the bq26500 uses a fully differential, dynamically balanced voltage-to-frequency converter (VFC) for charge and discharge counting and an analog-to-digital converter (ADC) for battery voltage and temperature measurement. Both VFC and ADC are automatically compensated for offset. No user calibration or compensation is required.

Charge and Discharge Counting

The bq26500 uses a voltage-to-frequency converter (VFC) to perform a continuous integration of the voltage waveform across a small value sense resistor in the negative lead of the battery, as shown in Figure 2. The integration of the voltage across the sense resistor is the charge added or removed from the battery. Since the VFC directly integrates the waveform, the shape of the current waveform through the sense resistor has no effect on the measurement accuracy. The low-pass filter that feeds the sense resistor voltage to the bq26500 SRP and SRN inputs serves to filter out system noise and does not affect the measurement accuracy, since the low-pass filter does not change the integrated value of the waveform.

Offset Calibration

The offset voltage of the VFC measurement must be very low to be able to measure small signal levels accurately. The bq26500 provides an auto-compensation feature to cancel the internal voltage offset error across SRP and SRN for maximum charge measurement accuracy.

> **NOTE:NO CALIBRATION IS REQUIRED**. See the *Layout Considerations* section for details on minimizing PCB induced offset across the SRP and SRN pins.

APPLICATION INFORMATION

Gas Gauge Operation

Figure 4 illustrates an operational overview of the gas gauge function.

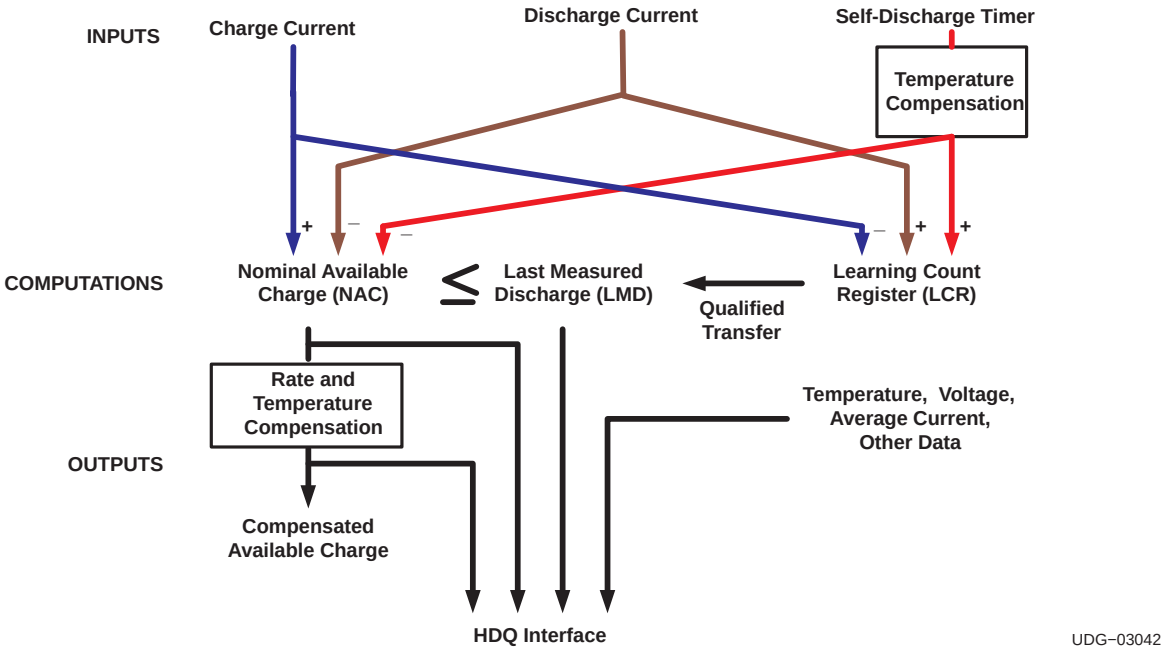


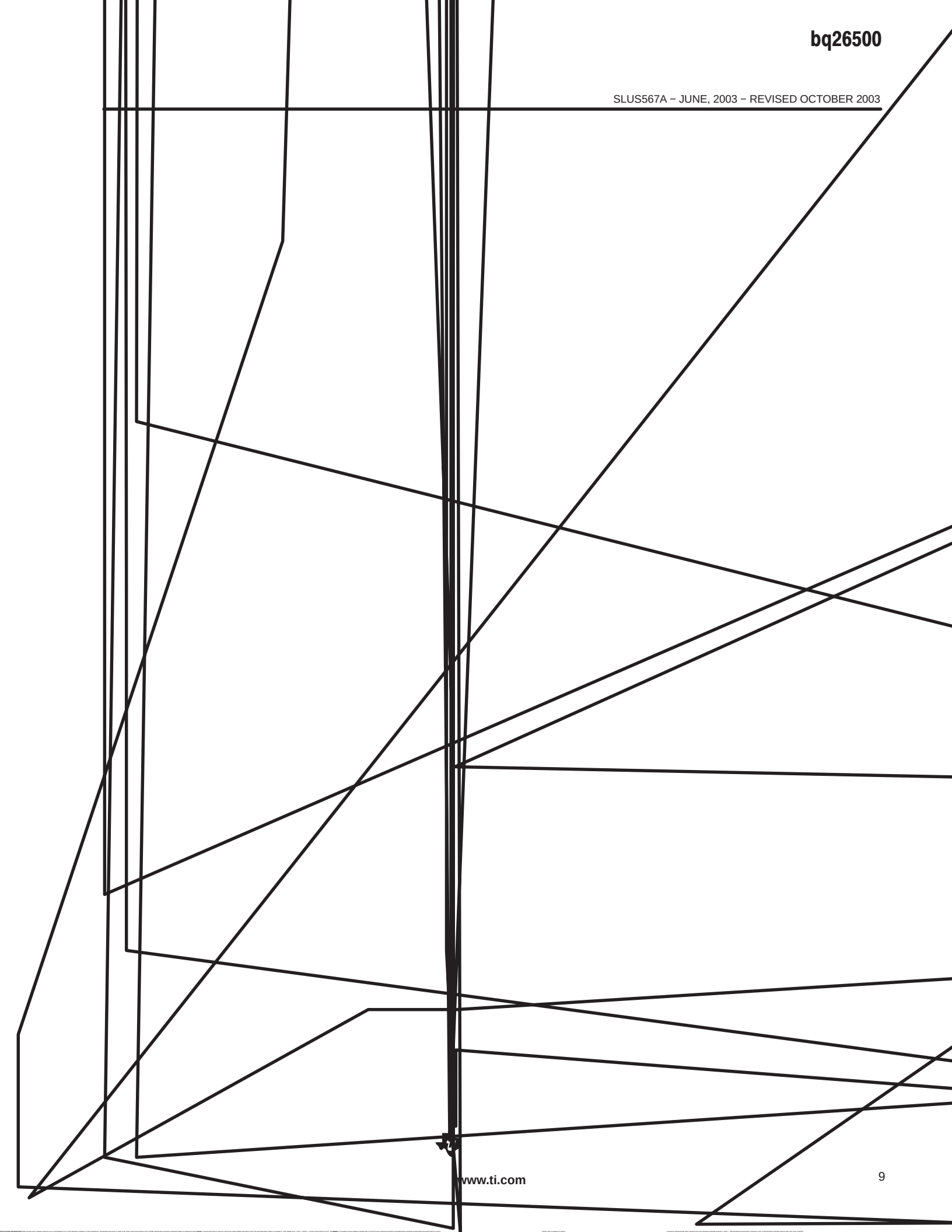
Figure 4. Operational Overview

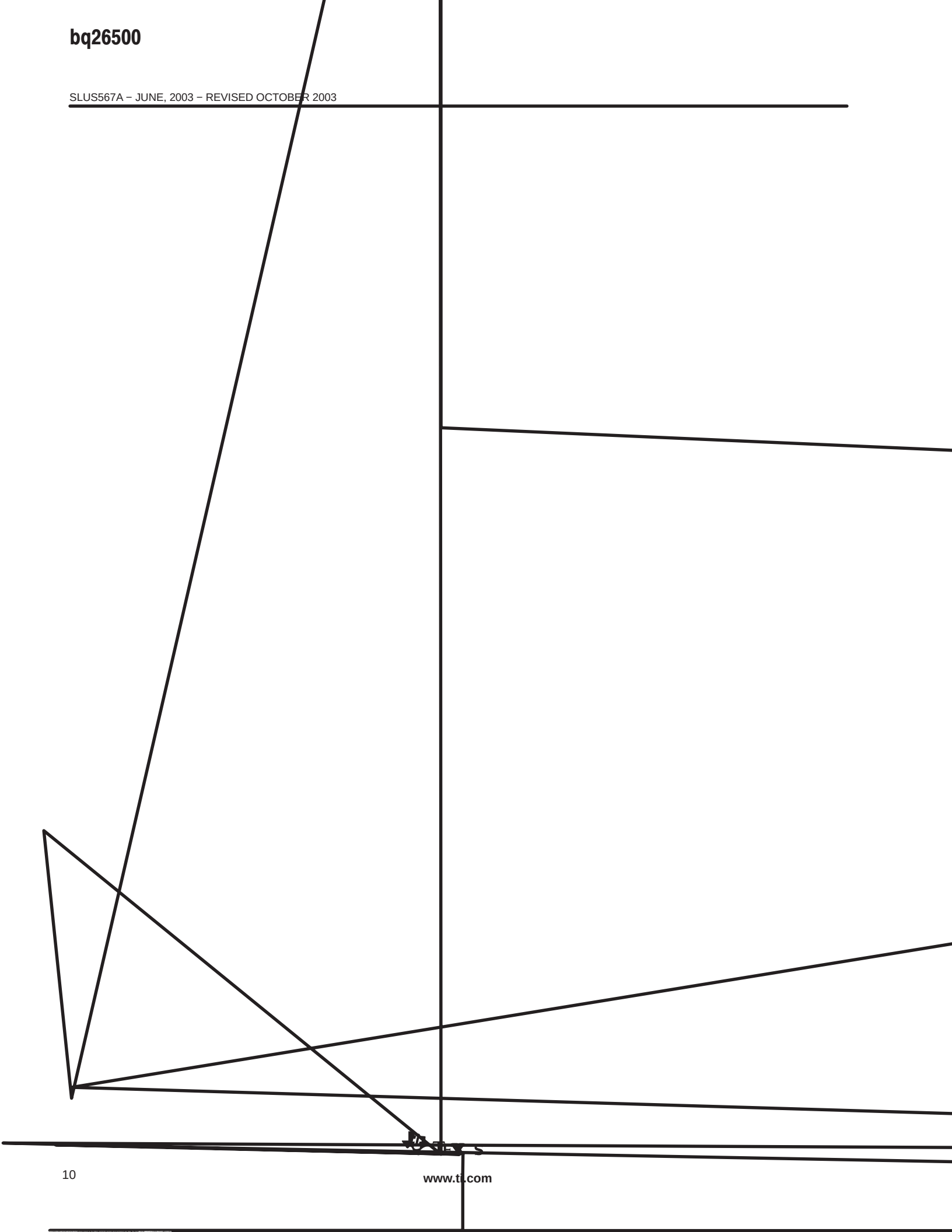
The bq26500 measures the capacity of the battery during actual use conditions and updates the last measured discharge (LMD) register with the latest measured value. The bq26500 retains the learned LMD value unless a full reset occurs. By measuring the capacity that the battery delivers as it is discharged from full to the EDV1 threshold without any disqualifying events, the bq26500 learns the capacity of the battery. During normal use conditions, the bq26500 should learn a new capacity only after a full discharge. Learning cycles are disqualified by several abnormal conditions (see list at end of section). In the event that a learning cycle occurs with a significant reduction in learned capacity, the new LMD value is restricted to a maximum LMD reduction during any single learning discharge of LMD/8. The capacity inaccurate (CI) bit in FLAGS is cleared after the first learning cycle. This bit remains cleared unless a full reset occurs.

The battery-full condition is defined as nominal available capacity (NAC) = LMD. The valid discharge flag (VDQ) in the FLAGS register is set when this condition occurs and remains set until the learning discharge cycle completes or an event occurs that disqualifies the learning cycle.

The learning discharge cycle completes when the battery is discharged to the condition where VOLT ≤ EDV1 threshold. The EDV1 threshold should be set at a voltage that guarantees at least 6.25% of battery capacity below that threshold. The EDVF threshold should be set at a voltage that the system sees as the zero capacity battery voltage.

The bq26500 does not learn the capacity between EDV1 and EDVF thresholds, but assumes that the capacity is 6.25% of LMD, so care should be taken to set EDV1 based on the characteristics of the battery. The measured LMD value is determined by measuring the capacity delivered from the battery from NAC=LMD until VOLT ≤ EDV1, plus LMD/16 to account for the 6.25% capacity remaining below the EDV1 threshold.





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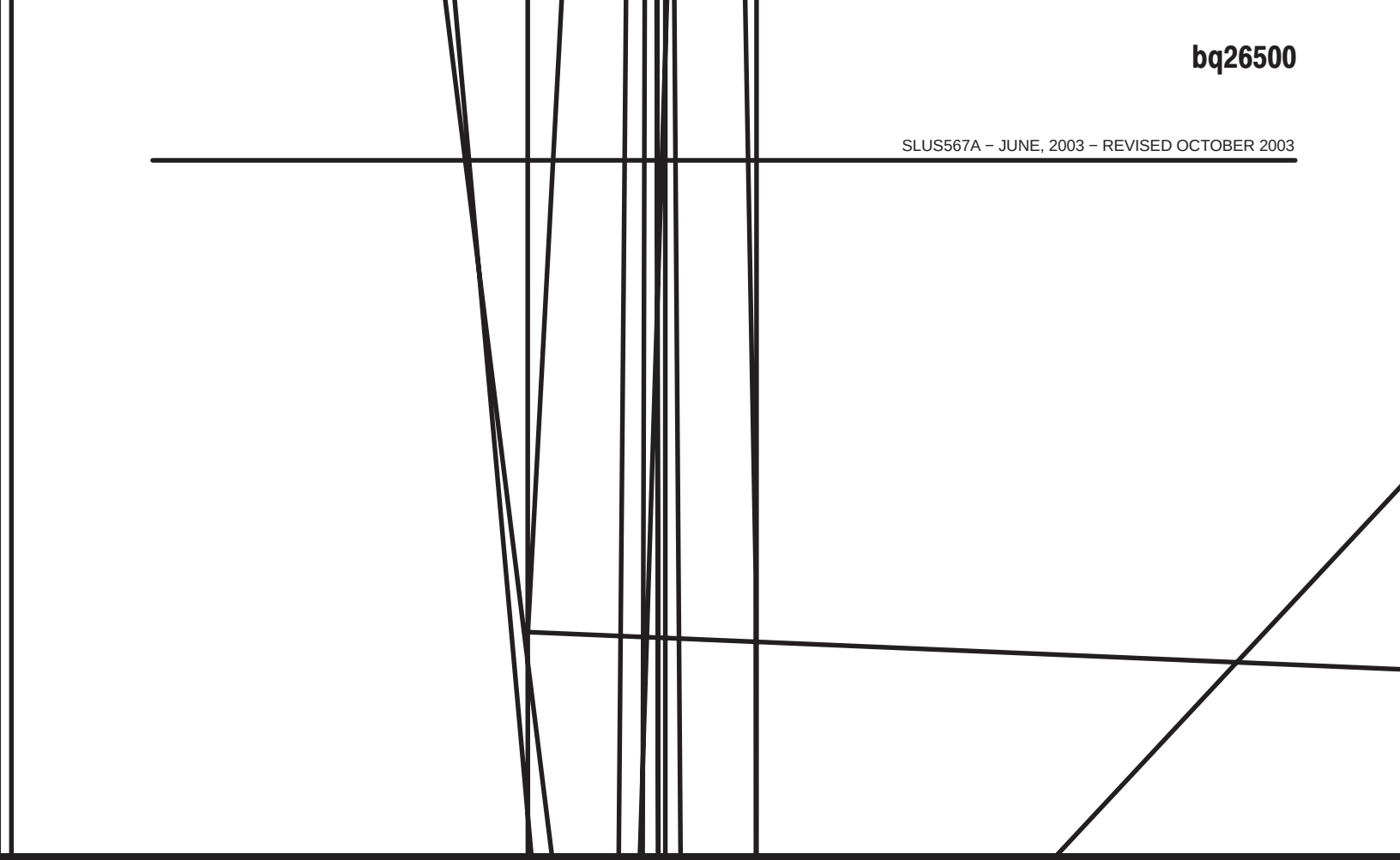


APPLICATION INFORMATION

Reserved Registers

The addresses 0x14 – 0x6D and addresses 0x6F – 0x75 are reserved and cannot be written by the host.

EEPROM Enable Register (EE_EN) – Address 0x6E

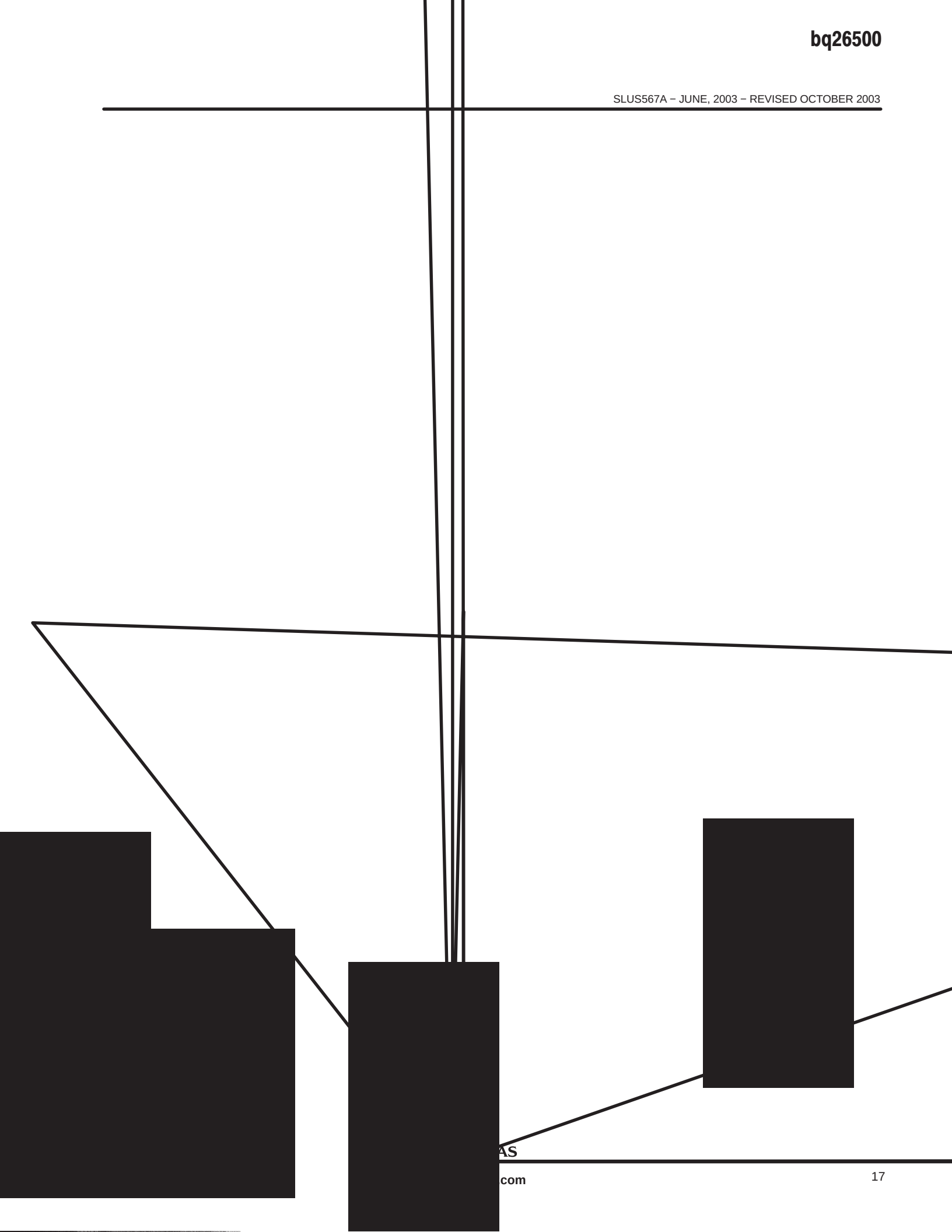
Register used to enable host writes to EEPROM data locations (addresses 0x76 – 0x7F). Host must write data 0xDD to this register to enable EEPROM programming. See the *Programming the EEPROM* section for further information on programming the EEPROM bytes.

EEPROM Data Registers (EE_DATA) – Address 0x76 – 0x7F

The EEPROM data registers contain information vital to the performance of the device. These registers are to be programmed during pack manufacturing to allow flexibility in the design values of the battery to be monitored. The EEPROM data registers are listed in Table 2. Detailed descriptions of what should be programmed follows. See *Programming the EEPROM* for detailed information on writing the values to EEPROM.

Table 2. bq26500 EEPROM Memory Map

ADDRESS	NAME	FUNCTION
0x7F	TCOMP	Temperature compensation constants, ***OR***, ID#1
0x7E	DCOMP	Discharge rate compensation constants, ***OR***, ID#2
0x7D	ID3	ID#3
0x7C	PKCFG	Pack configuration values
0x7B	TAPER	Charge termination taper current
0x7A	DMFSD	Digital magnitude filter and self-discharge rate constants
0x79	ISLC	Initial standby load current
0x78	SEDV1	Scaled EDV1 threshold
0x77	SEDVF	Scaled EDVF threshold
0x76	ILMD	Initial last measured discharge high byte



APPLICATION INFORMATION

Pack Configuration (PKCFG) − Address 0x7C

	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0
NAME	GPIEN	QV1	QV0	RSVD	RSVD	RSVD	DCFIX	TCFIX

PKCFG REGISTER	DESCRIPTION
GPIEN	Allows the pack manufacturer to set the state of the GPIO pin on initial power up. If the bit is “0”, the GPIEN bit is cleared on reset and the GPIO pin acts as a high impedance output. If the bit is “1”, the GPIEN bit is set on reset and the GPIO pin acts as an input. The state of the GPIO pin can then be read through the GPSTAT bit in the MODE register.
QV1	These bits set the end voltage for charge termination. The terminating voltage is set as shown in Table 3.
QV2	
RSVD	

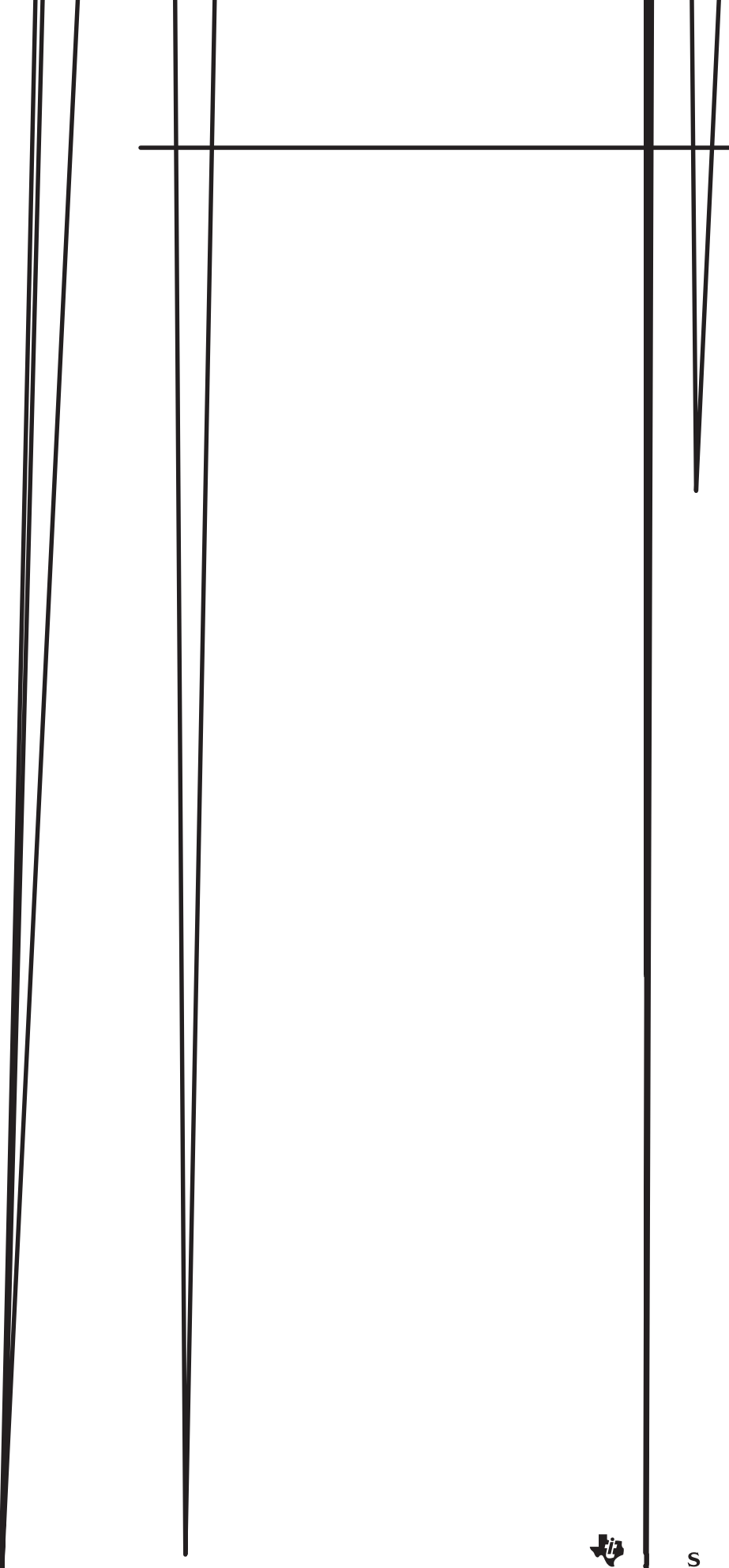
APPLICATION INFORMATION

Identification Byte #3 (ID3) − Address 0x7D

This register may be programmed to any desired value.The contents do not affect the operation of the bq26500.

Discharge Rate Compensation Constants (DCOMP) or ID2 − Address 0x7E

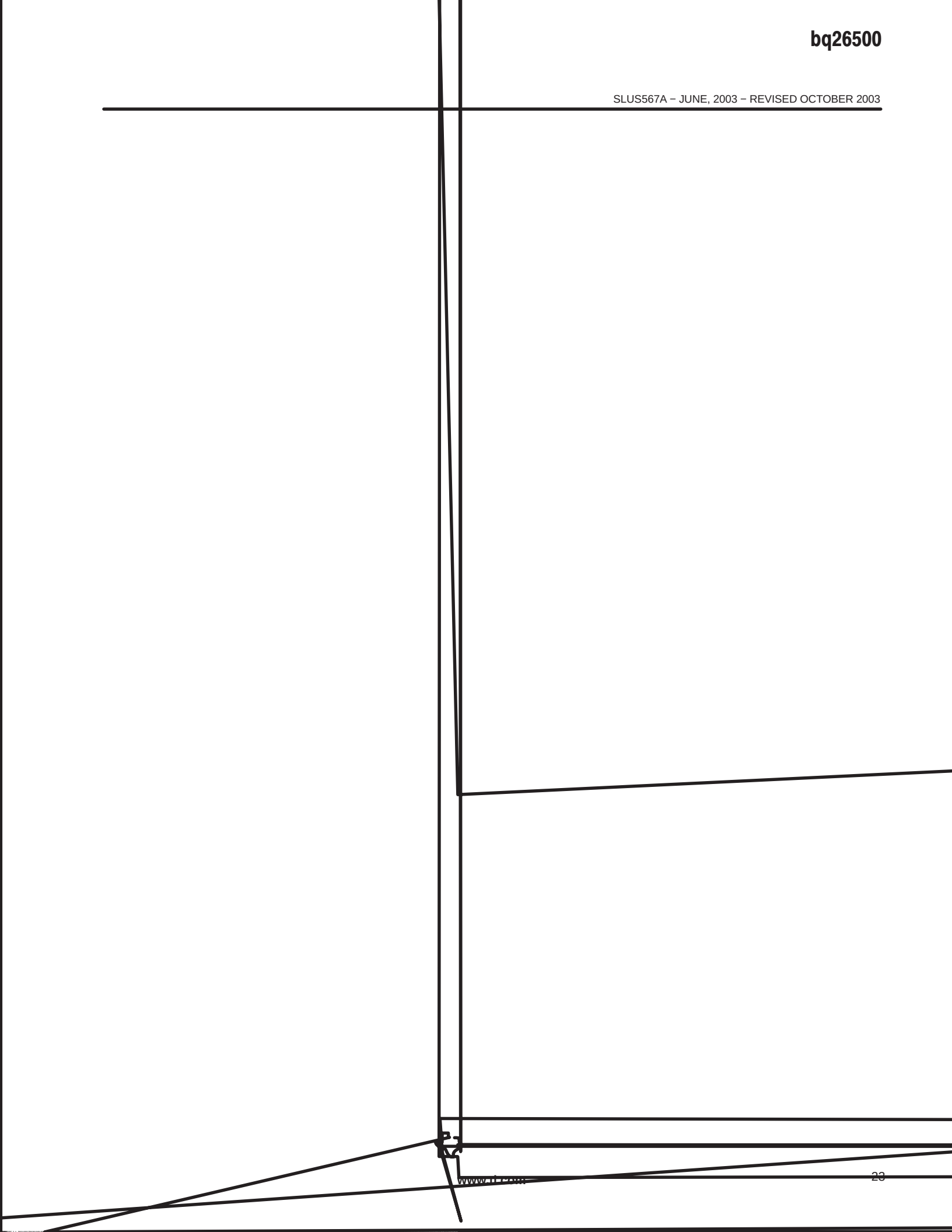
This register is used to set the compensation coefficients for discharge rate. These coefficients are applied to

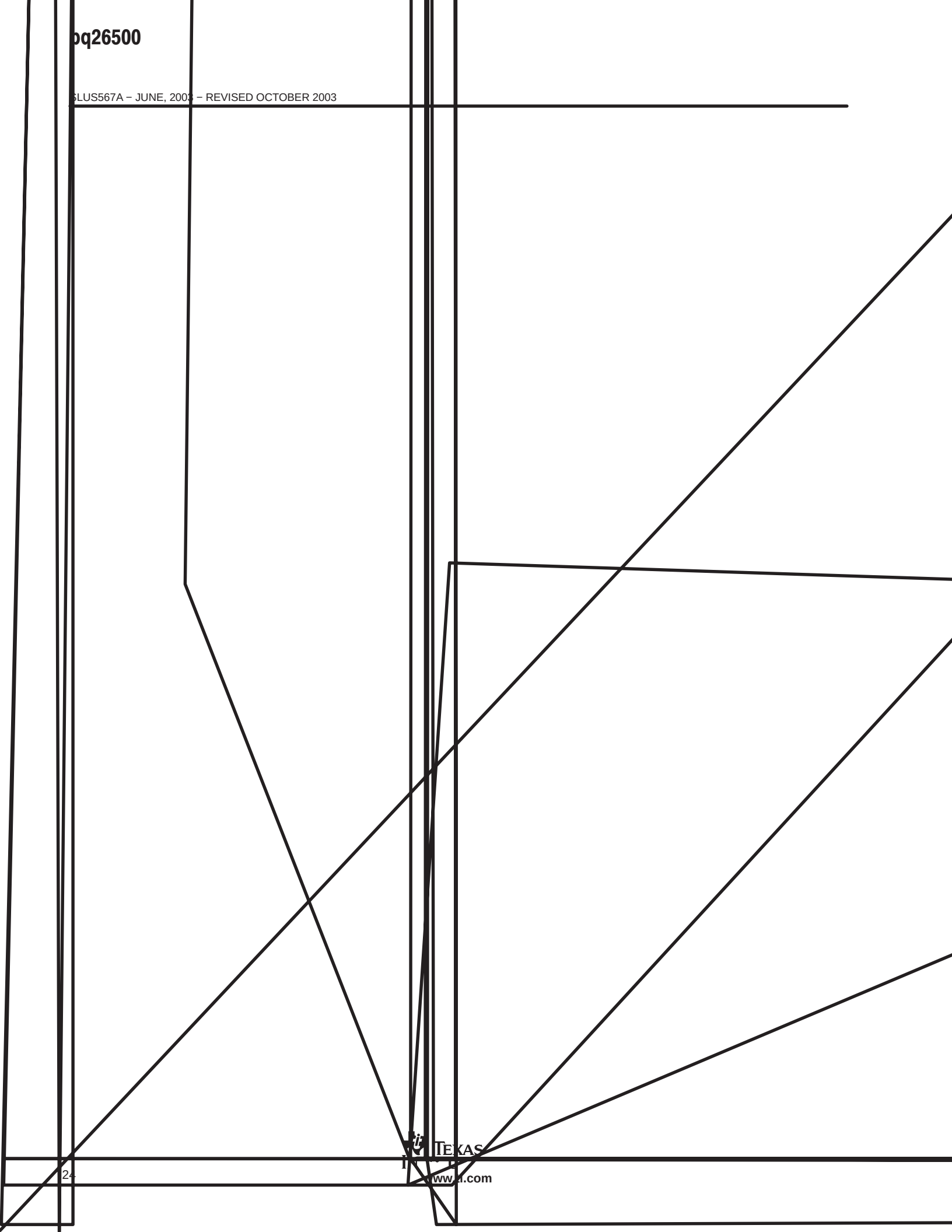


APPLICATION INFORMATION

Active Mode

During normal operation, the device is in active mode, which corresponds to the highest power consumption. Normal gas gauging is performed in this mode. If system requirements mandate that bq26500 should not enter sleep or ship modes then an external pull-up resistor between V_{CC} and HDQ is required on the bq26500 side





PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
BQ26500PW	ACTIVE	TSSOP	PW	8	100	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ26500PWG4	ACTIVE	TSSOP	PW	8	100	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ26500PWR	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
BQ26500PWRG4	ACTIVE	TSSOP	PW	8	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

(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) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

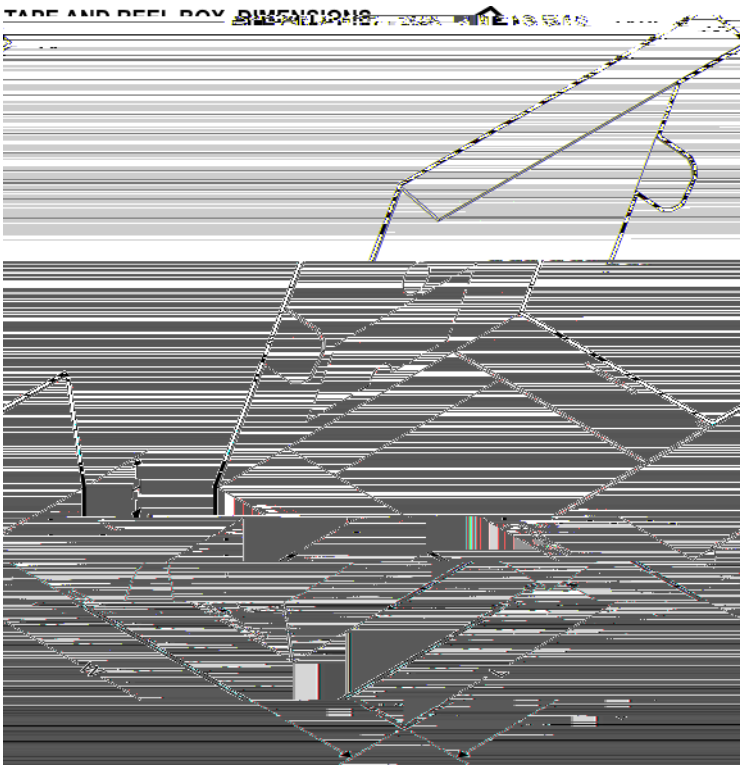
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

TAPE AND REEL INFORMATION

*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
BQ26500PWR	TSSOP	PW	8	2000	330.0	12.4	7.0	3.6	1.6	8.0	12.0	Q1

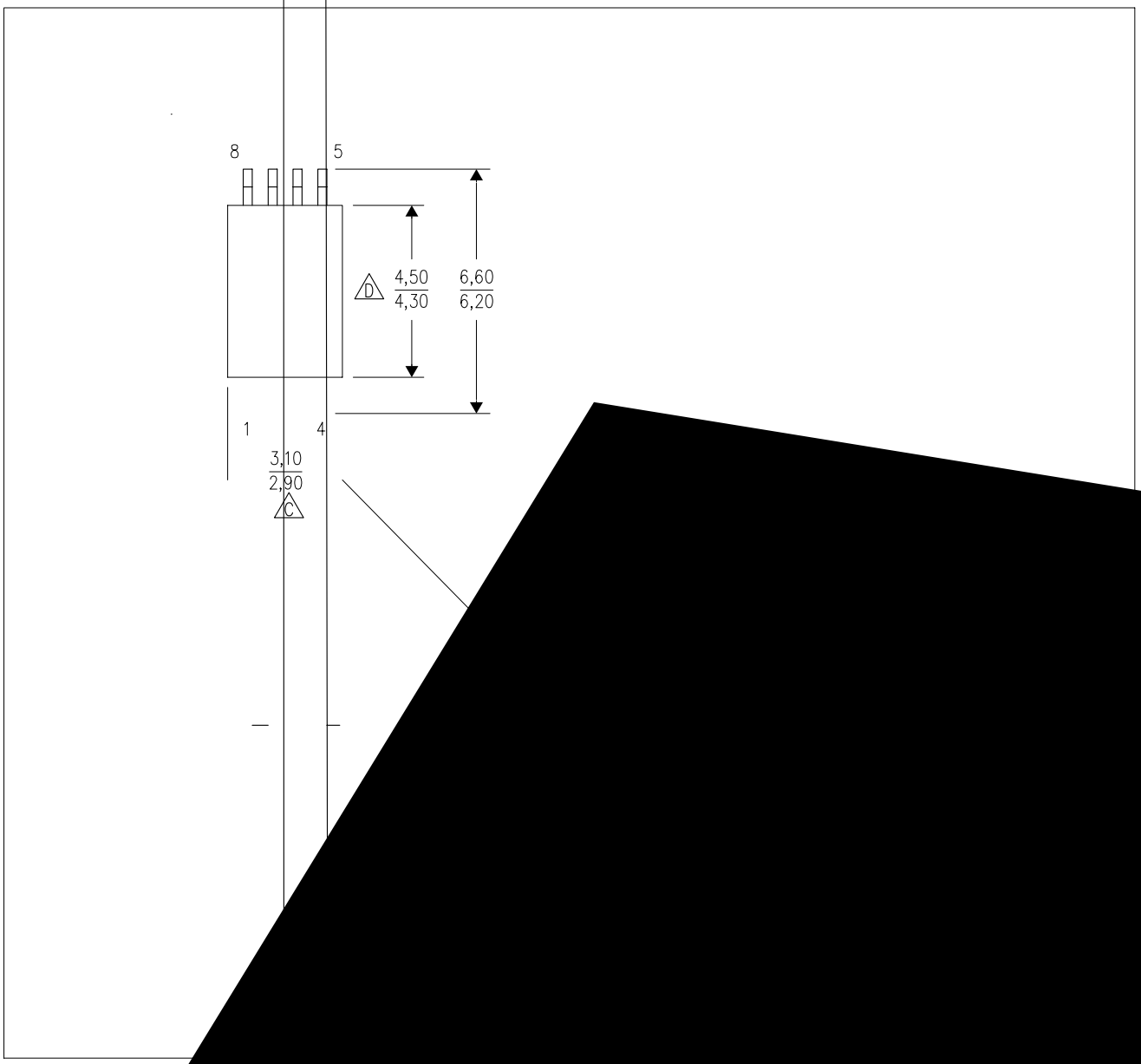
PACKAGE MATERIALS INFORMATION



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
BQ26500PWR	TSSOP	PW	8	2000	367.0	367.0	35.0

PW (R–PDSO–G8) PLASTIC SMALL OUTLINE



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