BATTERY PACK SECURITY AND AUTHENTICATION IC FOR PORTABLE APPLICATIONS (bqSECURE™)

Check for Samples: bq26150

FEATURES

- **Provides Authentication of Battery Packs Through a Programmable CRC With a 96-bit Unique Device ID**
- **16 Bytes of User-Programmable Nonvolatile Memory**
- **12.5 KV IEC ESD Protection on HDQ Input**
- **Internal Time-Base Eliminates External Crystal Oscillator**
- **Low-Power Operating: <30 µA**
- **Single-Wire HDQ Interface**
- **Powered Directly From the Communication Bus**
- **Pass-Through HDQ Version Supports Existing Packs With Gas Gauges**
- **Small 5-Pin SC 70 package**

APPLICATIONS

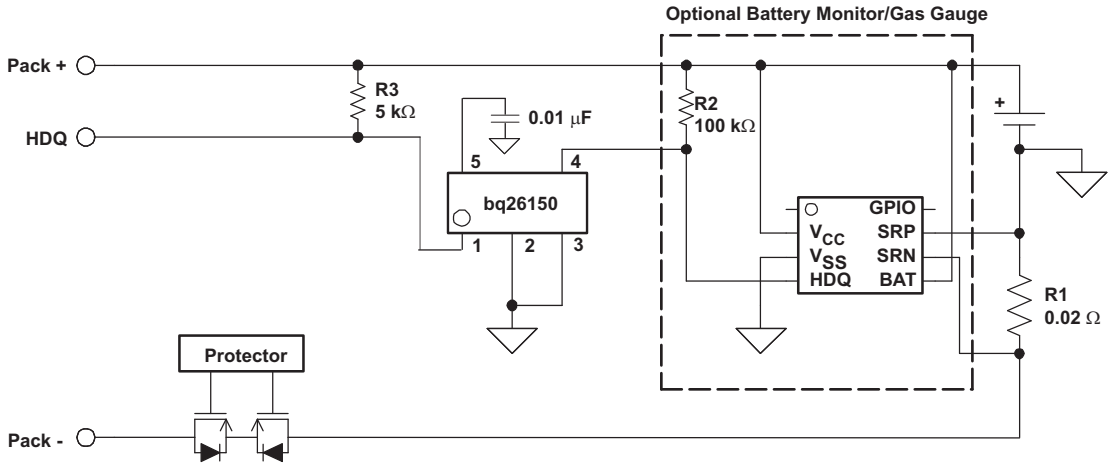
- **Cellular Phones**
- **PDA and Smart Phones**
- **MP3 Players**
- **Digital Cameras**
- **Internet Appliances**
- **Handheld Devices**

DESCRIPTION

The bq26150 provides a method to authenticate battery packs, ensuring that only packs manufactured by authorized sub-contractors are used in the end application. The bq26150 uses a 96-bit unique device ID, device unique 16-bit seed, and a 16-bit device specific CRC to provide security. The device ID, CRC seed, and CRC polynomial coefficients are stored securely in each bq26150 device, allowing the host to authenticate each pack.

The bq26150 communicates to the system over a simple one-wire, bidirectional serial interface. The 5 kbits/s HDQ bus interfaces reduces communications overhead in the external microcontroller. The bq26150 also uses the HDQ bus to charge an external capacitor that provides power to the bq26150.

TYPICAL APPLICATION



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

bqSECURE is a trademark of Texas Instruments.

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

AVAILABLE OPTIONS

T_A	PACKAGE	PART NUMBER
–20°C to 70°C	5-Lead SC 70	bq26150

ABSOLUTE MAXIMUM RATINGS(1)

		UNIT
V_{SS}	Supply voltage (HDQ with respect to V_{SS})	–0.3 V to 7.7 V
V_I	Input voltage (HDQP with respect to V_{SS})	–0.3 V to 7 V
I_O	Output current (HDQ and HDQP)	5 mA
T_A	Operating free-air temperature range	–20°C to 70°C
T_{stg}	Storage temperature range	–65°C to 150°C
T_J	Junction temperature range	–40°C to 125°C

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

		MIN	NOM	MAX	UNIT
	Supply voltage, HDQ pull-up	2.5		5	V
T_J	Operating free-air temperature range	–20		70	°C

ELECTRICAL CHARACTERISTICS

All parameters over recommended operating temperature and supply voltage range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
C_I	Input capacitance	HDQ		400		pF
t_{d1}	Power up communication delay	Power capacitor charge time		100		ms
I_{CC}	V_{CC} current	$V_{CC} > V_{CC(min)}$		20	30	µA
$V_{(POR)}$	POR threshold	Low-to-high			1.5	V
	Nonvolatile memory programming voltage		7.0		7.7	V
	Nonvolatile memory programming supply current	–40°C tjeVprogrammj 7.3 Td (7.0)Tj ET BT /F2 24.6 Td				

STANDARD SERIAL COMMUNICATION (HDQ) TIMING

over recommended operating temperature and supply voltage range (unless otherwise noted) See Figure 1

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	Power up delay	Power capacitor charge time		100		ms
$t_{(B)}$	Break timing		190			µs
$t_{(BR)}$	Break recovery		40			µs
$t_{(CYCH)}$	Host bit window		190			µs
$t_{(HW1)}$	Host sends 1		0.5		50	µs
$t_{(HW0)}$	Host sends 0		86		145	µs
$t_{(RSPS)}$	bq26150 to host response		190		320	µs
$t_{(CYCD)}$	bq26150 bit window		190		250	µs
$t_{(DW1)}$	bq26150 sends 1		32		50	µs
$t_{(DW0)}$	bq26150 sends 0		80		145	µs

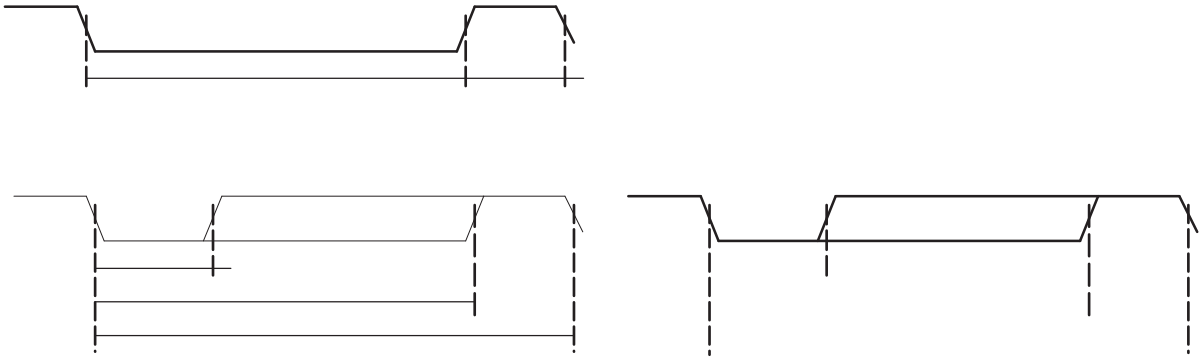
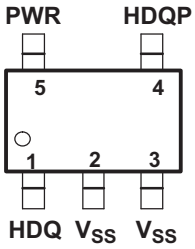


Figure 1. HDQ Bit Timing Diagrams

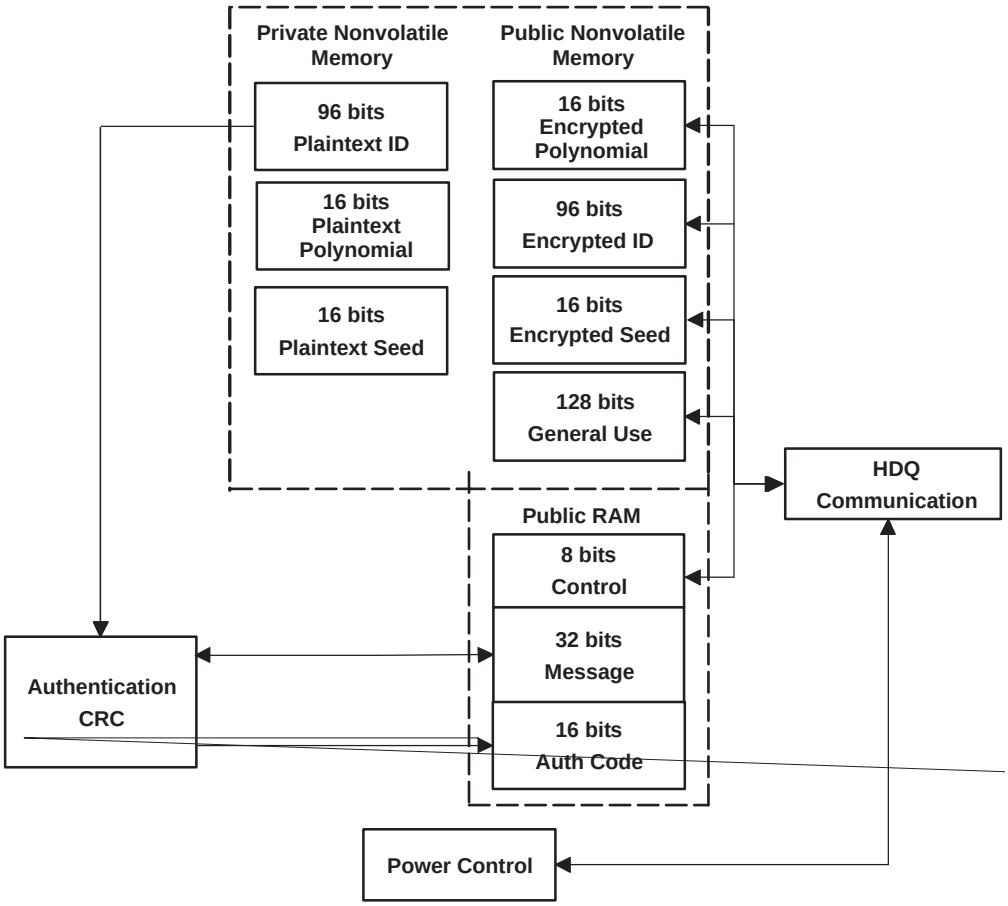
PIN ASSIGNMENT



TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
HDQ	1	I/O	Single-wire HDQ interface to host
VSS	2, 3	I	Ground
HDQP	4	I/O	Single-wire HDQ interface to 2nd HDQ device
PWR	5	I/O	Power capacitor

FUNCTIONAL BLOCK DIAGRAM



APPLICATION INFORMATION

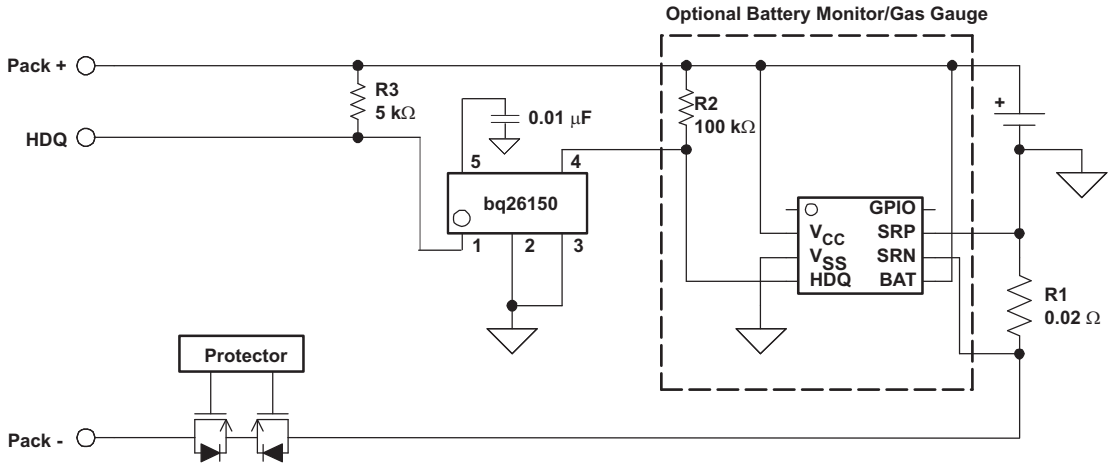


Figure 2. Typical Application Circuit

FUNCTIONAL DESCRIPTION

The bq26150 provides a simple and cost effective method to authenticate battery packs for end equipment. Security is achieved through the use of a 16-bit CRC, a 16-bit CRC seed, a 96-bit device ID, and a 32-bit random challenge. The CRC polynomial, CRC seed, and 96-bit ID are unique from device to device, and are stored as encrypted text in public memory, and as plain text in private memory. The host system can decrypt the polynomial, seed, and ID values using a shared key that is stored in end-equipments memory. The encryption method and shared key used to store the polynomial coefficients and the device ID can be selected by the manufacturer. *Contact TI for information regarding specifics for encryption of the device ID and CRC polynomial coefficients*.

To authenticate a battery pack, the host reads the encrypted device ID, polynomial, and seed values. It decrypts those values, then generates a 32-bit random challenge, which is transmitted to the bq26150. The bq26150 uses the plain-text version of the polynomial coefficients and device ID, along with the 32-bit random challenge from the host, to calculate the authentication CRC value. The host uses the polynomial coefficients, seed, and device ID that it decrypted, along with the 32-bit random challenge it sent to the bq26150, to calculate the authentication CRC value. When the host and bq26150 have completed the calculations, the host can read the authentication CRC value the bq26150 computed and compare to its own value. If the values match, the battery pack is authenticated.

The bq26150 has a communication pass-through mode that allows it to be used in systems with an existing HDQ based battery monitor or gas gauge. Once the battery pack is authenticated, the bq26150 can be put in continuous pass-through mode, allowing the host system to communicate with a second HDQ device with no additional overhead. A one-time pass-through mode is also available, allowing the host to communicate once to the second HDQ device as needed.

The bq26150 obtains the power needed to run from the HDQ bus. An external capacitor is charged when the bus is high and discharges while the bus is low. If the bq26150 is not authenticating or communicating and the HDQ bus is low, the power is reduced and it enters sleep mode. If the bus is held low until the capacitor fully discharges, the bq26150 is disabled.

Register Interface

Table 1. Memory

flag to the host system that the message/authentication registers contain the calculated CRC value. The bit is automatically cleared when the AUTH bit is set.

AUTH Writing this bit to **1** initiates the CRC calculation. The

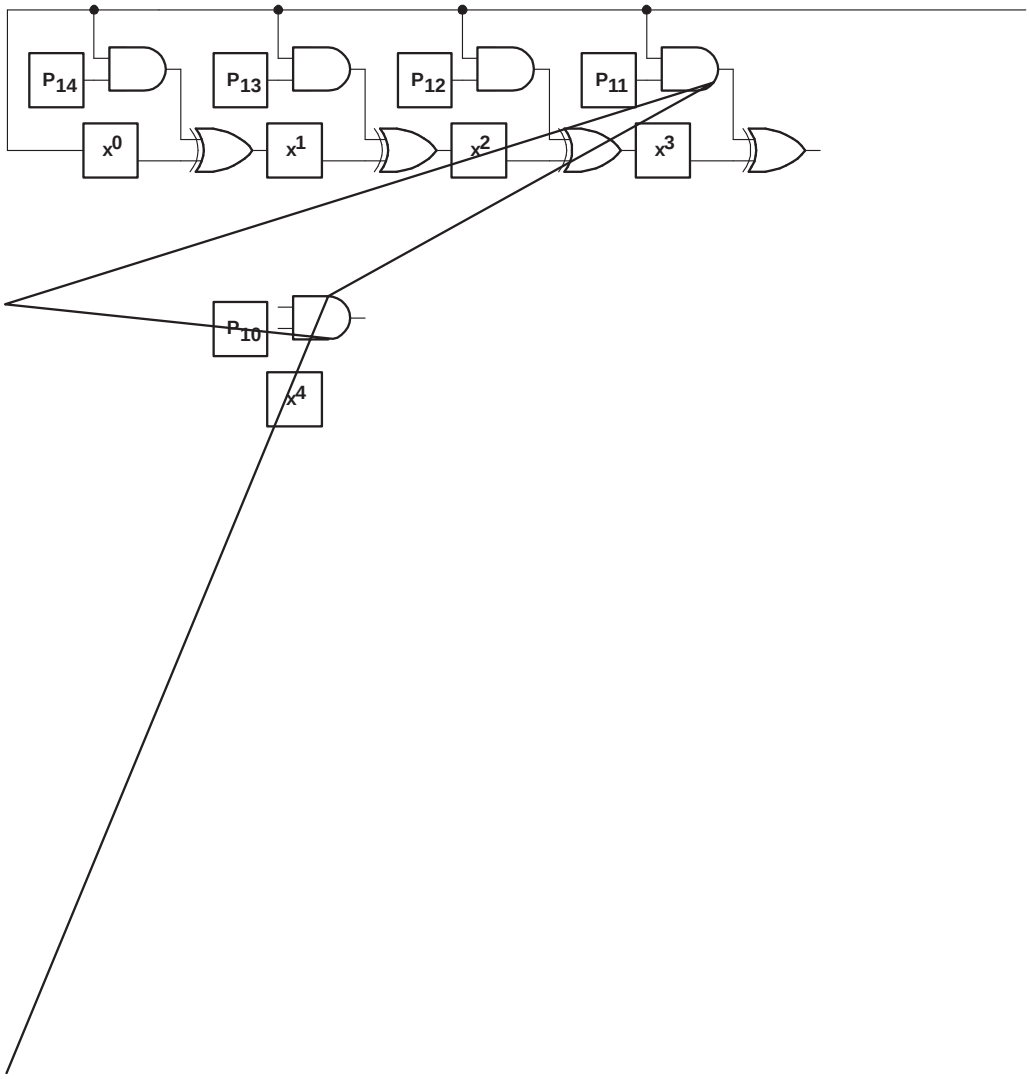

P14
P13
P12
P11
x0
x1
x2
x3
P10
x4

Figure 4 provides a pseudo-code example of calculating the CRC in software and Figure 5 shows an example of the CRC calculations inputs and associated output.

```
poly    P        0]
strcpy  input, key        0 ]
strcat  input, challenge        0 ]
for   i    o   i         i

    if  crc    0 ] ^ input    i ]
       crc      crc          ^ poly
     else
       crc     crc
```

Figure 4. Pseudo-C Code for CRC Calculation

Polynomial 1 x^2 x^5 x^{11} x^1	
P 15 ' 0] 1010010000010000	binary
A410	hex
Seed 15'0] a f	hex
Decrypted Device ID 5a b4f3 dcc21 d	hex
Random Challenge a00 1d e	hex
CRC input a00 1d e 5a b4f3 dcc21 d	hex
CRC output ef	

Figure 5. Example Inputs and Output of CRC Calculation

Writing and Reading Nonvolatile Memory

The bq26150 has sixteen bytes of nonvolatile one time programmable memory for general use and 32 bytes for authentication information that can be programmed by the HDQ engine. All OTP registers are cleared at final test, allowing for programming at pack manufacturing.

Programming a nonvolatile memory location requires sending the HDQ write command to that location and then pulling the HDQ line up to 7 V for 300 µs. If the programming pulse is not provided, the data transmitted by the host will not programmed into the OTP. Figure 6 shows an example of writing and programming address 0x71 with data 0x55 (*timings are not drawn to scale*). Figure 6, Figure 7 and Table 2 provide more information on the programming pulse specifications.

Figure 6. Writing and Programming OTP Example

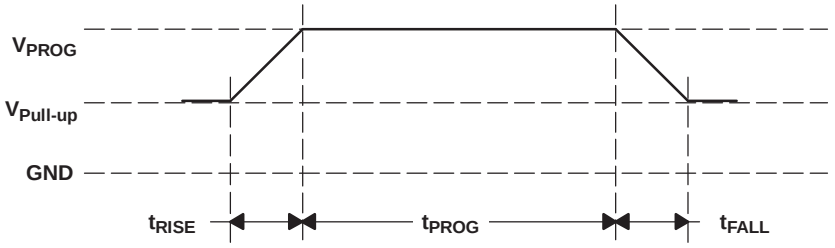


Figure 7. OTP Programming Pulse

Table 2. OTP Programming Specifications

PARAMETER		TEST CONDITIONS	MIN	MAX	UNIT
t_{PON}	Write to pulse rise		2		µs
t_{RISE}	Pulse rise time	No overshoot above 7.7 V	1	10	µs
t_{PROG}	Pulse high time		300		µs
t_{FALL}	Pulse fall time		1	10	µs

The nonvolatile memory can be written to more than once. However, the data already in the byte goes through a logical bitwise OR with the new data. For example, if address 0x71 was programmed with data 0x55 initially and a second program to address 0x71 with data 0xAA was performed, subsequent reads of address 0x71 would return data 0xFF (0x55 OR 0xAA

Cryptography Glossary

This glossary is not intended to be exhaustive, but provides a quick reference to some of the terms included in this document.

Plaintext

Data in an immediately usable form. *Texas Instruments Incorporated* is an example of a plaintext string.

Ciphertext

Data that has been encrypted with any of a number of cipher algorithms. If *bq26150* is the plaintext, the ciphertext string might be represented as *)d*0dsF.

Shared Secret Key

A key used by both Texas Instruments Incorporated and the host manufacturer to encrypt or decrypt the unique device ID. Contact the factory for more specific information.

Unique Device ID

A 96-bit value used to calculate the CRC authentication value.

Encrypted Polynomial Coefficients

Encrypted version of the 16-bit device specific CRC polynomial.

Encrypted Device ID

The encrypted version of the 96-bit unique device ID.

REVISION HISTORY

Changes from Original (January 2005) to Revision A	Page
• Changed Text and illustration throughout the data sheet	1

Changes from Revision A (July 2005) to Revision B	Page
• Changed the data sheet status from Product Preview to Production	1

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
BQ26150DCKR	OBSOLETE	SC70	DCK	5		TBD	Call TI	Call TI	-20 to 70	BNO	
BQ26150DCKRG4	ACTIVE	SC70	DCK	5		TBD	Call TI	Call TI	-20 to 70		Samples

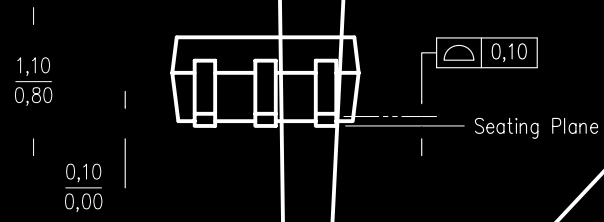
(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, 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) 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:

CAL

DCK (R-PDSO-C

Index Area



NOTES:

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