

Designed to GO . . .

Practical and Cost-Effective Battery Management Design Examples by Benchmark Series 2018, Number One



Universal Battery Monitor Using the bq2018 Power Minder™ IC



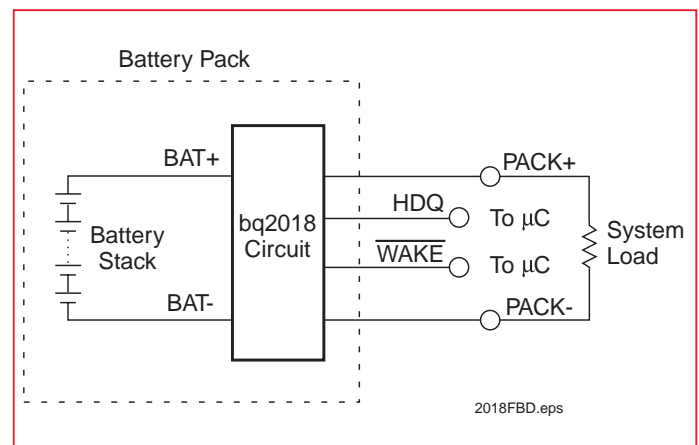
Features

- ◆ Counts charge and discharge for Li-Ion, NiCd, NiMH, and other chemistries
- ◆ Works with host controller to form comprehensive battery pack monitor
- ◆ Direct connection to battery stack
- ◆ Connects to 4 to 12 series NiCd/NiMH cells or 2 to 4 Li-Ion series cells; other configurations available
- ◆ Low operating current
- ◆ Measures a wide dynamic range of current
- ◆ Small size
 - Entire circuit can fit on less than 0.5 square inches of PCB space
- ◆ Low implementation cost
 - Fewer than 15 discrete components required

Typical Applications

- ◆ Cellular telephones
- ◆ Personal digital assistants
- ◆ Other portable handheld equipment

Figure 1. bq2018 Circuit Connection



General Description

The circuit shown in Figure 3 is a typical bq2018 Power Minder implementation. The battery is connected between BAT+ and BAT-. Q1 and C5, in conjunction with the REG output, regulate the supply voltage to the bq2018 to between 3.5V and 3.9V for the varying battery input at BAT+. The SR V-to-F input pins sense the charge and discharge current using the low-value resistor R1.

A microcontroller communicates with the Power Minder IC using an I/O port connected to the bq2018 HDQ pin. The microcontroller reads the charge/discharge and timer counters of the bq2018 and calculates remaining battery capacity for communication to the user or to the system's power management controls. The bq2018 WAKE output pin alerts the microcontroller that charge/discharge activity greater than a programmable level is taking place.

The circuit monitors a battery pack of any chemistry. The typical operating parameters of the circuit are:

Symbol	Parameter	Units
V_I	Input voltage BAT+ to BAT-	3.5V to 18.0V
I_{SR}	Measurable current range	$\pm 4A$ Max.(1)
I_{OPR}	Operating current	80 μA
I_S	Sleep current	10 μA
I_{BACK}	Register backup current	< 0.1 μA (2)

- (1) Assumes 50m Ω 1W sense resistor and bq2018 offset compensation.
- (2) Provides years of backup time when using cell(s) from the battery stack.

Sense Resistor Selection

R1 must be sized properly to measure the entire range of charge and discharge currents in the application within the limits of the bq2018. The input parameters include:

1. The potential of the SR input is limited to -200mV to +200mV. The charge/discharge currents through the sense resistor must not produce a voltage greater than $\pm 200mV$.
2. The bq2018 counts charge and discharge at a rate of 12.5 μV per hour. Signals < 12.5 μV require greater than one hour to resolve. The designer should consider the resolution vs. time when selecting a sense resistor.

The sense resistor must also handle the power dissipation of all charge and discharge activity. The circuit example uses a 50m Ω 1W sense resistor.

Measurement Offset

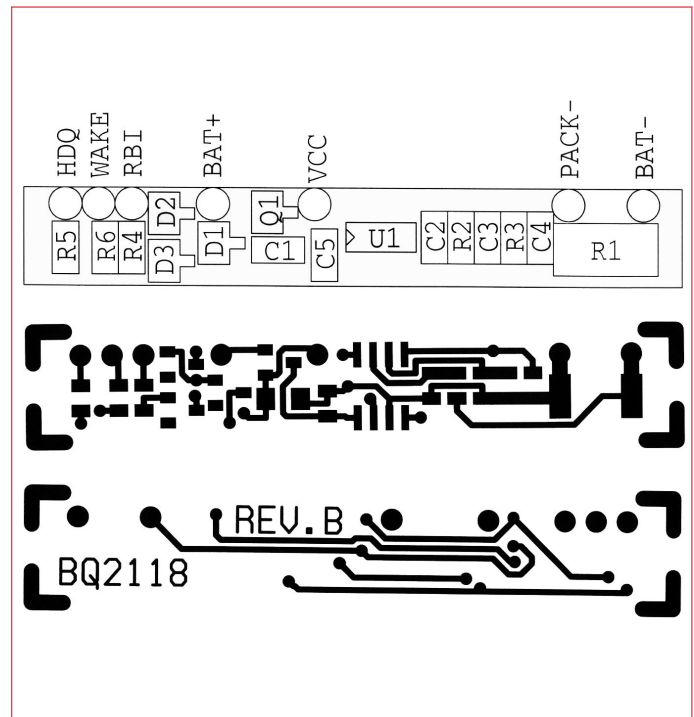
The bq2018 has a calibration test mode that measures the offset of the bq2018 based circuit. A final test setup for the battery pack can enable this mode by setting the appropriate bits in the bq2018. When the bq2018 is in calibration mode, no charge/discharge current should be applied. In calibration mode, the bq2018 measures the circuit offset and latches a value in the offset adjustment register. The host microcontroller uses the value in the register to periodically adjust the charge and discharge count values from the bq2018.

Note: Board layout affects offset. C2, C3, and C5 should be as close to the bq2018 as practical. Figure 2 shows one example of how to lay out the circuit in Figure 3.

Parts List

Item	Quantity	Reference	Part
1	1	U1	bq2018
2	2	R4, R6	1K
3	1	R5	100
4	2	R3, R2	100K
5	1	C1	0.1 μF /1.0 μF
6	3	C4, C2, C3	0.1 μF
7	1	C5	0.01 μF /0.001 μF
8	1	Q1	SST108
9	1	D3	BAV99
10	1	R1	0.05 Ω tolerance = 2%, Watt = 1W
11	2	D2, D1	BZX84C5V6 Zener

Figure 2. bq2018 Circuit Board Layout



Microcode Example for HDQ Interface

```

;TITLE    "HDQ.ASM - 201XH INTERFACE"
;LAST UPDATE: 04/15/96
;TIMING VALUES ARE FOR 8.0MHz CRYSTAL
:
;R A M   A S S I G N M E N T
;
W          EQU          00H
RTCC       EQU          01H
PC         EQU          02H          ;PROGRAM COUNTER
STATUS    EQU          03H
X         EQU          04H          ;FILE SELECT
;
;PORTB    EQU          06H          ;PORTB 0 is HDQ line
;
TIMEOUT    EQU          0AH          ;TIMEOUT FLAG, 0=NO TIMEOUT
HSERDAT    EQU          0BH          ;HIGH SERIAL DATA REGISTER
HSERBIT    EQU          0CH          ;HIGH SERIAL BIT COUNTER
WSTACK    EQU          0DH          ;TEMP STORE FOR W REGISTER
;
;HCMD     EQU          0FH          ;HOST COMMAND
;
BTRIS     EQU          1FH          ;MIRROR TRISB
;
ORG       00H
;
RESET     GOTO         BEGIN
;
; S U B R O U T I N E S
;
; HIGH-SPEED SERVICE FOR BATTERY
;
;HS_SERVA    MOVLW     08H          ;LOAD BIT COUNTER
              MOVWF    HSERBIT     ;WITH 8 FOR 8 BITS

READIT CLRf    WSTACK          ;GET TIMEOUT READY
              CLRF    TIMEOUT
HABQR0      BTFSS    PORTB,0     ;REQUEST FOR HS
              GOTO    HABQR1
              DECFSS  WSTACK,1   ;COUNT FOR TIMEOUT
              GOTO    HABQR0

;
; TIME-OUT ON RECEIVE
;
              MOVLW     0FFH
              MOVWF    TIMEOUT
              GOTO    BREAKIT

;
HABQR1  RRF     HSERDAT,1        ;SHIFT DATA
              CLRF    WSTACK     ;TIME LOW TIME

;
HABQR2      BTFSC    PORTB,0     ;CHECK FOR STOP BIT
              GOTO    HABQR3
              INCF    WSTACK,1
              BTFSS  WSTACK,6   ;BREAK DURING READ LOW 144us
              GOTO    HABQR2

;
;BREAK DETECTED
;
BREAKIT     CLRf    HCMD         ; CANCEL PENDING COMMAND
              MOVLW   08H         ;LOAD BIT COUNTER
              MOVWF  HSERBIT     ; WITH 8 FOR 8 BITS

HABQR5      NOP
              BTFSS  PORTB,0     ;CHECK FOR STOP BIT
              GOTO  HABQR5       ;WILL LOOP FOREVER IF LINE STAYS LOW
              RETLW   00H        ;DONE

;
HABQR3      BSF     HSERDAT,7
              MOVLW  30H
              ANDWF  WSTACK,W
              BTFSS  STATUS,2
              BCF   HSERDAT,7
              DECFSS HSERBIT,1

;
              GOTO    READIT     ;MORE TO DO!
;
              MOVF   HSERDAT,W
              MOVWF  HCMD
DONE_WA     MOVLW   08H         ;LOAD BIT COUNTER
              MOVWF  HSERBIT     ; WITH 8 FOR 8 BITS
              RETLW   00H

;
; SNDA_IT WILL SEND ONE BYTE TO HDQ MODULE
;
SNDA_IT     MOVLW   08H         ;LOAD BIT COUNTER
              MOVWF  HSERBIT     ;WITH 8 FOR 8 BITS
;
;DELAY A BIT
;
              CLRF   HCMD

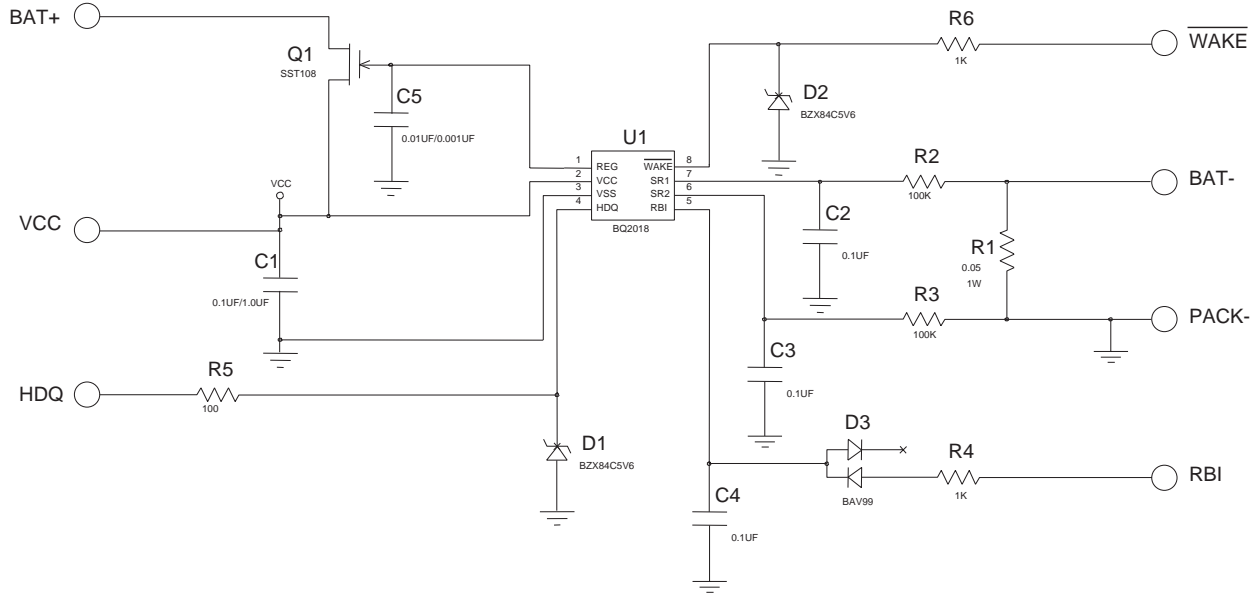
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Microcode Example for HDQ Interface (continued)

```

SNDA_1      INCF      HCMD,1
            BTFSS    HCMD,6
            GOTO     SNDA_1
;
SNDA_2      BCF      BTRIS,0
            MOVF     BTRIS,W
            TRIS    PORTB
            CLRF    HCMD
;
SNDA_3      INCF      HCMD,1
            BTFSS    HCMD,4
            GOTO     SNDA_3
;
SNDA_5      BTFSS    HSERDAT,0      ;TEST DATA BIT
            GOTO     SNDA_4
;
            BSF      BTRIS,0
            MOVF     BTRIS,W
            TRIS    PORTB
;
SNDA_4      CLRF    HCMD
;
SNDA_7      INCF      HCMD,1
            BTFSS    HCMD,5
            GOTO     SNDA_7
;
            BSF      BTRIS,0
            MOVF     BTRIS,W
            TRIS    PORTB
;
            CLRF    HCMD
            BSF      HCMD,4
;
SNDA_9      INCF      HCMD,1
            BTFSS    HCMD,6
            GOTO     SNDA_9
;
            RRF      HSERDAT,1      ;SHIFT DATA, FOR NEXT BIT
            DECFSZ   HSERBIT,1      ;DEC COUNTER
            GOTO     SNDA_2          ;MORE BITS TO SEND
;
            CLRF    HCMD
            MOVLW   08H              ;LOAD BIT COUNTER
            MOVWF   HSERBIT          ; WITH 8 FOR 8 BITS
            RETLW   00H              ;NO, DONE
;
;I N I T I A L I Z A T I O N
;
BEGIN      CLRWDT
            MOVLW   06H
            OPTION
            CLRW              ;SET UP PORT
            MOVWF   PORTB
            MOVLW   03H
            MOVWF   BTRIS
            TRIS    PORTB
            MOVLW   08H          ;LOAD BIT COUNTER
            MOVWF   HSERBIT      ;WITH 8 FOR 8 BIT
;
OTHER USER CODE
;
;READ EXAMPLE
;
;READ DCR
;
            MOVLW   03H
            MOVWF   HSERDAT
            CALL    SNDA_IT
            CALL    HS_SERVA
;
;
;      HSERDAT=NAC
;
;WRITE EXAMPLE
;
;WRITE RAM = 0xAA
;
            MOVLW   83H
            MOVWF   HSERDAT
            CALL    SNDA_IT
            MOVLW   0AAH
            MOVWF   HSERDAT
            CALL    SNDA_IT
;
OTHER USER C O D E
;
            GOTO     RESET
;
END
*
```

Figure 3. bq2018 Schematic

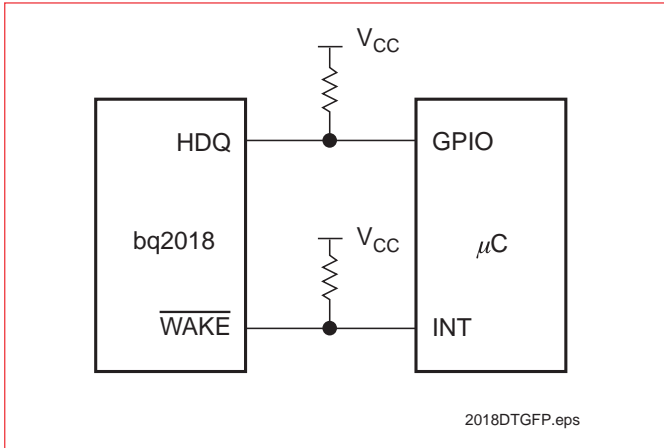


bq2118, Rev B, 6-24-97

- Notes:
- C1—bypass for V_{CC}
 - C2, C3, R2, R3—bypass for SR
 - D2, R6; D1, R5—ESD protection
 - D3, R4—isolation for RB1 cell connection
 - C5—bypass for REG
 - R1—sense resistor

Interfacing to a Microcontroller

A microcontroller can interface the bq2018 using a general purpose I/O port. The $\overline{\text{WAKE}}$ output of the bq2018 interrupts the microcontroller when it detects charge or discharge activity greater than a programmable level. HDQ and $\overline{\text{WAKE}}$ are open-drain and require a pull-up resistor as shown.

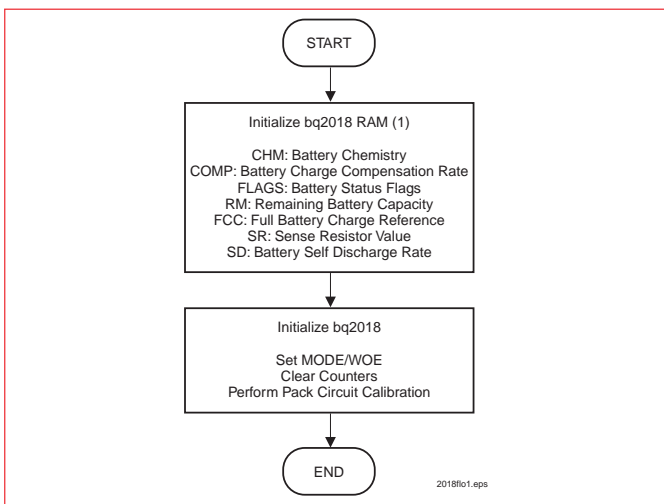


Microcontroller Software

A microcontroller must configure the bq2018 and read and format its counter data to implement a battery capacity monitor. There are three main aspects of the software: Factory Configuration Program, Operating Program, and Serial Communication Program.

Factory Configuration Program (Test System Microcontroller)

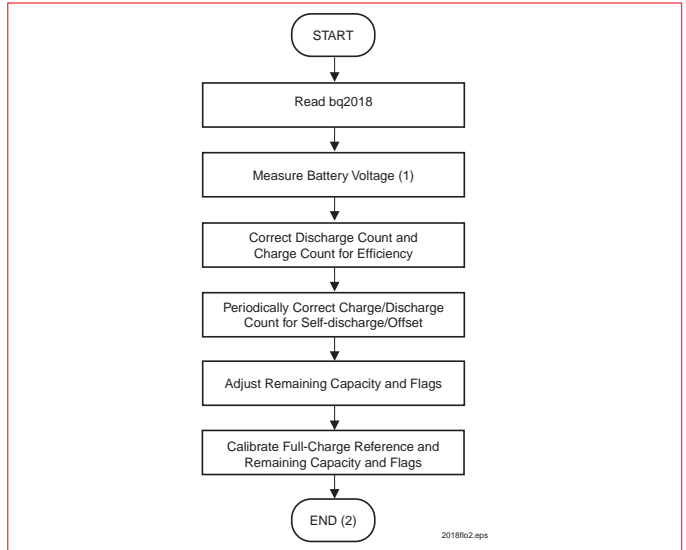
The factory program configures a bq2018 based intelligent battery pack for operation. Actual battery monitor information, such as remaining capacity, compensation rates, and status flags may be stored in the bq2018 user RAM. The factory program initializes the user RAM and the bq2018. The battery maintains the bq2018 data with a low backup current of $< 0.1\mu\text{A}$.



Note: 1. Write default values to RAM if necessary.

Operating Program (Host System Microcontroller)

The Operating program loop reads the bq2018 and updates the RAM locations for charge/discharge use conditions. The microcontroller periodically applies self-discharge and offset correction and calibrates remaining capacity and the full-charge reference based on state-of-charge and battery voltage.



Notes: 1. Requires A-to-D converter.
2. Typical loop time is once per minute.

Serial Communication Program (Test and Host Microcontroller)

The Designed to GO insert shows an example of the microcode required to communicate with the bq2018 using a port pin of a microcontroller. The code is for a PIC16C5X running at 8.0MHz.



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