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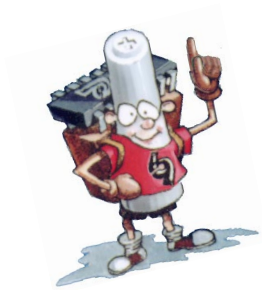
Practical and Cost-Effective Battery Management Design Examples by Benchmarq
Series 2018, Number One



Universal Battery Monitor Using the bq2018 Power Minder™ IC

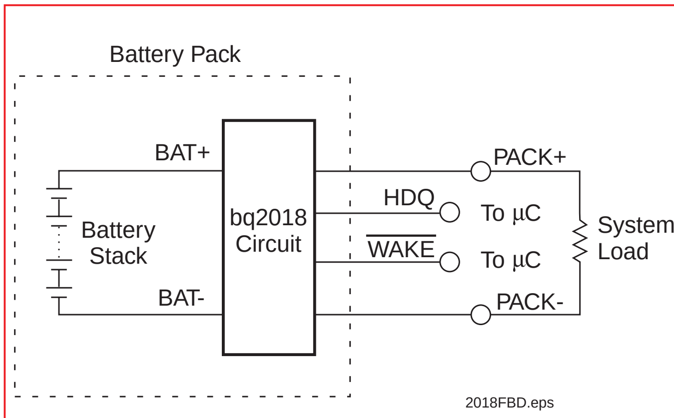
Features

- 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



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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 $\overline{\text{WAKE}}$ 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	± 4A Max.(1)
I_{OPR}	Operating current	80µA
I_S	Sleep current	10µA
I_{BACK}	Register backup current	< 0.1µA (2)

(1) Assumes 50mΩ 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 ±200mV.

2. The bq2018 counts charge and discharge at a rate of 12.5µV per hour. Signals < 12.5µV 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 50mΩ 1W sense resistor.

Measurement Offset

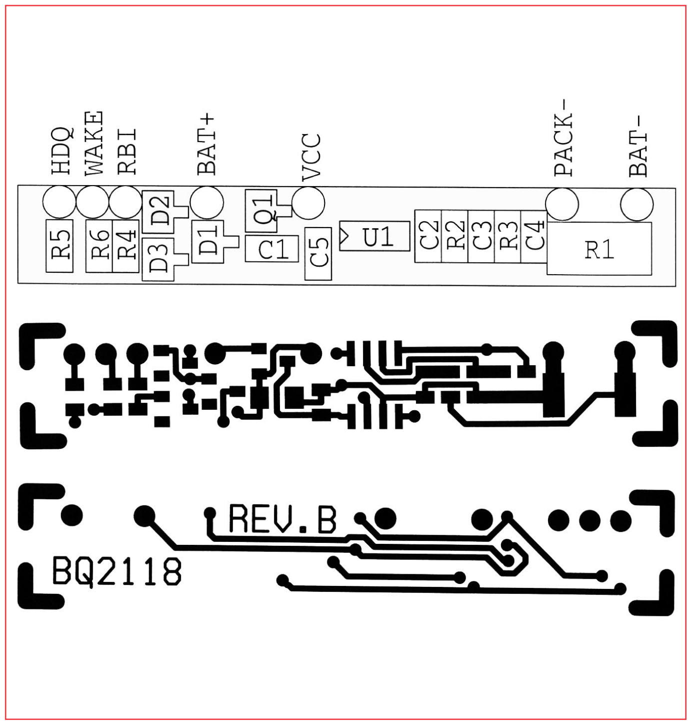
The bq2018 has a calibration test mode that measures the offset of the bq2018 based circuit. A final test setup for the battery pack can enable this mode by setting the appropriate bits in the bq2018. When the bq2018 is in calibration mode, no charge/discharge current should be applied. In calibration 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	0.1µF/1.0µF
6	3	C4, C2, C3	0.1µF
7	1	C5	0.01µF/0.001µF
8	1	Q1	SST108
9	1	D3	BAV99
10	1	R1	0.05Ω tolerance = 2%, Watt = 1W
11	2	D2, D1	BZX84C5V6 Zener

Figure 2. bq2018 Circuit Board Layout



Microcode Example for HDQ Interface

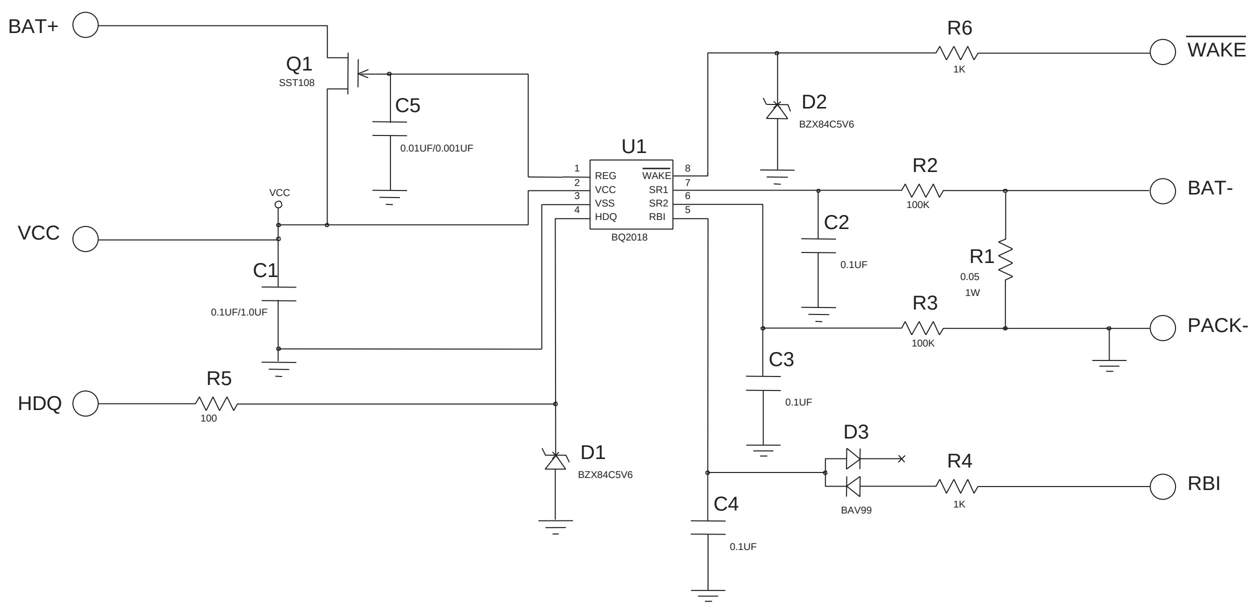
```
;TITLE   "HDQ.ASM — 201XH INTERFACE"
;LAST UPDATE:  04/15/96
;TIMING VALUES ARE FOR 8.0MHz CRYSTAL
:
;R A M   A S S I G N M E N T
;
W               EQU        00H
RTCC            EQU        01H
PC              EQU        02H              ;PROGRAM COUNTER
STATUS          EQU        03H
X               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
                DECFSZ     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
                DECFSZ     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
```

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



Notes: C1—bypass for V_{CC}

C2, C3, R2, R3—bypass for SR

D2, R6; D1, R5—ESD protection

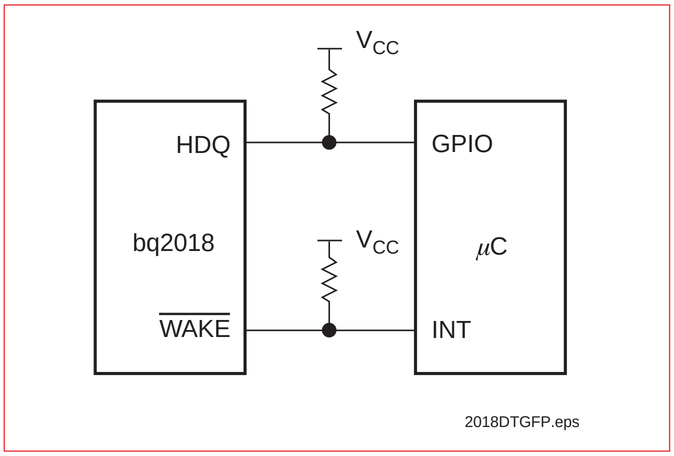
D3, R4—isolation for RB1 cell connection

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.

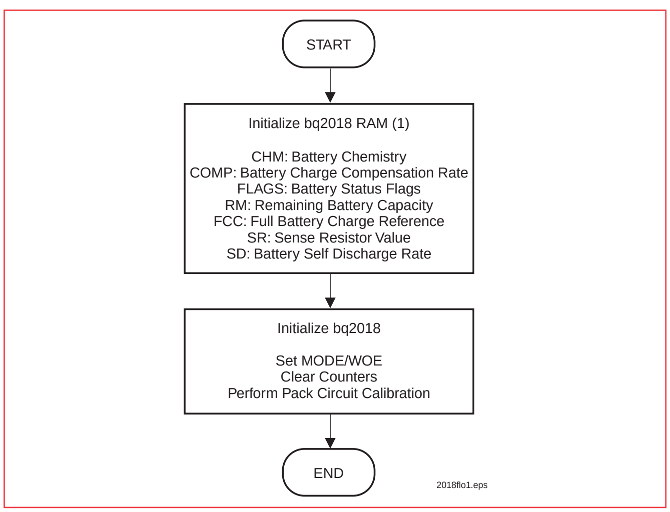


Microcontroller Software

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)

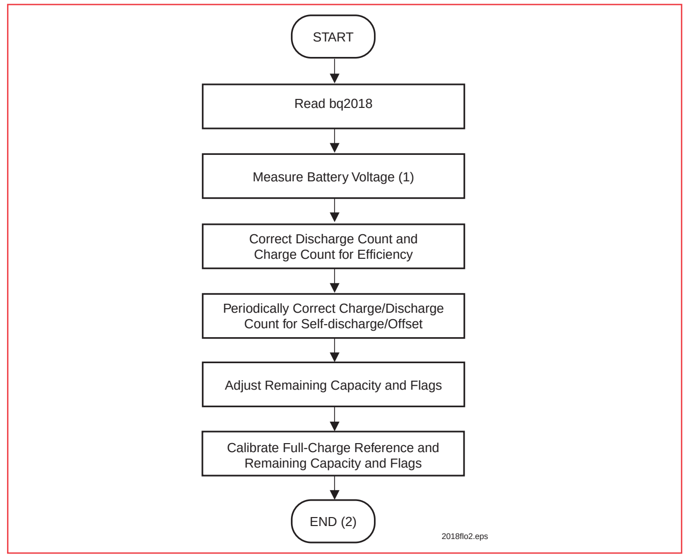
The factory program configures a bq2018 based intelligent battery pack for operation. Actual battery monitor information, such as remaining capacity, compensation rates, and status flags may be stored in the bq2018 user RAM. The factory program initializes the user RAM and the bq2018. The battery maintains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



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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