UNITRODE

EV2011

Gas Gauge Evaluation Board

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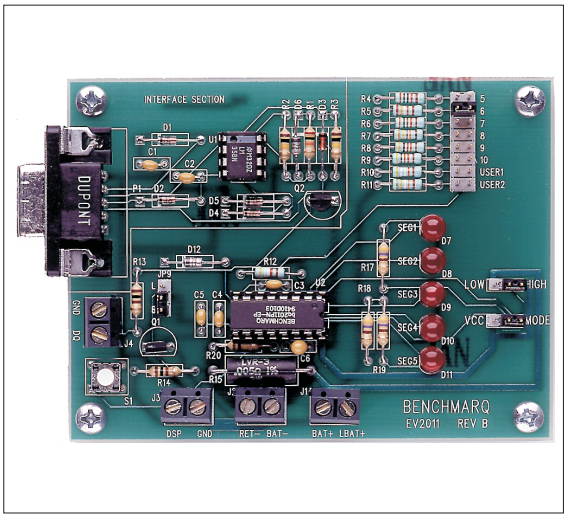
Introduction

The bq2011 Gas Gauge IC provides battery capacity monitoring in a single 16-pin SOIC or DIP package. The EV2011 Evaluation Board provides a useful means to test bq2011 functionality and easily interface with the device over the RS-232 port of a PC. The bq2011 features:

- Battery capacity monitoring functions
- LED display of available charge
- DQ serial I/O port communications functions

Functional Description

The EV2011 provides functional evaluation of the bq2011 IC on a PCB. The actual implementation of a bq2011-based design will be significantly smaller in size. See the bq2011 data sheet (July 1994 C or later) for bq2011 specifications.



Power Source

The bq2011 derives its V_{CC} from either an external source or from the battery connected to the BAT+ (J1) and BAT– (J2) terminal blocks. Refer to Table 4 in *Using the bq2010—A Tutorial for Gas Gauging* for the proper size of R16 as part of the V_{CC} regulation. The EV2011 Evaluation Board is shipped with a 301KΩ resistor for R16.

Current Path

The bq2011 uses a sense resistor (R15) on the negative terminal of the battery to measure charge and discharge of the battery. This resistor may be changed if necessary. The system load is connected between the BAT+ (J1) and RET– (J2) terminal blocks (see the schematic in Appendix C).

Parameter Programming

The EV2011 is programmed by the MODE and PFC programming pins. The programming pins determine:

- Programmed full count
- Scale factor
- Display mode

EV2011 Contents

Each package contains the following items:

1 EV2011 PC Board

This includes the bq2011 sample, current regulator, programming jumpers, battery divider resistors, and the PC serial port interface.

1 EV2011 DQ/RS-232 Cable

1 EV2011 (v2.0) User Interface Program Diskette

This program runs on *any AT-compatible computer* equipped with a standard RS-232 (COM1, COM2, COM3, or COM4) serial port, and provides the user with a complete menu-driven system to control, monitor, and log data from the EV2011 Evaluation Board. The User Interface Program communicates with the bq2011 over the DQ serial I/O port using the RS-232 interface.

Please check to make sure that all items are present and in good condition. If you have any problems, please contact your Benchmarq representative or call Benchmarq at 214-407-0011.

EV2011 Connections

The connections for the EV2011 are described below. Please refer to the attached schematic in conjunction with these descriptions.

JP1–JP8 **Battery cell divider.** JP1-JP6 are used to divide the battery voltage by 5 to 10. JP7 and JP8 are user-definable, but are configured for 11 and 12 cells on this board.

JP9 **V_{CC} supply**. This jumper is used to select the V_{CC} supply for the bq2011. When JP9 is on B (near Q1), the supply is taken from the BAT+ input and is regulated by the bq2011 and Q1. When JP9 is on L (near D12), the V_{CC} supply is provided by LBAT+. If V_{CC} is supplied by LBAT+, it must not exceed the specified V_{CC} voltage range in the bq2011 data sheet.

JP11 **PFC programming pins**. This jumper can be set low, high impedance, or high. If the jumper is between the middle pin and low, PFC is set low. If the jumper is removed, the PFC is high impedance, or Z. If the jumper is between the middle pin and high, PFC is set high.

JP10 **MODE selection jumper.** If the jumper is between the middle pin and V_{CC}, the display mode is relative. If the jumper is between the middle pin and MODE, the display mode is absolute. If the jumper is removed, no display is available.

DSP **Display input** ($\overline{DISP}$ pin). DSP is connected in parallel with the push-button switch S1 provided on the EV2011 board. An external switch configuration can be made using DSP. When the EV2011 is floating and detects charging or discharging, the LED outputs are active to reflect the charge state. When the $\overline{DISP}$ input is pulled low, the LEDs reflects the charge state.

EV2011 Configuration

The EV2011 Evaluation Board may be used with or without the DQ/RS-232 Interface Program. The Evaluation Board should first be configured before connecting the battery or the RS-232 cable.

Step 1 Connecting the power supply

The EV2011 can operate from power provided by the battery being monitored or from LBAT+. Set the battery divider (JP1–JP8) to the correct number of battery cells prior to connecting the battery. If the bq2011 will be powered from the battery, connect JP9 to B. If the bq2011 will be powered from an external supply, connect JP9 to L. **Important: Connect the battery ONLY after setting JP1-JP8 and JP9.**

Step 3 Connecting the RS-232 cable

Connect the cable provided to the serial port of any PC. Please ensure no memory-resident programs use this serial port.

Step 4 Connecting the load

The external load is connected between BAT+ and RET- (J2) on the EV2011. A sense resistor (R15) is in series with the negative terminal of the battery. The EV2011 board is supplied with a 0.005, 1% 3W resistor. Please ensure that the discharge load does not exceed the V_{SR} specification for the bq2011. R15 may be changed to a different-value resistor.

Installing the User Interface Program

The User Interface Program (named “EV2011”) runs on any PC-compatible computer. The program may be run from the disk provided, or it may be installed on any directory on the computer's hard disk. To run the program from the hard disk, simply copy all the files from the disk supplied to the hard disk. All the files should reside in the same directory.

The User Interface Program installs a driver to control the DQ/RS-232 interface. This driver asks which COM port is connected to the EV2011 Evaluation board. If communication is not established with the EV2011 board, the Main Menu does not appear. Please refer to Appendix B (Troubleshooting) if the program does not establish communication with the EV2011.

The EV2011 uses the PC-AT real-time clock to provide the proper bit timing for serial communication with the bq2011. The modem control lines are used as the single-wire serial interface to the bq2011. Any TSR that uses the PC real-time clock affects the operation of the EV2011. For proper operation, the EV2011 should not be operated from a DOS shell program.

If the PC is a notebook or portable type, it may be configured to save battery power by adjusting the clocks according to the activity under way. Configure the notebook to run in “High Performance” mode for reliable communication between the EV2011 and the PC. The EV2011 UIP terminates if communication with the EV2011 board is lost.

Start the User Interface Program as follows:

```
C>EV2011
```

Using the EV2011 Program

EV2011 is a menu-driven program. Almost all of the functions and entries are made by positioning the highlighted cursor on the function desired and pressing the ENTER key, or by typing a value and then pressing the ENTER key.

Key functions are as follows:

ARROW keys	Use the arrow keys to move the highlighted cursor around the screen.
ENTER key	Press the ENTER key to select the value currently being displayed for a parameter, or to perform a function selected by the highlighted cursor.
ESCAPE key	Press the ESCAPE key to escape from any function back to the main menu, or to escape from any parameter value screen back to the menu displaying that parameter.
F3 key	Press the F3 key to display a help file for the selected function or parameter.

Main Menu

The Main Menu appears after the EV2011 program has started. If this menu does not appear, communication with the EV2011 has not been established; please refer to Appendix B (Troubleshooting) if the EV2011 does not display the Main Menu.

The Main Menu shows six functions that may be activated; see Figure 1. Use the cursor keys (arrow keys) to position the highlighted cursor over the function to be activated and press the ENTER key. For help, press the F3 key, and a help note about the function appears. Press the ESCAPE key to exit from the EV2011 program.

```
                Benchmarq BQ2011 Evaluation Board Main Menu (v2.0)

                      <Initialize>              <Monitor>

                      <Output Control>          <Data Log>

                      <Display Program>         <Measure Vos>

              Please enter SR value B in Display Program for Proper Operation

ESC to exit program                                                  F3 for Help
```

Figure 1. Main Menu

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The Main Menu functions are as follows:

<Initialize>	Sends a reset command to the bq2011.
<Output Control>	Activates a screen from which the LEDs can be controlled.
<Monitor>	Activates a screen from which the bq2011 activity is monitored on a real-time basis.
<Data Log>	Allows entering a file name to which bq2011 data will be logged, and the logging period in seconds. When the log is activated, the display changes to the Monitor screen with a top display of: Logging Record: xx
<Display Program>	Activates a screen showing the current program settings for the bq2011.
<Measure V_{OS}>	This allows the user to determine the apparent offset voltage of the bq2011 under test. A minimum of 2 minutes is required to complete the V_{OS} measurement, which has a resolution of ±0.15mV per 2 minutes.

Output Control Screen

This screen controls the bq2011 LEDs; see Figure 2. Press the space bar to toggle the LED OFF and ON. Pressing the push-button switch activates the display. The bq2011 LED output returns to normal on exiting this screen.

Monitor Screen

This screen monitors real-time changes of the bq2011; see Figure 3. The program continually updates the monitor screen. As conditions change, the new values are displayed.

Time	Time of day in HH:MM:DD, 24-hour notation.
Empty/Full	This indicates the current value for GG in the TMPGG register of the bq2011. The capacity value is given in $\frac{1}{16}$th steps.
Date	Current date in MM/DD/YY notation.
NAC	NAC register values multiplied by the scale value and divided by the sense resistor value to give mAH.
LMD	Last Measured Discharge expressed in terms of mAH. This is the 8-bit LMD register value multiplied by the scale value times 256 and divided by the sense resistor to give mAH.
Sense Resistor Value	This is the sense resistor value from the Programming menu.
Average V_{SR} Current	This is the average battery current.
Time Remaining	During discharge only, this is the time remaining at the average current (NAC / Avg. V_{SR} current)
Digital Filter Setting	This is the value of the digital magnitude filter.
Temp Step	This is a display of the active temperature step, which ranges from 0 (for temperatures <-30°C) to 12 for temperatures > 80°C).
Activity	This indicates the charging/discharging activity occurring with the battery. CHARGE is displayed if the battery is charging, while DISCHARGING is displayed if the battery is being discharged, or if it is idle (no charging taking place). OVERLOAD is displayed if the voltage drop across the sense resistor exceeds the

```
                Benchmarq BQ2011 Evaluation Board Output Control Screen

                Output Pins

                 LED Display LED1: OFF/ON       LED2: OFF/ON
                 LED Display LED3: OFF/ON       LED4: OFF/ON
                 LED Display LED5: OFF/ON

           ESC to main menu
```

Figure 2. Output Control Screen

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V_{SR1} threshold. Please note that the application of a charging current or a discharge load depending on the PFC and scale selected, and the rate of charge or discharge being applied.

VSR Step This is the value of the V_{SR} current step as defined in the bq2011 data sheet.

GG Step This is the lower four bits of the TMPGG register that correspond to the current NAC value relative to either the LMD or the original programmed full count (as determined by $PROG_{1-4}$). The GG step is reported as a step number from 0 to 15, with step 0 representing available capacity from 0 to $\frac{1}{16}$ of full, and 15 representing available capacity from $\frac{15}{16}$ full to full.

Charge Rate Indicates whether the present charge is TRICKLE or FAST depending on the state of the charge rate (CR) bit in FLGS2.

EDV This is the state of the EDV flag. The EDV flag latches ON if V_{SB} drops below the EDV threshold value. It remains latched until charging is detected, at which time it is cleared.

Battery Removed This is the state of the battery removed flag. It is set (BRM = yes) if one of the conditions indicating battery removed occurs. This flag is reset when the battery is replaced.

Valid Discharge This is the state of the VDQ bit in FLGS1. VDQ = yes if the bq2011 is charged until NAC = LMD. VDQ = no indicates the present discharge is not valid for LMD update.

Full Count This value is the contents of the Full Count register. This value times 16 is the

```
Benchmarq BQ2011 Evaluation Board Real-Time Monitor Screen

     Time: 99:99:99       EMPTY ****_____FULL      Date: 99/99/99

     NAC: 99999 mAH       LMD:  99999 mAH   Sense Resistor Value: XXXΩ

     Avg Vsr Current: ±9999mA               Time remaining: 9999 min.

     Digital Filter Setting:  +0.50mV=Vsrd  -0.40mV=Vsrq    Temp Step:  XX

     Activity: XXXXX        Vsr Current Step:  XX         GG Step: XX

     Charge Rate: XXXX      First EDV:  XXX               Batt. Rem'vd: XXX

     Valid Discharge: XXX   Full Count:  XXX              Batt. Repl'd: XXX

     Capacity Inaccurate: XXX   Capacity Inaccurate Count: XXX

 FLGS1: X X X X X _ X _              FLGS2: X X X X _ _ _ X
        C B B C V N E N                     C D D D N N N O
        H R R I D / D /                     R R R R / / / V
        G P M   Q U V U                       2 1 0 U U U L
        S         1                                     D

 ESC to main menu       F1 to modify NAC          F2 to modify LMD
```

Figure 3. Real-Time Monitor Screen

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	number of times that NAC has counted up to LMD after a valid discharge.
Battery Replaced	This is the state of the battery replaced flag. It is set (BRP = yes) if the battery valid condition returns after setting the battery removed flag. The battery replaced flag is cleared if the battery is discharged to the EDV1 level or if it is charged to NAC = LMD. This flag is set after a EV2011 initialization.
Capacity Inaccurate	This is the state of the capacity inaccurate bit in FLGS1. It is set (CI = yes) to indicate that the battery capacity has not been updated during the last 64 charge cycles.
Capacity Inaccurate Count	This is the number of charge cycles between an LMD update. This counter is reset to zero when NAC = LMD after a valid LMD update.
FLGS1	This indicates the present state of the FLGS1 resistor.
FLGS2	This indicates the present state of the FLGS2 resistor.

Modifying NAC and LMD

It is possible to change the values of the NAC and LMD parameters from the screen using the F1 and F2 function keys as follows.

Changing NAC (F1)

1) Press the F1 key. The NAC field is highlighted.
2) Enter the value in mAH and press the ENTER key to store the value.

Note: Changing NAC disqualifies a subsequent LMD update.

Changing LMD (F2)

1) Press the F2 key. The LMD field is highlighted.
2) Enter the value in mAH and press the ENTER key to store the value.

Display Program Screen

This menu is accessed by selecting the <Display Program> function on the Main Menu. The Display Program Screen represents the state of the bq2011 programming pins; see Figure 4. To change the bq2011 programming, reconfigure jumpers MODE and PFC and

```
                    Benchmarq BQ2011 Programming Screen

          Sense Resistor:     0.005Ω          Scale Factor:      1/80

          Display Full:       RELATIVE      PFC Count:         XXXX

                                            PFC (mVH):         XXXX mVH

          Self-Discharge                    Battery Capacity:   9999 mAH
          Rate:               1/64 NAC/day

          Programming Pin Configuration

            LED Drive         ***

            PFC             ***

ESC to main menu                                                F3 for Help
```

Figure 4. Programming Menu

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initialize the bq2011. The reset allows the bq2011 to read the program pins.

Sense Resistor	Enter the value of sense resistor in ohms. Typical values range from 0.001 to 0.005Ω. The sense resistor value is used by the EV2011 UIP to develop meaningful information in terms of A, mA, and mAH in relation to battery capacity and current. The default value is 0.005. Values from 0.001 to 0.256 are saved in the battery ID RAM byte of the bq2011. Values greater than 0.256 must be re-entered each time EV2011 is started.
Scale Factor	Select the scale factor from the available scales using JP11. Like the sense resistor, the scale factor is used to develop meaningful information for the programmed full count tables, battery full, and available capacity indications.
Display Full	Use JP10 to choose between RELATIVE and ABSOLUTE full reference for the LED display.
PFC	Select the programmed full count using JP11. Note that the selected PFC and the sense resistor value are used to determine the initial battery full capacity (mAh) represented by the PFC.
Battery Capacity	This display indicates the battery capacity represented by dividing the PFC by the sense resistor. In practice, picking a PFC and sense resistor that provide a battery full value slightly lower than (within 5%) the rated battery capacity is recommended.
Programming Pin Configuration	This indicates the display mode as either LED DRIVE by MODE or V_{CC}. The PFC pin state is shown as L, Z, H. Please refer to the bq2011 data sheet for more information.

Data Logging

The data log is activated from the Main Menu by selecting the Data Log function. A filename to be used and the log sample period must be entered. For example:

Log Data to Filename: <filename.ext>
Enter Sample Period (10 sec or greater):<xx>
Opening Data Log File

When the data log is started, the Monitor Screen displays the number of the current log record between the time and date fields at the top of the screen. To terminate the data log, press the ESCAPE key. The file is closed and data logging is terminated.

The data log record contains fields of ASCII data separated by tab characters. The field names and descriptions in record order follow.

TIME	Time record written in seconds
LMD	LMD value in mAH
NAC	NAC value in mAH
Avg. Discharge Current	Average V_{SR} battery current
FLAGS1	Binary setting of FLAGS1 flags: **Bit Meaning** 0 Not used 1 EDV flag state 2 Not used 3 VDQ (valid discharge) 4 Capacity inaccurate 5 Battery removed flag state 6 Battery replaced flag state 7 Charge active flag state
FLAGS2	Binary setting of FLAGS2 flags: **Bit Meaning** 0 Overload flag state 1–3 Not used 4–6 Discharge rate 7 Charge rate

The log records should be readable by most spreadsheet programs.

Measure V_{OS} Screen

This screen is used to measure the V_{OS} of the bq2011; see Figure 5. A minimum of 120 seconds are required to perform this test. Pressing the ESC key terminates the test in progress. Operating the test for a longer period increases the resolution of the test. A “beep” signals test completion.

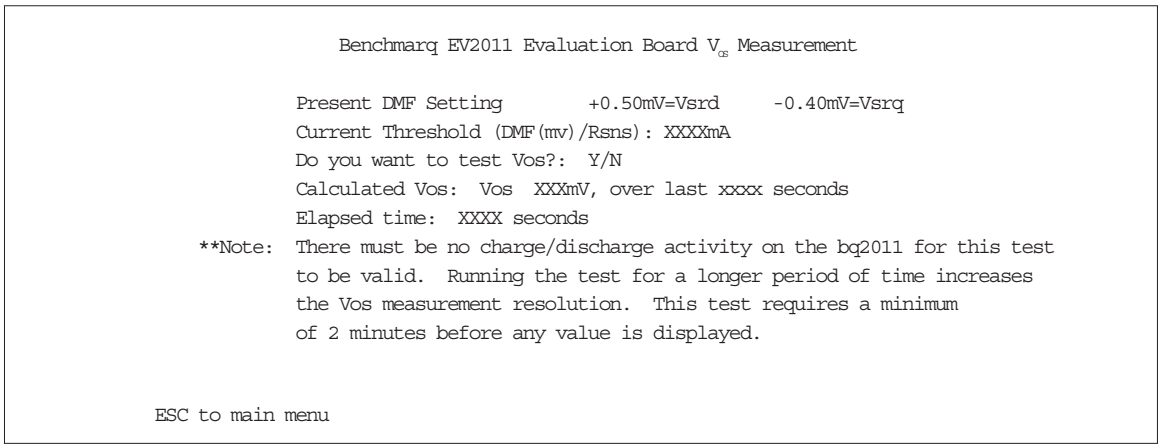


Figure 5. VOS Measurement Screen

Appendix A: AP11 User's Guide

The AP11 utility (AP11.EXE) is used to communicate with the bq2011 on a register basis. AP11 uses a driver to communicate with the EV2011 over serial port on a PC-AT personal computer.

AP11

The AP11 utility is started by executing AP11.EXE. After AP11 is started, the following prompt is displayed:

Select COM Port < 1 2 3 4 >

Commands

The user can respond with various commands at the prompt. Pressing "Q" causes the program to terminate.

–> ?

```
The following commands are available:
    ?          This display is shown.
    A          Send break.
    Q          Quit and return to DOS.
    R#         Read at address #.
    S#         Scan at address #.
    W# = **    Write at address # value **.
```

Pressing the ? key displays following menu:

These commands may be used to send or receive data from the EV2011.

–> A

If A is entered in response to –>, then a break bit is sent to the EV2011. This may be used to restart the communication if a problem appears. If the prompt does not return immediately, then proper communication has not been established; please refer to Appendix B for troubleshooting procedures.

–> R#

If R# is entered in response to –>, where # is an applicable address in HEX format, AP11 returns the value at that location from the EV2011. The addresses are defined in the bq2011 data sheet. For example:

–> R03

causes the display to show:

R03= ##

where ## is the current NAC value in HEX format.

Address 00 is used to read and display all readable registers.

–> S#

If S# is entered in response to –>, where # is a valid bq2011 address in HEX format, AP11 continuously reads and displays the value at that location. The addressed are defined in the bq2011 data sheet. For example:

–> S03

causes the display to show:

Address 3 = ## after XXX.XX sec.

where ## is the value at location 03 and XXX.XX is the number of seconds between changes in this value.

–> W# = **

If W#=** is entered in response to –>, where # is an applicable address in HEX format and ** is the value to be written, AP11 writes the value to that location. The addresses are defined in the bq2011 data sheet. For example:

–> W05 = A0

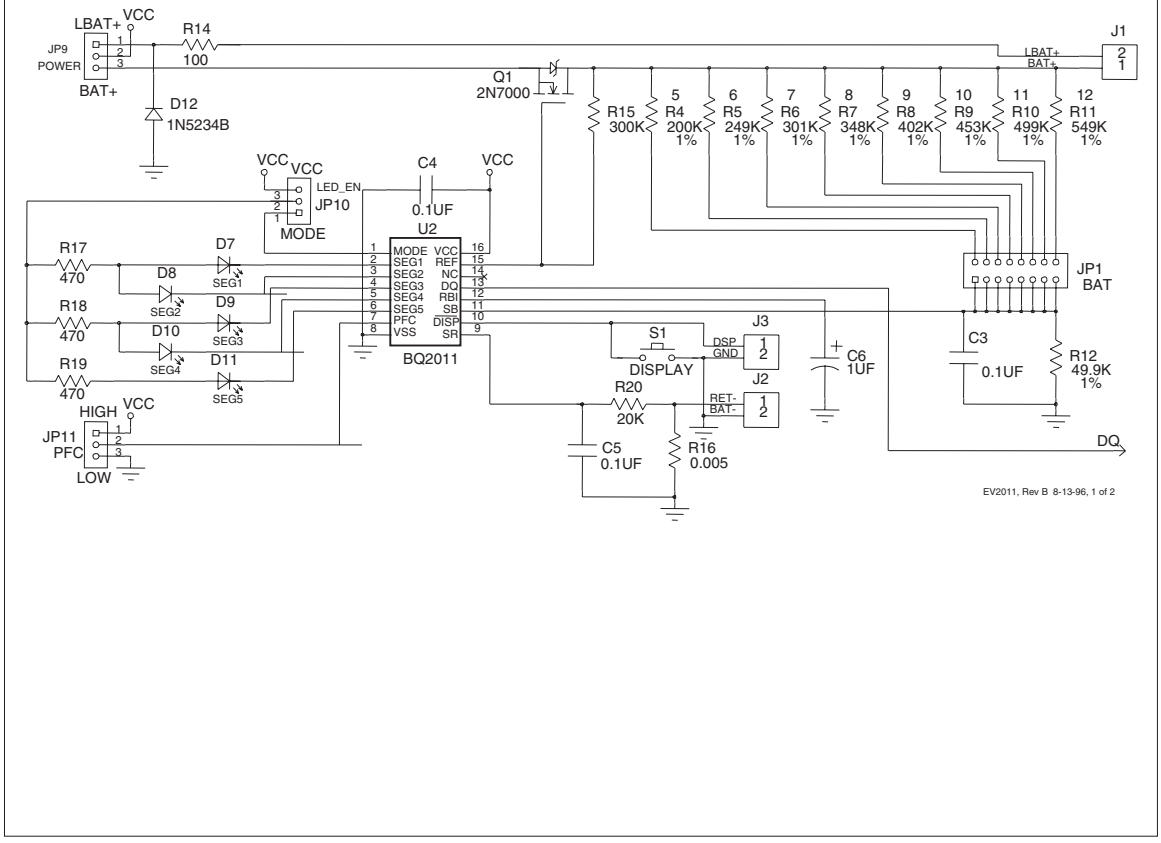
causes the program to write A0 in location 05hex (LMD register).

Appendix B: Troubleshooting

If the EV2011 Main Menu does not appear after starting EV2011, then communication to the bq2011 has not been established. Please check the following:

1. Confirm the proper serial port is being used.
2. Confirm the battery divider is properly set for the number of cells in the battery pack.
3. Confirm JP9 is properly set for either an external supply through LBAT+ (J1) or the microregulator. JP9 on B enables the microregulator, while JP9 on L enables LBAT+. If the battery divider on JP1–JP8 is not set properly, the bq2011 will not operate, and the EV2011 UIP or AP11 will not work.
4. Confirm the battery is attached between BAT+ and BAT– (J1 and J2).
5. Push S1. SEG1 LED should be on indicating that the bq2011 is properly powered.
6. If the LED is not on, check the battery voltage on pin 16 of the bq2011 to determine if it is above 3V but below 6.5V.
7. If the LED is on, and the EV2011 Main Menu still does not appear, try using AP11 to establish communication. Appendix A describes AP11.
8. If communication cannot be established using AP11, the problem is either the RS-232 port in the PC or the EV2011 interface section. Please contact Benchmarq if the interface section is not working properly on the EV2011 board.

Appendix C: EV2011 Schematic



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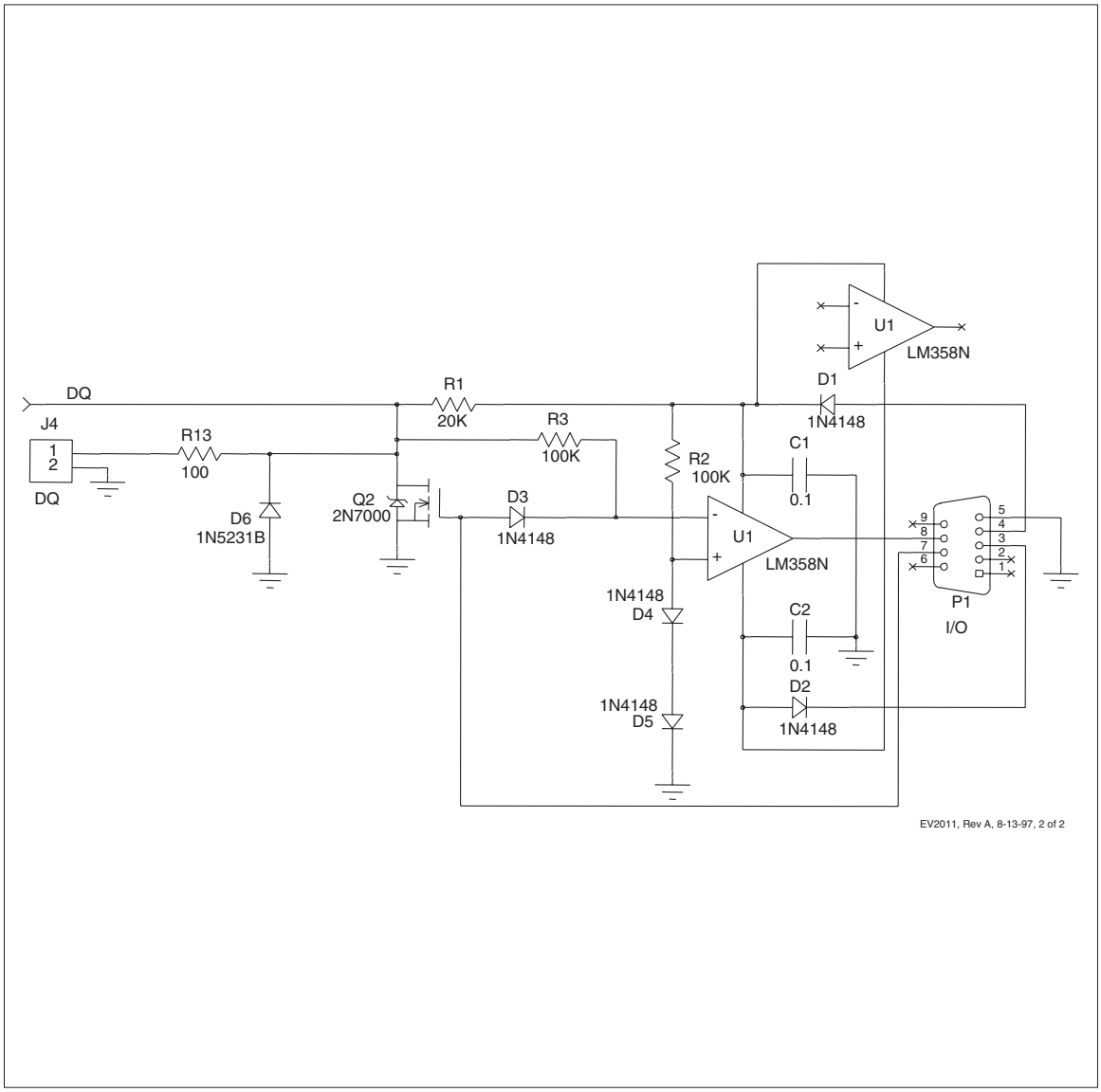
Appendix C: EV2011 Schematic Continued



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Data Sheet Revision History

Change No.	Page No.	Description	Nature of Change
1	1	Updated page numbers for Contents section	Update to page numbers
1	11,12	New two-part schematic	Changed schematic.

Note: Change 1 = Dec. 1996 changes from Aug. 1994.

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