UNITRODE

EV2050

Power Gauge™ Evaluation Board

Contents

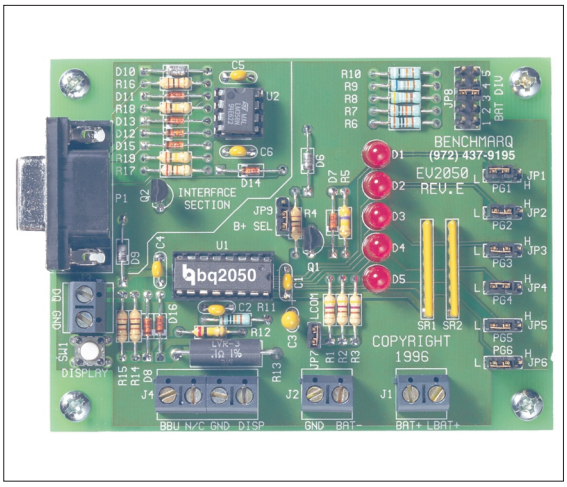
Introduction

The bq2050 Power Gauge IC provides battery capacity monitoring in a single 16-pin SOIC or DIP package. The EV2050 Evaluation Board provides a useful means to test bq2050 functionality and easily interface with the device over the serial port of a PC. The bq2050 features:

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

Functional Description

The EV2050 provides a functional evaluation interface for the bq2050 IC. The actual implementation of a bq2050-based design will be significantly smaller in size. See the bq2050 data sheet for bq2050 specifications.



Power Source

The bq2050 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 R5 as part of the V_{CC} regulation. The EV2050 Evaluation Board is shipped with a 200KΩ resistor for R5.

Current Path

The bq2050 uses a sense resistor (R13) 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 GND (J2) terminal blocks (see the schematic in Appendix C).

Parameter Programming

The EV2050 is programmed by the segment programming pins, using jumpers PROG1-PROG6. The programming pins determine:

- Programmed full count
- Scale factor
- Discharge compensation factor
- Self-discharge compensation (on/off)

EV2050 Contents

Each package contains the following items:

1 EV2050 Evaluation Board

This includes the bq2050 sample, current regulator, programming jumpers, battery divider resistors, and the PC serial port interface.

1 Serial Cable

1 EV2050 (v2.5) User Interface Program Diskette

This program runs on *any AT-compatible computer* equipped with a standard (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 EV2050 Evaluation Board. The User Interface Program communicates with the bq2050 over the DQ serial I/O port using the serial 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.

EV2050 Connections

The connections for the EV2050 are described below. Please refer to the attached schematic in conjunction with these descriptions.

JP1–JP6 **Programming pins 1–6**. These jumpers are used to configure the programming pins. When the jumper is positioned near the H designator, the pins are pulled high. If the jumper is in the other position, the pins are pulled low. If the jumper is removed, the pins are in the high-impedance state. The board is shipped with all pins in the high position. Please refer to the bq2050 data sheet for the proper configuration of $PROG_{1\text{-}6}$.

JP7 **LED enable** (LCOM connection). This jumper connects the LCOM pin of the bq2050 to the LEDs. The board is shipped with this jumper installed to enable LED indication.

JP8 **Battery cell divider.** JP8 is used to divide the battery voltage by 1 (R6) to 5 (R10).

JP9 **V_{CC} supply**. This jumper is used to select the V_{CC} supply for the bq2050. When JP9 is near Q1, the supply is taken from the BAT+ input and is regulated by the bq2050 and Q1. When JP9 is near D14, 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 bq2050 data sheet.

BBU **Register backup input**. This pin is used to provide backup potential to the bq2050 registers during periods when $V_{CC} \leq 3V$. A storage capacitor or a battery can be connected to RBI.

DISP **Display input** ($\overline{DISP}$ pin). DISP is connected in parallel with the push-button switch S1 provided on the EV2050 board. An external switch configuration can be made using DISP and GND on J4. On the EV2050, the LEDs indicate the remaining capacity when the bq2050 detects charge or when the DISP input is taken to GND.

EV2050 Configuration

The EV2050 Evaluation Board may be used with or without the Interface Program. The Evaluation Board should first be configured before connecting the battery or the serial cable.

Step 1 Enabling the LEDs (optional)

JP7 should be installed to enable the LEDs.

Step 2 Connecting the power supply

The EV2050 can operate from power provided by the battery being monitored or from LBAT+. Set the battery divider (JP8) to the correct number of battery cells prior to connecting the battery. If the bq2050 will be powered from the battery, connect JP9 closer to Q1. If the bq2050 will be powered from an external supply, connect JP9 closer to D14. **Important: Connect the battery ONLY after setting JP1–JP6 and JP9.**

Step 3 Connecting the serial 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 GND (J2) on the EV2050. A sense resistor (R3) is in series with the negative terminal of the battery. The EV2050 board is supplied with a 0.1, 1% 3W resistor. Please ensure that the dis-

charge load does not exceed the V_{SR} specification for the bq2050. R3 may be changed to a different-value resistor.

Installing the User Interface Program

The User Interface Program (named "EV2050") 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 serial interface. This driver asks which COM port is connected to the EV2050 Evaluation board. If communication is not established with the EV2050 board, the Main Menu does not appear. Please refer to Appendix B (Troubleshooting) if the program does not establish communication with the EV2050.

The EV2050 uses the PC-AT real-time clock to provide the proper bit timing for serial communication with the bq2050. The modem control lines are used as the single-wire serial interface to the bq2050. Any TSR that uses the PC real-time clock affects the operation of the EV2050. For proper operation, the EV2050 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 EV2050 and the PC. The EV2050 program terminates if communication with the EV2050 board is lost.

Start the User Interface Program as follows:

C>EV2050

Using the EV2050 Program

EV2050 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 EV2050 program has started. If this menu does not appear, communication with the EV2050 has not been established; please refer to Appendix B (Troubleshooting) if the EV2050 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 EV2050 program.

The Main Menu functions are as follows:

<Initialize>	Sends a reset command to the bq2050.
<Program>	Activates a screen showing the current program settings for the bq2050.
<Monitor mWh> and <Monitor mAh>	Activates a screen from which the bq2050 activity is monitored on a real-time basis. Capacity is indicated in mWh or mAh depending on the screen selected.
<Data Log>	Allows entering a file name to which bq2050 data will be logged, and the logging period in seconds. When the log is activated, the display changes to the Monitor mAh screen with a bottom display of: Logging Record: xx
<Measure V_{OS}>	This allows the user to determine the apparent offset voltage of the bq2050 under test. A minimum of 6 minutes is required to complete the V_{OS} measurement, which has a resolution of ±0.15mV per 6 minutes.

Monitor Screens

The EV2050 software provides two real-time monitoring screens. One reports available battery capacity in Amp-hours, the other in Watt-hours. See Figures 2 and 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 bq2050. 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.
SAE	Scaled available energy expressed in terms of mWh.
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.
LMDW	Last measured discharge expressed in terms of mWh.
Sense Resistor Value	This is the sense resistor value from the Program Menu.
CAC	Compensated available capacity expressed in terms of mAh. CAC is similar to NAC but compensates for discharge rate and temperature.
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).
Average V_{SR} Current	This is the average battery current.
Time Remaining	During discharge, this is the time remaining at the average current (NAC / Avg. V_{SR} current).
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 discharge rate exceeds 2C. Please note that the appearance of CHARGE or DISCHARGE indicators is rate-dependent, and may take some time after 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.
Discharge Rate	This is the value of the V_{SR} discharge rate current step as defined in the bq2050 data sheet.
GG Step	This is the lower four bits of the TMPGG register that correspond to the current CAC value relative to LMD. 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.
First EDV	This is the state of the EDV1 flag as programmed in the Program Menu. The default is 1.52V. The EDV1 flag latches ON if V_{SB} drops below the EDV1 threshold value. It remains latched until charging is detected, at which time it is cleared.

```
                Benchmarq bq2050 Evaluation Board Main Menu (v2.5)

                      <Initialize>                <Monitor mAh>

                      <Program>                   <Data Log>

                      <Monitor  mWh>              <Measure Vos>


            Please Enter SR, Avg. Pack Volts in Program Selection for Proper Operation.



                       ESC to exit program     F3 for Help
```

Figure 1. Main Menu

Valid Discharge	This is the state of the VDQ bit in FLGS1. VDQ = yes if the bq2050 is charged until NAC = LMD. VDQ = no indicates the present discharge is not valid for LMD update.
Final EDV	This is the state of the EDVF flag as programmed in the Program Menu. The value of EDVF is set at 1.47V. The EDVF flag latches ON if V_{SB} drops below the EDVF threshold value. It remains latched until charging is detected, at which time it is cleared.
Battery Replaced	This is the state of the battery replaced flag. It is set (BRP = yes) after an EV2050 initialization. The battery replaced flag is cleared if the battery is discharged to the EDV1 level or if it is charged to NAC = LMD.
Pack voltage	This is the cell voltage at the SB pin of the bq2050.
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 register.
FLGS2	This indicates the present state of the FLGS2 register.

```
                    Milli-Amp-Hour Capacity Monitor

    Time: 99:99:99       EMPTY ****_____FULL      Date: 99-99-9999

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

    CAC: 99999 mAh                          Temp Step: XX

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

    Activity: XXXXX        Vsr Discharge Rate:  XX   GG Step: XX

    Charge Rate: XXXX      First EDV:  XXX
    Valid Discharge: XXX   Final EDV:  XXX          Batt. Replaced: XXX
    Pack Voltage: XXX V
    Capacity Inaccurate: XXX   Capacity Inaccurate Count: XXX

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




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

Figure 2. Real-Time Monitor Screen (Milli-Amp-Hour)

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.

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 in the lower right-hand corner. 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 are listed below.

TIME Time record written in seconds

```
                    Milli-Watt-Hour Capacity Monitor

      Time: 99:99:99       EMPTY ****_____FULL      Date: 99-99-9999

      SAE: 99999 mWh       LMDW:  99999 mWh   Sense Resistor Value: XXXΩ

      CAC: 99999 mAh                          Temp Step: XX

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

      Activity: XXXXX        Vsr Discharge Rate:  XX   GG Step: XX

      Charge Rate: XXXX      First EDV:  XXX
      Valid Discharge: XXX   Final EDV:  XXX          Batt. Replaced: XXX
      Pack Voltage: XXX V
      Capacity Inaccurate: XXX   Capacity Inaccurate Count: XXX

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



                              ESC to main menu
```

Figure 3. Real-Time Monitor Screen (Milli-Watt-Hour)

LMD	LMD value in mAh
NAC	NAC value in mAh
Avg. Discharge Current	Average V_{SR} battery current
PACK V	Pack voltage
CAC	CAC value in mAh
SAE	SAE value in mWh
LMDW	LMDW value in mWh
FLAGS1	Binary setting of FLAGS1 flags:

Bit	Meaning
0	EDVF flag state
1	EDV1 flag state
2	Not used
3	VDQ (valid discharge)
4	Capacity inaccurate
5	Not used
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	Not used

The log records should be readable by most spreadsheet programs.

Program Menu

This menu is accessed by selecting the <Program> function on the Main Menu. The programming menu allows the user to set and observe the program state of the bq2050; see Figure 4. To change the bq2050 PFC programming, reconfigure jumpers JP1–JP6 and initialize the bq2050. The reset allows the bq2050 to read the program pins.

Sense Resistor	Press F1 to enter the value of sense resistor in ohms. Typical values range from 0.02 to 0.1Ω. The sense resistor value is used by the EV2050 program to develop meaningful inforEV2050 is started.

```
                    Benchmarq bq2050 Programming

Sense Resistor:     0.1 Ω          Scale Factor:      1/160

Display Mode:       RELATIVE       PFC Count:   XXXXX
                                   PFC (mVH):   XXXX
Self-Discharge                     Battery Capacity   9999 mAh
Rate:               1/512C/day
Battery Type:                X     1 = Graphite  2 = Coke

 End of Dschg:              X.XX
Avg  Pack V:               X.XX
Divider Ratio:                X
Programming Pin Configuration
  Prog-1  H    Prog-4  L
  Prog-2  Z    Prog-5  L
  Prog-3  Z    Prog-6  Z
```

Figure 4. Program Menu

Scale Factor	Select the scale factor from the available scales using JP3. 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 Mode	The RELATIVE display mode uses the last measured discharge capacity of the battery as the battery-full reference.
PFC Count	Program full count from Table 2 from the bq2050 data sheet.
PFC (mVH)	Select the programmed full count using JP1 and JP2. 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.
Self-Discharge Rate	Set at $\frac{1}{512}$C per day for lithium-ion.
Battery Type	Select coke or graphite anode with J5.
End of Dschg	Press F3 to enter the desired end of discharge voltage for the battery pack. The default value is 1.52V for the bq2050.
Avg Pack V	Press F4 to enter the average pack voltage.
Divider Ratio	Press F5 to adjust the reported pack voltage scaled per the equation in the bq2050 data sheet.
Programming Pin Configuration	This displays indicates the programming of the bq2050 by displaying H, Z, or L depending on the state of the program pins. Please refer to the bq2050 data sheet for further details.

Measure V_{OS} Screen

This screen is used to measure the V_{OS} of the bq2050; see Figure 5. A minimum of 360 seconds is 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.

```
                Benchmarq EV2050 Evaluation Board Vos Measurement

          Present DMF Setting        -XXXmV=Vsrd     +XXXmV=Vsrq
          Current Threshold (DMF(mv)/Rsns): XXXXmA
          Do you want to test Vos?:  Y/N
          Calculated Vos:  Vos  XXXmV, over last xxxx seconds
          Elapsed time:  XXXX seconds

-------------------------------------------------------------------------

     **Note:  There must be no charge/discharge activity on the bq2050 for this test
              to be valid.  Running the test for a longer period of time increases
              the Vos measurement resolution.  This test requires a minimum
              of 6 minutes before any value is displayed.
```

Figure 5. VOS Measurement Screen

Appendix A: AP50A User's Guide

The AP50 utility (AP50A.EXE) is used to communicate with the bq2050 on a register basis. AP50 uses a driver to communicate with the EV2050 over serial port on a PC-AT personal computer.

AP50

The AP50 utility is started by executing AP50A.EXE. After AP50 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.

–> ?

Pressing the ? key displays following menu:

```
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 **.
```

These commands may be used to send or receive data from the EV2050.

–> A

If A is entered in response to –>, then a break bit is sent to the EV2050. 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, AP50 returns the value at that location from the EV2050. The addresses are defined in the bq2050 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 bq2050 address in HEX format, AP50 continuously reads and displays the value at that location. The addressed are defined in the bq2050 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. Press ESC to return to the prompt.

–> W## = **

If W##=** is entered in response to –>, where ## is an applicable address in HEX format and ** is the value to be written, AP50 writes the value to that location. The addresses are defined in the bq2050 data sheet. For example:

–> W05 = A0

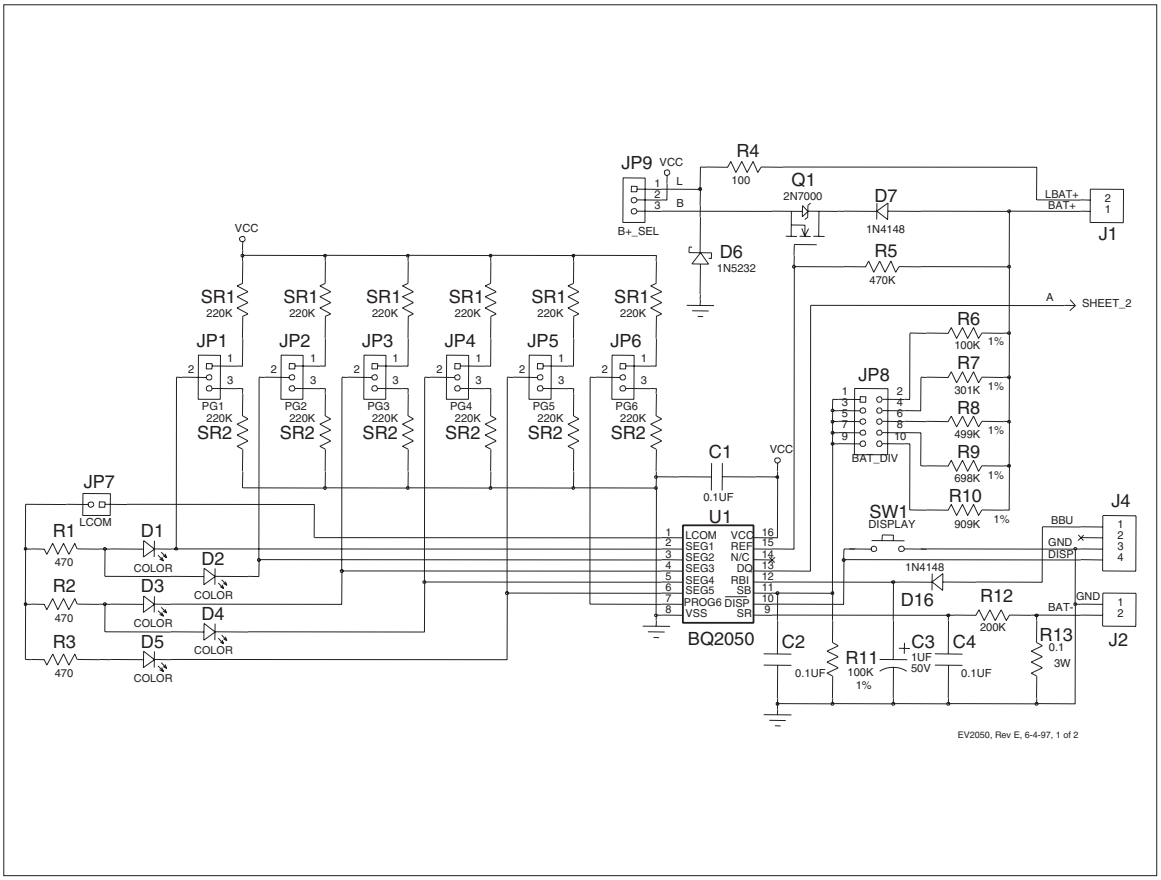
causes the program to write A0 in location 05hex (LMD register).

Appendix B: Troubleshooting

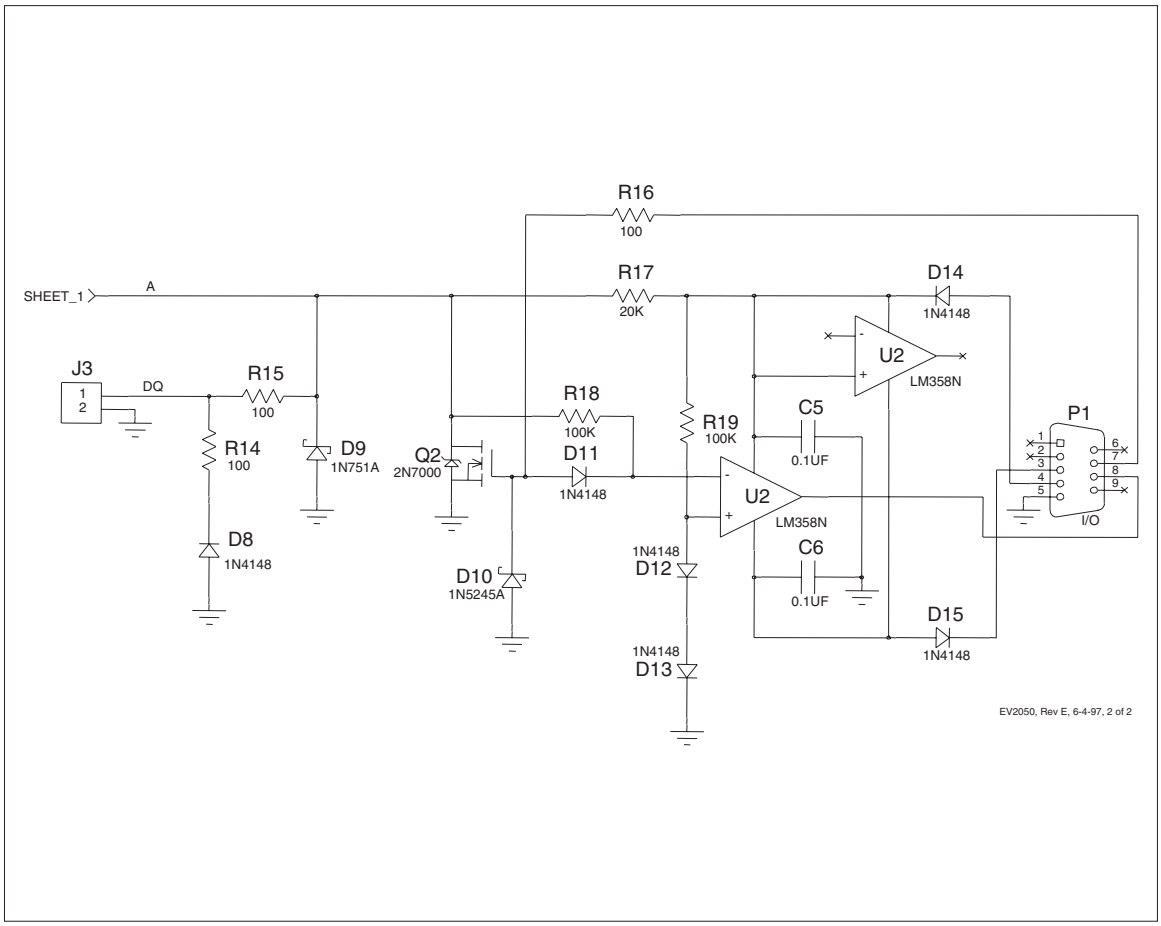
If the EV2050 Main Menu does not appear after starting EV2050, then communication to the bq2050 has not been established. Please check the following:

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 closer to Q1 enables the microregulator, while JP9 closer to D14 enables LBAT+. If the battery divider on JP9 is not set properly, the bq2050 will not operate, and the EV2050 program or AP50 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 bq2050 is properly powered.
6. If the LED is not on, check the battery voltage on pin 16 of the bq2050 to determine if it is above 3V but below 6.5V.
7. If the LED is on, and the EV2050 Main Menu still does not appear, try using AP50 to establish communication. Appendix A describes AP50.
8. If communication cannot be established using AP50, the problem is either the RS-232 port in the PC or the EV2050 interface section. Please contact Benchmarq if the interface section is not working properly on the EV2050 board.

Appendix C: EV2050 Schematic



Appendix C: EV2050 Schematic (Continued)



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