

## LTC6804-2 Addressable isoSPI Battery-Stack Monitor

### DESCRIPTION

Demonstration circuit 1942C is an addressable isoSPI battery-stack monitor featuring the [LTC6804-2](#). These boards can be linked through a 2-wire isolated serial interface to monitor any number of cells on a stack.

Communication to a PC uses a DC590 USB interface board. A control program for up to ten stacked boards has a Graphical User Interface (GUI) to implement the device command set.

Multiple DC1942C can be controlled using the DC1941B isoSPI adapter and RJ45 terminated Ethernet patch cables.

**Design files for this circuit board are available at <http://www.linear.com/demo>**

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### HARDWARE SETUP (SINGLE-BOARD)

Separate the screw-terminal section from J1 and wire cell voltage connections or resistors into the clamping contacts to provide the input stimulus for the ADC.

Cell voltages are wired from position 4 (most negative potential of the group) with increasing potentials up to position 16 (most positive potential).

Alternatively, resistors can be used to simulate battery cells. For this, connect twelve 100Ω leaded resistors between each contact from position 4 to position 16. Provide a stack-equivalent power supply connection to position 16 (positive) and position 4 (return). The supply may be adjusted to provide the desired nominal cell voltage (ex. 40V will be 3.33V/cell).

Make the following connections for one board interfaced to a PC:

1. Set jumpers on the board per Figure 1.
2. Connect a USB cable from the PC USB port to DC590.
3. Connect a 14-pin ribbon from DC590 to the SPI connector (J2) on DC1942C.
4. Preset a power supply to 9V and connect to VEXT+ (positive) and VEXT- (return). When powered on, a blue LED will illuminate. The 9V supply will run between 11mA and 30mA typically.
5. Mate the J1 cell-voltage connector.

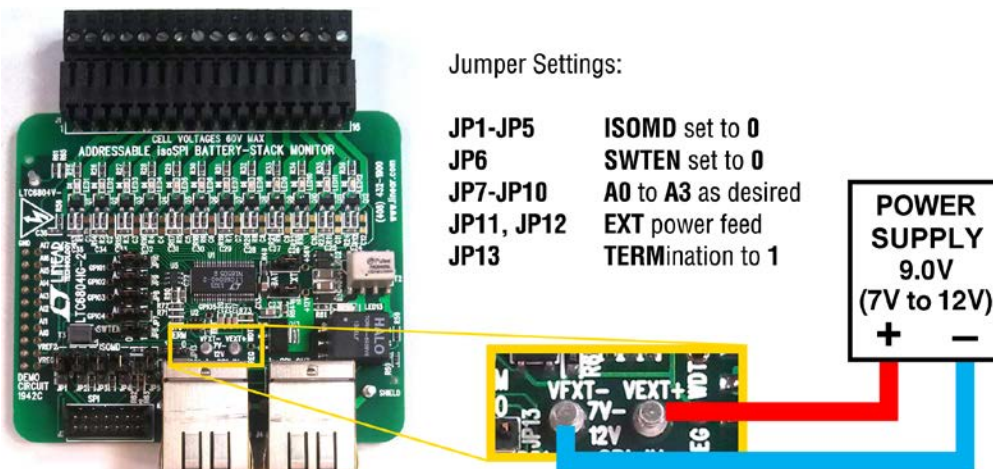


Figure 1. Connections and Jumpers

## SOFTWARE SETUP

### QUIKEVAL DRIVER

To use the DC590B USB Interface board, the PC must first have the proper driver installed. To do this, download the QuikEval™ software from Linear Technology, at [www.linear.com](http://www.linear.com):

[http://www.linear.com/designtools/software/quick\\_eval.jsp](http://www.linear.com/designtools/software/quick_eval.jsp)

- 1) Install the QuikEval software by running the executable `lqcgev.exe`. Follow the instructions to connect DC590B.

NOTE: You will be instructed to ensure that the DC590B is not connected to the PC:



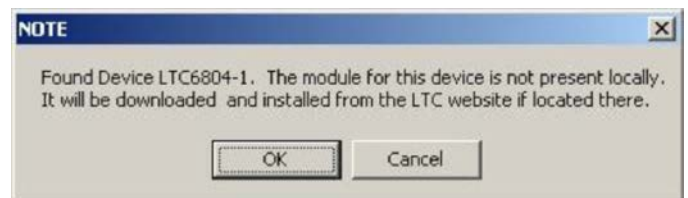
If you fail to unplug the DC590B, the DC590B driver `FTD2XX.DLL` will not install!

- 2) When installation of QuikEval is complete, close the QuikEval program.
- 3) Reopen QuikEval, then connect the DC590B to confirm that QuikEval software was installed correctly. If properly installed, QuikEval will show the following message:



If not properly installed, QuikEval will be unable to connect to the DC590B. Please retry the software installation, with the DC590B disconnected.

- 4) Connect the LTC6804 Demoboard to the DC590B with QuikEval software open.
- 5) The QuikEval software will recognize when the LTC6804 demo board has been found, and will offer to download and install the module from the LTC website:



At this point, select cancel (Remember, QuikEval will not be used to communicate with the LTC6804 demo board). If you select OK, instead of cancel, QuikEval will report that the module is not available on the LTC website.



- 6) The QuikEval software will open and indicate that the LTC6804 device has been found. It will also indicate that there is no module for this device. This is normal and indicates that QuikEval does not directly control the LTC6804 demo boards:



- 7) Close QuikEval Software, as it is no longer needed for this demosystem.

## LTC6804 Graphic User Interface

The LTC6804 Graphic User Interface (GUI) is provided in a zipped file, LTC6804\_GUI\_Vxx\_yyyyymmdd.zip.

- 1) Unzip this folder
- 2) Run the setup.exe file to start installation

- 3) Ignore the security warning by selecting Install.
- 4) The GUI control panel appears immediately after installation. Subsequent starts of the GUI are done through the Windows Start menu or the optional Windows Desktop shortcut icon.

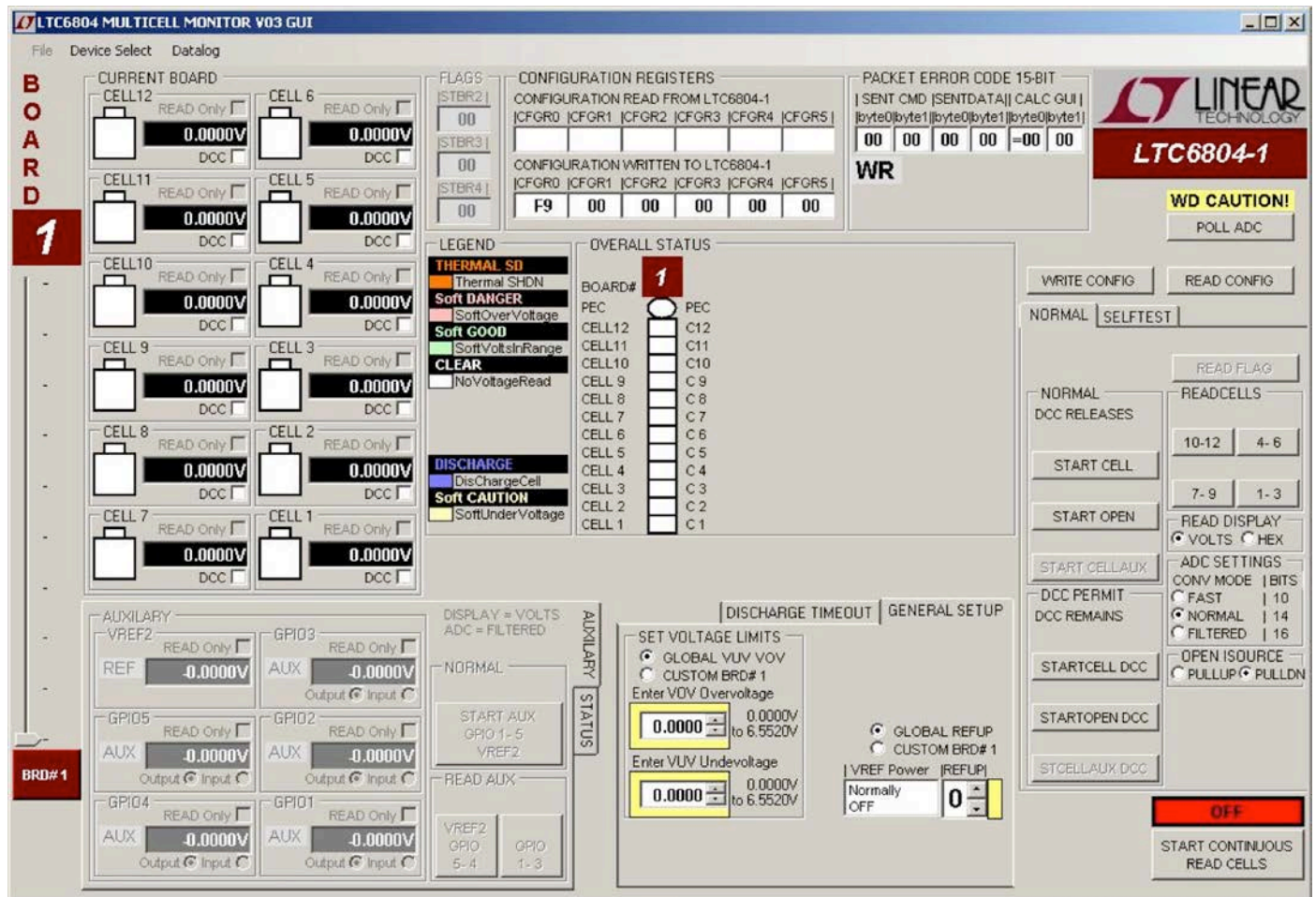


Figure 2. GUI Control Panel Start-Up Screen

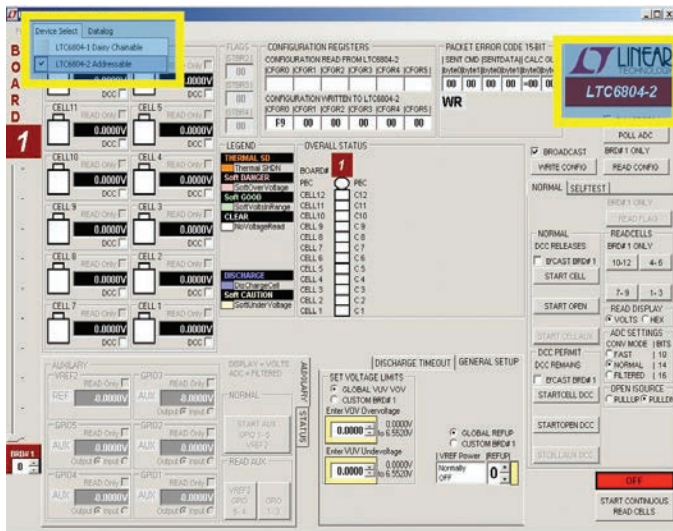


## OPERATING THE CONTROL SCREEN

### FIRST

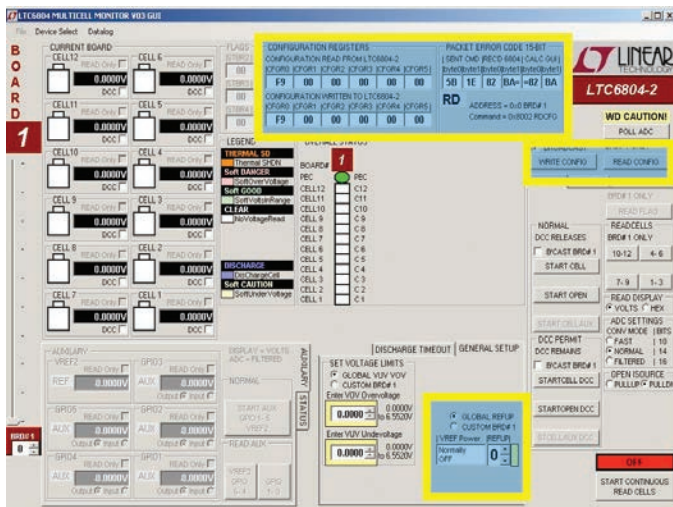
Figure 2 is the initial start-up screen that appears when the program is launched. Once power is supplied to the board from a stack of cells or a power supply, the communication between the PC and the board can be checked.

### 1: SET DEVICE MODE



Click the Device Select menu, upper left of the GUI, then click LTC6804-2 Addressable to set the correct GUI mode. Additional controls will appear and the upper right GUI label will display LTC6804-2.

### 2: READ CONFIGURATION



Click the command button labeled READ CONFIG. If all is properly connected and operating the start-up default configuration of the LTC6804-2 will be read from the board. The Hex codes for the six bytes of configuration setting will appear in the CONFIGURATION REGISTERS section in the boxes labeled CONFIGURATION READ FROM LTC6804-2. The initial configuration bytes should be 0xF1 for register 0 and 0x00 for the other five bytes. This default configuration is the sleep mode for the LTC6804-2 on DC1942C.

The LTC6804 calculates a 15-bit Packet Error Code, PEC15, as a 16-bit word and appends it to the data stream each time it sends out data. The LTC6804 responds to the READ CONFIG command by sending six bytes. For the six bytes sent by a READ CONFIG command and received by the GUI, the control program also calculates a PEC15. The received PEC15 word and the calculated PEC15 word are displayed in the top section labeled PACKET ERROR CODE 15-BIT. The oval located at the top of the color coded status panel for the one board will turn green if the received and calculated PEC15 words match. Data transmission errors will produce red warning indications when the PEC15 words do not match. There is also a display of the PEC15 that was sent with the most recent command to the LTC6804, which had to match an internally calculated value to be accepted as a valid command.

### 3: WRITE CONFIGURATION

The GUI allows the user to configure the LTC6804, such as the undervoltage and overvoltage levels, and the operating state. However, setting the configuration within the GUI does not change anything within the LTC6804 until the Write Configuration command is executed. Clicking the WRITE CONFIG command button sends the configuration to the LTC6804. When the command is sent, the six Hex bytes shown in the box labeled CONFIGURATION WRITTEN TO LTC6804 will become bold type. This box provides the exact hex values required by the LTC6804 and can be used to facilitate control program development.

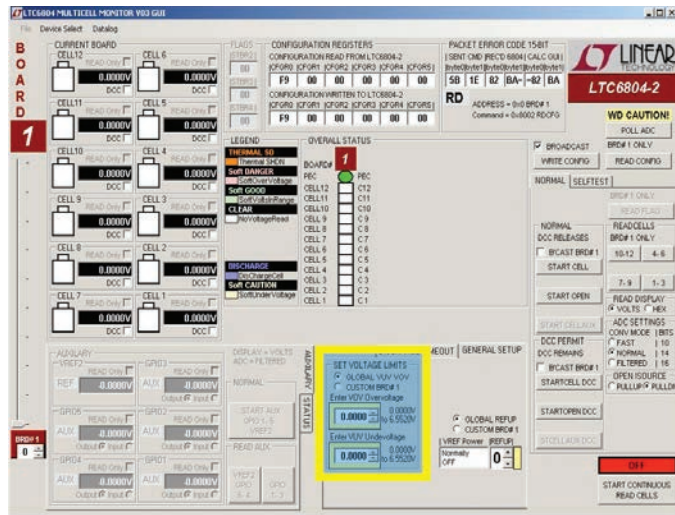
Clicking the READ CONFIG button can see confirmation that the configuration change was actually made. The six bytes read back should match the six bytes sent and the PEC15 should be a match (green PEC oval on stack display).

## OPERATING THE CONTROL SCREEN

When any configuration information is changed on the screen the WRITE CONFIG command button will be illuminated. This serves as a reminder that this command still needs to be executed.

NOTE: To get started, it is recommended to set REFUP to 1, followed by a WRITE CONFIG command. The Watchdog Timer (WDT) will now be continually serviced with the POLL ADC command and the stack is ready to be monitored. Leaving REFUP at the default setting of 0, the WDT times out in 2 seconds and all configuration information is reset.

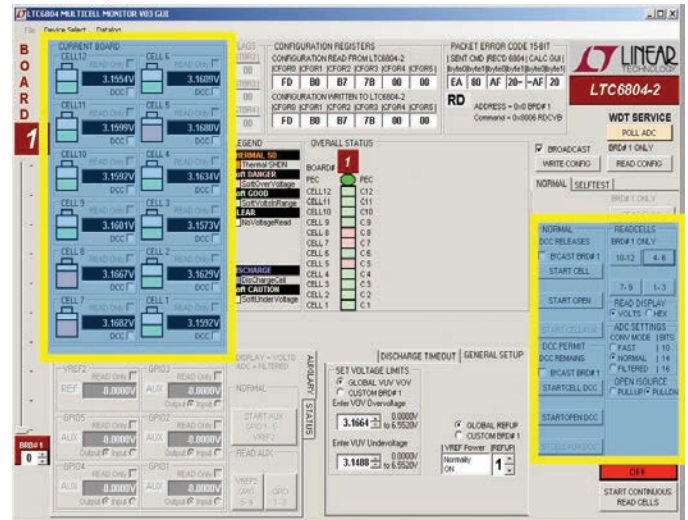
### 4: PROGRAM THE CELL MONITORING VOLTAGE THRESHOLDS



In the section labeled SET VOLTAGE LIMITS the user can enter voltage values for the overvoltage and undervoltage thresholds. The voltage value entered will be rounded to the actual value used by the LTC6804 and displayed in the box. The voltage ranges for these thresholds is 0V to 6.5520V.

These monitor thresholds can be applied globally to each and every cell in the system or customized for the cells connected to an individual board by clicking the desired option button. Individual boards are selected for programming by the left hand tabs in multiple board systems.

### 5: READ CELL VOLTAGES



The essential function of the LTC6804 is to measure and report the voltage on each battery cell. This is accomplished in two steps. First, click on the STARTCELL button. This commands an A/D conversion of all 12-cell voltages. Next, use the four buttons in the READ CELLS section to display the cell voltages. The actual cell voltage measurements are displayed in groups of 3 as each button is clicked.

NOTE: Before initiating cell measurements, the user can set the bit-resolution by selecting the desired mode within the box ADC SETTINGS CONV MODE.

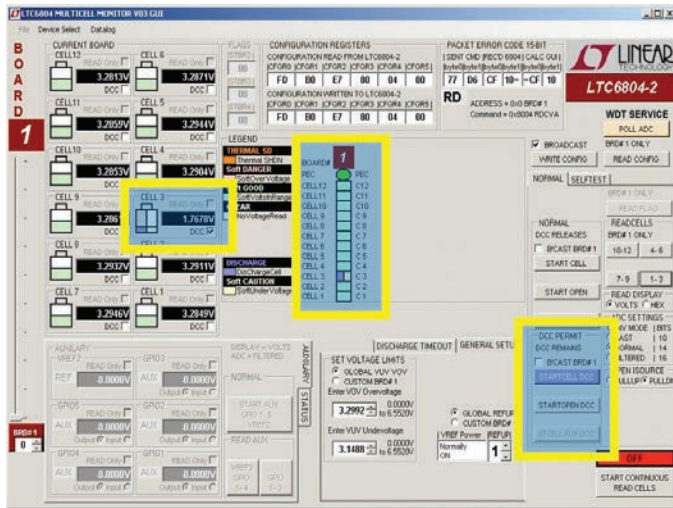
The READ DISPLAY box has options to display Cell Voltages in VOLTS or HEX. First select VOLTS or HEX then click on one of the command buttons inside READ CELLS box. Every time a command button inside the READ CELLS box is clicked; new data is downloaded from the board and displayed as selected in VOLTS or HEX.

### 6: DISCHARGE CELLS

Another major feature of the LTC6804 is the ability to remove charge from individual cells. This can help to distribute the cell charge evenly over a stack of batteries. DC1942C contains a P-channel MOSFET in series with a 33Ω resistor across each cell connection. When enabled, charge is pulled from the cell and energy dissipated in the switch and resistor.



## OPERATING THE CONTROL SCREEN



A check box is provided for each cell to be discharged. Checking this box (Cell 3 in the above example screenshot) and then writing the new configuration with a WRITE CONFIG button push will load the cell.

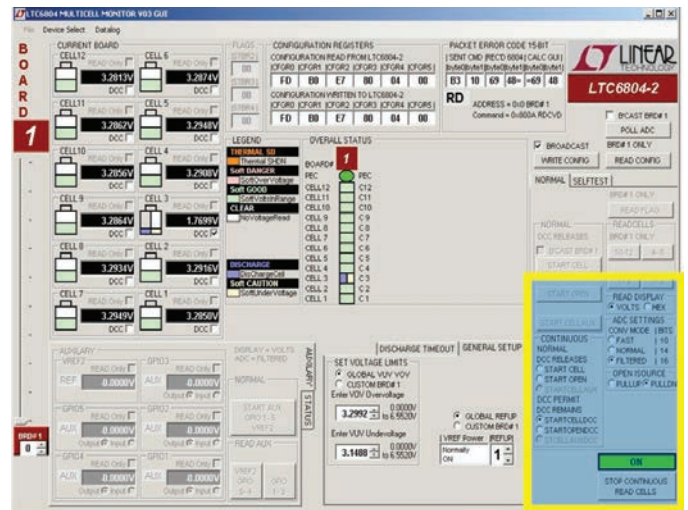
NOTE: The discharge transistors are automatically turned off momentarily when measuring cell voltages using the STARTCELL command. This prevents voltage drop errors caused by the discharge current and ensures that the true cell voltage is obtained. The LTC6804 offers the option of keeping the discharge transistors on while measuring cell voltages, using the STARTCELL DCC command button. This command button is illuminated blue when executed. In this mode, the lower voltage reading includes I \* R errors introduced by cabling and connectors, as well as the load on the cell.

### OTHER CONTROL FEATURES

Additional command buttons are provided on the control screen. The POLL ADC command button is used to determine if the ADC is busy (in the process of converting). The result of this command can be observed by monitoring the serial data output line of the SPI interface to the Bottom Port, J2. There is no indication provided on the control screen.

The START OPEN (WIRE) command button connects the built in open wire detection circuitry to all cells. This command must be followed by any command buttons inside the READ CELLS box click to see the result. The OPEN ISOURCE box provides options to use either PULLUP or PULLDOWN Open Wire Test Currents. An open wire connection to any cell will be indicated by an abnormally high voltage measurement for the cell above the open wire and a near 0V measurement for the cell with the open wire.

### CONTINUOUS OPERATION



For convenience, the control panel allows for continuous operation of the DC1942C board. Using the command button labeled START CONTINUOUS READ CELLS, the board control is placed in a continuous loop executing the following command sequence automatically:

- Start cell voltage
- Read cell voltage groups A (1-3), B (4-6), C (7-9), and D (10-12)

Options available are the READ DISPLAY box, ADC SETTINGS box, OPEN ISOURCE box, and the CONTINUOUS box. The CONTINUOUS box allows the selection of STARTCELL, STARTOPEN, STARTCELL DCC, and STARTOPEN DCC commands to be executed during continuous operation. This is useful for monitoring the cell voltage measurements under different ADC Test Conditions.

## OPERATING THE CONTROL SCREEN

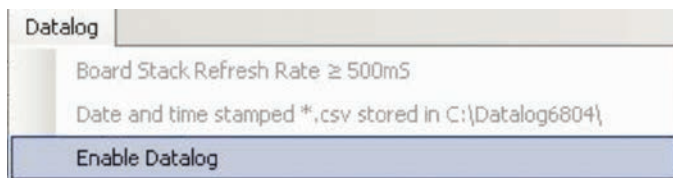
All values are updated continually (update rate is ~500ms in FAST or NORMAL and ~750ms in FILTERED Conversion Mode). While running, the configuration can be changed on the fly. Simply changing a configuration item (Discharge cells for example) and clicking the WRITE CONFIG button will implement the new configuration and return to continuous operation.

A green box with the label ON in the lower right corner of the GUI indicates that the system is running continuously. A red box with the label OFF means that the system is stopped and waiting for a new command to be sent.

## DATALOGGING OPERATION

The GUI program can datalog or store cell voltage results in a CSV (Comma Separated Value \*.csv) file. This feature is useful in characterizing cell voltages over time. Datalogging operates similarly to continuous operation but has the added functionality of storing results in a CSV file.

1. At the upper left of the GUI, click on the Datalog Menu then Enable Datalog.



Datalog mode is enabled when a maroon box appears to the left of the START CONTINUOUS READ CELLS command button and the red box label changes from OFF to DATALOG OFF. Datalog mode is disabled when the maroon box disappears and the red box label reverts to OFF.

NOTE. The \*.csv filenames include the time created and are stored by default into the C:\Datalog6804\ folder. More details about datalogging are in the file AboutCurrentVersion.txt inside the GUI's installation folder (normally C:\Program Files\LTC\MultiCellBatteryMonitor\LTC6804).

2. Click on the START CONTINUOUS READ CELLS command button to start datalogging onto a new CSV file.

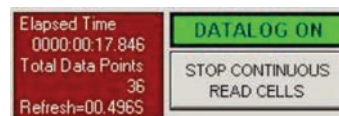


Elapsed Time = Total time of Datalog from start to finish.

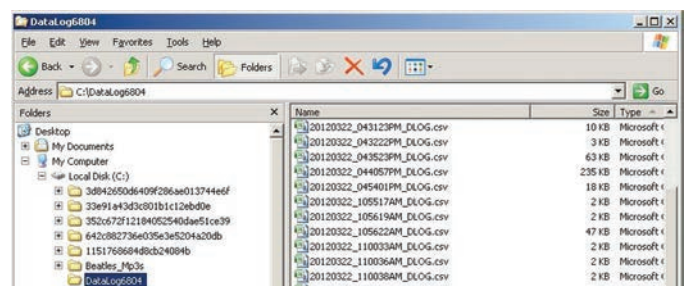
Total Data Points = Total data points of Datalog from start to finish.

Refresh = Time in seconds (s) between each Read Cells command; also known as Sample or Update Rate.

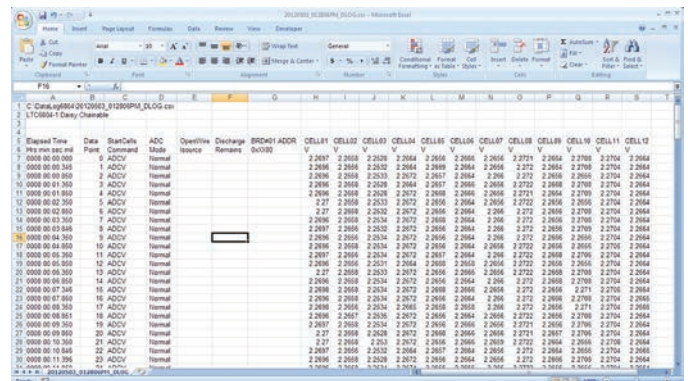
3. Click on the STOP CONTINUOUS READ CELLS command button to stop datalogging and close the CSV file.



4. The CSV file is ready to view. Go to C:\Datalog6804\ folder and open file.



5. View the CSV file in a compatible spreadsheet software program such as MS Excel.



# DEMO MANUAL DC1942C

## OPERATING THE CONTROL SCREEN

### SOFTWARE ADJUSTMENTS

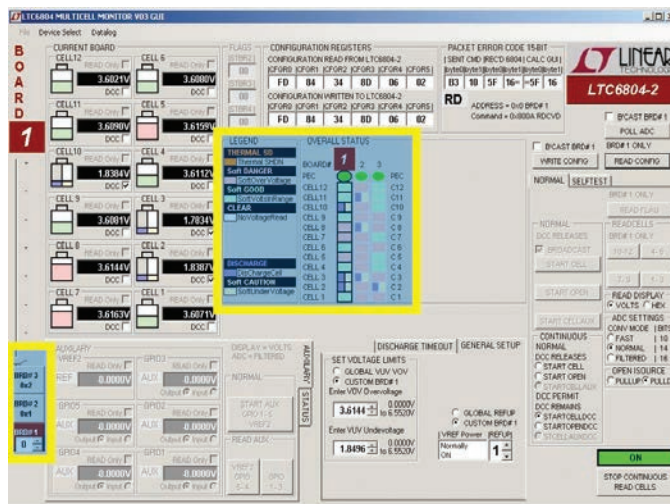
The GUI program can control up to ten boards on a stack.

1. Select the number of boards on the stack by sliding the track bar up or down; located at the bottom left of the screen.
2. A tab will appear on the left edge of the control panel for each board on the stack. Clicking on any of these tabs will transfer control commands and data to and from the display screen to that selected board.
3. Select whether the ADC's voltage reference powered state (Ref Up) and over/under voltage thresholds for each board are to be the same (GLOBAL) or different for each board (CUSTOM) and set the Ref Up and voltages accordingly.

### COLOR CODED STATUS PANEL

The color coded status panel will expand to include all boards connected in a stack. Each small square in this array represents an individual battery in the stack of

boards. The intent of this display is to provide a way to see the status of all cells at a glance. The significance of the colors used is explained in the legend on the screen.



The last page shows the schematic for DC1942C. Consult the data sheet for detailed information concerning the operation of the LTC6804-2.



## HARDWARE SETUP (MULTI-BOARD)

1. Connect a USB cable from the host computer to the DC590 as in Figure 4.
2. Connect a 14-pin ribbon from DC590 to the SPI connector (J2) of a DC1941 as in Figure 4.
3. Refer to the DC1941 manual to configure the jumpers as a master device for isoSPI.
4. Connect RJ45 patch cables for isoSPI. A cable will be connected between the DC1941 (J1) and the first DC1942C (at J3 usually). The two iso-SPI connectors on each DC1942C are inter-changeable, so the connection pattern is not important. Build out the isoSPI bus by adding RJ45 patch cables between each successive DC1942C as shown in Figure 3.
5. Configure the jumpers of the DC1942C units as shown in Figure 3.
6. Preset a power supply to 9V and connect unpowered to VEXT+ (positive) and VEXT- (return) of any DC1942C.
7. When powered on, blue LEDs will illuminate. The 9V supply will run about 17mA per board.
8. Prepare cell connections and then mate the J1 cell voltage connectors (they are separable so wiring can be done safely).

Jumper Settings:

**JP1-JP5 ISOMD** set to 1  
**JP6** SWTEN set to 0  
**JP7-JP10** A0 to A3 to 0,0,0,0  
**JP11, JP12** EXT power feed  
**JP13** TERMINATION to 0

Jumper Settings:

**JP1-JP5 ISOMD** set to 1  
**JP6** SWTEN set to 0  
**JP7-JP10** A0 to A3 to 1,0,0,0  
**JP11, JP12** EXT power feed  
**JP13** TERMINATION to 0

Jumper Settings:

**JP1-JP5 ISOMD** set to 1  
**JP6** SWTEN set to 0  
**JP7-JP10** A0 to A3 to 0,1,0,0  
**JP11, JP12** EXT power feed  
**JP13** TERMINATION to 1

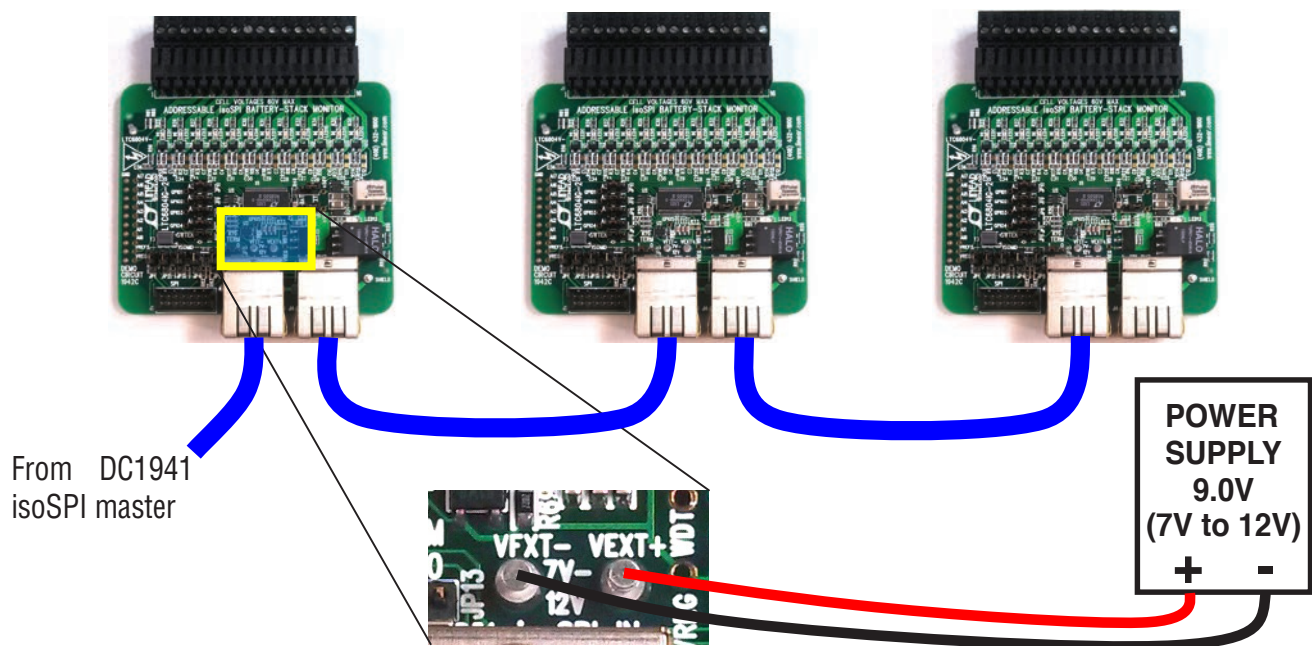


Figure 3. Connecting Multiple DC1942C in an isoSPI Bus

## HARDWARE SETUP (MULTI-BOARD)

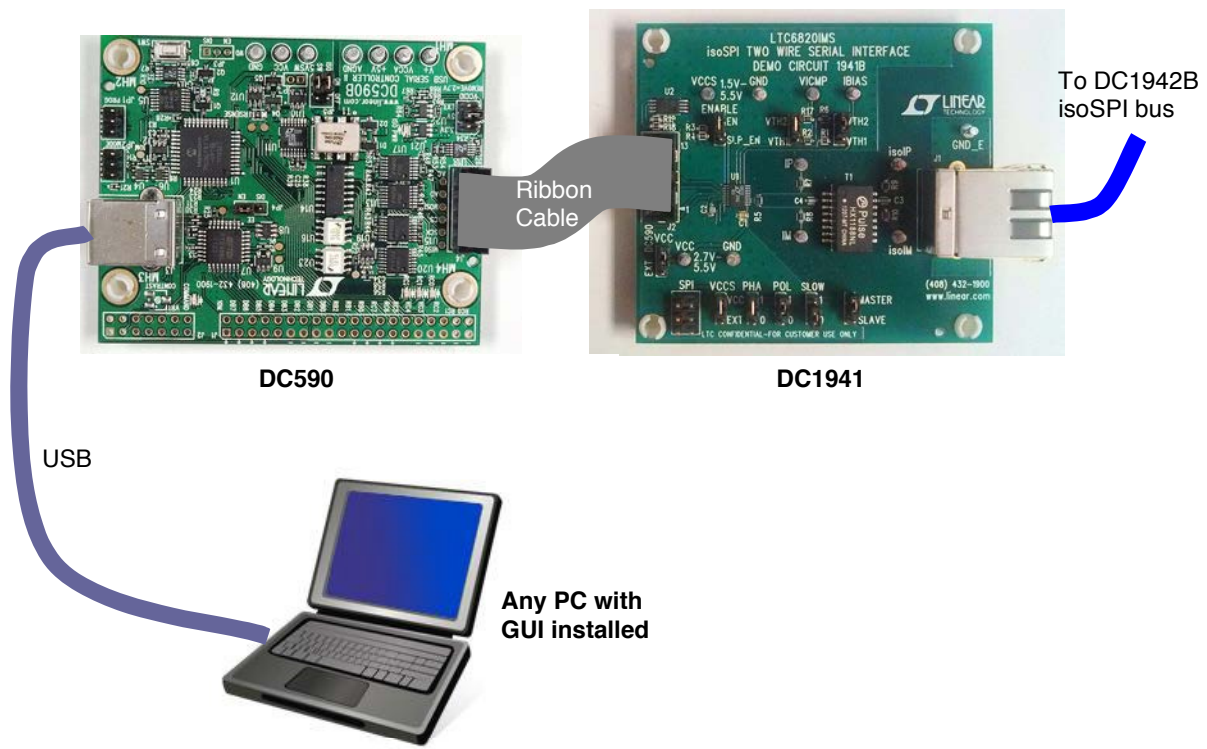


Figure 4. Connections for Setting Up isoSPI Master

## COMMANDS SUPPORTED (V05 VERSION)

POLLADC	READ CELL GROUPS (A, B, C and D. Read Volts/Hex)
WRITE CONFIG (REFUP, VUV, VOV, Discharge selected cells)	READ FLAGS
READ CONFIG	READ AUX
START CELL and OPEN WIRE conversions with and without discharge connected (ADC Settings: Conversion Mode, Open Wire Test Current (Open Isource))	START CONTINUOUS read all cells every 500ms.

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## COMMANDS NOT SUPPORTED (V05 VERSION)

SELFTTEST	For the latest software, contact your local LTC sales office. Design files for this circuit board are available. Call the LTC factory.
GPIO FUNCTIONS	



# DEMO MANUAL DC1942C

## PARTS LIST

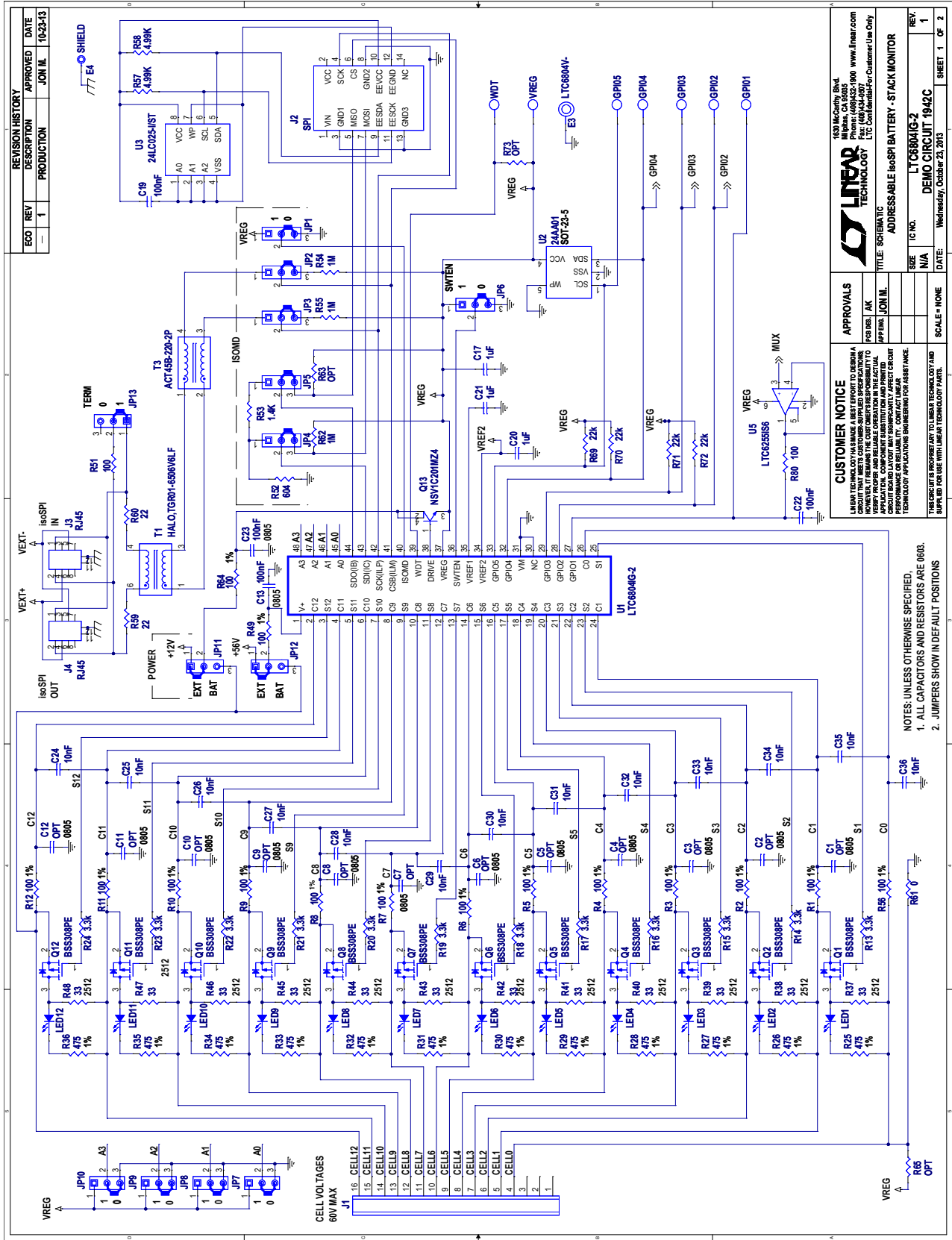
ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	0	C1-C12	CAP., 0805, OPT	
2	2	C13, C23	CAP, 0805 100nF 10% 100V X7R	MURATA GCM21BR72A104KA37L
3	3	C17, C20, C21	CAP, 0603 1µF 10% 16V X7R	MURATA GCM188R71C105KA64D
4	2	C19, C22	CAP, 0603 100nF 10% 25V X7R	MURATA GCM188R71E104KA57D
5	13	C24-C36	CAP, 0603 10nF 10% 50V X7R	MURATA GCD188R71H103KA01
6	2	C37, C40	CAP., 1206 4.7µF, 10%, 25V X7R	MURATA GCM31CR71E475KA55L
7	1	C38	CAP., 0603 4.7nF, 10%, 25V X7R	MURATA, GCM188R71E472KA37D
8	1	C39	CAP., 0603 220pF 10% 25V NPO	AVX, 06033A221KAT2A
9	1	C41	CAP., 1206 1µF 10% 100V X7R	MURATA GCM31CR72A105K
10	0	C42	CAP., 0603 27pF	C0603
11	1	D1	SM ZENER DIODE, SOD-123, CMHZ5264B	CENTRAL SEMI., CMHZ5264B TR
12	1	D2	SM LOW LEAKAGE SILICON DIODE, SOD123	CENTRAL SEMI., CMHD459A TR
13	1	D3	SCHOTTKY DIODE, SOD-123	CENTRAL SEMI, CMMSH1-40 TR
14	4	E1-E4	TURRET	MILL MAX 2308-2-00-80-00-00-07-0
15	13	JP1-JP13	HEADER, 3 PIN, 2mm	SAMTEC TMM-103-02-L-S
16	13	XJP1-XJP13	SHUNT	SAMTEC 2SN-BK-G
17	1	J1	CONNECTOR, 1X16 3.5mm, HORIZ.	WEIDMULLER 1761682001
18	1	J2	HEADER, 2X7 2mm	MOLEX 87831-1420
19	2	J3, J4	Connector RJ45, CACE CODE 00779	TYCO, 5406298-1
20	12	LED1-LED12	LED, 0603 GREEN	LITE-ON LTST-C190KGKT
21	1	LED13	LED, BLUE, LED-ROHM-SML-010MT	ROHM, SML-010BATT86K
22	2	L1, L2	IND., 1206	MURATA BLM31PG330SN1L
23	1	P1	CONN. MATING 1X16 3.5 HORZ	WEIDMULLER 1615770000
24	12	Q1-Q12	XSTR, MOSFET, P-CHANNEL	INFINEON, BSS308PEH6327XT
25	1	Q13	XSTR, NPN, 100V, 2.0A, SOT223	ON SEMI, NSV1C201MZ4
26	17	R1-R12, R49, R51, R56, R64, R80	RES., CHIP, 100Ω 1% 0603	NIC, NRC06F1000TRF
27	12	R13-R24	RES., CHIP, 3.3k, 1% 0603	VISHAY, CRCW06033K30FKEA
28	12	R25-R36	RES., CHIP, 475Ω, 1% 0603	NIC, NRC06F4750TRF
29	12	R37-R48	RES., CHIP, 33Ω, 1% 2512	VISHAY, CRCW251233R0FKEG
	12	ALTERNATE FOR R37-R48	RES., CHIP, 33Ω, 5% 2512	NIC, NRC100J330TRF

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
30	1	R52	RES., CHIP, 604Ω, 1% 0603	VISHAY, CRCW0603604RFKEA
31	1	R53	RES., CHIP, 1.4k, 1% 0603	VISHAY, CRCW06031K40FKEA
32	3	R54, R55, R62	RES., CHIP, 1M, 1% 0603	VISHAY, CRCW06031M00FKEA
33	2	R57, R58	RES., CHIP, 4.99k, 1% 0603	VISHAY, CRCW06034K99FKEA
34	2	R59, R60	RES., CHIP, 22Ω, 1% 0603	VISHAY, CRCW060322R0FKEA
35	1	R61	RES., CHIP, 0Ω, 1% 0603	NIC, NRC06Z0TRF
36	0	R63, R65, R73	RES., CHIP, 0603 OPT	
37	4	R69, R70, R71, R72	RES., CHIP, 22k, 1% 0603	VISHAY, CRCW060322K0FKEA
38	1	R74	RES., CHIP, 100k, 1% 0603	VISHAY, CRCW0603100KFKEA
39	2	R75, R77	RES., CHIP, 39.2k, 1% 0603	VISHAY, CRCW060339K2FKEA
40	1	R76	RES., CHIP, 402k, 1% 0603	VISHAY, CRCW0603402KFKEA
41	9	R78, R82-R89	RES., CHIP, 10k, 1% 0603	NIC, NRCF1002TRF
42	1	R79	RES., CHIP, 95.3k, 1% 0603	VISHAY, CRCW060395K3FKEA
43	1	R81	RES., CHIP, 4.7k, 1% 0603	VISHAY, CRCW06034K70FKEA
44	1	T1	XFMR, 1:1, 650mH	HALO, TGR01-A6506V6LF
45	1	T2	TRANSFORMER, PA0648NL	PULSE, PA0648NL
46	1	T3	COMMON MODE FILTERS FOR CAN	TDK, ACT45B-220-2P-TL003
47	1	U1	IC, BATTERY MONITOR, SSOP-48, 5.3MM	LINEAR TECH. LTC6804IG-2#PBF
48	1	U2	IC, 24AA01, SOT23-5, MARKING CODE B1	MICROCHIP TECH. 24AA01T-I/OT
49	1	U3	IC, 24LC025-I/ST	MICROCHIP TECH. 24LC025-I/ST
50	1	U4	IC, LT3511EMS, 16 PIN MSOP	LINEAR TECH. LT3511EMS#PBF
51	1	U5	IC, LTC625, 5IS6, 6-LEAD TSOT-23	LINEAR TECH. LTC6255IS6#PBF
52	1	U6	IC, 8-CHANNEL ANALOG 74HC4051PW	NXP SEMI., 74HC4051PW
53	4	MH1, MH2, MH3, MH4	STANDOFF, SNAP ON	KEYSTONE_8831
54	0		CABLE, 1FT PATCH CAT5	ASSMANN ELEC INC., DK-1611-001/BL

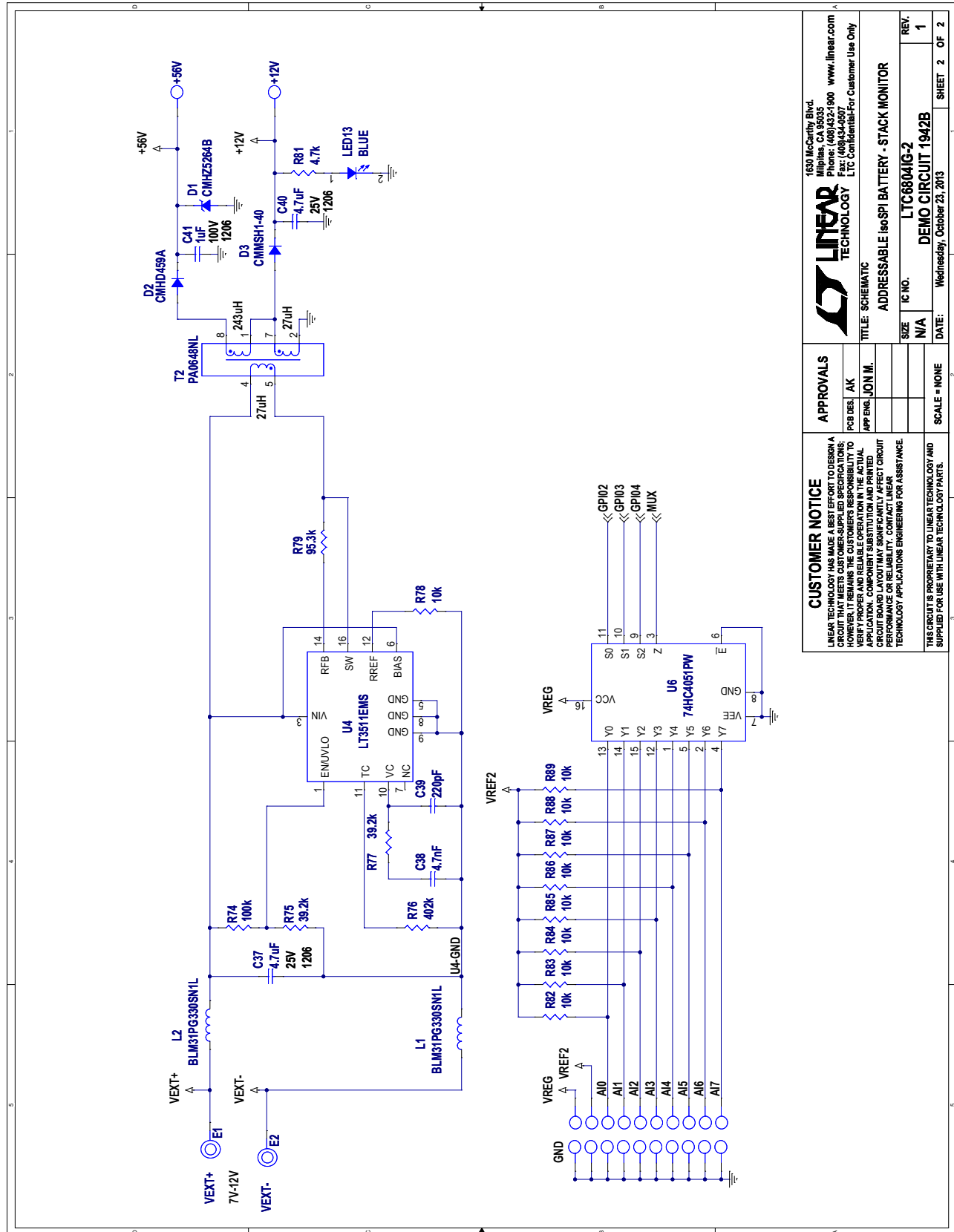
# DEMO MANUAL DC1942C

## SCHEMATIC DIAGRAM





SCHEMATIC DIAGRAM



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<p><b>LINEAR TECHNOLOGY</b></p>		<p>TITLE: SCHEMATIC</p> <p>ADDRESSABLE IsoSPI BATTERY - STACK MONITOR</p>		<p>REV. 1</p>	
<p>SCALE = NONE</p>		<p>IC NO. LTC6804IG-2</p>		<p>SHEET 2 OF 2</p>	
<p>DATE: Wednesday, October 23, 2013</p>		<p>DEMO CIRCUIT 1942B</p>		<p>REV. 1</p>	



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# DEMO MANUAL DC1942C

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