

## LTC4156EUFD Dual Input Power Manager/3.5A LiFePO<sub>4</sub> Battery Charger with I<sup>2</sup>C Control and USB OTG

### DESCRIPTION

Demonstration Circuit 1674A-B is dual input power manager/3.5A LiFePO<sub>4</sub> battery charger with I<sup>2</sup>C control and USB On-The-Go (OTG).

The dual input multiplexer, overvoltage protection (OVP) and reverse voltage protection (RVP) is implemented with external N-channel MOSFETs.

An on board buck regulator generates the V<sub>OUT</sub> voltage from the active input voltage. This voltage is regulated to minimize the dissipation in the battery charger. The minimum voltage of the V<sub>OUT</sub> regulator is 3.2V to provide an instant-on function when the battery is fully discharged.

Most functions on the LTC<sup>®</sup>4156EUFD are controlled via the I<sup>2</sup>C serial interface. The LTC4156EUFD also provides extensive status information via the I<sup>2</sup>C serial interface.

Please refer to the LTC4156EUFD data sheet for details about the I<sup>2</sup>C serial interface, control and status registers, and the electrical and timing specifications.

The LTC4156EUFD does modify several of its own control registers to reflect the current operating conditions.

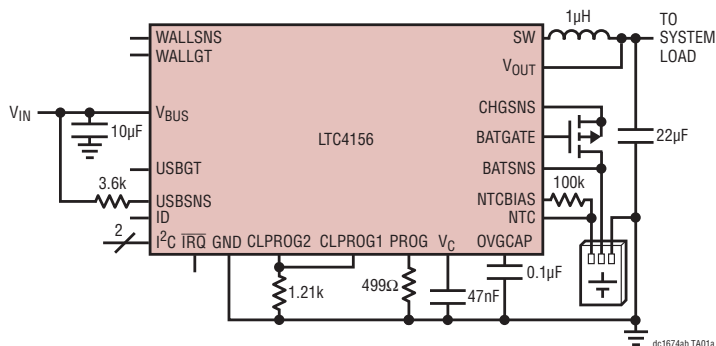
**Design files for this circuit board are available at <http://www.linear.com/demo>**

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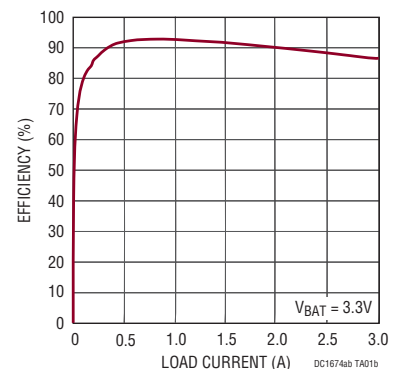
### PERFORMANCE SUMMARY (T<sub>A</sub> = 25°C)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>WALL</sub>	WALL Input Voltage Range		4.35	5	5.5	V
I <sub>WALL</sub>	Input Current from WALL Input	4.35V < V <sub>WALL</sub> < 6V	0	0.1	3	A
V <sub>USB</sub>	USB Input Voltage Range		4.35	5	5.5	V
I <sub>USB</sub>	Input Current from USB Input	4.35V < V <sub>USB</sub> < 6V	0	0.1	3	A
V <sub>OUT</sub>	Voltage on the V <sub>OUT</sub> Pin	0A < I <sub>VOUT</sub> ≤ 4A, 2.7V < V <sub>BAT</sub> ≤ 3.8V	3.19	3.5	4.6	V
I <sub>VOUT</sub>	Output Current from V <sub>OUT</sub>	Total Load Current Including Battery Charger			4.5	A
V <sub>BAT</sub>	Voltage on the BAT Pin			3.3	3.6	V
I <sub>BAT</sub>	BAT Pin Source or Sink Current		-4		3	A
V <sub>WALL-USB</sub>	Input Voltage Range, Non-Operating		5.75		27	V

I<sup>2</sup>C Controlled High Power Battery Charger/USB Power Manager



Switching Regulator Efficiency



dc1674abf

# DEMO MANUAL DC1674A-B

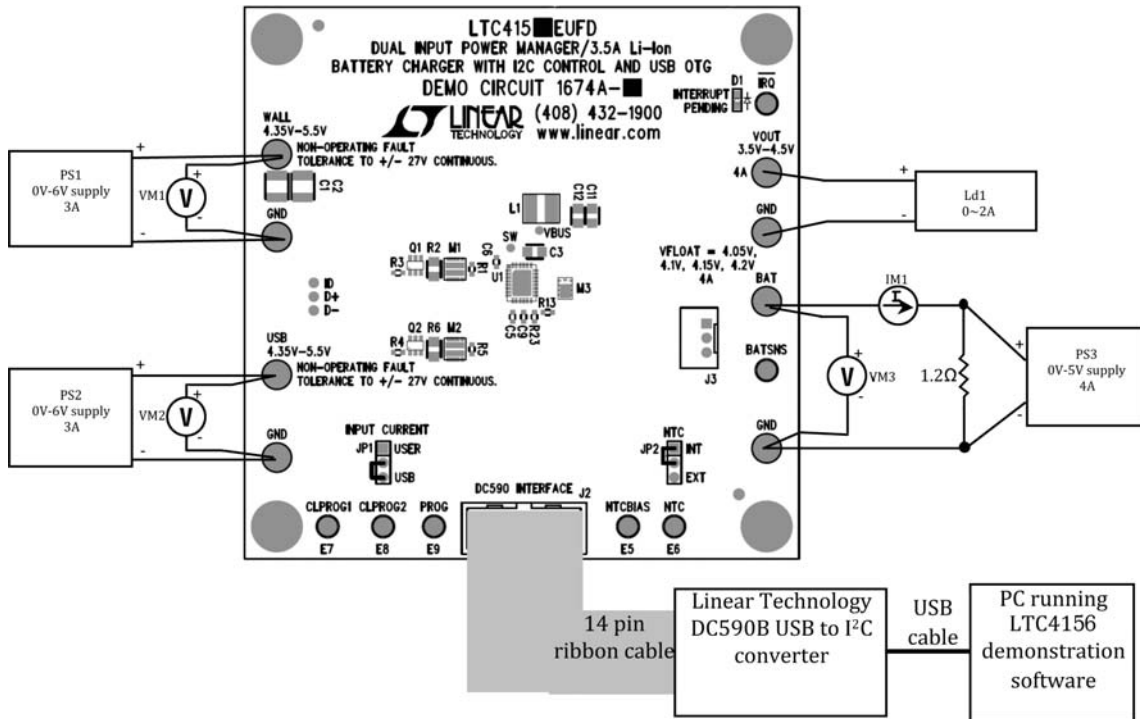
## QUICK START PROCEDURE

DC1674A-B working input voltage range is 4.35V to 5.5V on both the WALL and USB input. The DC1674A-B will tolerate non-operating overvoltage inputs up to 27V. DC1674A-B utilizes the DC590B, USB to I<sup>2</sup>C interface board, to control the LTC4156EUFD and to read back the contents of the command and status registers.

The DC1674A-B is easy to set up to evaluate the performance of the LTC4156EUFD. Refer to Figure 1 and Figure 2

for proper measurement equipment setup and follow the evaluation procedure below using the DC590B board.

NOTE. When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across the V<sub>IN</sub> or V<sub>OUT</sub> and GND terminals. See Figure 2 for proper scope probe technique.



Note: All connections from equipment should be Kelvin connected directly to the Board PINS which they are connected to on this diagram and any input, or output, leads should be twisted pair

Figure 1. Proper Measurement Equipment Setup

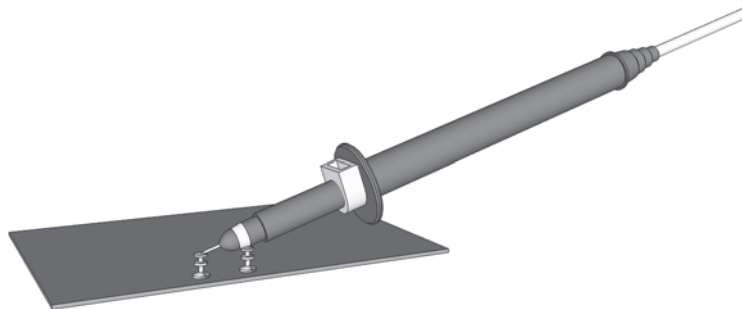


Figure 2. Measuring Input or Output Ripple

## QUICK START PROCEDURE

1. Ensure that JP1 and JP2 are in their default positions, as shown in Figure 1. Set PS3 to 3.6V and turn on. The  $DV_{CC}$  voltage level may be selected on the DC590B. This is done by setting the  $V_{CCIO}$  jumper, JP6, on the DC590B board to one of the following settings: 3.3V, 5V, removed for 2.7V or set to external if an external supply is desired to be used. Please set  $DV_{CC}$  to 3.3V.
2. Start the Linear Technology QuickEval™ program. Download and install the latest version of the QuickEval program from the following weblink: <http://www.linear.com/designtools/software/>. This program should automatically detect the presence of the LTC4156EUFD demo board (DC1674A-B) and activate the appropriate GUI, as seen in Figure 3.
3. Set PS1 to 5V, and turn on. The “WALL Input Power Available” and “External Power Available” indicators on the GUI should turn green. The current on PS1 should indicate approximately 80mA.
4. Set “WALL  $I_{LIM}$ ” to 3000mA. To compensate for the sense resistance of IM1, adjust PS3 such that VM3 reads 3.6V. PS1 should now read approximately 2A, and IM1 should read approximately 2.4A.
5. Set PS2 to 5V, and turn on. The only change should be the “USB Input Power Available” indicator should turn green.
6. Set the “USB  $I_{LIM}$ ” to 3000mA, and select the USB Input radio button in the “Input Power Priority” frame. PS1 should now read 0A, PS2 should read approximately 2A, and IM1 should be unchanged at 2.4A.
7. Set LD1 to 1A, and turn on. PS2 should now read approximately 3A, and IM1 should be unchanged.
8. Set “ $I_{CHARGE\%}$ ” to 50%. PS2 should now read approximately 2A, and IM1 should be 1.2A.
9. Turn off and disconnect PS1, VM1, and PS2.
10. Select the “Force OTG Boost On” radio button. VM2 should now read approximately 5V.

## USING THE LTC4156EUFD SOFTWARE

### Introduction

The DC1674A-B GUI provides control of most aspects of operation of the LTC4156EUFD. The DC1674A-B GUI continuously reads back the LTC4156EUFD registers and updates the displayed status accordingly. The DC1674A-B GUI also provides a means to change the value of the CLPROGx and PROG resistors, as well as the  $\beta$  of the NTC device. The user is responsible for ensuring that these values match the values on the physical Demo Board. The DC1674A-B GUI will remember these values from session to session, and they can be reset to the default values at any time.

The DC1674A-B GUI is composed of three forms, the LTC4156 form (Figure 3) that is brought up by the QuickEval program, the Manage Current Limit Resistors form (Figure 4), that is brought up by pressing the “Change Resistors” button on the LTC4156 form, and the Manage  $\beta$  Value form (Figure 5) that is brought up by pressing the “Change  $\beta$ ” button on the LTC4156 form.

Any changes made in the Manage Current Limit Resistors or Manage  $\beta$  Value forms will be reflected on the main form as soon as “Apply” is pressed. All changes made in these two forms will be remembered from session to session. The values can be set to default at any time.

### View LTC4156EUFD Product Page

This button opens your default internet browser, and searches the Linear Technology Corporation web site for information on the LTC4156EUFD when an internet connection is available.

### WALL and USB $I_{LIM}$ Sections

These sections allow control over the WALL and USB input current limit.

These sections should default to 100mA at power-up, when the USB/USER (JP1) is in the “USB” position. They

## QUICK START PROCEDURE

should both default to the 1000mA value at the top of the frame, at power-up, with the USB/USER (JP1) in the “USER” position.

If the USB input power becomes unavailable, the USB  $I_{LIM}$  section will return to 100mA.

### **$I_{CHARGE\%}$ Section**

This section controls the battery charging current as a percent of maximum. The maximum is shown at the top of the frame, and is calculated from the displayed PROG resistor value.

### **C/x Set**

Select the End of Charging condition. This selects the current, as a percent of the maximum that indicates end of charging. Optionally, charging may also be terminated at the C/x current threshold by selecting the “4hr or C/x” timer mode.

### **Timer**

This selects the timeout for the charging timer. When the end of charging condition is reached, the charger is not turned off, but the timer is started, and when it times out, the charger is turned off. The exception is “4hr or C/x” mode, where whichever 4hrs or C/x, occurs first will terminate charging.

### **$V_{FLOAT}$**

This selects the desired battery float voltage, and defaults to 3.45V.

### **Input Power Priority**

By default, the WALL input has priority on the input power multiplexer. The priority can be reassigned to USB input by selecting the appropriate radio button.

### **OTG Boost Automatic Enable**

Selects whether or not the ID pin of the USB connector enables USB On-The-Go (OTG) operation. It may be desirable to control USB OTG directly, without the need to set the USB connector ID pin voltage level below  $V_{ID\_OTG}$ . To control USB OTG directly, check the “Force OTG Boost On” box. Automatic enable has no effect on ID pin status indication.

### **Disable Input UVCL**

As the active input voltage (USB or WALL) drops below 4.3V, the LTC4156EUFDF will lower the input current limit to attempt to prevent the input voltage from drooping lower. This is a useful feature in the input supply voltage is not very stiff, or if there is significant impedance between the input supply and the LTC4156EUFDF. If this function is not desired, check the “Disable Input UVCL” box.

### **Interrupts**

The LTC4156EUFDF can monitor a variety of conditions, which it reports over the I<sup>2</sup>C buss. By selecting the check boxes in the Interrupt section, the LTC4156EUFDF can also issue interrupts whenever one of these conditions changes. The presence of an interrupt is indicated by the indicator changing to red and displaying “Interrupt Pending.” The interrupt can be cleared by pressing the “Clear Interrupt” button. Changing the interrupt mask also clears all pending interrupts.

# QUICK START PROCEDURE

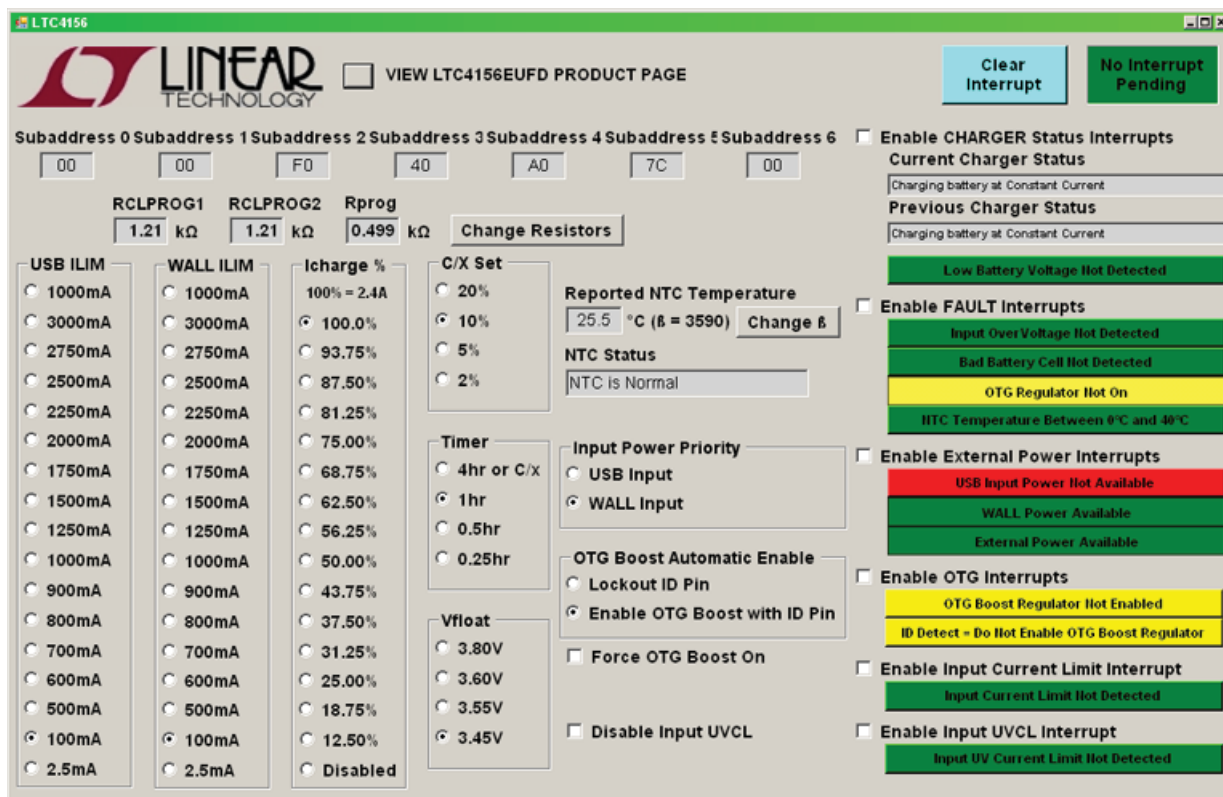


Figure 3. LTC4156 Main Form

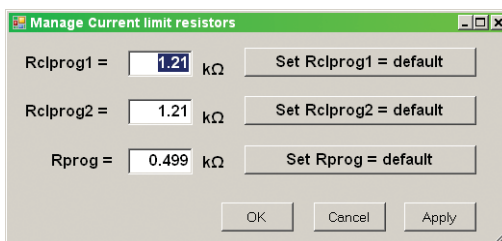


Figure 4. Manage Current Limit Resistors Form

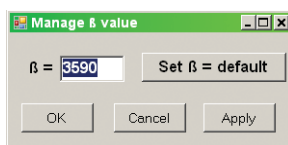


Figure 5. Manage β Value Form



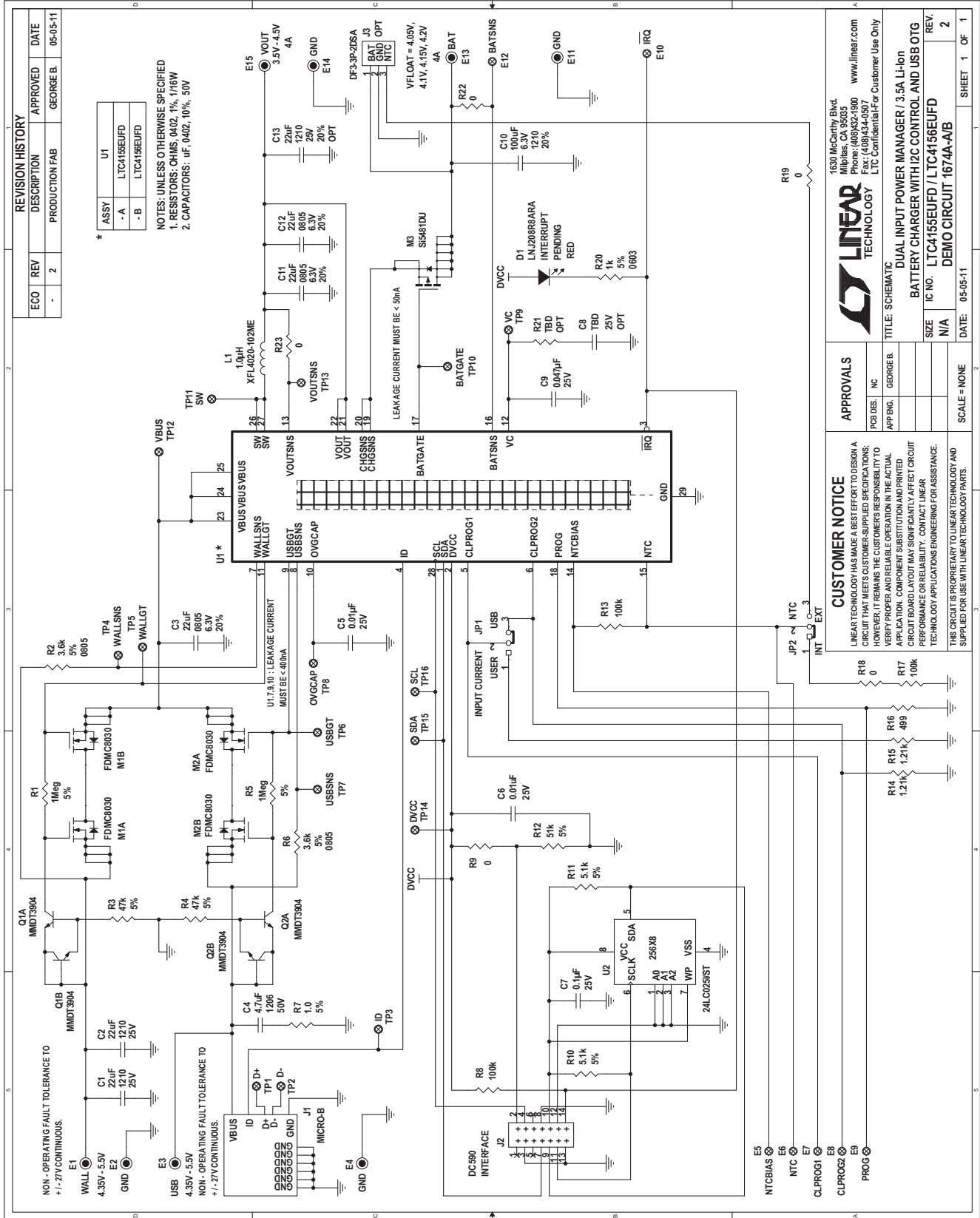
# DEMO MANUAL DC1674A-B

## PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
<b>Required Circuit Components</b>				
1	2	C1, C2	Capacitor, Chip, X5R, 22 $\mu$ F, $\pm$ 10%, 25V, 1210	Murata, GRM32ER61E226KE15L
2	3	C3, C11, C12	Capacitor, Chip, X5R, 22 $\mu$ F, $\pm$ 20%, 6.3V, 0805	TAIYO-YUDEN, JMK212BJ226MG
3	1	C5	Capacitor, Chip, X7R, 0.01 $\mu$ F, $\pm$ 10%, 25V, 0402	TDK, C1005X7R1E103K
4	1	C9	Capacitor, Chip, X7R, 0.047 $\mu$ F, $\pm$ 10%, 25V, 0402	TDK, C1005X7R1E473K
5	1	C10	Capacitor, Chip, X5R, 100 $\mu$ F, $\pm$ 20%, 6.3V, 1210	Murata, GRM32ER60J107ME20L
6	1	L1	Inductor, SMT, 1 $\mu$ H, 10.8m $\Omega$ , $\pm$ 20%, 4mm $\times$ 4mm	Coilcraft, XFL4020-102ME
7	2	M1-M2	MOSFET, 40V, 25m $\Omega$ , 12A, Power33	Fairchild, FDMC8030
8	1	M3	MOSFET, -20V, 22m $\Omega$ , 12A, Power PAK ChipFET Single	Vishay, Si5481DU-T1-GE3
9	1	Q1, Q2	Dual NPN, SOT363	Diodes/Zetex, MMDT3904-7-F
10	2	R1, R5	Resistor, Chip, 1M $\Omega$ , $\pm$ 5%, 1/16W, 0402	Vishay, CRCW04021M00JNED
11	2	R2, R6	Resistor, Chip, 3.6k, $\pm$ 5%, 1/8W, 0805	Vishay, CRCW08053K60JNED
12	2	R3, R4	Resistor, Chip, 47k, $\pm$ 5%, 1/16W, 0402	Vishay, CRCW040247K0JNED
13	2	R13, R17	Resistor, Chip, 100k, $\pm$ 1%, 1/16W, 0402	Vishay, CRCW0402100KFED
14	2	R14, R15	Resistor, Chip, 1.21k, $\pm$ 1%, 1/16W, 0402	Vishay, CRCW04021K21FKED
15	1	R16	Resistor, Chip, 499 $\Omega$ , $\pm$ 1%, 1/16W, 0402	Vishay, CRCW0402499RFED
16	4	R18, R19, R22, R23	Resistor, Chip, 0 $\Omega$ Jumper, 1/16W, 0402	Vishay, CRCW04020000Z0ED
17	1	U1 (ASSEMBLY - A) U1 (ASSEMBLY - B)	Dual Input Power Manager/3.5A Li-Ion Battery Charger with I <sup>2</sup> C Control and USB OTG	Linear Technology, LTC4155EUFD Linear Technology, LTC4156EUFD
<b>Additional Demo Board Circuit Components</b>				
1	1	C4	Capacitor, Chip, X7R, 4.7 $\mu$ F, $\pm$ 10%, 50V, 1206	Murata, GRM31CR71H475KA12L
2	1	C6	Capacitor, Chip, X7R, 0.01 $\mu$ F, $\pm$ 10%, 25V, 0402	TDK, C1005X7R1E103K
3	1	C7	Capacitor, Chip, X5R, 0.1 $\mu$ F, $\pm$ 10%, 25V, 0402	TDK, C1005X5R1E104K
4	0	C8-OPT	Capacitor, Chip, TBD, 0402	User Defined
5	0	C13-OPT	Capacitor, Chip, X5R, 22 $\mu$ F, $\pm$ 10%, 25V, 1210	Murata, GRM32ER61E226KE15L
6	1	D1	LED, Red, 0603	Panasonic, LNJ208R8ARA
7	1	R7	Resistor, Chip, 1.0 $\Omega$ , $\pm$ 5%, 1/16W, 0402	Vishay, CRCW04021R00JNED
8	1	R8	Resistor, Chip, 100k, $\pm$ 1%, 1/16W, 0402	Vishay, CRCW0402100KFED
9	1	R9	Resistor, Chip, 0 $\Omega$ Jumper, 1/16W, 0402	Vishay, CRCW04020000Z0ED
10	2	R10, R11	Resistor, Chip, 5.1k, $\pm$ 5%, 1/16W, 0402	Vishay, CRCW04025K10JNED
11	1	R12	Resistor, Chip, 51k, $\pm$ 5%, 1/16W, 0402	Vishay, CRCW040251K0JNED
12	1	R20	Resistor, Chip, 1k, $\pm$ 5%, 1/10W, 0603	Vishay, CRCW06031K00JNED
13	0	R21-OPT	Resistor, Chip, TBD, 0402	User Defined
14	1	U2	I <sup>2</sup> C EEPROM	Microchip, 24LC025-I/ST
<b>Hardware/Components (For Demo Board Only)</b>				
1	8	E1, E2, E3, E4, E11, E13, E14, E15	Turret, 0.09 DIA	Mill-Max, 2501-2-00-80-00-00-07-0
2	7	E5, E6, E7, E8, E9, E10, E12	Turret, 0.061 DIA	Mill-Max, 2308-2-00-80-00-00-07-0
3	1	J1	Connector, USB Micro-B	Tyco, 1981568-1
4	1	J2	Header, 2 $\times$ 7 Pin, 0.079CC	Molex, 87831-1420
5	0	J3-OPT	Connector, Battery	Hirose, DF3-3P-2DSA
6	2	JP1, JP2	Header, 3-Pin 1 Row 0.079CC	Samtec, TMM-103-02-L-S
7	2	JP1, JP2	Shunt, 2mm	Samtec, 2SN-KB-G
8	4		Stand-Off, Nylon, 0.375" Tall (Snap On)	Keystone, 8832 (SNAP ON)
9	1		FAB, Printed Circuit Board	Demo Circuit 1674A
10	2		Stencil - Top & Bottom	DC1674A-2

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SCHEMATIC DIAGRAM



dc1674abf

# DEMO MANUAL DC1674A-B

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This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

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