LTC4020EUHF
High Power Buck-Boost Multi-Chemistry Battery Charger

DESCRIPTION

Demonstration circuit 2134B is a high power buck-boost multi-chemistry battery charger featuring the LTC®4020. The board will accept an input voltage between 15V and 55V. The float voltage of the battery output (BAT) is 25.2V, with 6.3A maximum charge current. The converter output (V_{OUT}) has a voltage range of 21V to 28V, with 8A maximum load current. The LTC4020 contains a high efficiency synchronous buck-boost DC/DC controller and uses a proprietary average current mode architecture.

The LTC4020 battery charger can provide a constant-current/constant-voltage charge algorithm (CC/CV); a four-step, three-stage lead-acid battery-charge profile or constant-current charging (CC). Battery-chemistry type is selected using onboard jumper JP1.

The LTC4020 data sheet gives a complete description of the IC operation and application information. The data sheet must be read in conjunction with this quick start guide.

Design files for this circuit board are available.

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range		15		55	V
Battery Float Voltage (BAT) (Nominal)	I_{BAT} = 0A to 6.3A		25.2		V
Converter Output Voltage (V_{OUT})	I_{OUT} = 0A to 8A	21		28	V
Maximum Battery Charge Current, I_{BAT}	I_{OUT} = 0A		6.3		A
Maximum Converter Output Current, I_{OUT}	I_{BAT} = 0A		8		A
Typical Efficiency	V_{IN} = 24V, V_{OUT} = 25.2V, I_{OUT} = 8A		98		%
Typical Converter Output Ripple	V_{IN} = 55V, V_{OUT} = 27.7V, I_{OUT} = 8A (20MHz BW)		127		mV_{P-P}

QUICK START PROCEDURE

Demonstration circuit 2134B is easy to set up to evaluate the performance of the LTC4020. Refer to Figure 1 for the proper measurement equipment setup and follow the procedure below.

NOTE: Make sure that the voltage applied to VIN does not exceed 55V. The combined converter output load current and battery charging current should not exceed 8A.

1. With power off, connect the input power supply (set for 0V) to VIN and GND (input return).
2. Connect the converter output load between VOUT and GND (Initial load: no load).
3. Connect the DVMs to the input and outputs.
4. Turn on the input power supply and slowly increase to 24V. Check for the proper output voltages, V_{OUT} of 25.2V and BAT of 25.2V.
5. Once the proper output voltages are established, adjust the converter output load within the operating range (8A maximum) and/or adjust input voltage (15V to 55V) and observe the output voltage regulation, ripple voltage, efficiency, and other parameters.

NOTE: When measuring the output or input voltage ripple, do not use the long ground lead on the oscilloscope probe. See Figure 2 for the proper scope probe technique. Short, stiff leads need to be soldered to the (+) and (–) terminals of an output capacitor. The probe's ground ring needs to touch the (–) lead and the probe tip needs to touch the (+) lead.

WARNING:

BE CAREFUL WHEN TESTING WITH HIGH VOLTAGE. HIGH VOLTAGE CAN RESULT IN AN ELECTRIC SHOCK IF CARE IS NOT TAKEN.

BATTERIES ARE POTENTIALLY DANGEROUS HIGH ENERGY SOURCES. IMPROPER CONNECTION, OVERCHARGE, OR RAPID DISCHARGE COULD RESULT IN EXPLOSION AND/OR FIRE. PLEASE READ THE SPECIFICATION/MANUAL OF THE BATTERY BEFORE TEST.

Additional Notes

1. Without a proper battery, BAT output can be open or connected with other suitable loads for test purposes. It may be a good practice to add low ESR electrolytic capacitors to the BAT output (≥1000µF at ≥35V, for 25.2V float voltage).

   Note that hese capacitors help simulate the low impedance of a battery and maintain stability of the charge current loop. They are only needed for test purposes with electronic or resistive loads, and not needed in the actual battery application/test (where the BAT load is a battery).
2. The 0Ω, 2512 jumper (R41) in series with the inductor can be removed and a wire loop can be added in its place to facilitate the use of a current probe.
3. BAT float voltage can be easily adjusted with the resistor divider R44/R45. Converter output voltage VOUT can be adjusted with the resistor divider R9/R11. Adjust/optimize the loop compensations if necessary.

QUICK START PROCEDURE

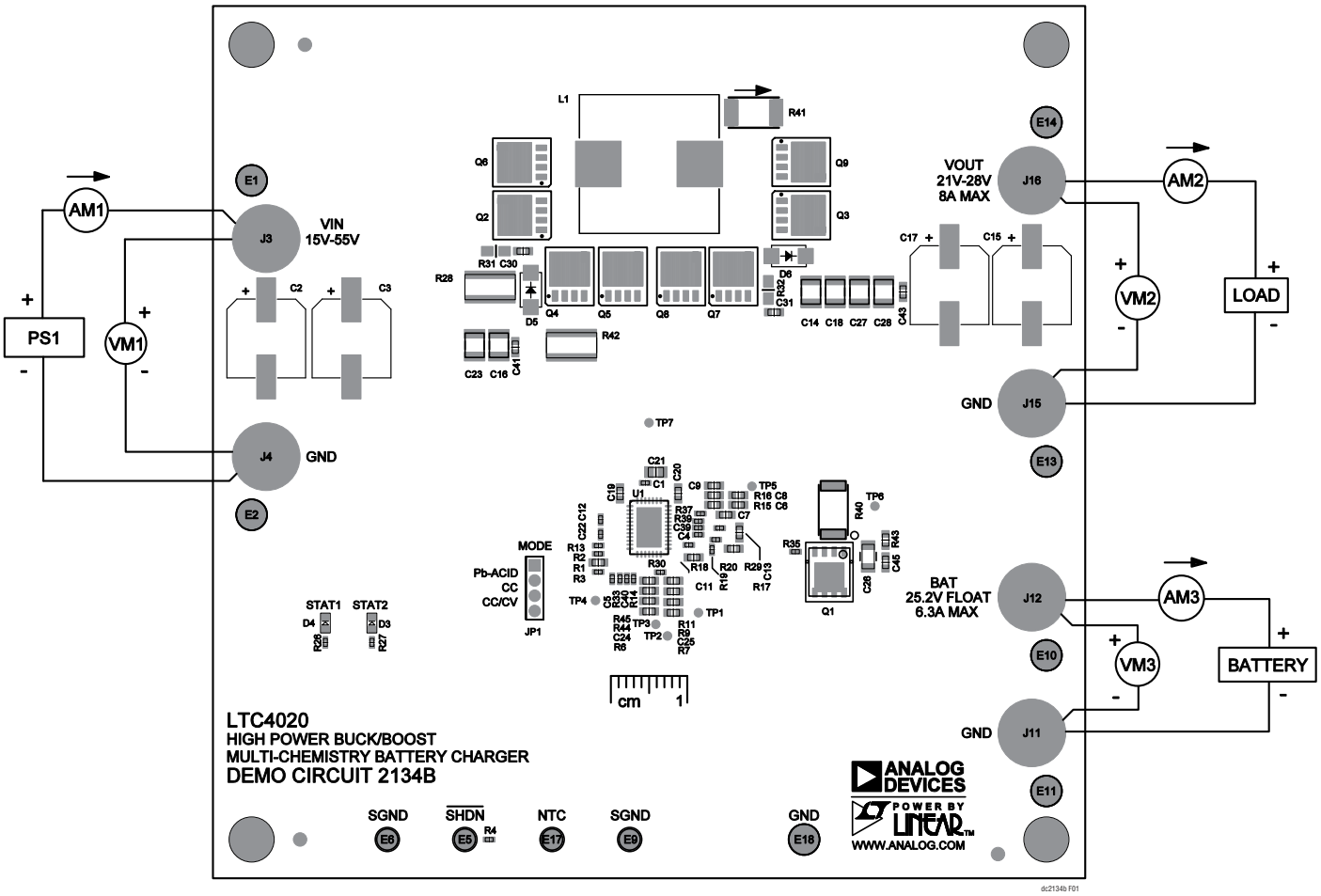


Figure 1. Proper Measurement Equipment Setup

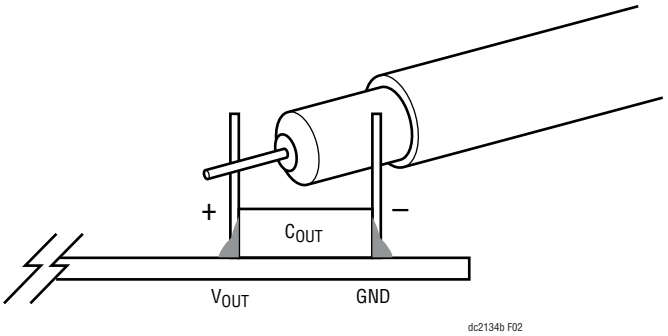


Figure 2. Measuring Output Voltage Ripple

TEST RESULTS

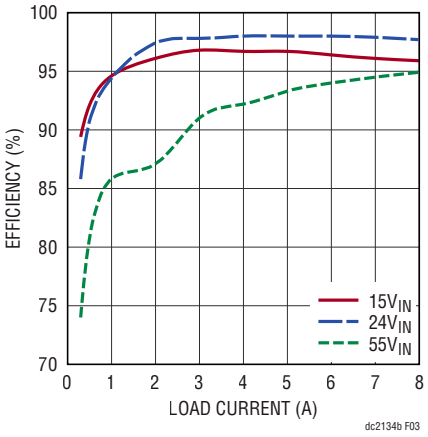


Figure 3. Efficiency vs Load Current (V_{OUT} = 25.2V)

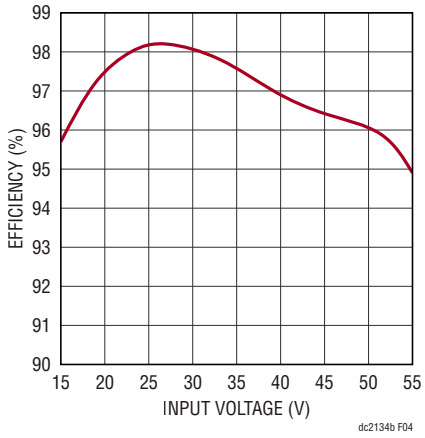


Figure 4. Efficiency vs Input Voltage (V_{OUT} = 25.2V, I_{OUT} = 8A)

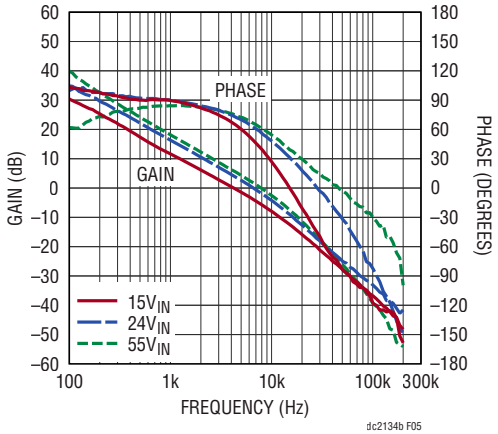


Figure 5. Bode Plots for V_{OUT} Voltage Control Loop (V_{OUT} = 27.7V, I_{OUT} = 8A, NTC = SGND)

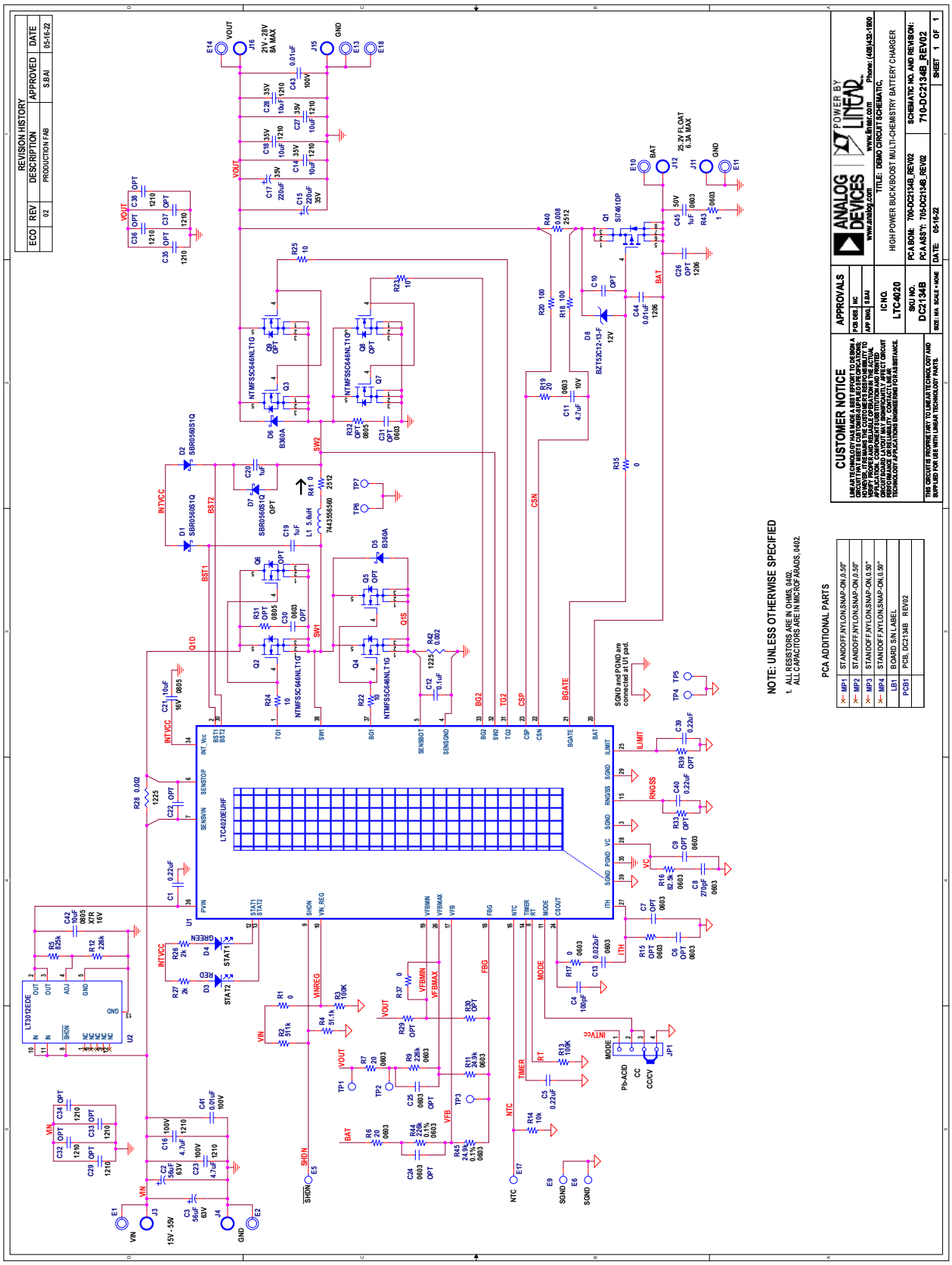
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Electrical Components				
1	2	C1, C5	CAP., 0.22µF, X7R, 16V, 10%, 0402, AEC-Q200	MURATA, GCM155R71C224KE02D
2	1	C11	CAP., 4.7µF, X7R, 10V, 10%, 0603	MURATA, GRM188Z71A475KE15D
3	1	C12	CAP., 0.1µF, X7R, 10V, 10%, 0402	MURATA, GRM155R71A104KA01D
4	1	C13	CAP., 0.022µF, X7R, 25V, 10%, 0603, AEC-Q200	KEMET, C0603C223K3RACAUTO
5	4	C14, C18, C27, C28	CAP., 10µF, X7R, 35V, 10%, 1210	AVX, 1210DD106KAT2A
6	2	C15, C17	CAP., 220µF, ALUM POLY HYB, 35V, 20%, 10mm × 12.5mm, SMD, AEC-Q200	SUN ELECTRONIC INDUSTRIES CORP, 35HVH220M
7	2	C16, C23	CAP., 4.7µF, X7S, 100V, 10%, 1210, AEC-Q200	MURATA, GCM32DC72A475KE02L
8	2	C19, C20	CAP., 1µF, X7R, 16V, 10%, 0603	KEMET, C0603C105K4RAC7867
9	2	C2, C3	CAP., 56µF, ALUM POLY HYB, 63V, 20%, 10mm × 112.5mm SMD, AEC-Q200	SUN ELECTRONIC INDUSTRIES CORP, 63HVH56M
10	2	C21, C42	CAP., 10µF, X7R, 16V, 10%, 0805	TAIYO YUDEN, EMK212BB7106MG-T
11	2	C39, C40	CAP., 0.22µF, X7R, 10V, 10%, 0402	MURATA, GRM155R71A224KE01D
12	1	C4	CAP., 100pF, C0G, 50V, 5%, 0402	AVX, 04025A101JAT2A
13	2	C41, C43	CAP., 0.01µF, X7R, 100V, 10%, 0603, AEC-Q200	MURATA, GCJ188R72A103KA01D
14	1	C44	CAP., 0.01µF, X7R, 50V, 10%, 1206	KEMET, C1206C103K5RAC7025
15	1	C45	CAP., 1µF, X7R, 50V, 10%, 0603	AVX, 06035C105KAT2A
16	1	C8	CAP., 270pF, C0G, 50V, 5%, 0603	AVX, 06035A271JAT2A
17	3	D1, D2, D7	DIODE, SBR, 60V, 500mA, SOD123	DIODES INC., SBR0560S1Q-7
18	1	D3	LED, RED, WATER-CLEAR, 0603	LITE-ON, LTST-C193KRKT-5A
19	1	D4	LED, GREEN, WATER-CLEAR, 0603	LITE-ON, LTST-C190KGKT
20	2	D5, D6	DIODE, SCHOTTKY RECTIFIER, 60V, 3A, 4.6mm × 2.92mm	DIODES INC., B360A-13-F
21	1	D8	DIODE, ZENER, 12V, 500mW, SOD123, AEC-Q101	DIODES INC., BZT52C12-13-F
22	1	L1	IND., 5.6µH, SHIELDED WIREWOUND, 20%, 19A, 18.30mm × 18.20mm SMT	WURTH ELEKTRONIK, 7443556560
23	1	Q1	XSTR., MOSFET, P-CH, 60V, 8.6A, PowerPAK SO-8	VISHAY, Si7461DP-T1-GE3
24	4	Q2, Q3, Q4, Q7	XSTR., MOSFET, N-CH, 60V, 93A, DFN5 (SO-8FL), AEC-Q101	ONSEMI, NTMFS5C646NLT1G
25	2	R1, R17	RES., 0Ω, JUMPER, 0603, AEC-Q200	KOA SPEER, RK73Z1JTTDD
26	1	R11	RES., 24.9k, 1%, 1/10W, 0603, AEC-Q200	NIC, NRC06F2492TRF
27	1	R12	RES., 226k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F2263TRF
28	1	R14	RES., 10k, 1%, 1/10W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP1002F
29	1	R16	RES., 82.5k, 1%, 1/10W, 0603, AEC-Q200	PANASONIC, ERJ3EKF8252V
30	2	R18, R20	RES., 100Ω, 1%, 1/16W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP1000F
31	1	R19	RES., 20Ω, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F20R0TRF
32	1	R2	RES., 511k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F5113TRF
33	4	R22-R25	RES., 10Ω, 1%, 1/16W, 0402	YAGEO, RC0402FR-0710RL
34	2	R26, R27	RES., 2k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04022K00FKED
35	2	R28, R42	RES., 0.002Ω, 2%, 3W, 2512, LONG-SIDE TERM., METAL, AEC-Q200	SUSUMU, KRL6432E-M-R002-G-T1
36	2	R3, R13	RES., 100k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F1003TRF

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
37	2	R35, R37	RES., 0Ω, 5%, 1/16W, 0402	ROHM, MCR01MZPJ000
38	1	R4	RES., 51.1k, 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCF0402FT51K1
39	1	R40	RES., 0.008Ω, 1%, 1W, 2512	VISHAY, WSL25128L000FEA
40	1	R41	RES., 0Ω, 200A, 2512, COPPER, SENSE	VISHAY, WSL251200000ZEA9
41	1	R43	RES., 1Ω, 1%, 1/10W, 0603	YAGEO, RC0603FR-071RL
42	1	R44	RES., 226k, 0.1%, 1/10W, 0603, HIGH STABILITY	VISHAY, TNPW0603226KBEEA
43	1	R45	RES., 24.9k, 0.1%, 1/8W, 0603, AEC-Q00	VISHAY, TNPW060324K9BEEA
44	1	R5	RES., 825k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW0402825KFKED
45	2	R6, R7	RES., 20Ω, 1%, 1/10W, 0603	YAGEO, RC0603FR-0720RL
46	1	R9	RES., 226k, 1%, 1/10W, 0603	NIC, NRC06F2263TRF
47	1	U1	IC, 55V BUCK-BOOST BATTERY CHARGER, 38-PIN QFN	ANALOG DEVICES, LTC4020EUHF#PBF
48	1	U2	IC, 250mA, 4V TO 80V LDO LINEAR REG, DFN-12	ANALOG DEVICES, LT3012EDE#PBF
Optional Electrical Components				
1	0	C6, C7, C9, C24, C25, C30, C31	CAP., OPTION, 0603	
2	0	C10, C22	CAP., OPTION, 0402	
3	0	C26, C44	CAP., OPTION, 1206	
4	0	C29, C32-C38	CAP., OPTION, 1210	
5	0	Q5, Q6, Q8, Q9	XSTR., OPTION, MOSFET, N-CH, DFN5 (SO-8FL)	
6	0	R15	RES., OPTION, 0603	
7	0	R29, R30, R33, R39	RES., OPTION, 0402	
8	0	R31, R32	RES., OPTION, 0805	
Hardware: For Demo Board Only				
1	7	E1, E2, E10, E11, E13, E14, E18	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062 THK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	4	E5, E6, E9, E17	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
3	6	J3, J4, J11, J12, J15, J16	CONN., BANANA JACK, FEMALE, THT, NON-INSULATED, SWAGE, 0.218"	KEYSTONE, 575-4
4	1	JP1	CONN., HDR, MALE, 1×4, 2mm, VERT, ST, THT	SULLINS CONNECTOR SOLUTIONS, NRPN041PAEN-RC
5	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.50"	WURTH ELEKTRONIK, 702935000
6	1	XJP1	CONN., SHUNT, FEMALE, 2-POS, 2mm	SAMTEC, 2SN-BK-G

SCHEMATIC DIAGRAM



Rev. 0

ESD Caution
ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

Legal Terms and Conditions

By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the "Evaluation Board"), you are agreeing to be bound by the terms and conditions set forth below ("Agreement") unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you ("Customer") and Analog Devices, Inc. ("ADI"), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term "Third Party" includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer may not disassemble, decompile or reverse engineer chips on the Evaluation Board. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, GUARANTEES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NONINFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER'S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI'S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS ($100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.