LTC4020EUHF
High Voltage Buck-Boost Multi-Chemistry Battery Charger

DESCRIPTION

Demonstration circuit 2044B is a 55V 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 3.3A maximum charge current. The converter output (V_{OUT}) has a voltage range of 21V to 28V, with 3A 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 on-board 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 at 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 3.3A		25.2		V
Converter Output Voltage (V_{OUT})	I_{OUT} = 0A to 3A	21		28	V
Maximum Battery Charge Current (I_{BAT})	I_{OUT} = 0A		3.3		A
Maximum Converter Output Current (I_{OUT})	I_{BAT} = 0A		3		A
Typical Efficiency	V_{IN} = 24V, V_{OUT} = 27.7V, I_{OUT} = 3A		97.7		%
Typical Converter Output Ripple Excluding Switching Spikes	V_{IN} = 55V, V_{OUT} = 27.7V, I_{OUT} = 3A, 20MHz BW		55		mV_{P-P}
Typical Converter Output Ripple Including Switching Spikes			105		mV_{P-P}

QUICK START PROCEDURE

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 3.3A.

Demonstration circuit 2044B 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:

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, VOUT 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 (3A 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 these 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. There are 3 jumpers on the board to set the MODE (JP1), NTC (JP2) and TIMER (JP3) functions. Note that for the NTC jumper (JP2) there are 2 jumper positions for the DISABLE mode. The DISABLE mode ties the NTC pin to a fixed 10k resistor, disabling any temperature-sensing function. The FAULT position simulates an NTC fault which disables charging, turns off the PMOS charging FET and forces voltage regulation at the output of the power stage (VOUT in the schematic).
3. The 0Ω, 2512 jumper (R14) 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.
4. BAT float voltage can be easily adjusted with the resistor divider R21/R25. Converter output voltage VOUT can be adjusted with the resistor divider R22/R26. Adjust/optimize the loop compensations if necessary.

QUICK START PROCEDURE

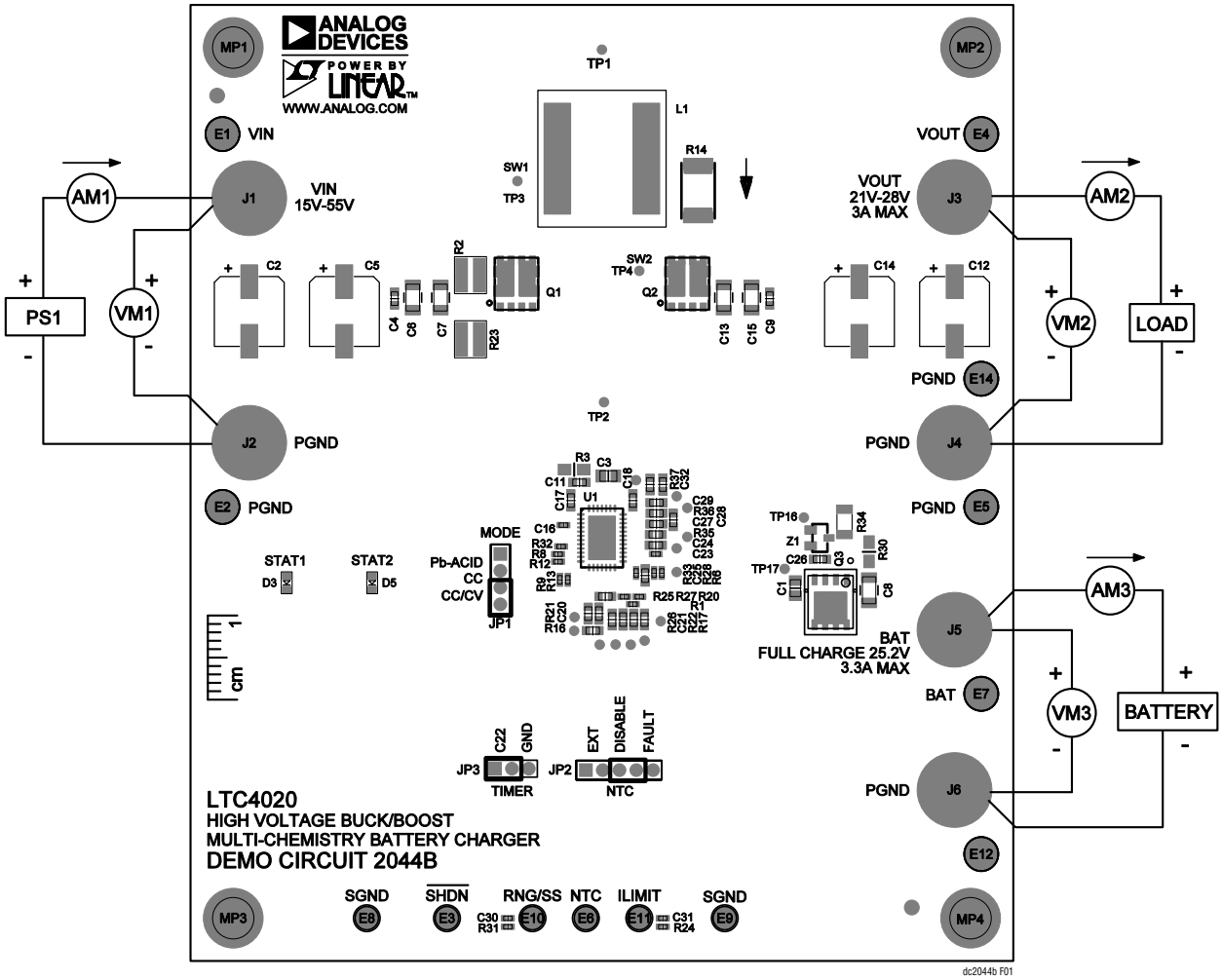


Figure 1. Proper Measurement Equipment Setup

QUICK START PROCEDURE

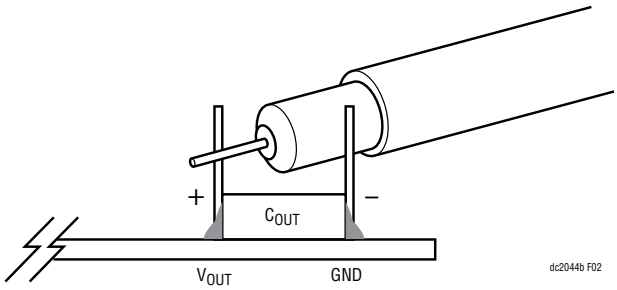


Figure 2. Measuring Output Voltage Ripple

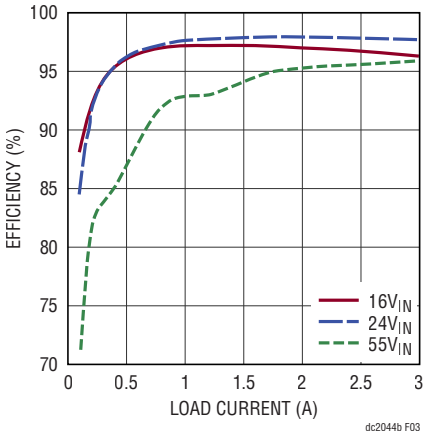


Figure 3. Efficiency vs Load Current (V_{OUT} = 25.2V)

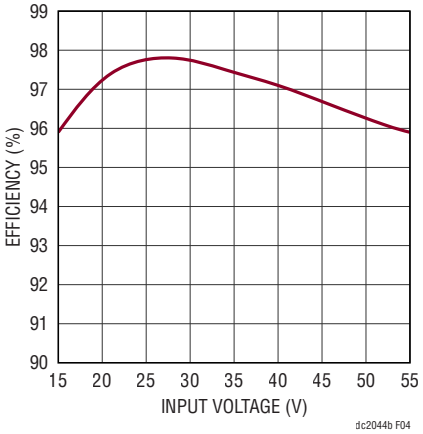


Figure 4. Efficiency vs Input Voltage (V_{OUT} = 25.2V, I_{OUT} = 3A)

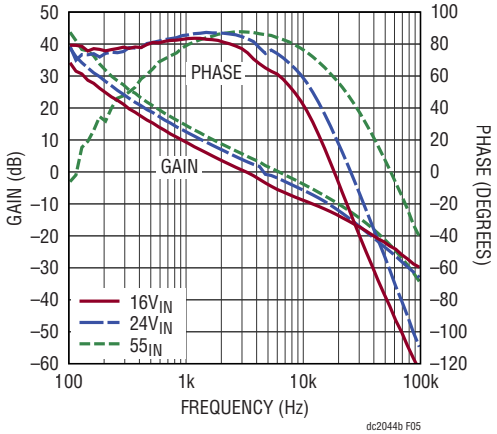


Figure 5. Bode Plots for V_{OUT} Voltage Control Loop (V_{OUT} = 27.7V, NTC = SGND)

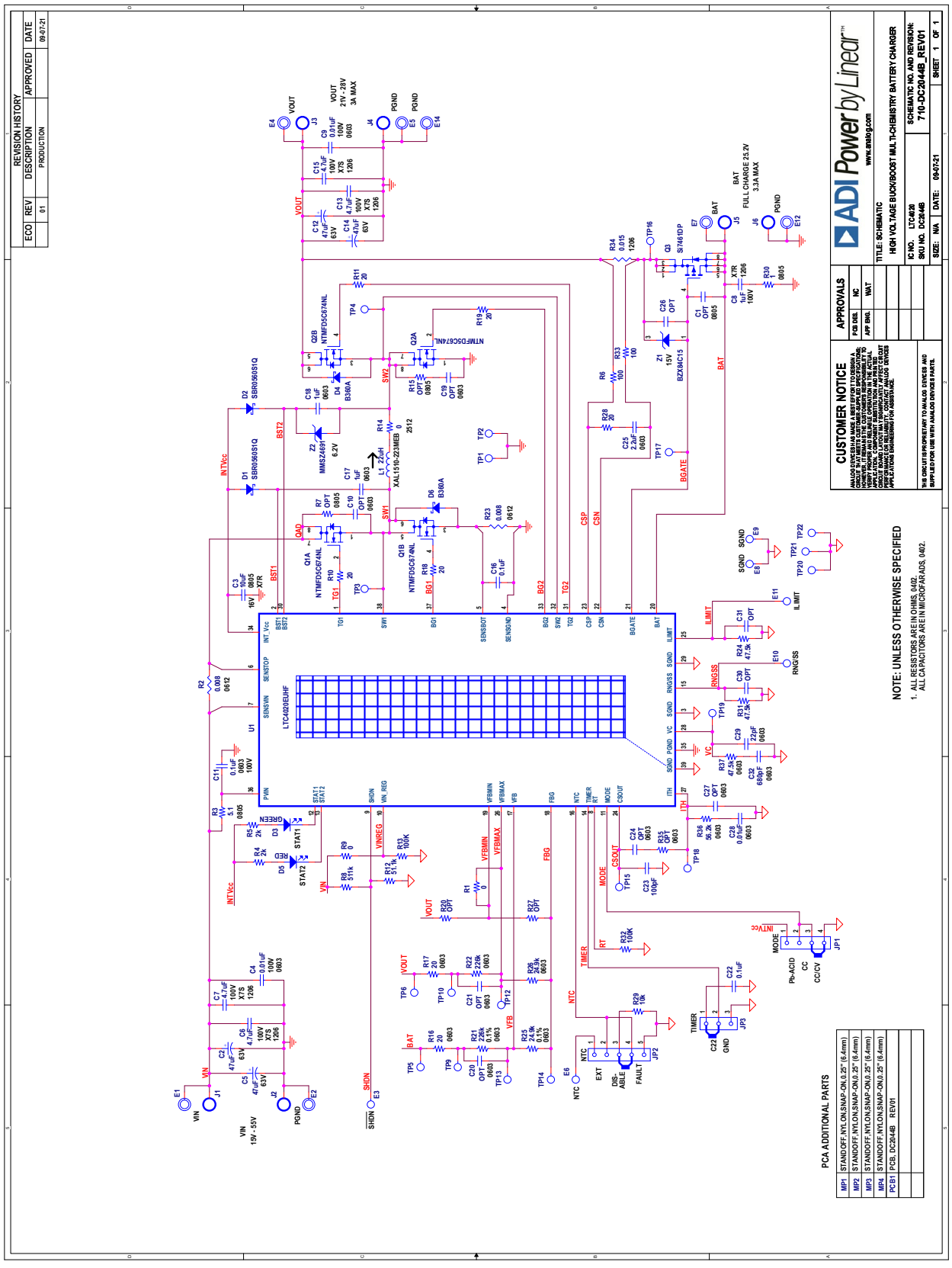
PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
Required Electrical Components				
1	4	C2, C5, C12, C14	CAP., 47µF, ALUM ELECT., 63V, 20%, SMD, 8.0mm × 10.2 mm, AEC-Q200	PANASONIC, EEHZA1J470P
2	1	C3	CAP., 10µF, X7R, 16V, 10%, 0805	TAIYO YUDEN, EMK212BB7106MG-T
3	2	C4, C9	CAP., 0.01µF, X7R, 100V, 10%, 0603, AEC-Q200	MURATA, GCJ188R72A103KA01D
4	4	C6, C7, C13, C15	CAP., 4.7µF, X7S, 100V, 20%, 1206	MURATA, GRM31CC72A475ME11L
5	1	C8	CAP., 1µF, X7R, 100V, 10%, 1206, AEC-Q200	TDK, CGA5L2X7R2A105K160AA
6	1	C11	CAP., 0.1µF, X7R, 100V, 10%, 0603, AEC-Q200	TAIYO YUDEN, HMK107B7104KAHT
7	2	C16, C22	CAP., 0.1µF, X7R, 16V, 10%, 0402, AEC-Q200	MURATA, GCM155R71C104KA55D
8	2	C17, C18	CAP., 1µF, X7R, 16V, 10%, 0603	KEMET, C0603C105K4RAC7867
9	1	C23	CAP., 100pF, C0G, 50V, 5%, 0402	AVX, 04025A101JAT2A
10	1	C25	CAP., 2.2µF, X7R, 10V, 10%, 0603	MURATA, GRM188R71A225KE15D
11	1	C28	CAP., 0.01µF, X7R, 50V, 10%, 0603	AVX, 06035C103KAT2A
12	1	C29	CAP., 22pF, C0G, 25V, 10%, 0603	AVX, 06033A220KAT2A
13	1	C32	CAP., 680pF, C0G, 25V, 5%, 0603	AVX, 06033A681JAT2A
14	2	D1, D2	DIODE, SBR, 60V, 500mA, SOD123	DIODES INC., SBR0560S1Q-7
15	1	D3	LED, GREEN, WATER-CLEAR, 0603	LITE-ON, LTST-C190KGKT
16	2	D4, D6	DIODE, SCHOTTKY RECTIFIER, 60V, 3A, 4.6mm × 2.92mm	DIODES INC., B360A-13-F
17	1	D5	LED, RED, WATER-CLEAR, 0603	LITE-ON, LTST-C193KRKT-5A
18	1	L1	IND., 22µH, PWR, 20%, 14A, 16mΩ, 16.2mm × 15.2mm, AEC-Q200	COILCRAFT, XAL1510-223MEB
19	2	Q1, Q2	XSTR., MOSFET, DUAL N-CH, 60V, 42A, DFN-8 (SO8FL)	ON SEMICONDUCTOR, NTMFD5C674NLT1G
20	1	Q3	XSTR., MOSFET, P-CH, 60V, 8.6A, POWERPAK SO-8	VISHAY, Si7461DP-T1-GE3
21	2	R1, R9	RES., 0Ω, 1/16W, 0402	VISHAY, CRCW04020000Z0ED
22	2	R2, R23	RES., 0.008Ω, 1%, 1W, 1206, LONG-SIDE, SENSE	SUSUMU, PRL1632-R008-F-T1
23	1	R3	RES., 5.1Ω, 5%, 1/8W, 0805, AEC-Q200	VISHAY, CRCW08055R10JNEA
24	2	R4, R5	RES., 2k, 1%, 1/16W, 0402, AEC-Q200	VISHAY, CRCW04022K00FKED
25	2	R6, R33	RES., 100Ω, 1%, 1/16W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP1000F
26	1	R8	RES., 511k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F5113TRF
27	4	R10, R11, R18, R19	RES., 20Ω, 1%, 1/16W, 0402	VISHAY, CRCW040220R0FKED
28	1	R12	RES., 51.1k, 1%, 1/16W, 0402, AEC-Q200	STACKPOLE ELECTRONICS, INC., RMCF0402FT51K1
29	2	R13, R32	RES., 100k, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F1003TRF
30	1	R14	RES., 0Ω, 200A, 2512, COPPER, SENSE	VISHAY, WSL251200000ZEA9
31	2	R16, R17	RES., 20Ω, 1%, 1/10W, 0603	YAGEO, RC0603FR-0720RL
32	1	R21	RES., 226k, 0.1%, 1/10W, 0603, HIGH STABILITY	VISHAY, TNPW0603226KBEEA
33	1	R22	RES., 226k, 1%, 1/10W, 0603	NIC, NRC06F2263TRF
34	2	R24, R31	RES., 47.5k, 1%, 1/16W, 0402	NIC, NRC04F4752TRF
35	1	R25	RES., 24.9k, 0.1%, 1/8W, 0603, AEC-Q00	VISHAY, TNPW060324K9BEEA
36	1	R26	RES., 24.9k, 1%, 1/10W, 0603, AEC-Q200	NIC, NRC06F2492TRF
37	1	R28	RES., 20Ω, 1%, 1/16W, 0402, AEC-Q200	NIC, NRC04F20R0TRF
38	1	R29	RES., 10k, 1%, 1/10W, 0402, AEC-Q200	KOA SPEER, RK73H1ETTP1002F

PARTS LIST

ITEM	QTY	REFERENCE	PART DESCRIPTION	MANUFACTURER/PART NUMBER
39	1	R30	RES., 1Ω, 1%, 1/8W, 0805, AEC-Q200	VISHAY, CRCW08051R00FKEA
40	1	R34	RES., 0.015Ω, 1%, 3/4W, 1206, AEC-Q200, METAL, SENSE	SUSUMU, KRL1632E-C-R015-F-T1
41	1	R36	RES., 56.2k, 1%, 1/10W, 0603, AEC-Q200	NIC, NRC06F5622TRF
42	1	R37	RES., 47.5k, 1%, 1/10W, 0603	VISHAY, CRCW060347K5FKEA
43	1	U1	IC, 55V BUCK-BOOST BATTERY CHARGER, 38-PIN QFN	ANALOG DEVICES, LTC4020EUHF#PBF
44	1	Z1	DIODE, ZENER, 15V, 350mW, SOT-23, AEC-Q101	NEXPERIA, BZX84-C15, 215
45	1	Z2	DIODE, ZENER, 6.2V, 500mW, SOD-123, AEC-Q101	VISHAY, MMSZ4691-E3-08
Optional Electrical Components				
1	0	C1	CAP., OPTION, 0805	
2	0	C10, C19-C21, C24, C26, C27	CAP., OPTION, 0603	
3	0	C30, C31	CAP., OPTION, 0402	
4	0	R7, R15	RES., OPTION, 0805	
5	0	R20, R27	RES., OPTION, 0402	
6	0	R35	RES., OPTION, 0603	
Hardware: For Demo Board Only				
1	7	E1, E2, E4, E5, E7, E12, E14	TEST POINT, TURRET, 0.094" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2501-2-00-80-00-00-07-0
2	6	E3, E6, E8-E11	TEST POINT, TURRET, 0.064" MTG. HOLE, PCB 0.062" THK	MILL-MAX, 2308-2-00-80-00-00-07-0
3	6	J1-J6	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	1	JP2	CONN., HEADER, MALE, 1×5, 2mm, ST, THT	SULLINS CONNECTOR SOLUTIONS, NRPN051PAEN-RC
6	1	JP3	CONN., HDR, MALE, 1×3, 2mm, VERT, ST, THT, NO SUBS. ALLOWED	SAMTEC, TMM-103-02-L-S
7	4	MP1-MP4	STANDOFF, NYLON, SNAP-ON, 0.25" (6.4mm)	KEYSTONE, 8831
8	3	XJP1-XJP3	CONN., SHUNT, FEMALE, 2-POS, 2mm	SAMTEC, 2SN-BK-G

SCHEMATIC DIAGRAM



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.

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