# 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

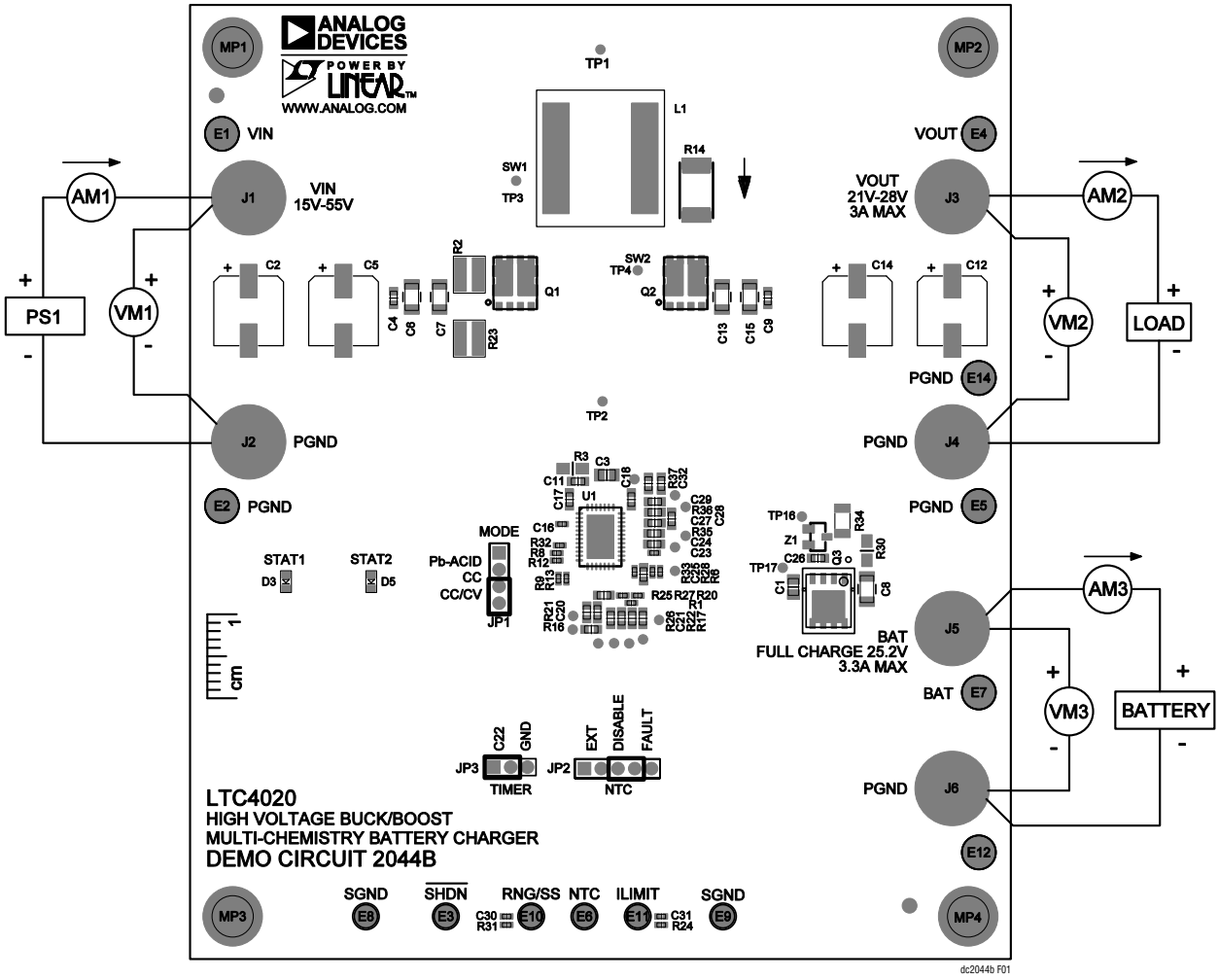



**Figure 1. Proper Measurement Equipment Setup**

## QUICK START PROCEDURE

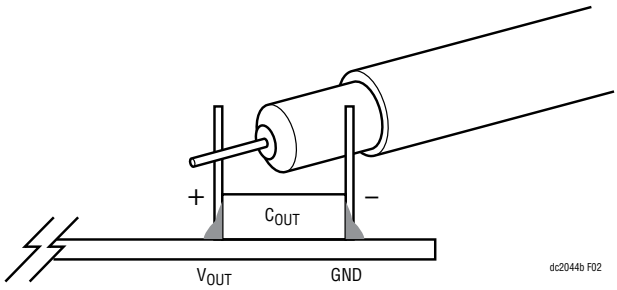



**Figure 2. Measuring Output Voltage Ripple**

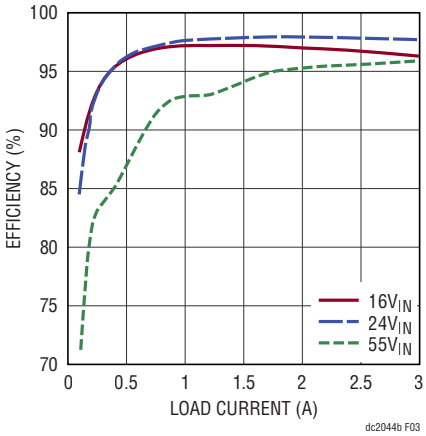



**Figure 3. Efficiency vs Load Current ($V_{OUT}$ = 25.2V)**

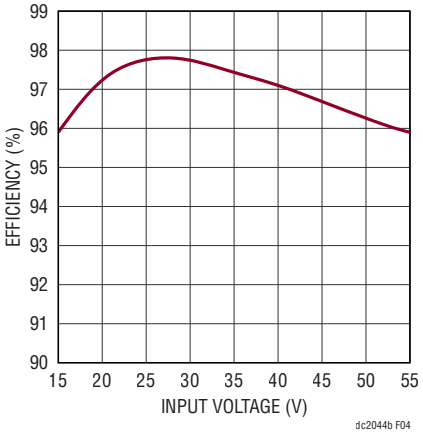



**Figure 4. Efficiency vs Input Voltage ($V_{OUT}$ = 25.2V, $I_{OUT}$ = 3A)**

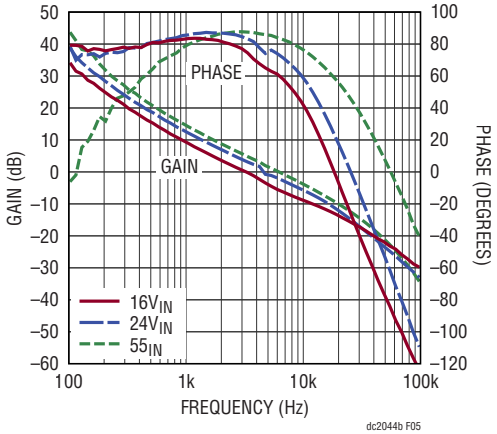



**Figure 5. Bode Plots for $V_{OUT}$ Voltage Control Loop ($V_{OUT}$ = 27.7V, NTC = SGND)**

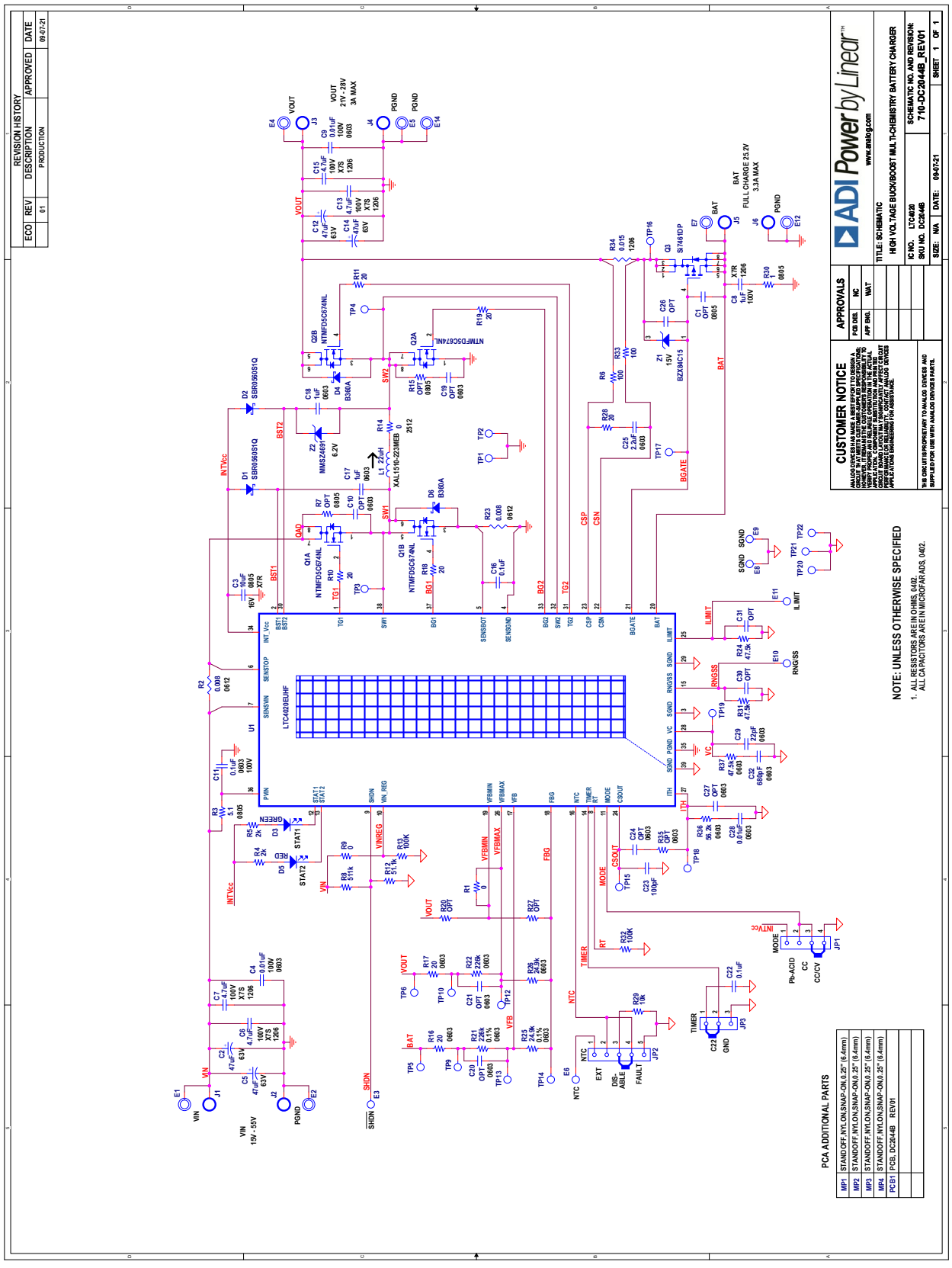
## PARTS LIST

| 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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