# LTC3128

# High Efficiency 2-Cell Supercapacitor Charger and Balancer Converter

## DESCRIPTION

Demonstration circuit 1887 is a DC/DC supercapacitor buck-boost charger and balancer converter featuring the LTC®3128. The DC1887A operates over 1.72V to 5.5V input and charges the output up to 5.5V. Also, the LTC3128 has 2% precision input current limit, which allows the circuit to operate effectively with current limited input power sources like the USB. The 1.2MHz switching frequency operation results in a small and efficient circuit. The converter provides high output voltage accuracy (typically ±2%) over a 1.72V to 5.5V input. The demonstration circuit can be easily modified to generate different output voltages.

The DC1887 has a small circuit footprint. It is a high performance and cost effective solution for charging and balancing supercapacitors. Please read the LTC3128 data sheet along with this manual.

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



## PERFORMANCE SUMMARY **Specifications are at $T_A$ = 25°C**

| PARAMETER | CONDITIONS | VALUE |
|---|---|---|
| Minimum Input Voltage | $I_{OUT}$ = 0A to 1A | 1.72V |
| Maximum Input Voltage | $I_{OUT}$ = 0A to 1A | 5.5V |
| $V_{OUT}$ | $V_{IN}$ = 1.72V to 5.5V, $I_{OUT}$ = 0A | 4.2V ±2% |
| Input Current Limit (Programmable to 3A) | $V_{IN}$ = 1.72V to 5.5V | 0.9A |
| Nominal Switching Frequency | | 1.2MHz |

# QUICK START PROCEDURE

Demonstration circuit 1887 is easy to set up to evaluate the performance of the LTC3128. For proper measurement equipment setup refer to Figure 1 and follow the procedure below:

**NOTE:** When measuring the input or output voltage ripple, care must be taken to minimize the length of oscilloscope probe ground lead. Measure the input or output voltage ripple by connecting the probe tip directly across the VIN or VOUT and GND terminals as shown in Figure 2.

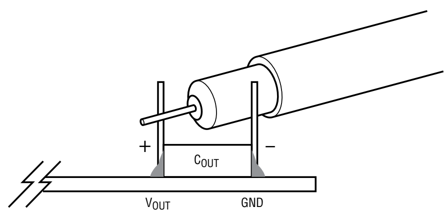



**Figure 2. Measuring Input or Output Ripple**

1. With power off, connect the input power supply to $V_{IN}$ and GND.
2. Keep the load set to 0A or disconnected.
3. Turn the input power source on and slowly increase the input voltage. Be careful not to exceed 5.5V.

   **NOTE:** Make sure that the input voltage $V_{IN}$ does not exceed 5.5V.
4. Set the input voltage to 3.3V and check for the proper output voltage of 4.2V. If there is no output, temporarily disconnect the load to make sure that the load is not set too high.
5. Once the proper output voltage is established, adjust the load and observe the output voltage regulation, ripple voltage, efficiency and other parameters.
6. Note that the output voltage $V_{OUT}$ will vary with load. This is due to the current source nature of the LTC3128 power converter. As the output voltage increases the output current will decrease in order to maintain the input current below the preset limit.

The LTC3128 circuit maximizes the output current while keeping the input current within the preset current limit. This keeps the supercapacitor charging time to a minimum.

## CHANGING THE OUTPUT VOLTAGE

To change the output voltage from the programmed 4.2V, change the voltage divider resistors connected to the LTC3128 FB pin (see the schematic on page 5).

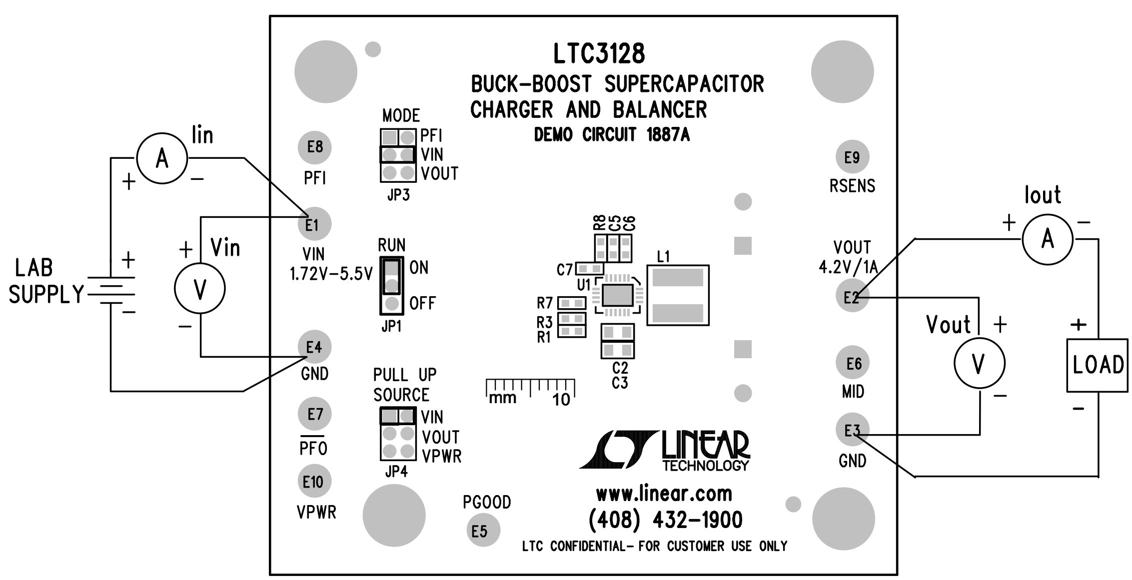



**Figure 1. Proper Measurement Equipment Setup**

# QUICK START PROCEDURE

### CONVERTER OUTPUT CURRENT

The DC1887 output current capability depends on the input voltage and programmed input current limit. Typical performance of the DC1887A is shown in Figure 3. As can be seen from Figure 3, the output current decreases as the output voltage is approaching the programmed output voltage of 4.2V.

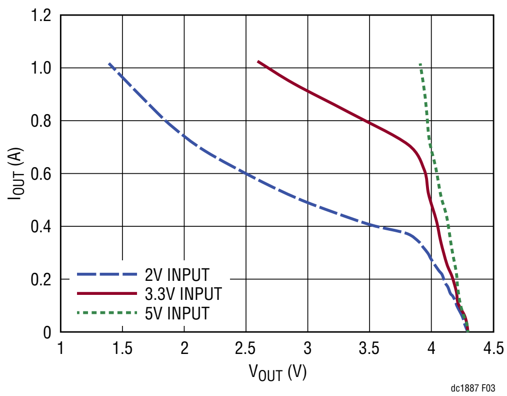



**Figure 3. The Output Current Decreases as the Supercap Voltage Increases Due to Precise Input Current Limit.**

### OUTPUT LOAD STEP RESPONSE

The load step response of DC1887A is dependent on the supercap used. If higher load steps need to be handled more output capacitance can be added in order to keep the voltage transients at the desired level. The load step transients are shown in Figure 4.

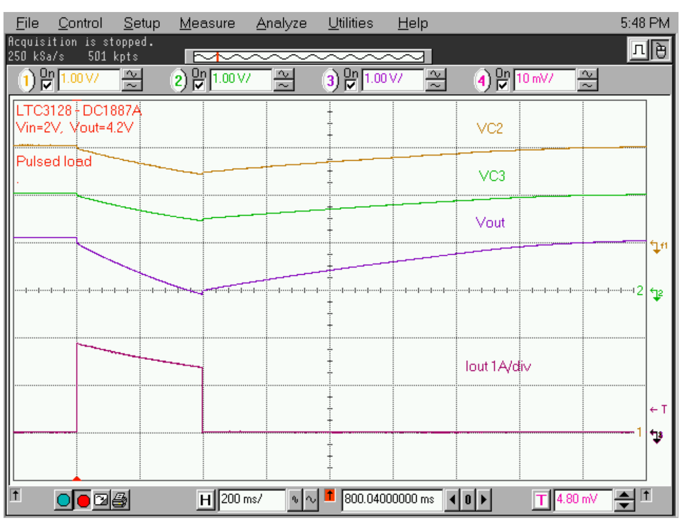



**Figure 4. The Supercap Supplies Most of the Pulsed Load Current. The LTC3128 Makes a Small Contribution to Load Current as Shown in Figure 3.**

### START-UP AND CURRENT LIMIT FUNCTION

The DC1887 features an input current limit circuit that controls the inrush current and output voltage ramp at start-up and during recharge cycles. The input current limit of DC1887 is set to 900mA and it should be suitable for operation from a USB port. The input current limit can be seen in Figure 5. While charging the supercap, the current is constant. Once the output voltage is close to the set point the current limit is reduced in order to prevent output voltage overshoot.

The input current limit can be programmed up to 3A by changing the resistor R8 in the Schematic Diagram.

### OUTPUT VOLTAGE BALANCING

The LTC3128 can charge two output capacitors in series that are not identical. The internal capacitor voltage balancing circuit can compensate for the difference in capacitance by moving the charge from the capacitor at a higher voltage (smaller cap) to a capacitor with a lower voltage (bigger cap).

To see this effect, monitor $V_{MID}$ (VC3) and $V_{OUT}$ with a scope as shown in Figure 5. The trace 1 in Figure 5 is showing the top cap voltage (VC3 = $V_{OUT} - V_{MID}$).

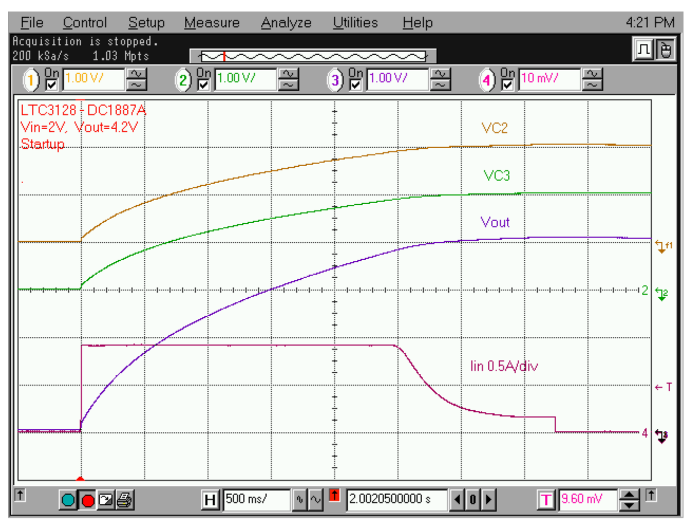
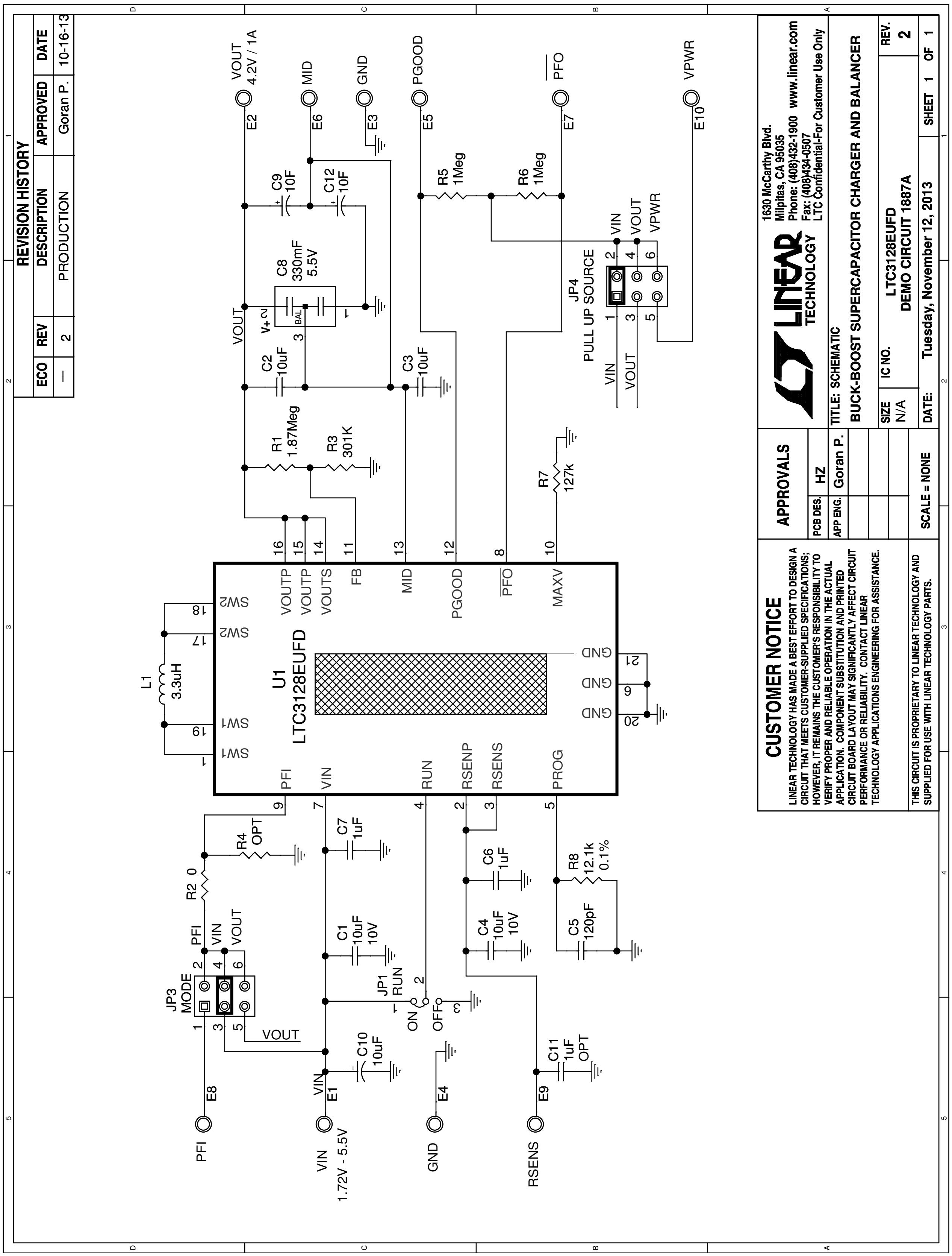



**Figure 5. The DC1887 Ramps the Output Slowly at Start-Up without Generating an Input Current Surge.**

## PARTS LIST

| ITEM | QTY | REFERENCE | PART DESCRIPTION | MANUFACTURER/PART NUMBER |
|---|---|---|---|---|
| **Required Circuit Components** | | | | |
| 1 | 2 | C2, C3 | CAP, X5R, 10µF, 25V, 10%, 0805 | AVX, 08053D106KAT2A |
| 2 | 2 | C1, C4 | CAP, X5R, 10µF, 25V, 10%, 1206 | MURATA, GRM31CR61E106KA12L |
| 3 | 1 | C5 | CAP, NPO, 120pF, 25V, 10%, 0603 | AVX, 06033A121JAT2A |
| 4 | 3 | C6, C7, C10 | CAP, X5R, 1µF, 25V, 10%, 0603 | AVX, 06033D105KAT2A |
| 5 | 1 | C8 | SUPERCAP, 5.5V, 330mF | MURATA, DMF3Z5R5H334M3DTA0 |
| 6 | 2 | C9, C12 | SUPERCAP, 10.0F, 2.7V, 10mm × 30mm | ILLINOIS CAP, 106DCN2R7Q |
| 7 | 1 | L1 | IND, POWER INDUCTOR, 3.3µH | COILCRAFT: XAL6030-332MEB |
| 8 | 1 | R1 | RES, CHIP, 1.87M, 1%, 0603 | VISHAY, CRCW06031M87FKEA |
| 9 | 1 | R2 | RES, CHIP, 0, 0603 | VISHAY, CRCW06030000Z0EA |
| 10 | 1 | R3 | RES, CHIP, 301k, 1%, 0603 | VISHAY, CRCW0603301KFKEA |
| 11 | 2 | R5, R6 | RES, CHIP, 1M, 1%, 0603 | VISHAY, CRCW06031M00FKEA |
| 12 | 1 | R7 | RES, CHIP, 127k, 1%, 0603 | VISHAY, CRCW0603127KFKEA |
| 13 | 1 | R8 | RES, CHIP, 12.1k, 0.1%, 0603 | VISHAY, TNPW060312K1BEEA |
| 14 | 1 | U1 | LTC3128EUFD, QFN 4mm × 5mm | LINEAR TECHNOLOGY, LTC3128EUFD |
| **Additional Demo Board Circuit Components** | | | | |
| 1 | 0 | C11 (OPT) | CAP, 0603 | |
| 2 | 0 | R4 OPT | RES, CHIP OPTIONAL | |
| **Hardware: For Demo Board Only** | | | | |
| 1 | 10 | E1 TO E10 | TESTPOINT, TURRET, 0.095" | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 2 | 1 | JP1 | 0.079 SINGLE ROW HEADER, 3 PIN | SAMTEC, TMM-103-02-L-S |
| 3 | 2 | JP3, JP4 | 0.079 DOUBLE ROW HEADER, 2X3 PIN | SAMTEC, TMM-103-02-L-D |
| 4 | 3 | JP1, JP3, JP4 | SHUNT | SAMTEC, 2SN-BK-G |
| 5 | 4 | STAND OFF | STAND OFF | KEYSTONE, 8833 |
| 6 | 1 | | FAB, PRINTED CIRCUIT BOARD | DEMO CIRCUIT 1887A |
| 7 | 1 | | STENCIL | STENCIL DC1887A |

## SCHEMATIC DIAGRAM



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