

# Ultralow Voltage Energy Harvester and Primary Battery Life Extender

## DESCRIPTION

Demonstration circuit 2103A featuring the [LTC®3107](#) is a highly integrated DC/DC converter designed to extend the life of a primary battery in low power wireless systems by harvesting and managing surplus energy from extremely low input voltage sources such as thermoelectric generators (TEG). The step-up topology operates from input voltages as low as 20mV.

The DC2103A demonstration circuit has been optimized for low start-up voltage with a 100:1 turns ratio transformer. For applications where it is desirable to trade-off a higher start-up voltage for higher current, a lower turns ratio transformer can be used. Refer to the LTC3107 data sheet for more information.

The LTC3107 is designed to accumulate and manage energy from low voltage and low impedance sources while providing battery backup with seamless transitions between Energy Harvesting (EH) and battery power.

By utilizing the EH source when it is available, the life of the battery can be extended by only taking energy from the battery only when necessary. The battery backup also ensures continuous power to the load. The demonstration

circuit has been set up with battery terminals to allow for different battery configurations to be used. Please consult the schematic for proper switch positioning. Space is provided, and alternate part footprints have been built into the PCB to allow experimentation with larger capacitors and different battery types for more energy storage.

Refer to the data sheet for more information including equations to properly size the output capacitors for a given application.

The DC2103A demo board also incorporates a connector (J1) which can be used to connect to a Dust Networks® mote demo board

The LTC3107 data sheet has detailed information about the operation, specification, and applications of the part. The data sheet should be read in conjunction with this Quick Start Guide.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC2103A>**

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## PERFORMANCE SUMMARY

Specifications are at  $T_A = 25^\circ\text{C}$

| PARAMETER           | CONDITIONS   |
|---------------------|--|
| Input Voltage Range | 30mV to 500mV (Typical No Load Start-Up = 20mV)                      |
| VLDO                | 2.2V   |
| VOUT                | Typically: VBAT – 30mV (Harvesting)<br>VBAT – 220mV (Not Harvesting) |
| VBAT                | 2V to 4V   |
| VSTORE              | 4.3V (Clamped to VAUX)   |

## QUICK START PROCEDURE

Using short twisted pair leads for any power connections and with all loads and power supplies off, refer to Figure 1 for the proper measurement and equipment setup. The Power Supply (PS1) should not be connected to the circuit until told to do so in the procedure below.

The LTC3107 and therefore the demo board require a battery to operate and regulate the output voltage, even if a source is available at the VIN terminals. The battery provides a reference for the output voltage regulation loop. Several battery options are provided on the demo board. A coin cell battery, CR2032 can be used by populating BTH1 and setting SW1 in the appropriate position (see schematic and step 2 below). A CR2032 battery is provided with the demo board. Alternatively, battery holders are provided for AA size batteries. In the case of a primary battery such as a Lithium Thionyl Chloride battery, in a AA case size, which has a terminal voltage of 3.6V, a single battery should be used and the switches configured as described below. Two

AA alkaline batteries can also be used. In that case, the switches should be configured to connect the batteries in series as described below for the 2 battery case.

The demo board can also be powered by a power supply, or any other custom battery configuration, (the voltage needs to be within 2V to 4V) by connecting the source between VBATT and ground using the terminals provided on the demo board (E9 and E10)

NOTE: The battery voltage, at the VBATT pin, should be a minimum of 2V and should not exceed 4V for proper operation.

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 VLDO or VOUT and GND terminals. See Figure 2 for proper scope probe technique.

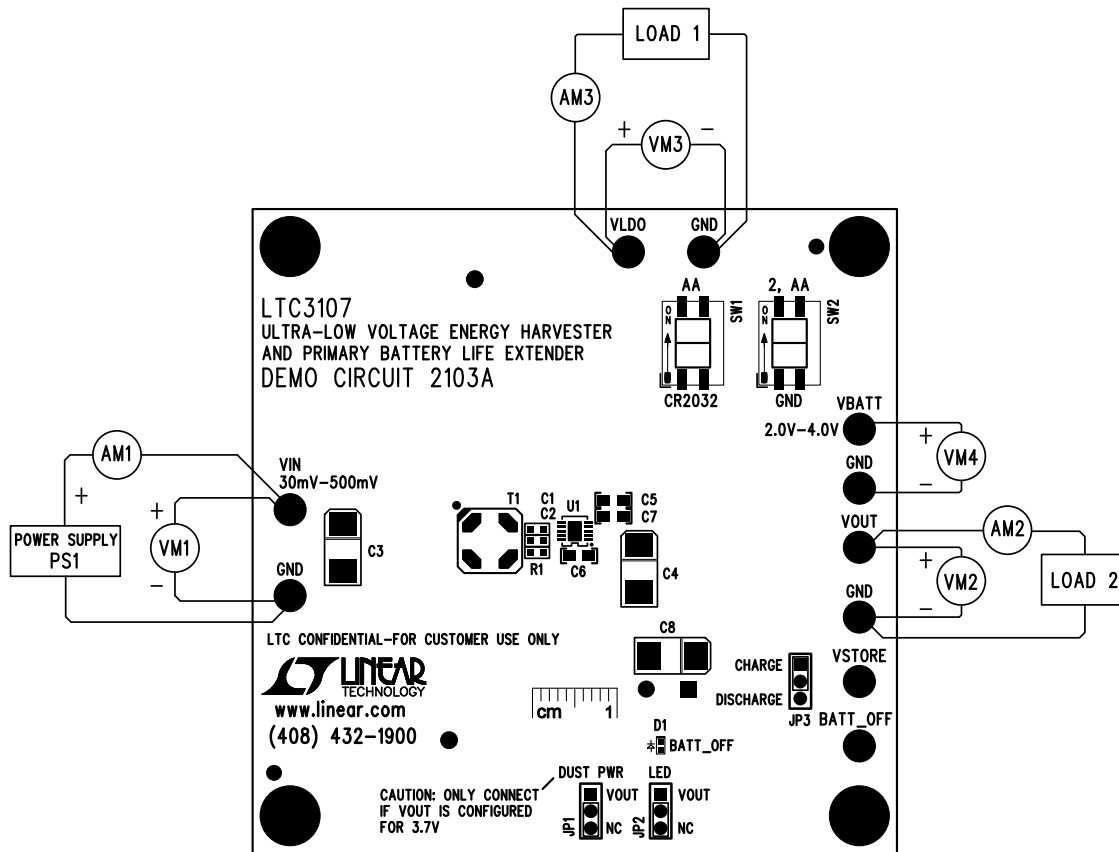


Figure 1. Connection Diagram

## QUICK START PROCEDURE

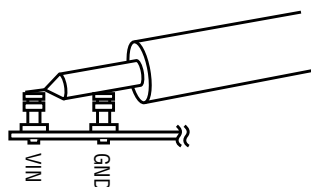


Figure 2. Measuring Input or Output Ripple

1. Jumper, Power Supply and LOAD Settings to start:

**PS1:** OFF

**LOADS:** OFF

**SW1:** CR2032

CR2032 installed

**JP1:** (DUST PWR) NC

**JP2:** (LED) NC

2. A CR2032 battery is supplied with the demo board. Install the battery in BTH1 and configure the switches as follows:

a. Set SW1 to CR2032. SW2 can be set to GND.

3. For operation with batteries other than a CR2032, refer to the Battery Settings section that follows.

4. Once the batteries are installed and the switches are set to the correct position, connect a power supply (PS1) to VIN.

5. Turn on PS1 and slowly increase voltage until the voltage at VIN is 50mV. Monitor input current. If input current exceeds 50mA turn off PS1 and look for shorts.

6. Confirm  $2V < VBATT < 4V$

7. Confirm VLDO = 2.2V (for VBATT > 2.4V)

8. Increase VIN = 100mV

9. Set LOAD on VLDO to 50μA. Set LOAD on VOUT = 25μA.

10. Confirm  $VOUT \approx VBATT - 30mV$ .

11. At this point VIN and the loads can be varied. As long as the input source can supply the average power to the load, the battery is acting solely as a reference for the output voltage. If the input source is disconnected, or the power available is less than the load requires, the load will be satisfied by the battery.

12. Battery Settings:

The LTC3107 demo board can be configured to operate with a coin cell primary battery, a AA battery, or 2 AA size batteries in series. In any of these configurations, the maximum battery voltage at the VBATT terminal should not exceed 4V. When using a single AA battery, the minimum voltage should be greater than 2V.

- a. For operation with a single AA battery:

Set SW1 to AA and SW2 to GND

- b. For operation with two AA batteries

Set SW1 to AA and SW2 to 2,AA

- c. To operate the demo board with an external supply, or a different battery case size, connect the source to the VBATT and GND terminal provided on the edge of the demo board. Care should be taken to not populate the battery holders with batteries, as this could potentially damage the batteries and/or damage the board.

## QUICK START PROCEDURE

### For use with a DUST Networks MOTE demo board:

13. Connector J1 is designed to interface with a Dust Networks mote demo board. Consult the Dust® documentation for more information on power requirements. In general the Dust Networks mote will operate with VOUT proportional to a primary battery such as a CR2032. However, care should be taken to not overvoltage the mote. Newer motes may require a different VOUT.
14. Once the output voltage has been configured to the proper voltage and with JP1 set to NC connect DC1922A to the Dust Networks mote demo board using J1. See Figure 3 for the proper connections and orientation.
15. Once the boards have been connected, move Jumper

JP1 to VOUT. The DC2103 can be operated as described above, with a power supply (PS1) or an Energy Harvesting source connected to the input terminals.

The board is now ready for operation. The voltage on VOUT should closely follow the battery voltage minus approximately 30mV when the EH source is present, and supplying power to the load, or minus approximately 220mV when no EH source is present.

Several variations of this design are possible, including increasing the energy storage by populating C9, or C10. Please refer to the data sheet for design equations.

**QUICK START PROCEDURE**

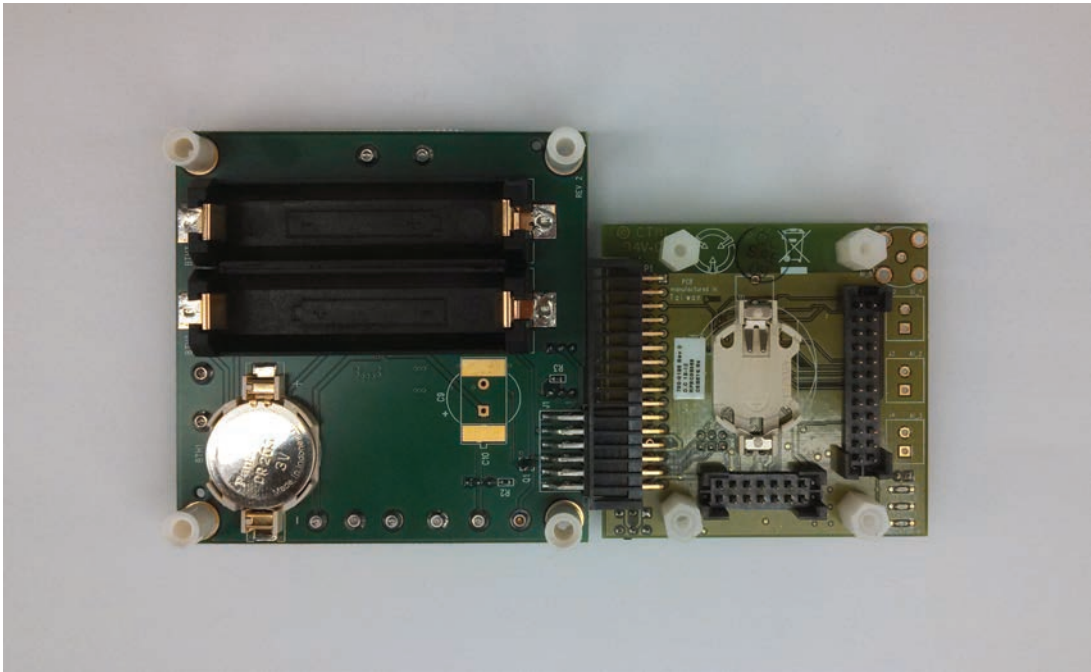
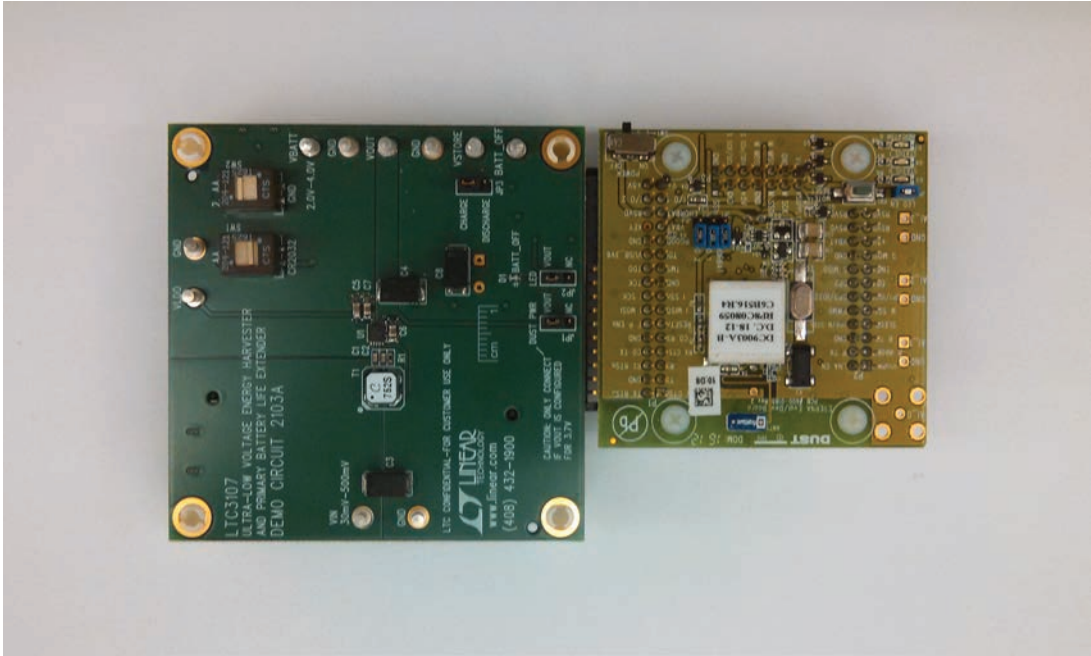


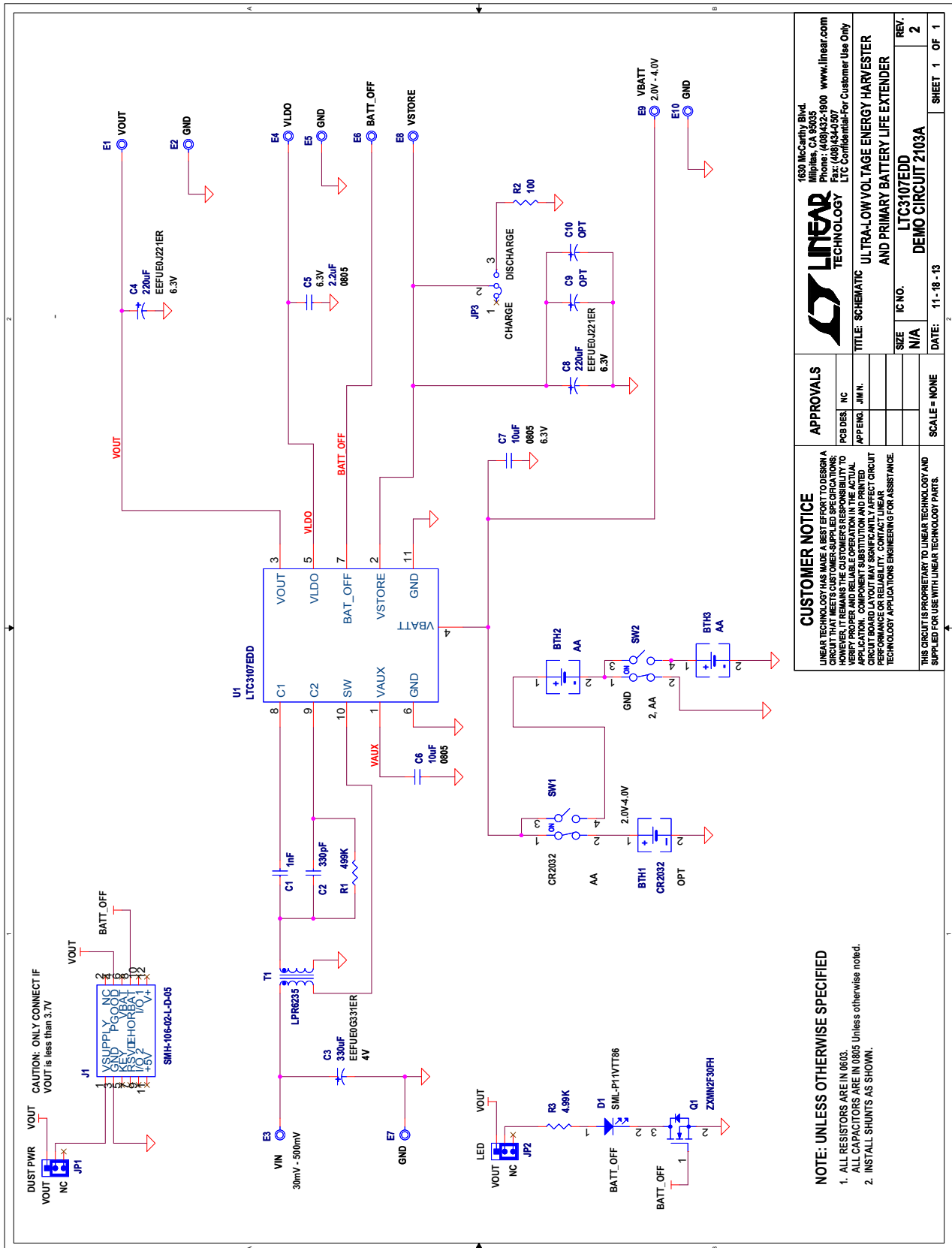
Figure 3. Top and Bottom View of DC2103 Connected to Dust Mote

# DEMO MANUAL DC2103A

## PARTS LIST

| ITEM  | QTY | REFERENCE  | PART DESCRIPTION   | MANUFACTURER/PART NUMBER          |
|---|-----|------------|--|-----------------------------------|
| <b>Required Circuit Components</b>              |     |            |  |                                   |
| 1   | 1   | C1         | CAP CER, X7R, 1000pF, 50V, 10%, 0603                                 | TDK, C1608X7R1H102K               |
| 2   | 1   | C2         | CAP CER, X7R, 330pF, 50V, 10%, 0603                                  | TDK, C1608X7R1H331K               |
| 3   | 1   | C3         | CAP POLYMER SMD, 330µF, 4V, 20%                                      | PANASONIC, EEFUE0G331ER           |
| 4   | 2   | C4, C8     | CAP POLYMER SMD, 220µF, 6.3V, 20%                                    | PANASONIC, EEFUE0J221ER           |
| 5   | 1   | C5         | CAP CER 2.2µF 6.3V 10% X7R 0805                                      | TDK, CGB4B3X7R0J225K055AB         |
| 6   | 1   | C6, C7     | CAP CER 10µF 6.3V 20% X5R 0805                                       | TDK, C2012X5R0J106M125AB          |
| 7   | 1   | D1         | LED 0402 RED 50mW 20mA SMD   | ROHM, SML-P11VTT86                |
| 9   | 1   | R1         | RES 499k, 1/10W, 0603  | PANASONIC, ERJ-3EKF4993V          |
| 10  | 1   | R2         | RES 100Ω, 1/10W, 0603  | PANASONIC, ERJ-3EKF1000V          |
| 11  | 1   | R3         | RES 4.99k 1/10W 1% 0603 SMD  | PANASONIC, ERJ-3EKF4991V          |
| 12  | 2   | SW1, SW2   | SWITCH, SPDT SWITCH DIP SPDT 1POS SMT LOWPRO                         | CTS, 204-121LPST                  |
| 13  | 1   | T1         | TRANSFORMERS, 100:1 TURNS RATIO                                      | COILCRAFT, LPR6235-752SML         |
| 14  | 1   | U1         | ULTRA-LOW VOLTAGE ENERGY HARVESTER AND PRIMARY BATTERY LIFE EXTENDER | LINEAR TECHNOLOGY, LTC3107EDD     |
| 15  | 1   | BTH1       | SMT, CR2032 BATTERY HOLDER   | MPD INC, BU2032SM-HD-GCT-ND       |
| 16  | 2   | BTH2, BTH3 | HOLDER BATTERY AA SMD  | KEYSTONE, 1024                    |
| 17  | 1   | BATTERY    | CR2032 COIN CELL BATTERY   | DURACELL, CR2032                  |
| <b>Additional Demo Board Circuit Components</b> |     |            |  |                                   |
| 1   | 0   | C9 (OPT)   | CAP, 0.47F, 5.5V   | COOPER/BUSSMAN, KR-5R5C474-R      |
| 2   | 0   | C10 (OPT)  | CAP, TANT, 2200µF, 6.3V  | VISHAY, 592D228X06R3X2T22H        |
| <b>Hardware: For Demo Board Only</b>            |     |            |  |                                   |
| 1   | 10  | E1-E10     | TESTPOINT, TURRET, 0.095"  | MILL-MAX, 2501-2-00-80-00-00-07-0 |
| 2   | 1   | J1         | HEADER, 2X6, 12-PIN, SMT HORIZONTAL SOCKET w/KEY, 0.100"             | SAMTEC, SMH-106-02-L-D-05         |
| 3   | 3   | JP1-JP3    | 3-PIN 0.079 SINGLE ROW HEADER  | SAMTEC, TMM-103-02-L-S            |
| 4   | 3   | JP1-JP3    | SHUNT  | SAMTEC, 2SN-BK-G                  |
| 5   | 4   |            | SPACER SELF-RETAIN #4 SCREW 3/4"                                     | RICHCO PLASTICS, SRS4-12-01       |

**SCHEMATIC DIAGRAM**





# DEMO MANUAL DC2103A

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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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