

## Low Power Wireless Current Sense

### INTRODUCTION

The DC2369A demo circuit is a reference design that implements a wireless current sense solution using Linear Technology's low power integrated circuits. The only external connection needed is the current to be measured, allowing this circuit to be inserted at any voltage level or isolation level.

The design combines components for current measurement, power management and wireless mesh networking. A micro-power zero-drift op amp ([LTC®2063](#)) amplifies the voltage across a sense resistor. A 16-bit SAR ADC and precision reference ([AD7988](#) and [LT®6656](#)) digitize the reading. A SmartMesh IP™ wireless radio module

([LTP5901-IPM](#)) runs the application, provides the wireless mesh connectivity and communicates with a central network manager. A switching power supply ([LTC3335](#)) counts the cumulative charge drawn from the included battery while also regulating the output voltage for the rest of the application. Table 1 shows featured components used along with their function.

**Design files for this circuit board are available at <http://www.linear.com/demo/DC2369A>**

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**Table 1**

| LTC PART NUMBER             | FUNCTION                                                   | BENEFITS                                                                                                         |
|-----------------------------|------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| <a href="#">LTC2063</a>     | 2µA Zero-Drift Op Amp                                      | Measures Small Voltage Drop Across Sense Resistor to Measure Current                                             |
| <a href="#">AD7988-1</a>    | 100ksps Ultra Low Power 16-Bit SAR ADC                     | Digitizes Measurement from Op Amp While Consuming <1µA at Low Sample Rate                                        |
| <a href="#">LT6656-3</a>    | 1µA Precision Voltage Reference                            | <10ppm/°C Reference for Stable ADC Measurement. Provides Low Noise Supply for Op Amp                             |
| <a href="#">LTP5901-IPM</a> | SmartMesh IP Mote Module                                   | Automatically Forms Low Power, Reliable Wireless Network. Built-In Microprocessor Manages ADC and Power Supplies |
| <a href="#">LTC3335</a>     | Nanopower Buck-Boost DC/DC with Integrated Coulomb Counter | Measures Total Charge Drawn from Battery. Regulates Output Supply for Rest of Application                        |

## DC2369A CONNECTIONS AND JUMPERS

1. Set the slide switch SW1 to ON to power on the circuit. DC2369A is powered from its included two AAA batteries and therefore does not need an external power supply. The slide switch asserts the enable pin of the LTC3335. You may verify correct operation of the power supplies by measuring (on the back of the circuit board) that  $V_{DD} - GND = 3.3V$  and  $V_{REF} - GND = 3.0V$ .
2. The only external connection needed to the DC2369A is for the current to be measured. The DC2369A circuitry does not draw its power from this current – it only uses it to develop a small voltage drop across the included  $10m\Omega$  sense resistor. The DC2369A is designed to measure up to  $\pm 1A$  full-scale current, developing a  $\pm 10mV$  voltage drop across the sense resistor. Connect the current to be measured using the banana connectors (J2 and J3). Set jumpers JP1 and JP2 to the INT position (to use the internal sense resistor). See Figure 1.
3. Alternatively, DC2369A can be used to measure the voltage across an external sense resistor. In this case, set jumpers JP1 and JP2 to EXT, and connect the voltage to be measured to the turrets labeled  $V_{IN}^{+}$  and  $V_{IN}^{-}$ . The preconfigured DC2369A firmware and software will still assume a  $\pm 10mV$  full-scale input voltage and report that as a  $\pm 1A$  full-scale current. See Figure 2.

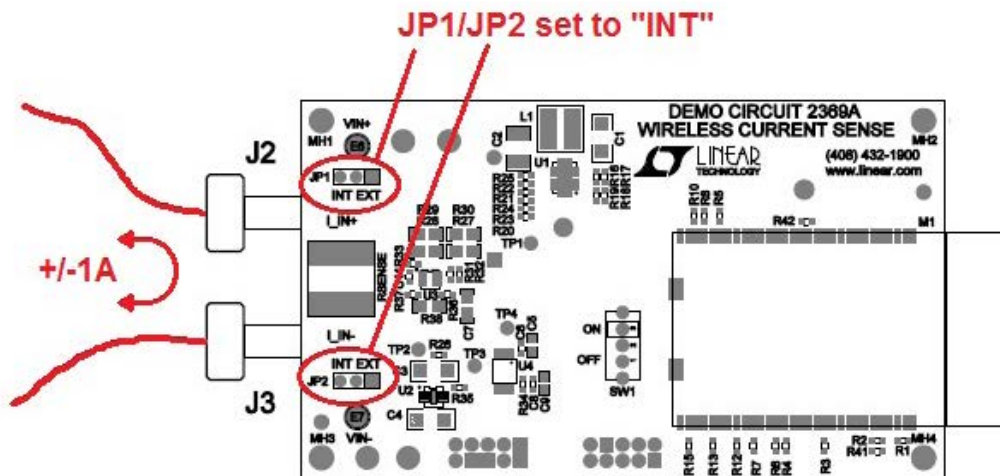


Figure 1. DC2369A Connections and Jumpers for Internal Sense Resistor

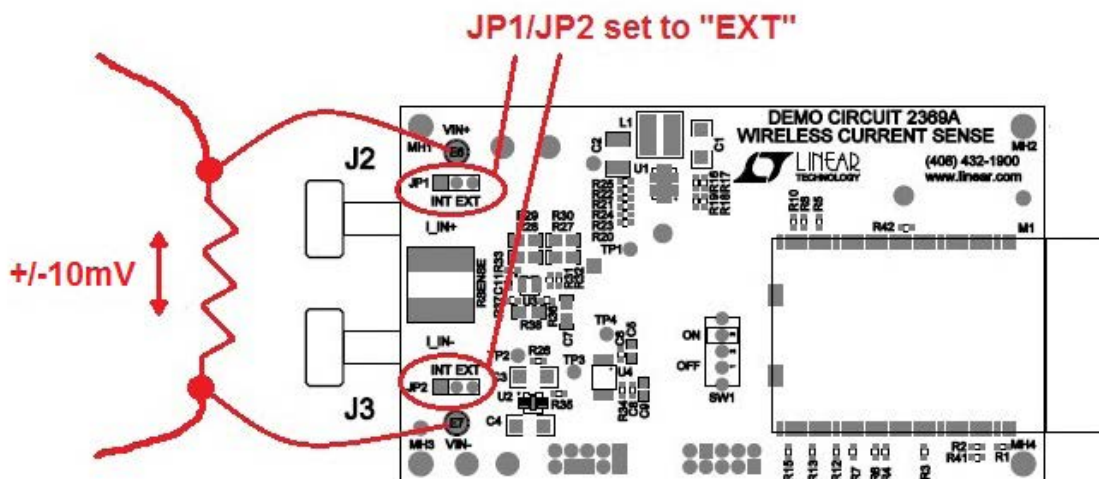


Figure 2. DC2369A Connections and Jumpers for External Sense Resistor

## INSTALL THE DC2369A GUI

For demonstration purposes, a small sample Python based graphical user interface (GUI) application was designed to subscribe to all incoming DC2369A device messages and display the data.

For more information on programming to the manager software application programming interface (API), refer to the [SmartMesh IP Embedded Manager API Guide](#).

### 1. Install FTDI USB-to-Serial Drivers

In order for your computer to communicate with the Manager, you may first need to install a driver from [FTDI](#). You should be able to simply follow the instructions within the driver installer, but detailed instructions are also available in the Setup section of the [SmartMesh IP Tools Guide](#).

### 2. Download GUI

The DC2369A GUI is found with this demo circuit's documentation on [www.linear.com/demo](http://www.linear.com/demo). Download and extract the zip file to a convenient location on your computer.

## FORM THE WIRELESS NETWORK

This document assumes some basic familiarity with SmartMesh IP wireless networking. Refer to the [SmartMesh IP Easy Start Guide](#) if needed.

1. Use any SmartMesh IP manager such as the [DC2274A-A SmartMesh IP USB Network Manager](#). Be aware of the manager's network ID.
2. Turn on power to at least three SmartMesh IP motes, operating on the same network ID as the manager. DC2369A will co-exist in a network with any other SmartMesh IP motes (of the same network ID), such as motes from the [SmartMesh IP Starter Kit DC9021B](#).

3. All DC2369A motes are shipped factory-programmed to the default network ID of 1229. This is the same network ID programmed by default into the standard SmartMesh IP evaluation kits. If it is needed to change the network ID of this mote to match the one used in your network, the DC2369A API or CLI can be accessed through the 10-pin connector labeled J1 PROG on the back of the board.
4. Connect the manager to a computer USB port. The network should now form. Proper operation of the network can be monitored by accessing the manager CLI or API in the usual manner.
5. Open the DC2369A GUI. You will see a window similar to that shown in Figure 3.

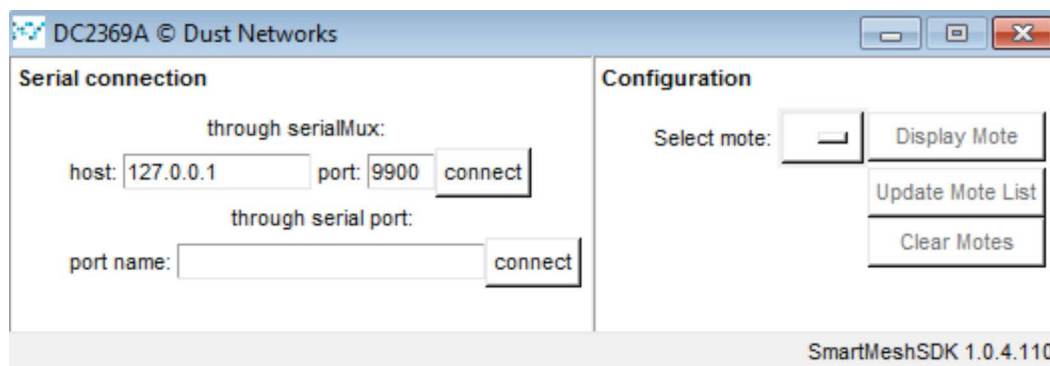


Figure 3. DC2369A GUI Start-Up Window

## FORM THE WIRELESS NETWORK

6. In the port name field, enter the COM port that corresponds to the Manager API. This is typically the last of the four COM ports added. Then click the connect button. The GUI window will change as shown in Figure 4 if connection is successful.

If you don't know what the Manager API COM port is, refer to the [SmartMesh IP Tools Guide](#) for instructions.

7. To select a mote for display, see the Select mote: pull down menu in the Configuration section, and select from the list of connected motes. The pull-down list will be populated with the MAC address of all DC2369A motes that are found on the network. The last few digits of

these MAC addresses can also be found on a label on your DC2369A motes. Click on Display Mote. The GUI window will change similar to Figure 5.

8. Measured Current (A) shows the current measured between the DC2369A input connectors. Used battery life shows an estimation of the percentage of the AAA batteries that has been used since last reset, based on the coulomb counter reading of the mote's LTC3335 power supply. This will likely start at 0.0% when the mote first powers up, and will only change after many hours of operation.

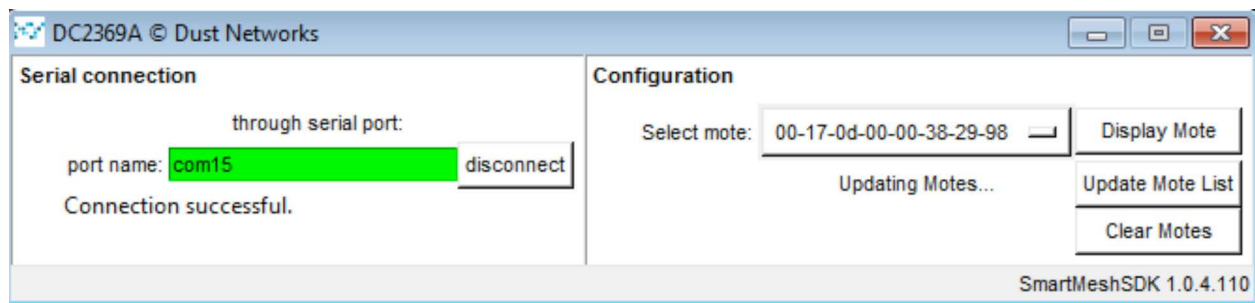


Figure 4. DC2369A GUI Successful Connection

## FORM THE WIRELESS NETWORK

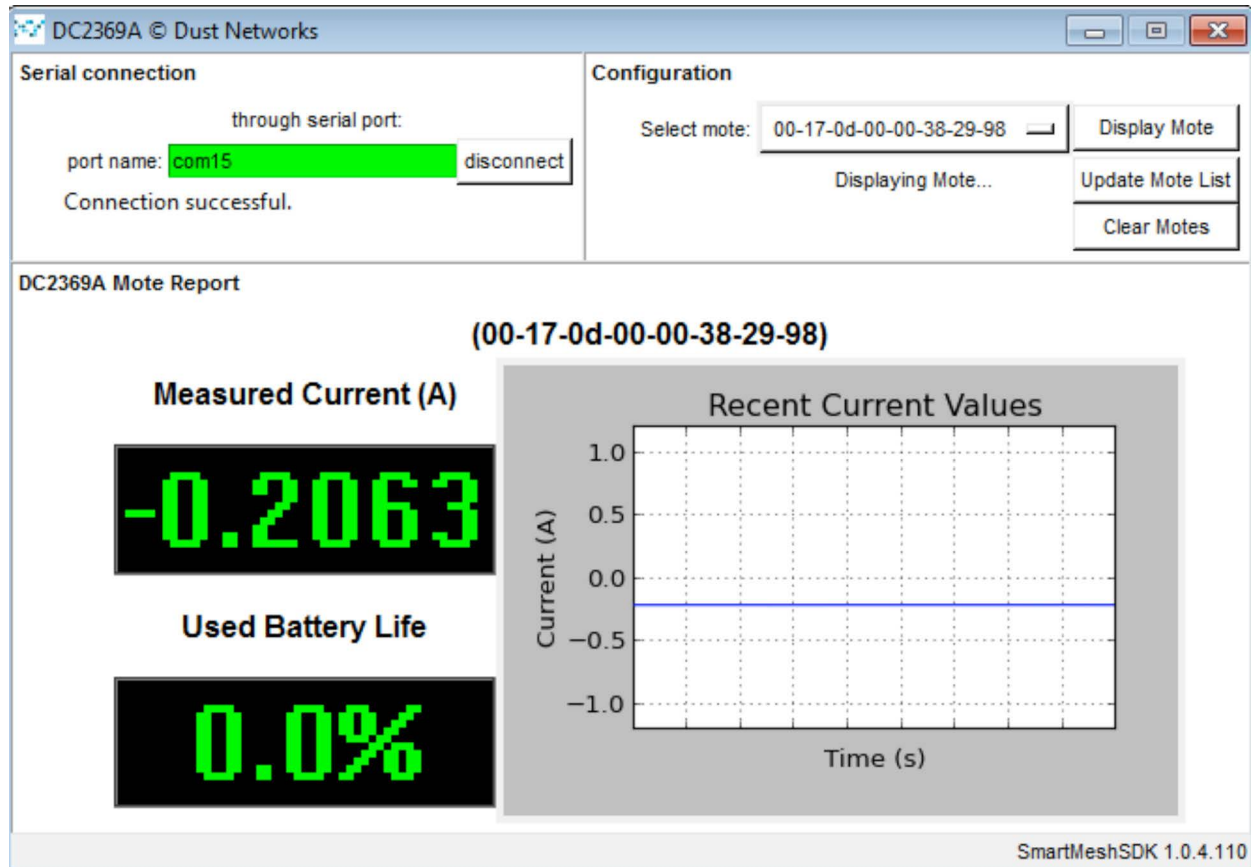


Figure 5. DC2369A GUI Showing Example Data for a Mote

## SOURCE CODE

1. DC2369A has been preprogrammed with custom firmware that runs on the internal microprocessor of the LTP5901-IPM. This firmware has been created in the SmartMesh IP On-Chip SDK (OCSDK), and can be accessed on [Github](#).
2. The DC2369A GUI has been created in Python, built on the SmartMesh® SDK. The source code can be accessed on [Github](#).

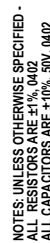
# DEMO MANUAL DC2369A

## PARTS LIST

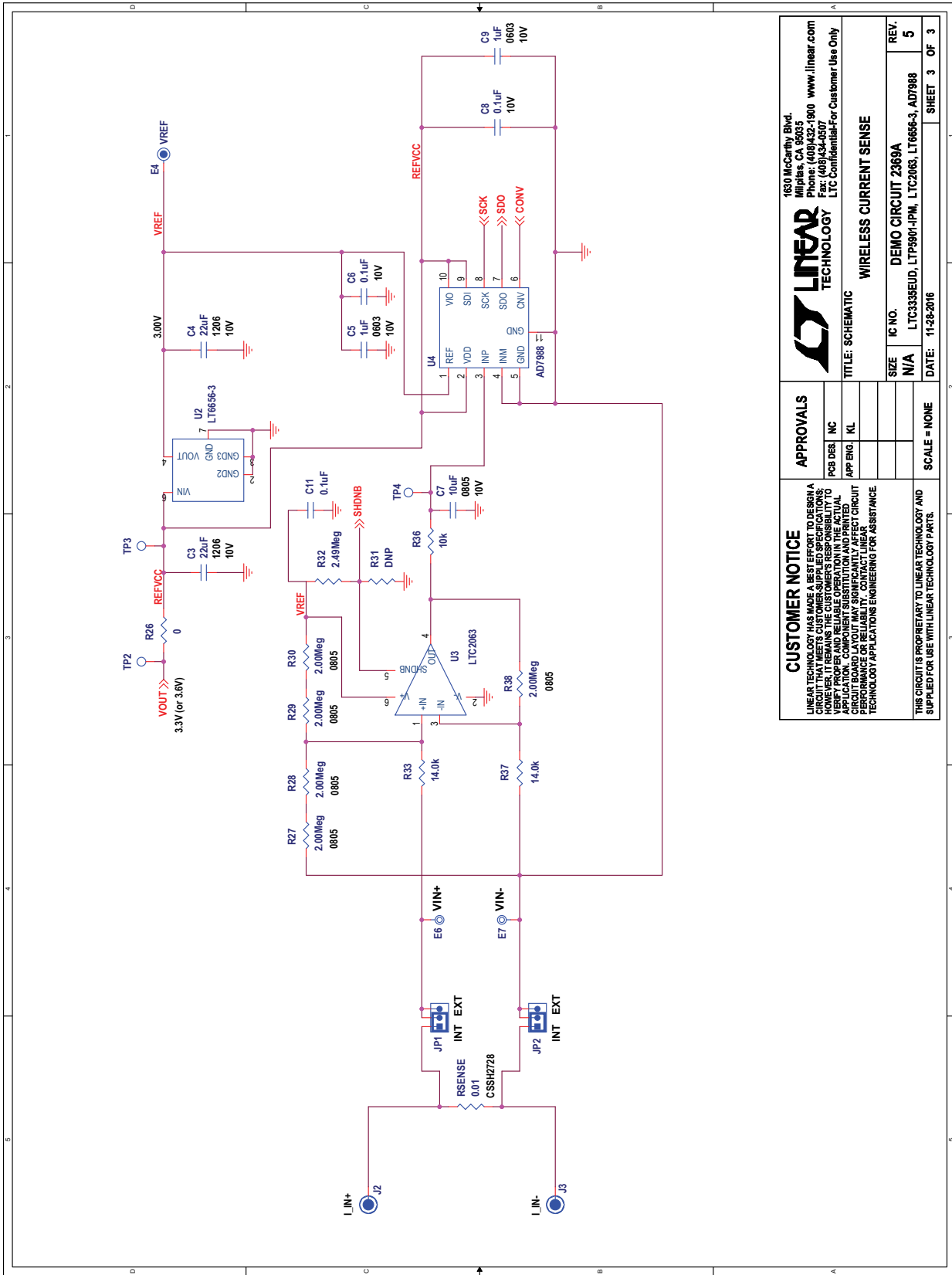
| ITEM                               | QTY | REFERENCE                              | PART DESCRIPTION                                                     | MANUFACTURER/PART NUMBER             |
|------------------------------------|-----|----------------------------------------|----------------------------------------------------------------------|--------------------------------------|
| <b>Required Circuit Components</b> |     |                                        |                                                                      |                                      |
| 1                                  | 1   | BTH1                                   | BATTERY HOLDER, 2CELL AAA, PC MNT                                    | KEYSTONE, 2468K-ND                   |
| 2                                  | 1   | C1                                     | CAP, CHIP, X5R, 22 $\mu$ F, 20%, 6.3V, 1206                          | SAMSUNG, CL31A226MQHNNNE             |
| 3                                  | 1   | C2                                     | CAP, CHIP, X5R, 150 $\mu$ F, 20%, 6.3V, 1210                         | SAMSUNG, CL32A157MQVNNNE             |
| 4                                  | 2   | C3, C4                                 | CAP, CHIP, X7R, 22 $\mu$ F, $\pm$ 10%, 10V, 1206                     | MURATA, GRM31CR71A226KE15L           |
| 5                                  | 2   | C5, C9                                 | CAP, CHIP, X7R, 1 $\mu$ F, $\pm$ 10%, 10V, 0603                      | TDK, C1608X7R1A105K080AC             |
| 6                                  | 3   | C6, C8, C11                            | CAP, CHIP, X7R, 0.1 $\mu$ F, $\pm$ 10%, 10V, 0402                    | TDK, C1005X7R1A104K050BB             |
| 7                                  | 1   | C7                                     | CAP, CHIP, X7R, 10 $\mu$ F, $\pm$ 10%, 10V, 0805                     | TDK, C2012X7R1A106K125AC             |
| 8                                  | 6   | E1, E2, E3, E4, E6, E7                 | TURRET, 0.061 DIA                                                    | MILL-MAX, 2308-2-00-80-00-00-07-0    |
| 9                                  | 2   | J1, J4                                 | 5 x 2 HEADER 2MM                                                     | MOLEX, 87831-1020                    |
| 10                                 | 1   | J2                                     | BANANA JACK, RED                                                     | CONN SOLUTIONS, 108-0902-001         |
| 11                                 | 1   | J3                                     | BANANA JACK, BLACK                                                   | CONN SOLUTIONS, 108-0903-001         |
| 12                                 | 2   | JP1, JP2                               | HEADER, 2MM, 1X3POS                                                  | SAMTEC, TMM-103-02-L-S               |
| 13                                 | 2   | JP1, JP2                               | SHUNT, 2MM                                                           | SAMTEC, 2SN-KB-G                     |
| 14                                 | 1   | L1                                     | IND, SMT, 100 $\mu$ H, 1.40, 350mA, 4mm x 4mm x 1.8mm                | COILCRAFT, LPS4018-104MLB            |
| 15                                 | 1   | M1                                     | SmartMesh IP MOTE MODULE                                             | LINEAR TECH, LTP5901IPC-IPMA#PBF     |
| 16                                 | 4   | R1, R2, R5, R8                         | RES, CHIP, 100k $\Omega$ , 1% 1/10W 0402                             | VISHAY MCS04020C1003FE000            |
| 17                                 | 8   | R3, R4, R6, R17, R20, R22, R24, R26    | RES, CHIP, 0.0 $\Omega$ JUMPER, 1/16W                                | VISHAY CRCW040220000Z0ED             |
| 18                                 | 5   | R7, R10, R12, R13, R15                 | RES, CHIP, 34 $\Omega$ , 1% 1/10W 0402                               | PANASONIC, ERJ-2RKF34R0X             |
| 19                                 | 0   | R16, R21, R23, R25, R31, R32, R41      | OPTIONAL, DO NOT POPULATE                                            |                                      |
| 20                                 | 2   | R18, R19                               | RES, CHIP, 4.99k $\Omega$ , 1% 1/10W 0402                            | PANASONIC, ERJ-2RKF4991X             |
| 21                                 | 5   | R27, R28, R29, R30, R38                | RES, CHIP, 2M $\Omega$ , $\pm$ 0.1%, 1/10W, 0805                     | TE CONNECTIVITY, CPF0805B2MOE1       |
| 22                                 | 2   | R33, R37                               | RES, CHIP, 14k $\Omega$ , $\pm$ 0.1%, 1/16W, 0402                    | TE CONNECTIVITY, CPF0402B14KE1       |
| 23                                 | 1   | R36                                    | RES, CHIP, 10k $\Omega$ , 1/10W, 0402                                | PANASONIC ERJ-2RKF1002X              |
| 24                                 | 1   | R42                                    | RES, CHIP, 237 $\Omega$ , 1%, 1/16W, 0402                            | VISHAY CRCW0402237RFKED              |
| 25                                 | 1   | RSense                                 | RES, CHIP, 0.01 $\Omega$ , $\pm$ 0.5%, $\pm$ 15PPM/C, 3W, 2728       | STACKPOLE ELECTRONICS, CSS2728DT10L0 |
| 26                                 | 1   | SW1                                    | SLIDE SWITCH SPDT                                                    | C&K COMPONENTS, OS102011MS2QN1       |
| 27                                 | 1   | U1                                     | IC, SMT, NANOPOWER BUCK-BOOST WITH COULOMB COUNTER, 3mm x 4mm, QFN20 | LINEAR TECH, LTC3335EUDC#PBF         |
| 28                                 | 1   | U2                                     | IC, SMT, MICROPOWER VOLTAGE REFERENCE, 2mm x 3mm, DFN6               | LINEAR TECH, LT6656AIDC-3#PBF        |
| 29                                 | 1   | U3                                     | IC, SMT, MICROPOWER ZERO-DRIFT OPAMP, SC70                           | LINEAR TECH, LTC2063ISC#PBF          |
| 30                                 | 1   | U4                                     | IC, SMT, 16-BIT ULTRA LOW POWER ADC, 10ID LFCSP 3mm x 3mm            | ANALOG DEVICES, AD7988-1BCPZ-RL7     |
| 31                                 | 4   | MH1 TO MH4                             | STAND-OFF, NYLON, HEX, #4-40, 3/4 INCH TALL                          | KEYSTONE 1902D                       |
| 32                                 | 4   | MH1 TO MH4                             | SCREW, NYLON, #4-40, 1/2 INCH                                        | KEYSTONE 9529                        |
| 33                                 | 2   | TO SECURE BTH1                         | SCREW, NYLON, 2-56, 1/4 INCH                                         | B&F NY PMS 256 0025 PH               |
| 34                                 | 2   | TO SECURE BTH1                         | NYLON HEX NUT 2-56                                                   | B&F NY HN 256                        |
| 35                                 | 2   | BAT1, BAT2 TO PLUG INTO BATTERY HOLDER | BATTERY LITHIUM AAA 1.5V PRIMARY CELL                                | ENERGIZER L92                        |
| 36                                 | 1   |                                        | FAB, PRINTED CIRCUIT BOARD                                           | DEMO CIRCUIT DC2369A-5               |
| 37                                 | 2   |                                        | STENCILS, DC2369A - TOP AND BOTTOM                                   | STENCILS, # DC2369A-5                |



## dc2369af



## SCHEMATIC DIAGRAM



# DEMO MANUAL DC2369A

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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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