High-Accuracy Wireless Temperature Sensor with Solar Battery Life Extender

DESCRIPTION

The DC2126A is a high-accuracy wireless temperature sensor that can be powered from ambient light. It is built using various integrated circuits from Linear Technology. A 24-bit delta-sigma ADC reads a thermistor biased from a precision voltage reference. A SmartMesh IP® wireless radio module provides the wireless mesh connectivity and communicates the temperature to a central access point (manager). A switching power supply harvests energy from the built-in solar panel, and automatically switches over to the internal battery when no ambient light is available. Table 1 shows Linear Technology® components used inside the DC2126A along with their function.

Table 1: DC2126A Components

LTC PART NUMBER	FUNCTION	BENEFITS
LTC®2484	24-bit delta-sigma ADC, reads thermistor	Easy-Drive inputs allow direct hook-up of thermistor.
LT®6654	Low Noise Voltage Reference	Bias thermistor for low noise reading of temperature
LTP™5901-IPM	SmartMesh IP Mote Module	Automatically forms low power, reliable wireless mesh network Built-in microprocessor manages ADC and power supplies
LTC3330	Energy Harvesting DC/DC Converter	Prioritizes between solar power and battery power

PHOTOGRAPHS
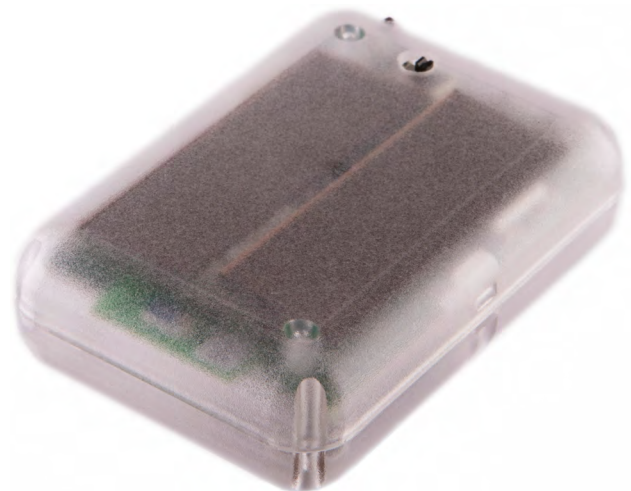
WHAT DO I NEED TO FORM THE WIRELESS NETWORK?

1. At Least 3-5 Motes, Operating on the Same Network ID

The DC2126A is a mote (wireless node) in a SmartMesh IP network. Motes perform two functions in the network: They are the sensor points that gather information (in this case, temperature), and they also automatically help route data from other motes through the network, forming a mesh network. Because the network functions best if it can form a mesh of nodes, with multiple paths through the network, we recommend always operating the DC2126A in a network of at least three to five motes. This is most easily accomplished by adding a DC2126A to a SmartMesh IP Starter Kit, such as the DC9000B (http://www.linear.com/solutions/4314), or the DC9021A, used primarily in Japan (http://www.linear.com/solutions/4316). The DC9000B includes five evaluation motes (labeled DC9003A-B) as well as a network manager (described in the next section). similarly, a DC9021A includes five DC9018A-B evaluation motes and a manager.

Alternatively, if you have three to five DC2126A motes ready to go, you have satisfied this requirement.

All DC2126A motes are shipped factory-programmed to the default network ID of 1229. This is the same network ID programmed by default into the standard DC9000B and DC9021A evaluation kits. If you have not changed the default network ID on your kit manager and devices, the DC2126A will join your network with no changes required. To change the network ID of this device to match the one used in your network (assuming different from the 1229 default), connect the DC2126A to a DC9006 adapter board supplied in the evaluation kit with the provided mini adapter board and cable.

Using a standard terminal program such as Putty or Hyperterm, connect to the CLI serial port, typically it is the third of the four COM ports added when the device is connected to your computer. In CLI type the following command:

```
mset netid < network ID>
```

To verify that the network ID was programmed correctly, type the following command:

```
mget netid
```

Note that a "reset" command must be issued, or power cycle the part for this change to take effect.

2. Network Manager

A network manager ("manager") is required to build a network, and then collect all sensor data. This manager is responsible for building and maintaining the wireless mesh network, telling each of the motes when to send, when to listen, and at which frequencies. The manager does this automatically without any user intervention or setup needed.

This guide assumes that you already have a SmartMesh IP Manager. The DC9001B SmartMesh IP Evaluation/Development Manager is an assembly consisting of a DC9011A radio board connected to a DC9006A USB-interface board. This is a standard part of the DC9000B SmartMesh IP Starter Kit. Alternatively, you can use a DC9020A RF Certified SmartMesh IP Evaluation/Development Manager, which is part of the DC9021A kit. Make sure that the manager is connected to a computer via a USB cable.

3. Way to Get Data Out of the Manager

All data published by DC2126 devices on the network will route through the DC9001B or DC9020A manager detailed above. For demonstration purposes, a small sample Python based Graphical User Interface (GUI) application called *DC2126A.exe* (available as part of the SmartMesh SDK) was designed to subscribe to all incoming DC2126A device messages and display the temperature data.

For more information on programming to the manager software application programming interface (API), refer to the SmartMesh IP User's Guide, http://www.linear.com/docs/41880.

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INSTALLING THE DC2126A.EXE GUI

1. Install FTDI USB-to-Serial Drivers

In order for your computer to communicate with the Manger, you will first need to install a Virtual COM Port (VCP) 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 DC2126A.exe GUI program is part of the SmartMesh SDK. Download and extract the zip file to a convenient location on your computer. The DC2126A.exe program is found in the /win directory within the SmartMesh SDK folder.

QUICK HOOK-UP

1. Power-on the DC9001B/DC9020A manager assembly.

   NOTE: the DC9006A interface board's green LEDs are ON when connected via USB, *but* the DC9011A manager board has its own ON/OFF switch. A blue LED will light when the manager board is actually powered.

2. Power-on each DC2126A mote using the on-off switch.

3. Power-on any other motes that are on the same network ID and expected to be in this network.

4. Open the *DC2126A.exe* GUI – you will see a window similar to that shown in Figure 1.

5. In the **port name** field, enter the COM port that corresponds to the Manager API – typically the last of the four COM ports added. Then click the **connect** button.

   Refer to the Setup section of the SmartMesh IP Tools Guide for instructions if you don't know what the Manager API COM port is.

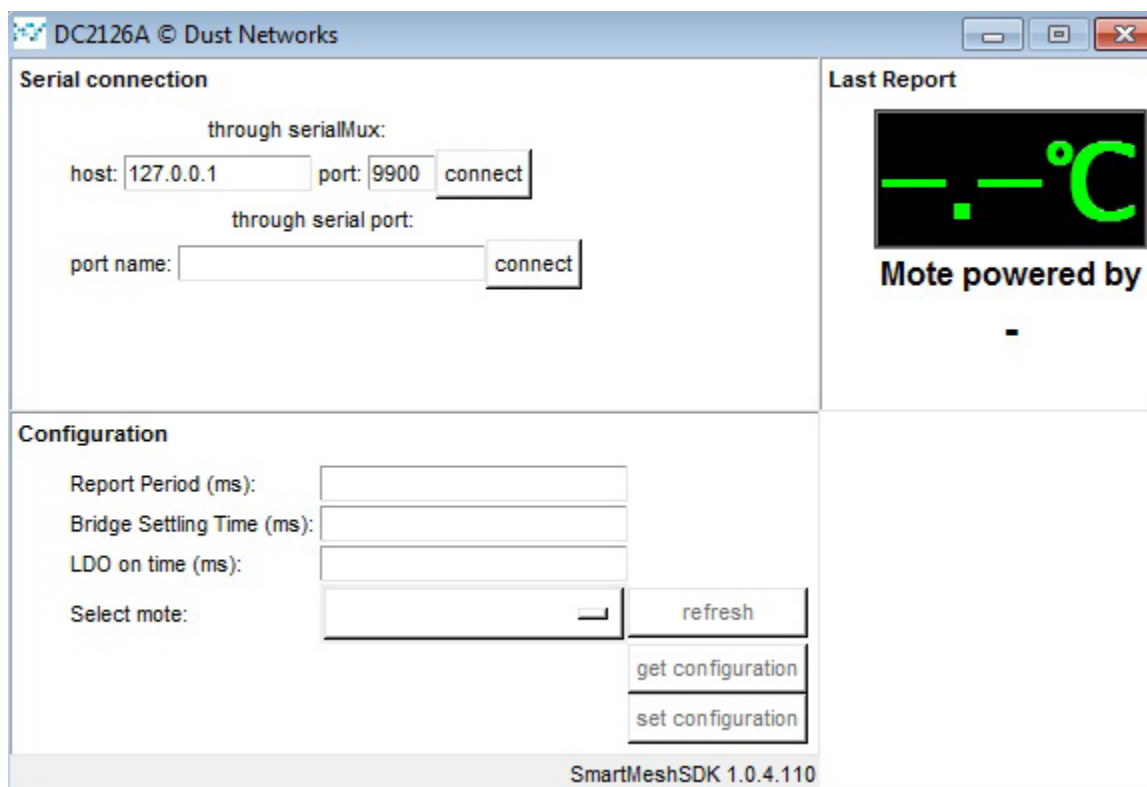

Figure 1. DC2126A GUI Window

QUICK START PROCEDURE

6. The GUI window will change as shown in Figure 2.

   The **Serial connection** will say "Connection successful" (COM7 in this example).

7. To select a device for display, navigate to the **Select mote:** pull down menu in the **Configuration** section, and select from the list of connected devices. The pull-down list will be populated with the MAC address of all motes that are found on the network. The last few digits of these MAC addresses can also be found on a label on your DC2126A motes.

8. The temperature and power source in the **Last Report** display section will blink when a new data set is received from a selected device. The **Mote powered by** field will read either "Battery" or "Solar" depending on whether the selected mote is powered from the included battery or from the included solar panels.

   NOTE: This power status will not update instantaneously, but with some delay, due to the network reporting interval, and due to internal capacitors in the DC2126A hardware charging or discharging. *(Note that the voltage reading (in mV) below the Solar or Battery statement corresponds to a voltage internal to the DC2126A, and not to the voltage of the solar panel or battery. You can ignore this number unless you are an advanced or particularly curious user.)*

9. Additional settings can be managed from the **Configuration** section as follows:

   a. **Get configuration** button: Retrieves the device's current settings and displays them

   b. **Set configuration** button: Pushes the settings in the setting fields to the device

   c. **Report Period (ms)**: The interval with which the device will take readings and publish. Valid range is between 7986ms and 3600000ms (1 hour).

   d. **Bridge Settling Time (ms)**: *Reserved – do not use.*

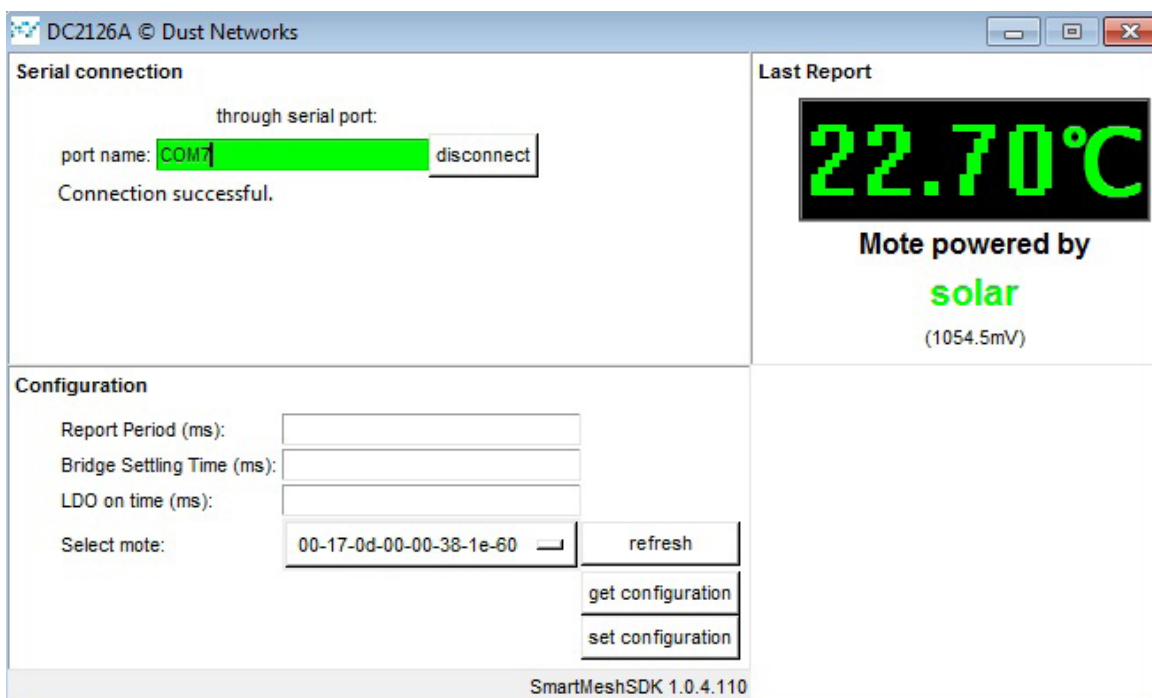   e. **LDO on time (ms)**: *Reserved – do not use.*

QUICK START PROCEDURE

Figure 2. DC2126A GUI Successful Connection

PLACEMENT CONSIDERATIONS

The DC2126A is designed to operate on relatively moderated indoor lighting conditions (200lux). When placing the DC2126A in such moderate indoor lighting, the DC2126A should be angled such that the photo-voltaic cells are pointing at the light source. Orienting the DC2126A vertically (e.g. flat on a wall) will reduce the effective light intensity that reaches the photo-voltaic cells.

REGULATORY AND STANDARDS COMPLIANCE

1 RF EXPOSURE

IMPORTANT NOTE: To comply with FCC, IC and CE RF exposure compliance requirements, the antenna used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons.

IMPORTANT NOTE: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

1. Reorient or relocate the receiving antenna.

2. Increase the separation between the equipment and receiver.

3. Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

4. Consult the dealer or an experienced radio/TV technician for help.

2 FCC COMPLIANCE

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

2.1 FCC Approved Wireless Devices

The following is a list of FCC approved wireless devices by their FCC Identifiers:

SJC-ETERNA2

3 INDUSTRY CANADA (IC) COMPLIANCE / CONFORMITÉ À LA NORME INDUSTRIE CANADA (IC)

Under Industry Canada regulations, this radio transmitter may only operate using an antenna with a maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna gain should be so chosen that the equivalent isotropic radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Suivant la législation Industrie Canada, ce transmetteur radio ne peut être utilisé qu'avec une antenne dont le gain est inferieur au gain approuvé pour le transmetteur par Industrie Canada. Pour réduire le risque d'interférence aux autres utilisateurs, l'antenne doivent être choisies telle que la puissance isotrope rayonnée équivalente (PIRE) ne dépasse pas ce qui est nécessaire pour une communication réussie.

3.1 RF Exposure / Exposition aux Rayonnements Radiofréquences

IMPORTANT NOTE: To comply with IC RF exposure compliance requirements, the antenna used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons.

IMPORTANT NOTE: Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

REGULATORY AND STANDARDS COMPLIANCE

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le manuel d'utilisateur du produit final doit comprendre et mettre en évidence les informations suivantes:

NOTE IMPORTANTE: afin d'assurer la conformité aux limites Industrie Canada d'exposition aux rayonnements, l'antenne utilisée pour ce transmetteur doit être installée en considérant une distance de séparation à toute personne d'au moins 20 cm.

NOTE IMPORTANTE: Toute modification non expressément approuvée par la partie responsable de la conformité pourrait annuler l'autorisation accordée à l'utilisateur d'utiliser cet équipement.

Cet appareil est conforme à la norme RSS Industrie Canada exempt de licence. Son fonctionnement est soumis aux deux conditions suivantes : (1) cet appareil ne peut pas provoquer d'interférences ; et, (2) Cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositif.

3.2 IC Testing / Protocole d'Essai

ETERNA2 is certified for modular Industry Canada (IC) RSS-210 approval. The OEM is responsible for its product to comply with IC ICES-003 and FCC Part 15, Sub. B - Unintentional Radiators. The requirements of ICES-003 are equivalent to FCC Part 15 Sub. B and Industry Canada accepts FCC test reports or CISPR 22 test reports for compliance with ICES-003.

ETERNA2 est un module certifié conforme d'après la norme RSS-210 d'Industrie Canada (IC). Le fabricant d'appareil d'origine est responsable de la conformité de son produit aux normes IC ICES-003 et FCC Part15, Sub. B « Unintentional Radiators ». Les exigences de ICES-003 sont équivalentes aux exigences de FCC Part 15 Sub.B et Industrie Canada reconnait les rapports d'essai FCC ou CISPR 22 pour démontrer la conformité avec ICES-003.

3.3 Industry Canada Approved Wireless Devices / Industrie Canada Approuvé périphériques sans fil

The following is a list of Industry Canada (IC) approved wireless devices by their IC Identifiers:

5853A-ETERNA2

Ce qui suit est une liste d'Industrie Canada (IC) a approuvé les dispositifs sans fil par leurs identificateurs IC:

5853A-ETERNA2

4 CE COMPLIANCE

4.1 Declaration of Conformity

We, Linear Technology, of 1630 McCarthy Blvd, Milpitas, CA 95035 USA, declare under our sole responsibility that our product, DC2126A, and in combination with our accessories, to which this declaration relates is in conformity with the appropriate standards ETSI EN 300 328, ETSI EN 301 489-17 and EN 60950, following the provisions of Radio Equipment and Telecommunication Terminal Equipment Directive 99/5/EC with requirements covering EMC Directive 2004/108/EC, and Low Voltage Directive 2006/95/EC.

5 COMPLIANCE TO JAPAN RADIO LAW

DC2126A is compliant to Japan Radio Law Article 38, Section 24.

6 KOREAN COMPLIANCE

DC2126A contains an ETERNA2 module compliant to Korean modular certification criteria.

6.1 경고 \ Warnings

1) 해당무선설비기기는운용중전파혼신가능성이있으므로인명안전과관련된서비스는할수없습니다

2) 해당무선설비기기는운용중전파혼신가능성이있음

REGULATORY AND STANDARDS COMPLIANCE

7 NCC \ TAIWAN COMPLIANCE

DC2126A contains an ETERNA2 module compliant to Taiwanese modular certification criteria

7.1 NCC Warnings (English)

According to "Administrative Regulations on Low Power Radio Waves Radiated Devices" Without permission granted by the NCC, any company, enterprise, or user is not allowed to change frequency, enhance transmitting power or alter original characteristic as well as performance to an approved low power radio-frequency devices shall not influence aircraft security and interfere legal communications; If found, the user shall cease operating immediately until no interference is achieved. The said legal communications means radio communications is operated in compliance with the Telecommunications Act.

The low power radio-frequency devices must be susceptible with the interference from legal communications or ISM radio wave radiated devices.

7.2 NCC WARNINGS (TRADITIONAL CHINESE)

經型式認證合格之低功率射頻電機，非經許可，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。低功率射頻電機之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前項合法通信，指依電信法規定作業之無線電通信。低功率射頻電機須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。"

RESET

To reset the DC2126A, shift the power switch to the OFF position. Because of the large amount of on-board energy storage combined with the low power consumption of the SmartMesh IP mote, it can take a while for the internal supply voltage to drop enough for a full reset. Either wait a minute to confirm a full reset, or observe that the voltage between "VOUT 3.6V" and "GND" has dropped to zero. Then, shift the power switch back to the ON position.

TROUBLESHOOTING

Problem: My DC2126A does not seem to join the network. How do I know if it is even powered-on correctly?

1. Power cycle with the switch. The DC2126 will search for a network with 100% search duty cycle from power on for 3 minutes, then step down to 25% for one hour, then abandon the search and go into deep sleep. A full power cycle is required to restart a search. This was done to guarantee that a device whose power switch is left in the on position by accident after a demo does not drain its battery.

2. Check that the battery is not dead. Set the power switch to the ON position. Open the plastic case. With a volt meter, measure between the nodes labeled VOUT 3.6V and GND. If that voltage is approximately 3.6V, then the circuitry is properly getting power (either from battery or solar). If it is significantly less than 3.6V, then the circuit is not powered correctly. This could be the case if the battery is dead and no solar power is present.

Problem: I measured voltage levels inside the unit, it is powered-on correctly, but still does not join the network.

1. Check netID. The netID of the device must match the netID of the network you are trying to join. Verify that it is set correctly with the "mget netID" command through the device CLI interface.

2. Check manager. Check that the network manager is ON and running. The blue LED on the manager board must be ON, and you should be able to connect the *DC21226A.exe* sample Python application to it.

ADDITIONAL RESOURCES

- For a detailed discussion on the design of the DC2126A, please also see www.linear.com/docs/45098.

- DC9000B SmartMesh IP Starter Kit – www.linear.com/solutions/4314.

- DC9021A SmartMesh IP RF Certified Starter Kit (primarily used in Japan) – www.linear.com/solutions/4316.

- DC2126A Mote Application Firmware Source Code – www.dustcloud.org.

DEMONSTRATION BOARD IMPORTANT NOTICE

Linear Technology Corporation (LTC) provides the enclosed product(s) under the following **AS IS** conditions:

This demonstration board (DEMO BOARD) kit being sold or provided by Linear Technology is intended for use for **ENGINEERING DEVELOPMENT OR EVALUATION PURPOSES ONLY** and is not provided by LTC for commercial use. As such, the DEMO BOARD herein may not be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including but not limited to product safety measures typically found in finished commercial goods. As a prototype, this product does not fall within the scope of the European Union directive on electromagnetic compatibility and therefore may or may not meet the technical requirements of the directive, or other regulations.

If this evaluation kit does not meet the specifications recited in the DEMO BOARD manual the kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY THE SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THIS INDEMNITY, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

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LTC currently services a variety of customers for products around the world, and therefore this transaction **is not exclusive**.

Please read the DEMO BOARD manual prior to handling the product. Persons handling this product must have electronics training and observe good laboratory practice standards. **Common sense is encouraged**.

This notice contains important safety information about temperatures and voltages. For further safety concerns, please contact a LTC application engineer.

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