# LMT01EVM-CVAL Evaluation Module (EVM)

The LMT01EVM-CVAL is an evaluation module for the space grade LMT01-SP two wire digital temperature sensor. The module can be connected to a PC through the included USB cable and can be operated with a Graphical User Interface (GUI). The board comes with one LMT01HTA/EM evaluation part and has space to add three more to demonstrate how to manage multiple temp sensors.

## Trademarks

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## 1 Features

- Evaluation model for the space grade LMT01-SP temp sensor
- Graphical User Interface (GUI)
- Real time temperature measurements and plotting
- Comes with one LMT01-SP temp sensor; three more can be added

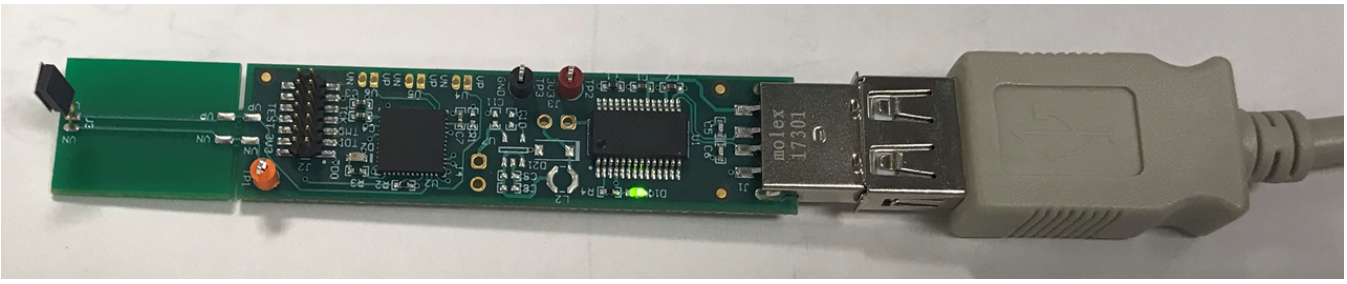


**Figure 1. LMT01EVM-CVAL Evaluation Board**


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# 2 Overview

## 2.1 LMT01-SP

The LMT01-SP is a radiation hardened, high accuracy, 2-pin digital temperature sensor with an easy-to use pulse count current loop interface. The LMT01-SP's pulse count interface is designed to directly interface with a GPIO comparator input, thereby simplifying hardware implementation. Integrated EMI suppression and a simple 2-pin architecture makes the device suitable for sensing in a noisy environment with cable lengths up to 2 m.

There are many ways to configure the LMT01-SP, depending upon the configuration and supply output of your MCU or FPGA. Multiple LMT01-SP units can be connected to a single MCU input pin for monitoring multiple zones.

The LMT01-SP is accurate to a temperature range of –50°C to +150°C and is specified and tested to a temperature range of –55°C to +125°C. It can be used to replace thermistors or analog temperature sensors in a space application with the added benefit of connecting directly to an MCU without the need for amplifiers or ADCs for signal conditioning, reducing board space and power consumption.



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## 2.2 LMT01EVM-CVAL

The LMT01EVM-CVAL evaluation module demonstrates the operation of the LMT01-SP space grade 2-pin digital temperature sensor. The module connects to a PC with the USB cable included in the kit and is controlled by a Graphical User Interface (GUI) downloaded for free from ti.com. The GUI will capture temperature readings and plot them out.

The board has a green LED that lights when the GUI is communicating with the board.

The board comes with one LMT01HTA/EM engineering unit. The LMT01HTA/EM is on a perforated tab and can be snapped off. The tab can then be reconnected to the main control board with wires for remote temperature sensing up to 2 m away.

The LM01HTA/EM unit is attached to the tab in a through-hole configuration and the body is 90° from the tab surface. The leads were left long enough so that the unit could be bent down and attached to the tab with thermal paste to demonstrate a surface mount for monitoring the temperature of a board.

There are spaces on the board to attach three more LMT01-SP units. They can be attached to the board in a through-hole or lead surface mount configuration (Note: in a lead surface mount configuration the package body would have to hang over the edge of the board as there is not enough room on the board to place the body head). The LMT01-SP units could also be connected to the board using a wire up to 2 m long.

The pulse stream from the LMT01-SP VN pins can be monitored at test point TP1 on the board.

As shown in Figure 13, the VP pin for each LMT01-SP unit is connected to a separate pin on the MCU. The VN pins for all four units are connected to a single GPIO pin on the MCU configured as a comparator. The MCU controls which LMT01-SP unit will be powered at any one time as instructed by the GUI settings. If more than one LMT01-SP is enabled, the units will be powered sequentially so that only one unit is sending pulses to the MCU at any one time.

The LMT01-SP units are connected to and controlled and monitored by a commercial grade MSP430FR5969IRGZR MCU. The GUI can be used to choose which LMT01-SP unit is monitored or allow up to 4 units to be monitored. The configuration demonstrates how multiple LMT01-SP units can be connected to a single MCU input pin as shown in the LMT01-SP datasheet.

The commercial MSP430FR5969IRGZR MCU is pin and footprint compatible with and can be replaced by the space grade MSP430FR5969-SP. The MCU firmware can be changed through the J2 header.

The board is configured so the FT245 USB interface is powered from the external USB bus. The MSP430FR5969 MCU is powered from the 3.3-V output of the FT245. There is the option to supply power to the FT245 and MSP430FR5969 externally and there is a footprint available for an LDO to be added to the board (see Figure 13 and Section 4).

The board files are available for download on the LMT01EVM-CVAL product page on ti.com:

www.ti.com/tools/lmt01evm-cval


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# 3 Graphical User Interface (GUI)

## 3.1 Start up

1. Download the GUI from the LMT01EVM-CVAL product page on ti.com: www.ti.com/tools/lmt01evm-cval
2. Drivers and all software will be downloaded when program installation is complete.
3. Connect the LMT01EVM-CVAL to the PC using the included USB cable.
4. Launch the LMT01EVM-CVAL software.
5. If the board is not connected to the computer, an error message will be shown.

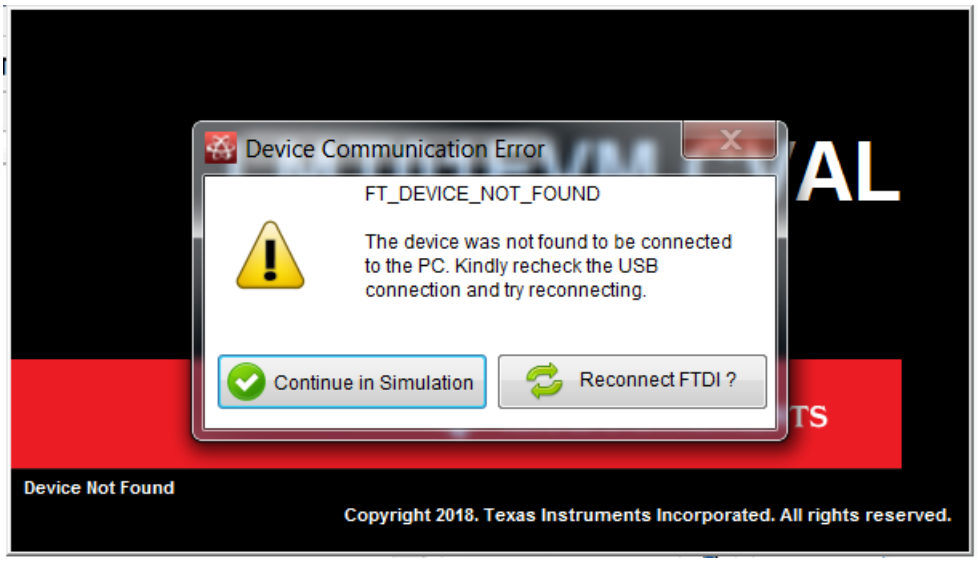


**Figure 2. Error Message if Board is Not Connected to PC**

6. If "Continue in Simulation" is chosen, the GUI will launch. In simulation mode, there will be a triangle wave of temperature readings covering the full –50°C to +150°C temperature range to demonstrate the temperature capture readings and plots.


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7. The GUI will appear the same whether in Simulation mode or if the board is connected. There will be a notification at the bottom of the GUI if in simulation mode.

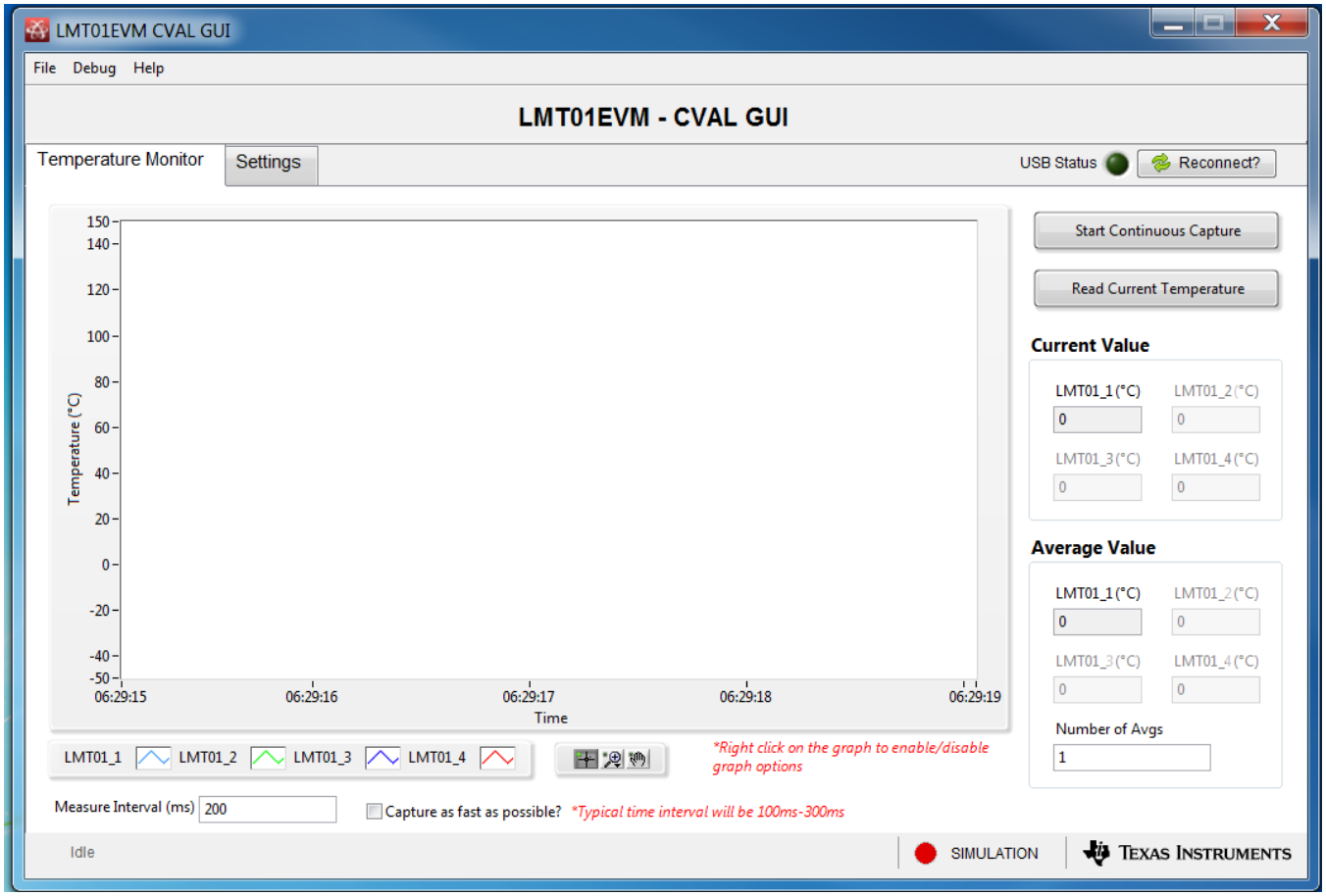


**Figure 3. GUI in Simulation Mode With No Board Connected to Computer**


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## 3.2 LED and Communication Indication

If the GUI communicates with the board upon start up, the green LED on the board will light up and the USB Status indicator on the GUI will turn green.

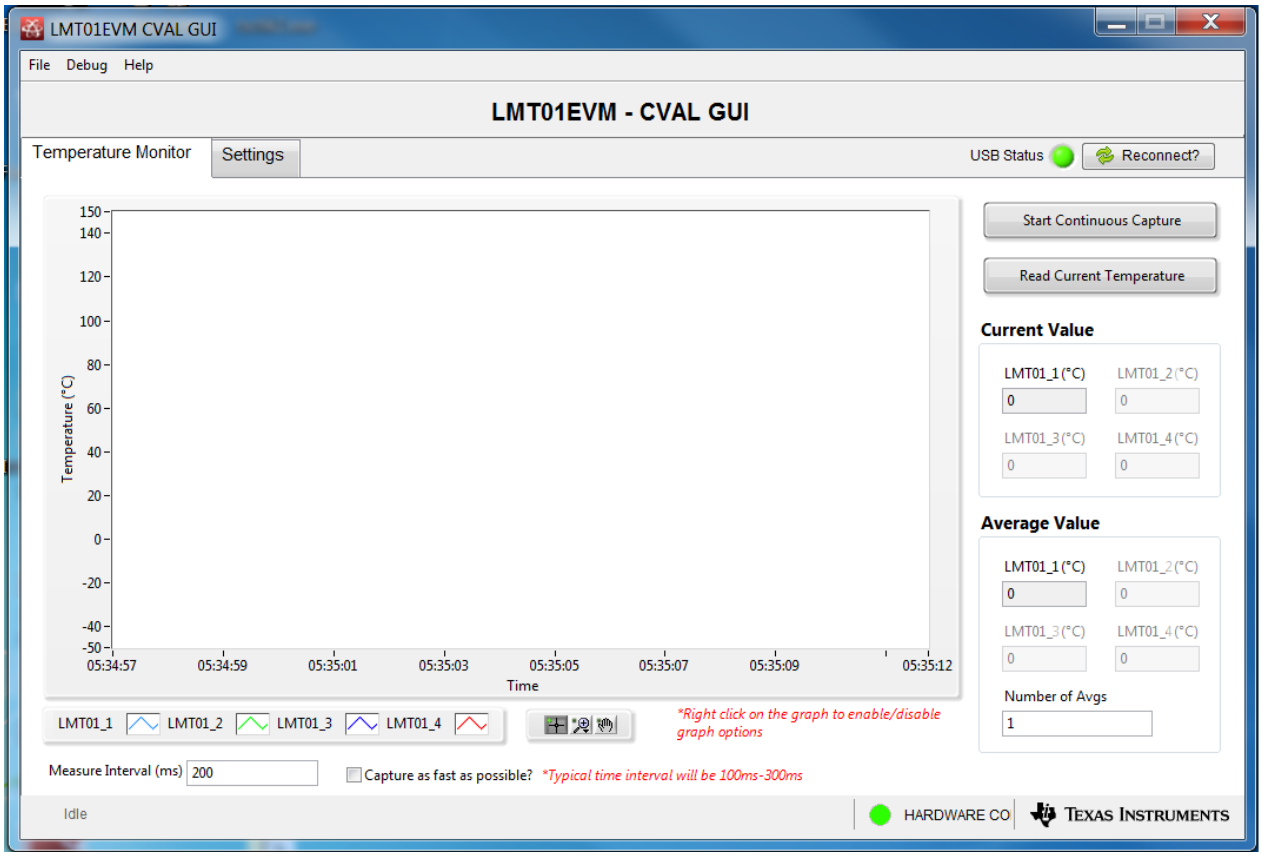


**Figure 4. GUI Start-up Page With LMT01EVM-CVAL Board Connected**



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### 3.3 Settings Tab

1. The LMT01-SP unit on the tab of the evaluation board is "LMT01_01" and is chosen by default on starting up the GUI. "LMT01_2" pertains to the U4 position on the board, "LMT01_3" to U5 and "LMT01_4" to U6. If more than one LMT01-SP unit is enabled, they will be powered and monitored sequentially (see Section 2.2 for details).
2. Graph Length is the number of points that appear on the graph before the older readings start rolling off.
3. If the "Save to file" box is checked, there must be an entry in the "Log Folder Path" box or the GUI will crash when data capture is attempted. Click on the folder icon next the box and navigate to the folder where the data files will be stored. Click "Current Folder" button and folder address should appear in the box.

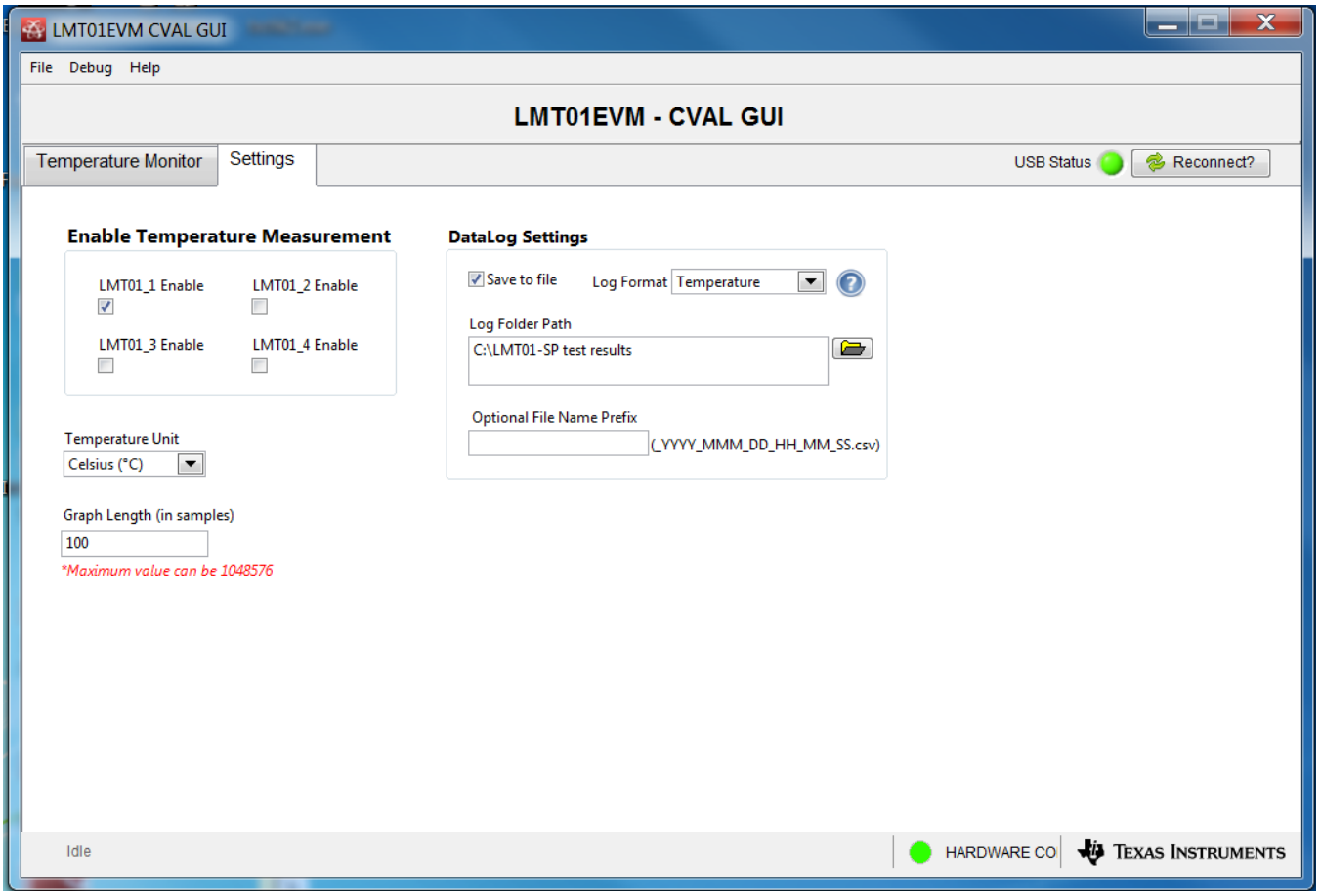


**Figure 5. Settings Tab**


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4. Checking the "Save to file" box will cause a file to be saved every time a data set capture is completed (by clicking the "Start Continuous Capture" button followed by clicking the "Stop Continuous Capture" button in the "Temperature Monitor" tab). The log files are named by default with a time stamp of when the data capture started. A different file name can be used by typing it into the "Optional File Name Prefix" box.

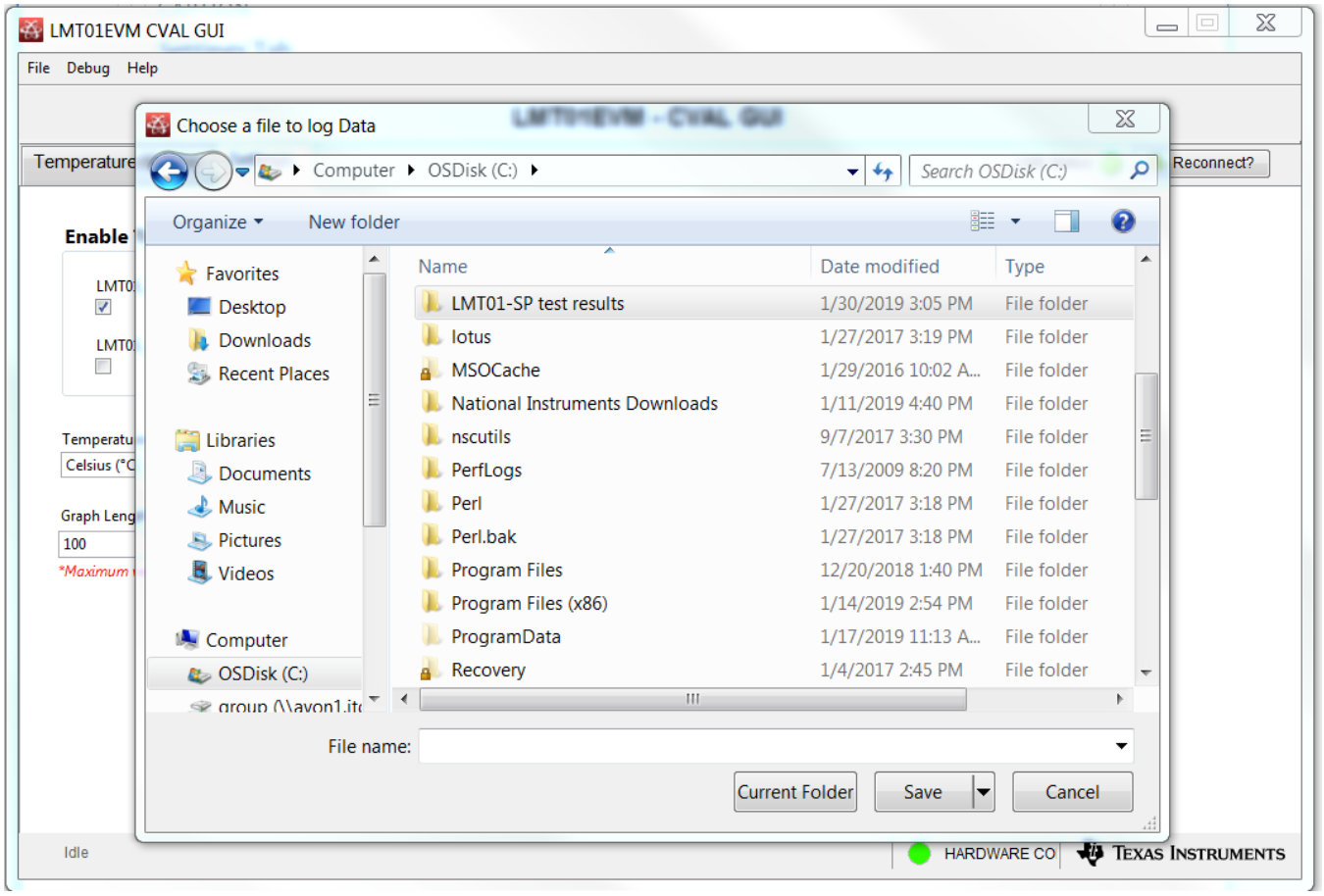


**Figure 6. Menu Window for Choosing Folder to Store Data Files**



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### 3.4 Temperature Monitor Tab

1. When there is no LMT01-SP unit attached to a position, that position will read "NaN."
2. Moving the cursor to the plot screen and right clicking will open the plot menu. The axes can be changed from dynamic (based on the data being captured) to fixed. Any part of the plot screen can be zoomed in or out. There are other options as well. The three most popular options (axis settings, zoom, and drag screen) are also available by clicking on the icons below the plot.
3. When "Capture as fast as possible" is checked, the speed of capture will be based on three things: the capture rate of the LMT01-SP, how many units are enabled, and the speed of the PC.
4. Clicking the "Start Continuous Capture" button will start the data capture and the button will change to "Stop Continuous Capture." Clicking the button again will stop the data capture. If a new data capture is started, the previous data set will be lost unless "Save to file" box was checked in the "Settings" tab.

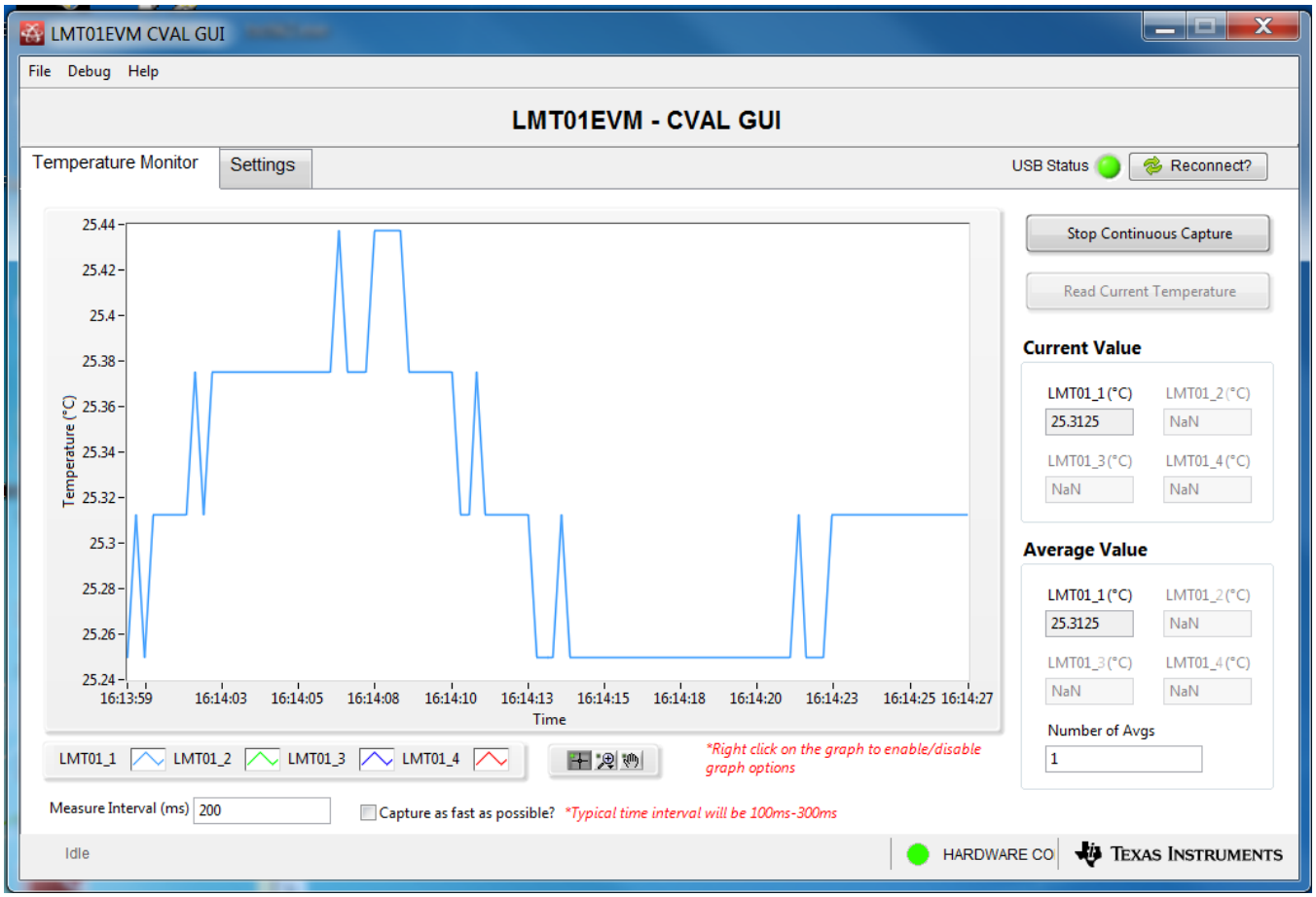


**Figure 7. Temperature Monitor Tab**


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# 4 Board Layout

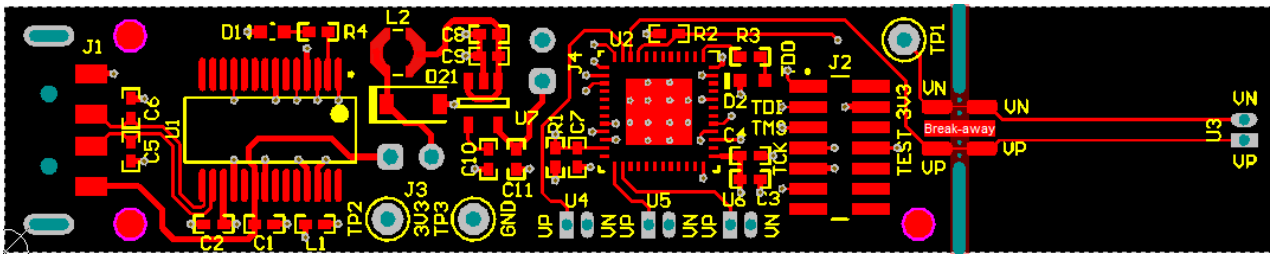


**Figure 8. Top Assembly Layer as Viewed From Top of Board**

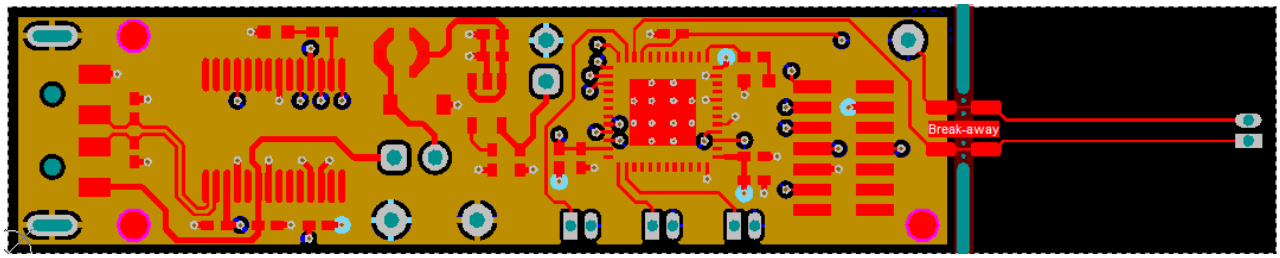


**Figure 9. Signal Layer**

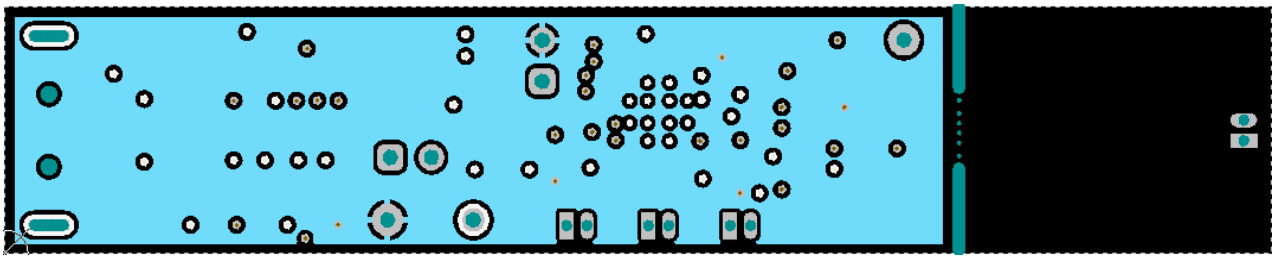

**Figure 10. Power Layer**

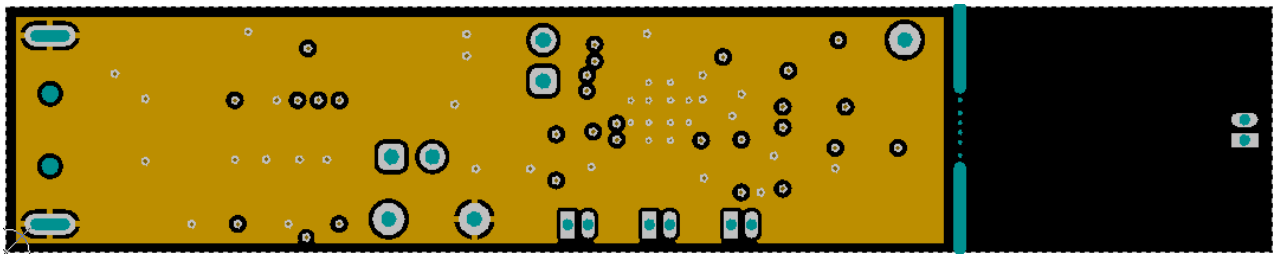

**Figure 11. Ground Layer**

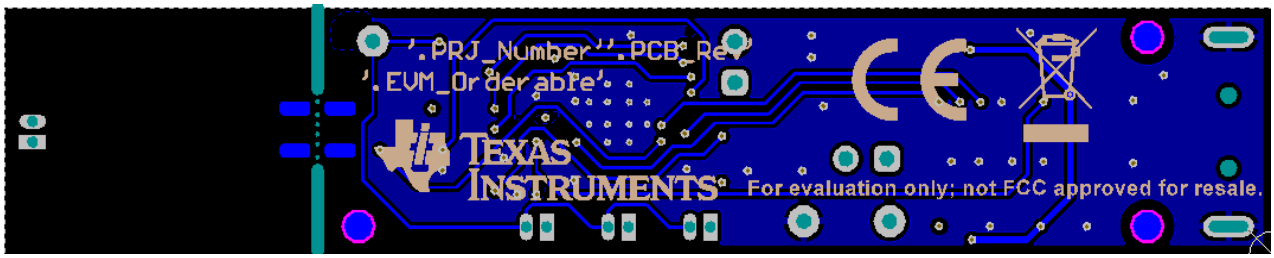


**Figure 12. Bottom Assembly Layer as Viewed From the Bottom**



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# 5 Schematic

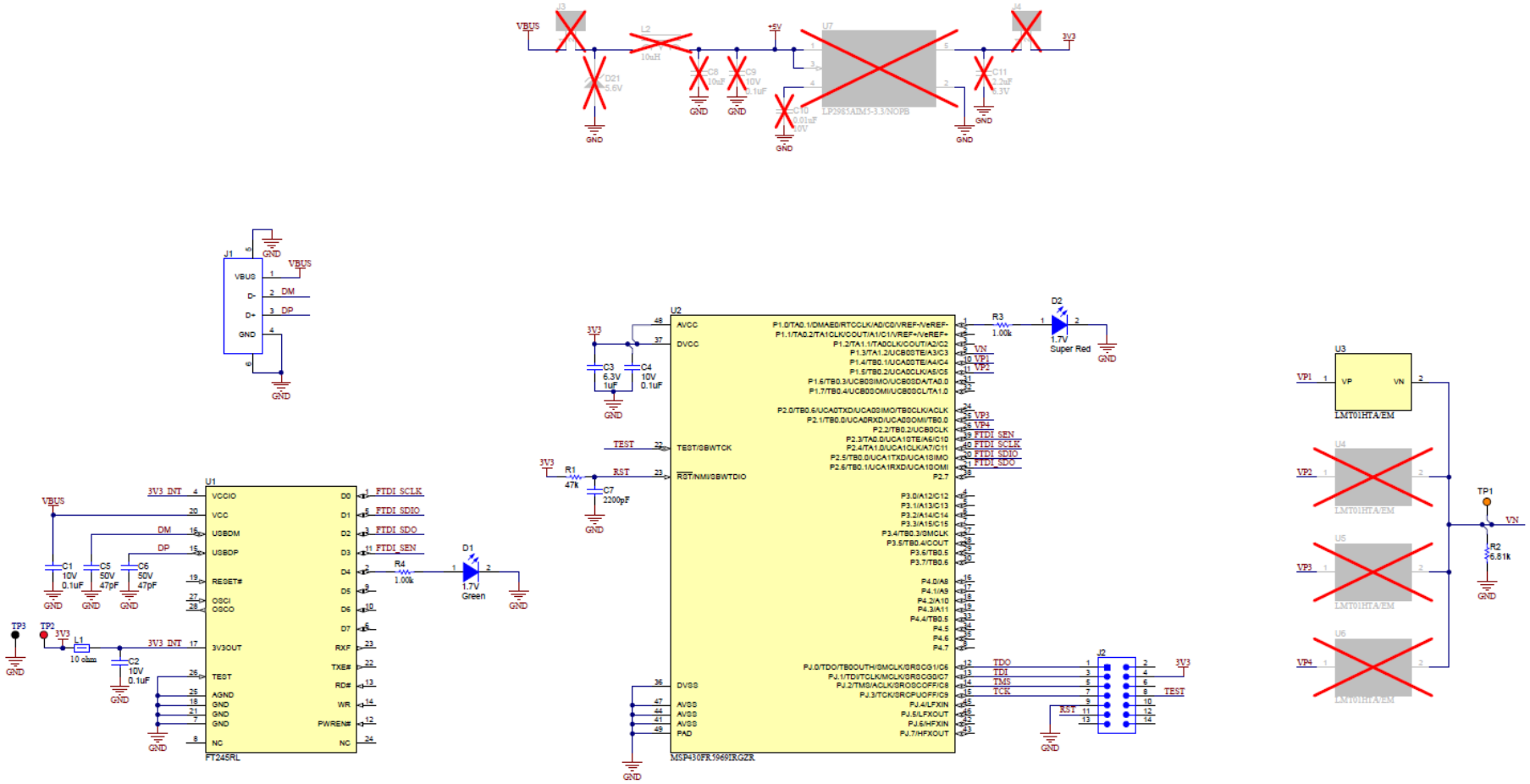


**Figure 13. LMT01EVM Schematic**



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# 6 Bill of Materials

**Table 1. LMT01EVM Bill of Materials**

| Designator | Qty. | Value | Description | PackageReference | PartNumber | Manufacturer | Alternate PartNumber | Alternate Manufacturer |
|---|---|---|---|---|---|---|---|---|
| !PCB | 1 | | Printed Circuit Board | | SLHR020 | Any | | |
| C1, C2, C4 | 3 | 0.1uF | CAP, CERM, 0.1 uF, 10 V,+/- 10%, X5R, 0402 | 0402 | LMK105BJ104KV-F | Taiyo Yuden | | |
| C3 | 1 | 1uF | CAP, CERM, 1 uF, 6.3 V, +/- 20%, X5R, 0402 | 0402 | GRM152R60J105ME15D | MuRata | | |
| C5, C6 | 2 | 47pF | CAP, CERM, 47 pF, 50 V, +/- 5%, C0G/NP0, 0402 | 0402 | UMK105CG470JVHF | Taiyo Yuden | | |
| C7 | 1 | 2200pF | CAP, CERM, 2200 pF, 10 V, +/- 10%, X7R, 0402 | 0402 | 885012205008 | Wurth Elektronik | | |
| D1 | 1 | Green | LED, Green, SMD | 1.7x0.65x0.8mm | LG L29K-G2J1-24-Z | OSRAM | | |
| D2 | 1 | Super Red | LED, Super Red, SMD | LED, 1.6x.6x.8mm | SML-LX0603SRW-TR | Lumex | | |
| J1 | 1 | | Connector, Plug, USB Type A, R/A, Top Mount SMT | Edge mount USB A CONN | 48037-2200 | Molex | | |
| J2 | 1 | | Header, 1.27 mm, 7x2, Au, SMT | Header, 1.27mm, 7x2, SMT | 20021121-00014T4LF | FCI | | |
| L1 | 1 | 10 ohm | Ferrite Bead, 10 ohm @ 100 MHz, 0.5 A, 0402 | 0402 | 742792701 | Wurth Elektronik | | |
| R1 | 1 | 47k | RES, 47 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402 | 0402 | CRCW040247K0JNED | Vishay-Dale | | |
| R2 | 1 | 6.81k | RES, 6.81 k, 0.1%, 0.0625 W, AEC-Q200 Grade 0, 0402 | 0402 | ERA2AEB6811X | Panasonic | | |
| R3, R4 | 2 | 1.00k | RES, 1.00 k, 1%, 0.1 W, 0402 | 0402 | ERJ-2RKF1001X | Panasonic | | |
| TP1 | 1 | | Test Point, Miniature, Orange, TH | Orange Miniature Testpoint | 5003 | Keystone | | |
| TP2 | 1 | | Test Point, Miniature, Red, TH | Red Miniature Testpoint | 5000 | Keystone | | |
| TP3 | 1 | | Test Point, Miniature, Black, TH | Black Miniature Testpoint | 5001 | Keystone | | |
| U1 | 1 | | USB FIFO IC, 28SSOP | SSOP28 | FT245RL | FTDI | | |
| U2 | 1 | | MSP430FR5969 16 MHz Ultra-Low-Power Microcontroller featuring 64 KB FRAM, 2 KB SRAM, 40 IO, RGZ0048B (VQFN-48) | RGZ0048B | MSP430FR5969IRGZR | Texas Instruments | MSP430FR5969IRGZT | Texas Instruments |
| U3 | 1 | | LMT01HTA/EM, HTA0002A (CTO-92-2) | HTA0002A | LMT01HTA/EM | Texas Instruments | | Texas Instruments |
| C8 | 0 | 10uF | CAP, CERM, 10 uF, 6.3 V, +/- 20%, X5R, 0402 | 0402 | GRM155R60J106ME15D | MuRata | | |



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**Table 1. LMT01EVM Bill of Materials (continued)**

| Designator | Qty. | Value | Description | PackageReference | PartNumber | Manufacturer | Alternate PartNumber | Alternate Manufacturer |
|---|---|---|---|---|---|---|---|---|
| C9 | 0 | 0.1uF | CAP, CERM, 0.1 uF, 10 V,+/- 10%, X5R, 0402 | 0402 | LMK105BJ104KV-F | Taiyo Yuden | | |
| C10 | 0 | 0.01uF | CAP, CERM, 0.01 uF, 10 V, +/- 10%, X7R, 0402 | 0402 | 0402ZC103KAT2A | AVX | | |
| C11 | 0 | 2.2uF | CAP, CERM, 2.2 uF, 6.3 V, +/- 10%, X5R, 0402 | 0402 | GRM155R60J225KE95D | MuRata | | |
| D21 | 0 | 5.6V | Diode, Zener, 5.6 V, 500 mW, SOD-123 | SOD-123 | MMSZ5232B-7-F | Diodes Inc. | | |
| FID1, FID2, FID3, FID4, FID5, FID6 | 0 | | Fiducial mark. There is nothing to buy or mount. | N/A | N/A | N/A | | |
| J3, J4 | 0 | | Header, 100mil, 2x1, Gold, TH | 2x1 Header | TSW-102-07-G-S | Samtec | | |
| L2 | 0 | 10uH | Inductor, Drum Core, Ferrite, 10 uH, 0.35 A, 1.08 ohm, SMD | 2.8x0.9x2.8mm | SRU2009-100Y | Bourns | | |
| U4, U5, U6 | 0 | | LMT01HTA/EM, HTA0002A (CTO-92-2) | HTA0002A | LMT01HTA/EM | Texas Instruments | | Texas Instruments |
| U7 | 0 | | Micropower 150-mA Low-Noise Ultra-Low-Dropout Regulator in SOT-23 and DSBGA Packages, DBV0005A (SOT-23-5) | DBV0005A | LP2985AIM5-3.3/NOPB | Texas Instruments | | Texas Instruments |



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