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This user's guide describes the characteristics, operation, and use of the TMP451EVM evaluation board. It discusses how to set up and configure the software, reviews the hardware, and reviews various aspects of the software operation. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TMP451EVM. This user's guide also includes information regarding operating procedures and input/output connections, an electrical schematic, PCB layout drawings, and a parts list for the EVM.
Overview

The TMP451 is a high-accuracy, low-power remote temperature sensor monitor with a built in local temperature sensor. The remote temperature sensors are typically low-cost discrete NPN or PNP transistors, or on-die transistor or diode structures that are an integral part of microprocessors, microcontrollers, or FPGAs. The temperature accuracy is ±1°C for the local and the remote temperature sensors. The two-wire serial interface accepts SMBus communication protocol. The module and GUI are designed to provide the user a quick setup to evaluate the system and register map with simply a few click powered by GUI Composer. The EVM features perforations that allows the temperature sensor, microcontroller, and remote BJT to be isolated and be connected to external systems.

1.1 TMP451EVM Kit Contents

Table 1-1 details the contents of the TMP451EVM kit, and Figure 1 below shows all of the included hardware. Contact the Texas Instruments Product Information Center nearest you if any component is missing. It is highly recommended that you check the TI website at http://www.ti.com to verify that you have the latest versions of the related software.

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<td>USB Cable Extender</td>
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1.2 Related Documentation from Texas Instruments

The following document provides information regarding Texas Instruments integrated circuits used in the assembly of the TMP451EVM. This user's guide is available from the TI website under literature number SBOU131. Any letter appended to the literature number corresponds to the document revision that is current at the time of the writing of this document. Newer revisions may be available from the TI website at http://www.ti.com, or call the Texas Instruments Literature Response Center at (800) 477-8924 or the Product Information Center at (972) 644-5580. When ordering, identify the document by both title and literature number.

<table>
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<tr>
<th>DOCUMENT</th>
<th>LITERATURE NUMBER</th>
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<tbody>
<tr>
<td>TMP451 Product Data Sheet</td>
<td>SBOS686</td>
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</table>
This section describes the set up and some of the hardware features present on the TMP451EVM.

**WARNING**

Many of the components on the TMP451EVM are susceptible to damage by electrostatic discharge (ESD). Customers are advised to observe proper ESD handling precautions when unpacking and handling the EVM, including the use of a grounded wrist strap at an approved ESD workstation.

## 2.1 Board Connectors and Components

Figure 2-1 shows the top side of the TMP451EVM. Highlighted are the USB connector, breakouts, TMP451 device, and the remote BJT. The USB connector is directly plugged into the computer for power and communication from the computer to the USB2ANY microcontroller. The breakouts are where the perforations are to break off each section to connect to external systems. Headers can also be soldered to the vias to be used as test point and are positioned 100 mils apart to be compatible with a standard breadboard.

![Figure 2-1. TMP451EVM Board Top Side](image)

### 2.1.1 EVM Power Supply Input – J1

J1 is the USB connector and is used to connect the PC. The interface is used to access the device’s registers and read the conversion data from the TMP451 through I2C communication protocol. TMP451EVM uses the +5-V input power supply of the USB connector to power the EVM. The EVM does not require an external power supply. The board is powered by the USB port and provides switched +5 V...
2.1.2 Pushbutton Switch – SW1

The SW1 push button is to bring the MSP430 into a BSL mode for upgrading the firmware with combination of the USB connector. Press and hold the switch SW1 next to the USB connector while plugging the USB cable from the board to the PC to bring the MSP430 into BSL mode.

2.1.3 LEDs-D3,5,6

D3 is a green LED that is used to indicate that the EVM has power and should turn on after plugging in the board. D5 is used to indicated a THERM fault and will turn on when the device detects a THERM fault and bring the pin LOW. D6 does the same function but for the ALERT/THERM2 pin. Both these LEDs are red.

2.1.4 Remote BJT - Q1

Q1 is a MMBT3904LP NPN BJT. This is used as the remote temperature sensor on the EVM. The MMBT3904LP typically has an N-factor of about 1.0042. Since the TMP451 assumes an N-Factor of 1.008 this can cause temperature error in the remote temperature reading. The GUI automatically sets the N-Factor correction register to 1.0042 to compensate for this. If the device is reset it will set the N-Factor correction register back to the default value or 1.008 and some temperature error may be seen. If remote temperature error is seen please use the N-Factor correction feature to adjust the temperature reading. The MMBT3904LP can also be broken off to allow for a different temperature remote to be connected.

2.2 Hardware Setup

The TMP451EVM hardware consists of the USB2ANY Platform and the TMP451 altogether in one single board. The unit is easily connected through USB connector into the computer as shown in Figure 2-2. The green LED (D3) should turn on after connecting to the computer, confirming the EVM is powered.

![Figure 2-2. Hardware Setup](image-url)
This section discusses how to install and use the TMP451EVM software.

3.1 TMP451EVM Software Installation

The EVM software is tested on Microsoft Windows 7 and 10 operating system (OS). The software also functions on other Windows operating systems. The EVM software is available through the EVM product folder on the TI website through the hyperlink. The hyperlink will redirect to the TI Cloud where a common repository of all published applications using GUI Composer framework. The applications can be ran directly from the Gallery with minimal install or download the applications from Gallery with runtime to run on a desktop local machine. The applications is supported to use on many platforms (web, Windows, Linux, OSX); however, Linux and OSX might require additional drivers. To download the software to your system, follow the instructions below.
3.1.1 Running GUI Online

Go to the TMP451EVM web page on the TI website: [http://www.ti.com/tool/TMP451EVM](http://www.ti.com/tool/TMP451EVM). Scroll down to the “Software” section and click on the hyperlink to download the latest evaluation software or an alternate way is to connect directly to the gallery by clicking on this link [http://dev.ti.com/gallery/](http://dev.ti.com/gallery/). It might require login user account privileges to use the online version as well as installation of the applications. On the top middle of the Gallery main page, navigating to search box and type TMP451EVM GUI as shown in the Figure 3-1.

![Figure 3-1. Gallery Home Page](image-url)
Click on the TMP451EVM GUI icon. Users may be prompted to download and install the browser extension for the Firefox or Chrome and TI Cloud Agent Application for the first time. Click on Agree and Proceed. After this the TMP451GUI should launch in your browser window.

Figure 3-2. Cookies Agreement
3.1.2 Running GUI on Desktop

In the TMP451EVM GUI icon, click on the download icon to download the TMP451EVM_GUI_installer_win.zip. A pop-up screen appears, and select the desired platform to install into your local machine as shown in **Figure 3-3**.

**Figure 3-3. TMP451EVM GUI Download From the Gallery**
Unzip the downloaded file into a known directory, and run the “TMP451EVM_GUI-1.0.0.setup-win_7.2.0.exe” file located in [Unzipped location]. The EVM software installer then begins the installation process.

Follow the on-screen instructions by clicking the “Next” button to install the GUI Composer runtime engine. If it is the first time installation, the TMP451EVM GUI requires GUI Composer runtime engine v7.2 in order to properly operate.

![Setup - TMP451EVM_GUI](image)

Welcome to the TMP451EVM_GUI Setup Wizard.

**Figure 3-4. GUI Composer Runtime Wizard**
Read through the License Agreement and click the checkbox if you agree and then click "Next".

Figure 3-5. TMP451EVM GUI License Agreement
Click on the “Next” button to accept the default installation directory. Installation takes some time to complete.

![Image of GUI Composer Installation Directory]

**Figure 3-6. GUI Composer Installation Directory**

Click “Next” to start installation.

![Image of Ready to Install]

**Figure 3-7. Ready to Install**

Setup is now ready to begin installing TMP451EVM_GUI on your computer.
The TMP451EVM GUI will start to install as shown in Figure 3-8.

After installation, click "Finish".

Setup has finished installing TMP451EVM_GUI on your computer:

- Create Start Menu Shortcuts
- Create Desktop Shortcut
- View readme file
- Launch TMP451EVM_GUI
Read the readme file and close it out after you are done. If you choose to Launch TMP451_GUI it should launch shortly after closing the readme file.

3.2 Using the TMP451EVM Software

3.2.1 Launching and Running the Software

The TMP451EVM GUI can be run from TI Cloud repository http://dev.ti.com/gallery/ through either the Firefox or Chrome browser or from the Windows desktop offline.

Connect the TMP451EVM to a USB port on a PC as shown in Figure 2-2.

Launch the TMP451EVM software by clicking on the TMP451EVM GUI icon in the Gallery or launching the offline app from windows. The TMP451EVM GUI should automatically initialize and connect to the HID port. A successful connection will show “HARDWARE CONNECTED” on the bottom of the GUI status indicator. If there is a connection problem, verify if the TMP451EVM has an established connection with the PC. A fail connection if the status indicator shows as “HARDWARE NOT CONNECTED”.

3.2.2 Home Tab

When the TMP451EVM GUI is launched, the Home tab will be selected and shown by default. From this page you can navigate to any one of the other 5 tabs. On the left you will see the tab bar that will be available on every tab in the GUI. Clicking on a tab icon will bring you to the respective tab. On the bottom you will see the same list of icons with a short description of each of the tabs. Similarly to the tab bar icons these icons will also bring you to the respective tab.

Figure 3-10. TMP451EVM Home Tab
3.2.3 Quick Start Tab

The Quick Start Tab is used to guide you through the basic settings of the TMP451EVM. It will start with a choice of either using default settings or to be guided through the set up. Choosing to use default settings will take you straight to the Data Capture tab. After choosing default settings you can always go back to the Quick Start Tab and choose to be guided through the set up or change the device settings in the Basic Settings Tab.

Figure 3-11. TMP451EVM Quick Start Tab
If you choose the set-up guide, you will see a page that will make sure the TMP451EVM is connected correctly. If it is connected correctly, click the “YES” button and a list of high-level settings that you can configure will appear as shown in Figure 3-13.

Figure 3-12. Quick Start Connection Check
At the bottom of these settings you will see a choice to go to the Basic Settings tab where a more extensive list of settings will be, or go to the Data Capture tab.

Figure 3-13. Quick Start Guide
3.2.4 Basic Settings Tab

The Basic Settings tab is where all the device settings along with I2C settings are configured.

3.2.4.1 I2C Configuration

- **I2C Frequency**: this drop-down sets the I2C clock frequency to either 100 kbps or 400 kbps
- **I2C Address**: this displays the I2C address of the TMP451
- **General Call Reset**: clicking this push button will send a General Call Reset of the device

3.2.4.2 Device Configuration

- **Mask Alert**: setting this checkbox masks the ALERT pin output
- **THERM2**: setting this checkbox configures pin 6 to the THERM2 output
- **SMBTO Enable**: setting this checkbox will enable the SMBus time-out function
- **Shutdown**: setting this checkbox will place the device into shutdown mode
- **Extended Range**: setting this checkbox will configure the TMP451 for the extended measurement range
- **Conversion per second**: this slider will set how many temperature conversions the TMP451 will perform per second
- **THERM Hysteresis**: this slider will set the THERM hysteresis value
Digital Filter: this drop down will set the digital filter to average either 4 or 8 samples or turn off the filter

Consecutive Alert: this drop-down will set the number of limit violations before the ALERT pin is tripped.

3.2.4.3 Channel Configuration

The TMP451EVM has a local channel and one remote channel. In the Channel Configuration section is where the settings that are specific to a channel are configured.

3.2.4.3.1 Local

Temperature Reading: displays the temperature of the channel

THERM Limit: this slider sets the THERM limit threshold

ALERT_THERM2 Limit: this slider sets the High and Low ALERT limit threshold. When pin 6 is configured to THERM2 this will set the THERM2 limit threshold.

3.2.4.3.2 Remote

Temperature Reading: displays the temperature of the channel

THERM Limit: this slider sets the THERM limit threshold

ALERT_THERM2 Limit: this slider sets the High and Low ALERT limit threshold. When pin 6 is configured to THERM2 this will set the THERM2 limit threshold.

Remote Offset: this number spinner will set the temperature offset of the remote channel temperature reading

N-Factor Correction: this number spinner is used to adjust for the N-factor of the remote BJT. Set this spinner to the N-factor of the remote BJT that is connected to the TMP451EVM
3.2.5 Data Capture Tab

The Data Capture Tab is where the temperature readings as well as the set temperature thresholds will be graphed.

In the bottom left of the Data Capture tab is a short list of device configurations that are also found on the Basic Settings tab with the addition of the "SEND ONE SHOT" button. This button will enable only when the conversion mode is set to "Shutdown" When this button is clicked a One Shot command will be sent to the device and a single temperature conversion will be done.

In the bottom right of the Data Capture tab, there are GUI settings. These settings do not configure the TMP451EVM but changes how the GUI will handle the data collected from the TMP451EVM.

Temperature Scale: this radio button group sets the units the temperature information is displayed

Show Threshold Sliders: setting this check box will show the threshold sliders to the right of the graph as well as displays for the temperature readings

Figure 3-15. TMP451EVM Data Capture Tab
Figure 3-16. Threshold Sliders

**Graph:** this is where the temperature data and thresholds are plotted. Clicking on traces in the legend in the top right will hide/show different traces. Hovering over the graph will display different point information and other features icons will appear in the top right.

**Data to Plot:** this drop-down determines which data is plotted on the graph

**Samples to Plot:** this drop-down sets how many samples are plotted on the graph

**Refresh Rate:** his drop-down sets the desired time frame to fetch the register data. This is directly tied to the Auto-read drop-down on the Register Tab

**Save Data:** clicking this button will save the plotted data into an .csv file

**Clear Data:** clicking this button will clear all the data that is plotted on the graph
3.2.6 Register Tab

The Register Map page shown in Figure 3-17 allows low-level access to all the I2C registers of the TMP451 device. Clicking on the question mark to the right of the Register Name will bring up an extraction short version from the datasheet describing that register. Clicking on a specific Register Name will populate the Field View to on the right side of the screen. The Field View describes each bit field within that register. The “Registers” tab provides access to the registers raw data of the TMP451. Changes to the configuration page are mirrored here, and vice versa.

**Figure 3-17. TMP451EVM Register Tab**

- **Read Registers**: performs a single read for the selected register.
- **Read All Registers**: performs a read for all registers contents.
- **Auto Read**: allows the user to set the desired time frame to fetch the register data.
3.2.7 Collateral

The Collateral Tab as shown in Figure 3-18 contains links to web documents pertinent to the TMP451EVM. The page is divided into four sections: (1) User Guide, (2) Datasheet, (3) Application Notes, and (4) MSP432 Firmware.

Figure 3-18. TMP451EVM Collateral Tab
This section contains the complete bill of materials, schematic diagram, and layout for the TMP451EVM.

4.1 TMP451EVM Board Schematic

Figure 4-1 shows the board schematic for the TMP451EVM board.

Figure 4-1. TMP451EVM Schematic
4.2 TMP451EVM Board Layout

The figures in this section show the board layout for the TMP451EVM board.

![Figure 4-2. Top Assembly Layer](image1)

![Figure 4-3. Top Routing Layer](image2)
Figure 4-4. Ground Layer Routing

Figure 4-5. Power Layer Routing

Figure 4-6. Bottom Layer Routing
Figure 4-7. Bottom Assembly Layer
### 4.3 TMP451 Test Board Bill of Materials

Table 4-1 lists the bill of materials for the TMP451EVM Test Board.

<table>
<thead>
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<th>MANUFACTURER</th>
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<td>C1, C6</td>
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<td>PTS820J20M J20M SMTR LFS</td>
<td>C&amp;K Components</td>
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<td>U1, U4</td>
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<td>Single Output LDO, 200 mA, Fixed 3.3 V Output, 2 to 5.5 V Input, with Low IQ, 5-pin SC70 (DCK), -40 to 125 degC, Green (RoHS &amp; no Sb/Br)</td>
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<td>TCA9517DGKR</td>
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<td>16-Bit Ultra-Low-Power Microcontroller, 128KB Flash, 8KB RAM, USB, 12Bit ADC, 2 USBcls, 32Bit HW MPY, RGC0064B (QFN-64)</td>
<td>RGC0064B</td>
<td>MSP430F5528IRG CR</td>
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<td>1.7V-Capable Remote and Local Temp Sensor with Auto Beta, N-Factor, Filter, and Series-R Correction, DQF0008A (WSON-8)</td>
<td>DQF0008A</td>
<td>TMP451AIDQFT</td>
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## Revision History

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<tr>
<td>• Updated graphics and screenshots of hardware and software changes</td>
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<tr>
<td>• Combined <em>TMP451EVM Hardware Setup</em> and <em>TMP451EVM Hardware Overview</em> sections</td>
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<tr>
<td>• Combined <em>TMP451EVM Software Setup</em> and <em>TMP451EVM Software Overview</em> sections</td>
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<td>• Changed <em>Using the TMP451EVM Software</em> section</td>
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