EVM User's Guide: TMP411

TMP411 Evaluation Module

Description

The TMP411 is a ±1°C accurate remote temperature sensor monitor with a built-in local temperature sensor. The TMP411EVM allows users to evaluate the performance of the TMP411 sensor. The TMP411EVM is designed to be used as is; using the evaluation module GUI. Alternatively, the sensor can be detached to be evaluated in the user's system. For this purpose, there are multiple alternatives to interface with the sensor for best user experience.

Get Started

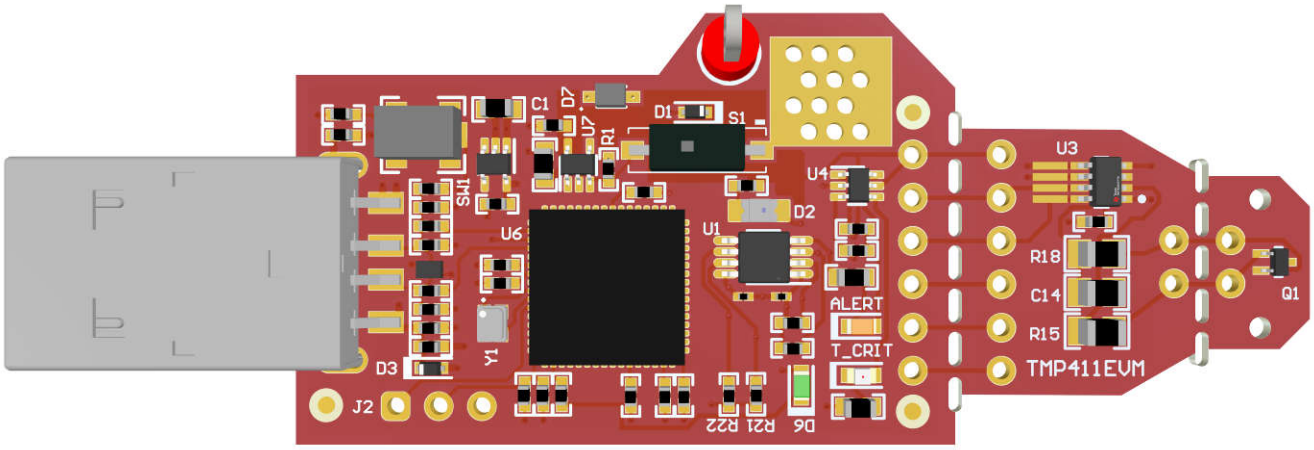
1. Order the TMP411EVM
2. Detach the breakable sensor PCB section (optional)
3. Connect the EVM to computer or user system
4. Go to the TMP411EVM gallery page on dev.ti.com to either download the GUI or run on the web
5. Refer to the TMP411 data sheet for IC details
6. Visit our E2E forums for support or questions

Features

- Easy to use cloud-based GUI is available on the web or can be downloaded for offline use
- NPN and PNP footprints for remote sensor evaluation
- Toggleable sub-regulator provides option for external power supply
- Assembled with SOT-23-THIN package option, with footprint for VSSOP package option for easy swap
- Breakable sensor board with 0.1" pitch header footprint to interface with the TMP411
- Data logging with GUI

Applications

- LCD and DLP and LCOS Projectors
- Servers
- Industrial Controllers
- Central Office Telecom Equipment
- Desktop and Notebook Computers
- Storage Area Networks (SAN)
- Industrial and Medical Equipment
- Processor and FPGA Temperature Monitoring



TMP411EVM

1 Evaluation Module Overview

1.1 Introduction

The EVM comes in a USB stick form factor, with an onboard MSP430F5528 microcontroller that interfaces with both the host computer and the TMP411 device. The module is designed with perforations between the sensor and host controller on the EVM board. The perforation allows the user flexibility in the evaluation:

- The user can connect the TMP411 sensor breakout section to the user's system/host.
- The user can connect the EVM host and software to the user's system with TMP411 devices.
- Small individual boards allow the user to place sensors in the user's system or in a temperature-controlled environment to evaluate performance.
- Hole spacing is compatible with common 0.1" prototyping breadboards.

This user's guide describes the characteristics, operation, and use of the TMP411EVM evaluation board by explaining how to set up and configure the software, describing the hardware, and reviewing various aspects of the software operation. Throughout this document, the terms evaluation board, evaluation module, and EVM are synonymous with the TMP411EVM. This user's guide also provides information on the operating procedure, input and output connections, an electrical schematic, printed-circuit board (PCB) layout drawings, and a parts list for the EVM.

1.2 Kit Contents

Table 1-1 details the contents of the EVM kit. Contact the Texas Instruments Product Information Center nearest you if any components are missing. TI highly recommends that users check the TI website at http://www.ti.com to verify that the latest versions of the related software is downloaded.

Table 1-1. EVM Kit Contents

Item	Quantity
TMP411EVM	1

1.3 Specification

Table 1-2 defines the absolute maximum thermal conditions of each section of the EVM. The main 2 sections are the controller section and the sensor breakout section. These limits must be considered when evaluating the performance of the device at extreme temperatures. In this case, if the setup conditions exceed the controller absolute maximum thermal specifications, then the sensor breakout section must be detached so that only the sensor (and not the MCU) is evaluated at these temperatures.

Table 1-2. Thermal Specifications

BOARD SECTION	CONDITIONS	TEMPERATURE RANGE
Controller board	Recommended operating free-air temperature, T_A	-40°C to 85°C
	Absolute maximum junction temperature, T_J	95°C
TMP411 breakout section	Recommended operating free-air temperature, T_A	-40°C to 125°C

1.4 Device Information

The TMP411 is a remote temperature sensor monitor with a built-in local temperature sensor. The local and remote temperature sensor accuracies are both ±1°C, with an adjustable resolution. The remote temperature sensors are typically low-cost, NPN- or PNP-type transistors or diodes that are an integral part of microcontrollers, microprocessors, or FPGAs. TMP411 supports two-wire and SMBUs serial interface. The device can be set to make continuous or one-shot conversions as needed. Additional features include series resistance cancellation, programmable non-ideality factor, and more. In addition to having multiple package options, the TMP411 has 4 orderable part numbers with different I^2C binary address options. For more information of the IC, please refer to the device data sheet. Table 1-3 includes some of the parameters of interest of the TMP411 to consider when using this EVM.

Table 1-3. Device Specifications

DEVICE SPECIFICATION	VALUE
Operating temperature range	-40°C to 125°C
Local temperature accuracy (T_A=15°C to 85°C)	± 1°C
Remote temperature accuracy (T_A=15°C to 75°C, T_{DIODE}=-40°C to 150°C)	± 1°C
Operating supply range	2.7V to 5.5V

2 Hardware

2.1 Overview

The EVM is divided into 2 sections: the controller section and the breakable sensor section. The sensor breakout section can be detached to use the sensor in the following scenarios:

- Using the controller section with the sensor section connected by soldered wires/connectors to evaluate the sensor far from the controller and PC at extreme temperatures or other conditions.
- Using the sensor section with the user's system by interfacing with the TMP411 using SMBus communication protocol.
- Using the controller section with TMP411 sensors in the user's system.

Figure 2-1 highlights the EVM sections as well as some components that must be identified by the user to understand the purpose and use. The components are further explained in detail in the sections below.

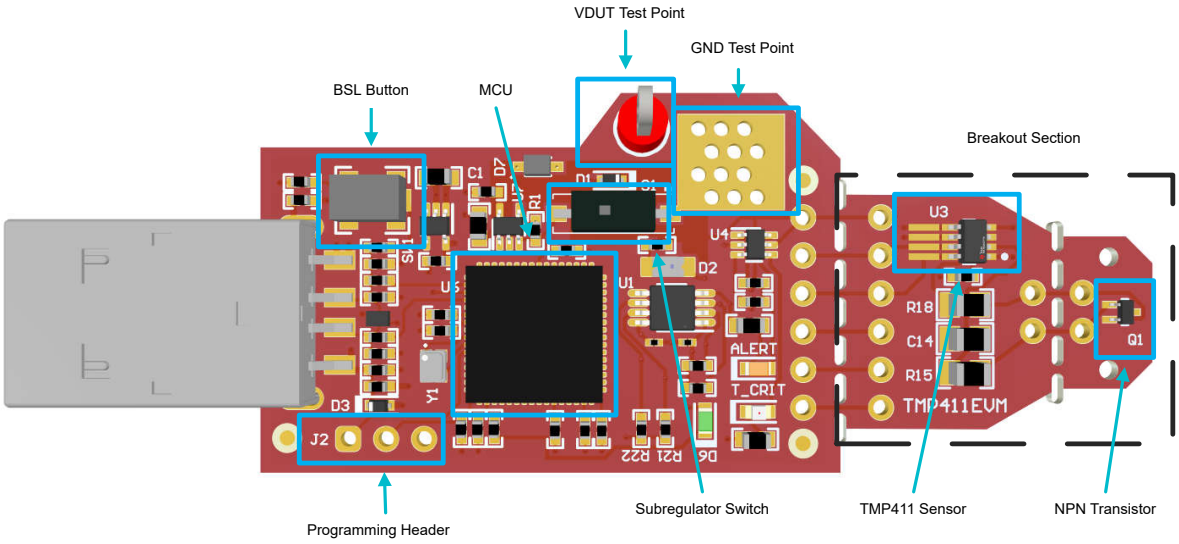


Figure 2-1. TMP411EVM Board Sections

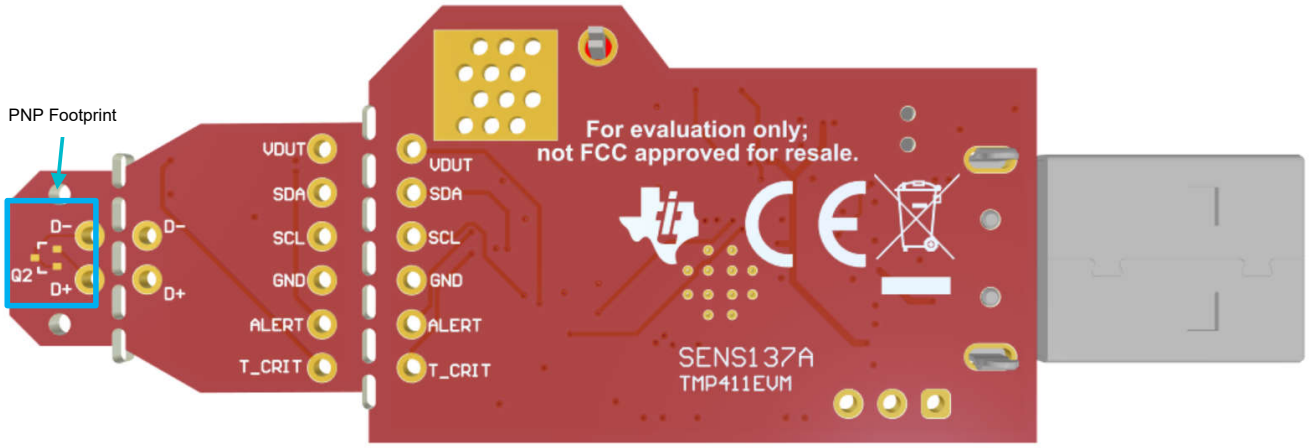


Figure 2-2. TMP411EVM Bottom Side

2.2 Perforations and Connectability

The perforation between the USB controller and TMP113 sensor breakout section is labeled on the bottom of the board on both sides for pin connections. Once the sensor section is detached from the controller section, the user can interface with the sensor section by soldering wires or 0.1" header connectors. With this approach, the user has access to all 8 pins of the device.

Note that pullup resistors and protection diodes are on the controller section. Thus, when interfacing with other controller boards, TI recommends to verify that pullup resistors and protection circuitry are present on any controller board for safe and proper functionality.

2.3 Status LEDs and Sub-regulator

The green LED D2 illuminates when VDD is supplied. VDD must be supplied for normal operation of the TMP113EVM as VDD is used for device power and communication line pullup voltages. VDD can be supplied via the on-board sub-regulator U7 or external power. See Section 2.6 for more details.

The orange ALERT LED and red T_CRIT LED illuminate when the corresponding ALERT/THERM2 and THERM device pins are asserted (active-low). An overtemperature or undertemperature alarm on local and remote temperatures is triggered when measurements exceed user-programmed limits. Additional thermal limits can be programmed to trigger the THERM flag.

The green LED D6 is the MSP430F5528 status LED. Table 2-1 shows how the different modes of operation are displayed by the LED status.

Table 2-1. Status LED Mode of Operation

D6 LED STATUS	MSP430F5528 MODE OF OPERATION
Off	EVM is connected to EVM GUI
Blinking in bursts of 4 blinks	EVM is plugged into PC, not connected to EVM GUI
Steady blinking	Connected to USB power

2.4 Remote Sensor

The TMP411EVM is assembled with the transistor Q1, which is a MMBT3904T NPN BJT. A PNP footprint Q2 is located on the back of the EVM to allow users to evaluate both types of transistors. Q1 and Q2 are on a perforated section of the board that can be broken off to connect different remote sensors.

2.5 Package Swapping

The EVM is assembled with the TMP411ADDFR device orderable option, which comes in a SOT-23-THIN (DDF) package. However, the EVM also has a landing pattern option for the VSSOP (DGK) package option. This allows the user to optionally remove the TMP411ADDFR and solder the DGK option onto the board to evaluate different device packages. The image below shows the available landing patterns for the DDF and DGK package options.

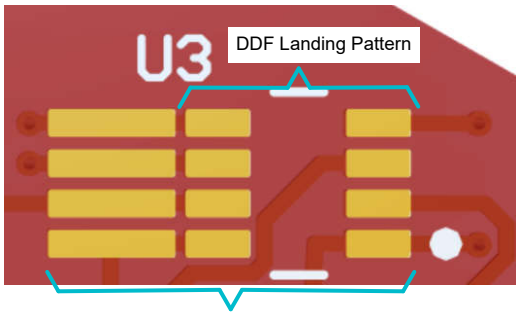


Figure 2-3. TMP411 Device Footprints

2.6 Power Supply

VDUT supplies power to the TMP411 device and pullup voltage of the communication lines, and must be set between 2.7V to 5.5V for normal operation of the TMP411EVM. The on-board regulator U7 regulates USB power down to 3.3V. The user can also disable the sub-regulator to apply a different supply voltage. To use an external power supply, follow these instructions:

1. Flip the switch S1 to disable the sub-regulator; the green LED D2 turns off
2. Connect the external power supply using the VDUT and GND test points, or by soldering headers or wires on the breakout section
3. Supply VDUT; the green LED D2 turns on
4. Use the GUI as normal

2.7 Programming Header

The TMP411EVM comes pre-loaded with firmware that is necessary for the correct operation of the USB interface and PC GUI software. The unpopulated header, J2, is provided for Spy-Bi-Wire access to the MSP430F5528. TI does not recommend that users access this header or reprogram the device.

2.8 BSL Button

The TMP411EVM features push-button SW1 for entering USB BSL mode. This can be used for firmware updates. To enter USB BSL mode, connect the EVM to a PC USB port while holding down SW1.

3 Software

3.1 Software Download

The PC GUI Software for TMP411EVM runs on TI's GUI Composer framework. The software is available as a live version which runs in your browser, and is available as a download for offline use. The software is compatible with Windows®, Mac®, and Linux® operating systems.

3.1.1 Live Software on dev.ti.com

The live software currently works on Chrome, Firefox, and Safari browsers. Internet Explorer is not supported. Users can access the live version through one of the following actions:

- Go to the EVM tool page and click on the View button
- Go to https://dev.ti.com/gallery/search/tmp411

Click on the application icon within the gallery to launch the software. Click on the prompt to install the TI Cloud Agent Bridge browser plugin.

3.1.2 Offline Software

3.1.2.1 Download From dev.ti.com

Users can access the latest version of the offline software by navigating to the live version as noted above. Look for the download icon and download both the application and runtime for the operating system as shown in the Gallery Download.

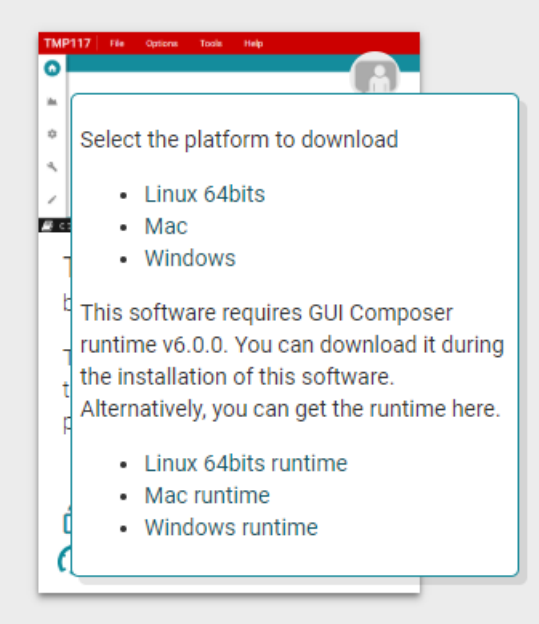


Figure 3-1. Download Pop-Up

3.2 Home Tab

The Home Tab is shown at software launch. From here, you can access the Information, Data, Registers and Collateral tabs which are explained below. The icons on the left side of the screen are shortcuts to the tabs.

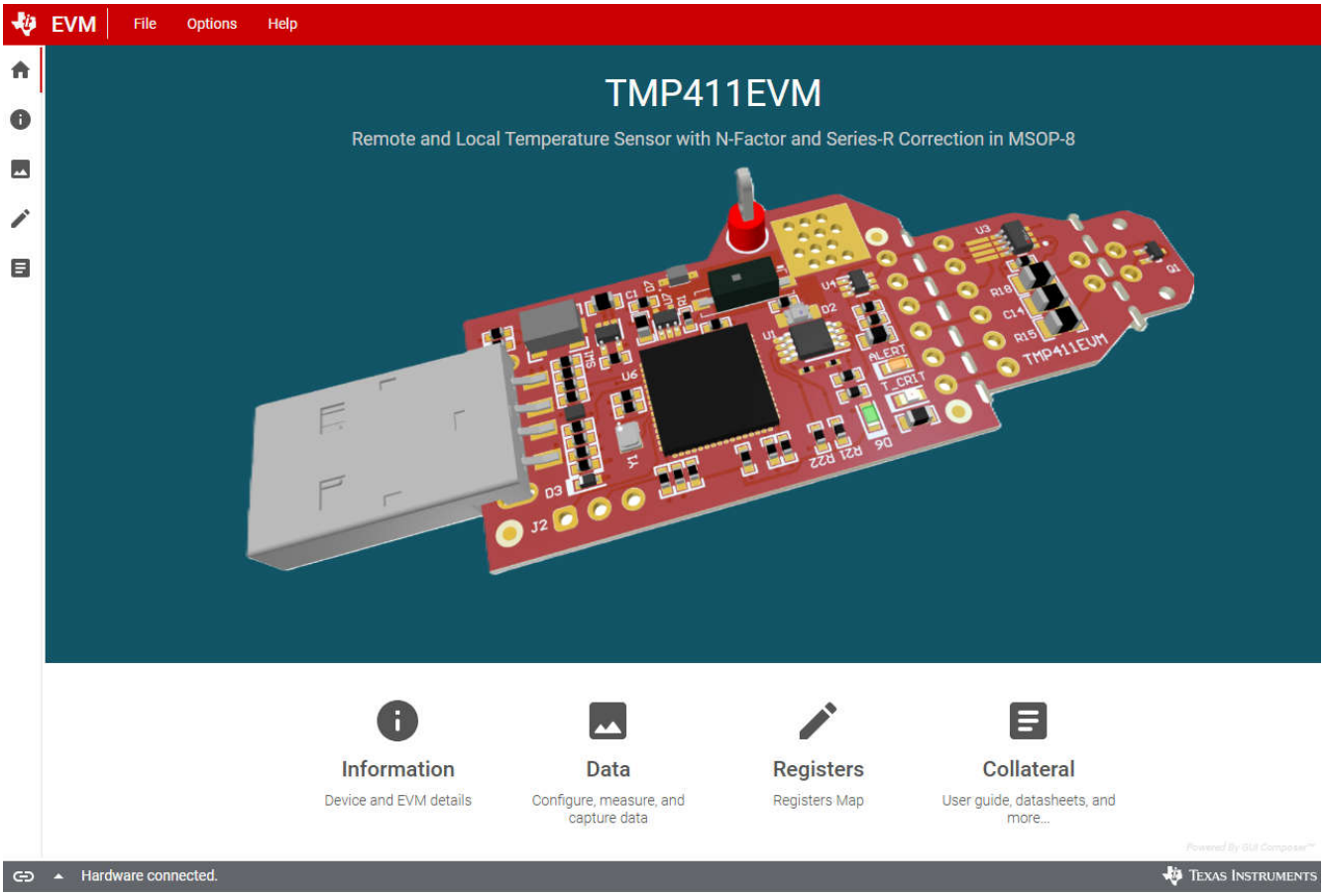


Figure 3-2. Home

3.3 Information Tab

The Information tab shows device details and features of the TMP411 and EVM. The Device Information & Features sub-tab includes a specifications summary, device block diagram, and description of functional modes. The EVM Details sub-tab includes the EVM schematic and legend.

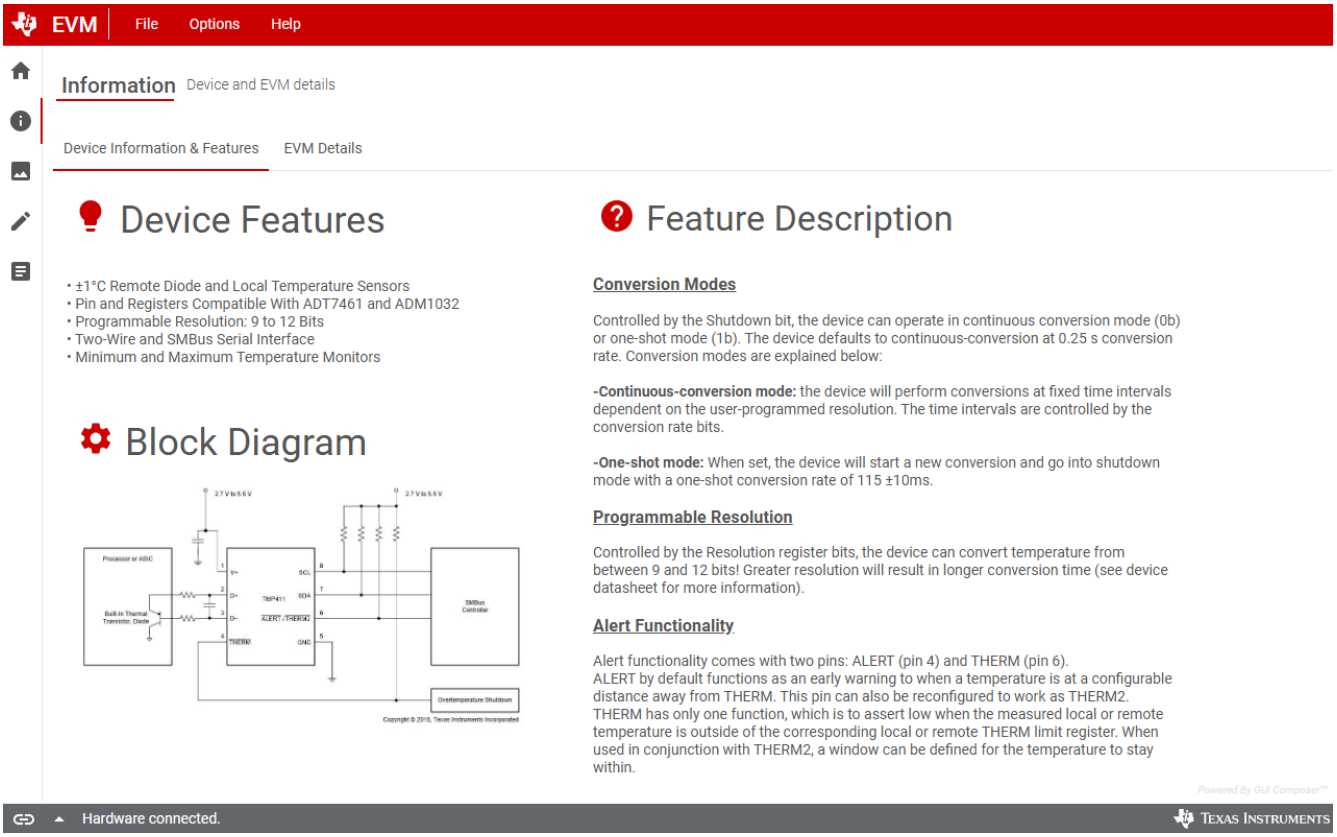


Figure 3-3. Information

3.4 Data Tab

The Data tab reports the temperature measurements from the TMP411 device included on the TMP411EVM. By default, once the EVM is connected and the GUI is loaded and running properly, the device starts converting and MCU starts reading the conversions which are automatically reported and displayed in the graph. On the right side of the graph, the user can also see the latest local and remote temperature read. The user can toggle visibility of specific line plots by clicking the corresponding item in the graph key.

The controls on the right side of the graph allow the user to easily configure the GUI and device settings, including:

- Set the polling rate. Once a value is selected from the dropdown, the MCU automatically starts reading the TMP411 at the set polling rate
- Set the device conversion rate when the TMP411 is in continuous conversion mode
- Save a data file. Click the Start button to start recording, and click the Stop button to stop recording and export the .csv file
- Program high and low Alert limits for local and remote temperature
- Program Therm limits and hysteresis for local and remote temperature
- Issue a general call reset
- Trigger a one shot when the device is in shutdown mode

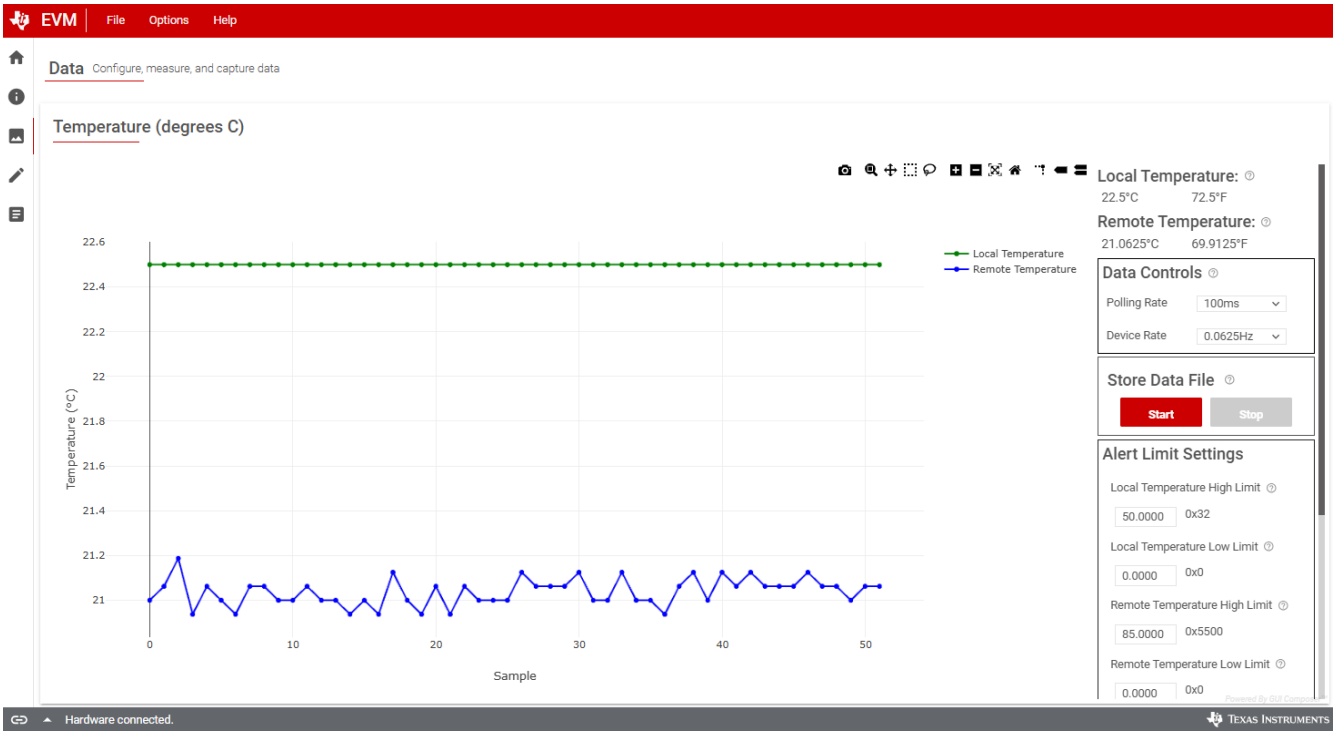


Figure 3-4. Data Graph

3.5 Registers Tab

The Registers tab interacts with the registers and bits within the TMP411 device. For more information on each register/bit, click on a register name to see what each bit defines.

The Auto Read drop-down box configures polling of register contents. By default, the MCU polls the registers with a 100ms delay. When Auto Read is Off, click Read Register to fetch the contents of the current register. Read All Registers can be used to fetch the contents of all registers at once.

By default, the Write Register button is grayed and disabled when the button is set to Immediate. Immediate mode triggers a Write operation each time a register is modified. When Deferred mode is selected, the Write Register button is enabled, and write operations are not performed unless the Write Register button is clicked.

These settings give the user total control over digital communication, and enable individual transactions to be easily observed with an oscilloscope, logic analyzer, or bus-sniffing device.

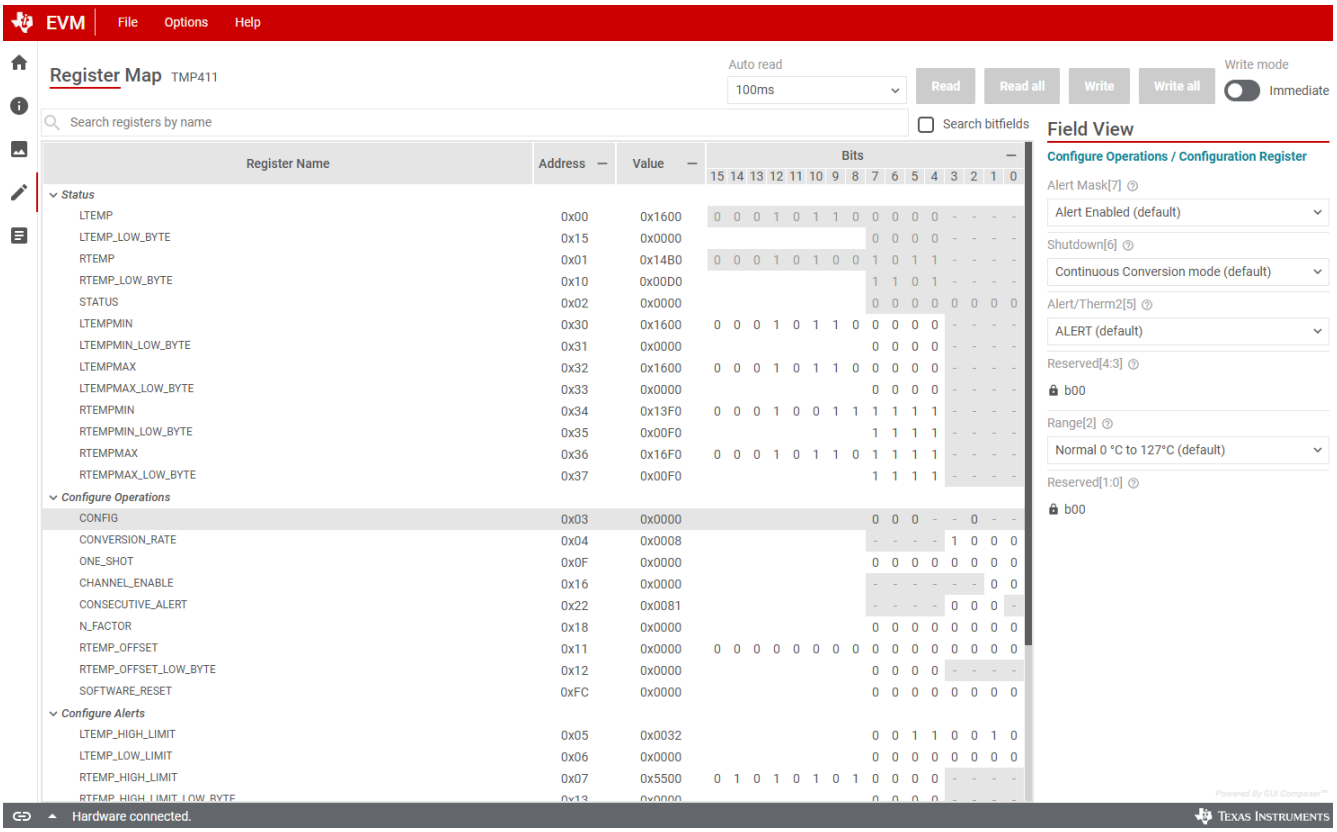


Figure 3-5. Registers

3.6 Collateral Tab

The Collateral tab contains links to the EVM user's guide, the tool page on ti.com, as well as links to the product data sheet and other relevant links.

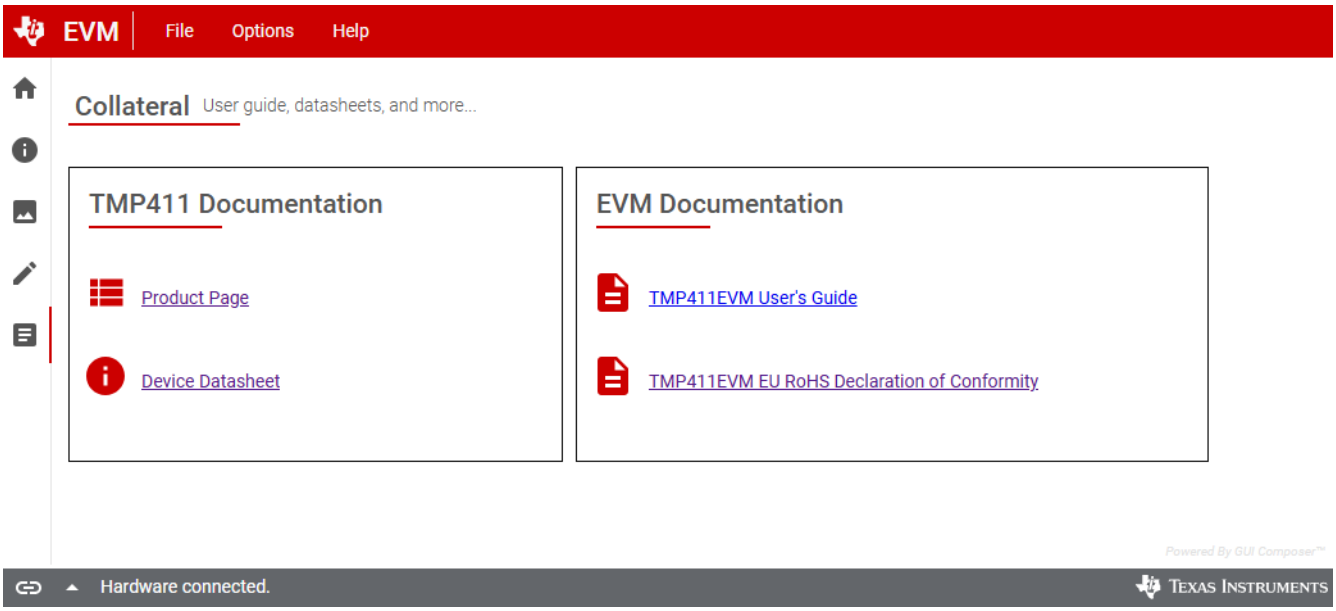


Figure 3-6. Collateral

4 Hardware Design Files

4.1 Schematic

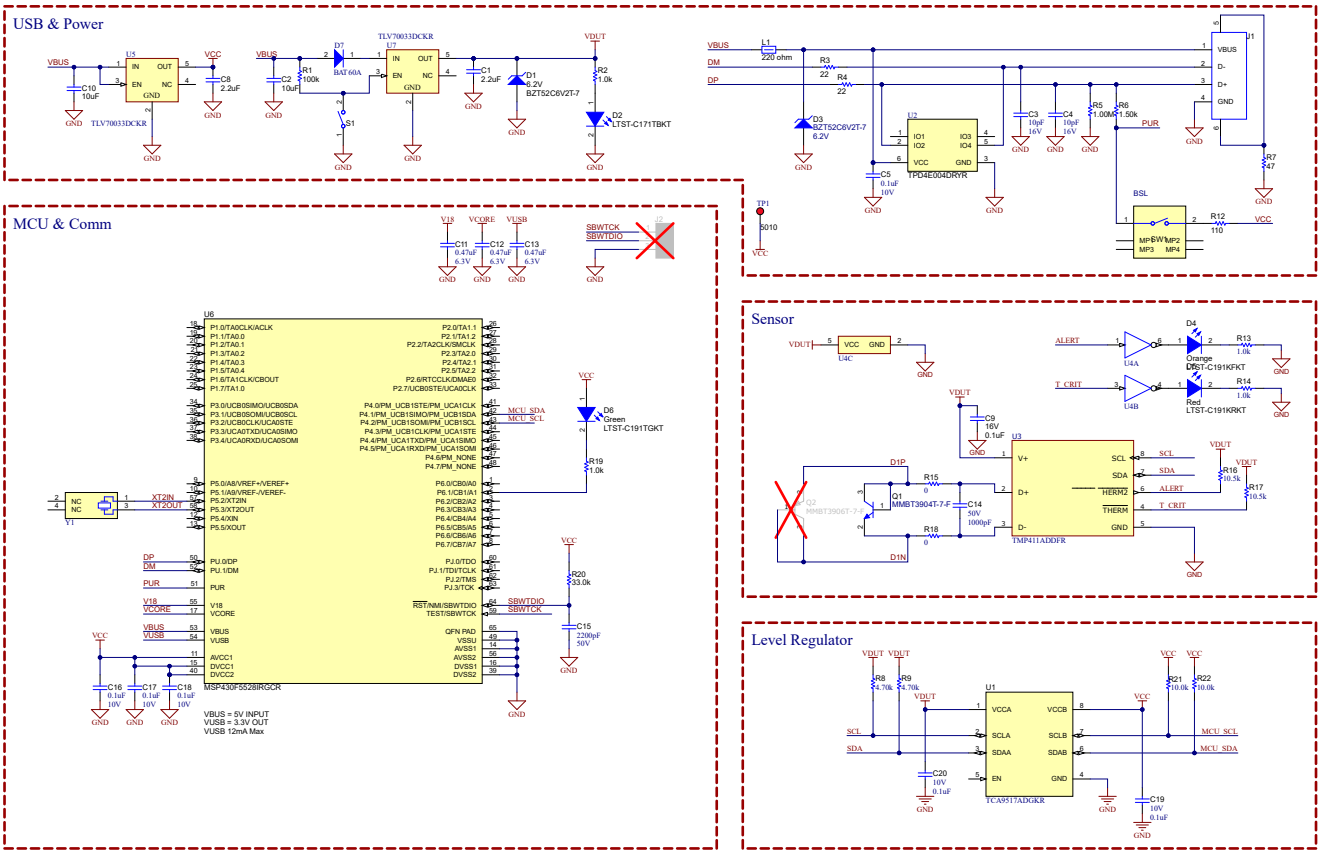


Figure 4-1. Schematic

4.2 PCB Layouts

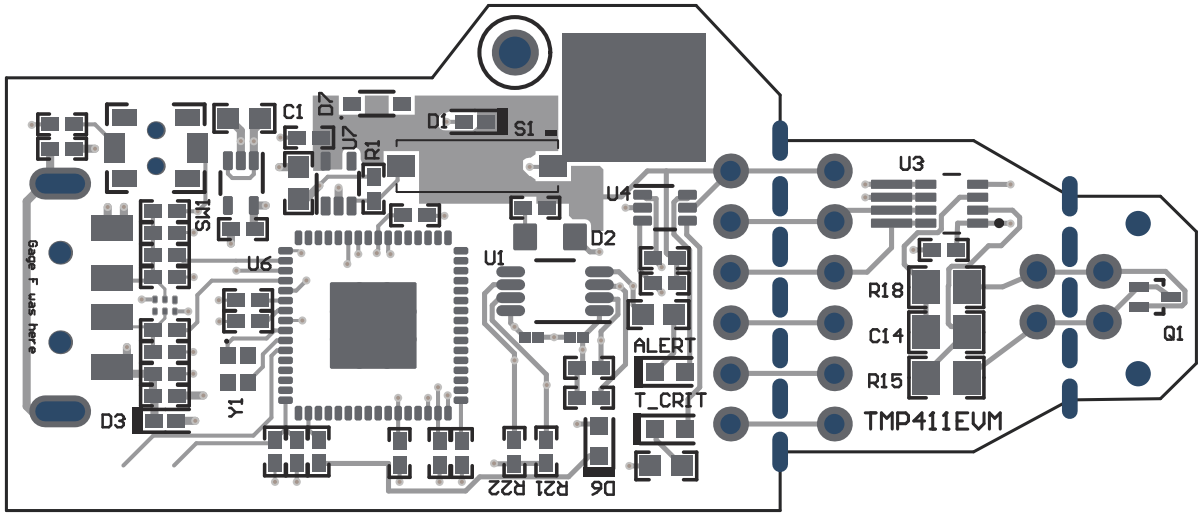


Figure 4-2. Top View

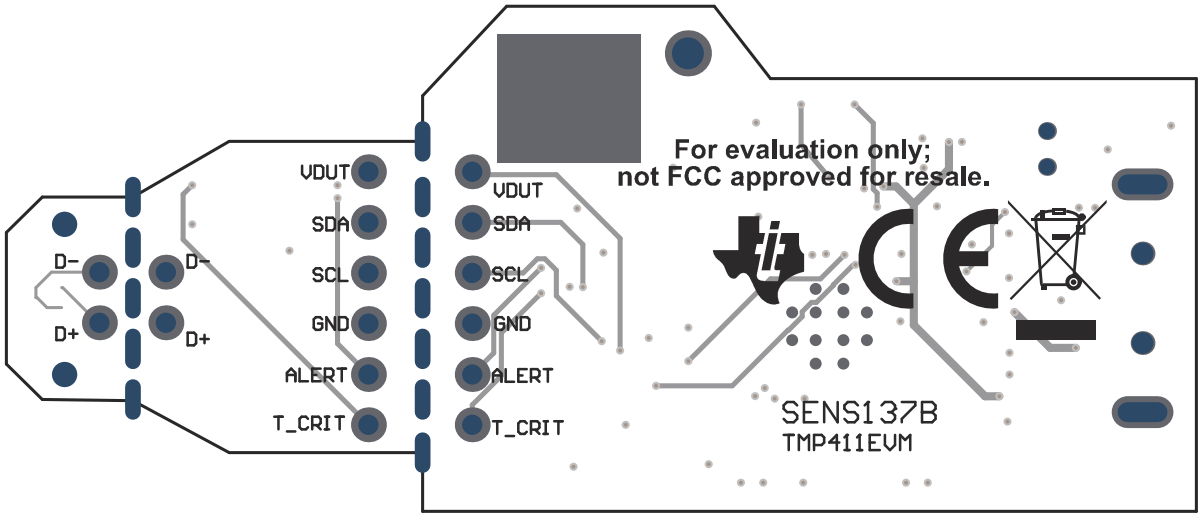


Figure 4-3. Bottom View

4.3 Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
!PCB1	1		Printed Circuit Board		SENS137	Any
C1, C8	2	2.2uF	CAP, CERM, 2.2 uF, 16 V, +/- 10%, X5R, 0402	402	GRM155R61C225KE11D	MuRata
C2, C10	2	10uF	CAP, CERM, 10 uF, 10 V, +/- 20%, X5R, 0603	603	C1608X5R1A106M080AC	TDK
C3, C4	2	10pF	CAP, CERM, 10 pF, 16 V,+/- 10%, C0G, 0402	402	C0402C100K4GACTU	Kemet
C5, C16, C17, C18	4	0.1uF	CAP, CERM, 0.1 uF, 10 V,+/- 10%, X5R, 0402	402	LMK105BJ104KV-F	Taiyo Yuden
C9	1	0.1uF	CAP, CERM, 0.1 uF, 16 V, +/- 10%, X7R, 0402	402	ATC530L104KT16T	AT Ceramics
C11, C12, C13	3	0.47uF	CAP, CERM, 0.47 uF, 6.3 V, +/- 10%, X7R, 0402	402	JMK105B7474KVHF	Taiyo Yuden
C14	1	1000pF	CAP, CERM, 1000 pF, 50 V, +/- 2%, C0G/NP0, 0805	805	08055A102GAT2A	AVX
C15	1	2200pF	CAP, CERM, 2200 pF, 50 V, +/- 5%, X7R, 0402	402	CL05B222JB5NNNC	Samsung Electro-Mechanics
C19, C20	2	0.1uF	CAP, CERM, 0.1 uF, 10 V, +/- 10%, X5R, 0201	201	CL03A104KP3NNNC	Samsung Electro-Mechanics
D1, D3	2	6.2V	Diode, Zener, 6.2 V, 300 mW, SOD-523	SOD-523	BZT52C6V2T-7	Diodes Inc.
D2	1	Blue	LED, Blue, SMD	2x1.25mm	LTST-C171TBKT	Lite-On
D4	1	Orange	LED, Orange, SMD	LED_0603	LTST-C191KFKT	Lite-On
D5	1	Red	LED, Red, SMD	LED_0603	LTST-C191KRKT	Lite-On
D6	1	Green	LED, Green, SMD	LED_0603	LTST-C191TGKT	Lite-On
D7	1		Silicon Schottky Diode, -55 to 85 degC, SOD323, Reel, Green	SOT323	BAT60A	Infineon
J1	1		Connector, Plug, USB Type A, R/A, Top Mount SMT	USB Type A right angle	48037-1000	Molex
L1	1	220 ohm	Ferrite Bead, 220 ohm @ 100 MHz, 0.45 A, 0402	402	BLM15AG221SN1D	MuRata
Q1	1	40 V	Transistor, NPN, 40 V, 0.2 A, SOT-523	SOT-523	MMBT3904T-7-F	Diodes Inc.

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
Q2	1	-40V	Bipolar (BJT) Transistor PNP 40 V 200 mA 250MHz 150 mW Surface Mount SOT-523	SOT523	MMBT3906T-7-F	Diodes
R1	1	100k	RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2GEJ104X	Panasonic
R2, R19	2	1.0k	RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2GEJ102X	Panasonic
R3, R4	2	22	RES, 22, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2GEJ220X	Panasonic
R5	1	1.00Meg	RES, 1.00 M, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	RMCF0402FT1M00	Stackpole Electronics Inc
R6	1	1.50k	RES, 1.50 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	402	RMCF0402FT1K50	Stackpole Electronics Inc
R7	1	47	RES, 47, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2GEJ470X	Panasonic
R8, R9	2	4.70k	RES, 4.70 k, 1%, 0.1 W, 0402	402	ERJ-2RKF4701X	Panasonic
R12	1	110	RES, 110, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	402	ERJ-2RKF1100X	Panasonic
R13, R14	2	1.0k	RES, 1.0 k, 5%, 0.1 W, 0603	603	RC0603JR-071KL	Yageo
R15, R18	2	0	RES, 0, 5%, 0.125 W, AEC-Q200 Grade 0, 0805	805	CRCW08050000Z0EA	Vishay-Dale
R16, R17	2	10.5k	RES, 10.5 k, 1%, 0.063 W, 0402	402	RC0402FR-0710K5L	Yageo America
R20	1	33.0k	RES, 33.0 k, 1%, 0.063 W, 0402	402	RC0402FR-0733KL	Yageo America
R21, R22	2	10.0k	RES, 10.0 k, 1%, 0.1 W, 0402	402	ERJ-2RKF1002X	Panasonic
S1	1		Switch, Slide, SPST, Top Slide, SMT	Switch, Single Top Slide, 2.5x8x2.5mm	CHS-01TB	Copal Electronics
SW1	1		Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	3.9x2.9mm	PTS820 J20M SMTR LFS	C&K Components
TP1	1		Test Point, Multipurpose, Red, TH	Red Multipurpose Testpoint	5010	Keystone Electronics
U1	1		Level-Translating I2C Bus Repeater, DGK0008A (VSSOP-8)	DGK0008A	TCA9517ADGKR	Texas Instruments

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer
U2	1		4-Channel ESD Protection Array for High-Speed Data Interfaces, DRY0006A (USON-6)	DRY0006A	TPD4E004DRYR	Texas Instruments
U3	1		±1°C Remote and Local Temperature Sensor With N-Factor and Series Resistance Correction	SOT-23-8	TMP411ADDFR	Texas Instruments
U4	1		Dual Inverter, DCK0006A (SOT-SC70-6)	DCK0006A	SN74LVC2G04DCKR	Texas Instruments
U5, U7	2		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 & no Sb/Br)	DCK0005A	TLV70033DCKR	Texas Instruments
U6	1		16-Bit Ultra-Low-Power Microcontroller, 128KB Flash, 8KB RAM, USB, 12Bit ADC, 2 USCIs, 32Bit HW MPY, RGC0064B (VQFN-64)	RGC0064B	MSP430F5528IRGCR	Texas Instruments
Y1	1		Crystal, 24 MHz, SMD	2x1.6mm	XRCGB24M000F2P00R0	MuRata
J2	0		Header, 100mil, 3x1, Gold, TH	3x1 Header	TSW-103-07-G-S	Samtec

5 Additional Information

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