EVM User's Guide: TMP113

TMP113 Evaluation Module

Description

The TMP113 is an I²C-compatible digital temperature sensor in a 6-pin WCSP package. The TMP113EVM allows users to evaluate the performance of the TMP113 digital temperature sensor. The TMP113EVM is designed to be used as is, along with 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

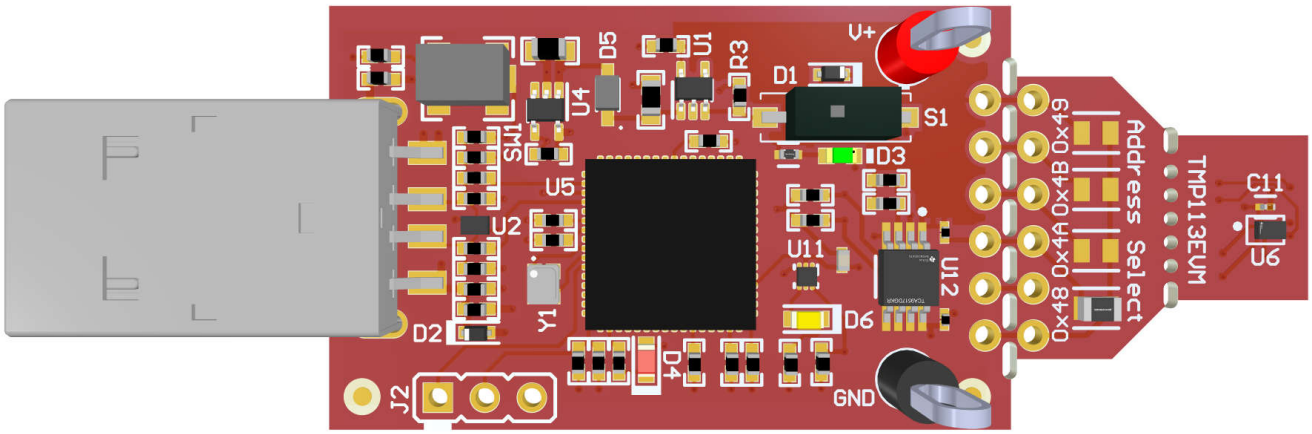
1. Order the TMP113EVM
2. Detach the sensor breakout PCB section (optional)
3. Connect the EVM to computer or user system
4. Go to the TMP113EVM gallery page on dev.ti.com to either download the GUI or run on the web
5. Refer to the TMP113 data sheet for IC details
6. Visit our E2E forums for support or questions

Features

- Easy to use cloud-based GUI is available on the web or can be downloaded for offline use
- Showcase the ultra-small digital temperature sensor with alert functionality
- Breakable sensor board with 0.1" pitch header footprint to interface with the TMP113
- Data logging with GUI

Applications

- Building automation
  - Occupancy detection
  - Video doorbell
  - HVAC: Wireless environmental sensor
- Factory automation & control
  - Machine vision camera
  - Power Delivery Units
  - Industrial PC: Single board computer
  - CPU (PLC controller)
- Medical equipment
  - Continuous glucose monitor
- Data center & enterprise computing
  - Solid State Drive (SSD)
  - Rack Server Motherboard
- Personal electronics
  - PC & notebooks, tablets
  - Digital still & video camera
  - Augmented reality glasses
  - Smart speakers



TMP113EVM

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 TMP113 device using an I^2C interface. 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 TMP113 sensor breakout section to the user's system/host.
- The user can connect the EVM host and software to the user's system with TMP113 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 TMP113EVM 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 TMP113EVM. 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
TMP113EVM	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
TMP113 breakout section	Recommended operating free-air temperature, T_A	-40°C to 125°C

1.4 Device Information

The TMP113 is a digital output temperature sensor that is calibrated in production to achieve high accuracy in a small 6-pin WCSP package. This device communicates in a two-wire environment compatible with SMBus and I^2C interfaces, and has 4 I^2C address options using the address select pin. The device can be set to make continuous or one-shot conversions and additionally has alert functionality. 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 TMP113 to consider when using this EVM.

Table 1-3. Device Specifications

DEVICE SPECIFICATION	VALUE
Operating temperature range	-40°C to 125°C
Operating supply range	1.4V to 5.5V
Temperature accuracy (0°C to 60°C)	± 0.3°C
Temperature accuracy (-25°C to 85°C)	± 0.5°C
Temperature accuracy (-40°C to 125°C)	± 0.75°C

2 Hardware

2.1 Overview

The EVM is divided into 2 sections: the controller section and the sensor breakout 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 through I^2C with the TMP113.
- Using the controller section with TMP113 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.

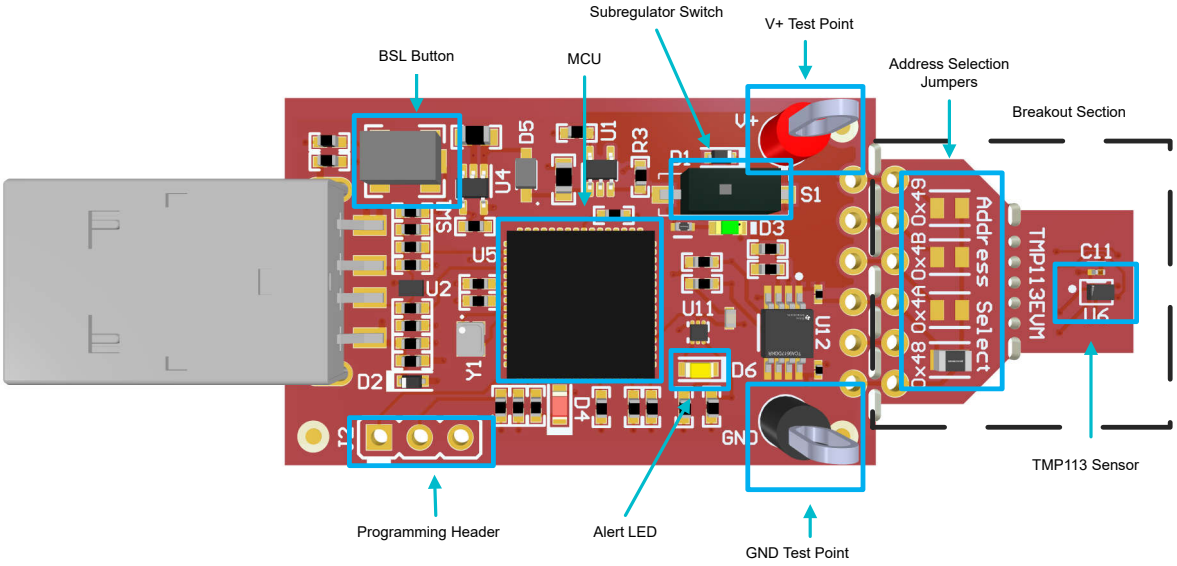


Figure 2-1. TMP113EVM Board Sections

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 6 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.

Additionally, note that the default EVM configuration connects the ADDR pin to GND via the solderable jumper resistor. When interfacing the ADDR pin on the sensor breakout section to an external connection, remember to remove the jumper first to avoid shorting any pins. See Section 2.4 for more details.

2.3 Status LEDs and Sub-regulator

The green LED D3 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 U1 or external power. See Section 2.5 for more details.

The yellow LED D6 illuminates when the ALERT pin is low. The default software configuration of the ALERT pin is active-low, and the LED illuminates when ALERT becomes active or "trips".

The red LED D4 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

D4 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 Address Selection

The TMP113EVM has an Address Selection portion of the breakout section, which has footprints for 4 solderable jumper resistors. The default EVM configuration connects the ADDR pin to GND via jumper R01. The jumper can be moved to the R02, R03, or R04 footprint to connect the ADDR pin to SDA, SCL, or VDD, respectively. See Table 2-2 for the corresponding I^2C address for each ADDR pin configuration. Take care to only install 1 jumper at a time to avoid shorts.

When interfacing the ADDR pin on the sensor breakout section to an external connection, all jumpers must be removed first to avoid shorts. Then, a header pin or wire can be soldered to connect ADDR to GND, VDD, SDA, or SCL through the user's custom connection.

Table 2-2. Address Pin and Device Target Address

TARGET I^2C ADDRESS	ADDR PIN CONNECTION
1001000	GND
1001001	VDD
1001010	SDA
1001011	SCL

2.5 Power Supply

VDD supplies power to the TMP113 device and pullup voltage of the communication lines, and must be set between 1.4V to 5.5V for normal operation of the TMP113EVM. The on-board regulator U1 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 D3 turns off
2. Connect the external power supply using the V+ and GND test points, or by soldering headers or wires on the breakout section
3. Supply VDD; the green LED D3 turns on
4. Use the GUI as normal

2.6 Programming Header

The TMP113EVM 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.

2.7 BSL Button

The TMP113EVM 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 TMP113EVM 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/tmp113

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.

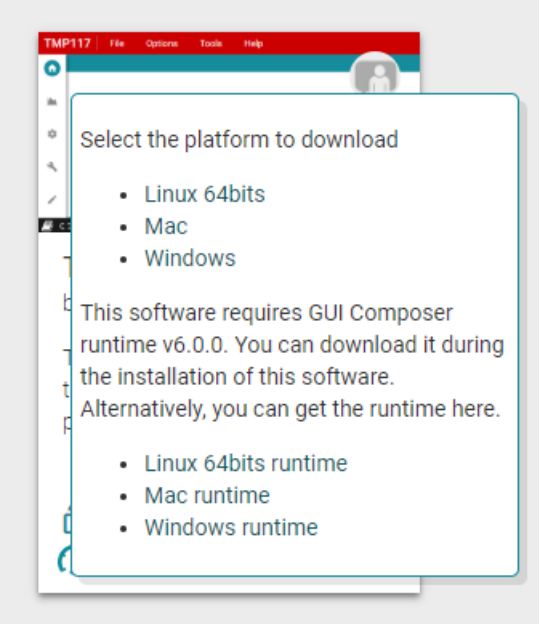


Figure 3-1. Download Pop-Up

3.2 Home Tab

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

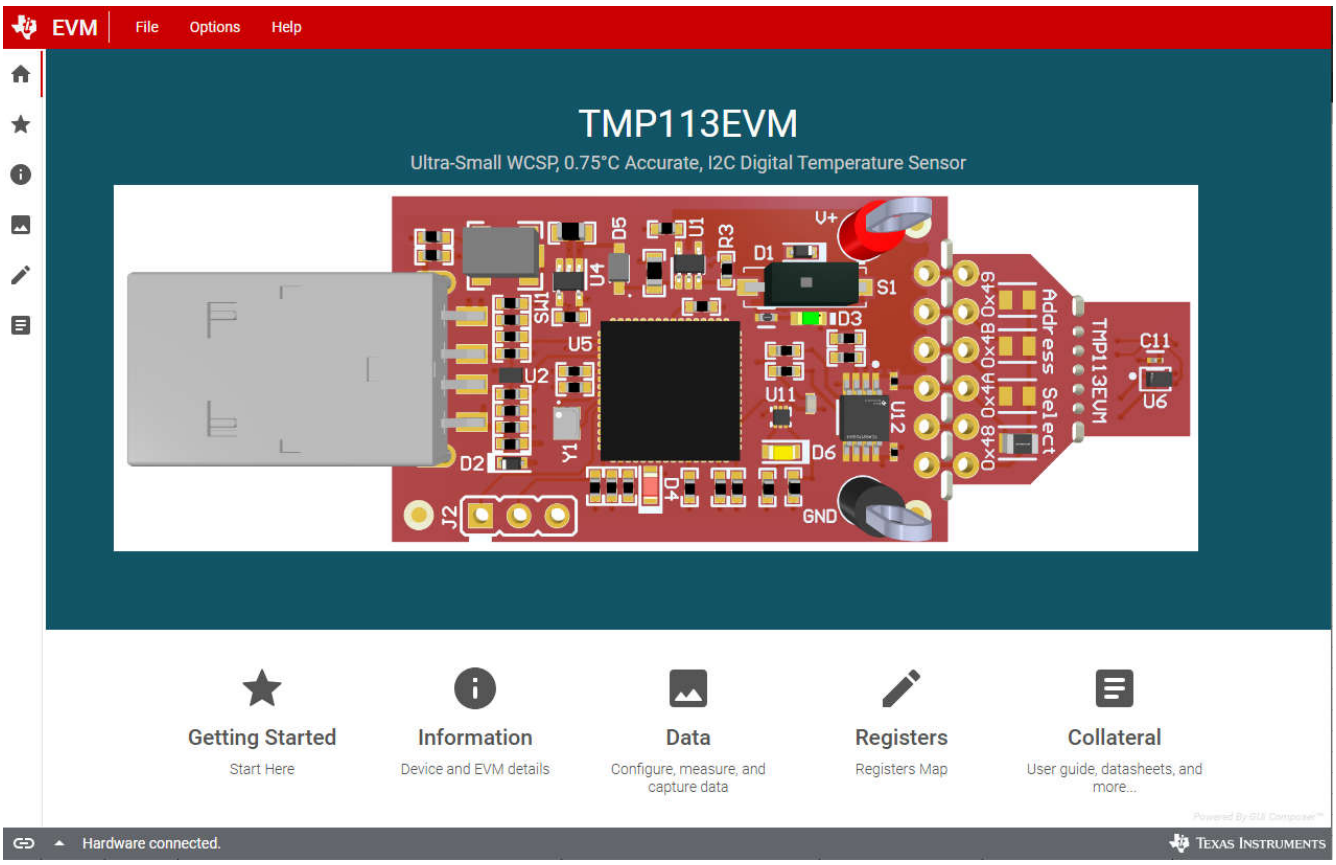


Figure 3-2. Home

3.3 Getting Started

The Getting Started tab is used to set the target I^{2}C address based on the ADDR pin connection. The default setting assumes that the ADDR pin is connected to GND. To change the I^{2}C configuration, make the appropriate selection from the dropdown list. Then, click the button on the bottom left of the GUI to reinitialize communication.

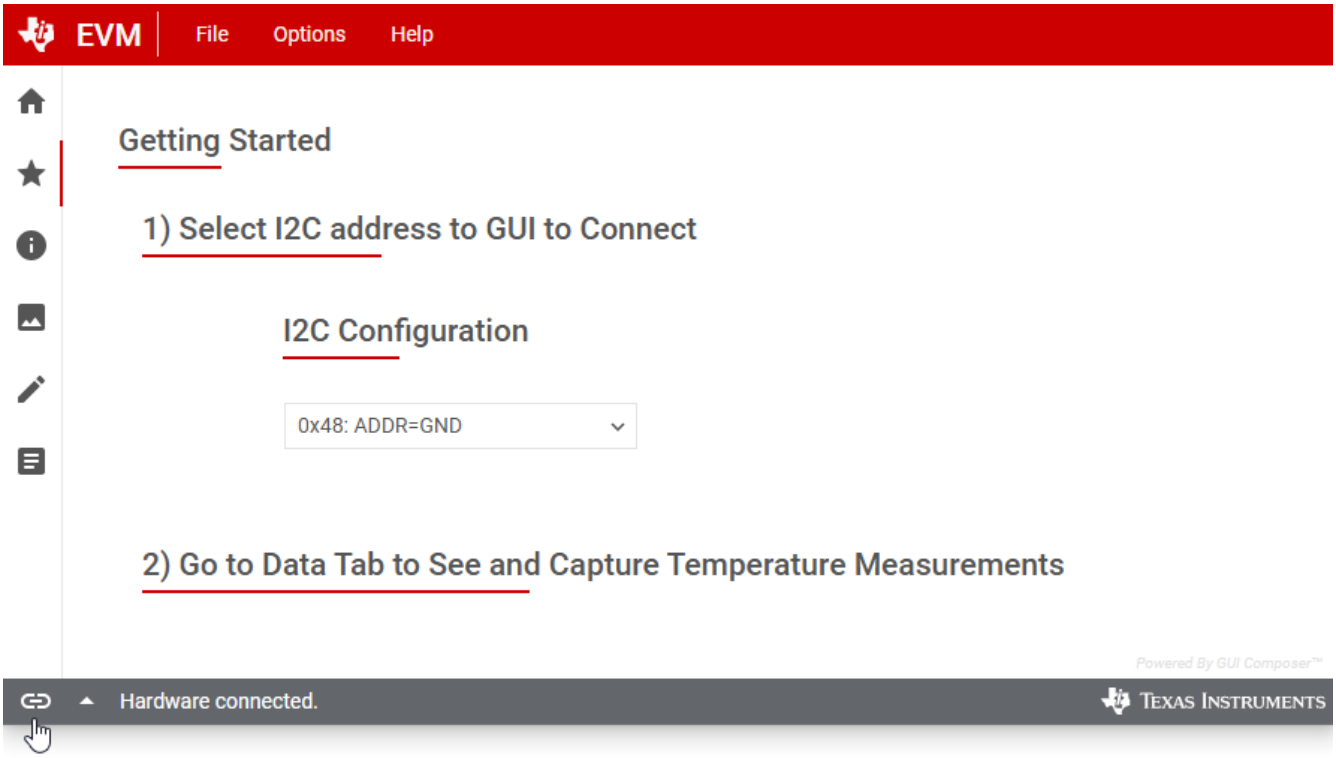


Figure 3-3. Getting Started

3.4 Information Tab

The Information tab shows device details and features of the TMP113 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.

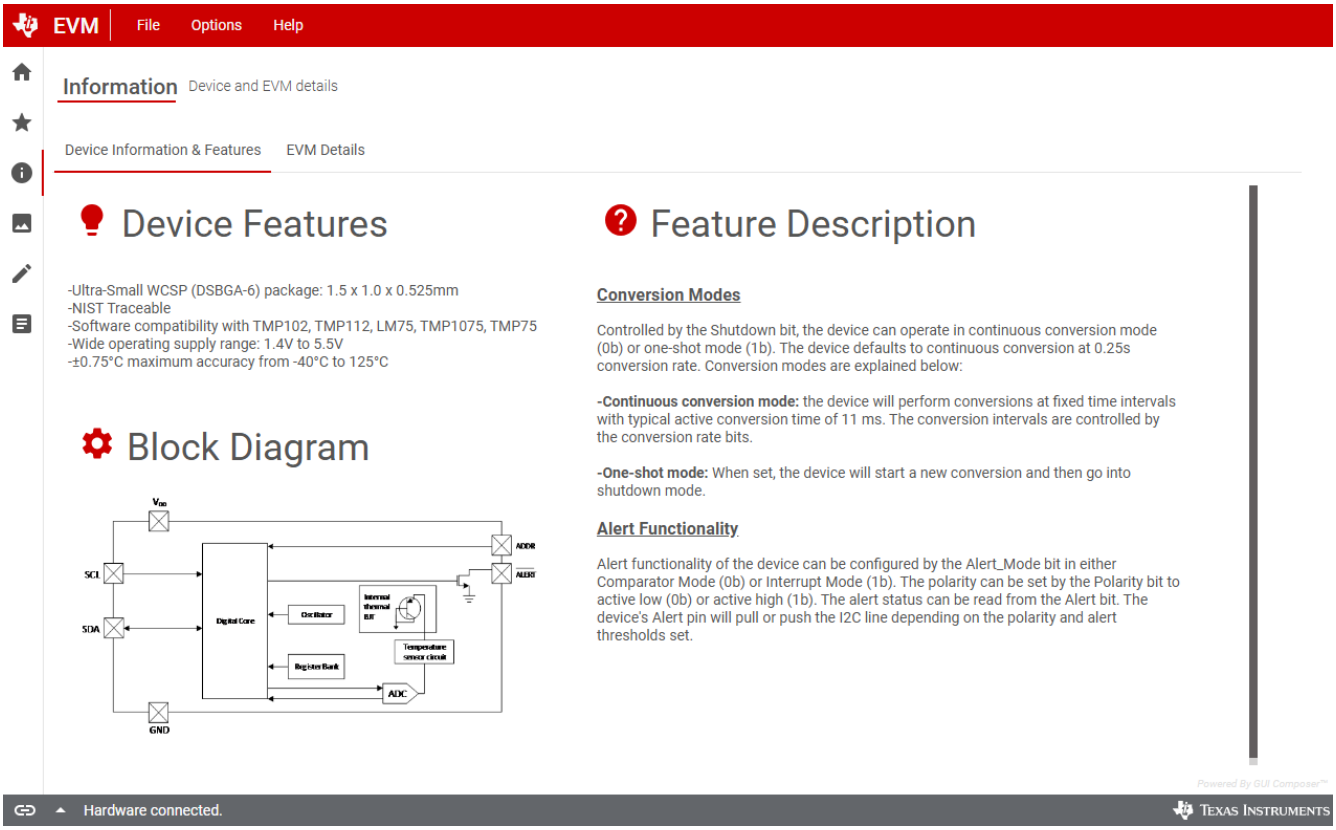


Figure 3-4. Information

3.5 Data Tab

The Data Capture tab reports the temperature from the TMP113 device included on the TMP113EVM. By default, once the EVM is connected and the GUI is loaded and running properly, the device starts in continuous conversion mode and the MCU starts polling the device. The conversion results are automatically reported and displayed in the Data tab graph.

On the right side of this tab, the user can view the latest temperature read value. There is also a chart controls box which allows the user to:

- Set the polling rate. Once a value is selected from the dropdown, the MCU automatically starts reading the TMP113 at the set polling rate.
- Write to the Conversion Rate bits using the Device Rate field. Once a value is selected from the dropdown, the MCU automatically writes to the TMP113, which then starts converting at the programmed rate.
- Start and stop polling the data read to export to CSV format for temperature monitoring. The user must start polling by clicking the Start button and the data (CSV) automatically exports once the stop button is clicked.

The Alert Config box allows the user to easily configure the alert functionality settings of the TMP113 such as polarity, mode, and limits. The limits can be written on the left box in decimal format, and the corresponding hexadecimal value is automatically displayed in the right box for reference. Once selected or updated, all of the settings are written automatically to the TMP113 by the MCU.

Figure 3-5. Data Capture

3.6 Registers Tab

The Registers tab interacts with the registers and bits within the TMP113 device. For more information on each register/bit, click on a register name to see what each bit defines.

The Auto Read dropdown box configures the polling rate of the 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 selected 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 Write Mode 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 I^{2}C Bus activity, and enable individual transactions to be easily observed with an oscilloscope, logic analyzer, or bus-sniffing device.

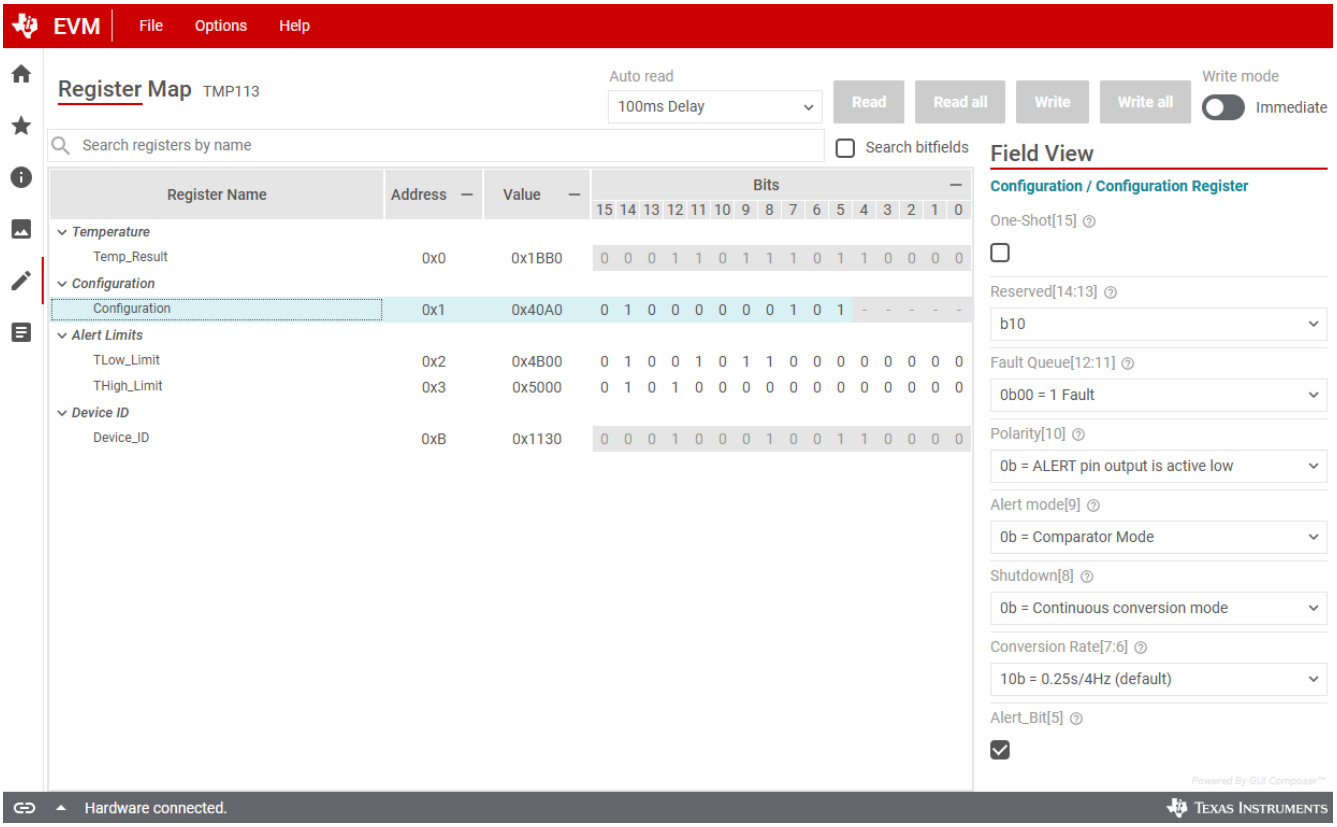


Figure 3-6. Registers

3.7 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.

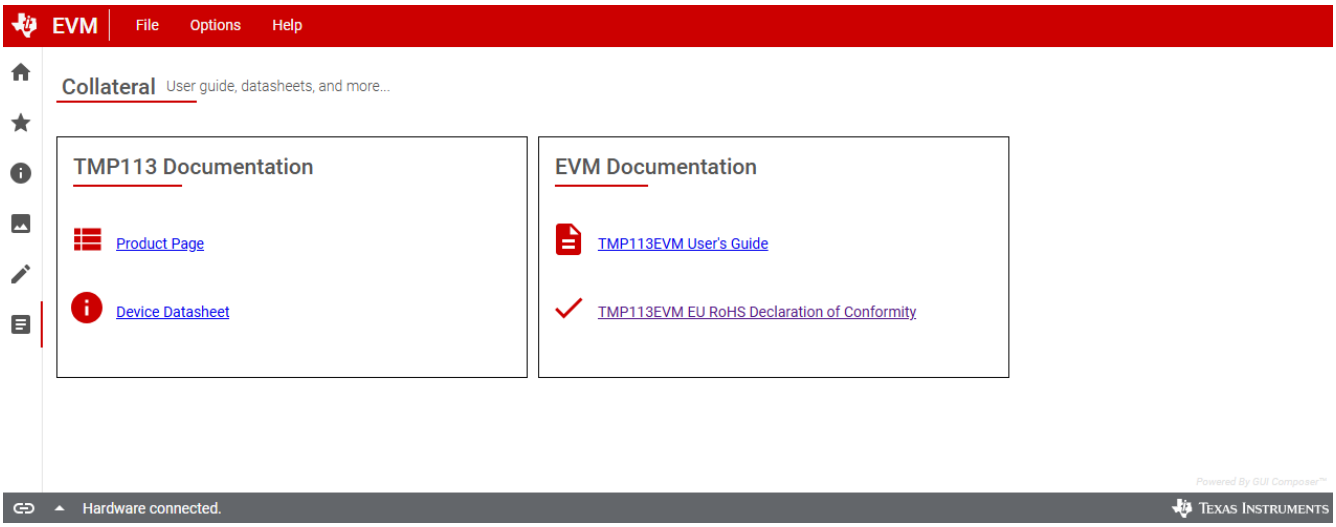


Figure 3-7. Collateral

4 Hardware Design Files

4.1 Schematic

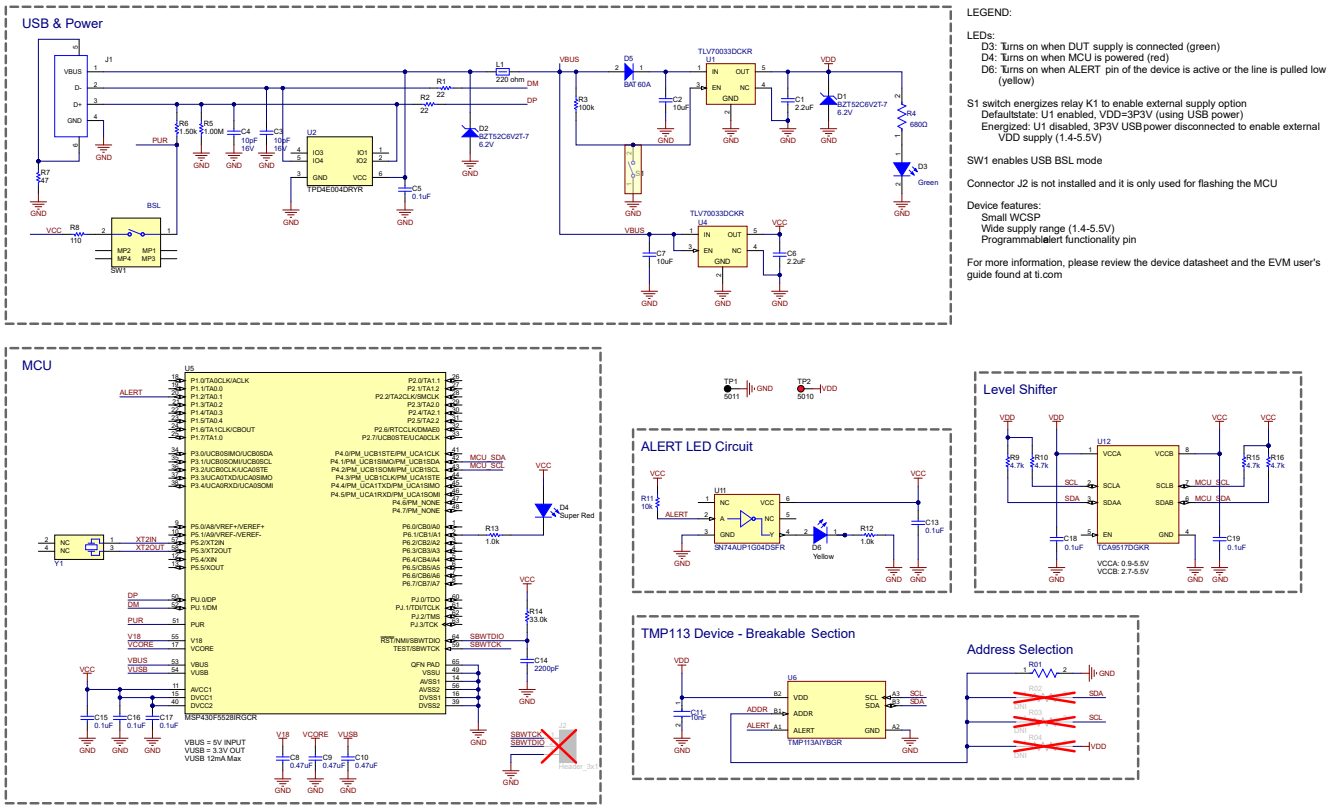


Figure 4-1. Schematic

4.2 PCB Layouts

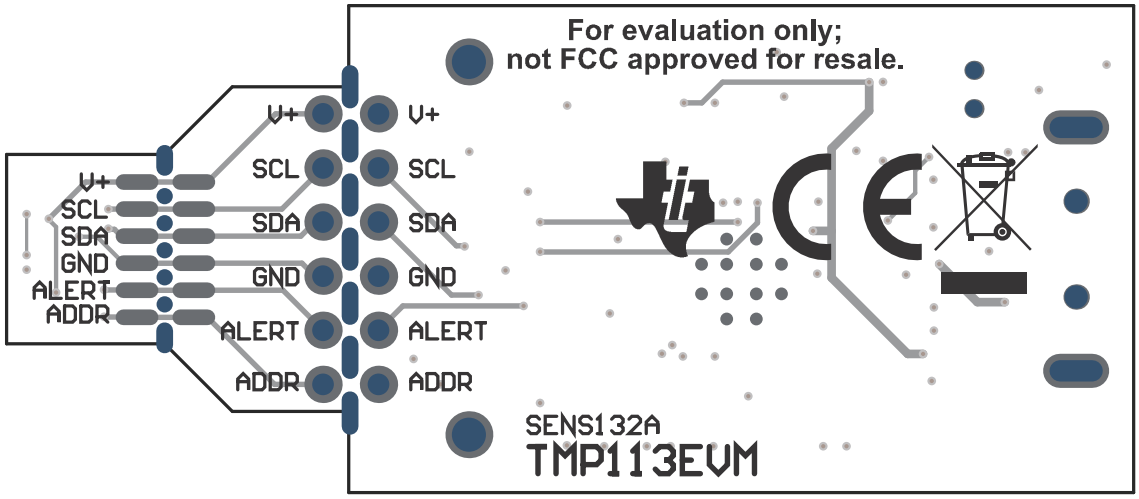


Figure 4-2. Top View

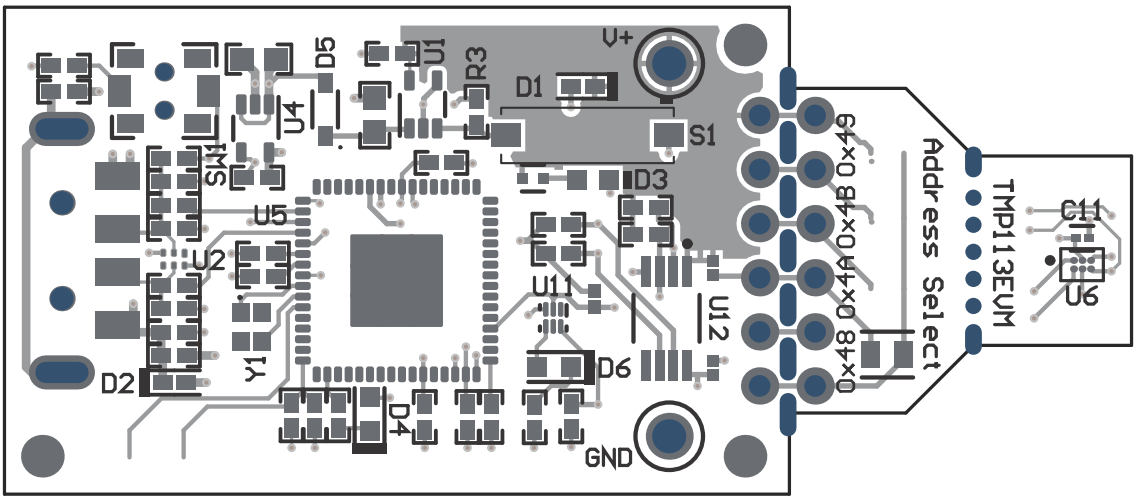


Figure 4-3. Bottom View

4.3 Bill of Materials

Table 4-1. Bill of Materials (BOM)

Description	Designator	PartNumber	Quantity	Manufacturer	PackageReference	Value
Printed Circuit Board	!PCB1	SENS132	1	Any		
CAP, CERM, 2.2 uF, 16 V, +/- 10%, X5R, 0402	C1, C6	GRM155R61C225KE11D	2	MuRata	0402	2.2µF
CAP, CERM, 10 uF, 10 V, +/- 20%, X5R, 0603	C2, C7	C1608X5R1A106M080AC	2	TDK	0603	10µF
CAP, CERM, 10 pF, 16 V,+/- 10%, C0G, 0402	C3, C4	C0402C100K4GACTU	2	Kemet	0402	10pF
CAP, CERM, 0.1 uF, 10 V,+/- 10%, X5R, 0402	C5, C13, C15, C16, C17	LMK105BJ104KV-F	5	Taiyo Yuden	0402	0.1µF
CAP, CERM, 0.47 uF, 6.3 V, +/- 10%, X7R, 0402	C8, C9, C10	JMK105B7474KVHF	3	Taiyo Yuden	0402	0.47µF
Chip Multilayer Ceramic Capacitors for General Purpose, 0201, 10000pF, X7R, 15%, 10%, 10V	C11	GRM033R71A103KA01D	1	MuRata	0201	10nF
CAP, CERM, 2200 pF, 50 V, +/- 5%, X7R, 0402	C14	CL05B222JB5NNNC	1	Samsung Electro-Mechanics	0402	2200pF
CAP, CERM, 0.1 uF, 10 V, +/- 10%, X5R, 0201	C18, C19	CL03A104KP3NNNC	2	Samsung Electro-Mechanics	0201	0.1µF
Diode, Zener, 6.2 V, 300 mW, SOD-523	D1, D2	BZT52C6V2T-7	2	Diodes Inc.	SOD-523	6.2V
LED, Green, SMD	D3	SML-LX0603GW-TR	1	Lumex	LED, GREEN, 0603	Green
LED, Super Red, SMD	D4	150060SS75000	1	Wurth Elektronik	LED_0603	Super Red
Silicon Schottky Diode, -55 to 85 degC, SOD323, Reel, Green	D5	BAT60A	1	Infineon	SOT323	
LED, Yellow, SMD	D6	150060YS75000	1	Wurth Elektronik	LED_0603	Yellow
Connector, Plug, USB Type A, R/A, Top Mount SMT	J1	48037-1000	1	Molex	USB Type A right angle	
Ferrite Bead, 220 ohm @ 100 MHz, 0.45 A, 0402	L1	BLM15AG221SN1D	1	MuRata	0402	220Ω
Thick Film Chip Resistors 0805 0Ω 0.125W 5%	R01	CR0805-J/-000ELF	1	Bourns	0805	0Ω
RES, 22, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	R1, R2	ERJ-2GEJ220X	2	Panasonic	0402	22Ω
RES, 100 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	R3	ERJ-2GEJ104X	1	Panasonic	0402	100kΩ

Table 4-1. Bill of Materials (BOM) (continued)

Description	Designator	PartNumber	Quantity	Manufacturer	PackageReference	Value
	R4	ERJ-2RKF6800X	1	Panasonic	0402	680Ω
RES, 1.00 M, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	R5	RMCF0402FT1M00	1	Stackpole Electronics Inc	0402	1.00MΩ
RES, 1.50 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	R6	RMCF0402FT1K50	1	Stackpole Electronics Inc	0402	1.50kΩ
RES, 47, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	R7	ERJ-2GEJ470X	1	Panasonic	0402	47Ω
RES, 110, 1%, 0.1 W, AEC-Q200 Grade 0, 0402	R8	ERJ-2RKF1100X	1	Panasonic	0402	110Ω
RES, 4.7 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	R9, R10, R15, R16	CRCW04024K70JNED	4	Vishay-Dale	0402	4.7kΩ
RES, 10 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	R11	RK73B1ETTP103J	1	KOA Speer	0402	10kΩ
RES, 1.0 k, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	R12, R13	ERJ-2GEJ102X	2	Panasonic	0402	1.0kΩ
RES, 33.0 k, 1%, 0.063 W, 0402	R14	RC0402FR-0733KL	1	Yageo America	0402	33.0kΩ
Switch, Slide, SPST, Top Slide, SMT	S1	CHS-01TB	1	Copal Electronics	Switch, Single Top Slide, 2.5x8x2.5mm	
Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	SW1	PTS820 J20M SMTR LFS	1	C&K Components	3.9x2.9mm	
Test Point, Black, Through Hole, RoHS, Bulk	TP1	5011	1	Keystone	Through-hole test point	
Test Point, Red, Through Hole, RoHS, Bulk	TP2	5010	1	Keystone	Through-hole test point	
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)	U1, U4	TLV70033DCKR	2	Texas Instruments	DCK0005A	
4-Channel ESD Protection Array for High-Speed Data Interfaces, DRY0006A (USON-6)	U2	TPD4E004DRYR	1	Texas Instruments	DRY0006A	

Table 4-1. Bill of Materials (BOM) (continued)

Description	Designator	PartNumber	Quantity	Manufacturer	PackageReference	Value
16-Bit Ultra-Low-Power Microcontroller, 128KB Flash, 8KB RAM, USB, 12Bit ADC, 2 USCIs, 32Bit HW MPY, RGC0064B (VQFN-64)	U5	MSP430F5528IRGCR	1	Texas Instruments	RGC0064B	
Ultra-Small, 1.4V to 5.5V Supply, ±0.75°C Accurate, I2C Digital Temperature Sensor	U6	TMP113AIYBGR	1	Texas Instruments	DSBGA6	
Low-Power Single Inverter Gate, DSF0006A, LARGE T&R	U11	SN74AUP1G04DSFR	1	Texas Instruments	DSF0006A	
IC TRNSLTR BIDIRECTIONAL 8VSSOP	U12	TCA9517DGKR	1	Texas Instruments	DGK0008A	
Crystal, 24 MHz, SMD	Y1	XRCGB24M000F2P00R0	1	MuRata	2x1.6mm	
Header, 2.54 mm, 3x1, Gold, TH	J2	GBC03SAAN	0	Sullins Connector Solutions	Header, 2.54 mm, 3x1, TH	
Thick Film Chip Resistors 0805 0Ω 0.125W 5%	R02, R03, R04	CR0805-J/-000ELF	0	Bourns	0805	0Ω

5 Additional Information

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