

EVM User's Guide: TMP4719

TMP4719 Evaluation Module



Description

The [TMP4719](#) is an I²C-compatible 3-channel (2-remote and 1-local) temperature sensor, available in VSSOP and WSON packages. The TMP4719EVM allows users to evaluate the performance of the TMP4719 digital temperature sensor. The TMP4719EVM 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

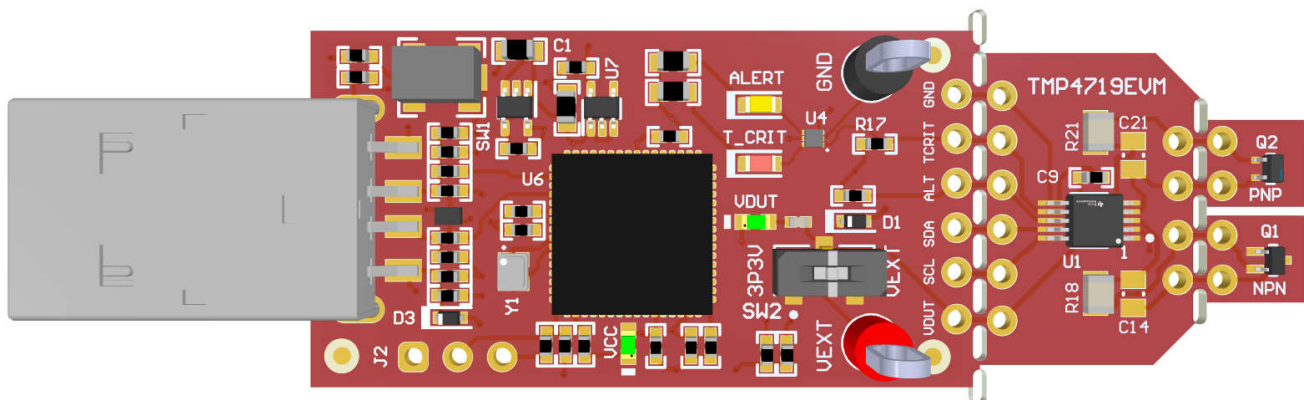
1. Order the [TMP4719EVM](#)
2. Detach the sensor breakout PCB section (optional)
3. Connect the EVM to computer or user system
4. Go to the [TMP4719EVM gallery page](#) on dev.ti.com to either download the GUI or run on the web
5. Refer to the [TMP4719 data sheet](#) for IC details
6. Visit our [E2E forums](#) for support or questions

Features

- Showcase the high-accuracy 3-channel digital temperature sensor with alert functionality
- Easy to use cloud-based GUI is available on the web or can be downloaded for offline use
- Breakable sensor board with 0.1in pitch header footprint to interface with the TMP4719
- Data logging with GUI

Applications

- [Standard notebook PC](#)
- [Rack server motherboard](#)
- [Smart network interface card \(NIC\)](#)
- [Small cell base station](#)
- [Baseband unit \(BBU\)](#)
- [Software-defined radio](#)



TMP4719EVM

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 TMP4719 device using an I²C 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 TMP4719 sensor breakout section to the user's system/host.
- The user can connect the EVM host and GUI software to the user's system with TMP4719 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 TMP4719EVM 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 TMP4719EVM. 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
TMP4719EVM	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
TMP4719 breakout section	Recommended operating free-air temperature, T _A	-40°C to 125°C

1.4 Device Information

The TMP4719 is a digital output temperature sensor with one local integrated sensor and two remote temperature sensor channels. This device communicates in a two-wire environment compatible with SMBus and I²C interfaces. The device can be set to make continuous or one-shot conversions, and additionally has alert functionalities using the ALERT and T_CRIT pins. The device is calibrated in production to achieve high accuracy, and is available in both VSSOP and WSON packages. The EVM includes a TMP4719DGSR (VSSOP) unit. 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 TMP4719 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	1.62V to 5.5V
Local Temperature accuracy ($T_A = -40^{\circ}\text{C}$ to 125°C)	$\pm 1^{\circ}\text{C}$
Remote Temperature accuracy ($T_D = -10^{\circ}\text{C}$ to 85°C , $T_A = -10^{\circ}\text{C}$ to 85°C)	$\pm 0.8^{\circ}\text{C}$
Remote Temperature accuracy ($T_D = -55^{\circ}\text{C}$ to 125°C , $T_A = -10^{\circ}\text{C}$ to 85°C)	$\pm 1.0^{\circ}\text{C}$
Temperature accuracy ($T_D = -55^{\circ}\text{C}$ to 125°C , $T_A = -40^{\circ}\text{C}$ to 125°C)	$\pm 1.5^{\circ}\text{C}$

2 Hardware

2.1 Overview

The EVM is divided into two 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 breakout section connected by soldered wires or connectors to evaluate the sensor far from the controller and PC at extreme temperatures or other conditions.
- Using the sensor breakout section with the user system by interfacing through I²C with the TMP4719.
- Using the controller section with TMP4719 sensors in the user's system.
- The right half of the sensor breakout section (containing the PNP and NPN transistors) can also be detached to instead connect the user's remote sensors, such as a different diode-connected transistor.

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.

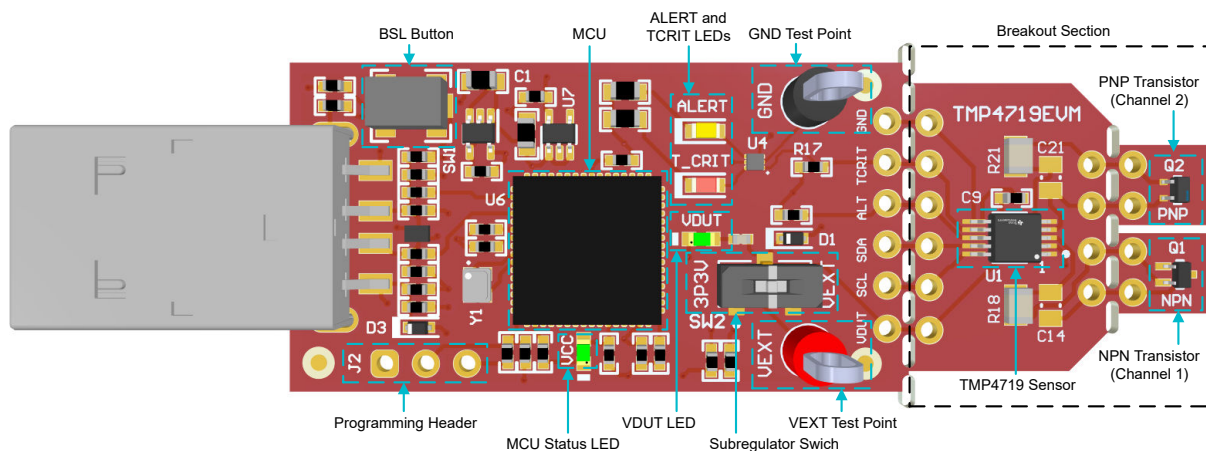


Figure 2-1. TMP4719EVM Board Sections

2.2 Perforations and Connectability

The perforation between the USB controller and TMP4719 sensor breakout section is labeled on the bottom of the board on both sides for pin connections. Once the sensor breakout section is detached from the controller section, the user can interface with the board sections by soldering wires or 0.1" header connectors. With this approach, the user has access to all 10 pins of the device.

The TMP4719 has built-in programmable digital filters to improve noise immunity. However, in especially noisy environments, a bypass capacitor can be placed differentially across the remote channel inputs to make the application more robust against unwanted coupled signals. The sensor breakout section includes 0805 footprints for the user to optionally install filter capacitors (C14 and C21 are default not installed). Additionally, some applications attain better overall accuracy with additional series resistance. The sensor breakout section includes 0805 footprints for the user to optionally install series resistors (R18 and R21 are default 0Ω). See the TMP4719 datasheet for specific recommendations on the filter capacitor and series resistor values.

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 VDUT is supplied. VDUT must be supplied for normal operation of the TMP4719EVM as VDUT is used for TMP4719 device power. VDUT can be supplied via the on-board sub-regulator U7 or external power. See [Section 2.4](#) for more details.

The yellow LED D4 illuminates when the ALERT pin is low. The red LED D5 illuminates when the T_CRIT pin is low. The default software configuration of the ALERT and T_CRIT pins are active-low, and the LEDs illuminate when the pins become active or "trip".

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 Power Supply

VDUT supplies power to the TMP4719 device, and must be set between 1.62V to 5.5V for normal operation of the TMP4719EVM. The mechanical switch SW2 is used to connect VDUT to the subregulator output (3P3V) or external supply (VEXT).

VDUT is default connected to the on-board subregulator U7, which regulates USB power down to 3.3V. When using an external supply voltage, the user can connect the external power supply using the VEXT and GND test points, or by soldering headers or wires on the breakout section. The green LED D2 lights up when VDUT is supplied properly.

2.5 Programming Header

The TMP4719EVM 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.

2.6 BSL Button

The TMP4719EVM 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 TMP4719EVM 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/tmp4719>

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.

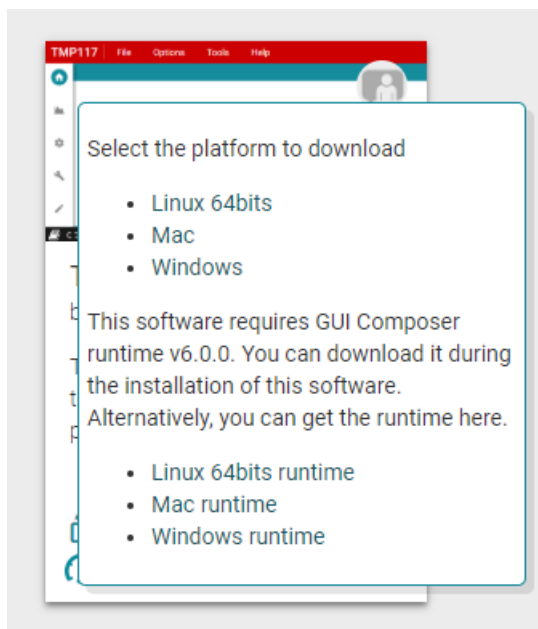


Figure 3-1. Download Pop-Up

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 further explained below. The icons on the left side of the screen are shortcuts to the tabs.

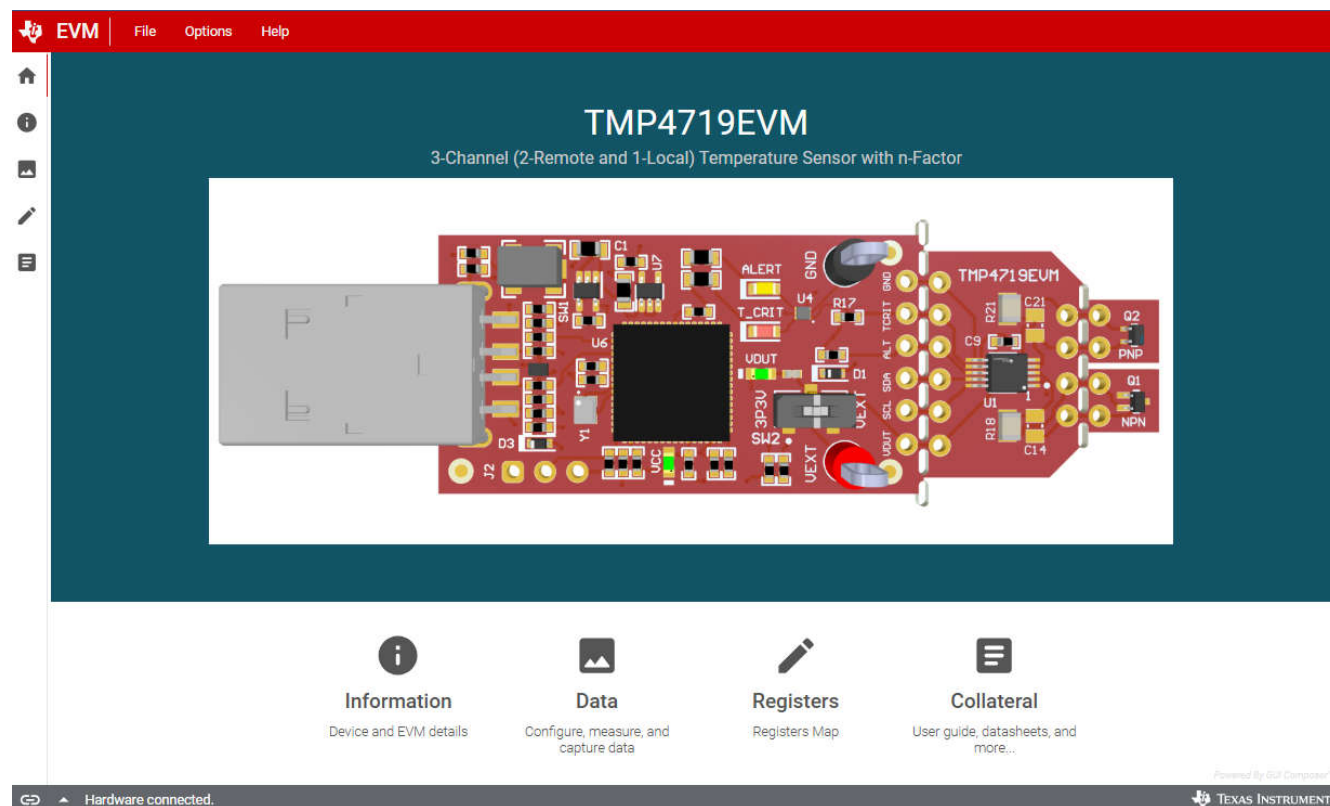
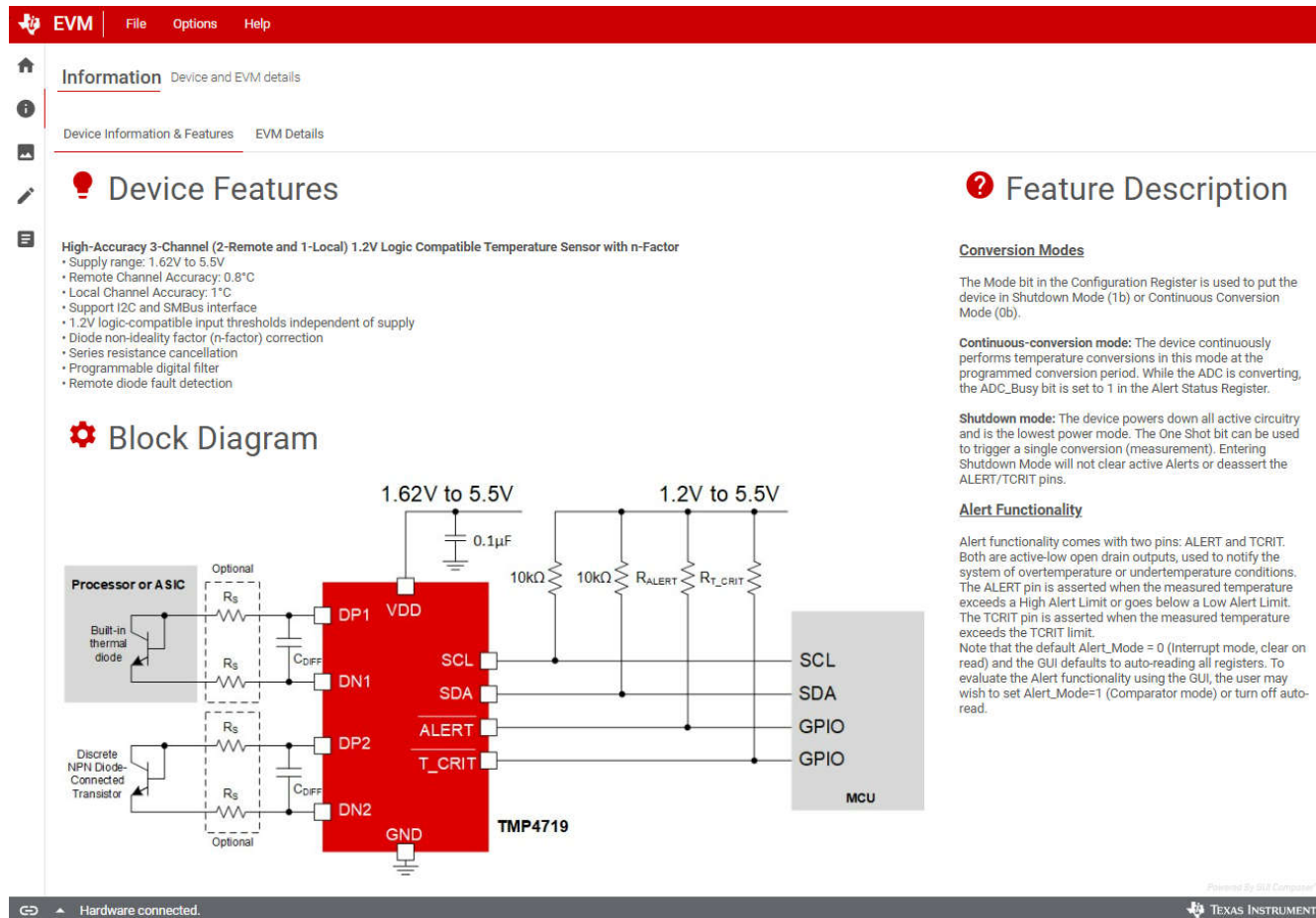


Figure 3-2. Home

3.3 Information Tab

The Information tab shows device details and features of the TMP4719 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.



Information Device and EVM details

Device Information & Features EVM Details

Device Features

High-Accuracy 3-Channel (2-Remote and 1-Local) 1.2V Logic Compatible Temperature Sensor with n-Factor

- Supply range: 1.62V to 5.5V
- Remote Channel Accuracy: 0.8°C
- Local Channel Accuracy: 1°C
- Support I2C and SMBus interface
- 1.2V logic-compatible input thresholds independent of supply
- Diode non-ideality factor (n-factor) correction
- Series resistance cancellation
- Programmable digital filter
- Remote diode fault detection

Block Diagram

The block diagram shows the TMP4719 chip connected to a Processor or ASIC and an MCU. The chip has pins DP1, DN1, DP2, DN2, SCL, SDA, ALERT, and T_CRIT. It is powered by a 1.62V to 5.5V supply with a 0.1µF capacitor. The MCU is connected to the SCL, SDA, and GPIO pins. The chip also has a built-in thermal diode and a discrete NPN diode connected transistor.

Feature Description

Conversion Modes

The Mode bit in the Configuration Register is used to put the device in Shutdown Mode (1b) or Continuous Conversion Mode (0b).

Continuous-conversion mode: The device continuously performs temperature conversions in this mode at the programmed conversion period. While the ADC is converting, the ADC_Busy bit is set to 1 in the Alert Status Register.

Shutdown mode: The device powers down all active circuitry and is the lowest power mode. The One Shot bit can be used to trigger a single conversion (measurement). Entering Shutdown Mode will not clear active Alerts or deassert the ALERT/TCRIT pins.

Alert Functionality

Alert functionality comes with two pins: ALERT and TCRIT. Both are active-low open drain outputs, used to notify the system of overtemperature or undertemperature conditions. The ALERT pin is asserted when the measured temperature exceeds a High Alert Limit or goes below a Low Alert Limit. The TCRIT pin is asserted when the measured temperature exceeds the TCRIT limit.

Note that the default Alert_Mode = 0 (Interrupt mode, clear on read) and the GUI defaults to auto-reading all registers. To evaluate the Alert functionality using the GUI, the user may wish to set Alert_Mode=1 (Comparator mode) or turn off auto-read.

Figure 3-3. Information

3.4 Data Tab

The Data Capture tab reports the temperature from the TMP4719 device included on the TMP4719EVM. 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 values. There is also a Data 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 TMP4719 at the set polling rate.
- Write the TMP4719 Conversion Period setting using the Device Rate field. Once a value is selected from the dropdown, the MCU automatically writes to the TMP4719, which then starts converting at the programmed rate.
- Start and stop logging 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 Limit Settings box allows the user to easily configure the Alert and TCRIT limits for the local sensor and remote sensors. The limits can be written in decimal format, and the corresponding hexadecimal value is automatically displayed to the right for reference. Once selected or updated, all of the settings are written automatically to the TMP4719 by the MCU.

There are also buttons to easily trigger a General Call Reset or a One Shot temperature measurement. Note that to trigger a One Shot, the device must be in Shutdown mode. Set the appropriate device mode by writing to the CONFIG register (Mode[6] bit).

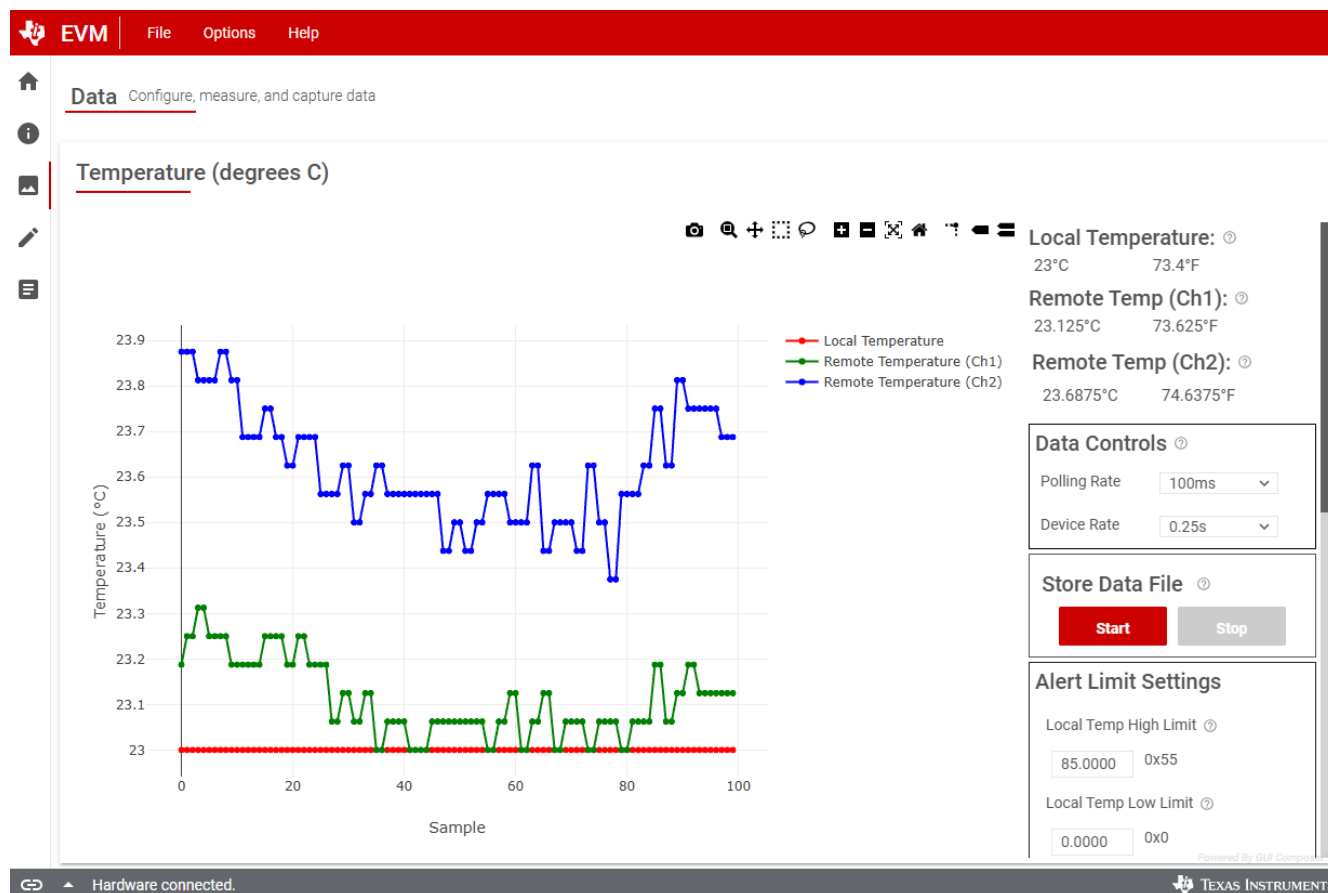


Figure 3-4. Data Capture

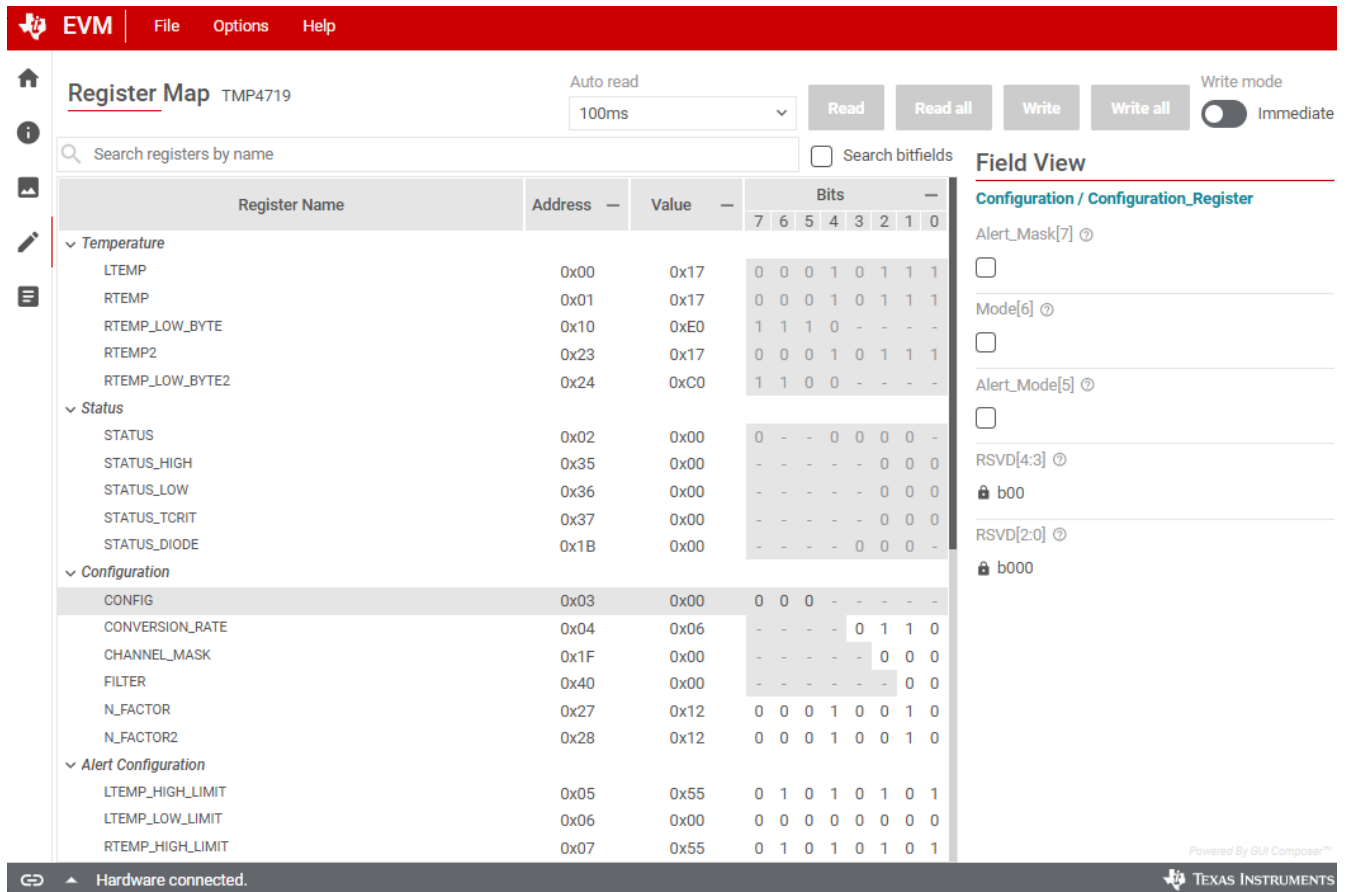
3.5 Registers Tab

The Registers tab interacts with the registers and bits within the TMP4719 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 I²C Bus activity, and enable individual transactions to be easily observed with an oscilloscope, logic analyzer, or bus-sniffing device.



EVM | File Options Help

Register Map TMP4719

Auto read: 100ms [v] [Read] [Read all] [Write] [Write all] Write mode: [Immediate]

Search registers by name [] Search bitfields []

Register Name	Address	Value	Bits
			7 6 5 4 3 2 1 0
Temperature			
LTEMP	0x00	0x17	0 0 0 1 0 1 1 1
RTEMP	0x01	0x17	0 0 0 1 0 1 1 1
RTEMP_LOW_BYTE	0x10	0xE0	1 1 1 0 - - - -
RTEMP2	0x23	0x17	0 0 0 1 0 1 1 1
RTEMP_LOW_BYTE2	0x24	0xC0	1 1 0 0 - - - -
Status			
STATUS	0x02	0x00	0 - - 0 0 0 0 -
STATUS_HIGH	0x35	0x00	- - - - 0 0 0 0
STATUS_LOW	0x36	0x00	- - - - 0 0 0 0
STATUS_TCRIT	0x37	0x00	- - - - 0 0 0 0
STATUS_DIODE	0x1B	0x00	- - - - 0 0 0 -
Configuration			
CONFIG	0x03	0x00	0 0 0 - - - - -
CONVERSION_RATE	0x04	0x06	- - - - 0 1 1 0
CHANNEL_MASK	0x1F	0x00	- - - - - 0 0 0
FILTER	0x40	0x00	- - - - - 0 0
N_FACTOR	0x27	0x12	0 0 0 1 0 0 1 0
N_FACTOR2	0x28	0x12	0 0 0 1 0 0 1 0
Alert Configuration			
LTEMP_HIGH_LIMIT	0x05	0x55	0 1 0 1 0 1 0 1
LTEMP_LOW_LIMIT	0x06	0x00	0 0 0 0 0 0 0 0
RTEMP_HIGH_LIMIT	0x07	0x55	0 1 0 1 0 1 0 1

Field View

Configuration / Configuration_Register

Alert_Mask[7] ☐

Mode[6] ☐

Alert_Mode[5] ☐

RSVD[4:3] ☐

b00

RSVD[2:0] ☐

b000

Hardware connected.

Powered By GUI Composer™

TEXAS INSTRUMENTS

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.

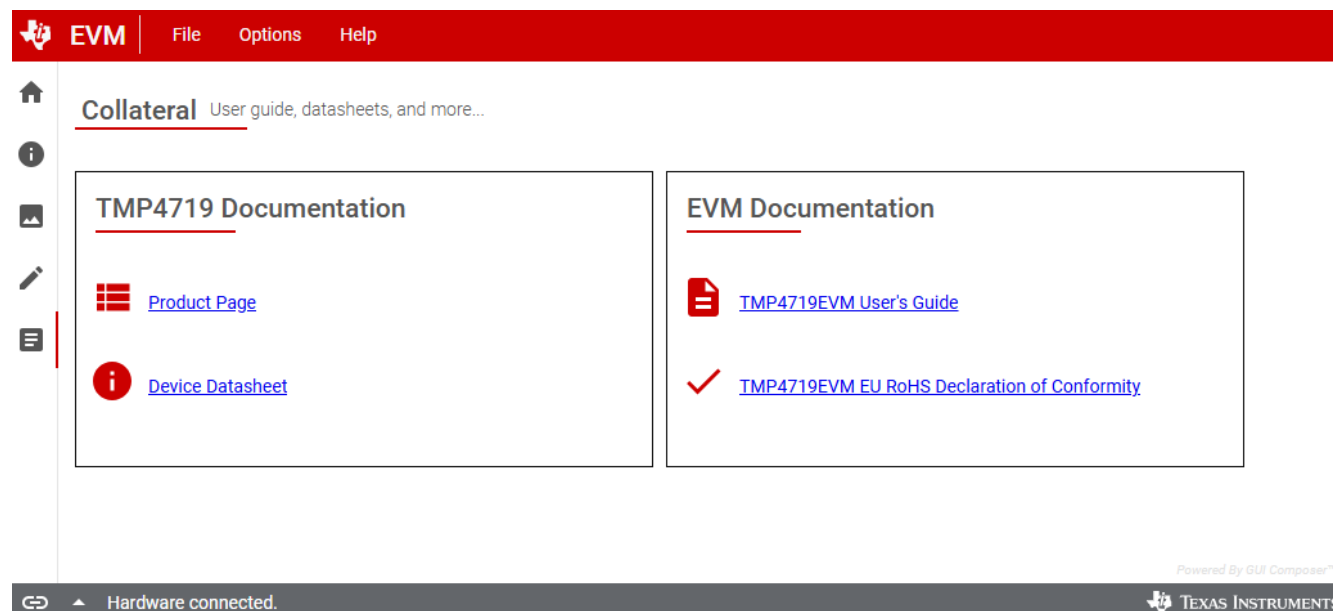


Figure 3-6. Collateral

4 Hardware Design Files

4.1 Schematic

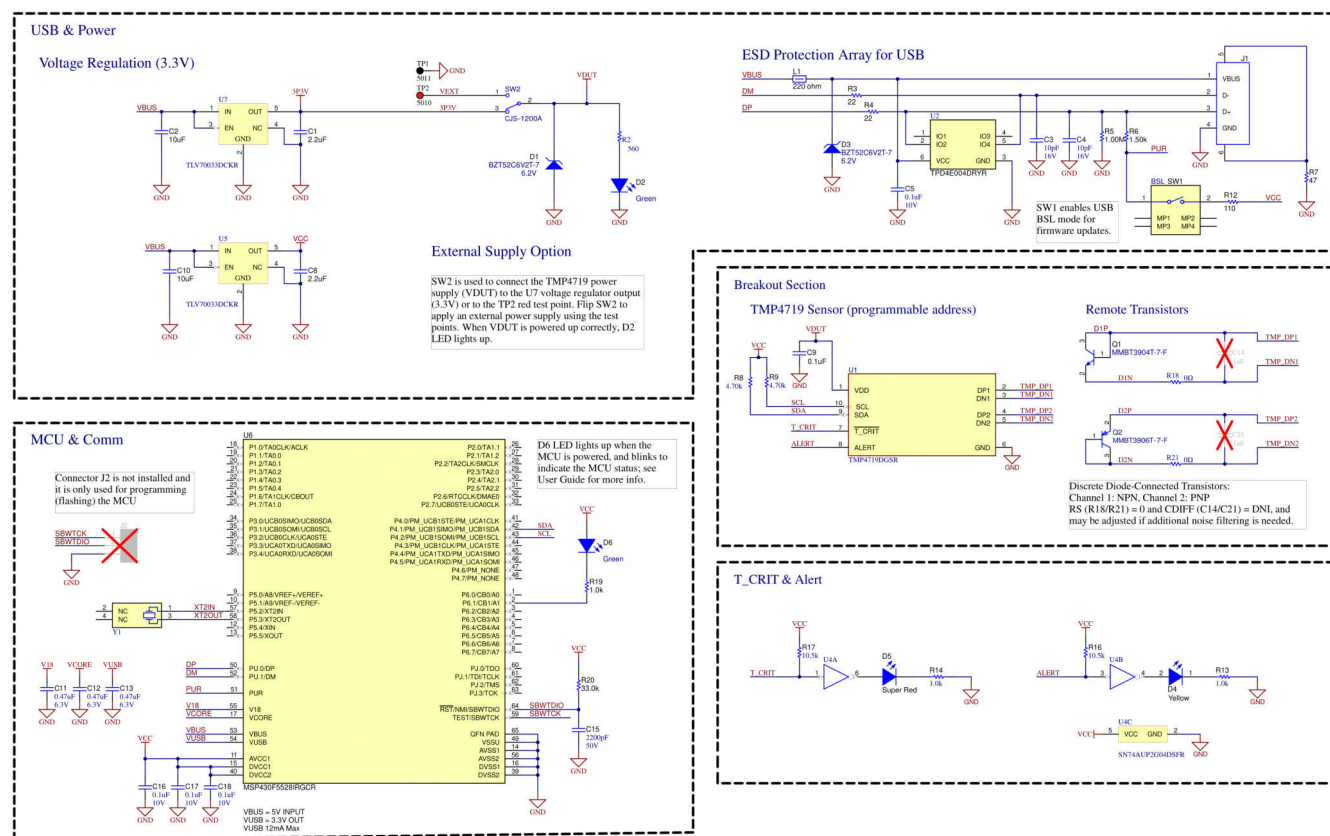


Figure 4-1. Schematic

4.2 PCB Layouts

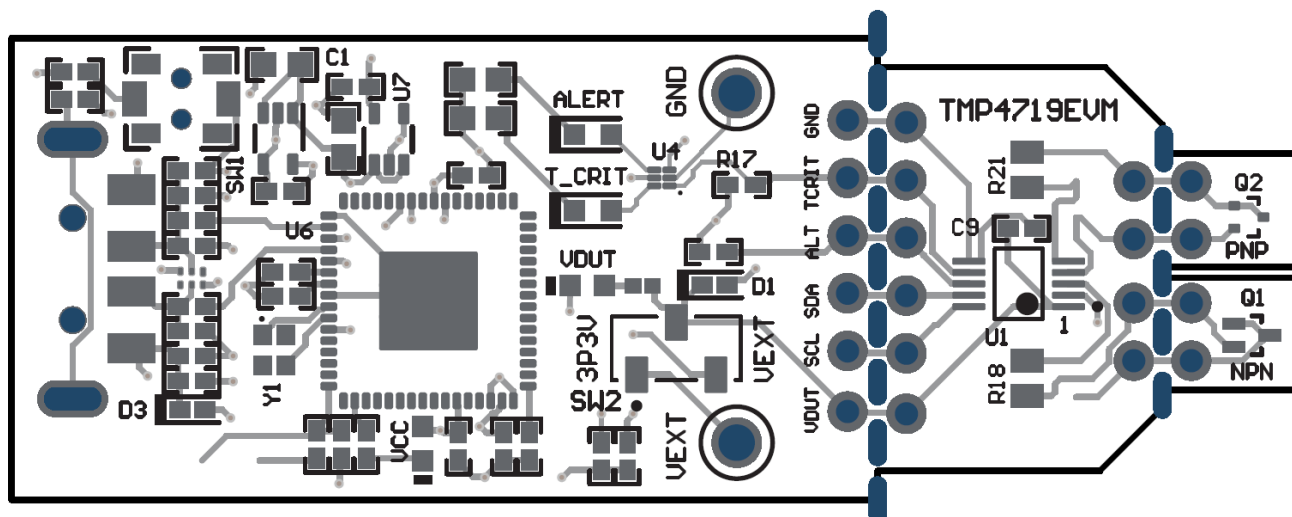


Figure 4-2. Top View

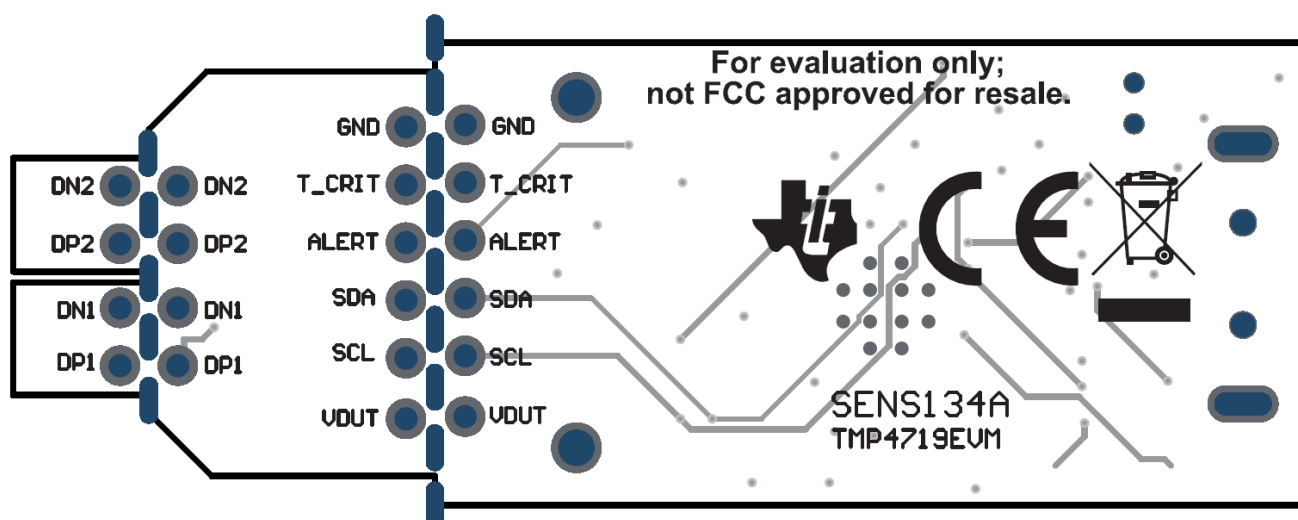


Figure 4-3. Bottom View

4.3 Bill of Materials

DESCRIPTION	DESIGNATOR	PARTNUMBER	QUANTITY	MANUFACTURE R	PACKAGE REFERENCE	VALUE
Printed Circuit Board	!PCB1	SENS134	1	Any		
CAP, CERM, 2.2uF, 16V, +/- 10%, X5R, 0402	C1, C8	GRM155R61C225KE11D	2	MuRata	0402	2.2uF
CAP, CERM, 10uF, 10V, +/- 20%, X5R, 0603	C2, C10	C1608X5R1A106M080AC	2	TDK	0603	10uF
CAP, CERM, 10pF, 16V, +/- 10%, C0G, 0402	C3, C4	C0402C100K4GACTU	2	Kemet	0402	10pF
CAP, CERM, 0.1uF, 10V, +/- 10%, X5R, 0402	C5, C16, C17, C18	LMK105BJ104KV-F	4	Taiyo Yuden	0402	0.1uF
CAP, CERM, 0.1uF, 16V, +/- 10%, X7R, 0402	C9	ATC530L104KT16T	1	AT Ceramics	0402	0.1uF
CAP, CERM, 0.47uF, 6.3V, +/- 10%, X7R, 0402	C11, C12, C13	JMK105B7474KVHF	3	Taiyo Yuden	0402	0.47uF
CAP, CERM, 2200pF, 50V, +/- 5%, X7R, 0402	C15	CL05B222JB5NNC	1	Samsung Electro-Mechanics	0402	2200pF
Diode, Zener, 6.2V, 300 mW, SOD-523	D1, D3	BZT52C6V2T-7	2	Diodes Inc.	SOD-523	6.2V
LED, Green, SMD	D2, D6	SML-LX0603GW-TR	2	Lumex	LED, GREEN, 0603	Green
LED, Yellow, SMD	D4	150060YS75000	1	Würth Elektronik	LED_0603	Yellow
LED, Super Red, SMD	D5	150060SS75000	1	Würth Elektronik	LED_0603	Super Red
Connector, Plug, USB Type A, R/A, Top Mount SMT	J1	48037-1000	1	Molex	USB Type A right angle	
Ferrite Bead, 220ohm @ 100MHz, 0.45A, 0402	L1	BLM15AG221SN1D	1	MuRata	0402	220ohm
Transistor, NPN, 40V, 0.2A, SOT-523	Q1	MMBT3904T-7F	1	Diodes Inc.	SOT-523	40V
Bipolar (BJT) Transistor PNP 40V 200mA 250MHz 150 mW Surface Mount SOT-523	Q2	MMBT3906T-7F	1	Diodes	SOT523	-40V
RES, 560ohm, 0402	R2	RC0402JR-07560RL	1	Yageo / Phycomp	0402	560ohm
RES, 22, 5%, 0.1W, AEC-Q200 Grade 0, 0402	R3, R4	ERJ-2GEJ220X	2	Panasonic	0402	22
RES, 1.00M, 1%, 0.063W, AEC-Q200 Grade 0, 0402	R5	RMCF0402FT1M00	1	Stackpole Electronics Inc	0402	1.00Meg
RES, 1.50k, 1%, 0.063W, AEC-Q200 Grade 0, 0402	R6	RMCF0402FT1K50	1	Stackpole Electronics Inc	0402	1.50k
RES, 47, 5%, 0.1W, AEC-Q200 Grade 0, 0402	R7	ERJ-2GEJ470X	1	Panasonic	0402	47
RES, 4.70k, 1%, 0.1W, 0402	R8, R9	ERJ-2RKF4701X	2	Panasonic	0402	4.70k

DESCRIPTION	DESIGNATOR	PARTNUMBER	QUANTITY	MANUFACTURE R	PACKAGE REFERENCE	VALUE
RES, 110, 1%, 0.1W, AEC-Q200 Grade 0, 0402	R12	ERJ-2RKF1100X	1	Panasonic	0402	110
RES, 1.0k, 5%, 0.1W, 0603	R13, R14	RC0603JR-071K L	2	Yageo	0603	1.0k
RES, 10.5k, 1%, 0.063W, 0402	R16, R17	RC0402FR-0710 K5L	2	Yageo America	0402	10.5k
Chip Resistor, 0 Ohm, 0.125W, -55 to 125 degC, 0805 (2012 Metric), RoHS, Tape and Reel	R18, R21	CRG0805ZR	2	TE Connectivity	0805	0ohm
RES, 1.0k, 5%, 0.1W, AEC-Q200 Grade 0, 0402	R19	ERJ-2GEJ102X	1	Panasonic	0402	1.0k
RES, 33.0k, 1%, 0.063W, 0402	R20	RC0402FR-0733 KL	1	Yageo America	0402	33.0k
Switch, SPST-NO, Off-Mom, 0.05A, 12VDC, SMD	SW1	PTS820J20M SMTR LFS	1	C&K Components	3.9x2.9mm	
Slide Switch, 2 Positions, SPDT, Latched, 0.1A, 6VDC, Solder Terminal, Surface Mount-straight	SW2	CJS-1200A	1	Nidec Copal	SMT_SW_5MM4 _2MM5	
Test Point, Black, Through Hole, RoHS, Bulk	TP1	5011	1	Keystone	5011	
Test Point, Red, Through Hole, RoHS, Bulk	TP2	5010	1	Keystone	5010	
High-Accuracy 3-Channel (2-Remote and 1-Local) 1.2V Logic Compatible Temperature Sensor with Series-R, η -Factor, and Automatic Beta Compensation	U1	TMP4719DGSR	1	Texas Instruments	VSSOP10	
4-Channel ESD Protection Array for High-Speed Data Interfaces, DRY0006A (USON-6)	U2	TPD4E004DRYR	1	Texas Instruments	DRY0006A	
Low-Power Dual Inverter Gate, DSF0006A, LARGE T&R	U4	SN74AUP2G04D SFR	1	Texas Instruments	DSF0006A	
Single Output LDO, 200mA, Fixed 3.3V Output, 2 to 5.5V Input, with Low IQ, 5-pin SC70 (DCK), -40 to 125 degC, Green (RoHS & no Sb/Br)	U5, U7	TLV70033DCKR	2	Texas Instruments	DCK0005A	
16-Bit Ultra-Low-Power Microcontroller, 128KB Flash, 8KB RAM, USB, 12Bit ADC, 2 USCIs, 32Bit HW MPY, RGC0064B (VQFN-64)	U6	MSP430F5528IR GCR	1	Texas Instruments	RGC0064B	
Crystal, 24MHz, SMD	Y1	XRCGB24M000F 2P00R0	1	MuRata	2x1.6mm	
CAP 1nF 50V $\pm$ 5% 0805 (2012 Metric) Thickness 1.45mm SMD	C14, C21	CC0805JRX7R9 BB102	0	Yageo	0805	1nF
Header, 100mil, 3x1, Gold, TH	J2	TSW-103-07G-S	0	Samtec	3x1 Header	

5 Additional Information

5.1 Trademarks

Windows® is a registered trademark of Microsoft Corporation.

Mac® is a registered trademark of Apple Inc.

Linux® is a registered trademark of Linus Torvalds.

All trademarks are the property of their respective owners.

STANDARD TERMS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, and/or documentation which may be provided together or separately (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms set forth herein. User's acceptance of the EVM is expressly subject to the following terms.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms that accompany such Software
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for a nonconforming EVM if (a) the nonconformity was caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI, (b) the nonconformity resulted from User's design, specifications or instructions for such EVMs or improper system design, or (c) User has not paid on time. Testing and other quality control techniques are used to the extent TI deems necessary. TI does not test all parameters of each EVM. User's claims against TI under this Section 2 are void if User fails to notify TI of any apparent defects in the EVMs within ten (10) business days after delivery, or of any hidden defects with ten (10) business days after the defect has been detected.
 - 2.3 TI's sole liability shall be at its option to repair or replace EVMs that fail to conform to the warranty set forth above, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

WARNING

Evaluation Kits are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems.

User shall operate the Evaluation Kit within TI's recommended guidelines and any applicable legal or environmental requirements as well as reasonable and customary safeguards. Failure to set up and/or operate the Evaluation Kit within TI's recommended guidelines may result in personal injury or death or property damage. Proper set up entails following TI's instructions for electrical ratings of interface circuits such as input, output and electrical loads.

NOTE:

EXPOSURE TO ELECTROSTATIC DISCHARGE (ESD) MAY CAUSE DEGRADATION OR FAILURE OF THE EVALUATION KIT; TI RECOMMENDS STORAGE OF THE EVALUATION KIT IN A PROTECTIVE ESD BAG.

3 Regulatory Notices:

3.1 United States

3.1.1 Notice applicable to EVMs not FCC-Approved:

FCC NOTICE: This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

3.1.2 For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:

CAUTION

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.

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

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

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:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSSs. 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.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。

<https://www.ti.com/ja-jp/legal/notice-for-evaluation-kits-delivered-in-japan.html>

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan may not be certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

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3.3.3 *Notice for EVMs for Power Line Communication:* Please see http://www.tij.co.jp/sds/ti_ja/general/eStore/notice_02.page

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3.4 European Union

3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive):*

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*

6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY MATERIALS PROVIDED WITH THE EVM (INCLUDING, BUT NOT LIMITED TO, REFERENCE DESIGNS AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY EPIDEMIC FAILURE WARRANTY OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.

6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT, REGARDLESS OF WHEN MADE, CONCEIVED OR ACQUIRED.

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8. *Limitations on Damages and Liability:*

8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS OR THE USE OF THE EVMS , REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN TWELVE (12) MONTHS AFTER THE EVENT THAT GAVE RISE TO THE CAUSE OF ACTION HAS OCCURRED.

8.2 *Specific Limitations.* IN NO EVENT SHALL TI'S AGGREGATE LIABILITY FROM ANY USE OF AN EVM PROVIDED HEREUNDER, INCLUDING FROM ANY WARRANTY, INDEMNITY OR OTHER OBLIGATION ARISING OUT OF OR IN CONNECTION WITH THESE TERMS, , EXCEED THE TOTAL AMOUNT PAID TO TI BY USER FOR THE PARTICULAR EVM(S) AT ISSUE DURING THE PRIOR TWELVE (12) MONTHS WITH RESPECT TO WHICH LOSSES OR DAMAGES ARE CLAIMED. THE EXISTENCE OF MORE THAN ONE CLAIM SHALL NOT ENLARGE OR EXTEND THIS LIMIT.

9. *Return Policy.* Except as otherwise provided, TI does not offer any refunds, returns, or exchanges. Furthermore, no return of EVM(s) will be accepted if the package has been opened and no return of the EVM(s) will be accepted if they are damaged or otherwise not in a resalable condition. If User feels it has been incorrectly charged for the EVM(s) it ordered or that delivery violates the applicable order, User should contact TI. All refunds will be made in full within thirty (30) working days from the return of the components(s), excluding any postage or packaging costs.
10. *Governing Law:* These terms and conditions shall be governed by and interpreted in accordance with the laws of the State of Texas, without reference to conflict-of-laws principles. User agrees that non-exclusive jurisdiction for any dispute arising out of or relating to these terms and conditions lies within courts located in the State of Texas and consents to venue in Dallas County, Texas. Notwithstanding the foregoing, any judgment may be enforced in any United States or foreign court, and TI may seek injunctive relief in any United States or foreign court.

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