

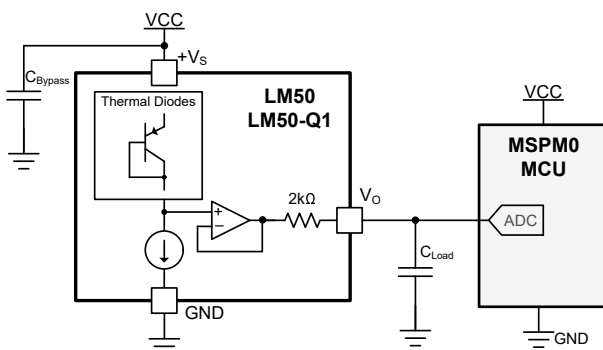
LM50-Q1 Automotive (Grade 1), $\pm 3^{\circ}\text{C}$ Accurate, Analog Centigrade ($10\text{mV}/^{\circ}\text{C}$) Temperature Sensor in SOT-23 Package

1 Features

- AEC-Q100 Qualified for automotive applications
 - LM50-Q1 (Grade-1): -40°C to $+125^{\circ}\text{C}$ operating temperature
 - Device HBM ESD classification level 2
- **Functional safety-capable**
 - [Documentation available to aid functional safety system design](#)
- Industry-Standard Sensor Gain/Offset:
 - $10\text{mV}/^{\circ}\text{C}$, 500mV at 0°C
- LM50-Q1 Temperature Accuracy:
 - $\pm 3^{\circ}\text{C}$ (Max) at 25°C
 - $\pm 4^{\circ}\text{C}$ (Max) over -40°C to 125°C
- Operating supply range: 4.5V to 10V
- Quiescent Current (Typ): $95\mu\text{A}$
- Available in Standard SOT23-3 package
- Nonlinearity: $\pm 0.8^{\circ}\text{C}$ (Max)
- DC Output Impedance: $2\text{k}\Omega/4\text{k}\Omega$ (typ/Max)
 - Enables driving large capacitive loads
- **UL Recognized Component**

2 Applications

- [Automotive](#)
- [HEV/EV OBC & DC/DC converter](#)
- [Electronic power steering \(EPS\)](#)
- [Head unit & digital cockpit](#)
- [Braking systems](#)
- [In-cabin sensing](#)
- [HVAC System](#)
- [Power Supply Modules](#)



Simplified Schematic

3 Description

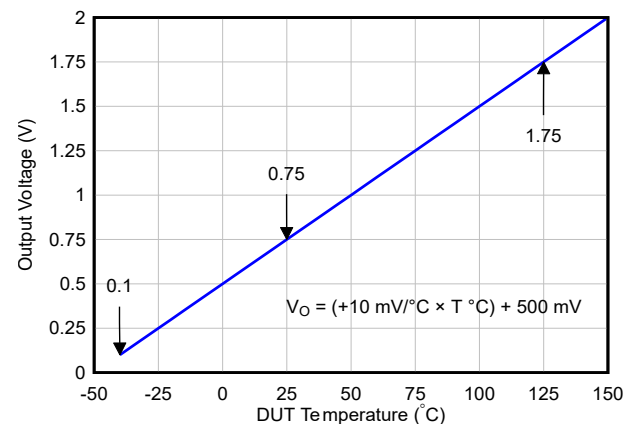
The LM50-Q1 device is an automotive-grade analog temperature sensor (AEC-Q100 Grade 1 qualified) that can measure temperatures from -40°C to 125°C using a single positive supply. The output voltage of the device is linearly proportional to temperature ($10\text{mV}/^{\circ}\text{C}$) and has a DC offset of 500mV at 0°C . The offset allows reading negative temperatures without the need for a negative supply. The output voltage of the LM50-Q1 ranges from 100mV (at -40°C) to 1.75V (at 125°C), simplifying automotive ADC interfacing (including ADC integrated in MCU).

Unlike NTC thermistors, LM50-Q1 does not require any external calibration, trimming or software linearization leading to simplifying the circuitry requirements in a single supply environment. Due to low quiescent current of LM50-Q1 (typically around $95\mu\text{A}$), self-heating is limited to a very low 0.2°C (in still air) and the device is ideal for automotive applications such as ECUs. Trimming and calibration of LM50-Q1 at the wafer level verify low cost and consistent accuracy: ($\pm 3^{\circ}\text{C}$ at 25°C , $\pm 4^{\circ}\text{C}$ across -40°C to 125°C). [Functional safety](#) documentation is also available for systems requiring enhanced reliability.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾
LM50-Q1	DBZ (SOT-23, 3)	2.37mm × 2.92mm

- (1) For more information, see [Section 11](#).
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.



Full-Range Centigrade Temperature Sensor (-40°C to 125°C)



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4 Device Comparison

Table 4-1. Device Comparison

Feature	LM50-Q1 ⁽¹⁾	TMP235-Q1	TMP236-Q1	LM60-Q1 ⁽¹⁾	LMT86-Q1	LMT87-Q1	LM94022-Q1
Sensor gain (mV/°C)	10	10	19.5	6.25	-10.9	-13.6	-5.5/-8.2 -10.9/-13.6
Sensor gain type	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Pin-Set
Offset (at 0°C) (mV)	500	500	400	424	2103	2637	1.035/1.57 2.103/2.637
Temp Range (°C)	-40 to 125	-40 to 150	-10 to 125	-40 to 125	-50 to 150	-50 to 150	-50 to 150
Power Supply Specifications							
V _{DD} (V)	4.5 to 10	2.3 to 5.5	3.1 to 5.5	2.7 to 10	2.2 to 5.5	2.7 to 5.5	1.5/1.8/ 2.2/2.7 to 5.5
I _Q (typ) (µA)	95	9	10	82	5.4	5.4	5.4
Automotive Specifications							
Automotive Grade	Grade-1	Grade-0	Grade-1	Grade-1	Grade-0	Grade-0	Grade-0
Functional Safety Capable	Yes	Yes	Yes	Yes	Yes	Yes	No
Temperature Accuracy							
25°C (typ)	-	±0.5	±0.5	-	±0.3	±0.3	-
-50°C (max)	-	-	-	-	±2.7	±2.7	±1.8
-40°C (max)	±4	±2.5	-	±4	±2.7	±2.7	±1.8
-25°C (max)	±3.8	±2.5	-	±3.8	±2.7	±2.7	±1.8
-10°C (max)	±3.5	±2.5	±2.5	±3.5	±2.7	±2.7	±1.8
0°C (max)	±3.4	-1.5/1.2	±2.5	±3.4	±2.7	±2.7	±1.8
20°C (max)	±3.1	-1.5/1.2	±2.5	±3.1	±2.7	±2.7	±1.5
25°C (max)	±3	-1.5/1.2	±2.5	±3	±2.7	±2.7	±1.5
40°C (max)	±3.15	-1.5/1.2	±2.5	±3.15	±2.7	±2.7	±1.5
70°C (max)	±3.45	-1.5/1.2	±2.5	±3.45	±2.7	±2.7	±1.8
85°C (max)	±3.6	±2.5	±2.5	±3.6	±2.7	±2.7	±2.1
90°C (max)	±3.65	±2.5	±2.5	±3.65	±2.7	±2.7	±2.1
120°C (max)	±3.95	±2.5	±2.5	±3.95	±2.7	±2.7	±2.4
125°C (max)	±4	±2.5	±2.5	±4	±2.7	±2.7	±2.7
150°C (max)	-	±2.5	-	-	±2.7	±2.7	±2.7
Packaging Dimension							
Dimensions [mm × mm × mm]	SOT23 (3-pin) 2.9 × 2.4 × 1.1	SOT23 (3-pin) 2.9 × 2.4 × 1.1 SC70 (5-pin) 2.0 × 2.1 × 1.1	SOT23 (3-pin) 2.9 × 2.4 × 1.1	SOT23 (3-pin) 2.9 × 2.4 × 1.1	SC70 (5-pin) 2.0 × 2.1 × 1.1	SC70 (5-pin) 2.0 × 2.1 × 1.1	SC70 (5-pin) 2.0 × 2.1 × 1.1

1. LM50-Q1 and LM60-Q1 temperature accuracy limits come from the "Accuracy vs Temperature" plot.

Table 4-2. LM50/LM50-Q1 Device Orderable Options

ORDER NUMBER	PACKAGE	ACCURACY OVER TEMPERATURE	SPECIFIED TEMPERATURE RANGE
LM50BIM3	SOT-23 (DBZ) 3-pin	±3°C	-25°C ≤ T _A ≤ +100°C
LM50BIM3X/NOPB ⁽¹⁾			-25°C ≤ T _A ≤ +100°C (Legacy chip)
			-40°C ≤ T _A ≤ +125°C (New chip)
LM50CIM3		±4°C	-40°C ≤ T _A ≤ +125°C
LM50CIM3X			
LM50CIM3X/NOPB		±4°C	-40°C ≤ T _A ≤ +125°C (Both legacy & new chip)
LM50QIM3X/NOPB	-40°C ≤ T _A ≤ +125°C (Both legacy & new chip)		

- LM50BIM3X/NOPB (Legacy chip) operates from -25°C to 100°C while LM50BIM3X/NOPB (New chip) operates from -40°C to 125°C.

Table 4-3. LM50/LM50-Q1 Device Nomenclature Detail

PRODUCT	DESCRIPTION
LM50xlyyy	<p>x indicates that the device has B, C or Q (grade-1 device in accordance with the AEC-Q100 standard) variant. These devices can ship with the legacy chip (CSO: GF6 or SHE) or the new chip (CSO: RFB) with different <i>chip source origin</i> (CSO). The reel packaging label provides date code information to distinguish which chip is being used. Device performance for new and legacy chips is denoted throughout the document.</p> <p>yyy indicates that the package type of the device which can be M3, M3X and M3X/NOPB all in SOT-23 3-pin package.</p>

5 Pin Configuration and Functions

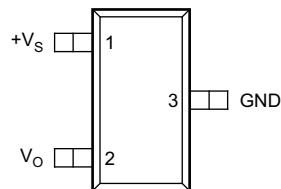


Figure 5-1. DBZ Package 3-Pin SOT-23 Top View

Table 5-1. Pin Functions

PIN		TYPE	DESCRIPTION
NO.	NAME		
1	+V _S	Power	Positive power supply pin.
2	V _O	Output	Temperature sensor analog output.
3	GND	Ground	Device ground pin, connected to power supply negative terminal.

6 Specifications

6.1 Absolute Maximum Ratings

Over operating free-air temperature range unless otherwise noted⁽¹⁾

		MIN	MAX	UNIT
Supply voltage, +V _S	LM50-Q1	-0.2	12	V
Output voltage, V _O		-1	+V _S + 0.6	V
Output current, I _{OUT}			10	mA
Maximum junction temperature, T _J			150	°C
Storage temperature, T _{stg}		-65	150	°C

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. *Absolute Maximum Ratings* do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

6.2 ESD Ratings

			VALUE	UNIT
V _(ESD) , Electrostatic discharge	LM50-Q1	Human-body model (HBM), per AEC Q100-002 ⁽¹⁾	±2000	V
		Charged-device model (CDM), per AEC Q100-011	±750	

- (1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

6.3 Recommended Operating Conditions

Over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
+V _S	Supply voltage	LM50-Q1	4.5	10	V
T _{MIN} , T _{MAX}	Specified temperature	LM50-Q1	-40	125	°C

6.4 Thermal Information

THERMAL METRIC ⁽¹⁾		LM50-Q1		UNIT
		DBZ (SOT-23) 3 PINS		
		LEGACY CHIP	NEW CHIP	
R _{θJA}	Junction-to-ambient thermal resistance	291.9	240.6	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	114.3	144.5	°C/W
R _{θJB}	Junction-to-board thermal resistance	62.3	72.3	°C/W
ψ _{JT}	Junction-to-top characterization parameter	7.4	28.7	°C/W
ψ _{JB}	Junction-to-board characterization parameter	61	71.7	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	-	-	°C/W

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application note.

6.5 Electrical Characteristics: LM50-Q1

LM50-Q1: +V_S = 5V (DC) and I_{LOAD} = 0.5μA, T_A = T_J = 25°C (unless otherwise noted)⁽¹⁾

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SENSOR ACCURACY							
T _{ACY}	Temperature accuracy ⁽²⁾	T _A = 25°C	LM50-Q1	-3		3	°C
		T _A = T _{MAX} = 125°C		-4		4	
		T _A = T _{MIN} = -40°C		-4		4	
SENSOR OUTPUT							
V _{0°C}	Output voltage offset at 0°C				500		mV
T _C	Temperature coefficient (sensor gain)	T _A = T _J = T _{MIN} to T _{MAX}		9.7	10	10.3	mV/°C
V _{ONL}	Output Nonlinearity ⁽³⁾	T _A = T _J = T _{MIN} to T _{MAX}		-0.8		0.8	°C
Z _{OUT}	Output impedance	T _A = T _J = T _{MIN} to T _{MAX}			2000	4000	Ω
T _{ON}	Turn-On Time				5		μs
				Legacy chip		30	
T _{LTD}	Long-term stability and drift ⁽⁴⁾	T _J = 125°C for 1000 hours			±0.08		°C
POWER SUPPLY							
I _{DD}	Operating current	T _A = T _{MIN} to T _{MAX} 4.5V ≤ +V _S ≤ 10V	Legacy chip		95	180	μA
			New chip		52	90	
PSR	Line regulation ⁽⁵⁾	T _A = T _{MIN} to T _{MAX} 4.5V ≤ +V _S ≤ 10V		-1.2		1.2	mV/V
ΔI _{DD}	Change of quiescent current	T _A = T _{MIN} to T _{MAX} 4.5V ≤ +V _S ≤ 10V	Legacy chip			2	μA
			New chip			8	
I _{DD_TEMP}	Temperature coefficient of quiescent current	T _A = T _{MIN} to T _{MAX} 4.5V ≤ +V _S ≤ 10V			2		μA/°C

- (1) Limits are specified to TI's AOQL (Average Outgoing Quality Level).
- (2) Accuracy is defined as the error between the output voltage and 10mv/°C multiplied by case temperature of the device plus 500mV, at specified conditions of voltage, current, and temperature (expressed in °C).
- (3) Nonlinearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the rated temperature range of the device.
- (4) For best long-term stability, any precision circuit provides best results if the unit is aged at a warm temperature, and/or temperature cycled for at least 46 hours before long-term life test begins. This is especially true when a small (Surface-Mount) part is wave-soldered; allow time for stress relaxation to occur. The majority of the drift occurs in the first 1000 hours at elevated temperatures. The drift after 1000 hours does not continue at the first 1000 hour rate.
- (5) Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output due to heating effects can be computed by multiplying the internal dissipation by the thermal resistance.

6.6 Typical Characteristics

To generate these curves the device is mounted to a printed circuit board as shown in [Figure 8-9](#) or [Figure 8-10](#).

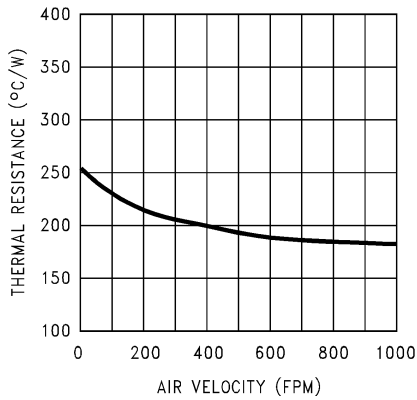


Figure 6-1. Thermal Resistance Junction-to-Ambient (Legacy chip)

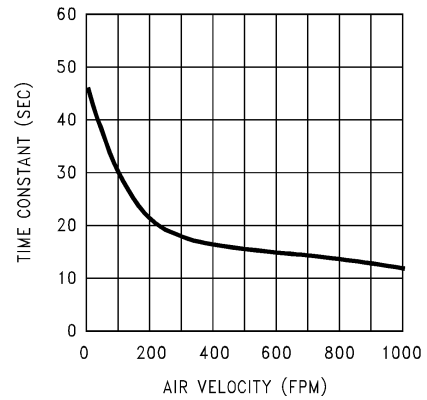


Figure 6-2. Thermal Time Constant (Legacy chip)

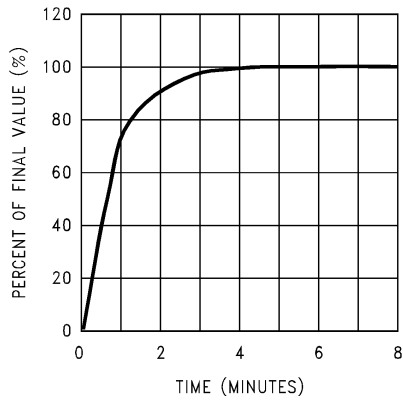


Figure 6-3. Thermal Response in Still Air With Heat Sink (Legacy chip)

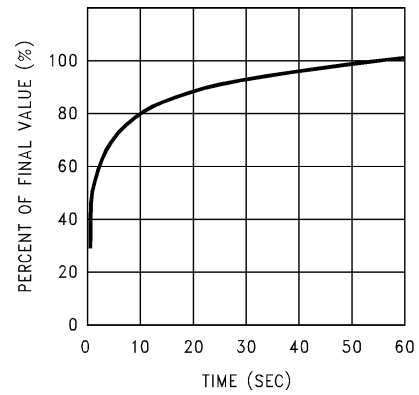


Figure 6-4. Thermal Response in Stirred Oil Bath With Heat Sink (Legacy chip)

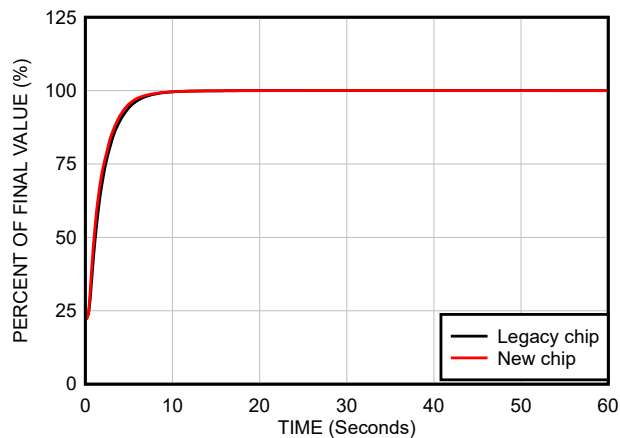


Figure 6-5. Thermal Response in Stirred Oil Bath With Heat Sink (0.5 inches x 0.5 inches PCB board)

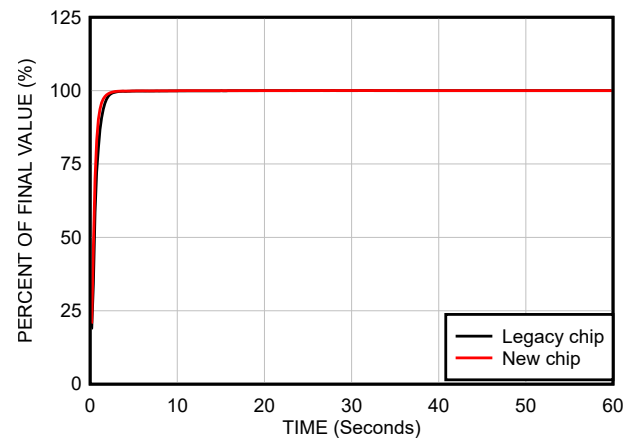


Figure 6-6. Thermal Response in Stirred Oil Bath Without Heat Sink

6.6 Typical Characteristics (continued)

To generate these curves the device is mounted to a printed circuit board as shown in [Figure 8-9](#) or [Figure 8-10](#).

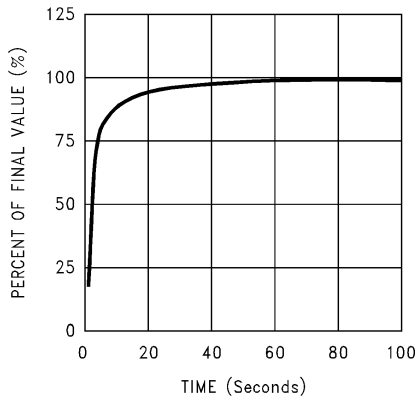


Figure 6-7. Thermal Response in Still Air Without a Heat Sink (Legacy chip)

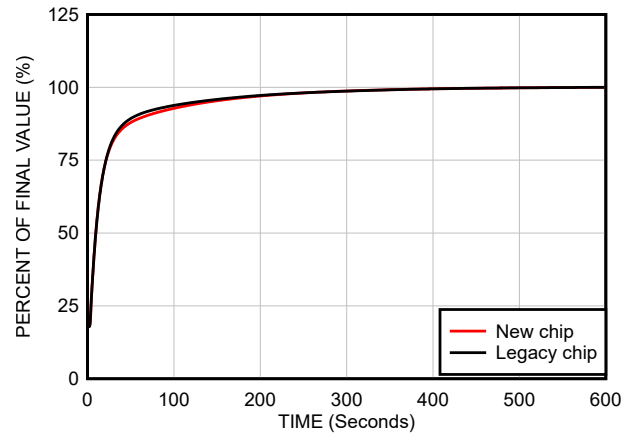


Figure 6-8. Thermal Response in Still Air Without a Heat Sink (Both Legacy and New Chip in the New Test Setup)

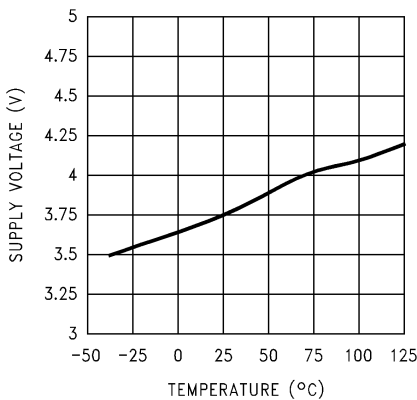


Figure 6-9. Start-Up Voltage vs Temperature (Legacy chip)

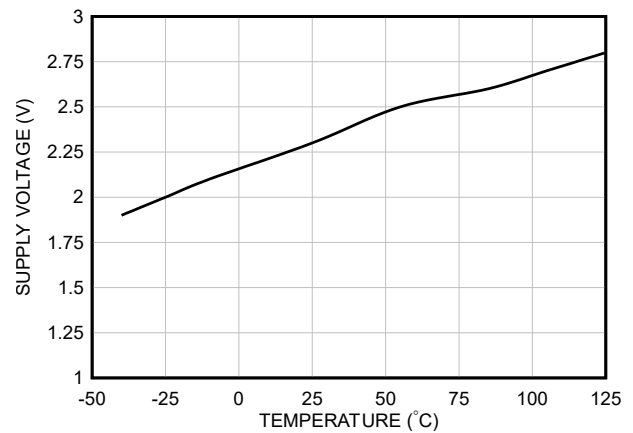


Figure 6-10. Start-Up Voltage vs Temperature (New chip)

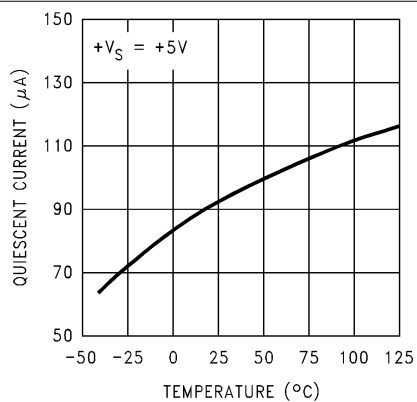


Figure 6-11. Quiescent Current vs Temperature (Legacy chip)

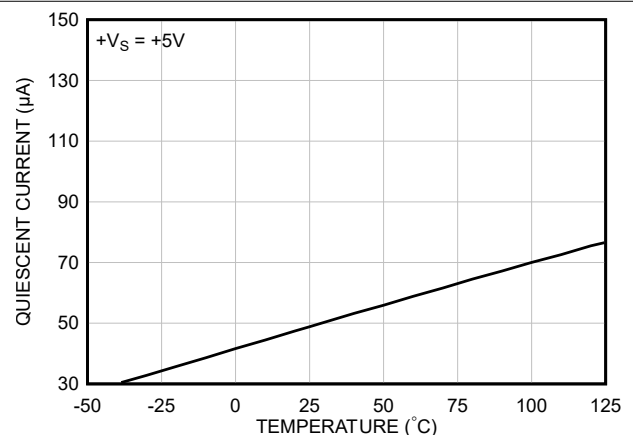


Figure 6-12. Quiescent Current vs Temperature (New chip)

6.6 Typical Characteristics (continued)

To generate these curves the device is mounted to a printed circuit board as shown in Figure 8-9 or Figure 8-10.

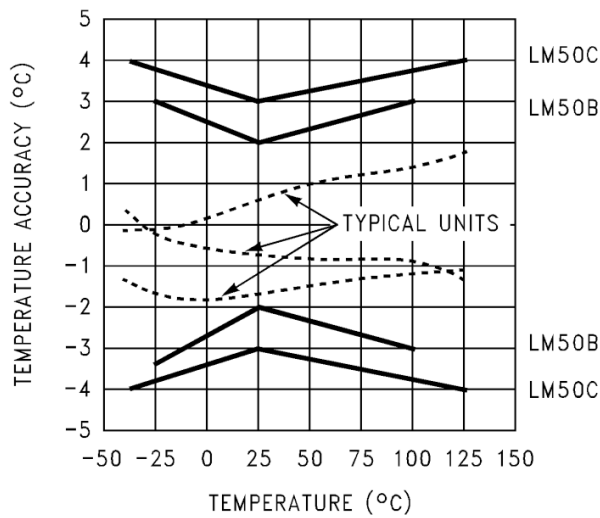


Figure 6-13. Accuracy vs Temperature (Legacy chip)

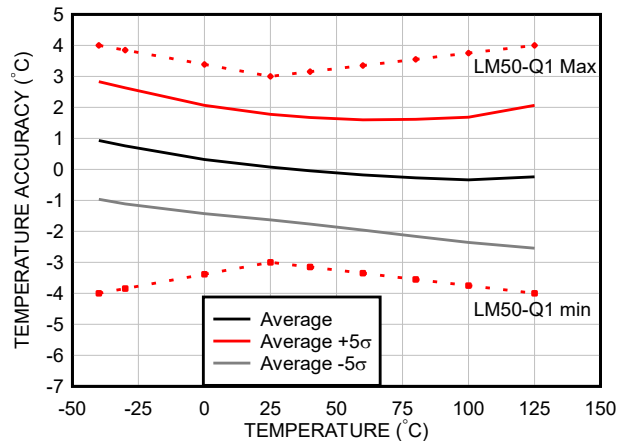


Figure 6-14. Accuracy vs Temperature (New chip)

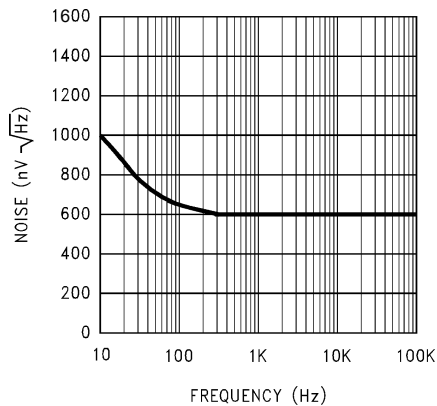


Figure 6-15. Noise Voltage (Legacy chip)

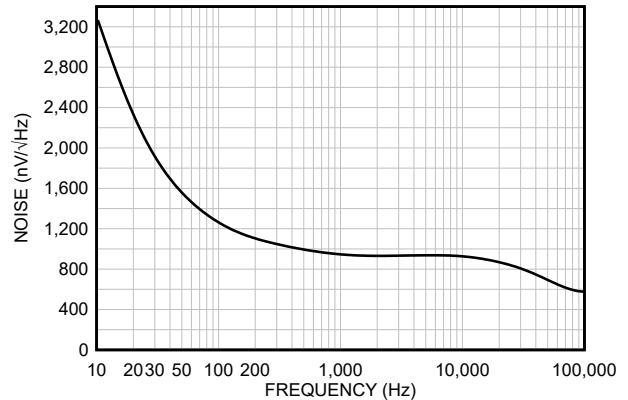


Figure 6-16. Noise Voltage (New chip)

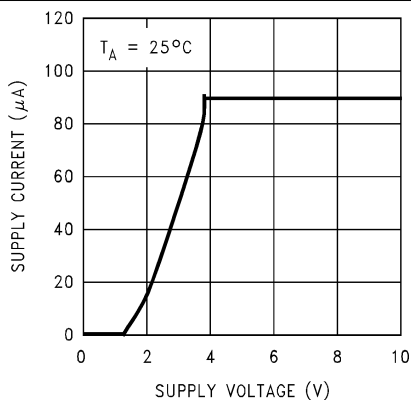


Figure 6-17. Supply Current vs Supply Voltage (Legacy chip)

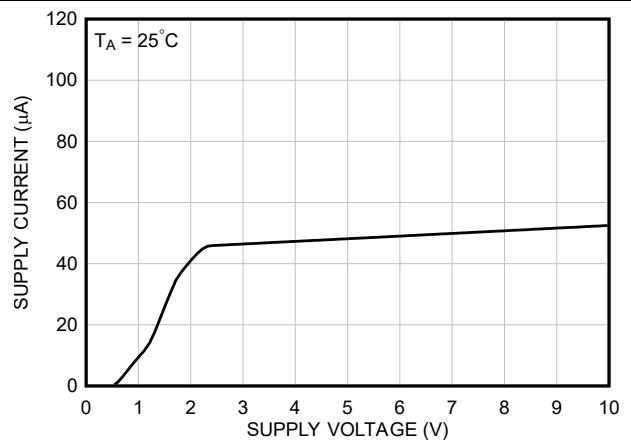


Figure 6-18. Supply Current vs Supply Voltage (New chip)

6.6 Typical Characteristics (continued)

To generate these curves the device is mounted to a printed circuit board as shown in [Figure 8-9](#) or [Figure 8-10](#).

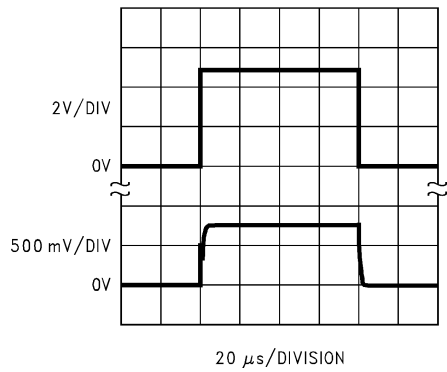


Figure 6-19. Start-Up Response (Legacy chip)

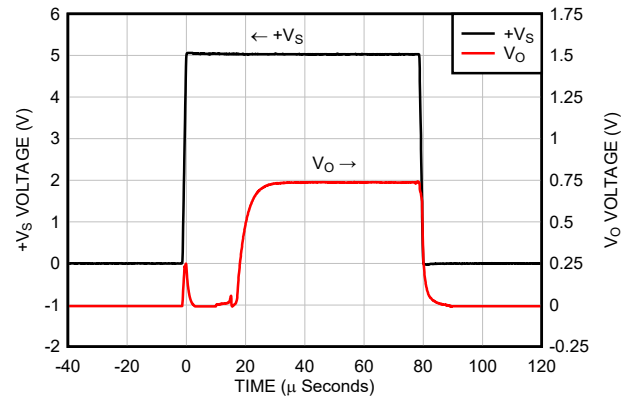


Figure 6-20. Start-Up Response (New chip)

7 Detailed Description

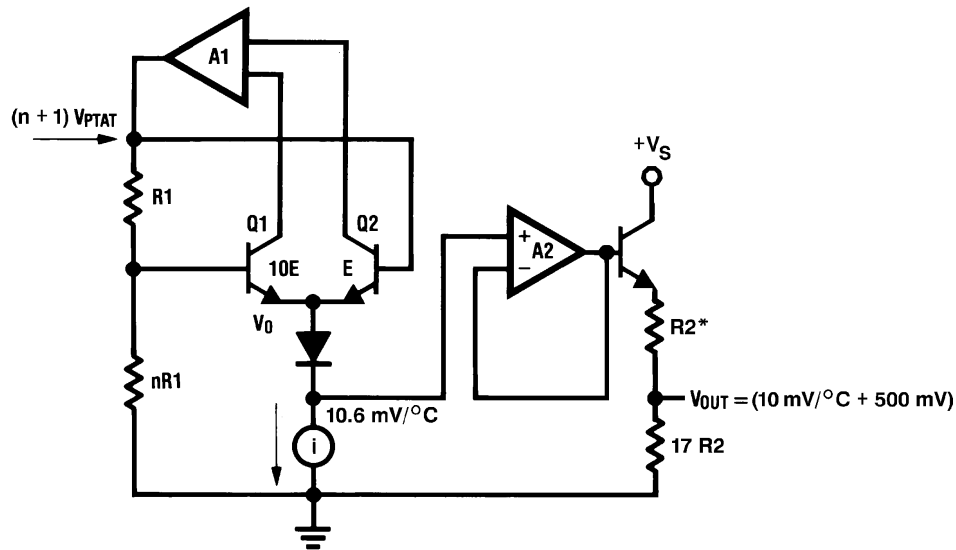
7.1 Overview

The LM50-Q1 device is a precision integrated-circuit temperature sensor that can sense a -40°C to 125°C temperature range using a single positive supply. The output voltage of the LM50-Q1 has a positive temperature slope of $10\text{mV}/^{\circ}\text{C}$. A 500mV offset is included enabling negative temperature sensing when biased by a single supply.

The temperature-sensing element is comprised of a ΔV_{BE} architecture. The temperature-sensing element is then buffered by an amplifier and provided to the V_O pin. The amplifier has a simple class A output stage with typical $2\text{k}\Omega$ output impedance as shown in the *Functional Block Diagram*.

7.2 Functional Block Diagram

*R2 \cong $2\text{k}\Omega$ with a typical $1300\text{ppm}/^{\circ}\text{C}$ drift.



7.3 Feature Description

7.3.1 LM50-Q1 Transfer Function

The LM50-Q1 follow a simple linear transfer function to achieve the accuracy as listed in the [Section 6.5](#) table. Use [Equation 1](#) to calculate the value of V_O .

$$V_O = 10\text{mV}/^{\circ}\text{C} \times T\ ^{\circ}\text{C} + 500\text{mV} \quad (1)$$

where

- T is the temperature in $^{\circ}\text{C}$
- V_O is the LM50-Q1 output voltage

7.4 Device Functional Modes

The only functional mode of the device has an analog output directly proportional to temperature.

8 Application and Implementation

Note

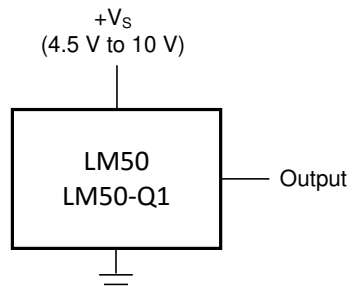
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The LM50-Q1 has a wide supply range and a 10mV/°C output slope with a 500mV DC offset. Therefore, the device can be easily placed in many temperature-sensing applications where a single supply is required for positive and negative temperatures.

8.2 Typical Application

8.2.1 Full-Range Centigrade Temperature Sensor



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Figure 8-1. Full-Range Centigrade Temperature Sensor Diagram (–40°C to 125°C)

8.2.1.1 Design Requirements

For this design example, use the parameters listed in [Table 8-1](#) as the input parameters.

Table 8-1. Design Parameters

PARAMETER	VALUE
Power supply voltage	4.5V to 10V
Output impedance	4kΩ (maximum)
Accuracy at 25°C	±3°C (maximum)
Accuracy over –40°C to 125°C	±4°C (maximum)
Temperature slope	10mV/°C

8.2.1.2 Detailed Design Procedure

The LM50-Q1 is a simple temperature sensor that provides an analog output. Therefore design requirements related to layout are more important than other requirements. See [Layout](#) for more information.

8.2.1.2.1 Capacitive Loads

The LM50-Q1 handles capacitive loading very well. Without any special precautions, the LM50-Q1 can drive any capacitive load. The device has a nominal 2kΩ output impedance (shown in [Functional Block Diagram](#)). The temperature coefficient of the output resistors is approximately 1300ppm/°C. Taking into account this temperature coefficient and the initial tolerance of the resistors the output impedance of the device does not exceed 4kΩ. In an extremely noisy environment adding filtering can be necessary to minimize noise pickup. TI recommends adding a 0.1μF capacitor between +V_S and GND to bypass the power supply voltage, as shown in [Figure 8-3](#). Adding a capacitor from V_O to ground can be necessary. A 1μF output capacitor with the 4kΩ output

impedance forms a 40Hz low-pass filter. Since the thermal time constant of the LM50-Q1 is much slower than the 25ms time constant formed by the RC, the overall response time of the device is not significantly affected. For much larger capacitors this additional time lag increases the overall response time of the LM50-Q1 .

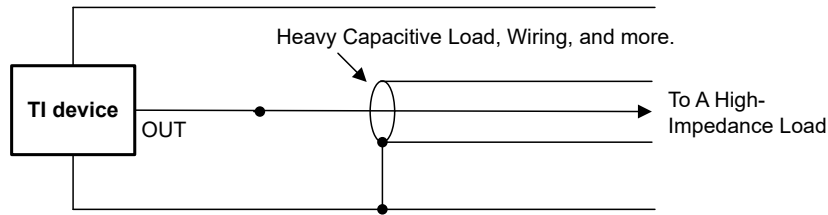


Figure 8-2. LM50-Q1 No Decoupling Required for Capacitive Load

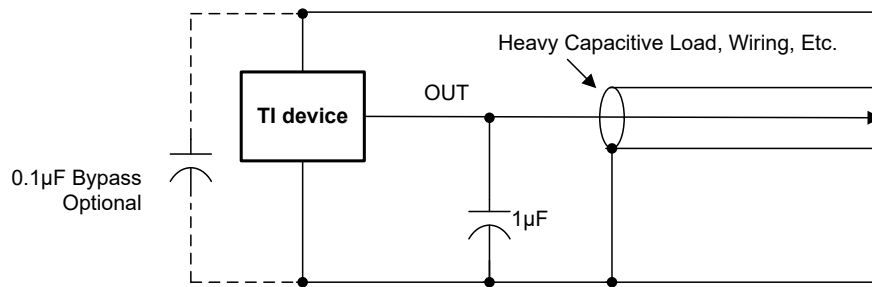


Figure 8-3. LM50-Q1 With Filter for Noisy Environment

8.2.1.3 Application Curve

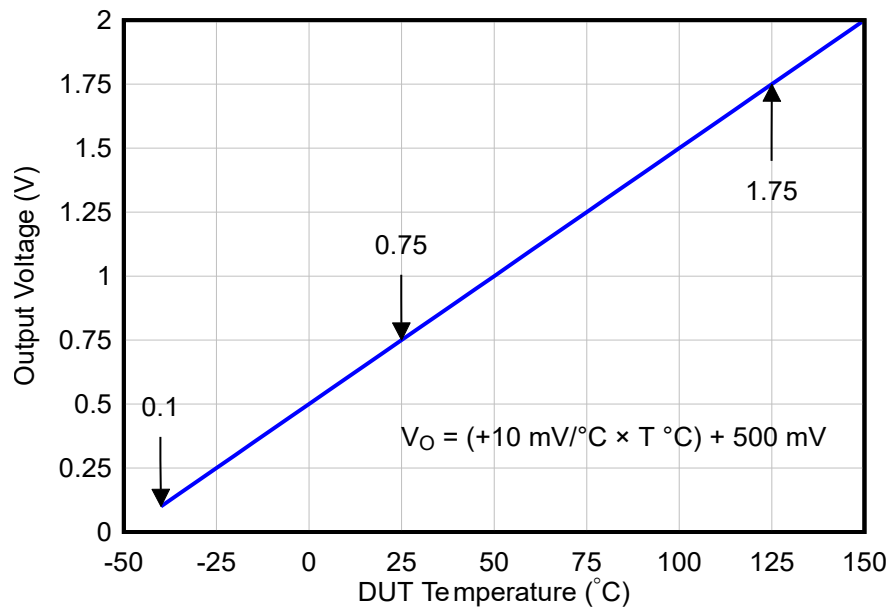
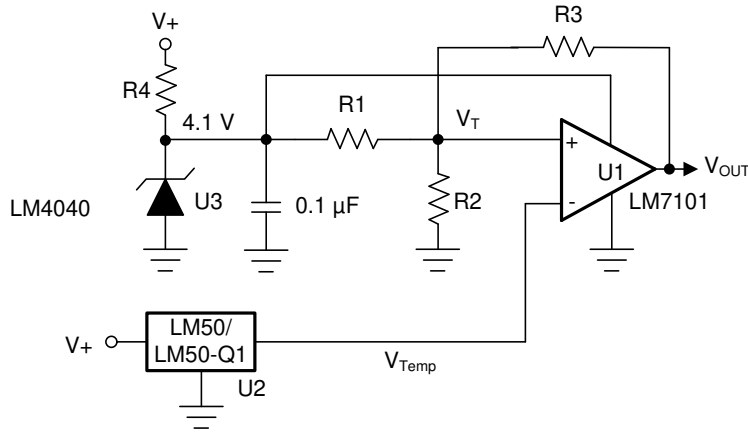


Figure 8-4. Output Transfer Function

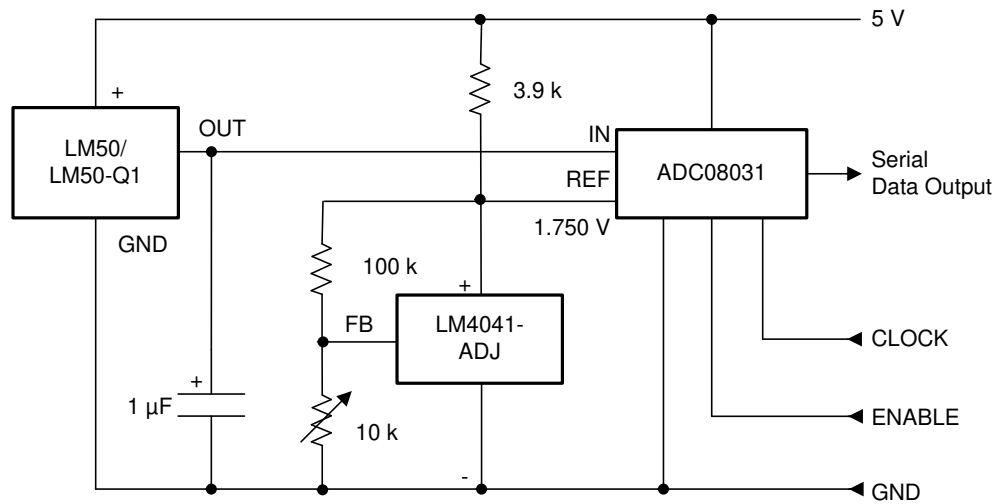
8.3 System Examples

Figure 8-5 to Figure 8-7 show application circuit examples using the LM50-Q1 device. Customers must fully validate and test any circuit before implementing a design based on an example in this section. Unless otherwise noted, the design procedures in *Full-Range Centigrade Temperature Sensor* are applicable.



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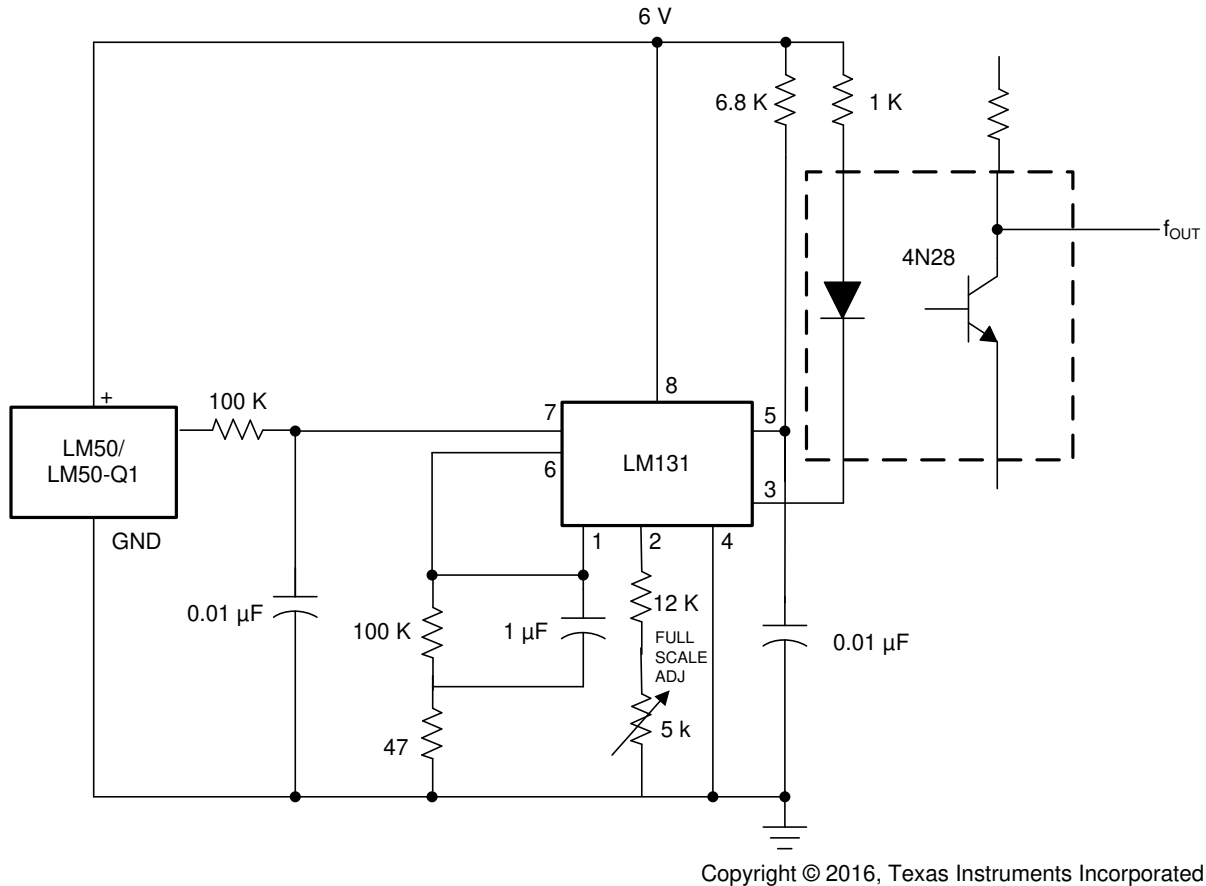
Figure 8-5. Centigrade Thermostat or Fan Controller



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125°C full scale

Figure 8-6. Temperature To Digital Converter (Serial Output)



–40°C to 125°C; 100Hz to 1750Hz

Figure 8-7. LM50-Q1 With Voltage-To-Frequency Converter and Isolated Output

8.4 Power Supply Recommendations

In an extremely noisy environment, adding some filtering to minimize noise pickup can be necessary. TI recommends that a 0.1µF capacitor be added from +V_S to GND to bypass the power supply voltage, as shown in Figure 8-3.

8.5 Layout

8.5.1 Layout Guidelines

The LM50-Q1 can be applied easily in the same way as other integrated-circuit temperature sensors. The device can be glued or cemented to a surface and the temperature is within about 0.2°C of the surface temperature.

This presumes that the ambient air temperature is approximately the same as the surface temperature; if the air temperature are much higher or lower than the surface temperature, the actual temperature of the LM50-Q1 die is at an intermediate temperature between the surface temperature and the air temperature.

To provide good thermal conductivity, the backside of the LM50-Q1 die is directly attached to the GND pin. The lands and traces to the device is part of the printed-circuit board, which is the object whose temperature is being measured. These printed-circuit board lands and traces do not cause the LM50-Q1 temperature to deviate from the desired temperature.

Alternatively, the LM50-Q1 can be mounted inside a sealed-end metal tube, and can then be dipped into a bath or screwed into a threaded hole in a tank. As with any device, the LM50-Q1 and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit

can operate at cold temperatures where condensation can occur. Printed-circuit coatings and varnishes such as HUMISEAL® and epoxy paints or dips are often used to verify that moisture cannot corrode the device or the connections.

8.5.2 Layout Example

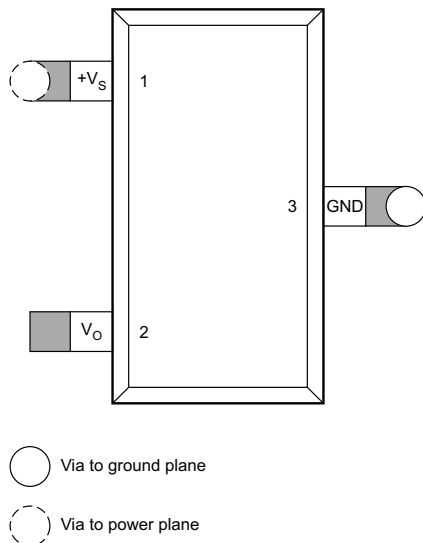
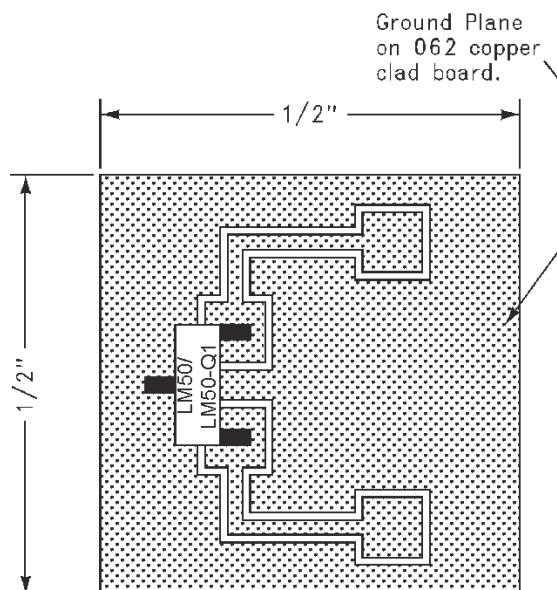


Figure 8-8. PCB Layout



1/2in, square printed-circuit board with 2oz foil or similar

Figure 8-9. Printed-Circuit Board Used for Heat Sink to Generate Thermal Response Curves (Legacy chip)

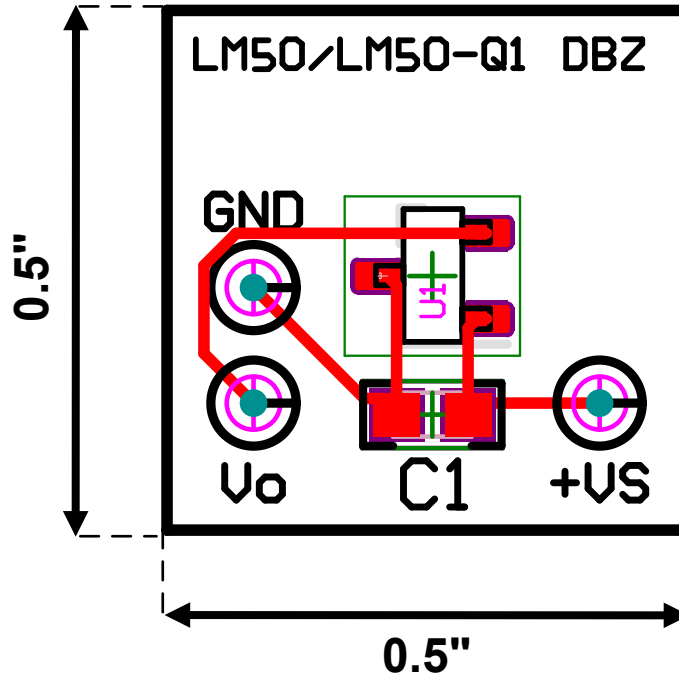


Figure 8-10. Printed-Circuit Board Used to Generate Thermal Response Curves (New Test Setup for Both New Chip and Legacy Chip)

8.5.3 Thermal Considerations

Table 8-2 summarizes the thermal resistance of the LM50-Q1 for different conditions.

Table 8-2. Temperature Rise of LM50-Q1 Due to Self-Heating

			$R_{\theta JA}$ (°C/W)
SOT-23	No heat sink ⁽¹⁾	Still air (Legacy chip)	291.9
		Moving air (Legacy chip)	-
	Small heat fin ⁽²⁾	Still air (Legacy chip)	260
		Moving air (Legacy chip)	180

(1) Part soldered to 30 gauge wire.

(2) Heat sink used is 0.5inch, square printed-circuit board with 2oz foil; part attached as shown in Figure 8-9.

9 Device and Documentation Support

9.1 Documentation Support

Related Documentation

For related documentation see the following:

- Texas Instruments, [TMP23x-Q1 Automotive Grade, High-Accuracy Analog Output Temperature Sensors](#), data sheet
- Texas Instruments, [ISOTMP35-Q1 Automotive \$\pm 1.5^{\circ}\text{C}\$, 3-kVRMS Isolated Temperature Sensor With Analog Output With < 2 Seconds Response Time and 500VRMS Working Voltage](#), data sheet
- Texas Instruments, [LM60-Q1 Automotive 2.7V, SOT-23 Temperature](#), data sheet
- Texas Instruments, [LM50-Q1 Functional Safety User's Guide](#), Functional safety information
- Texas Instruments, [Tiny Temperature Sensors for Remote Systems](#), application note
- Texas Instruments, [Semiconductor Temperature Sensors Challenge Precision RTDs and Thermistors in Building Automation](#), application note
- Texas Instruments, [LMT90 Temperature Sensor Evaluation Module](#), EVM

9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](#). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

9.3 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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9.4 Trademarks

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9.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

9.6 Glossary

TI Glossary

This glossary lists and explains terms, acronyms, and definitions.

10 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
May 2025	*	Initial Release. Moved the automotive device from the SNIS118 “G” revision to a standalone data sheet.

Note

The LM50-Q1 device is moved from the [SNIS118](#) “G” revision data sheet to the current standalone data sheet. The changes from [SNIS118](#) “G” revision to this document are as follows:

- Added specifications and graphs for the New LM50-Q1 and compared the device with the Legacy LM50-Q1 throughout the document
 - Added “Device Comparison”, “Device Orderable Options” and “Nomenclature Details” tables
 - Added DBZ package “Thermal Information” for the New chip
 - Added “Turn-on Time” for both Legacy chip and New chip
 - Added “Operating current” and “Change of quiescent current” for the New chip
 - Updated the typos in “Design Parameters” table
-

11 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
LM50QIM3/NOPB	Obsolete	Production	SOT-23 (DBZ) 3	-	-	Call TI	Call TI	-40 to 125	T5Q
LM50QIM3X/NOPB	Active	Production	SOT-23 (DBZ) 3	3000 LARGE T&R	Yes	SN	Level-1-260C-UNLIM	-40 to 125	T5Q
LM50QIM3X/NOPB.A	Active	Production	SOT-23 (DBZ) 3	3000 LARGE T&R	-	SN	Level-1-260C-UNLIM	-40 to 125	T5Q
LM50QIM3X/NOPB.B	Active	Production	SOT-23 (DBZ) 3	3000 LARGE T&R	-	SN	Level-1-260C-UNLIM	-40 to 125	T5Q

⁽¹⁾ **Status:** For more details on status, see our [product life cycle](#).

⁽²⁾ **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

⁽³⁾ **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

⁽⁴⁾ **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

⁽⁵⁾ **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

⁽⁶⁾ **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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OTHER QUALIFIED VERSIONS OF LM50-Q1 :

- Catalog : [LM50](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LM50QIM3X/NOPB	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

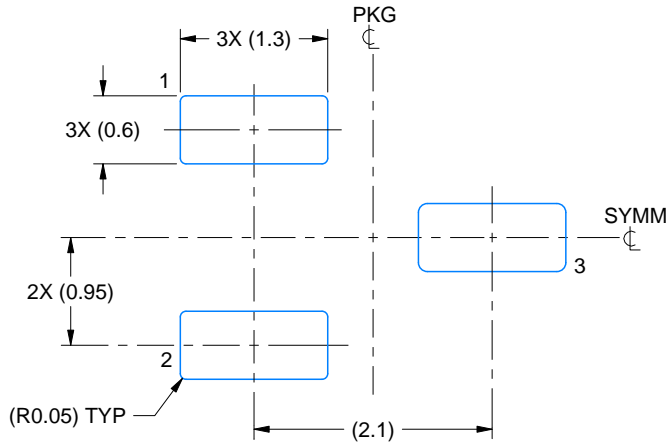
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LM50QIM3X/NOPB	SOT-23	DBZ	3	3000	208.0	191.0	35.0

EXAMPLE BOARD LAYOUT

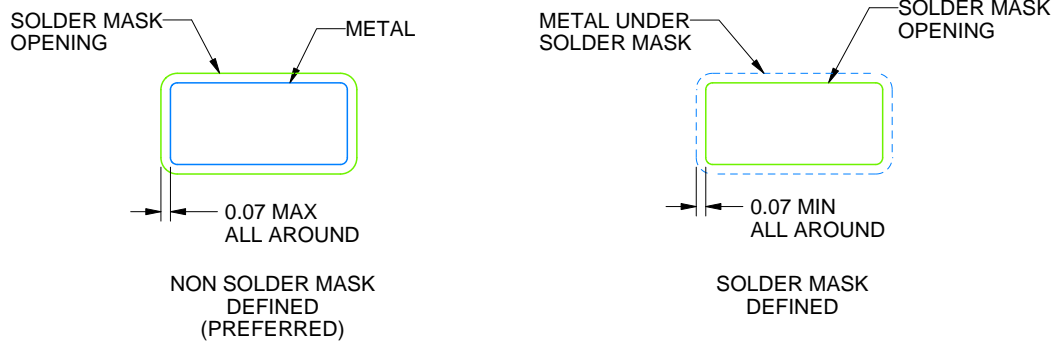
DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE
SCALE:15X



SOLDER MASK DETAILS

4214838/F 08/2024

NOTES: (continued)

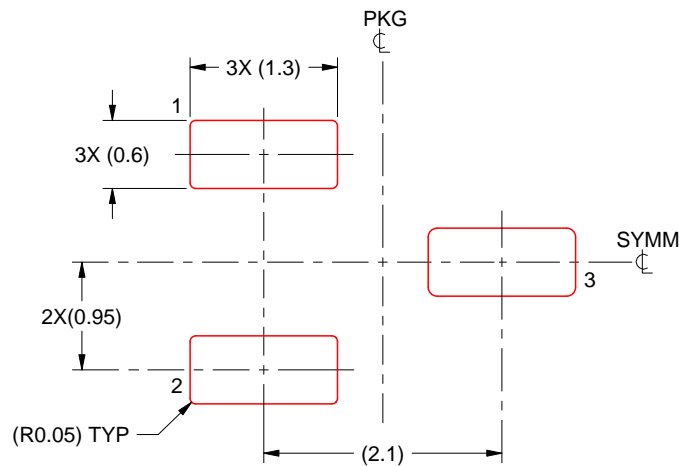
5. Publication IPC-7351 may have alternate designs.
6. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

EXAMPLE STENCIL DESIGN

DBZ0003A

SOT-23 - 1.12 mm max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE
BASED ON 0.125 THICK STENCIL
SCALE:15X

4214838/F 08/2024

NOTES: (continued)

7. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
8. Board assembly site may have different recommendations for stencil design.

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