LMT90 SOT-23 Single-Supply Centigrade Temperature Sensor

Check for Samples: LMT90

FEATURES

- **Cost-Effective Alternative to Thermistors**
- **Calibrated Directly in Degree Celsius (Centigrade)**
- **Linear + 10.0 mV/°C Scale Factor**
- **±2°C Accuracy Guaranteed at +25°C**
- **Specified for Full −40° to +125°C range**
- **Suitable for Remote Applications**
- **Low Cost Due to Wafer-level Trimming**
- **Operates from 4.5V to 10V**
- **Less than 130 µA Current Drain**
- **Low Self-heating, Less than 0.2°C in Still Air**
- **Nonlinearity Less than 0.8°C Over Temp**

APPLICATIONS

- **Industrial**
- **HVAC**
- **Disk Drives**
- **Automotive**
- **Portable Medical Instruments**
- **Computers**
- **Battery Management**
- **Printers**
- **Power Supply Modules**
- **FAX Machines**
- **Automotive**

DESCRIPTION

The LMT90 is a precision integrated-circuit temperature sensor that can sense a −40°C to +125°C temperature range using a single positive supply. The LMT90's output voltage is linearly proportional to Celsius (Centigrade) temperature (+10 mV/°C) and has a DC offset of +500 mV. The offset allows reading negative temperatures without the need for a negative supply. The ideal output voltage of the LMT90 ranges from +100 mV to +1.75V for a −40°C to +125°C temperature range. The LMT90 does not require any external calibration or trimming to provide accuracies of ±3°C at room temperature and ±4°C over the full −40°C to +125°C temperature range. Trimming and calibration of the LMT90 at the wafer level assure low cost and high accuracy. The LMT90's linear output, +500 mV offset, and factory calibration simplify circuitry required in a single supply environment where reading negative temperatures is required. Because the LMT90's quiescent current is less than 130 µA, self-heating is limited to a very low 0.2°C in still air.

The LMT90 is a cost-competitive alternative to thermistors.

CONNECTION DIAGRAM

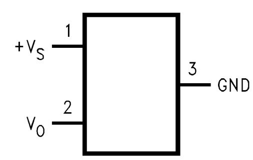


Figure 1. SOT-23 Top View

TYPICAL APPLICATION

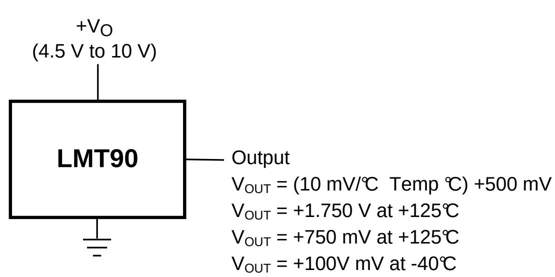


Figure 2. Full-Range Centigrade Temperature Sensor (−40°C to +125°C)

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ABSOLUTE MAXIMUM RATINGS(1)

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

		VALUES
Supply Voltage		+12V to −0.2V
Output Voltage		(+V_S + 0.6V) to −1.0V
Output Current		10 mA
Storage Temperature		−65°C to +150°C
T_{JMAX}, Maximum Junction Temperature		150°C
ESD Susceptibility (2)	Human Body Model	2000V
	Machine Model	250V

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its rated operating conditions.
(2) Human body model, 100 pF discharged through a 1.5 kΩ resistor. Machine model, 200 pF discharged directly into each pin.

OPERATING RATINGS

Specified Temperature Range:	T_{MIN} to T_{MAX}
LMT90	−40°C to +125°C
Operating Temperature Range	−40°C to +150°C
θ_{JA} (1)	450°C/W
Supply Voltage Range (+V_S)	+4.5V to +10V
Soldering process must comply with the Reflow Temperature Profile specifications. Refer to www.ti.com/packaging. (2)	

(1) Thermal resistance of the SOT-23 package is specified without a heat sink, junction to ambient.
(2) Reflow temperature profiles are different for lead-free and non-lead-free packages.

ELECTRICAL CHARACTERISTICS

Unless otherwise noted, these specifications apply for V_S = +5 V_{DC} and I_{LOAD} = +0.5 µA, in the circuit of Figure 2. **Boldface limits apply for the specified $T_A = T_J = T_{MIN}$ to T_{MAX}**; all other limits $T_A = T_J$ = +25°C, unless otherwise noted.

PARAMETER	CONDITIONS	TYPICAL	MAX(1)	UNITS (LIMIT)
Accuracy (2)	T_A = +25°C		±3.0	°C (max)
	$T_A = T_{MAX}$		±4.0	°C (max)
	$T_A = T_{MIN}$		±4.0	°C (max)
Nonlinearity (3)			**±0.8**	°C (max)
Sensor Gain			**+9.7**	mV/°C (min)
(Average Slope)			**+10.3**	mV/°C (max)
Output Resistance		2000	**4000**	Ω (max)
Line Regulation (4)	+4.5V ≤ V_S ≤ +10V		±0.8	mV/V (max)
			±1.2	mV/V (max)
Quiescent Current (5)	+4.5V ≤ V_S ≤ +10V		130	µA (max)
			180	µA (max)
Change of Quiescent Current (5)	+4.5V ≤ V_S ≤ +10V		**2.0**	µA (max)
Temperature Coefficient of Quiescent Current		**+2.0**		µA/°C
Long Term Stability (6)	T_J = 125°C, for 1000 hours	±0.08		°C

(1) Limits are specific to TI's AOQL (Average Outgoing Quality Level).
(2) Accuracy is defined as the error between the output voltage and 10mv/°C times the device's case temperature plus 500 mV, 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 device's rated temperature range.
(4) 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.
(5) Quiescent current is defined in the circuit of Figure 2.
(6) For best long-term stability, any precision circuit will give 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 will occur in the first 1000 hours at elevated temperatures. The drift after 1000 hours will not continue at the first 1000 hour rate.

TYPICAL PERFORMANCE CHARACTERISTICS

To generate these curves the LMT90 was mounted to a printed circuit board as shown in Figure 14.

Thermal Resistance Junction to Air

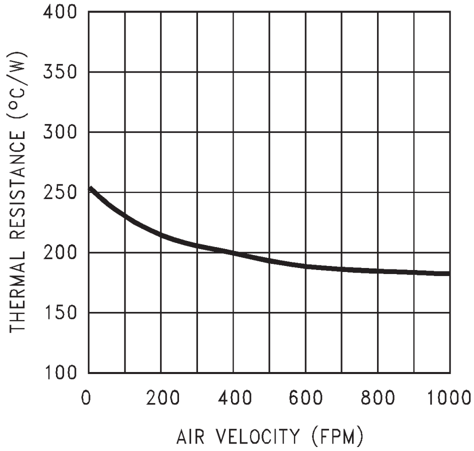


Figure 3.

Thermal Time Constant

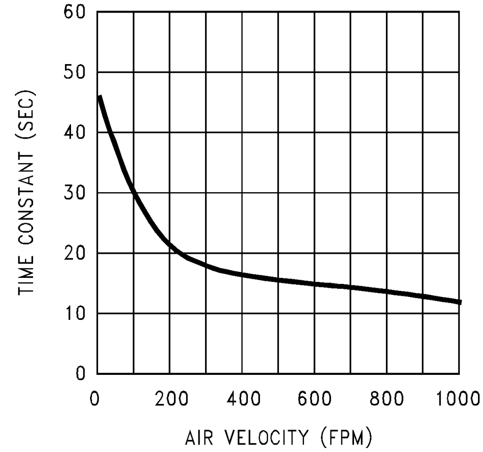


Figure 4.

Thermal Response in Still Air with Heat Sink (Figure 14)

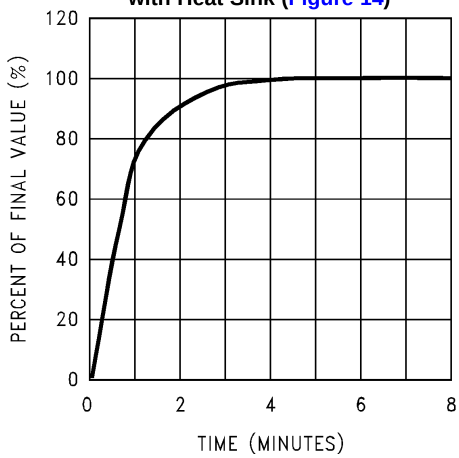


Figure 5.

Thermal Response in Stirred Oil Bath with Heat Sink

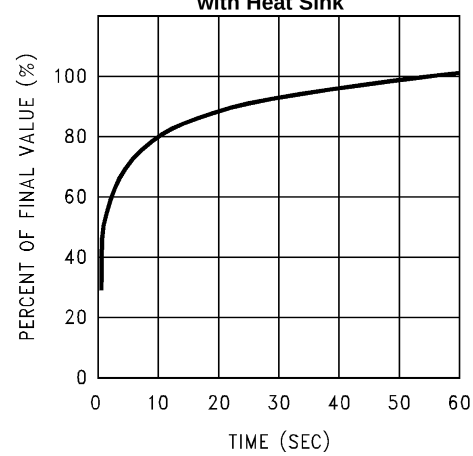


Figure 6.

Start-Up Voltage vs Temperature

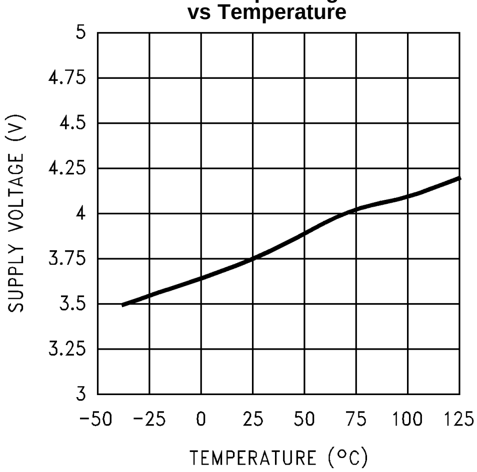


Figure 7.

Thermal Response in Still Air without a Heat Sink

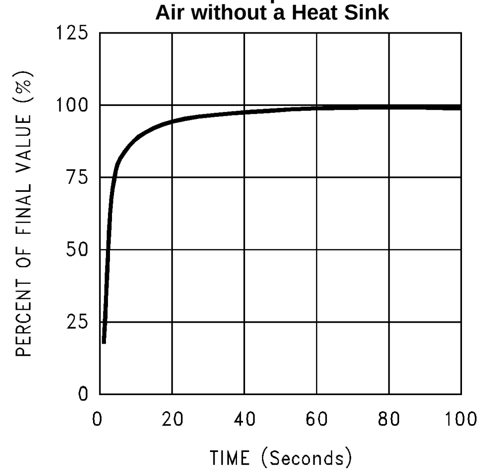


Figure 8.

TYPICAL PERFORMANCE CHARACTERISTICS (continued)

To generate these curves the LMT90 was mounted to a printed circuit board as shown in Figure 14.

Quiescent Current vs Temperature (Figure 2)

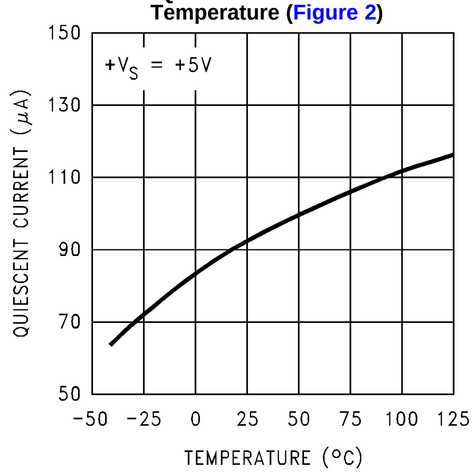


Figure 9.

Accuracy vs Temperature

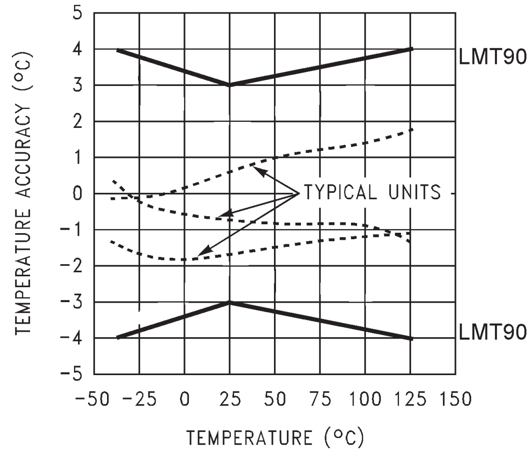


Figure 10.

Noise Voltage

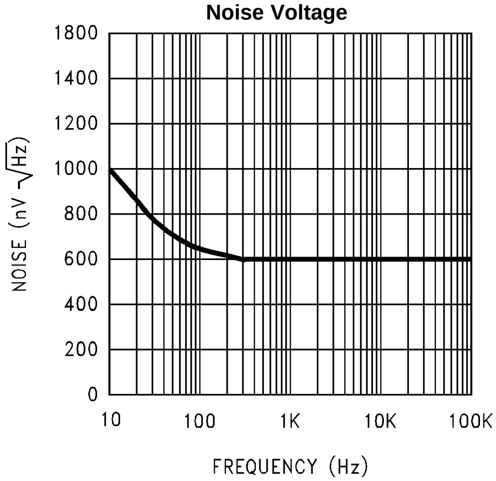


Figure 11.

Supply Voltage vs Supply Current

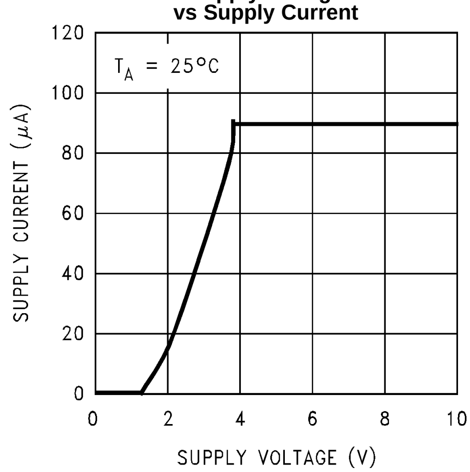


Figure 12.

Start-Up Response

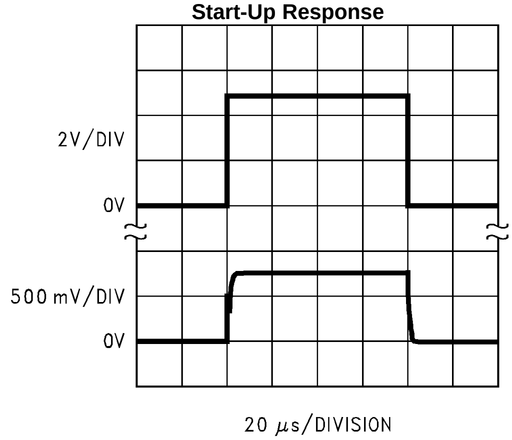
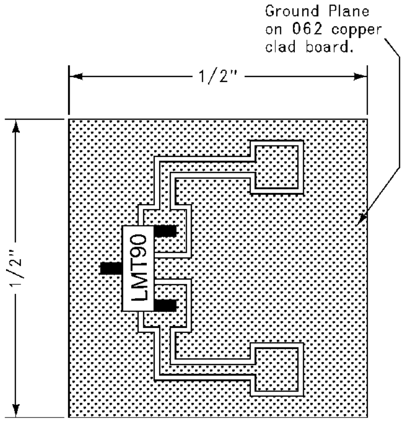


Figure 13.

PRINTED CIRCUIT BOARD



A. 1/2″ Square Printed Circuit Board with 2 oz. Foil or Similar

Figure 14. Printed Circuit Board Used for Heat Sink to Generate All Curves

MOUNTING

The LMT90 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.2°C of the surface temperature.

This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the LMT90 die would be at an intermediate temperature between the surface temperature and the air temperature.

To ensure good thermal conductivity the backside of the LMT90 die is directly attached to the GND pin. The lands and traces to the LMT90 will, of course, be part of the printed circuit board, which is the object whose temperature is being measured. These printed circuit board lands and traces will not cause the LMT90s temperature to deviate from the desired temperature.

Alternatively, the LMT90 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 IC, the LMT90 and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may 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 ensure that moisture cannot corrode the LMT90 or its connections.

Table 1. Temperature Rise of LMT90 Due to Self-Heating (Thermal Resistance, θ_{JA})

	SOT-23 no heat sink(1)	SOT-23 small heat fin(2)
Still air	450°C/W	260°C/W
Moving air		180°C/W

(1) Part soldered to 30 gauge wire.
(2) Heat sink used is 1/2″ square printed circuit board with 2 oz. foil with part attached as shown in Figure 14.

CAPACITIVE LOADS

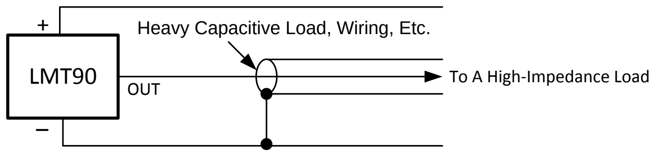


Figure 15. LMT90 No Decoupling Required for Capacitive Load

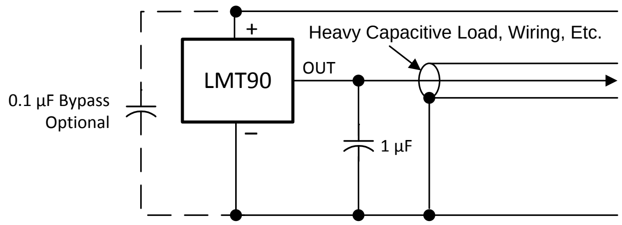
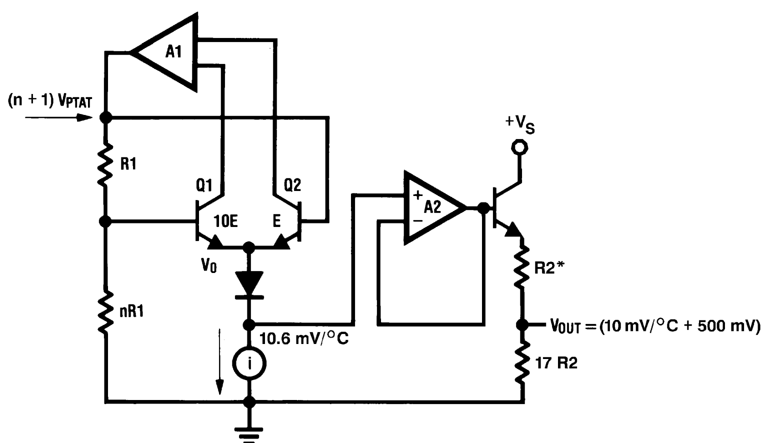


Figure 16. LMT90C with Filter for Noisy Environment

The LMT90 handles capacitive loading very well. Without any special precautions, the LMT90 can drive any capacitive load. The LMT90 has a nominal 2 kΩ output impedance (as can be seen in Figure 17). The temperature coefficient of the output resistors is around 1300 ppm/°C. Taking into account this temperature coefficient and the initial tolerance of the resistors the output impedance of the LMT90 will not exceed 4 kΩ. In an extremely noisy environment it may be necessary to add some filtering to minimize noise pickup. It is recommended that 0.1 µF be added from V_{IN} to GND to bypass the power supply voltage, as shown in Figure 16. In a noisy environment it may be necessary to add a capacitor from the output to ground. A 1 µF output capacitor with the 4 kΩ output impedance will form a 40 Hz lowpass filter. Since the thermal time constant of the LMT90 is much slower than the 25 ms time constant formed by the RC, the overall response time of the LMT90 will not be significantly affected. For much larger capacitors this additional time lag will increase the overall response time of the LMT90.



*R2 ≈ 2k with a typical 1300 ppm/°C drift.

Figure 17. Block Diagram

TYPICAL APPLICATIONS

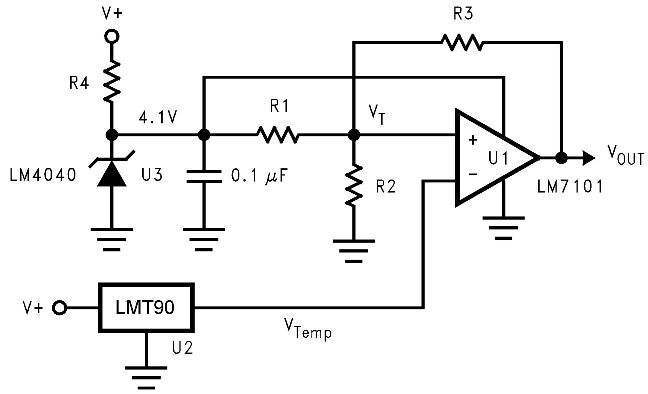


Figure 18. Centigrade Thermostat/Fan Controller

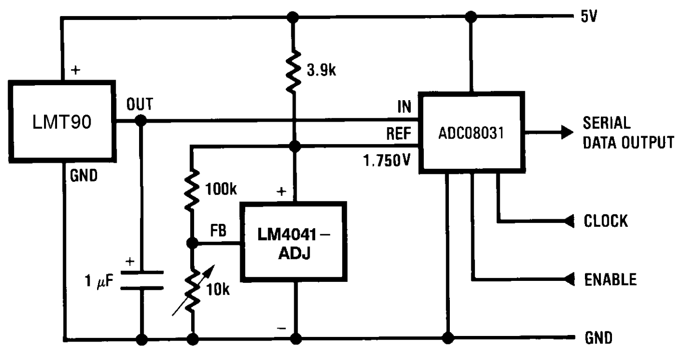


Figure 19. Temperature To Digital Converter (Serial Output) (+125°C Full Scale)

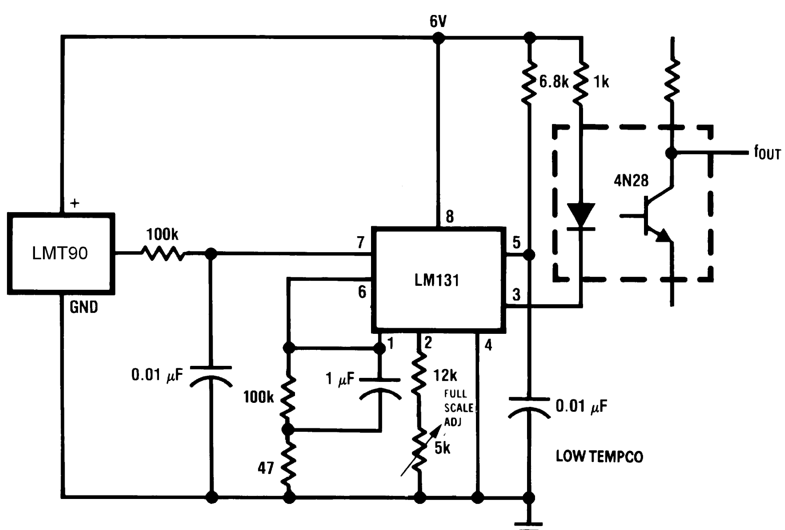


Figure 20. Temperature To Digital Converter (Parallel TRI-STATE Outputs for Standard Data Bus to µP Interface) (125°C Full Scale)

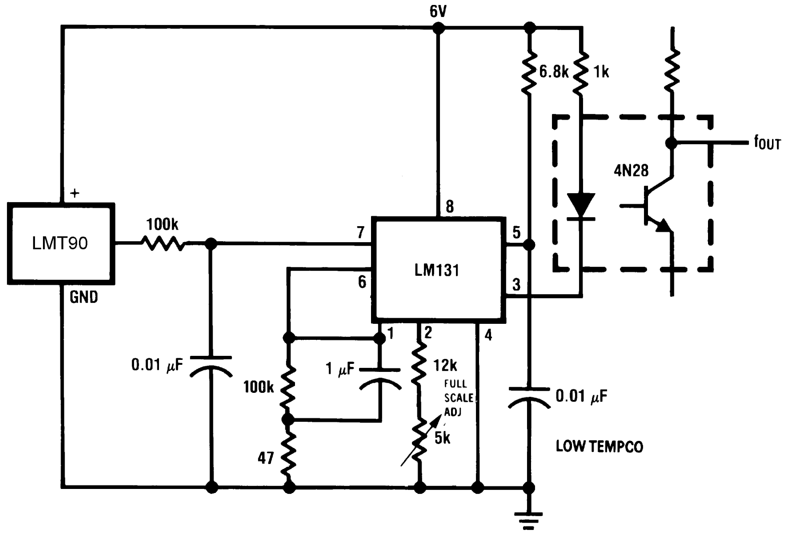


Figure 21. LMT90 With Voltage-To-Frequency Converter And Isolated Output (−40°C to +125°C; 100 Hz to 1750 Hz)

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)	Op Temp (°C)	Top-Side Markings (4)	Samples
LMT90DBZR	ACTIVE	SOT-23	DBZ	3	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	T8C	Samples
LMT90DBZT	ACTIVE	SOT-23	DBZ	3	250	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	T8C	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

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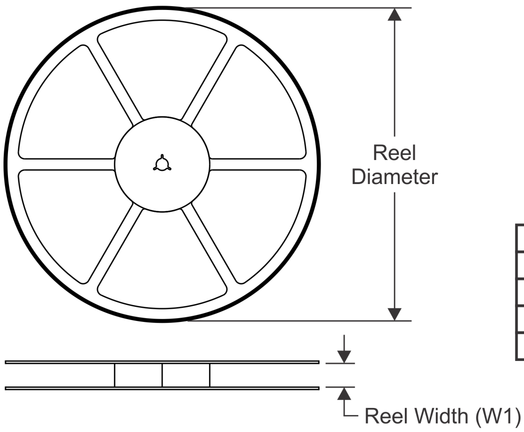
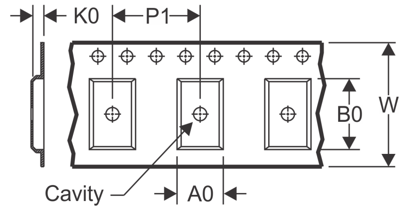
TAPE AND REEL INFORMATION

REEL DIMENSIONS

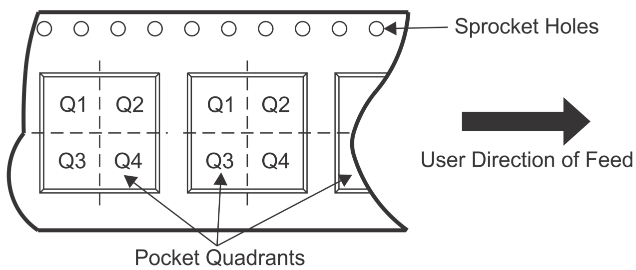


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

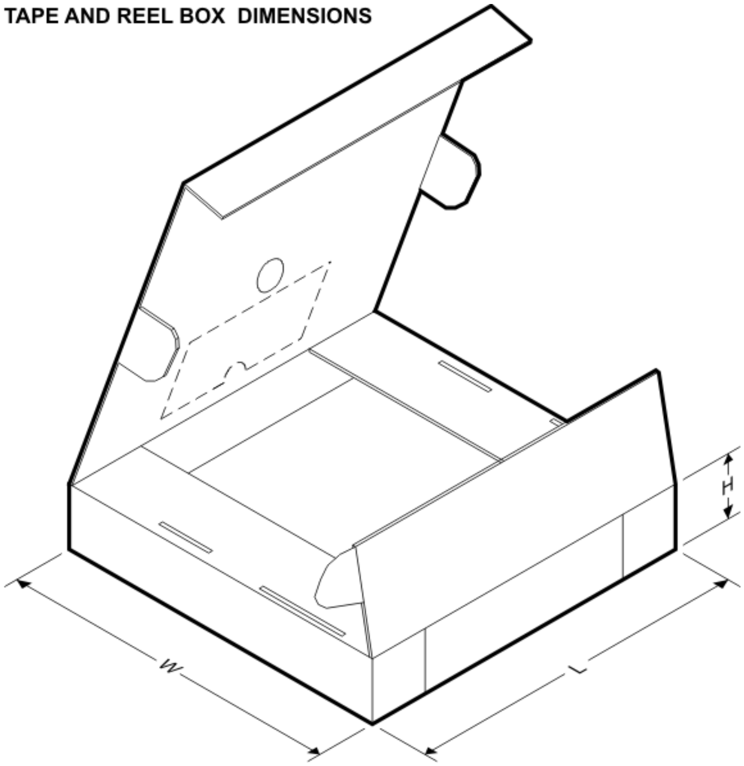
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LMT90DBZR	SOT-23	DBZ	3	3000	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3
LMT90DBZT	SOT-23	DBZ	3	250	178.0	8.4	3.3	2.9	1.22	4.0	8.0	Q3

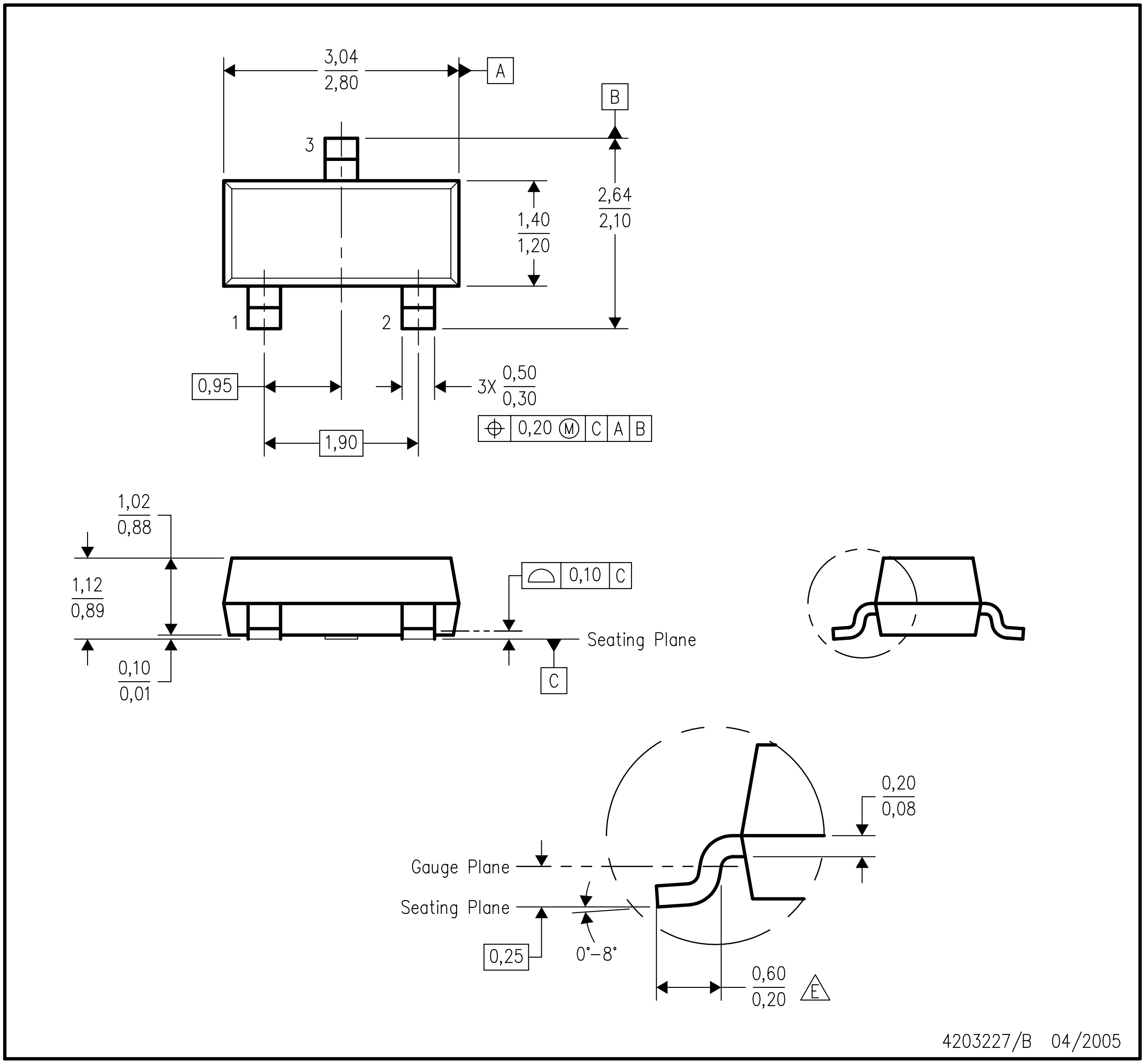
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMT90DBZR	SOT-23	DBZ	3	3000	210.0	185.0	35.0
LMT90DBZT	SOT-23	DBZ	3	250	210.0	185.0	35.0

DBZ (R–PDSO–G3) PLASTIC SMALL–OUTLINE



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. Lead dimensions are inclusive of plating.
D. Body dimensions are exclusive of mold flash and protrusion. Mold flash and protrusion not to exceed 0.25 per side.
E. Falls within JEDEC TO–236 variation AB, except minimum foot length.