LMT87/LMT87-Q1 SC70/TO-92/TO-126, Analog Temperature Sensors with Class-AB Output

1 Features

- LMT87-Q1 is AEC-Q100 Grade 0 qualified and is manufactured on an automotive grade flow
- Very accurate: ±0.3°C typical
- Wide temperature range of −50°C to 150°C
- Low 5.4 µA quiescent current
- Sensor gain of -13.6 mV/°C
- Packages:
  - Small SC70 (SOT 5-lead) surface mount
  - Leaded TO-92
  - Leaded heatsink or chassis screw-mount TO-126
- Output is short-circuit protected
- Push-pull output with 50 µA source current capability
- Footprint compatible with the industry-standard LM20/19 and LM35 temperature sensors
- Cost-effective alternative to thermistors

2 Applications

- Automotive
- Industrial
- White Goods – Appliances
- Battery Management
- Disk Drives
- Games
- Wireless Transceivers
- Cell phones

3 Description

The LMT87/LMT87-Q1 are precision CMOS integrated-circuit temperature sensors with an analog output voltage that is linearly and inversely proportional to temperature. Its features make it suitable for many general temperature sensing applications. It can operate down to 2.7V supply with 5.4 µA power consumption. Multiple package options including through-hole TO-92 and TO-126 packages also allow the LMT87 to be mounted on-board, off-board, to a heat sink, or on multiple unique locations in the same application. A class-AB output structure gives the LMT87/LMT87-Q1 strong output source and sink current capability that can directly drive up to 1.1 nF capacitive loads. This means it is well suited to drive an analog-to-digital converter sample-and-hold input with its transient load requirements. It has accuracy specified in the operating range of −50°C to 150°C. The accuracy, 3-lead package options, and other features also make the LMT87/LMT87-Q1 an alternative to thermistors.

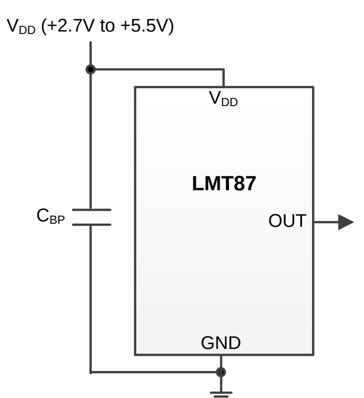
For devices with different average sensor gains and comparable accuracy the LMT84/LM84-Q1, LMT85/LMT85-Q1 and LMT86/LMT86-Q1 (For more details see Table 1 Comparable Alternative Devices.)

Device Information[(1)]

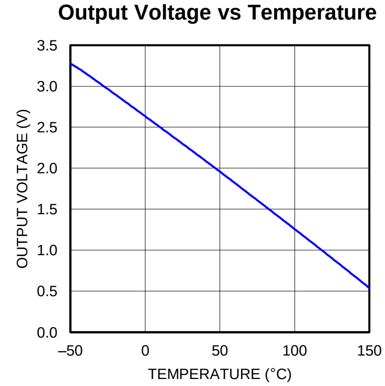
PART NUMBER	PACKAGE	BODY SIZE (NOM)
LMT87	SOT (5)	2.00 mm x 1.25 mm
	TO-92 (3)	4.3 mm x 3.5 mm
	TO-126 (3)	8 mm x 11 mm
LMT87-Q1	SOT (5)	2.00 mm x 1.25 mm

(1) For all available packages, see the orderable addendum addendum at the end of the data sheet.

4 Full-Range Celsius Temperature Sensor (−50°C to 150°C)



Output Voltage vs Temperature



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5 Revision History

Changes from Revision A (June 2013) to Revision B	Page
• Added data sheet flow and layout to conform with new TI standards. Added the following sections: Application and Implementation, Power Supply Recommendations, Layout, Device and Documentation Support, Mechanical, Packaging, and Orderable Information	1
• Added TO-92 and TO-126 package information.	1
• Changed 450 °C/W to 275 °C/W. New specification is derived using TI ' s latest methodology.	5
• Deleted Note: The input current is leakage only and is highest at high temperature. It is typically only 0.001 µA. The 1 µA limit is solely based on a testing limitation and does not reflect the actual performance of the part.	6

Device Comparison Table(1)

ORDER NUMBER	PACKAGE	PIN	BODY SIZE (NOM)	MOUNTING TYPE
LMT87DCK	SOT (AKA(2): SC70, DCK)	5	2.00 mm x 1.25 mm	Surface Mount
LMT87LP	TO-92 (AKA(2): LP)	3	4.3 mm x 3.5 mm	Through-hole
LMT87LPC	TO-126 (AKA(2): LPC)	3	8 mm x 11 mm	Screw-mount, Through-hole
LMT87DCK-Q1	SOT (AKA(2): SC70, DCK)	5	2.00 mm x 1.25 mm	Surface Mount

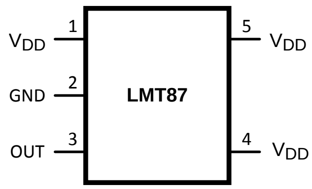
(1) For all available packages and complete order numbers, see the orderable addendum at the end of the data sheet.
(2) AKA = Also Known As

Table 1. Comparable Alternative Devices

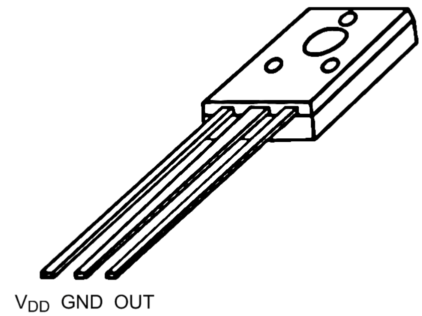
PART NUMBER	AVERAGE OUTPUT SENSOR GAIN	POWER SUPPLY RANGE
LMT84/LMT84-Q1	–5.5 mV/°C	1.5V to 5.5V
LMT85/LMT85-Q1	–8.2 mV/°C	1.8V to 5.5V
LMT86/LMT86-Q1	–10.9 mV/°C	2.2V to 5.5V
LMT87/LMT87-Q1	–13.6 mV/°C	2.7V to 5.5V

6 Pin Configuration and Functions

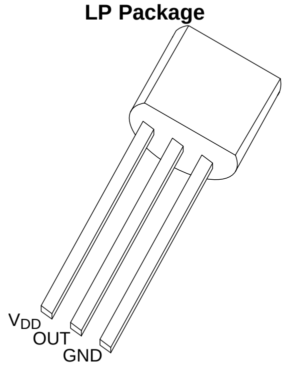
5-Pin SOT (SC70)
DCK Package
(TOP VIEW)



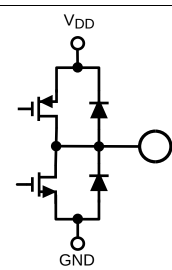
3-Pin TO-126
LPC Package



3-Pin TO-92
LP Package



Pin Functions

PIN				DESCRIPTION		
LABEL	DCK NUMBER	LP NUMBER	LPC NUMBER	TYPE	EQUIVALENT CIRCUIT	FUNCTION
V_{DD}	5			Power		Power Supply Voltage
V_{DD}	1			Power		Power Supply Voltage
OUT	3	See Pin Diagrams	See Pin Diagrams	Analog Output		Outputs a voltage which is inversely proportional to temperature
V_{DD}	4			Power		Positive Supply Voltage
GND	2			Ground		Power Supply Ground, (direct connection to the back side of the die)

7 Specifications

7.1 Absolute Maximum Ratings[(1)(2)]

	MIN	MAX	UNIT
Supply Voltage	−0.3	6	V
Voltage at Output Pin	−0.3	(V_{DD} + 0.5)	V
Output Current	-7	7	mA
Input Current at Any Pin[(3)]	-5	5	mA
Maximum Junction Temperature (T_{JMAX})		150	°C

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not specific performance limits. For specifications and test conditions, see the *Electrical Characteristics* . The specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
(2) Soldering process must comply with TI's Reflow Temperature Profile specifications. Refer to www.ti.com/packaging. Reflow temperature profiles are different for lead-free and non-lead-free packages.
(3) When the input voltage (V_I) at any pin exceeds power supplies (V_I < GND or V_I > V), the current at that pin should be limited to 5 mA.

7.2 Handling Ratings

			MIN	MAX	UNIT
T_{stg}	Storage temperature range		–65	150	°C
V_{ESD}	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins.[(1)] Applies for TO-92 package LMT87LP.	-2.5	2.5	kV
		Human body model (HBM), per JESD22-A114, all pin. Applies for SC70 package LMT87DCK and LMT87DCK-Q1.	-2.5	2.5	kV
		Charged device model (CDM), per JEDEC specification JESD22-C101, all pins. [(2)] Applies for all parts.	-1	1	kV
		Machine model ESD stress voltage, per JEDEC specification JESD22-A115.[(3)] Applies for SC70 package LMT87DCK and LMT87DCK-Q1.	-250	250	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.
(3) The machine model is a 200pF capacitor discharged directly into each pin.

7.3 Recommended Operating Conditions

		MIN	MAX	UNIT
	Specified Temperature Range	$T_{MIN} \le T_A \le T_{MAX}$		°C
		$-50 \le T_A \le 150$		°C
V_{DD}	Supply Voltage Range	2.7	5.5	V

7.4 Thermal Information

THERMAL METRIC[(1)]		LMT87 LMT87-Q1 DCK 5 PINS	LMT87 LP 3 PINS	LMT87 LPC 3 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance[(2)(3)]	275	167	TBD	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	84	90	TBD	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	56	146	TBD	°C/W
ψ_{JT}	Junction-to-top characterization parameter	1.2	35	TBD	°C/W
ψ_{JB}	Junction-to-board characterization parameter	55	146	TBD	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.
(2) The junction-to-ambient thermal resistance ($R_{\theta JA}$) under natural convection is obtained in a simulation on a JEDEC-standard, High K board as specified in JESD51-7, in an environment described in JESD51-2.
(3) Changes in output due to self heating can be computed by multiplying the internal dissipation by the thermal resistance.

7.5 Accuracy Characteristics

These limits do not include DC load regulation. These stated accuracy limits are with reference to the values in Table 2.

PARAMETER	CONDITIONS	MIN(1)	TYP	MAX(1)	UNIT
Temperature accuracy(2)	70°C to 150°C; V_{DD} = 3.0 V to 5.5 V	-2.7	±0.4	2.7	°C
	20°C to 40°C; V_{DD} = 2.7 V to 5.5 V		±0.6		°C
	20°C to 40°C; V_{DD} = 3.4 V to 5.5 V		±0.3		°C
	0°C; V_{DD} = 3.0 V to 5.5 V	-2.7	±0.6	2.7	°C
	0°C; V_{DD} = 3.6 V to 5.5 V		±0.3		°C
	–50°C; V_{DD} = 3.6 V to 5.5 V	-2.7	±0.6	2.7	°C
	–50°C; V_{DD} = 4.2 V to 5.5 V		±0.3		°C

(1) Limits are specific to TI's AOQL (Average Outgoing Quality Level).
(2) Accuracy is defined as the error between the measured and reference output voltages, tabulated in the Transfer Table at the specified conditions of supply gain setting, voltage, and temperature (expressed in °C). Accuracy limits include line regulation within the specified conditions. Accuracy limits do not include load regulation; they assume no DC load.

7.6 Electrical Characteristics

Unless otherwise noted, these specifications apply for $+V_{DD}$ = 2.7 V to 5.5 V. MIN and MAX limits apply for $T_A = T_J = T_{MIN}$ to T_{MAX} ; typical limits apply for $T_A = T_J$ = 25°C.

	PARAMETER	CONDITIONS	MIN(1)	TYP (2)	MAX (1)	UNIT
	Sensor gain (output transfer function slope)			–13.6		mV/°C
	Load regulation(3)	Source ≤ 50 µA, (V_{DD} – V_{OUT}) ≥ 200 mV	–1	–0.22		mV
		Sink ≤ 50 µA, V_{OUT} ≥ 200 mV		0.26	1	mV
	Line regulation(4)			200		µV/V
I_S	Supply current	T_A = 30°C to 150°C, (V_{DD} – V_{OUT}) ≥ 100 mV		5.4	8.1	µA
		T_A = –50°C to 150°C, (V_{DD} – V_{OUT}) ≥ 100 mV		5.4	9	µA
C_L	Output Load Capacitance			1100		pF
	Power-on time(5)	C_L= 0 pF to 1100 pF		0.7	1.9	ms
	Output drive	$T_A = T_J$ = 25°C	-50		50	µA

(1) Limits are specific to TI's AOQL (Average Outgoing Quality Level).
(2) Typicals are at $T_J = T_A$ = 25°C and represent most likely parametric norm.
(3) Source currents are flowing out of the LMT87 and LMT87-Q1. Sink currents are flowing into the LMT87 and LMT87-Q1.
(4) Line regulation (DC) is calculated by subtracting the output voltage at the highest supply voltage from the output voltage at the lowest supply voltage. The typical DC line regulation specification does not include the output voltage shift discussed in *Output Voltage Shift*.
(5) Specified by design and characterization.

7.7 Typical Characteristics

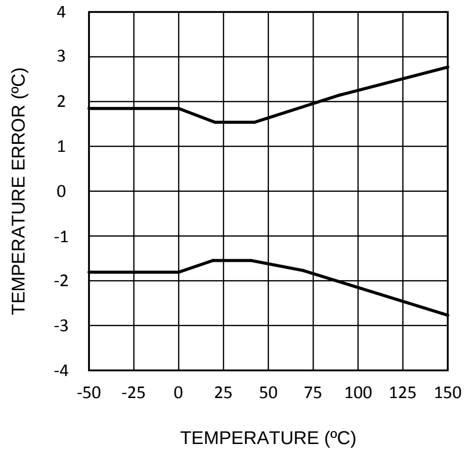


Figure 1. Temperature Error vs Temperature

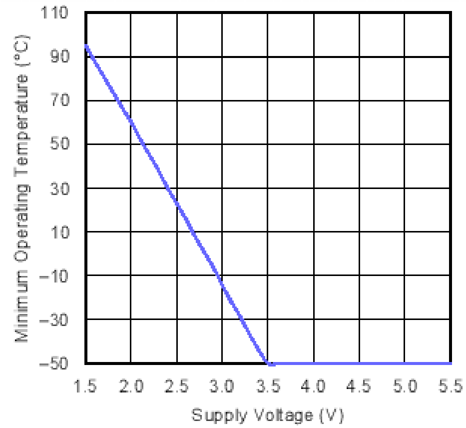


Figure 2. Minimum Operating Temperature vs Supply Voltage

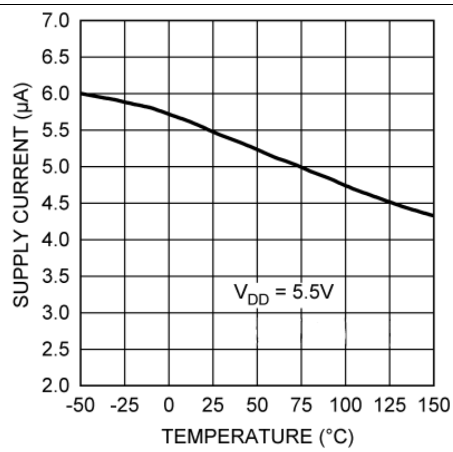


Figure 3. Supply Current vs Temperature

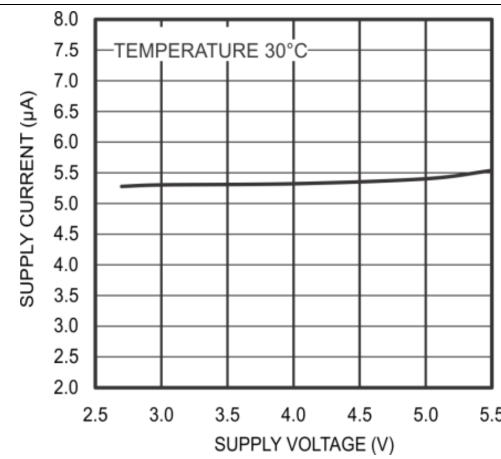


Figure 4. Supply Current vs Supply Voltage

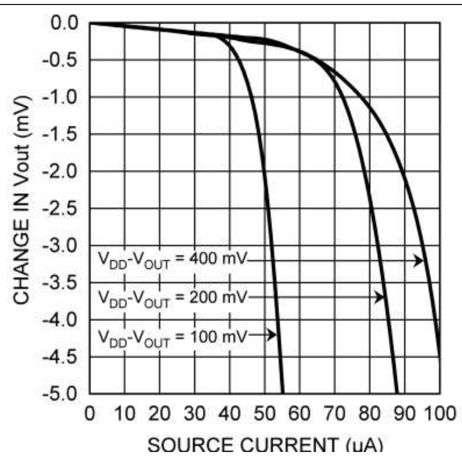


Figure 5. Load Regulation, Sourcing Current

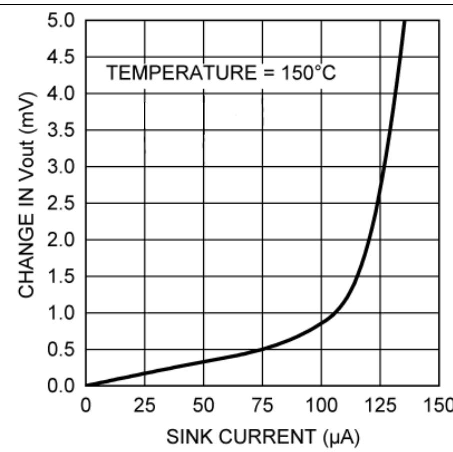


Figure 6. Load Regulation, Sinking Current

Typical Characteristics (continued)

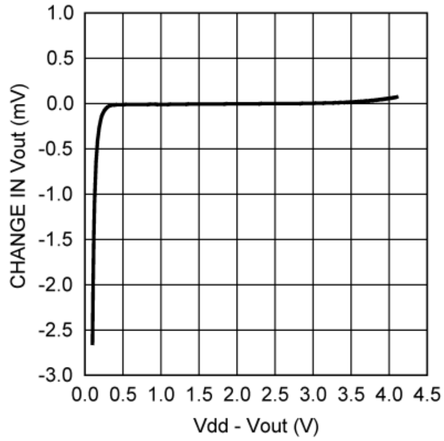


Figure 7. Change in V_{OUT} vs Overhead Voltage

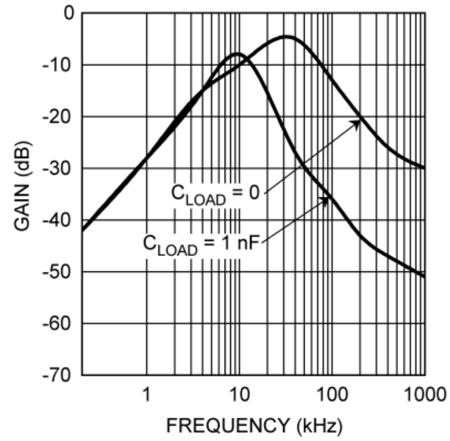


Figure 8. Supply-Noise Gain vs Frequency

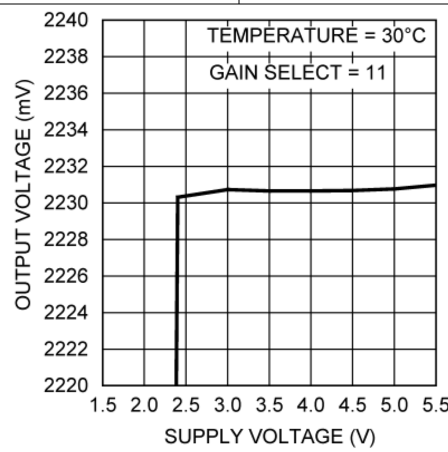


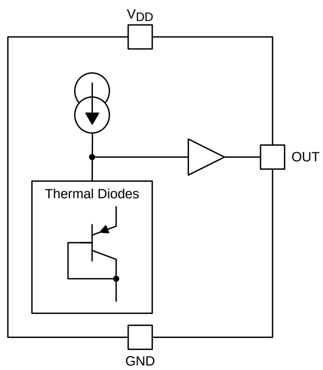
Figure 9. Output Voltage vs Supply Voltage

8 Detailed Description

8.1 Overview

The LMT87/LMT87-Q1 is an analog output temperature sensor. The temperature sensing element is comprised of a simple base emitter junction that is forward biased by a current source. The temperature sensing element is then buffered by an amplifier and provided to the OUT pin. The amplifier has a simple push-pull output stage thus providing a low impedance output source.

8.2 Functional Block Diagram



8.3 Feature Description

8.3.1 LMT87/LMT87-Q1 Transfer Function

The output voltage of the LMT87 and LMT87-Q1, across the complete operating temperature range is shown in Table 2. This table is the reference from which the LMT87 and LMT87-Q1 accuracy specifications (listed in the *Accuracy Characteristics* section) are determined. This table can be used, for example, in a host processor look-up table. A file containing this data is available for download at LMT87 product folder under Tools and Software Models.

Table 2. LMT87/LMT87-Q1 Transfer Table

TEMP (°C)	V_{OUT} (mV)	TEMP (°C)	V_{OUT} (mV)	TEMP (°C)	V_{OUT} (mV)	TEMP (°C)	V_{OUT} (mV)	TEMP (°C)	V_{OUT} (mV)
-50	3277	-10	2767	30	2231	70	1679	110	1115
-49	3266	-9	2754	31	2217	71	1665	111	1101
-48	3254	-8	2740	32	2204	72	1651	112	1087
-47	3243	-7	2727	33	2190	73	1637	113	1073
-46	3232	-6	2714	34	2176	74	1623	114	1058
-45	3221	-5	2700	35	2163	75	1609	115	1044
-44	3210	-4	2687	36	2149	76	1595	116	1030
-43	3199	-3	2674	37	2136	77	1581	117	1015
-42	3186	-2	2660	38	2122	78	1567	118	1001
-41	3173	-1	2647	39	2108	79	1553	119	987
-40	3160	0	2633	40	2095	80	1539	120	973
-39	3147	1	2620	41	2081	81	1525	121	958
-38	3134	2	2607	42	2067	82	1511	122	944
-37	3121	3	2593	43	2054	83	1497	123	929
-36	3108	4	2580	44	2040	84	1483	124	915
-35	3095	5	2567	45	2026	85	1469	125	901
-34	3082	6	2553	46	2012	86	1455	126	886
-33	3069	7	2540	47	1999	87	1441	127	872

Table 2. LMT87/LMT87-Q1 Transfer Table (continued)

TEMP (°C)	V_{OUT} (mV)	TEMP (°C)	V_{OUT} (mV)	TEMP (°C)	V_{OUT} (mV)	TEMP (°C)	V_{OUT} (mV)	TEMP (°C)	V_{OUT} (mV)
-32	3056	8	2527	48	1985	88	1427	128	858
-31	3043	9	2513	49	1971	89	1413	129	843
-30	3030	10	2500	50	1958	90	1399	130	829
-29	3017	11	2486	51	1944	91	1385	131	814
-28	3004	12	2473	52	1930	92	1371	132	800
-27	2991	13	2459	53	1916	93	1356	133	786
-26	2978	14	2446	54	1902	94	1342	134	771
-25	2965	15	2433	55	1888	95	1328	135	757
-24	2952	16	2419	56	1875	96	1314	136	742
-23	2938	17	2406	57	1861	97	1300	137	728
-22	2925	18	2392	58	1847	98	1286	138	713
-21	2912	19	2379	59	1833	99	1272	139	699
-20	2899	20	2365	60	1819	100	1257	140	684
-19	2886	21	2352	61	1805	101	1243	141	670
-18	2873	22	2338	62	1791	102	1229	142	655
-17	2859	23	2325	63	1777	103	1215	143	640
-16	2846	24	2311	64	1763	104	1201	144	626
-15	2833	25	2298	65	1749	105	1186	145	611
-14	2820	26	2285	66	1735	106	1172	146	597
-13	2807	27	2271	67	1721	107	1158	147	582
-12	2793	28	2258	68	1707	108	1144	148	568
-11	2780	29	2244	69	1693	109	1130	149	553
								150	538

Although the LMT87 and LMT87-Q1 is very linear, its response does have a slight umbrella parabolic shape. This shape is very accurately reflected in Table 2. The Transfer Table can be calculated by using the parabolic equation.

$$V_{TEMP}(mV) = 2230.8mV - \left[13.582\frac{mV}{°C}(T - 30°C)\right] - \left[0.00433\frac{mV}{°C^2}(T - 30°C)^2\right] \quad (1)$$

The parabolic equation is an approximation of the transfer table and the accuracy of the equation degrades slightly at the temperature range extremes. Equation 1 can be solved for T resulting in:

$$T = \frac{13.582 - \sqrt{(-13.582)^2 + 4 \times 0.00433 \times (2230.8 - V_{TEMP}(mV))}}{2 \times (-0.00433)} + 30 \quad (2)$$

For an even less accurate linear transfer function approximation, a line can easily be calculated over the desired temperature range from the Table using the two-point equation:

$$V - V_1 = \left(\frac{V_2 - V_1}{T_2 - T_1}\right) \times (T - T_1) \quad (3)$$

Where V is in mV, T is in °C, T_1 and V_1 are the coordinates of the lowest temperature, T_2 and V_2 are the coordinates of the highest temperature.

For example, if we want to resolve this equation, over a temperature range of 20°C to 50°C, we would proceed as follows:

$$V - 2365\text{ mV} = \left(\frac{1958\text{ mV} - 2365\text{ mV}}{50^oC - 20^oC}\right) \times (T - 20^oC) \quad (4)$$

$$V - 2365\text{ mV} = (-13.6\text{ mV} / {}^oC) \times (T - 20^oC) \quad (5)$$

$$V = (-13.6\text{ mV} / {}^oC) \times T + 2637\text{ mV} \quad (6)$$

Using this method of linear approximation, the transfer function can be approximated for one or more temperature ranges of interest.

8.4 Device Functional Modes

8.4.1 Mounting and Thermal Conductivity

The LMT87 and LMT87-Q1 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface.

To ensure good thermal conductivity, the backside of the LMT87 and LMT87-Q1 die is directly attached to the GND pin (Pin 2 of the SC70 DCK package). The temperatures of the lands and traces to the other leads of the LMT87 and LMT87-Q1 will also affect the temperature reading.

Alternatively, the LMT87 and LMT87-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 IC, the LMT87 and LMT87-Q1 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. If moisture creates a short circuit from the output to ground or V_{DD}, the output from the LMT87 and LMT87-Q1 will not be correct. Printed-circuit coatings are often used to ensure that moisture cannot corrode the leads or circuit traces.

The thermal resistance junction to ambient ($R_{\theta JA}$ or θ_{JA}) is the parameter used to calculate the rise of a device junction temperature due to its power dissipation. The equation used to calculate the rise in the LMT87 and LMT87-Q1's die temperature is:

$$T_J = T_A + \theta_{JA}\left[(V_{DD}I_S) + (V_{DD} - V_{OUT})\, I_L\right] \quad (7)$$

where T_A is the ambient temperature, I_S is the supply current, I_L is the load current on the output, and V_{out} is the output voltage. For example, in an application where T_A = 30°C, V_{DD} = 5 V, I_S = 5.4 μA, V_{OUT} = 2231 mV, and I_L = 2 μA, the junction temperature would be 30.014°C, showing a self-heating error of only 0.014°C. Since the LMT87 and LMT87-Q1's junction temperature is the actual temperature being measured, care should be taken to minimize the load current that the LMT87 and LMT87-Q1 is required to drive. *Thermal Information* shows the thermal resistance of the LMT87 and LMT87-Q1.

8.4.2 Output Noise Considerations

A push-pull output gives the LMT87 and LMT87-Q1 the ability to sink and source significant current. This is beneficial when, for example, driving dynamic loads like an input stage on an analog-to-digital converter (ADC). In these applications the source current is required to quickly charge the input capacitor of the ADC. See the section for more discussion of this topic. The LMT87 and LMT87-Q1 is ideal for this and other applications which require strong source or sink current.

The LMT87 and LMT87-Q1 supply-noise gain (the ratio of the AC signal on V_{OUT} to the AC signal on V_{DD}) was measured during bench tests. Its typical attenuation is shown in Figure 8 found in the Typical Characteristics section. A load capacitor on the output can help to filter noise.

For operation in very noisy environments, some bypass capacitance should be present on the supply within approximately 5 centimeters of the LMT87 and LMT87-Q1.

8.4.3 Capacitive Loads

The LMT87 and LMT87-Q1 handles capacitive loading well. In an extremely noisy environment, or when driving a switched sampling input on an ADC, it may be necessary to add some filtering to minimize noise coupling. Without any precautions, the LMT87 and LMT87-Q1 can drive a capacitive load less than or equal to 1100 pF as shown in Figure 10. For capacitive loads greater than 1100 pF, a series resistor may be required on the output, as shown in Figure 11.

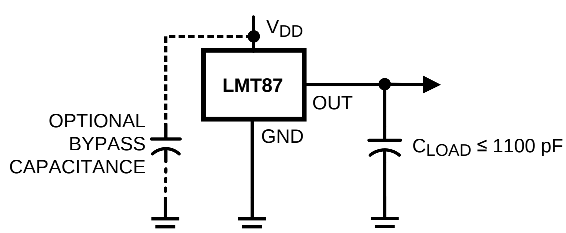


Figure 10. LMT87 No Decoupling Required for Capacitive Loads Less than 1100 pF

Device Functional Modes (continued)

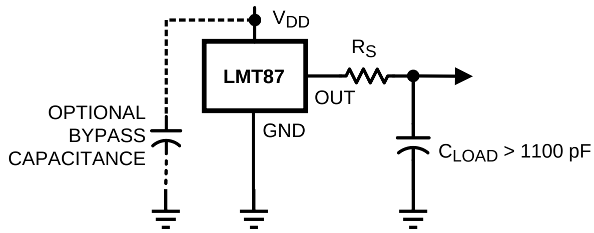


Figure 11. LMT87 with Series Resistor for Capacitive Loading Greater than 1100 pF

C_{LOAD}	MINIMUM R_S
1.1 nF to 99 nF	3 kΩ
100 nF to 999 nF	1.5 kΩ
1 µF	800 Ω

8.4.4 Output Voltage Shift

The LMT87 and LMT87-Q1 is very linear over temperature and supply voltage range. Due to the intrinsic behavior of an NMOS/PMOS rail-to-rail buffer, a slight shift in the output can occur when the supply voltage is ramped over the operating range of the device. The location of the shift is determined by the relative levels of V_{DD} and V_{OUT}. The shift typically occurs when V_{DD}- V_{OUT} = 1 V.

This slight shift (a few millivolts) takes place over a wide change (approximately 200 mV) in V_{DD} or V_{OUT}. Since the shift takes place over a wide temperature change of 5°C to 20°C, V_{OUT} is always monotonic. The accuracy specifications in the *Accuracy Characteristics* table already include this possible shift.

9 Application and Implementation

9.1 Application Information

The LMT87/LMT87-Q1 features make it suitable for many general temperature sensing applications. It can operate down to 2.7V supply with 5.4 uA power consumption. Multiple package options including through-hole TO-92 and TO-126 packages also allow the LMT87 to be mounted on-board, off-board, to a heat sink, or on multiple unique locations in the same application.

9.2 Typical Applications

9.2.1 Connection to ADC

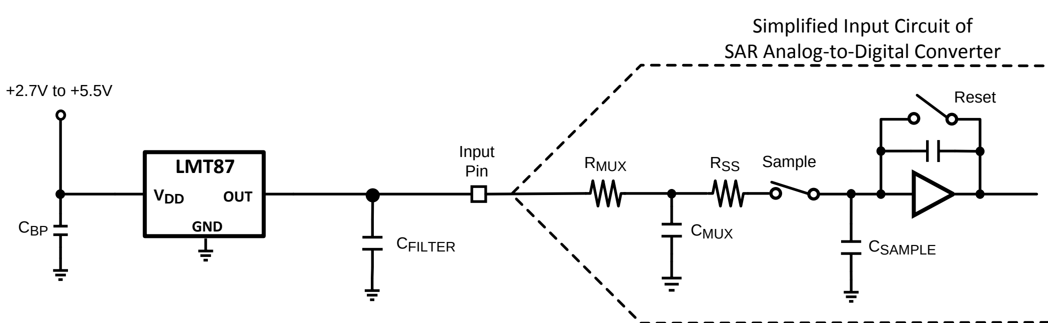


Figure 12. Suggested Connection to a Sampling Analog-to-Digital Converter Input Stage

Typical Applications (continued)

9.2.1.1 Design Requirements

Most CMOS ADCs found in microcontrollers and ASICs have a sampled data comparator input structure. When the ADC charges the sampling cap, it requires instantaneous charge from the output of the analog source such as the LMT87 and LMT87-Q1 temperature sensor and many op amps. This requirement is easily accommodated by the addition of a capacitor (C_{FILTER}).

9.2.1.2 Detailed Design Procedure

The size of C_{FILTER} depends on the size of the sampling capacitor and the sampling frequency. Since not all ADCs have identical input stages, the charge requirements will vary. This general ADC application is shown as an example only.

9.2.1.3 Application Curves

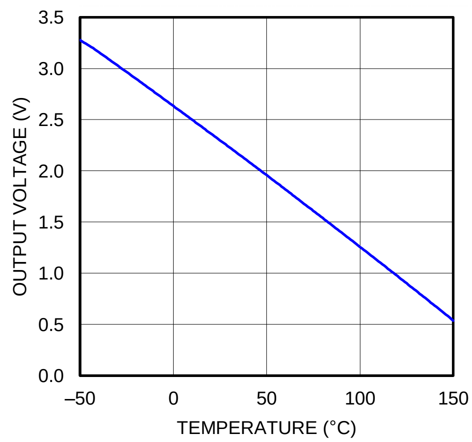


Figure 13. Analog Output Transfer Function

9.2.2 Conserving Power Dissipation with Shutdown

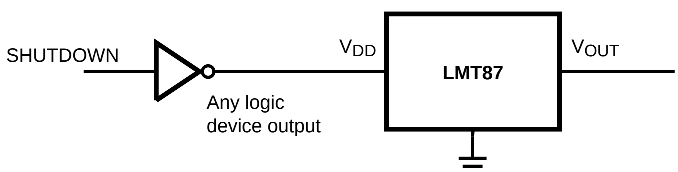


Figure 14. Simple Shutdown Connection of the LMT87

9.2.2.1 Design Requirements

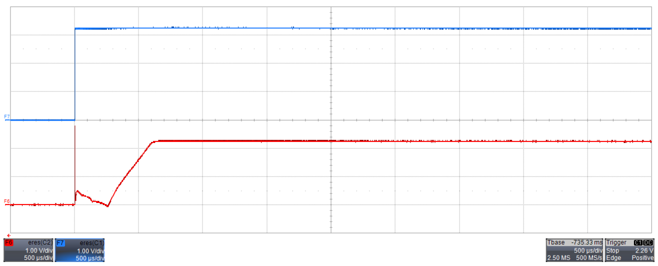
Since the power consumption of the LMT87 is less than 9 µA it can simply be powered directly from any logic gate output, thus not requiring a specific shutdown pin. The device can even be powered directly from a microcontroller GPIO. In this way it can easily be turned off for cases such as battery powered systems where power savings is critical.

9.2.2.2 Detailed Design Procedure

Simply connect the V_{DD} pin of the LMT87 directly to the logic shutdown signal from a microcontroller.

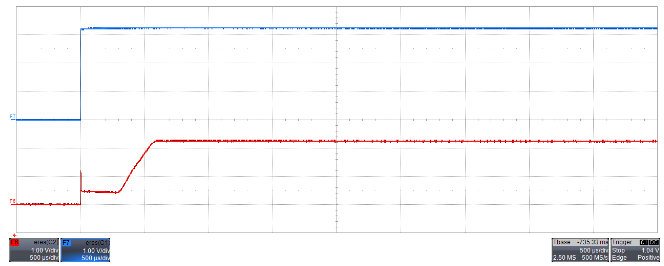
Typical Applications (continued)

9.2.2.3 Application Curves



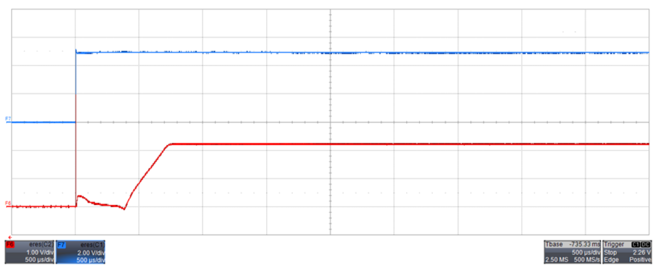
Time: 500 µsec/div; Top trace: V_{DD} 1 V/div;
Bottom trace: OUT 1 V/div

Figure 15. Output Turn-on Response Time without a Capacitive Load and V_{DD}=3.3V



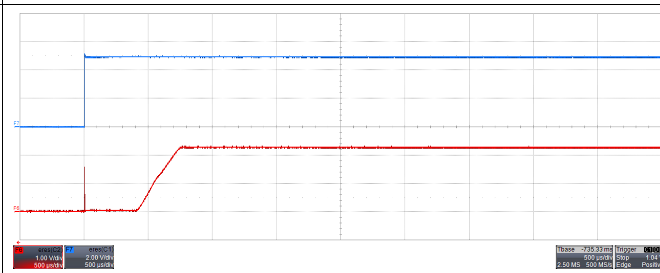
Time: 500 µsec/div; Top trace: V_{DD} 1 V/div;
Bottom trace: OUT 1 V/div

Figure 16. Output Turn-on Response Time with a 1.1 nF Capacitive Load and V_{DD}=3.3V



Time: 500 µsec/div; Top trace: V_{DD} 2 V/div;
Bottom trace: OUT 1 V/div

Figure 17. Output Turn-on Response Time without a Capacitive Load and V_{DD}=5V



Time: 500 µsec/div; Top trace: V_{DD} 2 V/div;
Bottom trace: OUT 1 V/div

Figure 18. Output Turn-on Response Time with a 1.1 nF Capacitive Load and V_{DD}=5V

10 Power Supply Recommendations

The LMT87's low supply current and supply range of 2.7V to 5.5V allow the device to easily be powered from many sources.

Power supply bypassing is optional and is mainly dependent on the noise on the power supply used. In noisy systems it may be necessary to add bypass capacitors to lower the noise that is coupled to the LMT87's output.

11 Layout

11.1 Layout Guidelines

The LMT87 is extremely simple to layout. If a power supply bypass capacitor is used it should be connected as shown in the Layout Example.

11.2 Layout Example

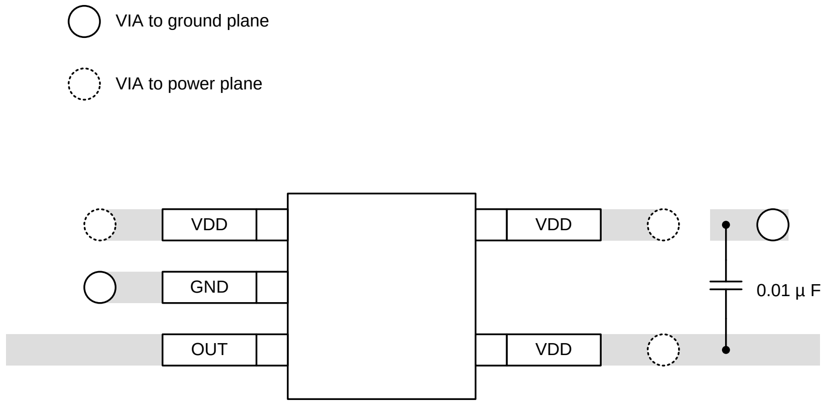


Figure 19. SC70 Package Recommended Layout

12 Device and Documentation Support

12.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 3. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
LMT87	Click here	Click here	Click here	Click here	Click here
LMT87-Q1	Click here	Click here	Click here	Click here	Click here

12.2 Trademarks

All trademarks are the property of their respective owners.

12.3 Electrostatic Discharge Caution

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.

12.4 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms and definitions.

13 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 Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LMT87DCKR	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-50 to 150	BUA	Samples
LMT87DCKT	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-50 to 150	BUA	Samples
LMT87LP	ACTIVE	TO-92	LP	3	1800	Green (RoHS & no Sb/Br)	CU SN	N / A for Pkg Type	-50 to 150	LMT87	Samples
LMT87LPC	PREVIEW	TO-126	LPC	3	60	TBD	Call TI	Call TI	-50 to 150		
LMT87LPM	ACTIVE	TO-92	LP	3	2000	Green (RoHS & no Sb/Br)	CU SN	N / A for Pkg Type	-50 to 150	LMT87	Samples
LMT87QDCKRQ1	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-50 to 150	BVA	Samples
LMT87QDCKTQ1	ACTIVE	SC70	DCK	5	250	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-50 to 150	BVA	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) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

[5] Multiple Device Markings will be inside parentheses. Only one Device 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 Device Marking for that device.

[6] Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF LMT87, LMT87-Q1 :

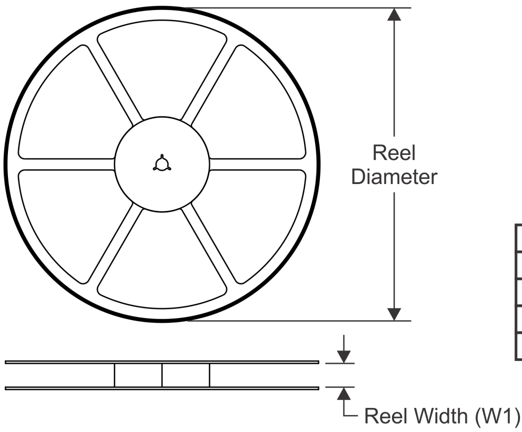
- Catalog: LMT87
- Automotive: LMT87-Q1

NOTE: Qualified Version Definitions:

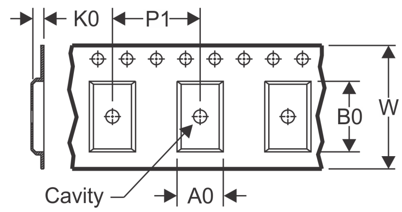
- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

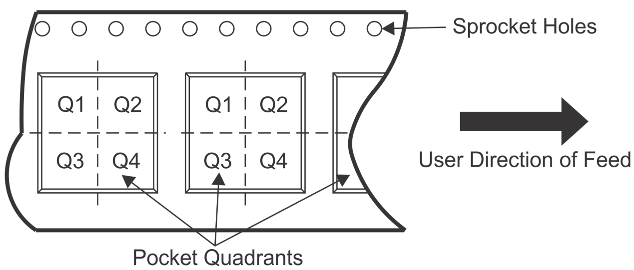


TAPE DIMENSIONS



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

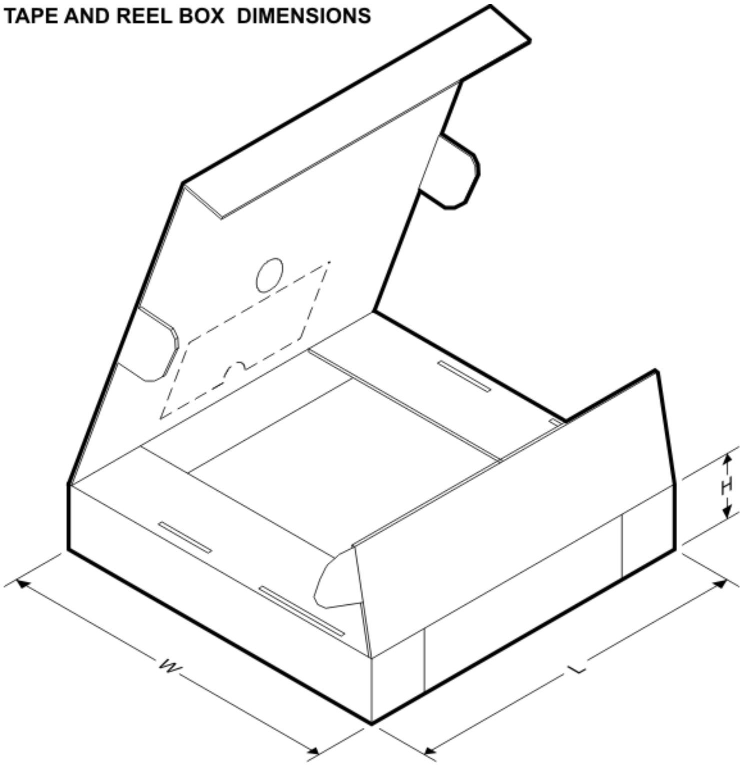
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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
LMT87DCKR	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMT87DCKT	SC70	DCK	5	250	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMT87QDCKRQ1	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMT87QDCKTQ1	SC70	DCK	5	250	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3

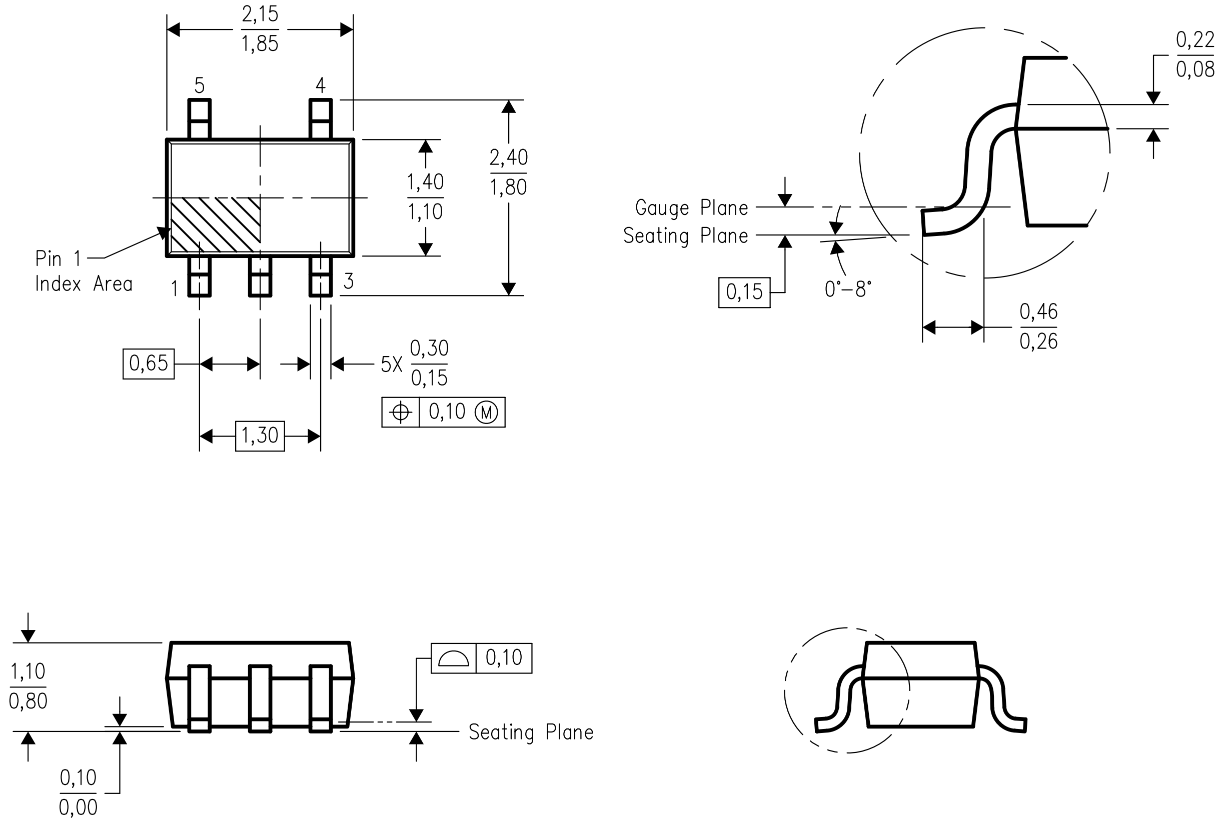
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMT87DCKR	SC70	DCK	5	3000	210.0	185.0	35.0
LMT87DCKT	SC70	DCK	5	250	210.0	185.0	35.0
LMT87QDCKRQ1	SC70	DCK	5	3000	210.0	185.0	35.0
LMT87QDCKTQ1	SC70	DCK	5	250	210.0	185.0	35.0

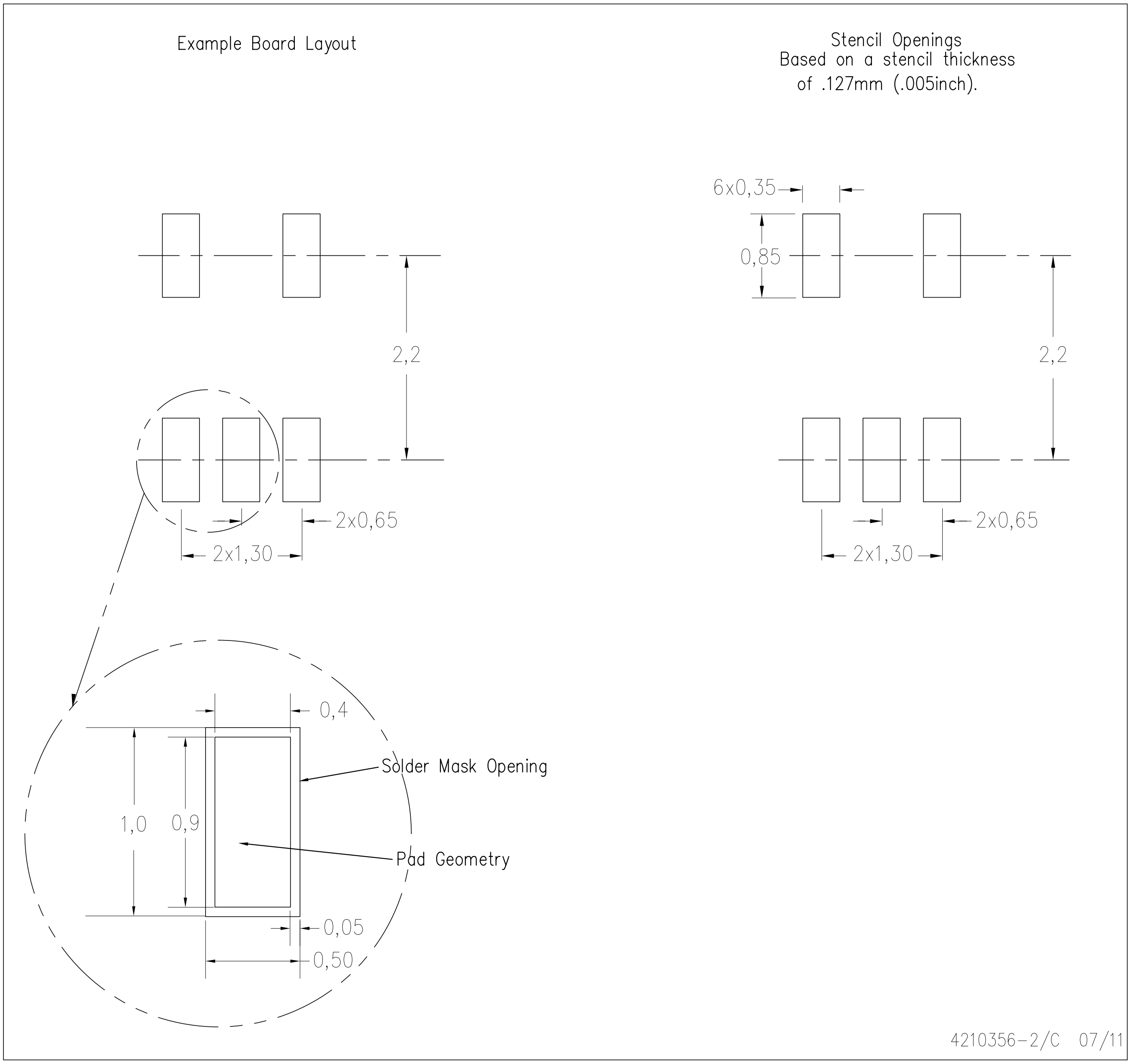
DCK (R-PDSO-G5) PLASTIC SMALL-OUTLINE PACKAGE



4093553-3/G 01/2007

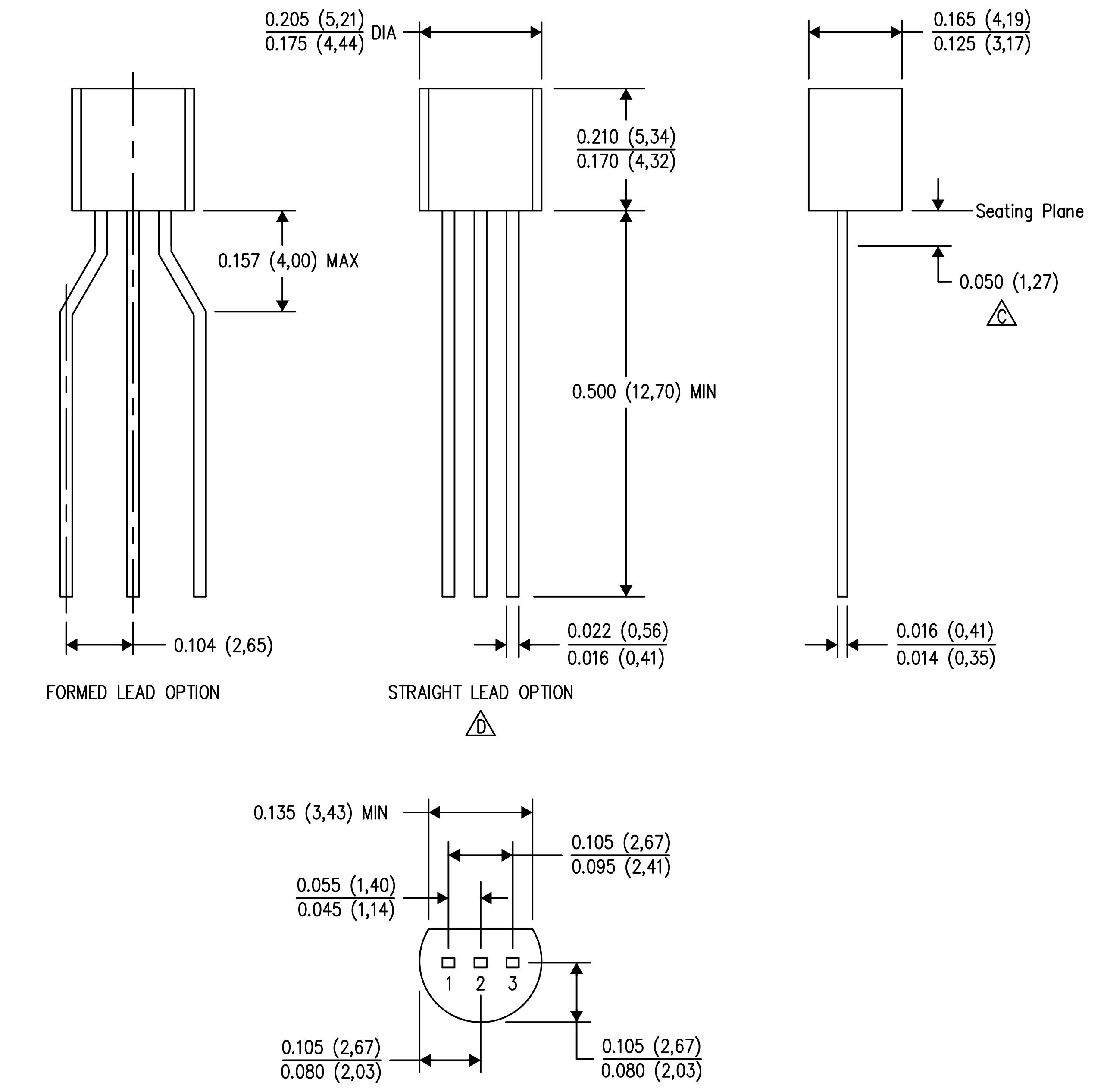
NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
D. Falls within JEDEC MO-203 variation AA.

DCK (R–PDSO–G5) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
- D. Publication IPC–7351 is recommended for alternate designs.
- E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC–7525 for other stencil recommendations.

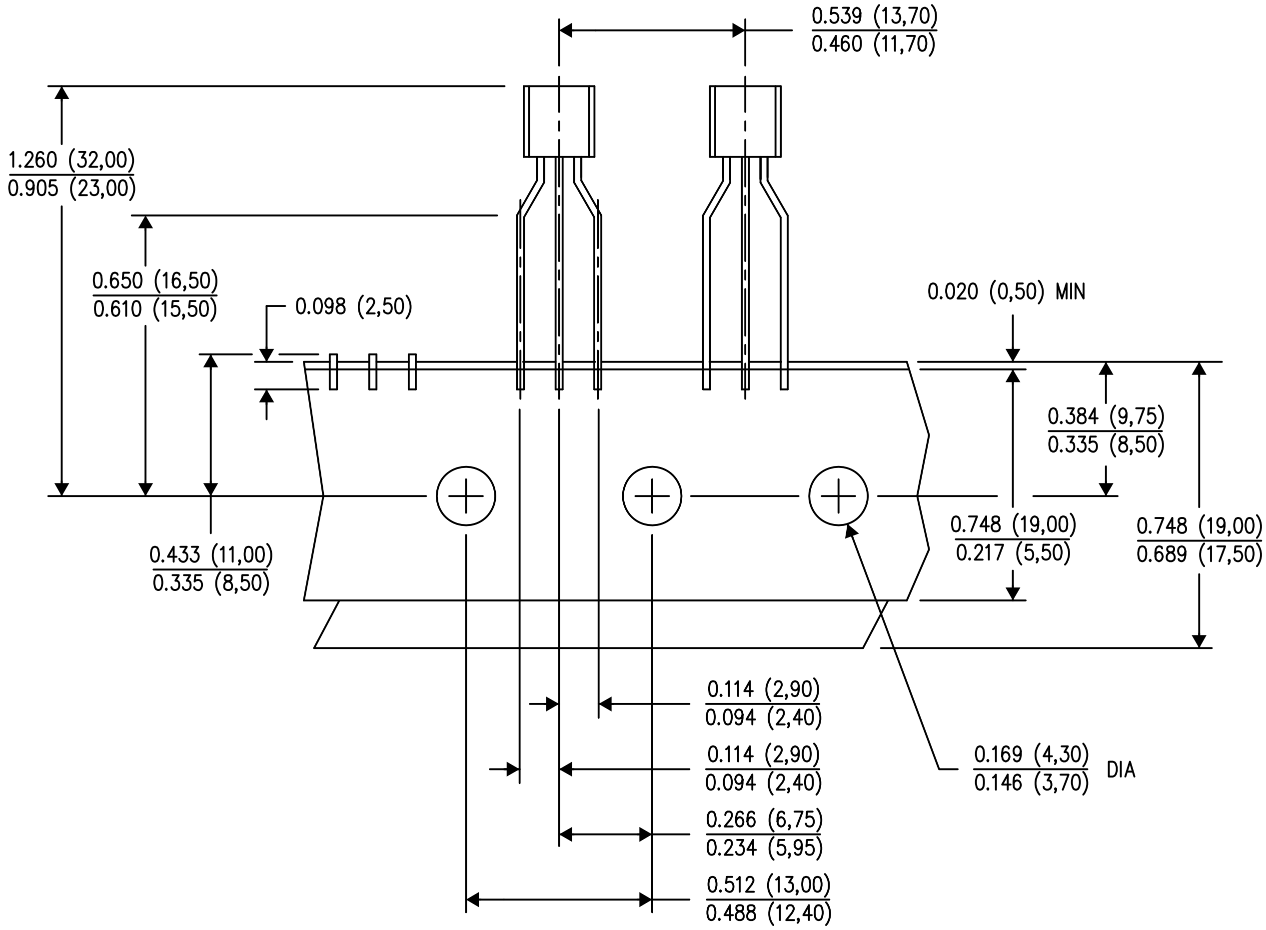
LP (O-PBCY-W3) PLASTIC CYLINDRICAL PACKAGE



4040001-2/E 08/13

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Lead dimensions are not controlled within this area.
D. Falls within JEDEC TO-226 Variation AA (TO-226 replaces TO-92).
E. Shipping Method:
Straight lead option available in bulk pack only.
Formed lead option available in tape & reel or ammo pack.
Specific products can be offered in limited combinations of shipping mediums and lead options.
Consult product folder for more information on available options.

LP (O-PBCY-W3) PLASTIC CYLINDRICAL PACKAGE



TAPE & REEL

4040001-3/E 08/13

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Tape and Reel information for the Formed Lead Option package.

IMPORTANT NOTICE

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
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DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
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Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
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