

# LMT86、LMT86-Q1 2.2V、SC70/TO-92/TO-92S

## 模拟温度传感器

### 1 特性

- LMT86-Q1 符合 AEC-Q100 标准，适用于汽车应用：
  - 器件温度等级 0:  $-40^{\circ}\text{C}$  至  $+150^{\circ}\text{C}$
  - 器件人体放电模式 (HBM) 静电放电 (ESD) 分类等级 2
  - 器件 CDM ESD 分类等级 C6
- LMT86LPG (TO-92S 封装) 具有快速热时间常量，典型值为 10s (空气流量为 1.2m/s)
- 非常精确：典型值  $\pm 0.4^{\circ}\text{C}$
- 2.2V 低压运行
- $-10.9\text{mV}/^{\circ}\text{C}$  的平均传感器增益
- $5.4\mu\text{A}$  低静态电流
- 宽温度范围： $-50^{\circ}\text{C}$  至  $150^{\circ}\text{C}$
- 输出受到短路保护
- 具有  $\pm 50\mu\text{A}$  驱动能力的推挽输出
- 封装尺寸兼容符合行业标准的 LM20/19 和 LM35 温度传感器
- 具有成本优势的热敏电阻替代产品

### 2 应用

- 汽车
- 信息娱乐系统与仪表组
- 动力传动系统
- 烟雾和热量探测器
- 无人机
- 电器

### 3 说明

LMT86 和 LMT86-Q1 是精密 CMOS 温度传感器，其典型精度为  $\pm 0.4^{\circ}\text{C}$  (最大值为  $\pm 2.7^{\circ}\text{C}$ )，且线性模拟输出电压与温度成反比关系。2.2V 工作电源电压、 $5.4\mu\text{A}$  静态电流和 0.7ms 加电时间可实现有效的功率循环架构，以最大限度地降低无人机和传感器节点等电池供电应用的功耗。LMT86LPG 穿孔 TO-92S 封装快速热时间常量支持非板载时间温度敏感型应用，例如烟雾和热量探测器。LMT86-Q1 器件符合 AEC-Q100 0 级标准，在整个工作温度范围内可保持  $\pm 2.7^{\circ}\text{C}$  的最大精度，且无需校准；因此 LMT86-Q1 适用于汽车应用，例如信息娱乐系统、仪表组和动力传动系统。得益于宽工作范围内的精度和其他特性，LMT86 和 LMT86-Q1 成为热敏电阻的优质替代产品。

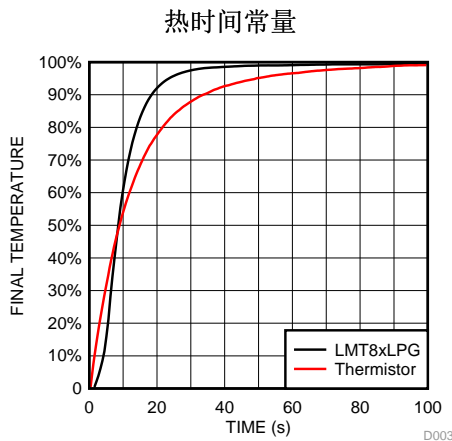
对于具有不同平均传感器增益和类似精度的器件，请参阅 [类似替代器件](#) 了解 LMT8x 系列中的替代器件。

器件信息<sup>(1)</sup>

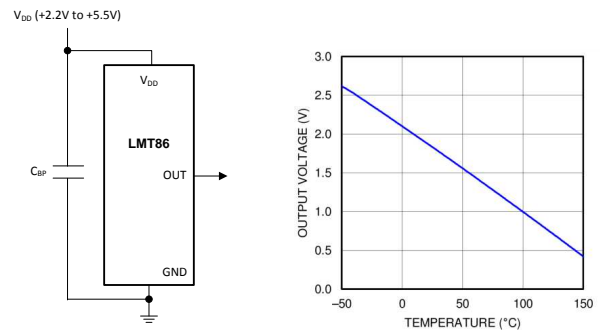
器件型号	封装	封装尺寸 (标称值)
LMT86	SOT (5)	2.00mm × 1.25mm
	TO-92 (3)	4.3mm × 3.5mm
LMT86-Q1	SOT (5)	2.00mm × 1.25mm

(1) 如需了解所有可用封装，请参阅产品说明书末尾的可订购产品附录。

### 输出电压与温度间的关系



\* 快速热响应 NTC



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目录

1	特性 .....	1	8.3	Feature Description .....	9
2	应用 .....	1	8.4	Device Functional Modes .....	11
3	说明 .....	1	<b>9</b>	<b>Application and Implementation .....</b>	<b>13</b>
4	修订历史记录 .....	2	9.1	Application Information .....	13
5	<b>Device Comparison Tables .....</b>	<b>3</b>	9.2	Typical Applications .....	13
6	<b>Pin Configuration and Functions .....</b>	<b>3</b>	<b>10</b>	<b>Power Supply Recommendations .....</b>	<b>14</b>
7	<b>Specifications .....</b>	<b>4</b>	<b>11</b>	<b>Layout .....</b>	<b>15</b>
7.1	Absolute Maximum Ratings .....	4	11.1	Layout Guidelines .....	15
7.2	ESD Ratings – LMT86 .....	4	11.2	Layout Example .....	15
7.3	ESD Ratings – LMT86-Q1 .....	4	<b>12</b>	<b>器件和文档支持 .....</b>	<b>16</b>
7.4	Recommended Operating Conditions .....	5	12.1	相关链接 .....	16
7.5	Thermal Information .....	5	12.2	接收文档更新通知 .....	16
7.6	Accuracy Characteristics .....	6	12.3	社区资源 .....	16
7.7	Electrical Characteristics .....	6	12.4	商标 .....	16
7.8	Typical Characteristics .....	7	12.5	静电放电警告 .....	16
<b>8</b>	<b>Detailed Description .....</b>	<b>9</b>	12.6	Glossary .....	16
8.1	Overview .....	9	<b>13</b>	<b>机械、封装和可订购信息 .....</b>	<b>16</b>
8.2	Functional Block Diagram .....	9			

4 修订历史记录

注：之前版本的页码可能与当前版本有所不同。

Changes from Revision C (October 2015) to Revision D	Page
• 将产品说明书文本更新为最新的文档和翻译标准 .....	1
• 将 AEC-Q100 汽车标准项目符号添加到了“特性”中 .....	1
• 添加了时间常量图 .....	1
• 将磁盘驱动器、游戏、无线收发器和手机从“应用”中进行了删除 .....	1
• Added LPG (TO-92S) package .....	3
• Added <a href="#">Figure 10</a> to <i>Typical Characteristics</i> .....	7

Changes from Revision B (May 2014) to Revision C	Page
• 已删除 所有涉及 TO-126 封装的内容 .....	1
• Added TO-92 LPM pin configuration graphic .....	3
• Changed Handling Ratings to ESD Ratings and moved Storage Temperature to Absolute Maximum Ratings table .....	4
• Changed KV to V .....	4
• Added layout recommendation for TO-92 LP and LPM packages .....	15

Changes from Revision A (June 2013) to Revision B	Page
• 已更改 产品说明书流程和布局，以符合新的 TI 标准。添加了以下部分：应用和实施；电源建议；布局；器件和文档支持；机械、封装和可订购信息 .....	1
• 已添加 TO-92 和 TO-126 封装信息。 .....	1
• Changed from 450°C/W to 275 °C/W. New specification is derived using TI ' s latest methodology. ....	5
• Changed Temperature Accuracy $V_{DD}$ condition from 2.4V to 2.2V for range of 40°C to 150°C. ....	6
• Deleted Note: The input current is leakage only and is highest at high temperature. It is typically only 0.001 $\mu$ A. The 1 $\mu$ A limit is solely based on a testing limitation and does not reflect the actual performance of the part.....	6

## 5 Device Comparison Tables

**Table 1. Available Device Packages**

ORDER NUMBER <sup>(1)</sup>	PACKAGE	PIN	BODY SIZE (NOM)	MOUNTING TYPE
LMT86DCK	SOT (AKA <sup>(2)</sup> : SC70, DCK)	5	2.00 mm × 1.25 mm	Surface Mount
LMT86LP	TO-92 (AKA <sup>(2)</sup> : LP)	3	4.30 mm × 3.50 mm	Through-hole; straight leads
LMT86LPG	TO-92S (AKA <sup>(2)</sup> : LPG)	3	4.00 mm × 3.15 mm	Through-hole; straight leads
LMT86LPM	TO-92 (AKA <sup>(2)</sup> : LPM)	3	4.30 mm × 3.50 mm	Through-hole; formed leads
LMT86DCK-Q1	SOT (AKA <sup>(2)</sup> : SC70, DCK)	5	2.00 mm × 1.25 mm	Surface Mount

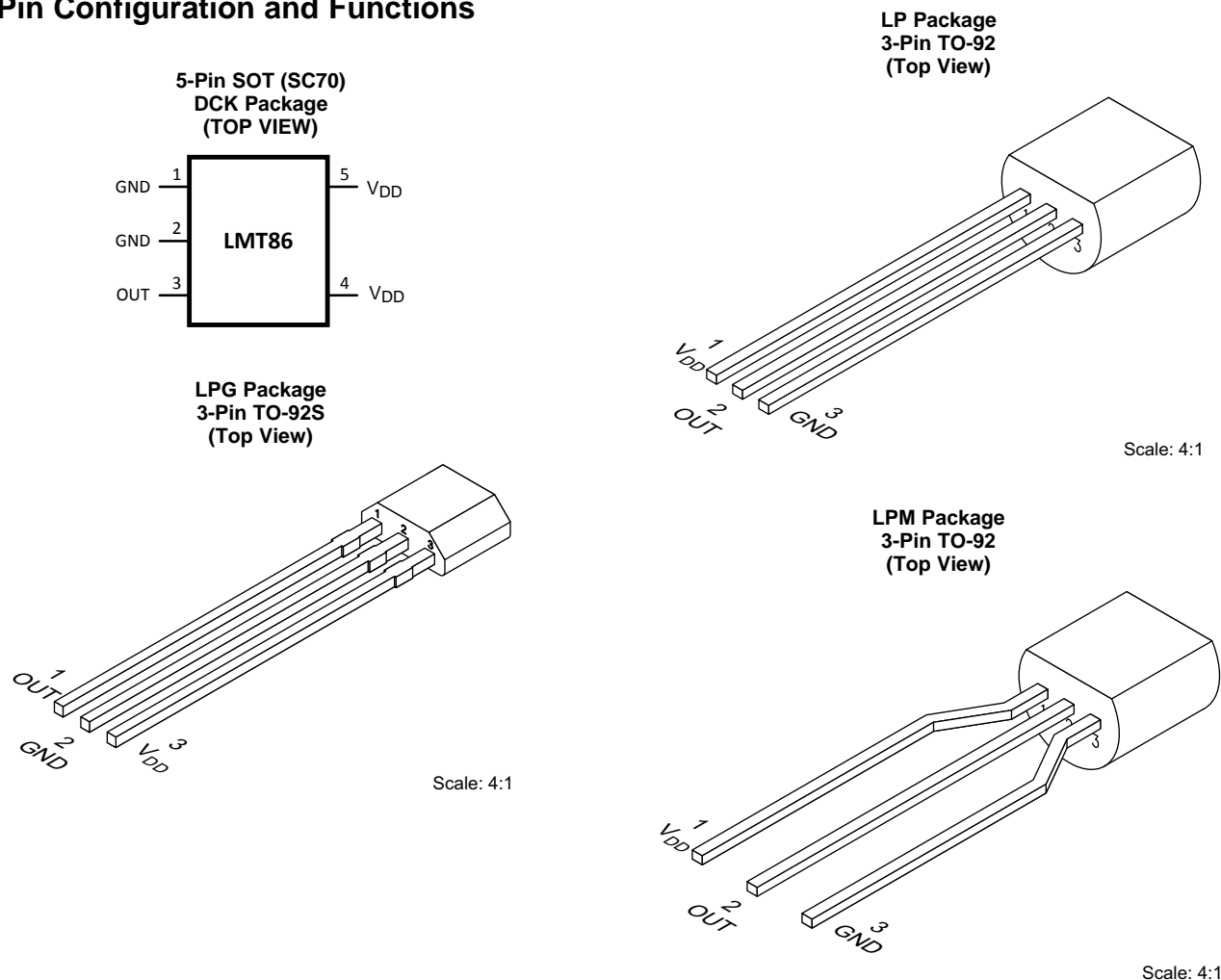
(1) For all available packages and complete order numbers, see the Package Option addendum at the end of the data sheet.

(2) AKA = Also Known As

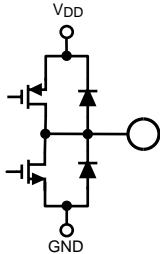
**Table 2. Comparable Alternative Devices**

DEVICE NAME	AVERAGE OUTPUT SENSOR GAIN	POWER SUPPLY RANGE
<a href="#">LMT84/LMT84-Q1</a>	-5.5 mV/°C	1.5 V to 5.5 V
<a href="#">LMT85/LMT85-Q1</a>	-8.2 mV/°C	1.8 V to 5.5 V
<a href="#">LMT86/LMT86-Q1</a>	-10.9 mV/°C	2.2 V to 5.5 V
<a href="#">LMT87/LMT87-Q1</a>	-13.6 mV/°C	2.7 V to 5.5 V

## 6 Pin Configuration and Functions



**Pin Functions**

PIN				DESCRIPTION		
NAME	SOT (SC70)	TO-92	TO-92S	TYPE	EQUIVALENT CIRCUIT	FUNCTION
GND	1, 2 <sup>(1)</sup>	1	2	Ground	N/A	Power Supply Ground
OUT	3	2	1	Analog Output		Outputs a voltage that is inversely proportional to temperature
V <sub>DD</sub>	4, 5	3	3	Power	N/A	Positive Supply Voltage

(1) Direct connection to the back side of the die

## 7 Specifications

### 7.1 Absolute Maximum Ratings <sup>(1)(2)</sup>

	MIN	MAX	UNIT
Supply voltage	-0.3	6	V
Voltage at output pin	-0.3	(V <sub>DD</sub> + 0.5)	V
Output current	-7	7	mA
Input current at any pin <sup>(3)</sup>	-5	5	mA
Maximum junction temperature (T <sub>JMAX</sub> )		150	°C
Storage temperature, T <sub>stg</sub>	-65	150	°C

- Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- Soldering process must comply with TI's Reflow Temperature Profile specifications. Refer to [www.ti.com/packaging](http://www.ti.com/packaging). Reflow temperature profiles are different for lead-free and non-lead-free packages.
- When the input voltage (V<sub>I</sub>) at any pin exceeds power supplies (V<sub>I</sub> < GND or V<sub>I</sub> > V), the current at that pin should be limited to 5 mA.

### 7.2 ESD Ratings – LMT86

		VALUE	UNIT
LMT86LP in TO-92 package			
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)(2)</sup>	±2500
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(3)</sup>	±1000
LMT86DCK in SC70 package			
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per JESD22-A114 <sup>(2)</sup>	±2500
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(3)</sup>	±1000

- JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- The human body model is a 100-pF capacitor discharged through a 1.5-kΩ resistor into each pin.
- JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 7.3 ESD Ratings – LMT86-Q1

		VALUE	UNIT
LMT86DCK-Q1 in SC70 package			
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per AEC Q100-002 <sup>(1)</sup>	±2500
		Charged-device model (CDM), per AEC Q100-011	±1000

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

## 7.4 Recommended Operating Conditions

	MIN	MAX	UNIT
Specified temperature	$T_{\text{MIN}} \leq T_A \leq T_{\text{MAX}}$		°C
	$-50 \leq T_A \leq 150$		°C
Supply voltage ( $V_{\text{DD}}$ )	2.2	5.5	V

## 7.5 Thermal Information<sup>(1)</sup>

THERMAL METRIC <sup>(2)</sup>	LMT86/ LMT86-Q1	LMT86LP	LMT86LPG	UNIT
	DCK (SOT/SC70)	LP/LPM (TO-92)	LPG (TO-92S)	
	5 PINS	3 PINS	3 PINS	
$R_{\theta\text{JA}}$ Junction-to-ambient thermal resistance <sup>(3)(4)</sup>	275	167	130.4	°C/W
$R_{\theta\text{JC(top)}}$ Junction-to-case (top) thermal resistance	84	90	64.2	°C/W
$R_{\theta\text{JB}}$ Junction-to-board thermal resistance	56	146	106.2	°C/W
$\Psi_{\text{JT}}$ Junction-to-top characterization parameter	1.2	35	14.6	°C/W
$\Psi_{\text{JB}}$ Junction-to-board characterization parameter	55	146	106.2	°C/W

- (1) For information on self-heating and thermal response time, see section [Mounting and Thermal Conductivity](#).
- (2) For more information about traditional and new thermal metrics, see the [IC Package Thermal Metrics](#) application report.
- (3) The junction to ambient thermal resistance ( $R_{\theta\text{JA}}$ ) 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. Exposed pad packages assume that thermal vias are included in the PCB, per JESD 51-5.
- (4) Changes in output due to self heating can be computed by multiplying the internal dissipation by the thermal resistance.

## 7.6 Accuracy Characteristics

These limits do not include DC load regulation. These stated accuracy limits are with reference to the values in [Table 3](#).

PARAMETER	CONDITIONS	MIN <sup>(1)</sup>	TYP <sup>(2)</sup>	MAX <sup>(1)</sup>	UNIT
Temperature accuracy <sup>(3)</sup>	40°C to 150°C; V <sub>DD</sub> = 2.2 V to 5.5 V	-2.7	±0.4	2.7	°C
	0°C to 40°C; V <sub>DD</sub> = 2.4 V to 5.5 V	-2.7	±0.7	2.7	°C
	0°C to 70°C; V <sub>DD</sub> = 3.0 V to 5.5 V		±0.3		°C
	-50°C to 0°C; V <sub>DD</sub> = 3.0 V to 5.5 V	-2.7	±0.7	2.7	°C
	-50°C to 0°C; V <sub>DD</sub> = 3.6 V to 5.5 V		±0.25		°C

- (1) Limits are specified to TI's AOQL (Average Outgoing Quality Level).
- (2) Typical values are at T<sub>J</sub> = T<sub>A</sub> = 25°C and represent most likely parametric norm.
- (3) 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.

## 7.7 Electrical Characteristics

Unless otherwise noted, these specifications apply for +V<sub>DD</sub> = 2.2 V to 5.5 V. MIN and MAX limits apply for T<sub>A</sub> = T<sub>J</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>, unless otherwise noted; typical values apply for T<sub>A</sub> = T<sub>J</sub> = 25°C.

PARAMETER	TEST CONDITIONS	MIN <sup>(1)</sup>	TYP <sup>(2)</sup>	MAX <sup>(1)</sup>	UNIT
Average sensor gain (output transfer function slope)	-30°C and 90°C used to calculate average sensor gain		-10.9		mV/°C
Load regulation <sup>(3)</sup>	Source ≤ 50 μA, (V <sub>DD</sub> - V <sub>OUT</sub> ) ≥ 200 mV	-1	-0.22		mV
	Sink ≤ 50 μA, V <sub>OUT</sub> ≥ 200 mV		0.26	1	mV
Line regulation <sup>(4)</sup>			200		μV/V
I <sub>S</sub> Supply current	T <sub>A</sub> = 30°C to 150°C, (V <sub>DD</sub> - V <sub>OUT</sub> ) ≥ 100 mV		5.4	8.1	μA
	T <sub>A</sub> = -50°C to 150°C, (V <sub>DD</sub> - V <sub>OUT</sub> ) ≥ 100 mV		5.4	9	μA
C <sub>L</sub> Output load capacitance			1100		pF
Power-on time <sup>(5)</sup>	C <sub>L</sub> = 0 pF to 1100 pF		0.7	1.9	ms
Output drive	T <sub>A</sub> = T <sub>J</sub> = 25°C	-50		50	μA

- (1) Limits are specific to TI's AOQL (Average Outgoing Quality Level).
- (2) Typical values are at T<sub>J</sub> = T<sub>A</sub> = 25°C and represent most likely parametric norm.
- (3) Source currents are flowing out of the LMT86 and LMT86-Q1. Sink currents are flowing into the LMT86 and LMT86-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.

### 7.8 Typical Characteristics

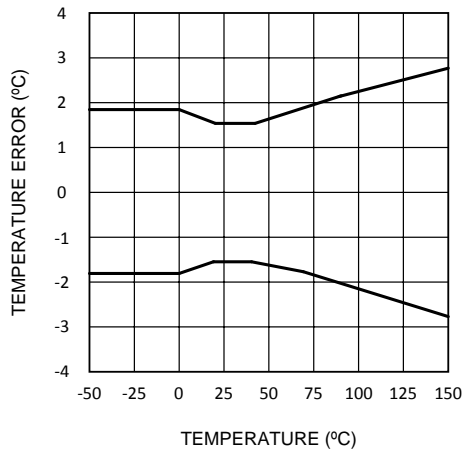


Figure 1. Temperature Error vs Temperature

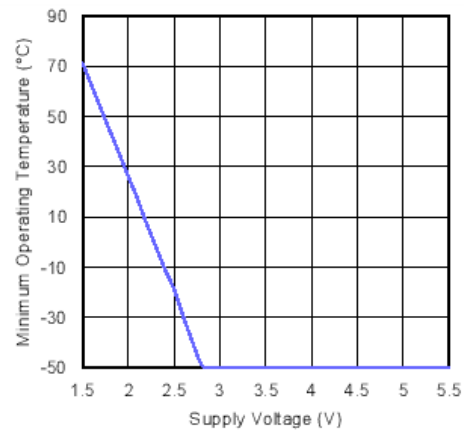


Figure 2. Minimum Operating Temperature vs Supply Voltage

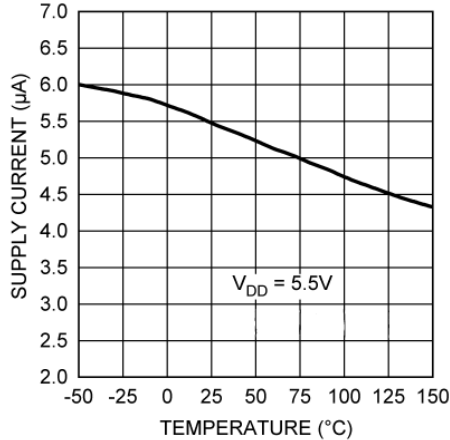


Figure 3. Supply Current vs Temperature

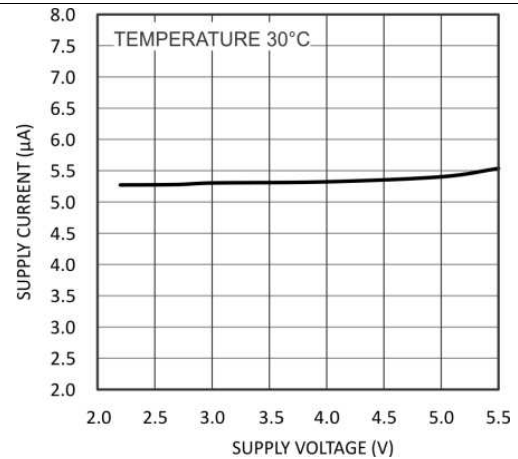


Figure 4. Supply Current vs Supply Voltage

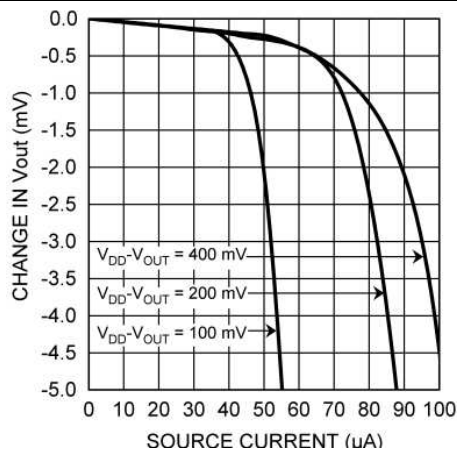


Figure 5. Load Regulation, Sourcing Current

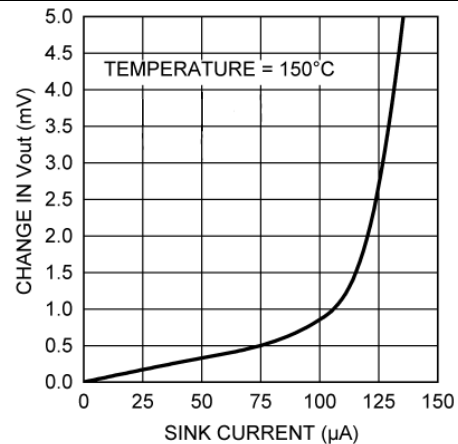


Figure 6. Load Regulation, Sinking Current

Typical Characteristics (continued)

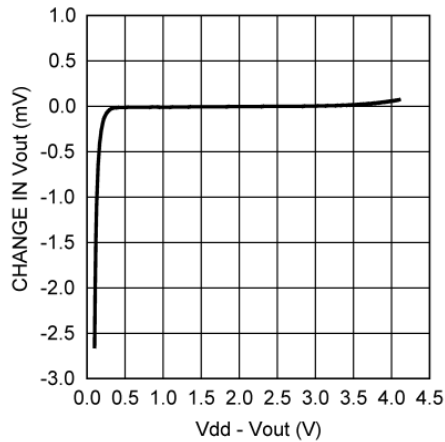


Figure 7. Change in  $V_{OUT}$  vs Overhead Voltage

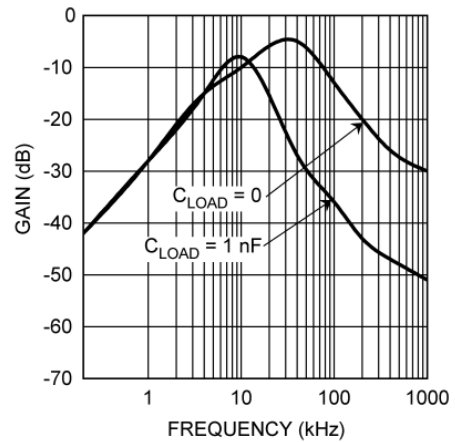


Figure 8. Supply-Noise Gain vs Frequency

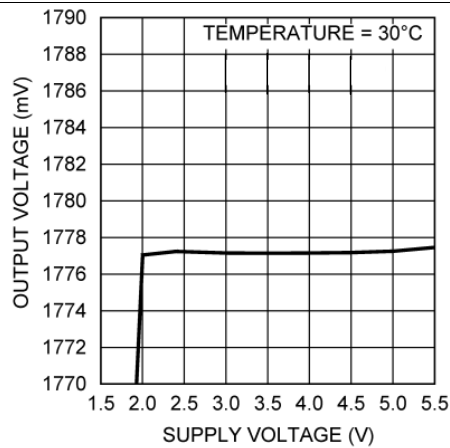


Figure 9. Output Voltage vs Supply Voltage

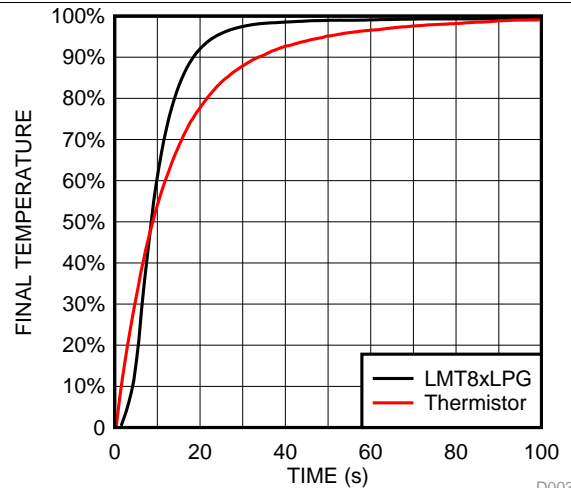


Figure 10. LMT86LPG Thermal Response vs Common Leaded Thermistor With 1.2-m/s Airflow



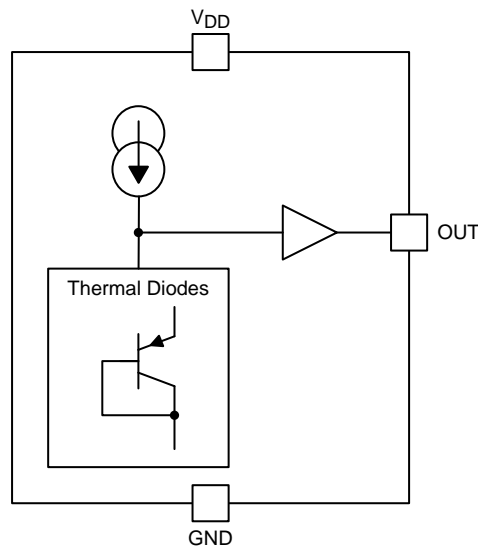
## 8 Detailed Description

### 8.1 Overview

The LMT86 and LMT86-Q1 are analog output temperature sensors. The electrical characteristics of the LMT86 and LMT86-Q1 are identical, so for clarity, the devices will be subsequently referred to as simply LMT86. 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

Full-Range Celsius Temperature Sensor (–50°C to +150°C)



### 8.3 Feature Description

#### 8.3.1 LMT86 Transfer Function

The output voltage of the LMT86, across the complete operating temperature range, is shown in [Table 3](#). This table is the reference from which the LMT86 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 [LMT86 product folder](#) under *Tools and Software Models*.

**Table 3. LMT86 Transfer Table**

TEMP (°C)	V <sub>OUT</sub> (mV)	TEMP (°C)	V <sub>OUT</sub> (mV)	TEMP (°C)	V <sub>OUT</sub> (mV)	TEMP (°C)	V <sub>OUT</sub> (mV)	TEMP (°C)	V <sub>OUT</sub> (mV)
-50	2616	-10	2207	30	1777	70	1335	110	883
-49	2607	-9	2197	31	1766	71	1324	111	872
-48	2598	-8	2186	32	1756	72	1313	112	860
-47	2589	-7	2175	33	1745	73	1301	113	849
-46	2580	-6	2164	34	1734	74	1290	114	837
-45	2571	-5	2154	35	1723	75	1279	115	826
-44	2562	-4	2143	36	1712	76	1268	116	814
-43	2553	-3	2132	37	1701	77	1257	117	803
-42	2543	-2	2122	38	1690	78	1245	118	791
-41	2533	-1	2111	39	1679	79	1234	119	780
-40	2522	0	2100	40	1668	80	1223	120	769
-39	2512	1	2089	41	1657	81	1212	121	757
-38	2501	2	2079	42	1646	82	1201	122	745

**Feature Description (continued)**
**Table 3. LMT86 Transfer Table (continued)**

TEMP (°C)	V <sub>OUT</sub> (mV)	TEMP (°C)	V <sub>OUT</sub> (mV)	TEMP (°C)	V <sub>OUT</sub> (mV)	TEMP (°C)	V <sub>OUT</sub> (mV)	TEMP (°C)	V <sub>OUT</sub> (mV)
-37	2491	3	2068	43	1635	83	1189	123	734
-36	2481	4	2057	44	1624	84	1178	124	722
-35	2470	5	2047	45	1613	85	1167	125	711
-34	2460	6	2036	46	1602	86	1155	126	699
-33	2449	7	2025	47	1591	87	1144	127	688
-32	2439	8	2014	48	1580	88	1133	128	676
-31	2429	9	2004	49	1569	89	1122	129	665
-30	2418	10	1993	50	1558	90	1110	130	653
-29	2408	11	1982	51	1547	91	1099	131	642
-28	2397	12	1971	52	1536	92	1088	132	630
-27	2387	13	1961	53	1525	93	1076	133	618
-26	2376	14	1950	54	1514	94	1065	134	607
-25	2366	15	1939	55	1503	95	1054	135	595
-24	2355	16	1928	56	1492	96	1042	136	584
-23	2345	17	1918	57	1481	97	1031	137	572
-22	2334	18	1907	58	1470	98	1020	138	560
-21	2324	19	1896	59	1459	99	1008	139	549
-20	2313	20	1885	60	1448	100	997	140	537
-19	2302	21	1874	61	1436	101	986	141	525
-18	2292	22	1864	62	1425	102	974	142	514
-17	2281	23	1853	63	1414	103	963	143	502
-16	2271	24	1842	64	1403	104	951	144	490
-15	2260	25	1831	65	1391	105	940	145	479
-14	2250	26	1820	66	1380	106	929	146	467
-13	2239	27	1810	67	1369	107	917	147	455
-12	2228	28	1799	68	1358	108	906	148	443
-11	2218	29	1788	69	1346	109	895	149	432
								150	420

Although the LMT86 is very linear, its response does have a slight umbrella parabolic shape. This shape is very accurately reflected in [Table 3](#). The Transfer Table can be calculated by using the parabolic equation ([Equation 1](#)).

$$V_{TEMP} (mV) = 1777.3mV - \left[ 10.888 \frac{mV}{^{\circ}C} (T - 30^{\circ}C) \right] - \left[ 0.00347 \frac{mV}{^{\circ}C^2} (T - 30^{\circ}C)^2 \right] \quad (1)$$

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:

$$T = \frac{10.888 - \sqrt{(-10.888)^2 + 4 \times 0.00347 \times (1777.3 - V_{TEMP} (mV))}}{2 \times (-0.00347)} + 30 \quad (2)$$

For an even less accurate linear approximation, a line can easily be calculated over the desired temperature range from the table using the two-point equation ([Equation 3](#)):

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

where

- V is in mV,
- T is in °C,
- T<sub>1</sub> and V<sub>1</sub> are the coordinates of the lowest temperature,
- and T<sub>2</sub> and V<sub>2</sub> are the coordinates of the highest temperature.

(3)

For example, if the user wanted to resolve this equation, over a temperature range of 20°C to 50°C, they would proceed as follows:

$$V - 1885 \text{ mV} = \left( \frac{1558 \text{ mV} - 1885 \text{ mV}}{50^\circ\text{C} - 20^\circ\text{C}} \right) \times (T - 20^\circ\text{C}) \quad (4)$$

$$V - 1885 \text{ mV} = (-10.9 \text{ mV} / ^\circ\text{C}) \times (T - 20^\circ\text{C}) \quad (5)$$

$$V = (-10.9 \text{ mV} / ^\circ\text{C}) \times T + 2103 \text{ mV} \quad (6)$$

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 LMT86 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 LMT86 die is directly attached to the GND pin. The temperatures of the lands and traces to the other leads of the LMT86 will also affect the temperature reading.

Alternatively, the LMT86 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 LMT86 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 LMT86 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  $\theta_{JA}$ ) is the parameter used to calculate the rise of a device junction temperature due to its power dissipation. Use [Equation 7](#) to calculate the rise in the LMT86 die temperature:

$$T_J = T_A + \theta_{JA} [(V_{DD}I_S) + (V_{DD} - V_O) I_L]$$

where

- $T_A$  is the ambient temperature,
- $I_S$  is the supply current,
- $I_L$  is the load current on the output,
- and  $V_O$  is the output voltage. (7)

For example, in an application where  $T_A = 30^\circ\text{C}$ ,  $V_{DD} = 5\text{V}$ ,  $I_S = 5.4 \mu\text{A}$ ,  $V_O = 1777 \text{ mV}$  junction temp  $30.014^\circ\text{C}$  self-heating error of  $0.014^\circ\text{C}$ . Because the junction temperature of the LMT86 is the actual temperature being measured, take care to minimize the load current that the LMT86 is required to drive. [Thermal Information<sup>\(1\)</sup>](#) shows the thermal resistance of the LMT86.

### 8.4.2 Output Noise Considerations

A push-pull output gives the LMT86 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. The LMT86 is ideal for this and other applications which require strong source or sink current.

The LMT86 supply-noise gain (the ratio of the AC signal on  $V_{OUT}$  to the AC signal on  $V_{DD}$ ) was measured during bench tests. The typical attenuation is shown in [Figure 8](#) found in the [Typical Characteristics](#) section. A load capacitor on the output can help to filter noise.

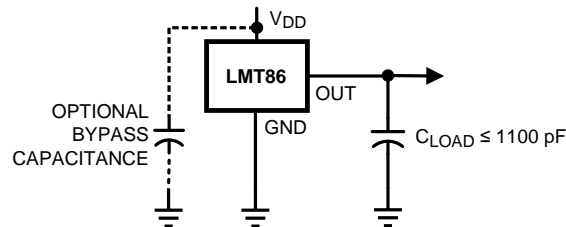
For operation in very noisy environments, some bypass capacitance should be present on the supply within approximately 5 centimeters of the LMT86.

(1) For information on self-heating and thermal response time, see section [Mounting and Thermal Conductivity](#).

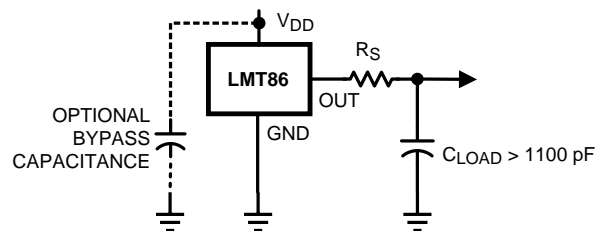
## Device Functional Modes (continued)

### 8.4.3 Capacitive Loads

The LMT86 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 LMT86 can drive a capacitive load less than or equal to 1100 pF as shown in [Figure 11](#). For capacitive loads greater than 1100 pF, a series resistor may be required on the output, as shown in [Figure 12](#).



**Figure 11. LMT86 No Decoupling Required for Capacitive Loads Less than 1100 pF**



**Figure 12. LMT86 with Series Resistor for Capacitive Loading Greater than 1100 pF**

**Table 4. Recommended Series Resistor Values**

$C_{LOAD}$	MINIMUM $R_S$
1.1 nF to 99 nF	3 k $\Omega$
100 nF to 999 nF	1.5 k $\Omega$
1 $\mu$ F	800 $\Omega$

### 8.4.4 Output Voltage Shift

The LMT86 are 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  $V_{OUT}$ . Because 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

### 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. Customers should validate and test their design implementation to confirm system functionality.

### 9.1 Application Information

The LMT86 features make it suitable for many general temperature-sensing applications. It can operate down to 2.2-V supply with 5.4- $\mu$ A power consumption, making it ideal for battery-powered devices. Package options like the through-hole TO-92 package allow the LMT86 to be mounted onboard, off-board, to a heat sink, or on multiple unique locations in the same application.

### 9.2 Typical Applications

#### 9.2.1 Connection to an ADC

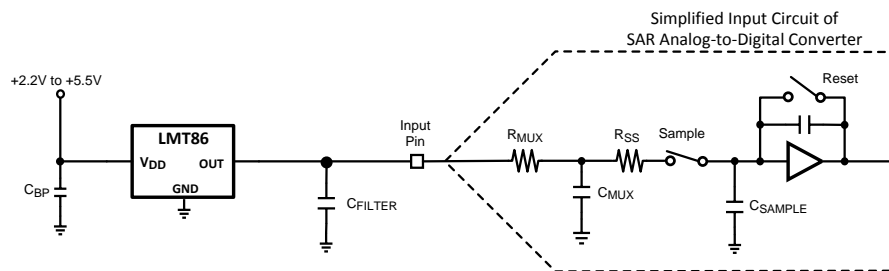


Figure 13. Suggested Connection to a Sampling Analog-to-Digital Converter Input Stage

##### 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 LMT86 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. Because 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 Curve

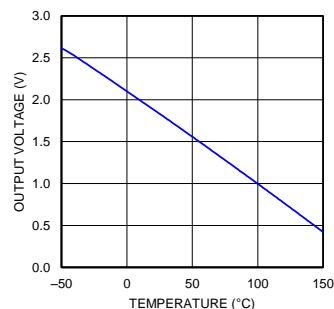


Figure 14. Analog Output Transfer Function

## Typical Applications (continued)

### 9.2.2 Conserving Power Dissipation With Shutdown

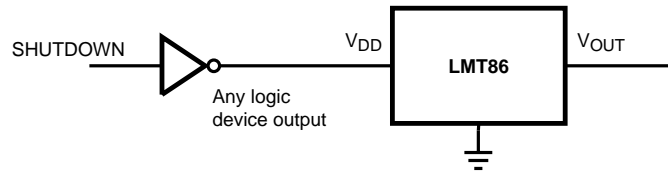


Figure 15. Conserving Power Dissipation With Shutdown

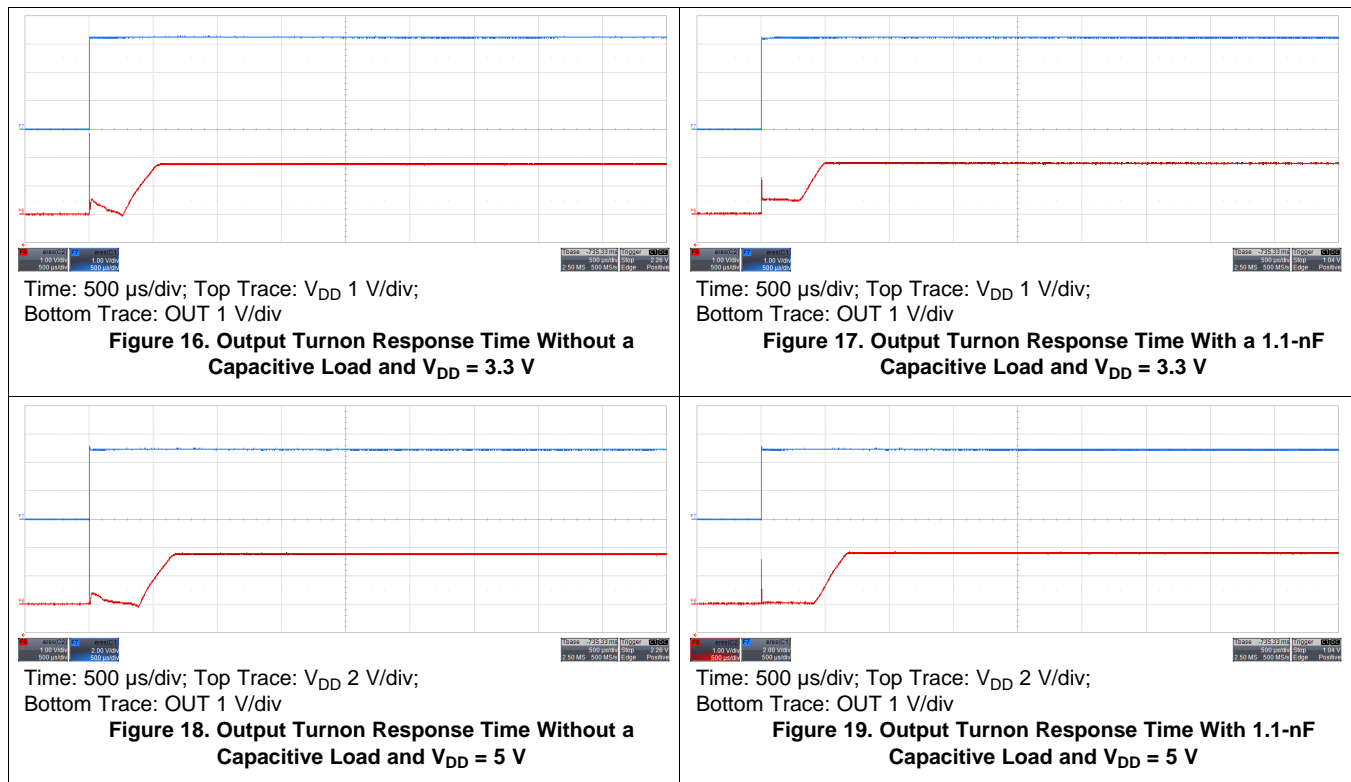
#### 9.2.2.1 Design Requirements

Because the power consumption of the LMT86 is less than 9  $\mu\text{A}$ , it can simply be powered directly from any logic gate output and therefore not require 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 are critical.

#### 9.2.2.2 Detailed Design Procedure

Simply connect the V<sub>DD</sub> pin of the LMT86 directly to the logic shutdown signal from a microcontroller.

#### 9.2.2.3 Application Curves



## 10 Power Supply Recommendations

The low supply current and supply range (2.2 V to 5.5 V) of the LMT86 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 output of the LMT86.

## 11 Layout

### 11.1 Layout Guidelines

The LMT86 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

○ VIA to ground plane

○ VIA to power plane

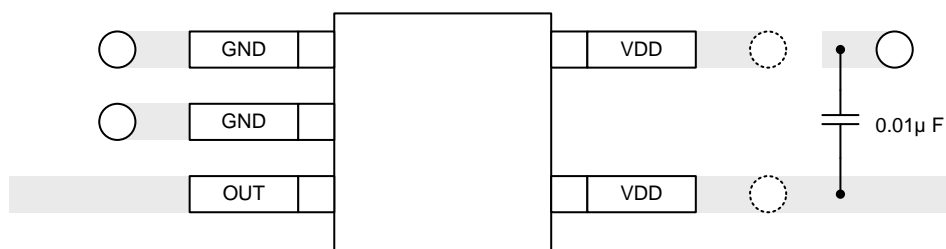


Figure 20. SC70 Package Recommended Layout

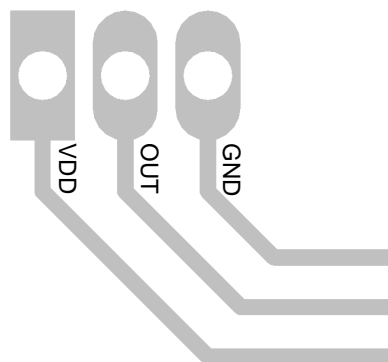


Figure 21. TO-92 LP Package Recommended Layout

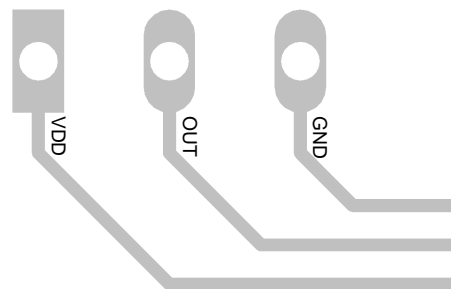


Figure 22. TO-92 LPM Package Recommended Layout

## 12 器件和文档支持

### 12.1 相关链接

下面的表格列出了快速访问链接。类别包括技术文档、支持与社区资源、工具和软件，以及申请样片或购买产品的快速链接。

表 5. 相关链接

器件	产品文件夹	样片与购买	技术文档	工具和软件	支持和社区
LMT86	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>
LMT86-Q1	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>	<a href="#">请单击此处</a>

### 12.2 接收文档更新通知

要接收文档更新通知，请导航至德州仪器 [TI.com.cn](http://TI.com.cn) 上的器件产品文件夹。点击右上角的提醒我 (Alert me) 注册后，即可每周定期收到已更改的产品信息。有关更改的详细信息，请查阅已修订文档中包含的修订历史记录。

### 12.3 社区资源

下列链接提供到 TI 社区资源的连接。链接的内容由各个分销商“按照原样”提供。这些内容并不构成 TI 技术规范，并且不一定反映 TI 的观点；请参阅 TI 的《使用条款》。

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### 12.5 静电放电警告



这些装置包含有限的内置 ESD 保护。存储或装卸时，应将导线一起截短或将装置放置于导电泡棉中，以防止 MOS 门极遭受静电损伤。

### 12.6 Glossary

[SLYZ022](#) — *TI Glossary*.

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

## 13 机械、封装和可订购信息

以下页面包括机械、封装和可订购信息。这些信息是指定器件的最新可用数据。这些数据发生变化时，我们可能不会另行通知或修订此文档。如欲获取此产品说明书的浏览器版本，请参阅左侧的导航栏。



**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LMT86DCKR	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-50 to 150	BSA	<a href="#">Samples</a>
LMT86DCKT	ACTIVE	SC70	DCK	5	250	RoHS & Green	SN	Level-1-260C-UNLIM	-50 to 150	BSA	<a href="#">Samples</a>
LMT86LP	ACTIVE	TO-92	LP	3	1800	RoHS & Green	SN	N / A for Pkg Type	-50 to 150	LMT86	<a href="#">Samples</a>
LMT86LPG	ACTIVE	TO-92	LPG	3	1000	RoHS & Green	SN	N / A for Pkg Type	-50 to 150	LMT86	<a href="#">Samples</a>
LMT86LPGM	ACTIVE	TO-92	LPG	3	3000	RoHS & Green	SN	N / A for Pkg Type	-50 to 150	LMT86	<a href="#">Samples</a>
LMT86LPM	ACTIVE	TO-92	LP	3	2000	RoHS & Green	SN	N / A for Pkg Type	-50 to 150	LMT86	<a href="#">Samples</a>
LMT86QDCKRQ1	ACTIVE	SC70	DCK	5	3000	RoHS & Green	SN	Level-1-260C-UNLIM	-50 to 150	BTA	<a href="#">Samples</a>
LMT86QDCKTQ1	ACTIVE	SC70	DCK	5	250	RoHS & Green	SN	Level-1-260C-UNLIM	-50 to 150	BTA	<a href="#">Samples</a>

(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.

**OBSELETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(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.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices 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.

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## 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
LMT86DCKR	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMT86DCKT	SC70	DCK	5	250	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMT86QDCKRQ1	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMT86QDCKTQ1	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)
LMT86DCKR	SC70	DCK	5	3000	208.0	191.0	35.0
LMT86DCKT	SC70	DCK	5	250	208.0	191.0	35.0
LMT86QDCKRQ1	SC70	DCK	5	3000	208.0	191.0	35.0
LMT86QDCKTQ1	SC70	DCK	5	250	208.0	191.0	35.0

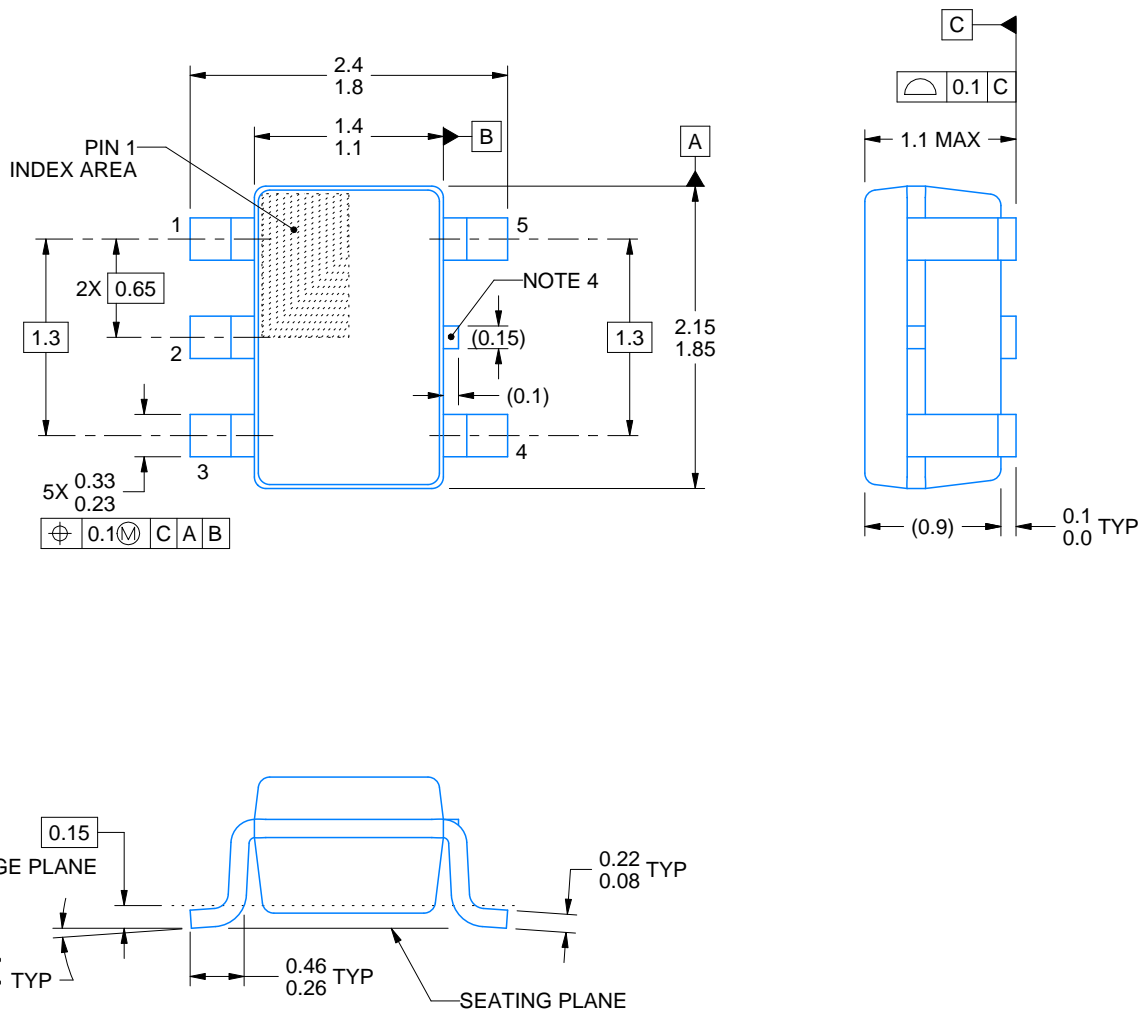
DCK0005A



# PACKAGE OUTLINE

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



4214834/C 03/2023

## NOTES:

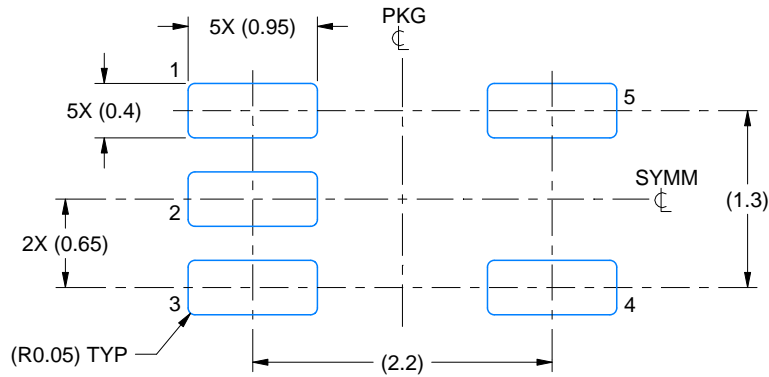
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Reference JEDEC MO-203.
4. Support pin may differ or may not be present.

# EXAMPLE BOARD LAYOUT

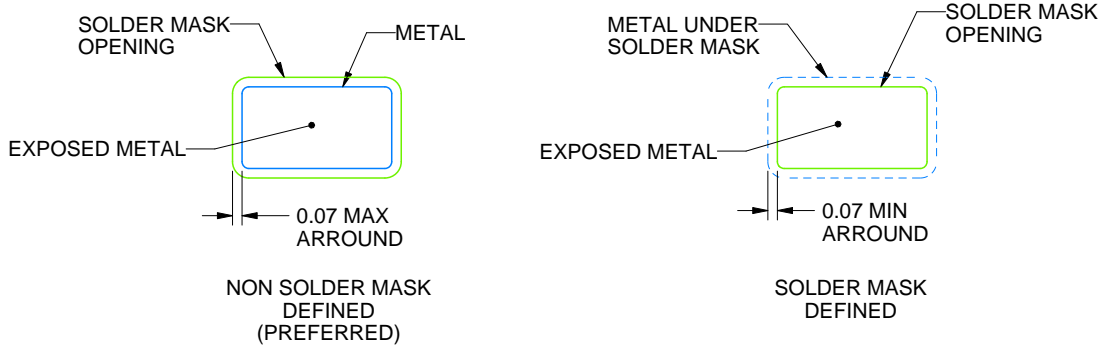
DCK0005A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:18X



SOLDER MASK DETAILS

4214834/C 03/2023

NOTES: (continued)

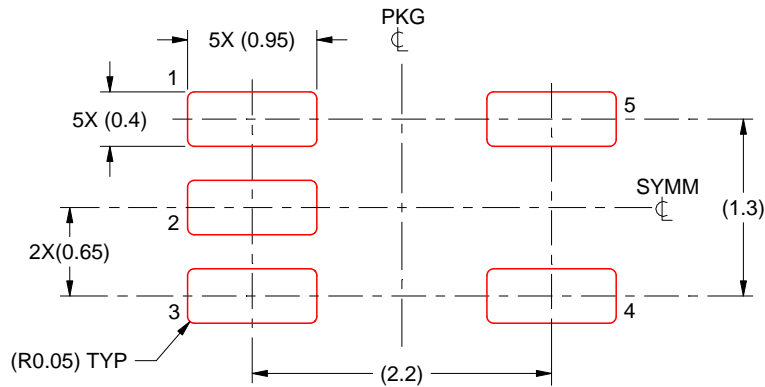
- 4. Publication IPC-7351 may have alternate designs.
- 5. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

# EXAMPLE STENCIL DESIGN

DCK0005A

SOT - 1.1 max height

SMALL OUTLINE TRANSISTOR



SOLDER PASTE EXAMPLE  
BASED ON 0.125 THICK STENCIL  
SCALE:18X

4214834/C 03/2023

NOTES: (continued)

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

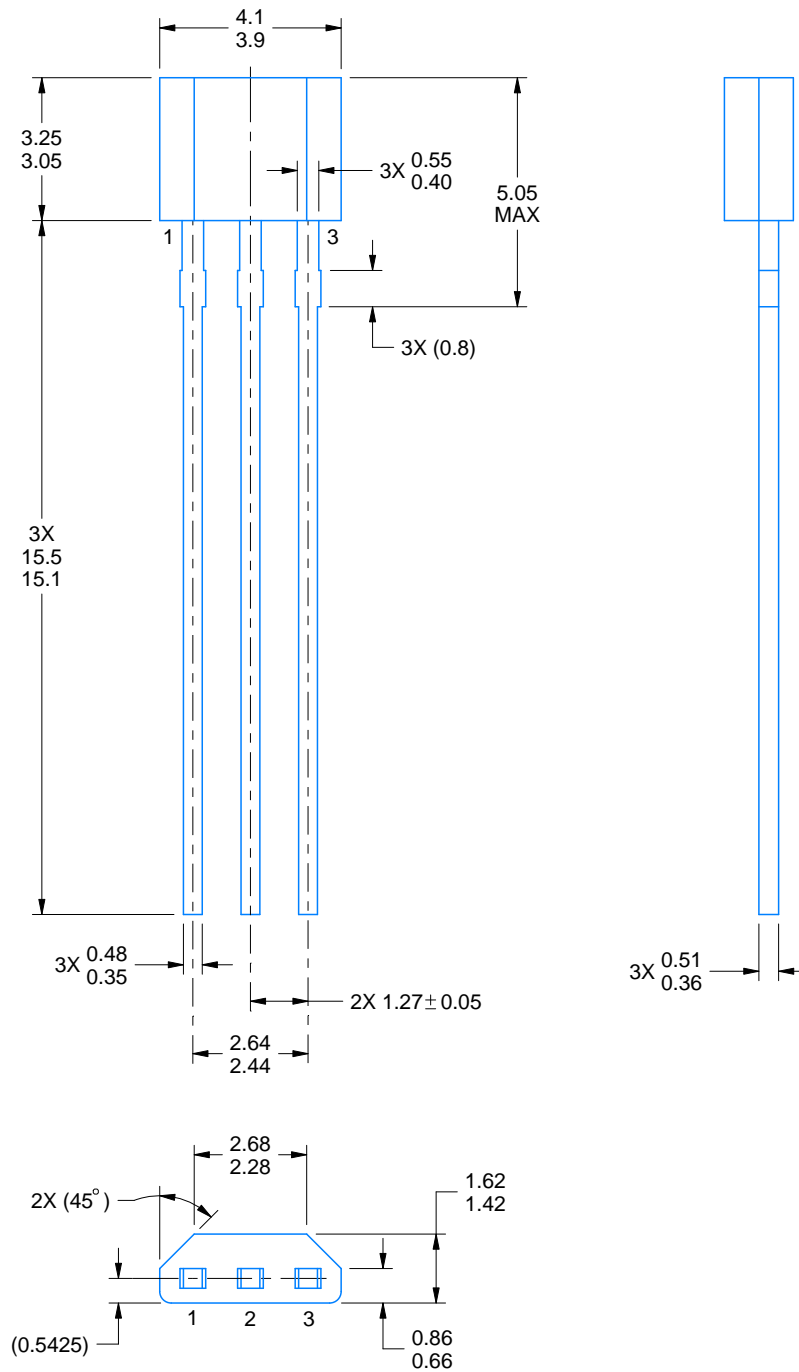
# LPG0003A



# PACKAGE OUTLINE

## TO-92 - 5.05 mm max height

TRANSISTOR OUTLINE



4221343/C 01/2018

### NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

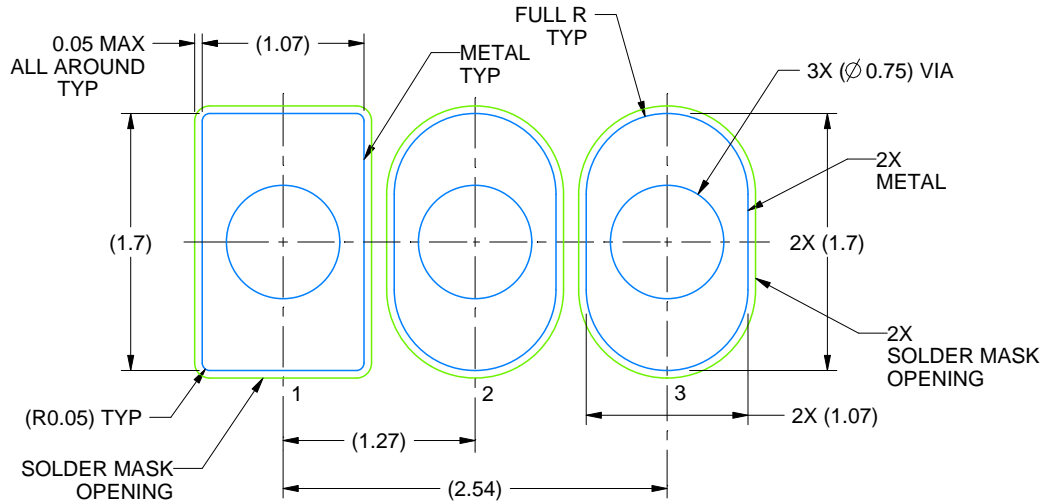


# EXAMPLE BOARD LAYOUT

LPG0003A

TO-92 - 5.05 mm max height

TRANSISTOR OUTLINE



LAND PATTERN EXAMPLE  
NON-SOLDER MASK DEFINED  
SCALE:20X

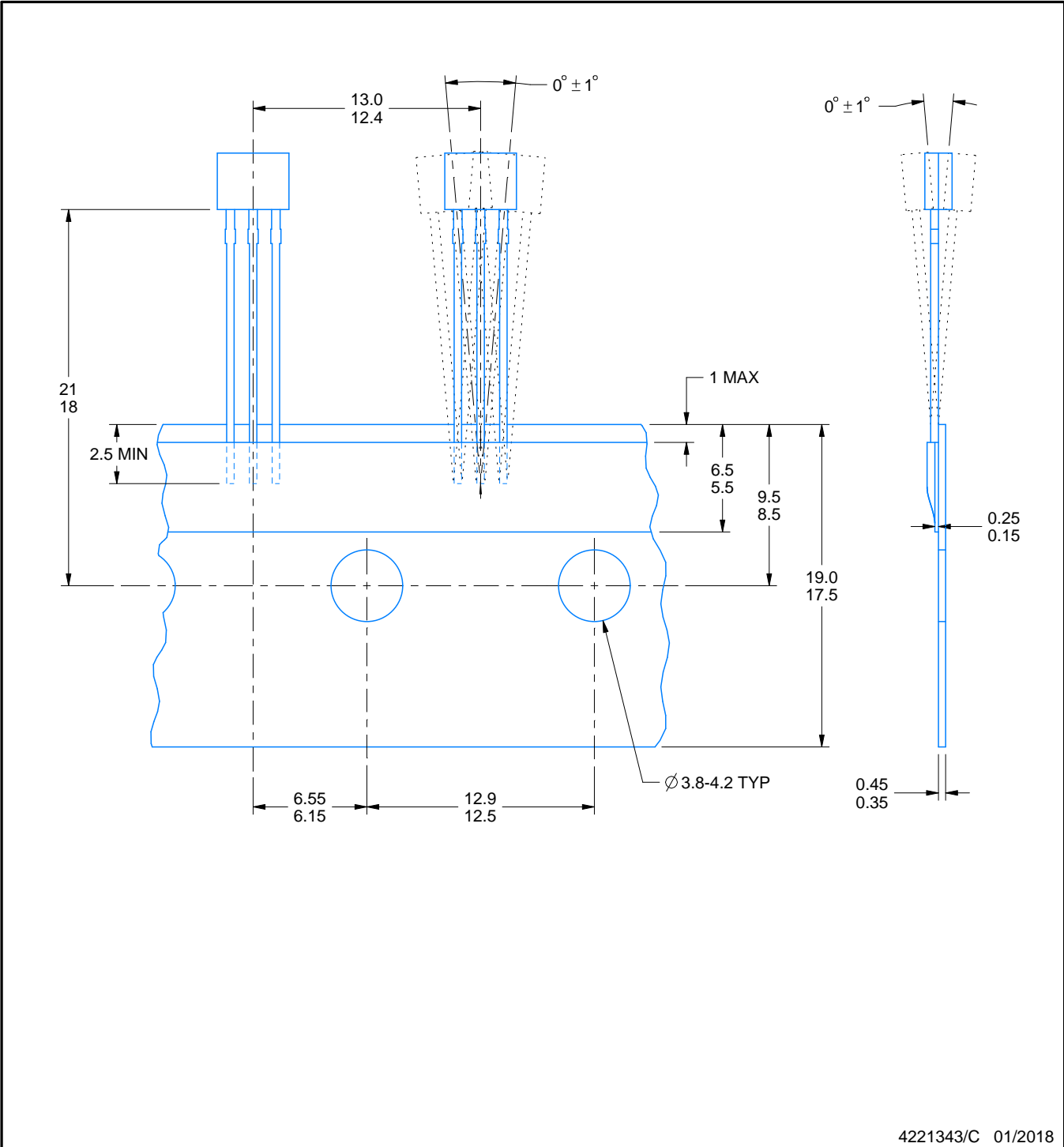
4221343/C 01/2018

# TAPE SPECIFICATIONS

LPG0003A

TO-92 - 5.05 mm max height

TRANSISTOR OUTLINE



4221343/C 01/2018

## GENERIC PACKAGE VIEW

LP 3

TO-92 - 5.34 mm max height

TRANSISTOR OUTLINE



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4040001-2/F

LP0003A



PACKAGE OUTLINE

TO-92 - 5.34 mm max height

TO-92



4215214/B 04/2017

NOTES:

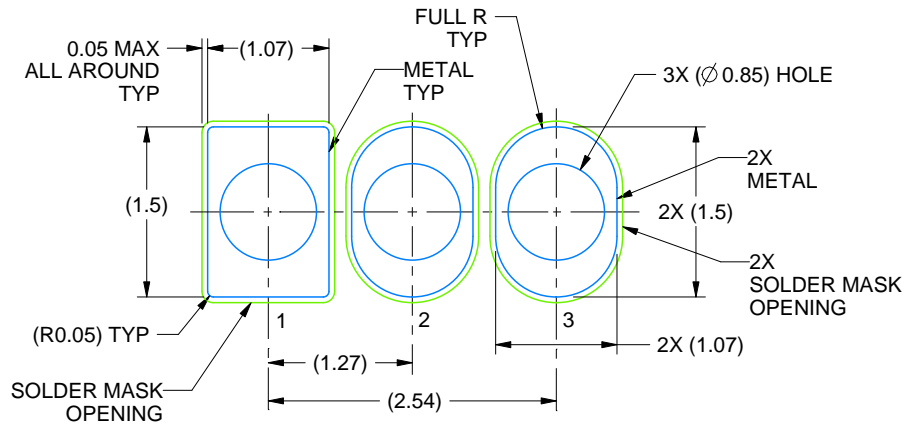
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Lead dimensions are not controlled within this area.
4. Reference JEDEC TO-226, variation AA.
5. Shipping method:
  - a. Straight lead option available in bulk pack only.
  - b. Formed lead option available in tape and reel or ammo pack.
  - c. Specific products can be offered in limited combinations of shipping medium and lead options.
  - d. Consult product folder for more information on available options.

# EXAMPLE BOARD LAYOUT

LP0003A

TO-92 - 5.34 mm max height

TO-92



LAND PATTERN EXAMPLE  
STRAIGHT LEAD OPTION  
NON-SOLDER MASK DEFINED  
SCALE:15X



LAND PATTERN EXAMPLE  
FORMED LEAD OPTION  
NON-SOLDER MASK DEFINED  
SCALE:15X

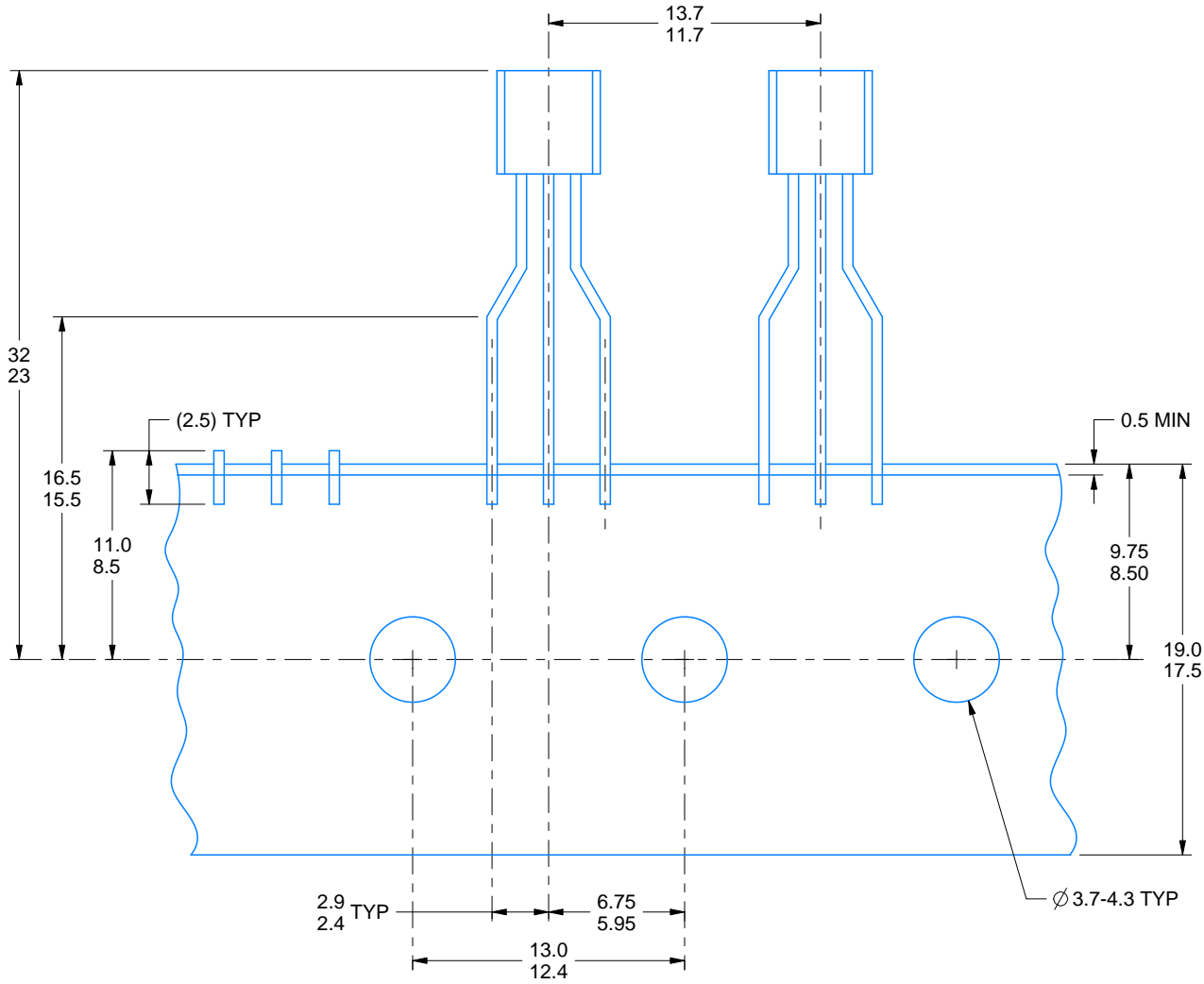
4215214/B 04/2017

# TAPE SPECIFICATIONS

LP0003A

TO-92 - 5.34 mm max height

TO-92



FOR FORMED LEAD OPTION PACKAGE

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