

1. Description

The LMT8x are a series of analog temperature sensors with negative temperature coefficients that provide an analog voltage output which is linearly proportional to the Celsius temperature. The LMT8x performs factory calibration, so no external calibration is required, with a typical accuracy of $\pm 0.4^{\circ}\text{C}$ at $+25^{\circ}\text{C}$ and a maximum accuracy of $\pm 2.7^{\circ}\text{C}$ in the temperature range from 40°C to $+125^{\circ}\text{C}$.

The LMT8x (the LMT8x series only include these four models) feature low-output impedance, linear output, and factory calibration, enabling significant simplification of temperature control circuits and ADC requirements. This series of sensor components can operate with a single power supply ranging from 1.5V to 5.5V. The power supply current is below $10\mu\text{A}$, and the self-heating effect is minimal, with a temperature change of less than 0.1°C in static air.

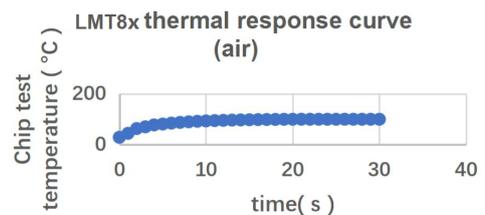
The LMT8x are available in low-cost 5-pin SOT-23 surface mount, 3-pin TO-92 and 8-pin SOIC and three packages.

2. Features

- The LMT8x are a series of analog temperature sensors with negative temperature coefficients and average sensor gains of $-5.5\text{mV}/^{\circ}\text{C}$, $-8.2\text{mV}/^{\circ}\text{C}$, $-10.9\text{mV}/^{\circ}\text{C}$, $-13.6\text{mV}/^{\circ}\text{C}$.
- Temperature range: $-55^{\circ}\text{C} \sim +125^{\circ}\text{C}$, up to $+140^{\circ}\text{C}$
- Temperature accuracy: $\pm 0.4^{\circ}\text{C}$ (typ.)
- The output is short-circuit protected
- Power supply voltage: $2.5\text{V} \sim 5.5\text{V}$
- Low quiescent current: less than $10\mu\text{A}$
- Analog temperature sensors compatible with LM20/19 and LM35 package

3. Applications

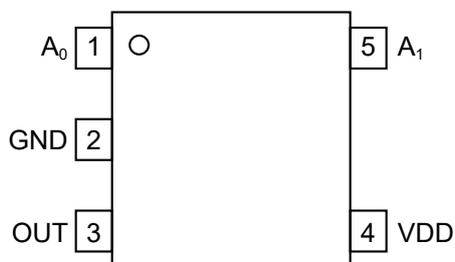
- Thermal management system
- Temperature control
- Home appliances



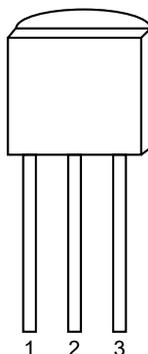
* Where X can represent 4, 5, 6, 7



4. Pinning Information



SC70-5



TO-92

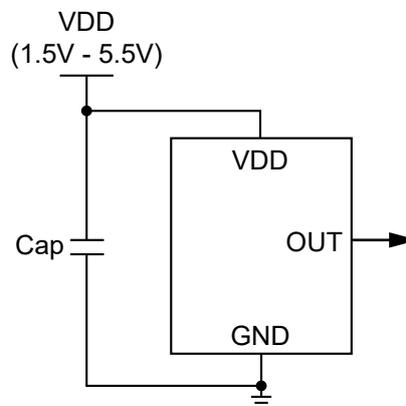


Table 1 Chip pin description

| Pin name | | Pin name | Description |
|-----------|-------|----------------|------------------------|
| SOT(SC70) | TO-92 | | |
| 1 | / | A ₀ | Chip enable pin 0 |
| 2 | 3 | GND | Ground |
| 3 | 2 | OUT | Analog voltage output |
| 4 | 1 | VDD | Chip power supply port |
| 5 | / | A ₁ | Chip enable pin 1 |

Table 2 Description of the LMT8x SOT (SC70) package and connections of pin A0 and A1

| SOT(SC70) | Chip model and corresponding connection method | | | |
|----------------|--|-------|-------|-------|
| | LMT84 | LMT85 | LMT86 | LMT87 |
| A ₀ | GND | VDD | GND | VDD |
| A ₁ | GND | GND | VDD | VDD |



5. Absolute Maximum Ratings

| Parameter | Min | Max | Units |
|--------------------------|-----|---------|-------|
| Power Supply Voltage +Vs | | 6 | V |
| OUT Pin | GND | VDD+0.4 | V |
| Junction Temperature | | 150 | °C |
| Storage Temperature | -60 | 150 | °C |

6. Electrostatic Protection

| | | Value | Units |
|---------------------------------|---|-------|-------|
| Electrostatic Discharge Voltage | Human Body Mode (HBM), per ANSI/ESDA/JEDEC JS-001 | ±4000 | V |
| | Machine Mode (MM), per JEDEC-STD Classification | ±200 | V |

7. Recommended Operating Conditions

| Parameter | Min | Typ | Max | Units |
|--|-----|-----|-----|-------|
| Supply Voltage (VDD) LMT 84 | 1.5 | 3.3 | 5.5 | V |
| Supply Voltage (VDD) LMT 85 | 1.8 | 3.3 | 5.5 | V |
| Supply Voltage (VDD) LMT 86 | 2.2 | 3.3 | 5.5 | V |
| Supply Voltage (VDD) LMT 87 | 2.7 | 3.3 | 5.5 | V |
| LMT8X Operating Temperature Range (TA) | -50 | | 140 | °C |

Unless otherwise noted, the specifications in the above table apply within the atmospheric temperature range.



8. Electrical Characteristic

Unless otherwise specified, the following data refer to the characteristics of the chips at +25°C and the power supply voltage is within the corresponding maximum and minimum operating voltage range of each chip. (Typical working conditions are at +25°C and 3.3V.)

| Parameter | Conditions | Min | Typ | Max | Units |
|------------------------------------|--|-----|-------|------|-------|
| Supply voltage range | LMT84 | 1.5 | | 5.5 | V |
| | LMT85 | 1.8 | | 5.5 | V |
| | LMT86 | 2.2 | | 5.5 | V |
| | LMT87 | 2.7 | | 5.5 | V |
| Supply current | Normal operation | | 5.6 | 9.3 | μA |
| Temperature range | LMT 8x | -50 | | 140 | °C |
| LMT8X accuracy (temperature error) | +25°C, +V _S =3.3V | | ±0.4 | | °C |
| | -50°C to +140°C, +V _S =3.3V | | ±1 | ±2.7 | °C |
| Supply voltage sensitivity | T _A =25°C, 3.0V<+V _S <5.5V | | 20 | 100 | m°C/V |
| Scale factor | LMT84 | | -5.5 | | mV/°C |
| | LMT85 | | -8.2 | | mV/°C |
| | LMT86 | | -10.9 | | mV/°C |
| | LMT87 | | -13.6 | | mV/°C |
| Voltage linear regulation rate | LMT8X | | 200 | | μV/V |
| Output load current | | -50 | | 50 | μA |
| Capacitive load drive | | | 1100 | | pF |
| Device turn-on time | C _L =0pF - 1nF | | 0.7 | 2 | ms |



9. Typical Characteristic

| | |
|---|---|
| | |
| <p>Figure 1: Temperature Error vs Temperature</p> | <p>Figure 2: Operating Temperature vs Minimum Operating Voltage</p> |
| | |
| <p>Figure 3: Operating Current vs Operating Temperature</p> | <p>Figure 4: Operating Current vs Operating Voltage</p> |
| | |
| <p>Figure 5: Current Load Adjustment</p> | <p>Figure 6: Sample test</p> |



10.LMT85 Transfer Table

| Temp(°C) | V _{OUT} (mV) |
|----------|-----------------------|----------|-----------------------|----------|-----------------------|----------|-----------------------|----------|-----------------------|
| -50 | 1955 | -10 | 1648 | 30 | 1324 | 70 | 991 | 110 | 651 |
| -49 | 1949 | -9 | 1639 | 31 | 1316 | 71 | 983 | 111 | 642 |
| -48 | 1942 | -8 | 1631 | 32 | 1308 | 72 | 974 | 112 | 634 |
| -47 | 1935 | -7 | 1623 | 33 | 1299 | 73 | 966 | 113 | 625 |
| -46 | 1928 | -6 | 1615 | 34 | 1291 | 74 | 957 | 114 | 617 |
| -45 | 1921 | -5 | 1607 | 35 | 1283 | 75 | 949 | 115 | 608 |
| -44 | 1915 | -4 | 1599 | 36 | 1275 | 76 | 941 | 116 | 599 |
| -43 | 1908 | -3 | 1591 | 37 | 1267 | 77 | 932 | 117 | 591 |
| -42 | 1900 | -2 | 1583 | 38 | 1258 | 78 | 924 | 118 | 582 |
| -41 | 1892 | -1 | 1575 | 39 | 1250 | 79 | 915 | 119 | 573 |
| -40 | 1885 | 0 | 1567 | 40 | 1242 | 80 | 907 | 120 | 565 |
| -39 | 1877 | 1 | 1559 | 41 | 1234 | 81 | 898 | 121 | 556 |
| -38 | 1869 | 2 | 1551 | 42 | 1225 | 82 | 890 | 122 | 547 |
| -37 | 1861 | 3 | 1543 | 43 | 1217 | 83 | 881 | 123 | 539 |
| -36 | 1853 | 4 | 1535 | 44 | 1209 | 84 | 873 | 124 | 530 |
| -35 | 1845 | 5 | 1527 | 45 | 1201 | 85 | 865 | 125 | 521 |
| -34 | 1838 | 6 | 1519 | 46 | 1192 | 86 | 856 | 126 | 513 |
| -33 | 1830 | 7 | 1511 | 47 | 1184 | 87 | 848 | 127 | 504 |
| -32 | 1822 | 8 | 1502 | 48 | 1176 | 88 | 839 | 128 | 495 |
| -31 | 1814 | 9 | 1494 | 49 | 1167 | 89 | 831 | 129 | 487 |
| -30 | 1806 | 10 | 1486 | 50 | 1159 | 90 | 822 | 130 | 478 |
| -29 | 1798 | 11 | 1478 | 51 | 1151 | 91 | 814 | 131 | 469 |
| -28 | 1790 | 12 | 1470 | 52 | 1143 | 92 | 805 | 132 | 460 |
| -27 | 1783 | 13 | 1462 | 53 | 1134 | 93 | 797 | 133 | 452 |
| -26 | 1775 | 14 | 1454 | 54 | 1126 | 94 | 788 | 134 | 443 |
| -25 | 1767 | 15 | 1446 | 55 | 1118 | 95 | 779 | 135 | 434 |
| -24 | 1759 | 16 | 1438 | 56 | 1109 | 96 | 771 | 136 | 425 |



| Temp(°C) | V _{OUT} (mV) |
|----------|-----------------------|----------|-----------------------|----------|-----------------------|----------|-----------------------|----------|-----------------------|
| -23 | 1751 | 17 | 1430 | 57 | 1101 | 97 | 762 | 137 | 416 |
| -22 | 1743 | 18 | 1421 | 58 | 1093 | 98 | 754 | 138 | 408 |
| -21 | 1735 | 19 | 1413 | 59 | 1084 | 99 | 745 | 139 | 399 |
| -20 | 1727 | 20 | 1405 | 60 | 1076 | 100 | 737 | 140 | 390 |
| -19 | 1719 | 21 | 1397 | 61 | 1067 | 101 | 728 | - | - |
| -18 | 1711 | 22 | 1389 | 62 | 1059 | 102 | 720 | - | - |
| -17 | 1703 | 23 | 1381 | 63 | 1051 | 103 | 711 | - | - |
| -16 | 1695 | 24 | 1373 | 64 | 1042 | 104 | 702 | - | - |
| -15 | 1687 | 25 | 1365 | 65 | 1034 | 105 | 694 | | |
| -14 | 1679 | 26 | 1356 | 66 | 1025 | 106 | 685 | - | - |
| -13 | 1671 | 27 | 1348 | 67 | 1017 | 107 | 677 | - | - |
| -12 | 1663 | 28 | 1340 | 68 | 1008 | 108 | 668 | - | - |
| -11 | 1656 | 29 | 1332 | 69 | 1000 | 109 | 660 | - | - |



11. Transfer Function

Table 3 gives the output voltage values corresponding to different temperatures for the LMT8X series products, and this data can be used for look-up

Table 3, LMT8X temperature and output voltage relationship.

| Ambient Temperature (°C) | VOUT Output Voltage (mV) | | | |
|-----------------------------|--------------------------|-------|-------|-------|
| | LMT84 | LMT85 | LMT86 | LMT87 |
| -50 | 1299 | 1955 | 2616 | 3277 |
| -40 | 1247 | 1885 | 2522 | 3160 |
| -30 | 1194 | 1806 | 2418 | 3030 |
| -20 | 1141 | 1727 | 2313 | 2899 |
| -10 | 1088 | 1648 | 2207 | 2767 |
| 0 | 1034 | 1567 | 2100 | 2633 |
| 10 | 980 | 1486 | 1993 | 2500 |
| 20 | 925 | 1405 | 1885 | 2365 |
| 30 | 871 | 1324 | 1777 | 2231 |
| 40 | 816 | 1242 | 1668 | 2095 |
| 50 | 760 | 1159 | 1558 | 1958 |
| 60 | 704 | 1076 | 1448 | 1819 |
| 70 | 647 | 991 | 1335 | 1679 |
| 80 | 591 | 907 | 1223 | 1539 |
| 90 | 534 | 822 | 1110 | 1399 |
| 100 | 476 | 737 | 997 | 1257 |
| 110 | 419 | 651 | 883 | 1115 |
| 120 | 361 | 565 | 769 | 973 |
| 130 | 302 | 478 | 653 | 829 |
| 140 | 243 | 390 | 537 | 684 |

Although the output curve of the LMT8X series sensor is relatively linear, as can be seen from Table 3. The output voltage of the sensor be approximately expressed by the following equation:



The approximate formula for calculating the temperature of the LMT84 is as follows:

$$V_{OUT}=870.6\text{mV}-[5.506 \frac{\text{mV}}{^{\circ}\text{C}} (T-30^{\circ}\text{C})]-0.00176 \frac{\text{mV}}{^{\circ}\text{C}^2} (T-30^{\circ}\text{C})^2 \quad (1)$$

$$T_{84}=\frac{5.506-\sqrt{(5.506)^2+4\times 0.00176\times(870.6-V_{OUT}(\text{mV}))}}{2\times(-0.00176)}+30 \quad (2)$$

If the temperature range is not wide (e.g., 0-50°C), the following equivalent formula can also be used to calculate temperature.

$$T_{84}=\frac{V_{OUT}(\text{mV})-1035\text{mV}}{-55\text{mV}/^{\circ}\text{C}} \quad (3)$$

The approximate formula for calculating the temperature of LMT85 is as follows

$$V_{OUT}=1324.0\text{mV}-[8.194 \frac{\text{mV}}{^{\circ}\text{C}} (T-30^{\circ}\text{C})]-0.00262 \frac{\text{mV}}{^{\circ}\text{C}^2} (T-30^{\circ}\text{C})^2 \quad (4)$$

$$T_{85}=\frac{8.194-\sqrt{(8.194)^2+4\times 0.00262\times(1324-V_{OUT}(\text{mV}))}}{2\times(-0.00262)}+30 \quad (5)$$

If the temperature range is not wide (e.g., 0-50°C), the following equivalent formula can also be used to calculate temperature.

$$T_{85}=\frac{V_{OUT}(\text{mV})-1569\text{mV}}{-8.2\text{mV}/^{\circ}\text{C}} \quad (6)$$

The approximate formula for calculating the temperature of the LMT86 is as follows:

$$V_{OUT}=1777.3\text{mV}-[10.888 \frac{\text{mV}}{^{\circ}\text{C}} (T-30^{\circ}\text{C})]-0.00347 \frac{\text{mV}}{^{\circ}\text{C}^2} (T-30^{\circ}\text{C})^2 \quad (7)$$

$$T_{86}=\frac{10.888-\sqrt{(10.888)^2+4\times 0.00347\times(1777.3-V_{OUT}(\text{mV}))}}{2\times(-0.00347)}+30 \quad (8)$$



If the temperature range is not wide (e.g., 0-50°C), the following equivalent formula can also be used to calculate temperature.

$$T_{86} = \frac{V_{OUT}(mV) - 2103mV}{-10.9mV/°C} \quad (9)$$

The approximate formula for calculating the temperature of the LMT87 is as follows:

$$V_{OUT} = 2230.8mV - [13.582 \frac{mV}{°C} (T - 30°C)] - 0.00433 \frac{mV}{°C^2} (T - 30°C)^2 \quad (10)$$

$$T_{87} = \frac{13.582 - \sqrt{(13.582)^2 + 4 \times 0.00433 \times (2230.8 - V_{OUT}(mV))}}{2 \times (-0.00433)} + 30 \quad (11)$$

If the temperature range is not wide (e.g., 0-50°C), the following equivalent formula can also be used to calculate temperature.

$$T_{87} = \frac{V_{OUT}(mV) - 2637mV}{-13.6mV/°C} \quad (12)$$



12. Thermal Conduction And Installation Notes

To ensure good thermal conductivity of the LMT8X sensor, the back of the chip can be directly connected to the GND pin. At same time, the temperature of the solder pad and trace of other pins (pins) of the LMT8X will also affect the temperature reading. According to the requirements, the customer made the LMT8X into a sealed metal probe for measuring the temperature of the liquid. As with other IC applications, the LMT8X its accompanying wiring and circuitry must remain insulated and dry to avoid leakage and corrosion. In this application scenario, some protective measures are needed to prevent short circuits or damage to the, which can cause the LMT8X to operate abnormally.

The formula for chip self-heating is as follows:

$$T_J = T_A + \phi_{JA} [V_{DD} \times I_D + (V_{DD} - V_{OUT}) \times I_L]$$

T_J Temperature of the chip after self-heating

T_A For ambient temperature

ϕ_{JA} Thermal resistance

V_{DD} Supply voltage

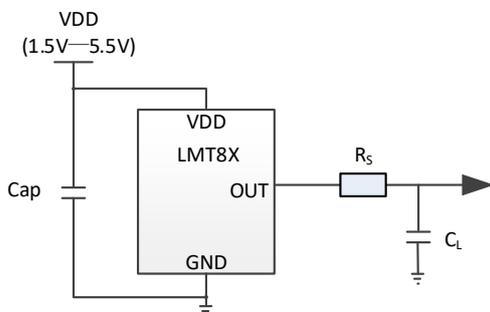
I_D Chip power consumption

V_{OUT} Chip output voltage

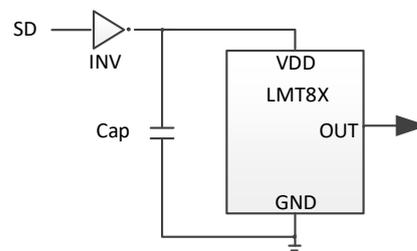
I_L Voltage output from the output pin

For example, for SOT(5), $T_A = 30^\circ\text{C}$, $\phi_{JA} = 300 \frac{^\circ\text{C}}{\text{W}}$, $V_{DD} = 5\text{V}$, $I_D = 5.4\mu\text{A}$, $V_{OUT} = 1.7\text{V}$, $I_L = 0\mu\text{A}$, is calculated $T = 30.008^\circ\text{C}$, indicating that the chip self-heating caused a temperature rise of 0.008°C .

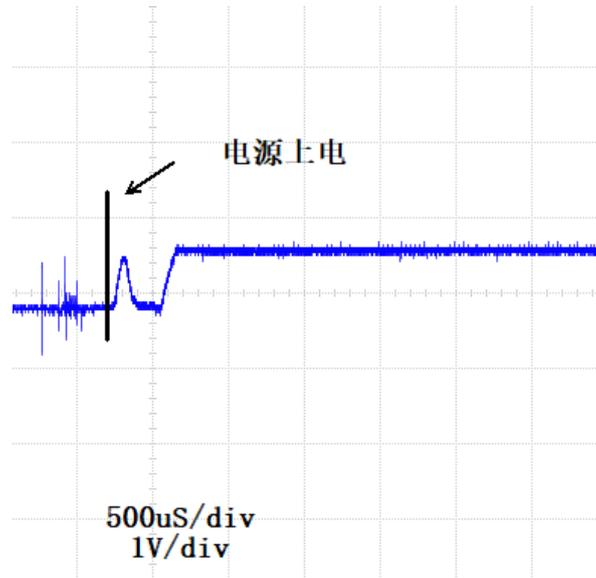
13. Filtering And Low-power Applications



LMT8X with filter capacitors application



LMT8X low power consumption application



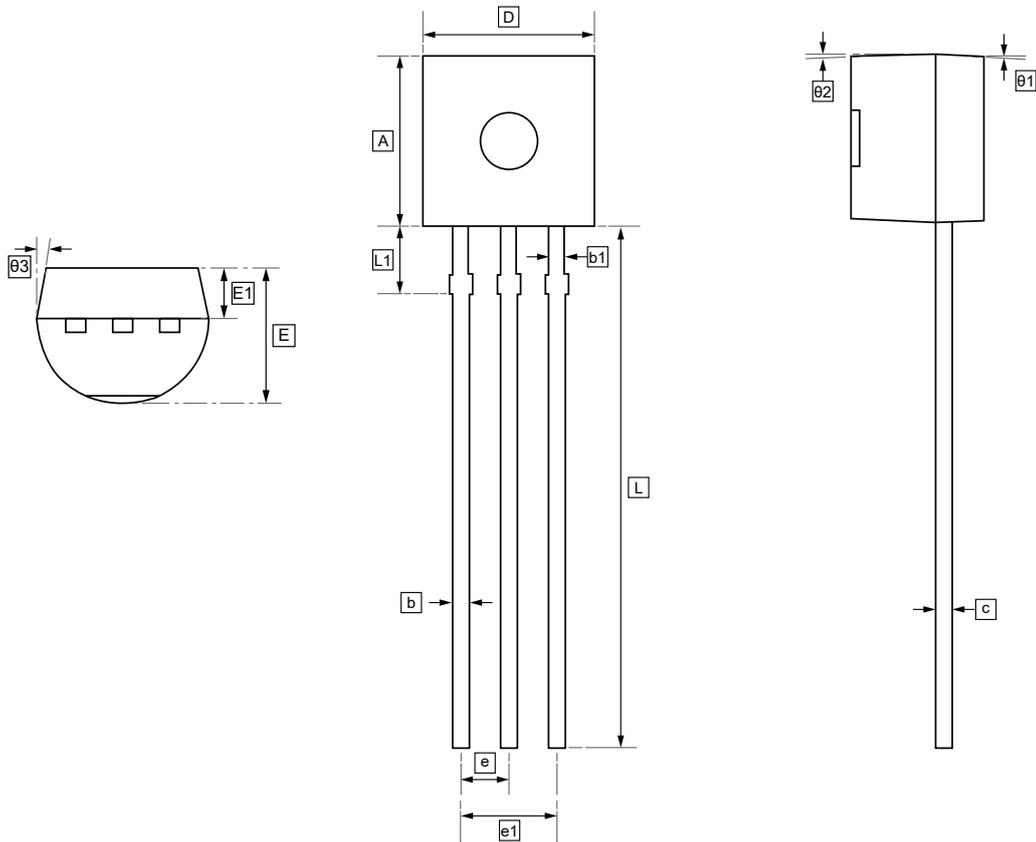
LMT8X start-up response diagram

Peripheral Circuit Recommended Value

| C_L | Minimum Resistance R_S | Cap |
|-------------|--------------------------|-------------|
| <1.1nF | 0k Ω | 0.1 μ F |
| 1.1nF—99nF | 3k Ω | 0.1 μ F |
| 100nF—999nF | 1.5k Ω | 0.1 μ F |
| >1 μ F | 800 Ω | 0.1 μ F |



14.1 TO-92 Package Outline Dimensions



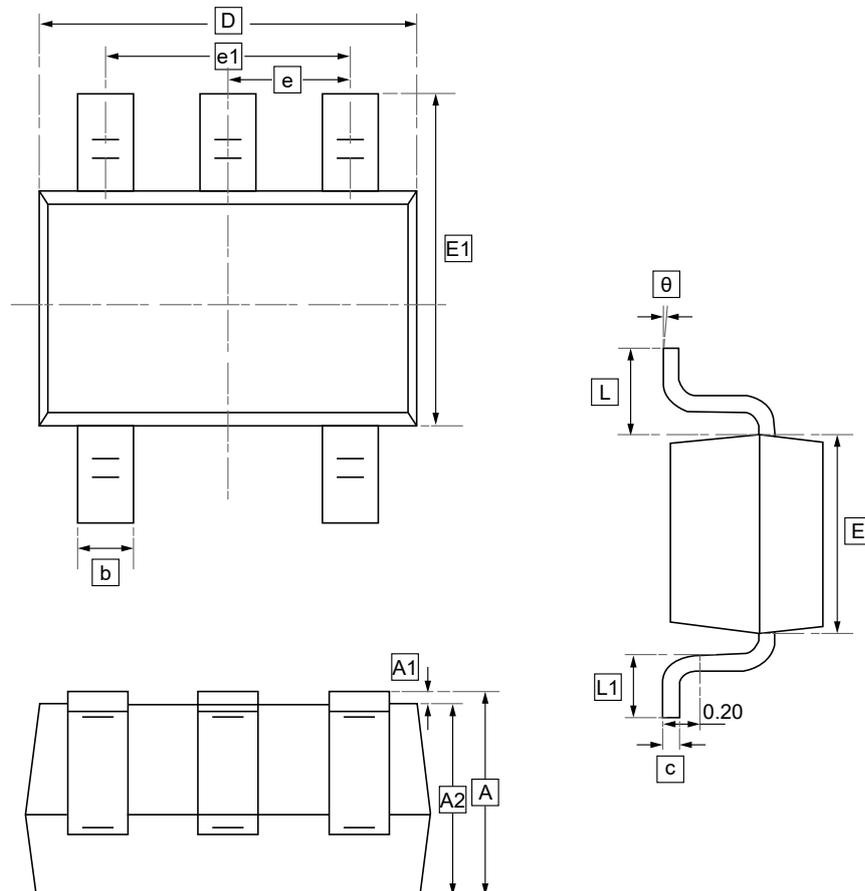
DIMENSIONS (mm are the original dimensions)

| Symbol | A | b | b1 | c | D | E | E1 | e | e1 | L | L1 | θ1 |
|--------|-----|------|------|------|-----|------|-----|------|------|------|------|----|
| Min | 4.5 | 0.38 | 0.46 | 0.36 | 4.5 | 3.45 | 1.2 | 1.27 | 2.54 | 13.5 | 1.96 | 2° |
| Max | 4.7 | 0.56 | | 0.51 | 4.7 | 3.75 | 1.4 | | | 15.3 | | |

| Symbol | θ2 | θ3 |
|--------|----|----|
| Min | 2° | 5° |
| Max | | |



14.2 SC70-5 Package Outline Dimensions

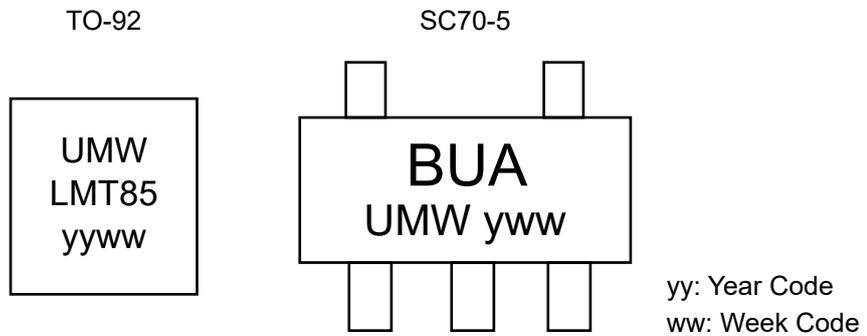


DIMENSIONS (mm are the original dimensions)

| Symbol | A | A1 | A2 | b | c | D | E | E1 | e | e1 | L | θ |
|--------|------|------|------|------|------|------|------|------|------|------|------|----------|
| Min | 0.90 | 0.00 | 0.90 | 0.15 | 0.08 | 2.05 | 1.15 | 2.15 | 0.65 | 1.20 | 0.26 | 7° |
| Max | 1.10 | 0.10 | 1.00 | 0.35 | 0.15 | 2.25 | 1.35 | 2.45 | TYP | 1.40 | 0.46 | REF. |



15. Ordering Information



| Order Code | Marking | Package | Base QTY | Delivery Mode |
|---------------|---------|---------|----------|---------------|
| UMW LMT84LP | LMT84 | TO-92 | 2000 | Bulk bag |
| UMW LMT85LP | LMT85 | TO-92 | 2000 | Bulk bag |
| UMW LMT86LP | LMT86 | TO-92 | 2000 | Bulk bag |
| UMW LMT87LP | LMT87 | TO-92 | 2000 | Bulk bag |
| UMW LMT84DCKR | BNA | SC70-5 | 3000 | Tape and reel |
| UMW LMT85DCKR | BPA | SC70-5 | 3000 | Tape and reel |
| UMW LMT86DCKR | BSA | SC70-5 | 3000 | Tape and reel |
| UMW LMT87DCKR | BUA | SC70-5 | 3000 | Tape and reel |



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