

## Low-Power Linear Active Thermistor™ ICs

### Features

- Tiny Analog Temperature Sensor
- Available Packages: SC-70-5, SOT-23-5, TO-92-3
- Wide Temperature Measurement Range:
  - $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$
- Accuracy:
  - $\pm 2^{\circ}\text{C}$  (max.),  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  (**MCP9700A/9701A**)
  - $\pm 4^{\circ}\text{C}$  (max.),  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  (**MCP9700/9701**)
- Optimized for Analog-to-Digital Converters (ADCs):
  - $10.0\text{ mV}/^{\circ}\text{C}$  (typical) **MCP9700/9700A**
  - $19.5\text{ mV}/^{\circ}\text{C}$  (typical) **MCP9701/9701A**
- Wide Operating Voltage Range:
  - $V_{\text{DD}} = 2.3\text{V}$  to  $5.5\text{V}$  **MCP9700/9700A**
  - $V_{\text{DD}} = 3.1\text{V}$  to  $5.5\text{V}$  **MCP9701/9701A**
- Low Operating Current:  $6\text{ }\mu\text{A}$  (typical)
- Optimized to Drive Large Capacitive Loads

### Typical Applications

- Hard Disk Drives and Other PC Peripherals
- Entertainment Systems
- Home Appliance
- Office Equipment
- Battery Packs and Portable Equipment
- General Purpose Temperature Monitoring

### Description

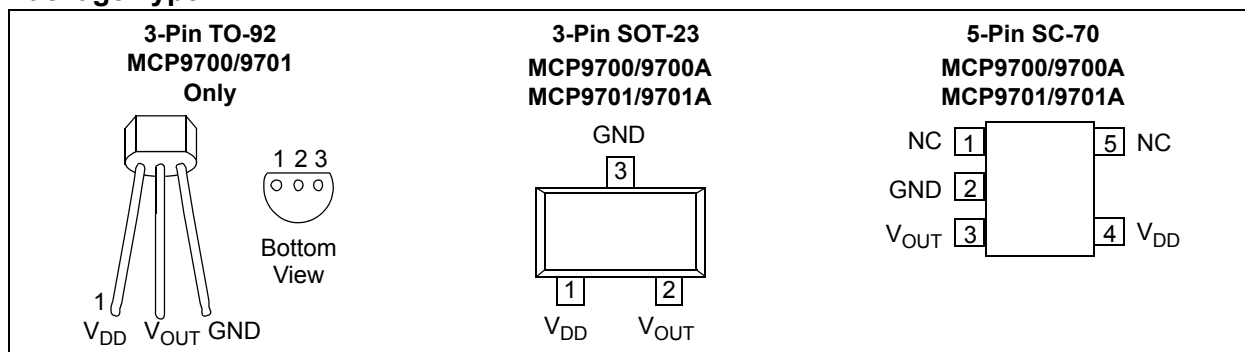
The MCP9700/9700A and MCP9701/9701A family of Linear Active Thermistor™ Intergrated Circuit (IC) is an analog temperature sensor that converts temperature to analog voltage. It's a low-cost, low-power sensor with an accuracy of  $\pm 2^{\circ}\text{C}$  from  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  (MCP9700A/9701A)  $\pm 4^{\circ}\text{C}$  from  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$  (MCP9700/9701) while consuming  $6\text{ }\mu\text{A}$  (typical) of operating current.

Unlike resistive sensors (such as thermistors), the Linear Active Thermistor IC does not require an additional signal-conditioning circuit. Therefore, the biasing circuit development overhead for thermistor solutions can be avoided by implementing this low-cost device. The voltage output pin ( $V_{\text{OUT}}$ ) can be directly connected to the ADC input of a microcontroller. The MCP9700/9700A and MCP9701/9701A temperature coefficients are scaled to provide a  $1^{\circ}\text{C}/\text{bit}$  resolution for an 8-bit ADC with a reference voltage of  $2.5\text{V}$  and  $5\text{V}$ , respectively.

The MCP9700/9700A and MCP9701/9701A provide a low-cost solution for applications that require measurement of a relative change of temperature. When measuring relative change in temperature from  $+25^{\circ}\text{C}$ , an accuracy of  $\pm 1^{\circ}\text{C}$  (typical) can be realized from  $0^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ . This accuracy can also be achieved by applying system calibration at  $+25^{\circ}\text{C}$ .

In addition, this family is immune to the effects of parasitic capacitance and can drive large capacitive loads. This provides Printed Circuit Board (PCB) layout design flexibility by enabling the device to be remotely located from the microcontroller. Adding some capacitance at the output also helps the output transient response by reducing overshoots or undershoots. However, capacitive load is not required for sensor output stability.

### Package Type



# MCP9700/9700A and MCP9701/9701A

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

$V_{DD}$ : ..... 6.0V  
 Storage temperature: ..... -65°C to +150°C  
 Ambient Temp. with Power Applied:.. -40°C to +125°C  
 Junction Temperature ( $T_J$ ):..... 150°C  
 ESD Protection On All Pins (HBM:MM):.... (4 kV:200V)  
 Latch-Up Current at Each Pin: ..... ±200 mA

†**Notice:** Stresses above those listed under “Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

### DC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated:						
<b>MCP9700/9700A:</b> $V_{DD}$ = 2.3V to 5.5V, GND = Ground, $T_A$ = -40°C to +125°C and No load.						
<b>MCP9701/9701A:</b> $V_{DD}$ = 3.1V to 5.5V, GND = Ground, $T_A$ = -10°C to +125°C and No load.						
Parameter	Sym	Min	Typ	Max	Unit	Conditions
<b>Power Supply</b>						
Operating Voltage Range	$V_{DD}$	2.3	—	5.5	V	<b>MCP9700/9700A</b> <b>MCP9701/9701A</b>
	$V_{DD}$	3.1	—	5.5	V	
Operating Current	$I_{DD}$	—	6	12	µA	
Power Supply Rejection	$\Delta^\circ\text{C}/\Delta V_{DD}$	—	0.1	—	°C/V	
<b>Sensor Accuracy (Notes 1, 2)</b>						
$T_A$ = +25°C	$T_{ACY}$	—	±1	—	°C	
$T_A$ = 0°C to +70°C	$T_{ACY}$	-2.0	±1	+2.0	°C	<b>MCP9700A/9701A</b>
$T_A$ = -40°C to +125°C	$T_{ACY}$	-2.0	±1	+4.0	°C	<b>MCP9700A</b>
$T_A$ = -10°C to +125°C	$T_{ACY}$	-2.0	±1	+4.0	°C	<b>MCP9701A</b>
$T_A$ = 0°C to +70°C	$T_{ACY}$	-4.0	±2	+4.0	°C	<b>MCP9700/9701</b>
$T_A$ = -40°C to +125°C	$T_{ACY}$	-4.0	±2	+6.0	°C	<b>MCP9700</b>
$T_A$ = -10°C to +125°C	$T_{ACY}$	-4.0	±2	+6.0	°C	<b>MCP9701</b>
<b>Sensor Output</b>						
Output Voltage, $T_A$ = 0°C	$V_{0^\circ\text{C}}$	—	500	—	mV	<b>MCP9700/9700A</b>
Output Voltage, $T_A$ = 0°C	$V_{0^\circ\text{C}}$	—	400	—	mV	<b>MCP9701/9701A</b>
Temperature Coefficient	$T_C$	—	10.0	—	mV/°C	<b>MCP9700/9700A</b>
	$T_C$	—	19.5	—	mV/°C	<b>MCP9701/9701A</b>
Output Non-linearity	$V_{ONL}$	—	±0.5	—	°C	$T_A$ = 0°C to +70°C ( <b>Note 2</b> )
Output Current	$I_{OUT}$	—	—	100	µA	
Output Impedance	$Z_{OUT}$	—	20	—	Ω	$I_{OUT}$ = 100 µA, $f$ = 500 Hz
Output Load Regulation	$\Delta V_{OUT}/\Delta I_{OUT}$	—	1	—	Ω	$T_A$ = 0°C to +70°C, $I_{OUT}$ = 100 µA

- Note 1:** The MCP9700/9700A family accuracy is tested with  $V_{DD}$  = 3.3V, while the MCP9701/9701A accuracy is tested with  $V_{DD}$  = 5.0V.
- 2:** The MCP9700/9700A and MCP9701/9701A family is characterized using the first-order or linear equation, as shown in [Equation 4-2](#).
- 3:** The MCP9700/9700A and MCP9701/9701A family is characterized and production tested with a capacitive load of 1000 pF.
- 4:** SC-70-5 package thermal response with 1x1 inch, dual-sided copper clad, TO-92-3 package thermal response without PCB (lead).

# MCP9700/9700A and MCP9701/9701A

## DC ELECTRICAL CHARACTERISTICS (CONTINUED)

<b>Electrical Specifications:</b> Unless otherwise indicated: <b>MCP9700/9700A:</b> $V_{DD} = 2.3V$ to $5.5V$ , GND = Ground, $T_A = -40^{\circ}C$ to $+125^{\circ}C$ and No load. <b>MCP9701/9701A:</b> $V_{DD} = 3.1V$ to $5.5V$ , GND = Ground, $T_A = -10^{\circ}C$ to $+125^{\circ}C$ and No load.						
Parameter	Sym	Min	Typ	Max	Unit	Conditions
Turn-on Time	$t_{ON}$	—	800	—	$\mu s$	
Typical Load Capacitance ( <b>Note 3</b> )	$C_{LOAD}$	—	—	1000	pF	
SC-70 Thermal Response to 63%	$t_{RES}$	—	1.3	—	s	30°C (Air) to +125°C (Fluid Bath) ( <b>Note 4</b> )
TO-92 Thermal Response to 63%	$t_{RES}$	—	1.65	—	s	

- Note 1:** The MCP9700/9700A family accuracy is tested with  $V_{DD} = 3.3V$ , while the MCP9701/9701A accuracy is tested with  $V_{DD} = 5.0V$ .
- 2:** The MCP9700/9700A and MCP9701/9701A family is characterized using the first-order or linear equation, as shown in [Equation 4-2](#).
- 3:** The MCP9700/9700A and MCP9701/9701A family is characterized and production tested with a capacitive load of 1000 pF.
- 4:** SC-70-5 package thermal response with 1x1 inch, dual-sided copper clad, TO-92-3 package thermal response without PCB (lead).

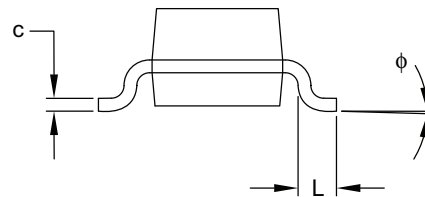
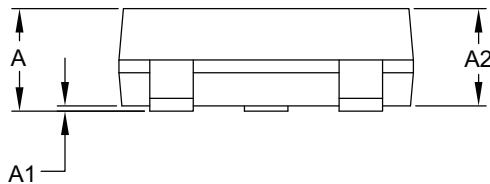
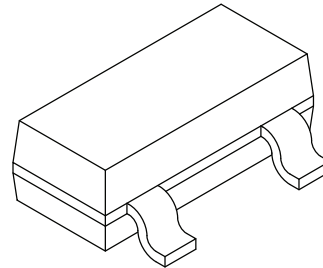
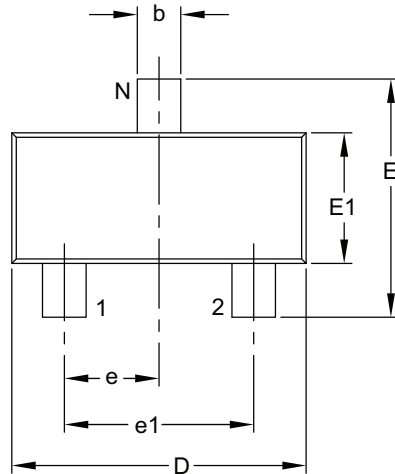
## TEMPERATURE CHARACTERISTICS

<b>Electrical Specifications:</b> Unless otherwise indicated: <b>MCP9700/9700A:</b> $V_{DD} = 2.3V$ to $5.5V$ , GND = Ground, $T_A = -40^{\circ}C$ to $+125^{\circ}C$ and No load. <b>MCP9701/9701A:</b> $V_{DD} = 3.1V$ to $5.5V$ , GND = Ground, $T_A = -10^{\circ}C$ to $+125^{\circ}C$ and No load.						
Parameters	Sym	Min	Typ	Max	Units	Conditions
<b>Temperature Ranges</b>						
Specified Temperature Range	$T_A$	-40	—	+125	$^{\circ}C$	<b>MCP9700/9700A (Note)</b>
	$T_A$	-10	—	+125	$^{\circ}C$	<b>MCP9701/9701A (Note)</b>
Operating Temperature Range	$T_A$	-40	—	+125	$^{\circ}C$	
Storage Temperature Range	$T_A$	-65	—	+150	$^{\circ}C$	
<b>Thermal Package Resistances</b>						
Thermal Resistance, 5LD SC-70	$\theta_{JA}$	—	331	—	$^{\circ}C/W$	
Thermal Resistance, 3LD SOT-23	$\theta_{JA}$	—	336	—	$^{\circ}C/W$	
Thermal Resistance, 3LD TO-92	$\theta_{JA}$	—	131.9	—	$^{\circ}C/W$	

**Note:** Operation in this range must not cause  $T_J$  to exceed Maximum Junction Temperature ( $+150^{\circ}C$ ).

# MCP9700/9700A and MCP9701/9701A

## 3-Lead Plastic Small Outline Transistor (TT) [SOT-23]



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	3		
Lead Pitch	e	0.95 BSC		
Outside Lead Pitch	e1	1.90 BSC		
Overall Height	A	0.89	–	1.12
Molded Package Thickness	A2	0.79	0.95	1.02
Standoff	A1	0.01	–	0.10
Overall Width	E	2.10	–	2.64
Molded Package Width	E1	1.16	1.30	1.40
Overall Length	D	2.67	2.90	3.05
Foot Length	L	0.13	0.50	0.60
Foot Angle	$\phi$	0°	–	10°
Lead Thickness	c	0.08	–	0.20
Lead Width	b	0.30	–	0.54

**Notes:**

- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.25 mm per side.
- Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-104B

# MCP9700/9700A and MCP9701/9701A

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	-	<u>X</u>	<u>/XX</u>	
Device		Temperature Range	Package	
<p>Device:</p> <p>MCP9700T: Linear Active Thermistor™ IC, Tape and Reel, Pb free</p> <p>MCP9700AT: Linear Active Thermistor™ IC, Tape and Reel, Pb free</p> <p>MCP9701T: Linear Active Thermistor™ IC, Tape and Reel, Pb free</p> <p>MCP9701AT: Linear Active Thermistor™ IC, Tape and Reel, Pb free</p> <p>Temperature Range: E = -40°C to +125°C</p> <p>Package:</p> <p>LT = Plastic Small Outline Transistor, 5-lead</p> <p>TO = Plastic Small Outline Transistor, 3-lead</p> <p>TT = Plastic Small Outline Transistor, 3-lead</p>				<p><b>Examples:</b></p> <p>a) MCP9700T-E/LT: Linear Active Thermistor™ IC, Tape and Reel, 5LD SC-70 package.</p> <p>b) MCP9700-E/TO: Linear Active Thermistor™ IC, 3LD TO-92 package.</p> <p>c) MCP9700T-E/OT: Linear Active Thermistor™ IC, Tape and Reel, 3LD SOT-23 package.</p> <p>d) MCP9700AT-E/LT: Linear Active Thermistor™ IC, Tape and Reel, 5LD SC-70 package.</p> <p>e) MCP9700AT-E/OT: Linear Active Thermistor™ IC, Tape and Reel, 3LD SOT-23 package.</p> <p>a) MCP9701T-E/LT: Linear Active Thermistor™ IC, Tape and Reel, 5LD SC-70 package.</p> <p>b) MCP9701-E/TO: Linear Active Thermistor™ IC, 3LD TO-92 package.</p> <p>c) MCP9701T-E/OT: Linear Active Thermistor™ IC, Tape and Reel, 3LD SOT-23 package.</p> <p>d) MCP9701AT-E/LT: Linear Active Thermistor™ IC, Tape and Reel, 5LD SC-70 package.</p> <p>e) MCP9701AT-E/OT: Linear Active Thermistor™ IC, Tape and Reel, 3LD SOT-23 package.</p>