

SM73710

2.7V, SOT-23 Temperature Sensor

General Description

The SM73710 is a precision integrated-circuit temperature sensor that can sense a -40°C to $+125^{\circ}\text{C}$ temperature range while operating from a single $+2.7\text{V}$ supply. The SM73710's output voltage is linearly proportional to Celsius (Centigrade) temperature ($+6.25\text{ mV}/^{\circ}\text{C}$) and has a DC offset of $+424\text{ mV}$. The offset allows reading negative temperatures without the need for a negative supply. The nominal output voltage of the SM73710 ranges from $+174\text{ mV}$ to $+1205\text{ mV}$ for a -40°C to $+125^{\circ}\text{C}$ temperature range. The SM73710 is calibrated to provide accuracies of $\pm 2.0^{\circ}\text{C}$ at room temperature and $\pm 4^{\circ}\text{C}$ over the full -40°C to $+125^{\circ}\text{C}$ temperature range.

The SM73710's linear output, $+424\text{ mV}$ offset, and factory calibration simplify external circuitry required in a single supply environment where reading negative temperatures is required. Because the SM73710's quiescent current is less than $110\text{ }\mu\text{A}$, self-heating is limited to a very low 0.1°C in still air in the SOT-23 package. Shutdown capability for the SM73710 is intrinsic because its inherent low power consumption allows it to be powered directly from the output of many logic gates.

Features

- Renewable Energy Grade
- Calibrated linear scale factor of $+6.25\text{ mV}/^{\circ}\text{C}$
- Rated for full -40°C to $+125^{\circ}\text{C}$ range
- Suitable for remote applications
- Available in SOT-23 package

Applications

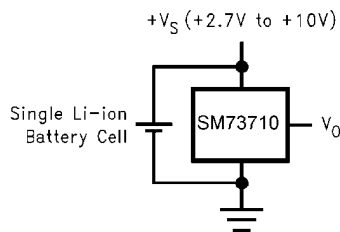
- Photovoltaic Electronics
- Cellular Phones
- Computers
- Power Supply Modules
- Battery Management
- FAX Machines
- Printers
- HVAC
- Disk Drives
- Appliances

Key Specifications

- Accuracy at 25°C : $\pm 3.0^{\circ}\text{C}$ (max)
- Accuracy for -40°C to $+125^{\circ}\text{C}$: $\pm 4.0^{\circ}\text{C}$ (max)
- Temperature Slope: $+6.25\text{ mV}/^{\circ}\text{C}$
- Power Supply Voltage Range: $+2.7\text{V}$ to $+10\text{V}$
- Current Drain @ 25°C : $110\text{ }\mu\text{A}$ (max)
- Nonlinearity: $\pm 0.8^{\circ}\text{C}$ (max)
- Output Impedance: $800\text{ }\Omega$ (max)



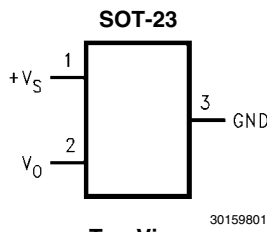
Typical Application



$$V_O = (+6.25\text{ mV}/^{\circ}\text{C} \times T) + 424\text{ mV}$$

Temperature (T)	Typical V_O
$+125^{\circ}\text{C}$	$+1205\text{ mV}$
$+100^{\circ}\text{C}$	$+1049\text{ mV}$
$+25^{\circ}\text{C}$	$+580\text{ mV}$
0°C	$+424\text{ mV}$
-25°C	$+268\text{ mV}$
-40°C	$+174\text{ mV}$

Connection Diagram



Top View
See NS Package Number MF03A

FIGURE 1. Full-Range Centigrade Temperature Sensor (-40°C to $+125^{\circ}\text{C}$) Operating from a Single Li-Ion Battery Cell

Ordering Information

Order Number	Device Top Mark	Supplied In	NSC Package Drawing	Package Type
SM73710MF	S737	1000 Units, Tape and Reel	MF03A	SOT-23
SM73710MFE	S737	250 Units, Tape and Reel		
SM73710MFX	S737	3000 Units, Tape and Reel		

Absolute Maximum Ratings *(Note 1)*

Supply Voltage	+12V to -0.2V
Output Voltage	(+V _S + 0.6V) to -0.6V
Output Current	10 mA
Input Current at any pin <i>(Note 2)</i>	5 mA
ESD Susceptibility <i>(Note 3)</i> :	
Human Body Model	2500V
Machine Model	250V

Storage Temperature	-65°C to +150°C
Maximum Junction Temperature (T _{JMAX})	+125°C

Operating Ratings *(Note 1)*

Specified Temperature Range:	T _{MIN} ≤ T _A ≤ T _{MAX}
SM73710	-40°C ≤ T _A ≤ +125°C
Supply Voltage Range (+V _S)	+2.7V to +10V
Thermal Resistance, θ _{JA} <i>(Note 5)</i>	450°C/W

Soldering process must comply with National Semiconductor's Reflow Temperature Profile specifications. Refer to www.national.com/packaging. *(Note 4)*

Electrical Characteristics

Unless otherwise noted, these specifications apply for +V_S = +3.0 V_{DC} and I_{LOAD} = 1 μA. **Boldface limits apply for T_A = T_J = T_{MIN} to T_{MAX}**; all other limits T_A = T_J = 25°C.

Parameter	Conditions	Typical <i>(Note 6)</i>	Limits <i>(Note 7)</i>	Units <i>(Limit)</i>
Accuracy <i>(Note 8)</i>			±3.0	°C (max)
			±4.0	°C (max)
Output Voltage at 0°C		+424		mV
Nonlinearity <i>(Note 9)</i>			±0.8	°C (max)
Sensor Gain (Average Slope)		+6.25	+6.00	mV/°C (min)
			+6.50	mV/°C (max)
Output Impedance			800	Ω (max)
Line Regulation <i>(Note 10)</i>	+3.0V ≤ +V _S ≤ +10V		±0.3	mV/V (max)
	+2.7V ≤ +V _S ≤ +3.3V		±2.3	mV (max)
Quiescent Current	+2.7V ≤ +V _S ≤ +10V	82	110	μA (max)
			125	μA (max)
Change of Quiescent Current	+2.7V ≤ +V _S ≤ +10V	±5.0		μA (max)
Temperature Coefficient of Quiescent Current		0.2		μA/°C
Long Term Stability <i>(Note 11)</i>	T _J =T _{MAX} =+125°C, for 1000 hours	±0.2		°C

Note 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 guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

Note 2: When the input voltage (V_I) at any pin exceeds power supplies (V_I < GND or V_I > +V_S), the current at that pin should be limited to 5 mA.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin. The machine model is a 200 pF capacitor discharged directly into each pin.

Note 4: Reflow temperature profiles are different for lead-free and non-lead-free packages.

Note 5: The junction to ambient thermal resistance (θ_{JA}) is specified without a heat sink in still air.

Note 6: Typicals are at T_J = T_A = 25°C and represent most likely parametric norm.

Note 7: Limits are guaranteed to National's AOQL (Average Outgoing Quality Level).

Note 8: Accuracy is defined as the error between the output voltage and +6.25 mV/°C times the device's case temperature plus 424 mV, at specified conditions of voltage, current, and temperature (expressed in °C).

Note 9: Nonlinearity is defined as the deviation of the output-voltage-versus-temperature curve from the best-fit straight line, over the device's rated temperature range.

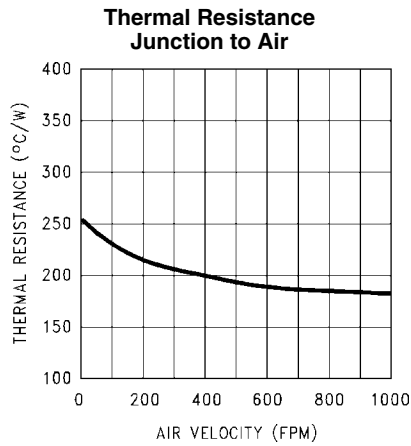
Note 10: Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output due to heating effects can be computed by multiplying the internal dissipation by the thermal resistance.

Note 11: For best long-term stability, any precision circuit will give best results if the unit is aged at a warm temperature, and/or temperature cycled for at least 46 hours before long-term life test begins. This is especially true when a small (Surface-Mount) part is wave-soldered; allow time for stress relaxation to occur. The majority of the drift will occur in the first 1000 hours at elevated temperatures. The drift after 1000 hours will not continue at the first 1000 hour rate.

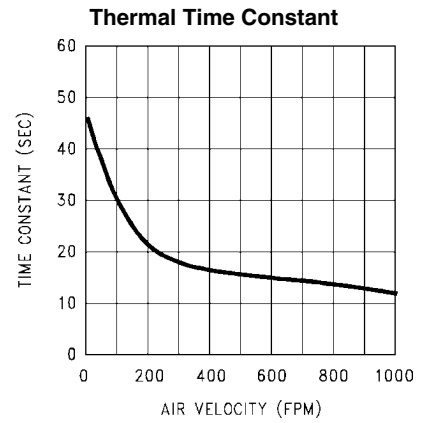
Typical Performance Characteristics

to generate these curves the SM73710 was mounted to a printed circuit board as shown in *Figure 2*.

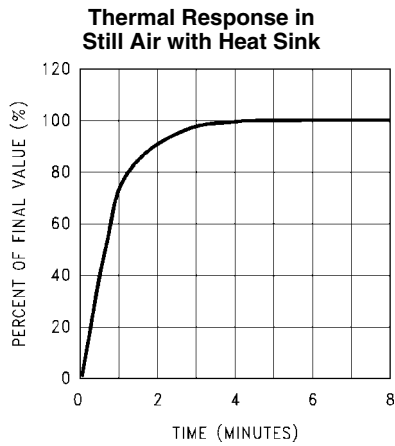
To generate these curves the SM73710 was mounted to a printed circuit board as shown in *Figure 2*.



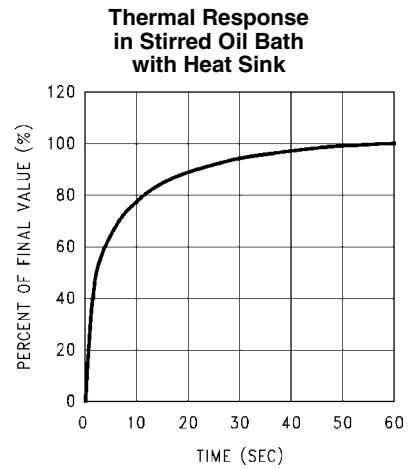
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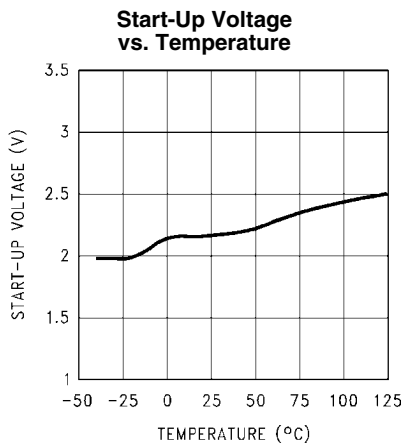
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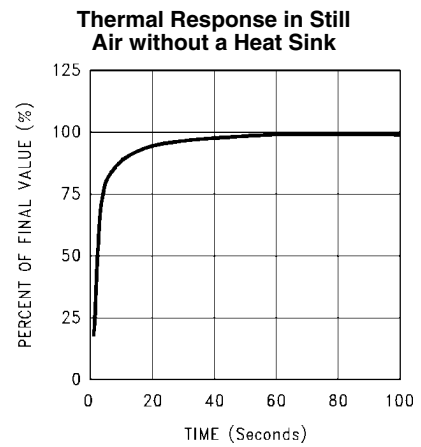
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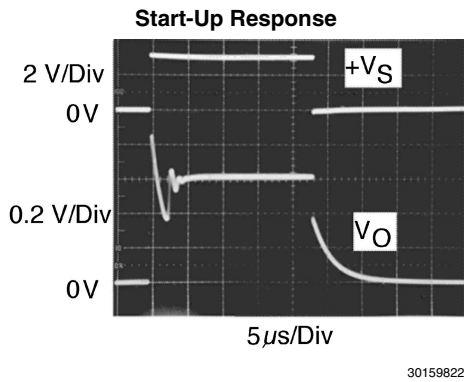
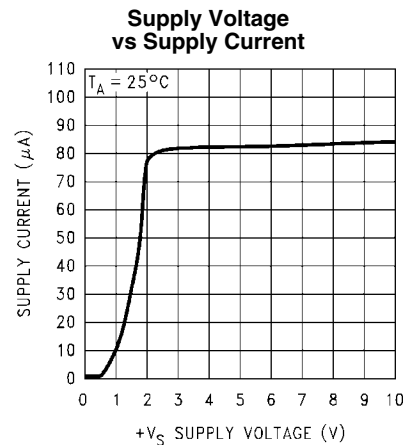
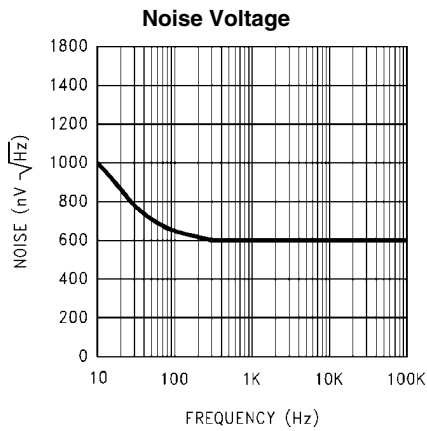
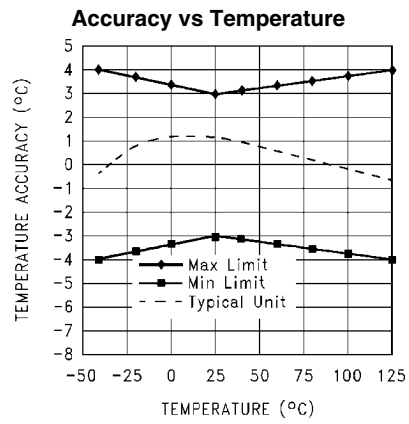
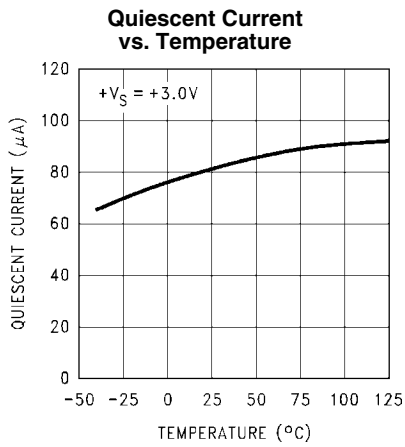
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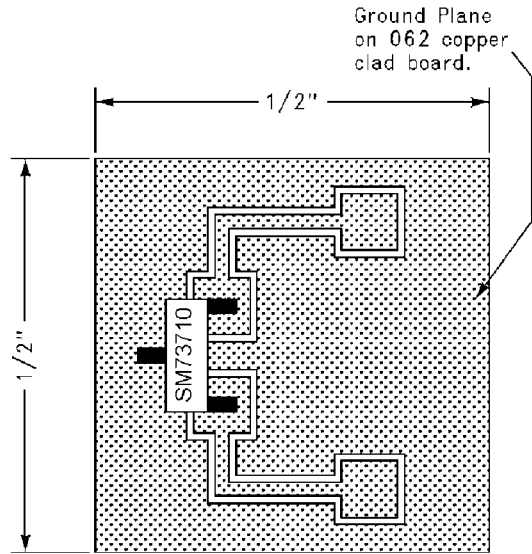


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FIGURE 2. Printed Circuit Board Used for Heat Sink to Generate All Curves.
1/2 Square Printed Circuit Board with 2 oz. Copper Foil or Similar.

1.0 Mounting

The SM73710 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface. The temperature that the SM73710 is sensing will be within about +0.1°C of the surface temperature that SM73710's leads are attached to.

This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature, the actual temperature of the SM73710 die would be at an intermediate temperature between the surface temperature and the air temperature.

To ensure good thermal conductivity the backside of the SM73710 die is directly attached to the GND pin. The lands and traces to the SM73710 will, of course, be part of the printed circuit board, which is the object whose temperature is being measured. These printed circuit board lands and traces will not cause the SM73710's temperature to deviate from the desired temperature.

Alternatively, the SM73710 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 SM73710 and accompanying wiring and circuits must be kept insulated and dry, to avoid leakage and corrosion. This is especially true if the circuit may operate at cold temperatures where condensation can occur. Printed-circuit coatings and varnishes such as Humiseal and epoxy paints or dips are often used to ensure that moisture cannot corrode the SM73710 or its connections.

The thermal resistance junction to ambient (θ_{JA}) is the parameter used to calculate the rise of a device junction temperature due to the device power dissipation. For the SM73710 the equation used to calculate the rise in the die temperature is as follows:

$$T_J = T_A + \theta_{JA} [(+V_S I_Q) + (+V_S - V_O) I_L]$$

where I_Q is the quiescent current and I_L is the load current on the output.

The table shown in [Figure 3](#) summarizes the rise in die temperature of the SM73710 without any loading, and the thermal resistance for different conditions.

	SOT-23* no heat sink		SOT-23** small heat fin	
	θ_{JA} (°C/W)	$T_J - T_A$ (°C)	θ_{JA} (°C/W)	$T_J - T_A$ (°C)
Still air	450	0.17	260	0.1
Moving air			180	0.07

*-Part soldered to 30 gauge wire.

**-Heat sink used is 1/2 square printed circuit board with 2 oz. foil with part attached as shown in [Figure 2](#).

FIGURE 3. Temperature Rise of SM73710 Due to Self-Heating and Thermal Resistance (θ_{JA})

2.0 Capacitive Loads

The SM73710 handles capacitive loading well. Without any special precautions, the SM73710 can drive any capacitive load as shown in *Figure 4*. Over the specified temperature range the SM73710 has a maximum output impedance of 800Ω. In an extremely noisy environment it may be necessary to add some filtering to minimize noise pickup. It is recommended that 0.1 μF be added from +V_S to GND to bypass the power supply voltage, as shown in *Figure 5*. In a noisy environment it may be necessary to add a capacitor from the output to ground. A 1 μF output capacitor with the 800Ω output impedance will form a 199 Hz lowpass filter. Since the thermal time constant of the SM73710 is much slower than the 6.3 ms time constant formed by the RC, the overall response time of the SM73710 will not be significantly affected. For much larger capacitors this additional time lag will increase the overall response time of the SM73710.

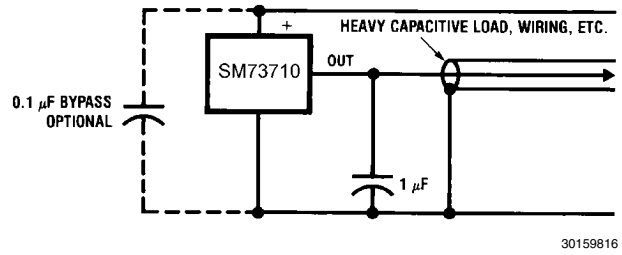


FIGURE 5. SM73710 with Filter for Noisy Environment

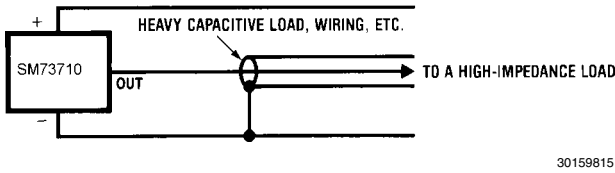


FIGURE 4. SM73710 No Decoupling Required for Capacitive Load

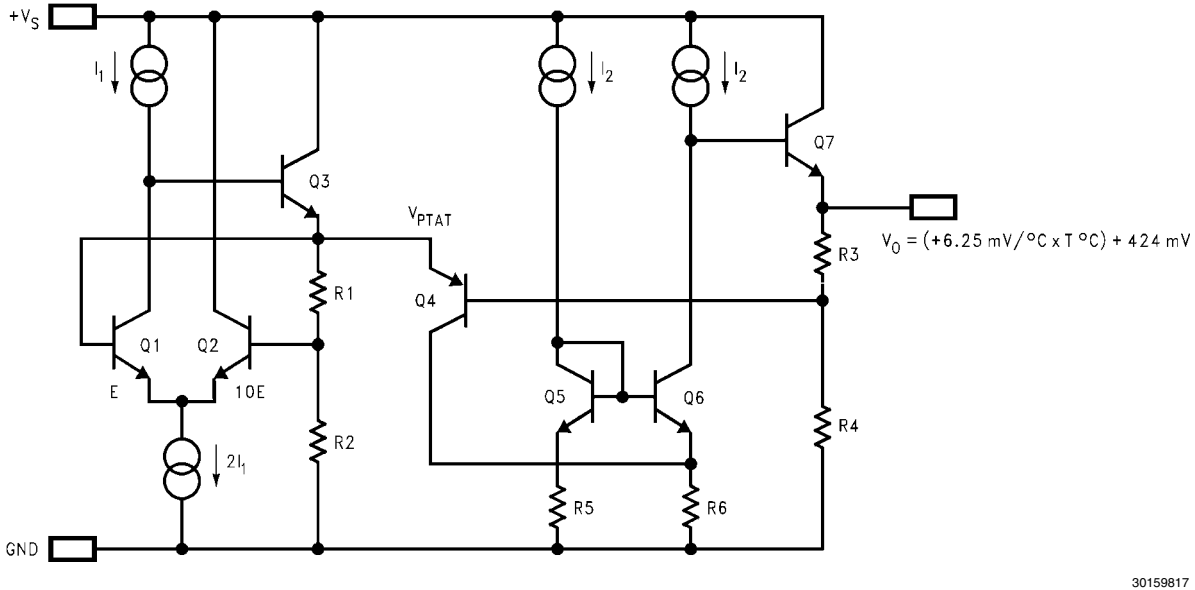
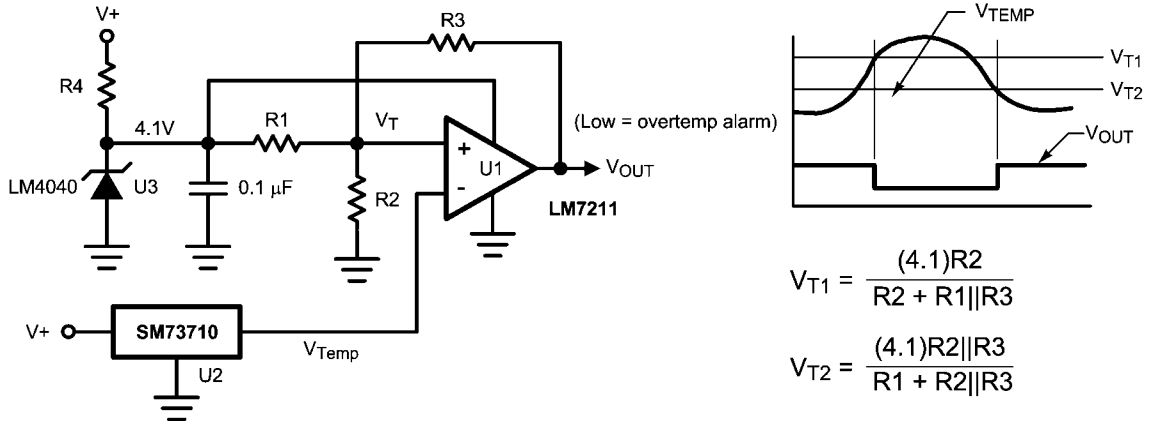


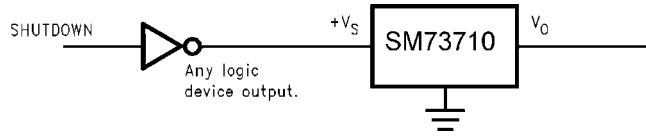
FIGURE 6. Simplified Schematic

3.0 Applications Circuits



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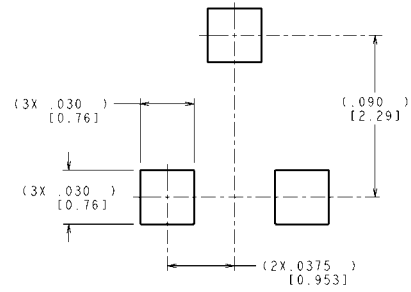
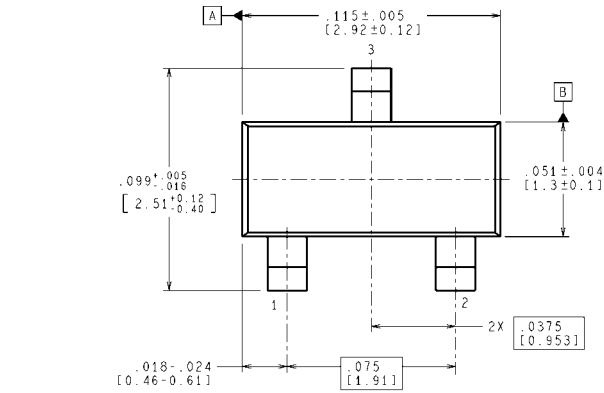
FIGURE 7. Centigrade Thermostat



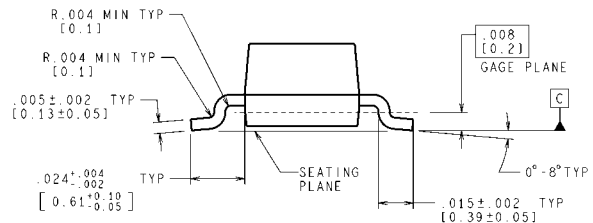
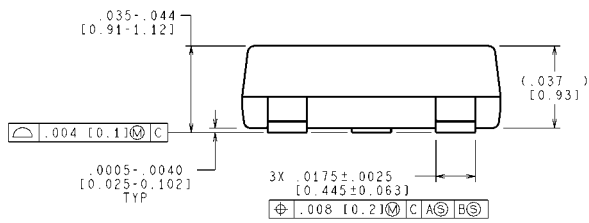
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FIGURE 8. Conserving Power Dissipation with Shutdown

Physical Dimensions inches (millimeters) unless otherwise noted



RECOMENDED LAND PATTERN



CONTROLLING DIMENSION IS INCH
VALUES IN [] ARE MILLIMETERS

**SOT-23 Molded Small Outline Transistor Package (MF)
NS Package Number MF03A**

MF03A (Rev B)

Notes

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