

SM73710 2.7V, SOT-23 Temperature Sensor

Check for Samples: [SM73710](#)

FEATURES

- Renewable Energy Grade
- Calibrated Linear Scale Factor of +6.25 mV/°C
- Rated for Full -40°C to +125°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

DESCRIPTION

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

The SM73710's linear output, +424 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 µA, 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.

Table 1. Key Specifications

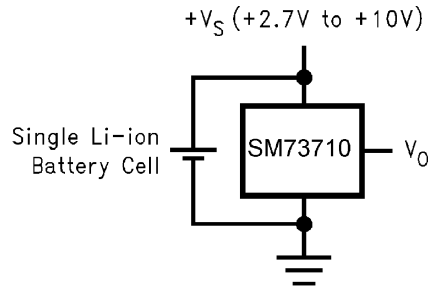
	VALUE	UNIT
Accuracy at 25°C:	±3.0	°C (max)
Accuracy for -40°C to +125°C:	±4.0	°C (max)
Temperature Slope:	+6.25	mV/°C
Power Supply Voltage Range:	+2.7 to +10	V
Current Drain @ 25°C:	110	µA (max)
Nonlinearity:	±0.8	°C (max)
Output Impedance:	800	Ω (max)



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Typical Application



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

Figure 1. Full-Range Centigrade Temperature Sensor (–40°C to +125°C) Operating from a Single Li-Ion Battery Cell

Temperature (T)	Typical V _O
+125°C	+1205 mV
+100°C	+1049 mV
+25°C	+580 mV
0°C	+424 mV
–25°C	+268 mV
–40°C	+174 mV

Connection Diagram

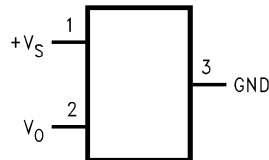


Figure 2. SOT-23 Package Number DBZ0003A Top View



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.

Absolute Maximum Ratings ⁽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 ⁽²⁾	5 mA
ESD Susceptibility ⁽³⁾ :	
Human Body Model	2500V
Machine Model	250V
Storage Temperature	-65°C to +150°C
Maximum Junction Temperature (T _{JMAX})	+125°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 ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured 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) 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.
- (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.

Operating Ratings ⁽¹⁾⁽²⁾⁽³⁾

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} ⁽⁴⁾	450°C/W

- (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 ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured 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 Texas Instruments's Reflow Temperature Profile specifications. Refer to www.ti.com/packaging.*
- (3) Reflow temperature profiles are different for lead-free and non-lead-free packages.
- (4) The junction to ambient thermal resistance (θ_{JA}) is specified without a heat sink in still air.

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 ⁽¹⁾	Limits ⁽²⁾	Units (Limit)
Accuracy ⁽³⁾			±3.0	°C (max)
			±4.0	°C (max)
Output Voltage at 0°C		+424		mV
Nonlinearity ⁽⁴⁾			±0.8	°C (max)
Sensor Gain		+6.25	+6.00	mV/°C (min)
(Average Slope)			+6.50	mV/°C (max)
Output Impedance			800	Ω (max)
Line Regulation ⁽⁵⁾	+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)

- (1) Typicals are at T_J = T_A = 25°C and represent most likely parametric norm.
- (2) Limits are ensured to TI's AOQL (Average Outgoing Quality Level).
- (3) 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).
- (4) 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.
- (5) 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.

Electrical Characteristics (continued)

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

Parameter	Conditions	Typical (1)	Limits (2)	Units (Limit)
Temperature Coefficient of Quiescent Current		0.2		$\mu A/^\circ C$
Long Term Stability (6)	$T_J = T_{MAX} = +125^\circ C$, for 1000 hours	± 0.2		$^\circ C$

- (6) 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 14](#).

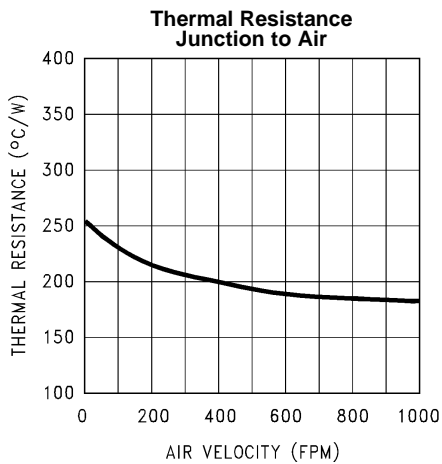


Figure 3.

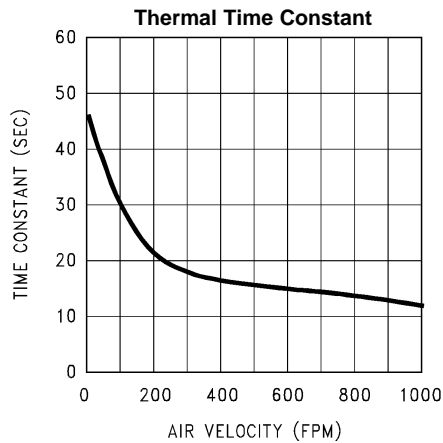


Figure 4.

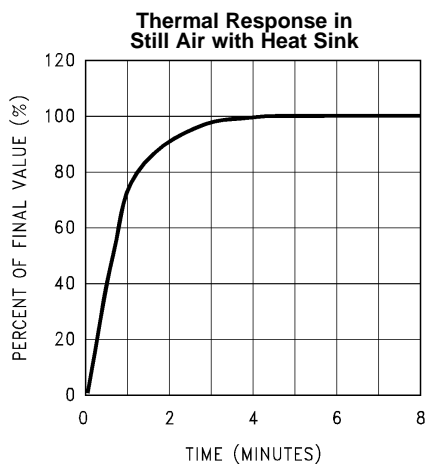


Figure 5.

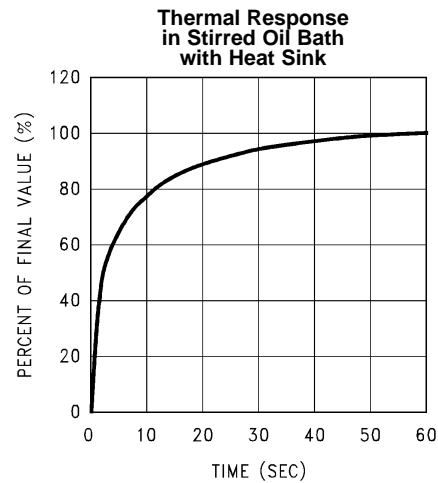


Figure 6.

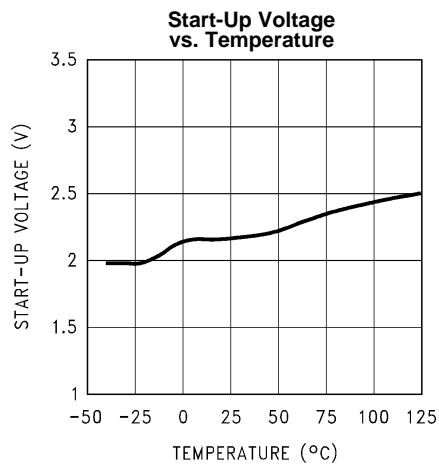


Figure 7.

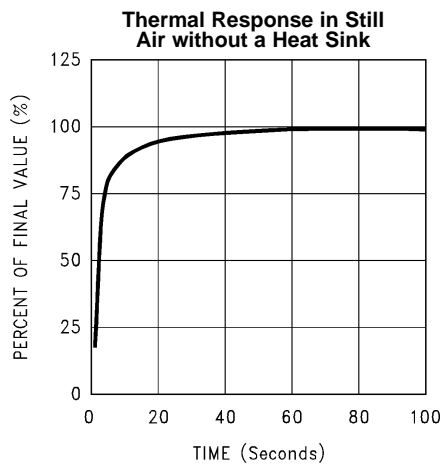


Figure 8.

Typical Performance Characteristics (continued)

To generate these curves the SM73710 was mounted to a printed circuit board as shown in [Figure 14](#).

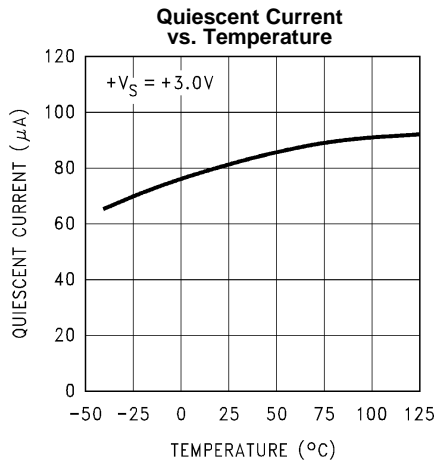


Figure 9.

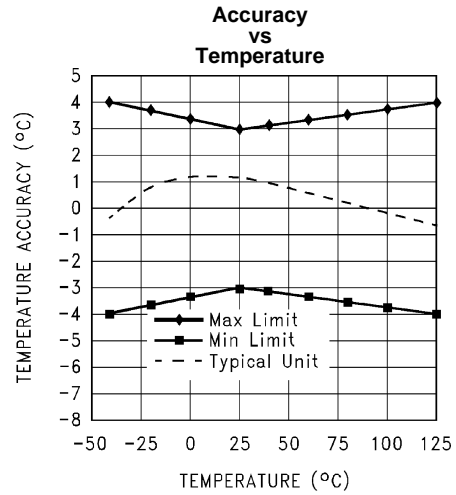


Figure 10.

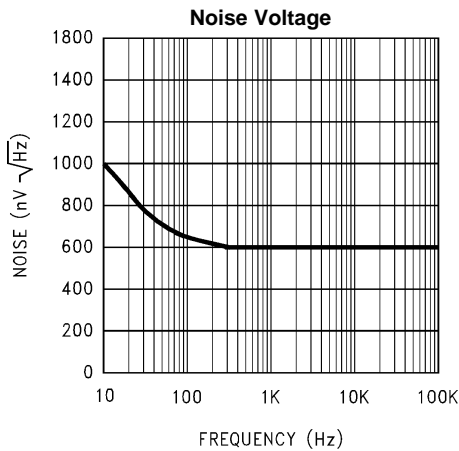


Figure 11.

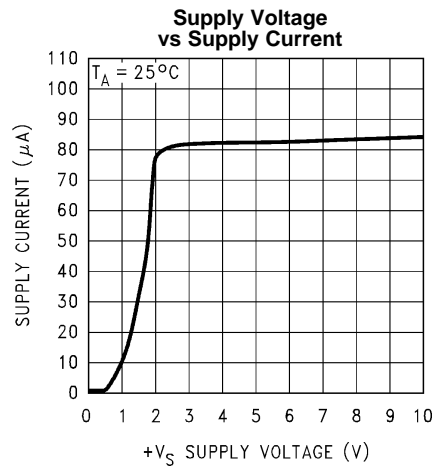


Figure 12.

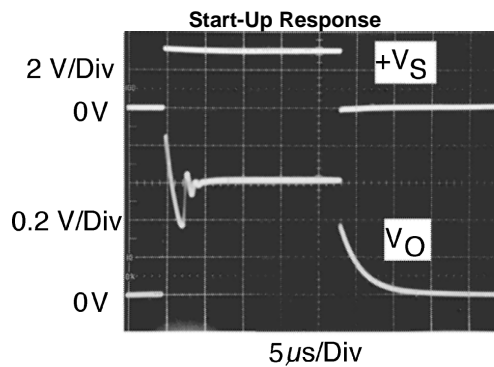
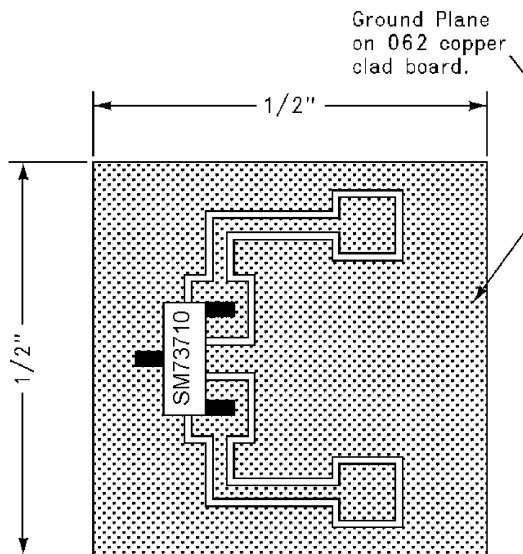


Figure 13.

Typical Performance Characteristics (continued)

To generate these curves the SM73710 was mounted to a printed circuit board as shown in [Figure 14](#).



**Figure 14. Printed Circuit Board Used for Heat Sink to Generate All Curves.
1/2" Square Printed Circuit Board with 2 oz. Copper Foil or Similar.**

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 [Table 2](#) summarizes the rise in die temperature of the SM73710 without any loading, and the thermal resistance for different conditions.

Table 2. Temperature Rise of SM73710 Due to Self-Heating and Thermal Resistance (θ_{JA})

	SOT-23 ⁽¹⁾		SOT-23 ⁽²⁾	
	no heat sink		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

(1) Part soldered to 30 gauge wire.

(2) Heat sink used is ½" square printed circuit board with 2 oz. foil with part attached as shown in [Figure 14](#).

Capacitive Loads

The SM73710 handles capacitive loading well. Without any special precautions, the SM73710 can drive any capacitive load as shown in [Figure 15](#). 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 16](#). 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.

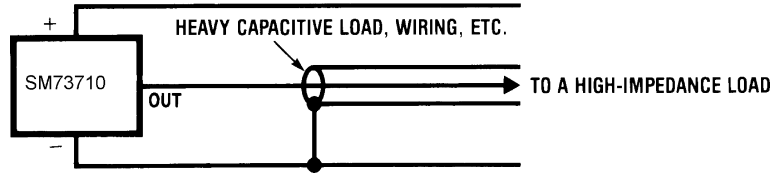


Figure 15. SM73710 No Decoupling Required for Capacitive Load

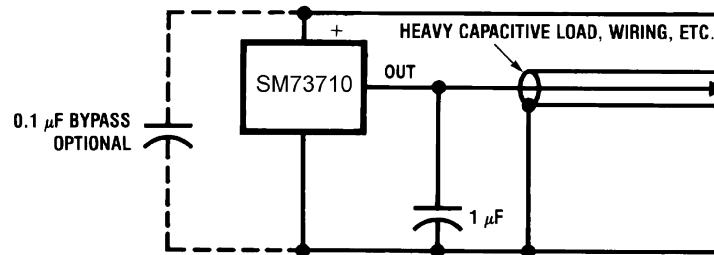


Figure 16. SM73710 with Filter for Noisy Environment

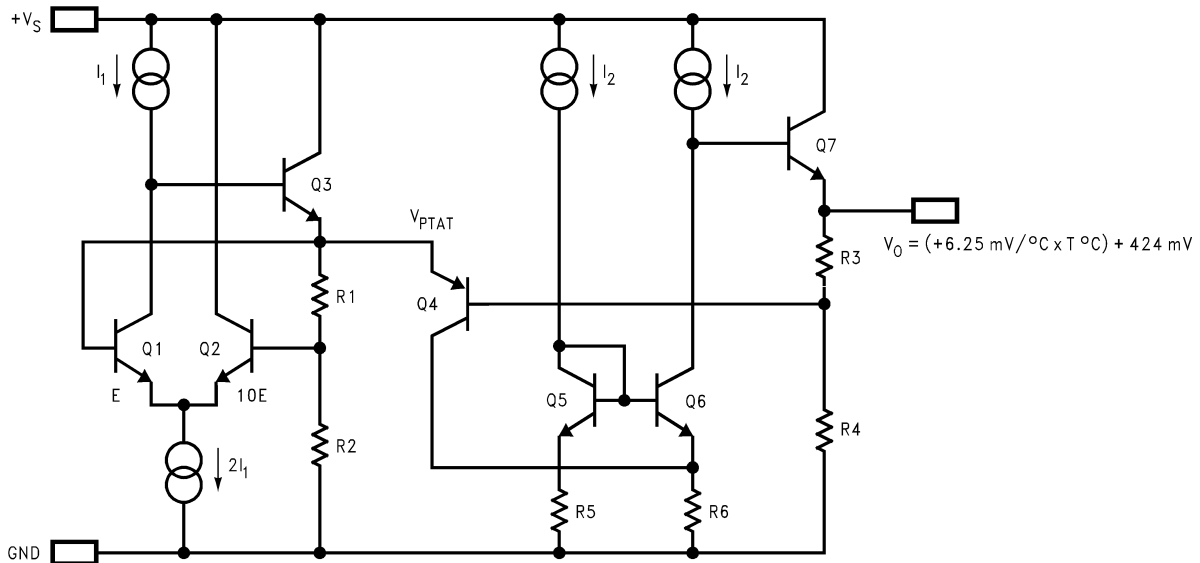


Figure 17. Simplified Schematic

Applications Circuits

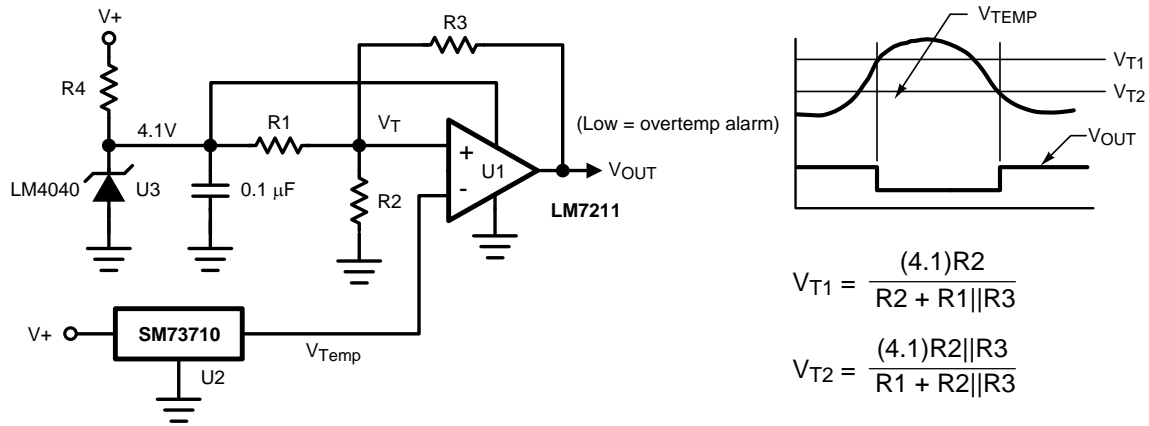


Figure 18. Centigrade Thermostat

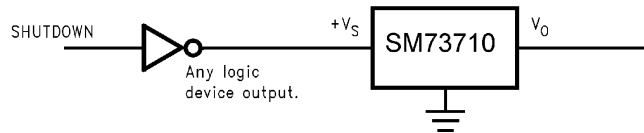


Figure 19. Conserving Power Dissipation with Shutdown

REVISION HISTORY

Changes from Original (April 2013) to Revision A	Page
• Changed layout of National Data Sheet to TI format	10

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