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

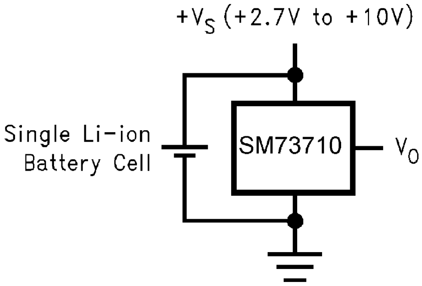
The SM73710 is a precision integrated-circuit temperature sensor that can sense a −40°C to +125°C temperature range while operating from a single +2.7V supply. The SM73710's output voltage is linearly proportional to Celsius (Centigrade) temperature (+6.25 mV/°C) and has a DC offset of +424 mV. The offset 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)

Typical Application



V_O = (+6.25 mV/°C × T °C) + 424 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

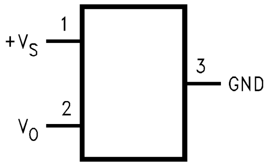


Figure 2. SOT-23
Package Number DBZ0003A
Top View

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 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.
(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:	$\mathbf{T_{MIN} \le T_A \le T_{MAX}}$
SM73710	$-40°C \le T_A \le +125°C$
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 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.
(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 $I_{LOAD} = 1\ \mu A$. **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)	$+3.0V \le +V_S \le +10V$		**±0.3**	mV/V (max)
	$+2.7V \le +V_S \le +3.3V$		**±2.3**	mV (max)
Quiescent Current	$+2.7V \le +V_S \le +10V$	82	110	µA (max)
			125	µA (max)
Change of Quiescent Current	$+2.7V \le +V_S \le +10V$	±5.0		µA (max)

---

(1) Typicals are at $T_J = T_A = 25°C$ and represent most likely parametric norm.
(2) Limits are guaranteed 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 $T_A = T_J = 25°C$.

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

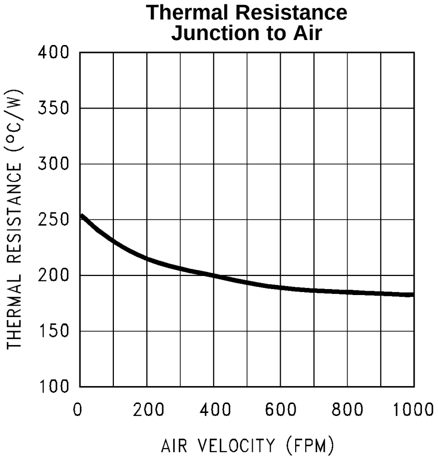


Figure 3.

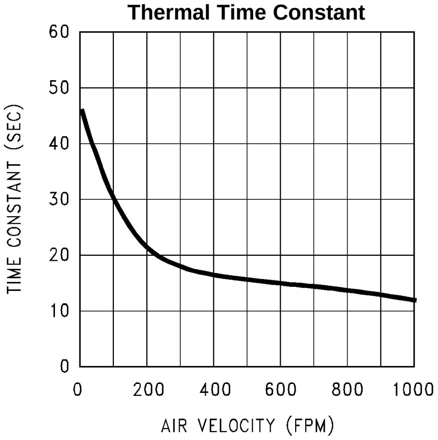


Figure 4.

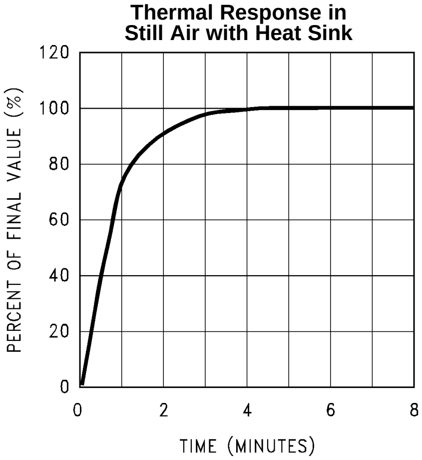


Figure 5.

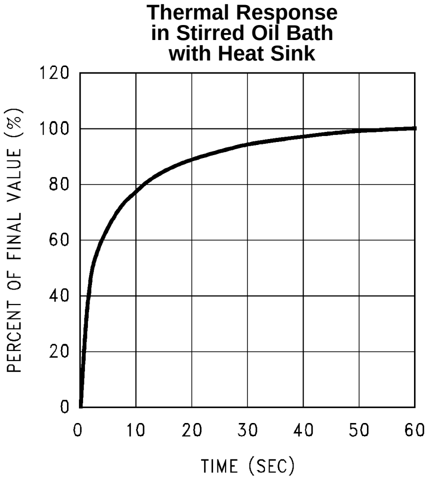


Figure 6.

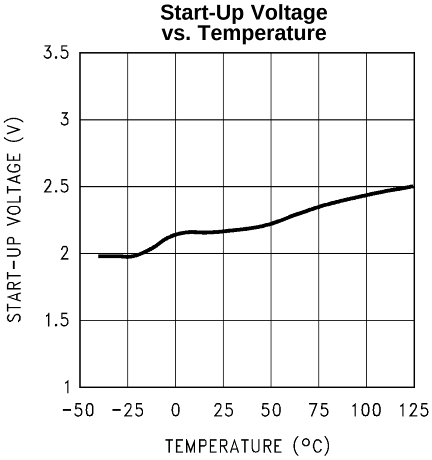


Figure 7.

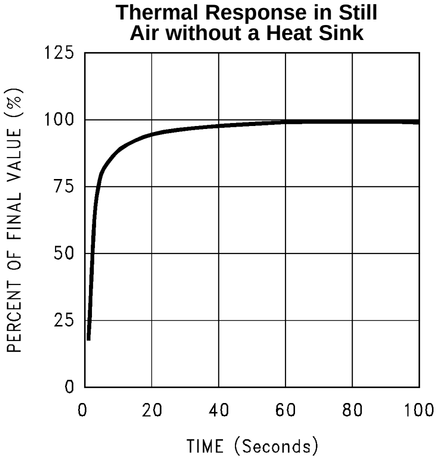


Figure 8.

Typical Performance Characteristics (continued)

To generate these curves the SM73710 was mounted to a printed circuit board as shown in Figure 14.

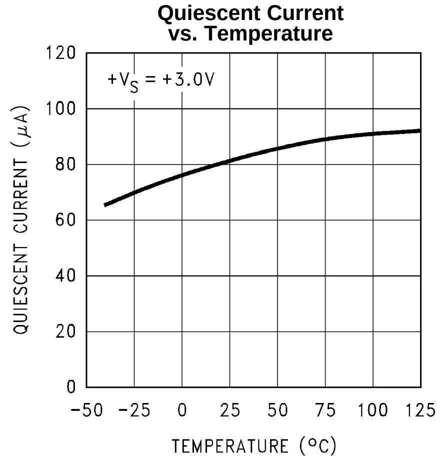


Figure 9.

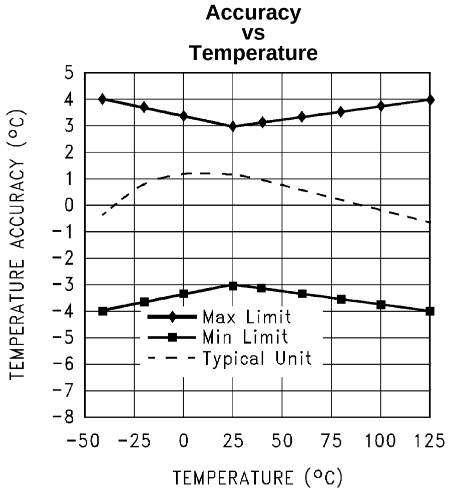


Figure 10.

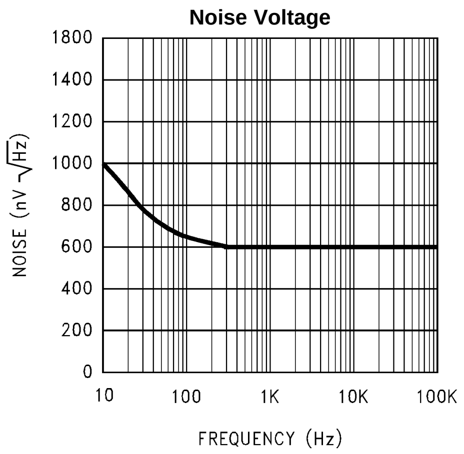


Figure 11.

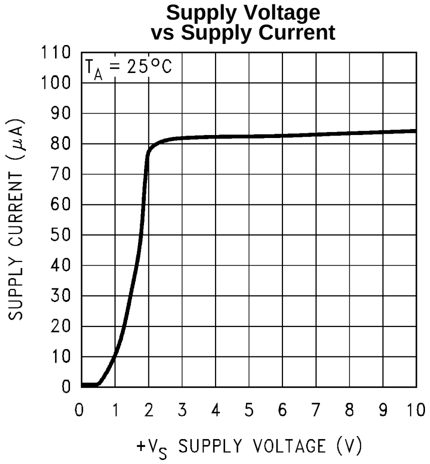


Figure 12.

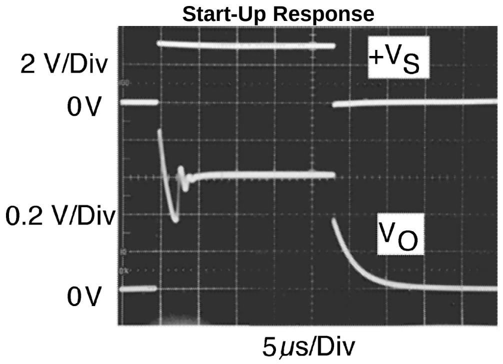


Figure 13.

Typical Performance Characteristics (continued)

To generate these curves the SM73710 was mounted to a printed circuit board as shown in Figure 14.

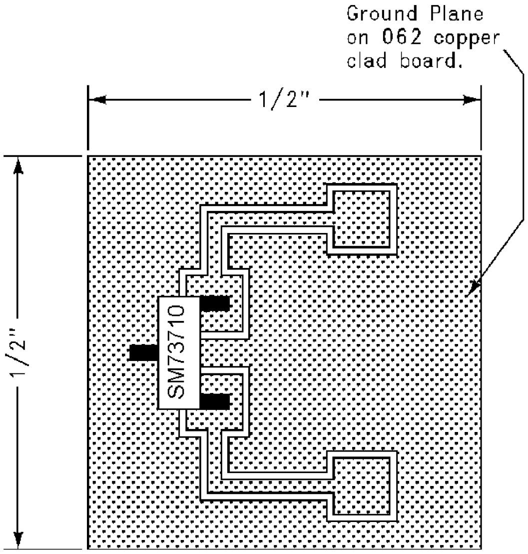


Figure 14. Printed Circuit Board Used for Heat Sink to Generate All Curves. ½″ Square Printed Circuit Board with 2 oz. Copper Foil or Similar.

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.

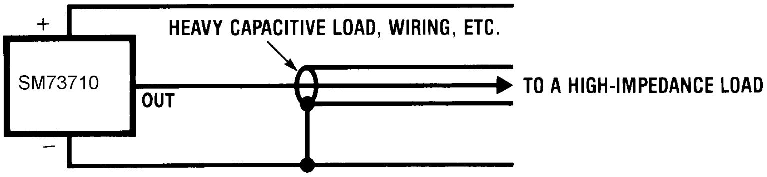


Figure 15. SM73710 No Decoupling Required for Capacitive Load

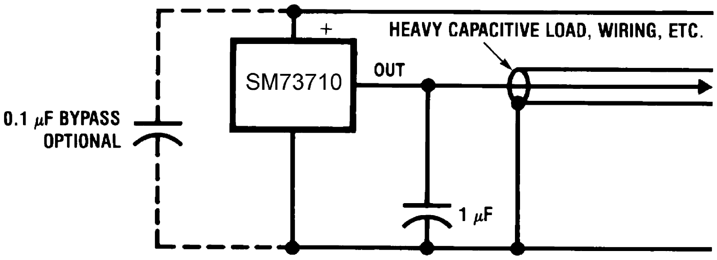


Figure 16. SM73710 with Filter for Noisy Environment

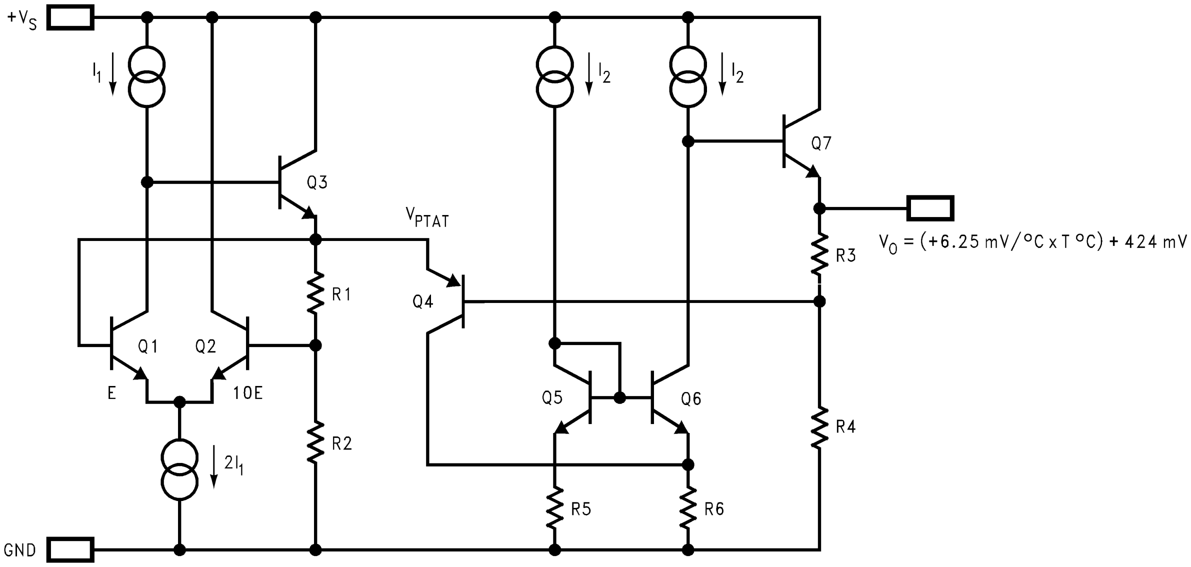


Figure 17. Simplified Schematic

Applications Circuits

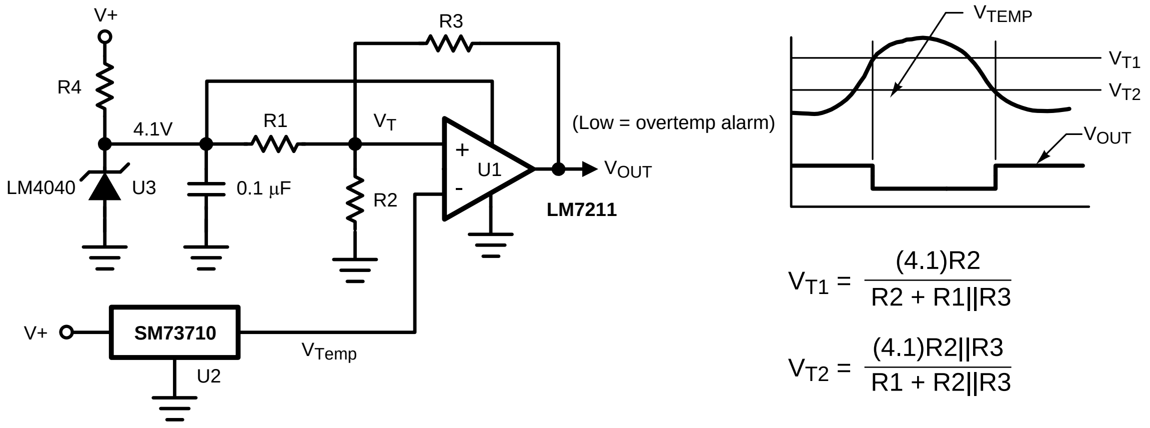


Figure 18. Centigrade Thermostat

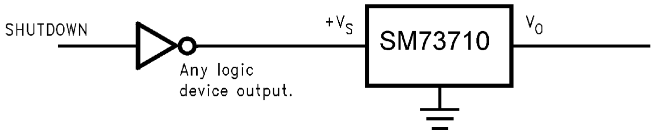


Figure 19. Conserving Power Dissipation with Shutdown

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265