TMP01: Low Power, Programmable Temperature Controller (Temperature Sensor)

Product Description

The TMP01 is a temperature sensor which generates a voltage output proportional to absolute temperature and a control signal from one of two outputs when the device is either above or below a specific temperature range. Both the high/low temperature trip points and hysteresis (overshoot) band are determined by user-selected external resistors. For high volume production, these resistors are available on-board.

The TMP01 consists of a bandgap voltage reference combined with a pair of matched comparators. The reference provides both a constant 2.5 V output and a voltage proportional to absolute temperature (VPTAT) which has a precise temperature coefficient of 5 mV/K and is 1.49 V (nominal) at +25°C. The comparators compare VPTAT with the externally set temperature trip points and generate an open-collector output signal when one of their respective thresholds has been exceeded.

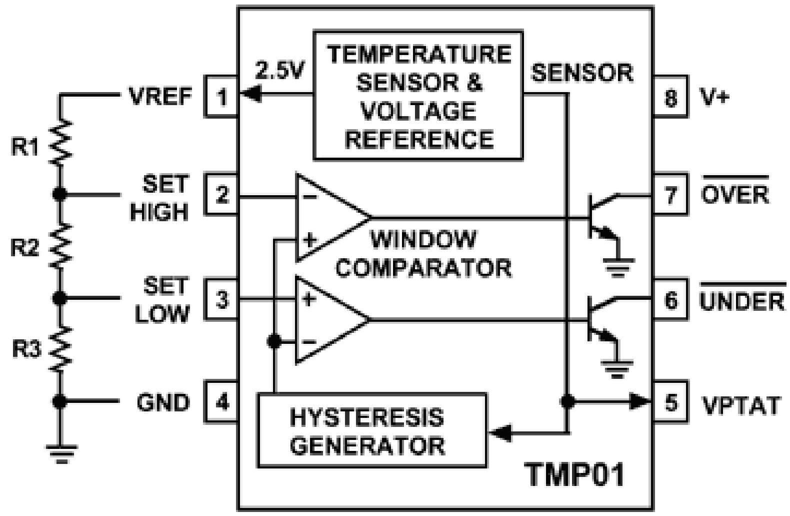
Hysteresis is also programmed by the external resistor chain and is determined by the total current drawn out of the 2.5 V reference. This current is mirrored and used to generate a hysteresis offset voltage of the appropriate polarity after a comparator has been tripped. The comparators are connected in parallel, which guarantees that there is no hysteresis overlap and eliminates erratic transitions between adjacent trip zones.

The TMP01 utilizes proprietary thin-film resistors in conjunction with production laser trimming to maintain a temperature accuracy of ±1°C (typ) over the rated temperature range, with excellent linearity. The open-collector outputs are capable of sinking 20 mA, enabling the TMP01 to drive control relays directly. Operating from a +5 V supply, quiescent current is only 500 µA (max).

The TMP01 is available in the low cost 8-pin epoxy mini-DIP and SO (small outline) packages, and in die form.

Features

- –55°C to +125°C (–67°F to +257°F) Operation
- ±1.0°C Accuracy Over Temperature (typ)
- Temperature-Proportional Voltage Output
- User Programmable Temperature Trip Points
- User Programmable Hysteresis
- 20 mA Open Collector Trip Point Outputs
- TTL/CMOS Compatible
- Single-Supply Operation (4.5 V to 13.2 V)
- Low Cost 8-Pin DIP and SO Packages



Functional Block Diagram for TMP01

Model	Package	Pins	ROHS Compilant
TMP01FPZ	8 ld PDIP	8	Y Material Declaration
TMP01FSZ	8 ld SOIC	8	Y Material Declaration

Low Power Programmable Temperature Controller

TMP01*

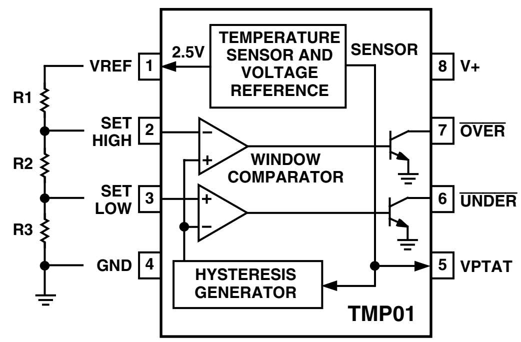
FEATURES

–558C to +1258C (–678F to +2578F) Operation
61.08C Accuracy Over Temperature (typ)
Temperature-Proportional Voltage Output
User-Programmable Temperature Trip Points
User-Programmable Hysteresis
20 mA Open Collector Trip Point Outputs
TTL/CMOS Compatible
Single-Supply Operation (4.5 V to 13.2 V)
Low-Cost 8-Pin DIP and SO Packages

APPLICATIONS

Over/Under Temperature Sensor and Alarm
Board Level Temperature Sensing
Temperature Controllers
Electronic Thermostats
Thermal Protection
HVAC Systems
Industrial Process Control
Remote Sensors

FUNCTIONAL BLOCK DIAGRAM



GENERAL DESCRIPTION

The TMP01 is a temperature sensor that generates a voltage output proportional to absolute temperature and a control signal from one of two outputs when the device is either above or below a specific temperature range. Both the high/low temperature trip points and hysteresis (overshoot) band are determined by user-selected external resistors. For high volume production, these resistors are available on-board.

The TMP01 consists of a band gap voltage reference combined with a pair of matched comparators. The reference provides both a constant 2.5 V output and a voltage proportional to absolute temperature (VPTAT) which has a precise temperature coefficient of 5 mV/K and is 1.49 V (nominal) at 25°C. The comparators compare VPTAT with the externally set temperature trip points and generate an open-collector output signal when one of their respective thresholds has been exceeded.

Hysteresis is also programmed by the external resistor chain and is determined by the total current drawn out of the 2.5 V reference. This current is mirrored and used to generate a hysteresis offset voltage of the appropriate polarity after a comparator has been tripped. The comparators are connected in parallel, which guarantees that there is no hysteresis overlap and eliminates erratic transitions between adjacent trip zones.

The TMP01 utilizes proprietary thin-film resistors in conjunction with production laser trimming to maintain a temperature accuracy of ±1°C (typical) over the rated temperature range, with excellent linearity. The open-collector outputs are capable of sinking 20 mA, enabling the TMP01 to drive control relays directly. Operating from a 5 V supply, quiescent current is only 500 µA (max).

The TMP01 is available in low-cost 8-pin epoxy mini-DIP and SO (small outline) packages.

TMP01FP, TMP01ES/TMP01FS–SPECIFICATIONS Plastic DIP and Surface Mount

Packages (V+ = 5 V, GND = 0 V, –40°C ≤ T_A ≤ +85°C, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUTS SET HIGH, SET LOW						
Offset Voltage	V_{OS}			0.25		mV
Offset Voltage Drift	TCV_{OS}			3		µV/°C
Input Bias Current, "E"	I_B			25	50	nA
Input Bias Current, "F"	I_B			25	100	nA
OUTPUT VPTAT[1]						
Output Voltage	VPTAT	T_A = 25°C, No Load		1.49		V
Scale Factor	TC_{VPTAT}			5		mV/K
Temperature Accuracy, "E"		T_A = 25°C, No Load	–1.5	±0.5	1.5	°C
Temperature Accuracy, "F"		T_A = 25°C, No Load	–3	±1.0	3	°C
Temperature Accuracy, "E"		10°C < T_A < 40°C, No Load		±0.75		°C
Temperature Accuracy, "F"		10°C < T_A < 40°C, No Load		±1.5		°C
Temperature Accuracy, "E"		–40°C < T_A < 85°C, No Load	–3.0	±1	3.0	°C
Temperature Accuracy, "F"		–40°C < T_A < 85°C, No Load	–5.0	±2	5.0	°C
Temperature Accuracy, "E"		–55°C < T_A < 125°C, No Load		±1.5		°C
Temperature Accuracy, "F"		–55°C < T_A < 125°C, No Load		±2.5		°C
Repeatability Error[4]	ΔVPTAT			0.25		Degree
Long-Term Drift Error[2,6]				0.25	0.5	Degree
Power Supply Rejection Ratio	PSRR	T_A = 25°C, 4.5 V ≤ V+ ≤ 13.2 V		±0.02	±0.1	%/V
OUTPUT VREF						
Output Voltage, "E"	VREF	T_A = 25°C, No Load	2.495	2.500	2.505	V
Output Voltage, "F"	VREF	T_A = 25°C, No Load	2.490	2.500	2.510	V
Output Voltage, "E"	VREF	–40°C < T_A < 85°C, No Load	2.490	2.500	2.510	V
Output Voltage, "F"	VREF	–40°C < T_A < 85°C, No Load	2.485	2.500	2.515	V
Output Voltage, "E"	VREF	–55°C < T_A < 125°C, No Load		2.5 ± 0.01		V
Output Voltage, "F"	VREF	–55°C < T_A < 125°C, No Load		2.5 ± 0.015		V
Drift	TC_{VREF}			–10		ppm/°C
Line Regulation		4.5 V ≤ V+ ≤ 13.2 V		±0.01	±0.05	%/V
Load Regulation		10 µA ≤ I_{VREF} ≤ 500 µA		±0.1	±0.25	%/mA
Output Current, Zero Hysteresis	I_{VREF}			7		µA
Hysteresis Current Scale Factor[1]	SF_{HYS}			5.0		µA/°C
Turn-On Settling Time		To Rated Accuracy		25		µs
OPEN-COLLECTOR OUTPUTS OVER, UNDER						
Output Low Voltage	V_{OL}	I_{SINK} = 1.6 mA		0.25	0.4	V
	V_{OL}	I_{SINK} = 20 mA		0.6		V
Output Leakage Current	I_{OH}	V+ = 12 V		1	100	µA
Fall Time	t_{HL}	See Test Load		40		ns
POWER SUPPLY						
Supply Range	V+		4.5		13.2	V
Supply Current	I_{SY}	Unloaded, +V = 5 V		400	500	µA
	I_{SY}	Unloaded, +V = 13.2 V		450	800	µA
Power Dissipation	P_{DISS}	+V = 5 V		2.0	2.5	mW

NOTES

[1]K = °C + 273.15.

[2]Guaranteed but not tested.

[3]Does not consider errors caused by heating due to dissipation of output load currents.

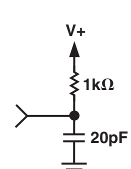
[4]Maximum deviation between 25°C readings after temperature cycling between –55°C and +125°C.

[5]Typical values indicate performance measured at T_A = 25°C.

[6]Observed in a group sample over an accelerated life test of 500 hours at 150°C.

Specifications subject to change without notice.

Test Load



TMP01FJ–SPECIFICATIONS

TO-99 Metal Can Package (V+ = 5 V, GND = 0 V, –40°C ≤ T_A ≤ +85°C, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUTS SET HIGH, SET LOW						
Offset Voltage	V_{OS}			0.25		mV
Offset Voltage Drift	TCV_{OS}			3		µV/°C
Input Bias Current, "F"	I_B			25	100	nA
OUTPUT VPTAT[1]						
Output Voltage	VPTAT	T_A = 25°C, No Load		1.49		V
Scale Factor	TC_{VPTAT}			5		mV/K
Temperature Accuracy, "F"		T_A = 25°C, No Load	–3	±1.0	3	°C
		10°C < T_A < 40°C, No Load		±1.5		°C
		–40°C < T_A < 85°C, No Load	–5.0	±2	5.0	°C
		–55°C < T_A < 125°C, No Load		±2.5		°C
Repeatability Error[4]	ΔVPTAT			0.25		Degree
Long-Term Drift Error[2,6]				0.25	0.5	Degree
Power Supply Rejection Ratio	PSRR	T_A = 25°C, 4.5 V ≤ V+ ≤ 13.2 V		±0.02	±0.1	%/V
OUTPUT VREF						
Output Voltage, "F"	VREF	T_A = 25°C, No Load	2.490	2.500	2.510	V
	VREF	–40°C < T_A < 85°C, No Load	2.480	2.500	2.520	V
	VREF	–55°C < T_A < 125°C, No Load		2.5 ± 0.015		V
Drift	TC_{VREF}			–10		ppm/°C
Line Regulation		4.5 V ≤ V+ ≤ 13.2 V		±0.01	±0.05	%/V
Load Regulation		10 µA ≤ I_{VREF} ≤ 500 µA		±0.1	±0.25	%/mA
Output Current, Zero Hysteresis	I_{VREF}			7		µA
Hysteresis Current Scale Factor[1]	SF_{HYS}			5.0		µA/°C
Turn-On Settling Time		To Rated Accuracy		25		µs
OPEN-COLLECTOR OUTPUTS OVER, UNDER						
Output Low Voltage	V_{OL}	I_{SINK} = 1.6 mA		0.25	0.4	V
	V_{OL}	I_{SINK} = 20 mA		0.6		V
Output Leakage Current	I_{OH}	V+ = 12 V		1	100	µA
Fall Time[2]	t_{HL}	See Test Load		40		ns
POWER SUPPLY						
Supply Range	V+		4.5		13.2	V
Supply Current	I_{SY}	Unloaded, +V = 5 V		400	500	µA
	I_{SY}	Unloaded, +V = 13.2 V		450	800	µA
Power Dissipation	P_{DISS}	+V = 5 V		2.0	2.5	mW

NOTES
[1]K = °C + 273.15.
[2]Guaranteed but not tested.
[3]Does not consider errors caused by heating due to dissipation of output load currents.
[4]Maximum deviation between 25°C readings after temperature cycling between –55°C and +125°C.
[5]Typical values indicate performance measured at T_A = 25°C.
[6]Observed in a group sample over an accelerated life test of 500 hours at 150°C.

Specifications subject to change without notice.

ABSOLUTE MAXIMUM RATINGS[1]

Maximum Supply Voltage . . . . –0.3 V to +15 V
Maximum Input Voltage
(SETHIGH, SETLOW) . . . . –0.3 V to [(V+) +0.3 V]
Maximum Output Current (VREF, VPTAT) . . . . 2 mA
Maximum Output Current (Open-Collector Outputs) . . 50 mA
Maximum Output Voltage (Open-Collector Outputs) . . . . 15 V
Operating Temperature Range . . . . –55°C to +150°C
Dice Junction Temperature . . . . 150°C
Storage Temperature Range . . . . – 65°C to +150°C
Lead Temperature (Soldering 60 sec) . . . . 300°C

NOTES
[1]Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating; functional operation at or above this specification is not implied. Exposure to the above maximum rating conditions for extended periods may affect device reliability.
[2]Digital inputs and outputs are protected, however, permanent damage may occur on unprotected units from high energy electrostatic fields. Keep units in conductive foam or packaging at all times until ready to use. Use proper antistatic handling procedures.
[3]Remove power before inserting or removing units from their sockets.

Package Type	θ_{JA}	θ_{JC}	Unit
8-Pin Plastic DIP (P)	103[1]	43	°C/W
8-Lead SOIC (S)	158[2]	43	°C/W
8-Lead TO-99 Can (J)	150[1]	18	°C/W

NOTES
[1]θ_{JA} is specified for device in socket (worst-case conditions).
[2]θ_{JA} is specified for device mounted on PCB.

ORDERING GUIDE

Model/Grade	Temperature Range[1]	Package Description	Package Option
TMP01FP	XIND	Plastic DIP	N-8
TMP01ES	XIND	SOIC	SO-8
TMP01FS	XIND	SOIC	SO-8
TMP01FJ[2]	XIND	TO-99 Can	H-08A

NOTES
[1]XIND = –40°C to +85°C.
[2]Consult factory for availability of MIL/883 version in TO-99 can.

GENERAL DESCRIPTION

The TMP01 is a linear voltage-output temperature sensor, with a window comparator that can be programmed by the user to activate one of two open-collector outputs when a predetermined temperature setpoint voltage has been exceeded. A low drift voltage reference is available for setpoint programming.

The temperature sensor is basically a very accurate, temperature compensated, band gap-type voltage reference with a buffered output voltage proportional to absolute temperature (VPTAT), accurately trimmed to a scale factor of 5 mV/K. See the Applications Information following.

The low drift 2.5 V reference output VREF is easily divided externally with fixed resistors or potentiometers to accurately establish the programmed heat/cool setpoints, independent of temperature. Alternatively, the setpoint voltages can be supplied by other ground referenced voltage sources such as user-programmed DACs or controllers. The high and low setpoint voltages are compared to the temperature sensor voltage, thus creating a two-temperature thermostat function. In addition, the total output current of the reference (I_{VREF}) determines the magnitude of the temperature hysteresis band. The open collector outputs of the comparators can be used to control a wide variety of devices.

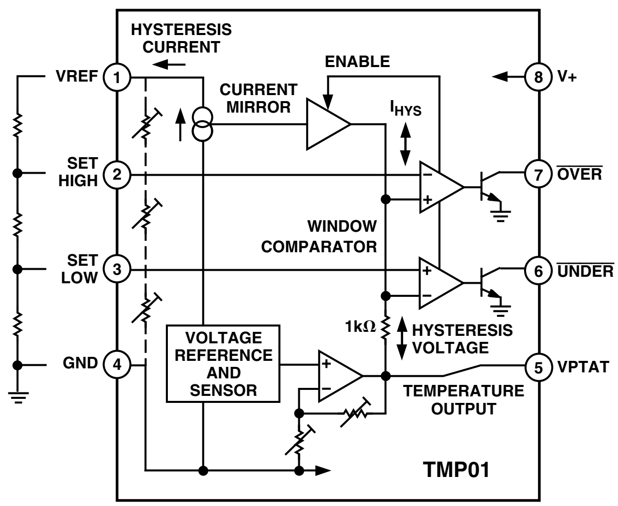
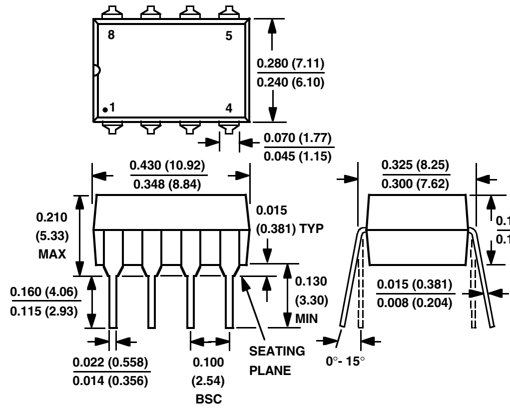


Figure 2. Detailed Block Diagram

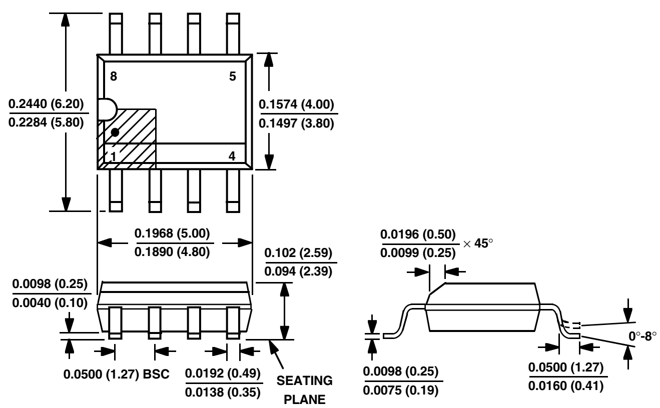
OUTLINE DIMENSIONS

Dimensions shown in inches and (mm).

8-Lead Epoxy DIP
(N-8)



8-Lead SOIC
(R-8)



8-Lead TO-99
(TO-99)