

TI Designs

Basic fan controller reference design with over-temperature detection



Design Overview

TIDA-00517 provides a complete reference design for basic fan control leveraging minimal components. This design features a TMP302 temperature switch to detect over temperature conditions in personal electronics, industrial PCs, power distribution units and other applications leveraging fans to control temperature conditions. This simple design can be easily modified for different voltage fans, making it applicable for a broad range of uses.

Design Resources

[TIDA-00517](#)

Design Folder

[TMP302](#)

Product Folder

[SN74AHC1G14](#)

Product Folder

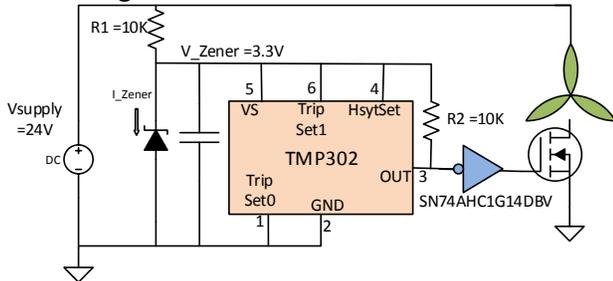
Design Features

- Simple temperature switch to activate fan
- Flexible design can operate with many fan voltages
- Low BOM count and cost

Featured Applications

- Factory Automation and Control
- Telecom Infrastructure
- Printers and Other Peripherals
- Storage
- Multi-Function Printers
- Audio Power Amplifiers

Block Diagram



Board Image



1 Key System Specifications

PARAMETER	SPECIFICATIONS and FEATURES	DETAILS
Voltage Supply	18.3 V to 27.6 V	Section 4
Max Fan Current Through MOSFET @70°C	190 mA at 70°C	Section 4
Tigger Temperature	58°C to 62°C	Section 3.1
Temperature Hysteresis	10°C typical	Section 3.1

2 System Description

Many designs need a fan controller for thermal management. This design implements a simple method to control the fan using a small number of components. Component replacement and connection can easily be modified to meet other thermal requirements.

Block Diagram

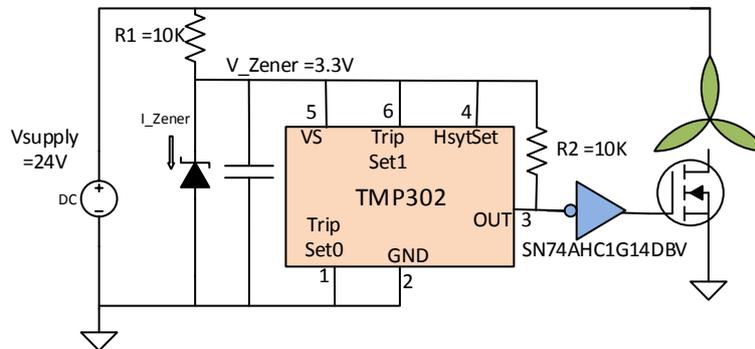


Figure 1: System Block Diagram

2.1 Highlighted Products

This Simple Fan Controller Reference Design features the following devices:

- **TMP302**
 - Easy-to-Use, Low-Power, Low-Supply Temperature Switch in Micropackage
- **SN74AHC1G14**
 - Single Schmitt-Trigger Inverter Gate

For more information on each of these devices, see the respective product folders at www.ti.com

2.1.1 TMP302 Description

The TMP302 is a temperature switch in a micropackage (SOT563). The TMP302 offers low power (15- μ A maximum) and ease-of-use through pin-selectable trip points and hysteresis. These devices require no additional components for operation; they can function independent of microprocessors or microcontrollers. The TMP302 is available in several different versions.

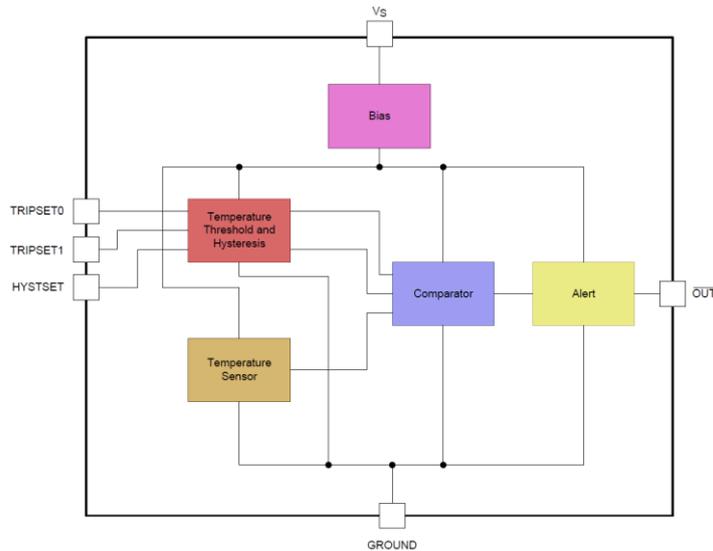


Figure 2: TMP302 Block Diagram

3.1.1.2 TMP302 Features

- Low Power: 15 μ A (maximum)
- SOT563 Package: 1.6-mm \times 1.6-mm \times 0.6 mm
- Trip-Point Accuracy: $\pm 0.2^\circ\text{C}$ (typical) From $+40^\circ\text{C}$ to $+125^\circ\text{C}$
- Pin-Selectable Trip Points
- Open-Drain Output
- Pin-Selectable Hysteresis: 5°C and 10°C
- Low Supply Voltage Range: 1.4 V to 3.6 V

2.1.1 SN74AHC1G14

2.1.1.1 SN74AHC1G14 Description

The SN74AHC1G14 device is a single inverter gate. The device performs the Boolean function $Y = \bar{A}$. The device functions as an independent inverter gate, but because of the Schmitt action, gates may have different input threshold levels for positive- (V_{T+}) and negative-going (V_{T-}) signals.

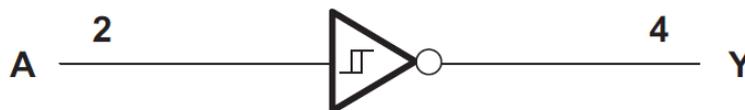


Figure 3 SN74HC1G14 Block Diagram

2.1.1.2 SN74AHC1G14 Features

- Operating Range 2 V to 5.5 V
- Maximum t_{pd} of 10 ns at 5 V
- Low Power Consumption, 10- μ A Max I_{cc}
- ± 8 -mA Output Drive at 5 V
- Latch-Up Performance Exceeds 250 mA Per JESD 17

3 System Design Theory

This design uses the power for the fan to provide the power for the additional control circuitry. The stand-by current, when the fan is off, is mostly through the resistor and zener diode connected between the positive supply and ground. This zener diode is used to provide the voltage required to power up the temperature switch (TMP302) and the inverter (SN74AHC1G14). The power supply voltage range of the TMP302 is 1.4 V to 3.6 V and the zener provides a 3.3 V. If the voltage for the fan is different, the resistor between the zener diode and the supply can be modified to meet other fan voltage requirements. Using an inverter and an N-Channel MOSFET give the ability to use multiple fans and have the inverter drive the N-Channel MOSFET.

3.1 Temperature control

The TMP302 has many trigger options to turn the fan on (see Figure 5). This design turns the fan on when the TMP302 gets to 60°C and does not turn off until the TMP302 gets to 50°C. The temperature trip point is done by using TMP302A and setting the digital pins of TripSet0= Low and TripSet1 = High. This sets the trip temperature to 60°C. The fan will remain on until the temperature hysteresis is met. The hysteresis is set to 10°C by setting the digital pin HystSet = High (See Figure 5).

TRIPSET1	TRIPSET0	TMP302A	TMP302B	TMP302C	TMP302D
GND	GND	50°C	70°C	90°C	110°C
GND	V _S	55°C	75°C	95°C	115°C
V _S	GND	60°C	80°C	100°C	120°C
V _S	V _S	65°C	85°C	105°C	125°C

Figure 4 TMP302 Temperature Trip Point Setting

HYSTSET	THRESHOLD HYSTERESIS
GND	5°C
V _S	10°C

Figure 5 Hysteresis Setting for TMP302

3.2 N-Channel MOSFET Driver

To drive the N-Channel MOSFET that powers up the fan we need to invert the signal from the TMP302 as it is an open drain, active-low output that cannot exceed its supply voltage. Add an inverter at the output of the TMP302 to drive the N-Channel MOSFET. The output of the TMP302 is pulled up to its supply voltage when it is not triggered.

4 Getting Started Hardware

The PCB's external connection requires a fan and a power supply of 24 V. The high side of power supply connects to "24 V Fan+" node and connects to the fan's positive supply. The negative side of fan then connects to the "Fan-" connection which is controlled by the design to turn the fan on at the temperature set on the TMP302. The low side of the power supply is connected to the labeled "Ground" connection. The fan used is the Sunon PMD2406PTB1-A which is a 24-V fan. The fan is

specified to draw 158 mA at 24 V. The N-Channel MOSFET driving the fan can drive 190 mA at 70°C and 250 mA at 25°C. The positive supply voltage on the high side is limited by the fan’s high voltage rating of 27.6 V. The lowest voltage of the power supply is limited by the biasing required on the zener diode to maintain a voltage and to power up the TMP302 and the SN74AHC1G14. Both devices require low power so a minimum bias of 1.5 mA on the zener should be enough to provide the voltage needed, per typical specification of the zener. With 1.5-mA bias current the lowest voltage is defined by equation 3.

$$(V_{supply} - V_{Zener}) / R1 = I_{Zener} \quad (1)$$

Solving for V_{supply} :

$$V_{supply} = I_{Zener} * R1 + V_{Zener} \quad (2)$$

$$V_{supplymin} = 1.5mA * 10Kohm + 3.3V = 18.3V \quad (3)$$



Figure 6 TIDA-00517 Board

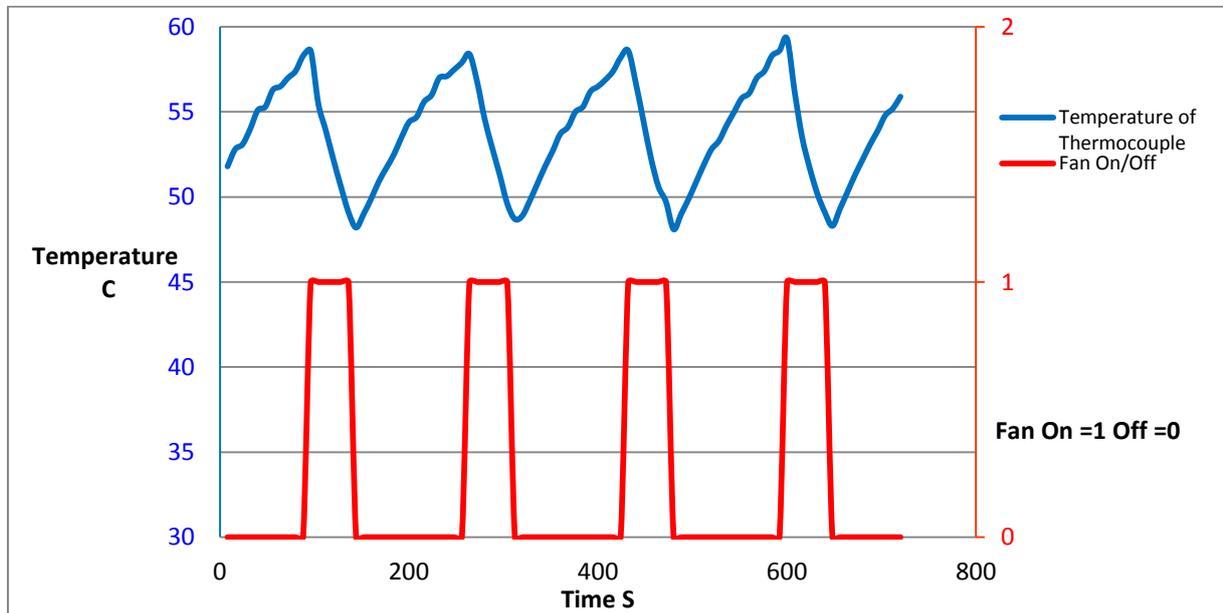
5 Test Setup

For the test setup two power supplies, a fan, heat source and a thermocouple are required. A thermocouple is placed on the TMP302 using a thermally conductive epoxy to get better measurements of the TMP302. Thermal resistance from the TMP302 to the thermocouple is still a cause of error in the temperature measurement. A 50-ohm power resistor was mounted on the bottom of the board under the TMP302 to heat the PCB. The fan is placed 12 inches away. Once the TMP302 is warmed up above the 60°C the fan will turn on and will stay on until the temperature is below 50°C. The setup can be changed to modify the change of temperature by increasing/decreasing the voltage across the power resistor within the resistor’s specifications. The rate of the cooling can also be modified by placing the fan closer/further away or modifying the airflow direction.



6 Test Data

The data was collected by observing the thermocouple temperature and the condition of the fan being either on or off. The heat source is on the bottom of the board and the TMP302 gets to temperature before the thermocouple important factors to consider. The TMP302 needs to be placed very close to the heat source being. Thermal mass and thermal resistance in the setup needs to be controlled. Also the TMP302 is a small device that does not have a high thermal mass and can change temperature easily. See [PCB layout recommendations](#).



7 Design Files

7.1 Schematics

To download the Schematics for each board, see the design files at <http://www.ti.com/tool/TIDA-00517>

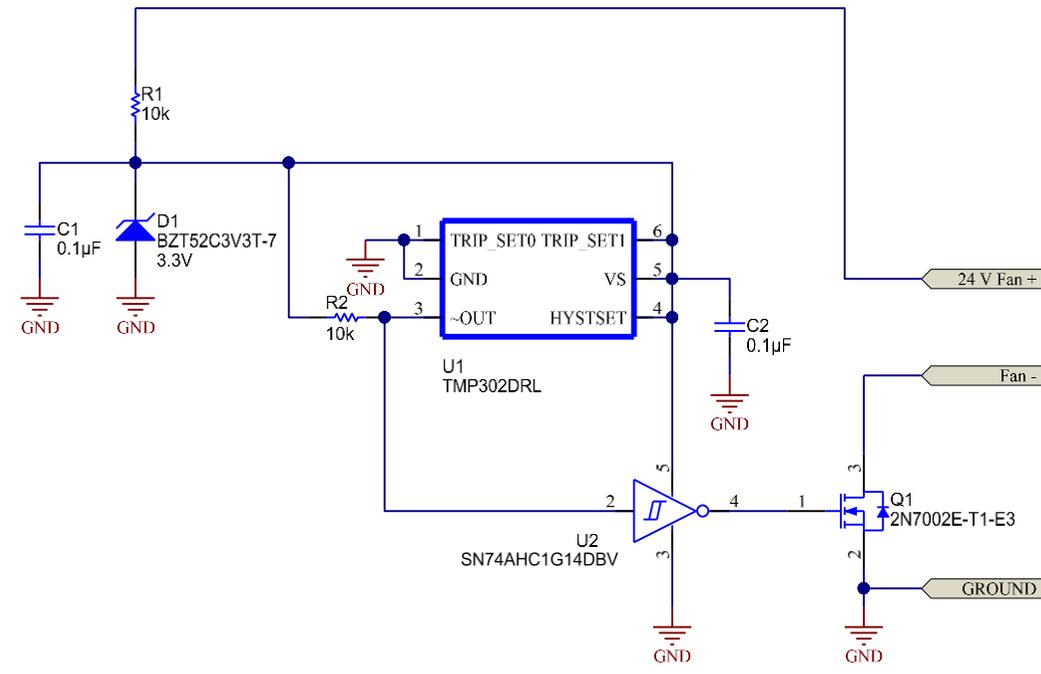


Figure 7: TIDA-00517 Schematic

7.2 Bill of Materials

To download the Bill of Materials for each board, see the design files at <http://www.ti.com/tool/TIDA-00517>

7.3 PCB Layout Recommendations

The temperature conductivity on the PCB needs to be considered when layout of board is done. There needs to be a low thermal resistance from TMP302 to the heat source of interest. It is recommended to have a bigger mass, such as a metal plane, that can conduct the temperature that is being controlled. The TMP302 should be in close proximity to this thermal mass so that the temperature is better conducted.

7.3.1 Layout Prints

To download the Layout Prints for each board, see the design files at <http://www.ti.com/tool/TIDA-00517>

7.4 Altium Project

To download the Altium project files for each board, see the design files at <http://www.ti.com/tool/TIDA-00517>

7.5 Gerber files

To download the Gerber files for each board, see the design files at <http://www.ti.com/tool/TIDA-00517>

7.6 Assembly Drawings

To download the Assembly Drawings for each board, see the design files at <http://www.ti.com/tool/TIDA-00517>

8 References

1. TMP302 Data Sheet, Easy-to-Use, Low-Power, Low-Supply Temperature Switch, [TMP302](#), 2015
2. SN74AHC1G14 Data Sheet, Single Schmitt-Trigger Inverter Gate, [SN74AHC1G14](#), 2015
3. Texas Instruments E2E Community, <http://e2e.ti.com/>

9 About the Author

Javier Contreras is an Application Engineer at Texas Instruments, where he is responsible for supporting customers for current shunt monitors and temperature sensors. This involves answering technical queries on the TI E2E forum, developing EVMs and reference design solutions, writing application notes and developing technical materials. Javier brings to this role his experience in testing/characterizing precision analog devices and mixed signal devices. Javier earned his Bachelor of Science in Electrical Engineering (BSEE) from University of Arizona, AZ.

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