



# ELM331

## Solid State Thermostat

### Description

The ELM331 is a complete temperature measurement and control system in an 8 pin package.

This integrated circuit is designed to compare two resistances and drive an output pin depending on the relative value of each. Typically, one of the resistors will be an NTC thermistor, and the other one will be a temperature independent resistor (whether fixed or variable). When the magnitude of the resistance connected to pin 2 exceeds the value of the resistance connected to pin 3, the output pin will be driven to a high state. Hysteresis maintains the output in that state until the relative values differ by approximately 8% (or typically 2°C for a 10KΩ thermistor).

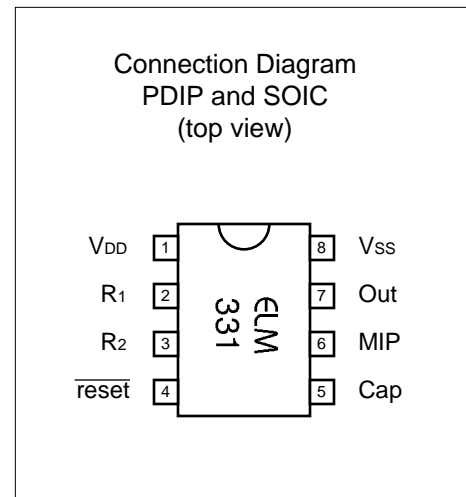
To reduce the possibility of sporadic outputs, a condition must exist for three successive cycles, or 6 seconds, before the output pin can change state.

### Applications

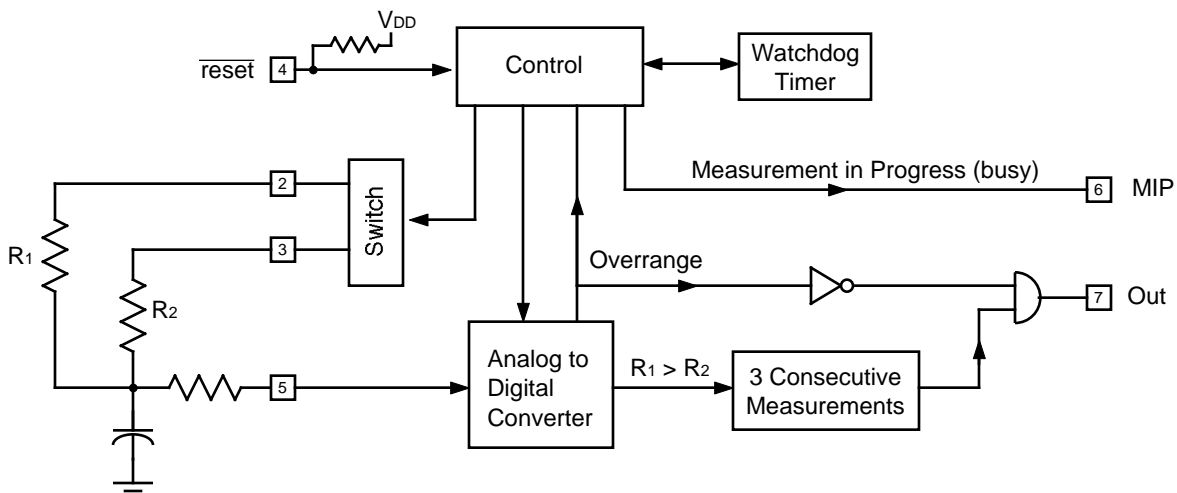
- Primary thermostat in temperature control systems
- Staging control for auxiliary heating or cooling installations
- Under or over temperature alarms

### Features

- Low power CMOS design - typically 1mA at 5V
- Wide supply range - 3.0 to 5.5 volt operation
- Built-in proportional hysteresis
- Measurement in progress output
- Time delay on operate improves noise immunity
- Internal pullup resistor on the reset input
- High current drive outputs - up to 25 mA



### Block Diagram





## Pin Descriptions

### V<sub>DD</sub> (pin 1)

This pin is the positive supply pin, and should always be the most positive point in the circuit. Internal circuitry connected to this pin is used to provide power on reset of the microprocessor, so an external reset signal is normally not required. Refer to the Electrical Characteristics section for further information.

### R<sub>1</sub> (pin 2)

One of the two resistance input pins. A temperature dependent resistance is usually connected to this input for heating or under-temperature alarm type applications. When the value of this resistor is greater than the value of the resistance connected to pin 3 (for three successive measurements) the output will be driven high.

### R<sub>2</sub> (pin 3)

The reference resistance is connected to this pin for heating applications, and the temperature dependent resistance is connected here for cooling applications. The other end of this resistor is connected to the integrating capacitor.

### reset (pin 4)

The active low reset input. An internal pullup resistor is provided for convenience. If unused, this pin may be connected to V<sub>DD</sub> or left open.

### Cap (pin 5)

Temperature measurements are made by determining the time to charge and discharge this integrating capacitor. Pin 5 forces the capacitor to a known voltage for these measurements though, resulting in large current flows. To limit these capacitor currents, and protect the ELM331, a series resistor must be connected to this pin. The value of the resistance, and of the capacitance, is not critical to the measurements.

### MIP (pin 6)

This pin provides a logic high level output while the ELM331 is busy (measurements are in progress). It is suitable for directly driving an LED through a current limiting resistor. As a warning, this output pulses rapidly if either resistor input is found to be open circuited.

### Out (pin 7)

The output pin assumes a logic high state once the resistance of R<sub>1</sub> exceeds that of R<sub>2</sub> for three successive measurement cycles. The output is maintained until R<sub>1</sub> is less than R<sub>2</sub> by the hysteresis amount for an additional three counts.

### V<sub>SS</sub> (pin 8)

Circuit common is connected to this pin. This is the most negative point in the circuit.

## Ordering Information

These integrated circuits are available in either the 300 mil plastic DIP format, or in the 200 mil SOIC surface mount type of package. To order, add the appropriate suffix to the part number:

300 mil Plastic DIP..... ELM331P

200 mil SOIC..... ELM331SM

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## Absolute Maximum Ratings

Storage Temperature..... -65°C to +150°C  
 Ambient Temperature with  
 Power Applied.....-40°C to +85°C  
 Voltage on V<sub>DD</sub> with respect to V<sub>SS</sub>..... 0 to +7.5V  
 Voltage on any other pin with  
 respect to V<sub>SS</sub>..... -0.6V to (V<sub>DD</sub> + 0.6V)

Note:  
 Stresses beyond those listed here will likely damage the device. These values are given as a design guideline only. The ability to operate to these levels is neither inferred nor recommended.

## Electrical Characteristics

All values are for operation at 25°C and a 5V supply, unless otherwise noted. For further information, refer to note 1 below.

Characteristic	Minimum	Typical	Maximum	Units	Conditions
Supply Voltage, V <sub>DD</sub>	3.0	5.0	5.5	V	
V <sub>DD</sub> rate of rise	0.05			V/ms	see note 2
Average Supply Current, I <sub>DD</sub>		1.0 0.6	2.4 2.4	mA mA	V <sub>DD</sub> = 5V, see note 3 V <sub>DD</sub> = 3V, see note 3
Frequency of measurements		2.0		sec	see note 4
Reset pin internal pullup resistance	300	470	600	KΩ	see note 5
R <sub>1</sub> C or R <sub>2</sub> C time constant	500		500,000	μs	see note 6
Input low voltage - reset pin	V <sub>SS</sub>		0.15 V <sub>DD</sub>	V	
Input high voltage - reset pin	0.85 V <sub>DD</sub>		V <sub>DD</sub>	V	
Output low voltage			0.6	V	Current (sink) = 8.7mA
Output high voltage	V <sub>DD</sub> - 0.7			V	Current (source) = 5.4mA

- Notes:
1. This integrated circuit is produced with a Microchip Technology Inc.'s PIC12C5XX as the core embedded microcontroller. For further device specifications, and possibly clarification of those given, please refer to the appropriate Microchip documentation.
  2. This spec must be met in order to ensure that a correct power on reset occurs. It is quite easily achieved using most common types of supplies, but may be violated if one uses a slowly varying supply voltage, as may be obtained through direct connection to solar cells, or some charge pump circuits.
  3. Device only. Does not include any LED or drive currents.
  4. If a measured resistance is determined to be out of limits, the frequency of measurements is increased to provide visual feedback as well as a faster recovery.
  5. The value of the pullup resistance is supply and temperature dependent.
  6. One should also maintain R<sub>1</sub> and R<sub>2</sub> to not less than about 5KΩ. When C is chosen, select the pin 5 current limiting resistance so that R<sub>LIM</sub>C is less than 1msec, and R<sub>LIM</sub> is greater than 1KΩ.

## Example Application

Figure 1 shows the ELM331 in an example heating control circuit. A closed contact output occurs whenever the temperature measured by  $R_{TEMP}$  falls to a value less than that determined by  $R_{SET}$ . It is anticipated that this type of circuit could possibly be used to control temperatures over the range of  $-40^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ .

Power for the circuit is from a 12V supply, that is reduced to 5V by the 78L05 regulator. This gives a stable supply voltage for the ELM331, as well as convenient voltage for use with a standard relay coil. The type of relay is not important, as long as consideration is given to its coil requirements, and the capabilities of the ELM331. In this example, a relay with a  $400\Omega$  coil resistance was chosen so that a 2N3904 could drive it directly.

Temperature measuring is performed by  $R_{TEMP}$ , which is a negative temperature coefficient type thermistor. It has a resistance of  $10\text{K}\Omega$  at  $25^{\circ}\text{C}$ , and this value decreases with increasing temperature. This value was chosen both because it is commonly available, and because it limits the  $0.1\mu\text{F}$  integrating capacitor currents to less than 1mA over the typical range of operation (keeping the thermistor self-heating to a minimum).

If the thermistor is mounted any appreciable distance from the ELM331, consideration must be given to cabling effects such as capacitive and induced

currents. Generally the integrated circuit can be adequately protected by mounting a small value ( $220\Omega$ ) resistor physically close to the ELM331 as shown below. Take into account it's value when determining the setpoint, though.

For this design,  $R_{SET}$  was selected to be equal to the resistance of  $R_{TEMP}$  at  $10^{\circ}\text{C}$ , so that the relay contact closes for any measured temperatures less than  $10^{\circ}\text{C}$ . The resistance value was determined from specs given by the manufacturer, but could have been determined experimentally as well.

An LED has been provided for visual feedback of the circuit operation. It is connected to the 'measurement in progress' output, so that it is energized each time a measurement is being made. Typically, this would be for about 25mS every 2 seconds.

Variations on this circuit could easily be made... Simply by reversing  $R_{SET}$  and  $R_{TEMP}$ , one obtains a cooling control thermostat... Rather than a relay output, the circuit could have been connected directly to other logic circuits. The measurement in progress pin could then be used either as an interrupt, or as a busy flag that can clock in new results on it's falling edge...

Battery backup is another option that could be added to this circuit, but then consideration should be given to using the ELM341 Low Power Thermostat...

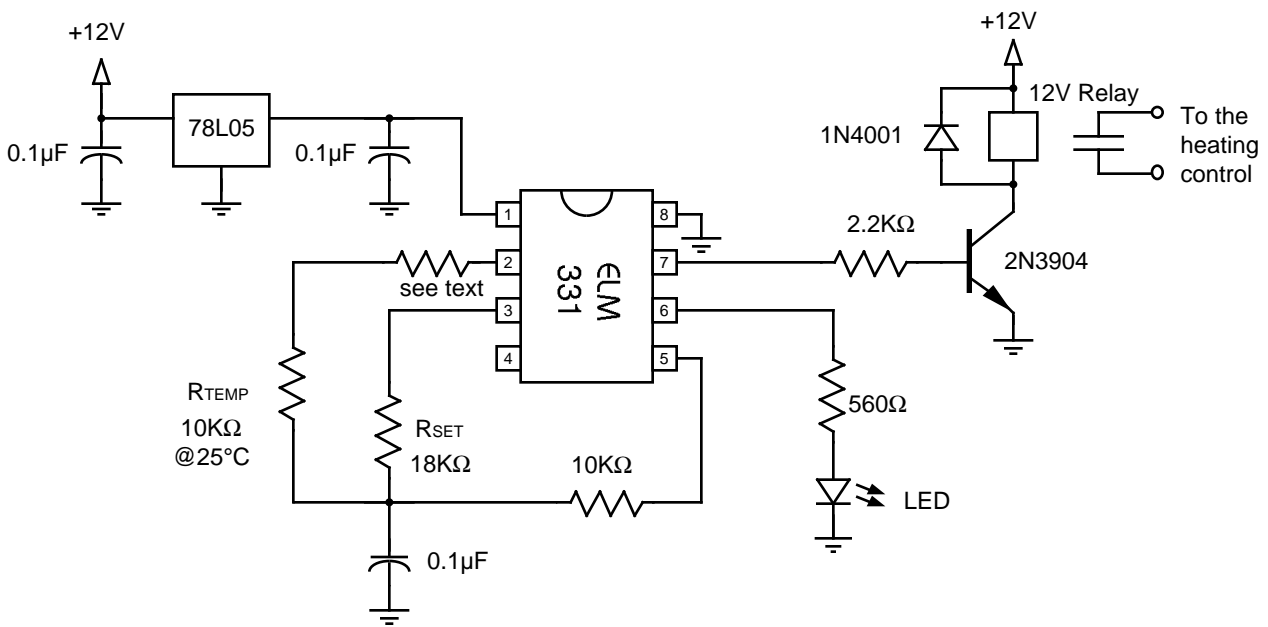


Figure 1. Backup Heating Control Thermostat