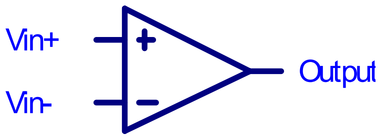
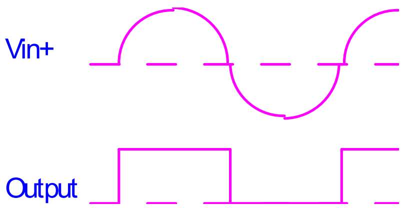
Voltage Comparators:

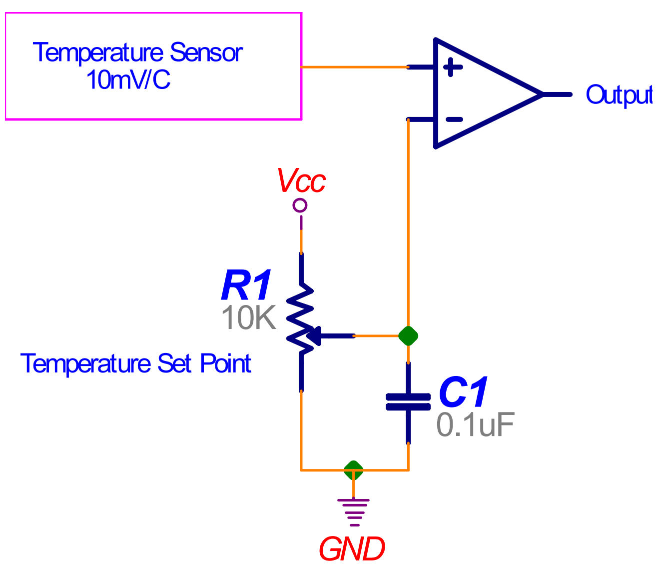


A comparator compares the voltages at the + and – inputs. If the + input is at a higher voltage than the – input the comparator output will be high. If the – input is at a higher voltage than the + input the comparator output will be low.

Comparator uses:



Convert a sine wave to a square wave (usually with a TTL output, i.e. a digital output, 0-5V). This can be used to make a frequency counter by sending the output into a counter and counting the number of pulses in one second.



This is an example of a thermostat circuit. The temp sensor puts out 10mV/C (the LM35 for example). The pot (short for potentiometer) lets the user dial in desired temperature. The capacitor helps to short any high frequency noise on the set point voltage to ground. Note: The cap isn't needed but it's a good idea to have it.

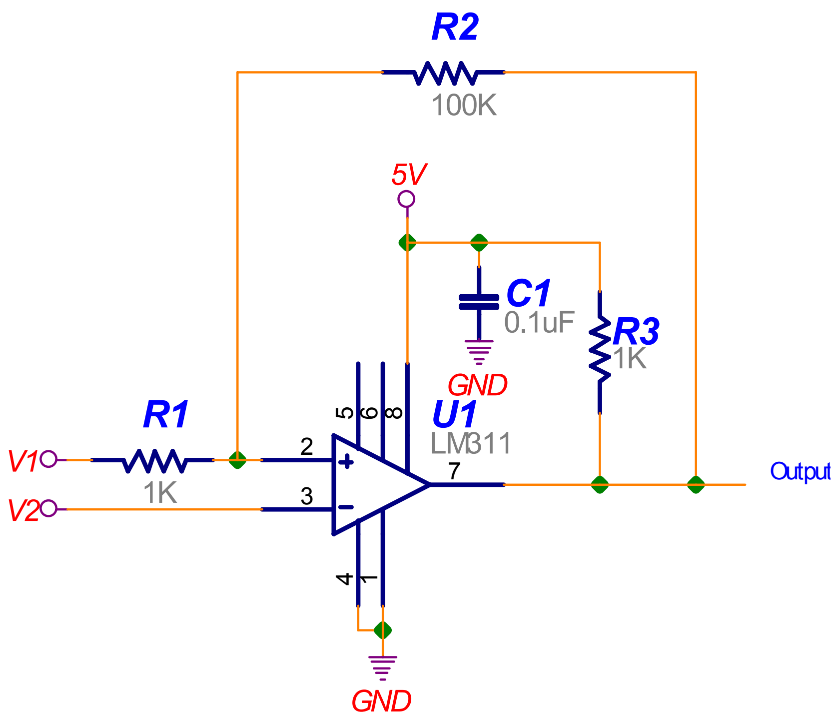
Ex: Adjust the pot to so the wiper is at 0.25V. When the temp rises past 0.25V (25C) the comparator output will go high and the AC unit would come on to cool the room. Once the temp falls below 25C the output will go low and the AC unit would go off. This is an example of an on/off controller. Note: If you swap the comparator inputs (i.e. temp sensor to – and set point to +) the output will go high when the temp is below the set point (could be used to turn on a heater).

Some comparators have TTL or CMOS outputs that will go to high or low without a pull-up resistor. We'll be using the LM311 comparator in our circuits. The output is open-collector type which requires a pull-up resistor for the output to go high. Note: The rise time of open-collector outputs depend on the size of the pull-up resistor and the load connected to the output. The smaller the pull-up resistor the quicker the rise time will be.

Hysteresis:

In the above example the AC would come on the instant the temp dropped below the set point and would go off the instant the temp rose above the set point. In the real world this would cause excess ware on the AC unit so hysteresis is added. Hysteresis allows the temperature to rise say one degree above the set point before the AC comes on. Once on the AC will continue to cool until the temp is one degree below the set point. A home thermostat operates with hysteresis.

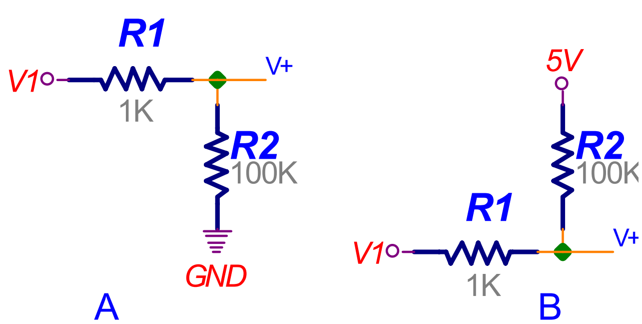
Hysteresis Example using the LM311:



This circuit will compare two voltages, V1 & V2, and will add a little hystereses so that the output won't oscillate when V1 = V2. Note: Since the comparator is powered off a 0-5V supply the two input voltages should be between 0 & 5V.

Pins 5 & 6 are to adjust the input offset voltage and won't be used in this example. C1 is the decoupling cap. This cap should be placed as close as possible to the power pins of the IC. R3 is the pull-up resistor. When the output goes low the output transistor inside the IC will pull the output low. For the output to go high the output transistor switches to the off state and the output is left floating. R3 pulls the output high.

How to adjust the amount of hysteresis:



Ex: V2 is at 1V and V1 lets say is at 0.5V. Because V+ is less than V- the output is low. R2 feeds back some of the output voltage to the V+ input (Fig A). This makes the voltage at V+ slightly lower than V1. The larger the ratio of R2/R1 the smaller the hysteresis will be. In this case V+ will be about 1% less than V1. Because of the feedback V1 must now increase to 1.01V before V+ will reach 1V and cause the comparator output to go high. When the output goes high the voltage at V+ jumps from the 1V to 1.04V (Fig B) even though V1 is still at 1.01V. This positive feedback keeps the output from oscillating by making the + input even more positive than before after the output goes high. Similarly, V1 has to decrease to 0.96V to get V+ to reach 1V and cause the comparator output to go low. In this case there is about 50mV of hysteresis (1.01V-0.96V).

Note: if the output went to 10V instead of 5V the high output part of the hysteresis would double (i.e. instead of 1.04V & 0.96V it would be 1.08V and 0.92V resulting in 90mV of hysteresis, 1.01V - 0.92V).

The above calculation assumes the comparator output swings all the way to ground and 5V. In reality the low will be around 0.2V and the high near 5V. The output voltage depends on the pull-up resistor and the load. Ex: If there was a 1KΩ resistor from the output to ground the output would only go to 2.5V when high. R3 should be much smaller than the load resistance (but don't use a 100Ω resistor because the comparator may not be able to draw enough current to pull the output low – and it wastes a lot of power).