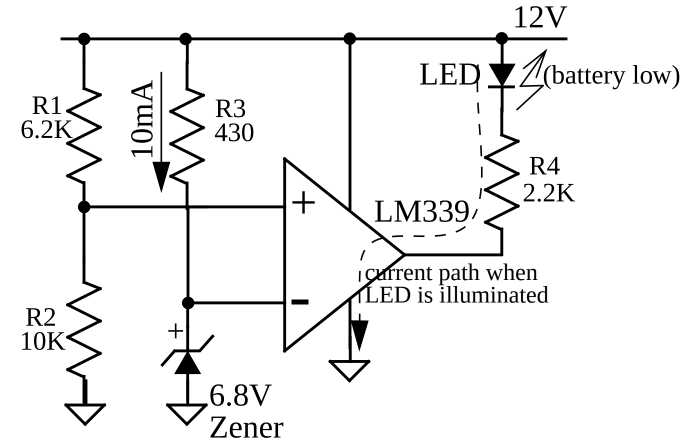
Comparator Circuits

Low Battery Detector

To truly understand the comparator's operation, let's look at a few circuits. First we will build a "low battery" circuit. This circuit will illuminate an LED whenever the 12 volt line goes below 11 volts. See the schematic below.



A Low Battery Detector

A reference voltage is established at the inverting input to the comparator by R3 and the 6.8 volt zener. R3 serves to limit the current through the 6.8 volt zener to about 10mA. The voltage developed across the zener is fairly stable over a wide range of zener current. To see why, go back and look at the steepness of the zener V-I curve in the reverse breakdown region.

R3 sets the current through the Zener diode at least 10mA even when the battery voltage drops to 11V. To find R3, we us a KVL loop with the supply voltage, Vr3 and the zener voltage:

KVL: $-11 + (.01)R3 + 6.8 = 0$

$R3 = 420$ ohms; The nearest standard value is 430 ohms.

R1 and R2 form a voltage divider such that when the 12 volt supply is above 11 volts, the non-inverting input will be above 6.8 volts. This is true because the voltage divider formed by R1 and R2 multiply the input voltage by 0.617. In this situation the output will be a high voltage since the output transistor is off. This means no current flows through the LED so it will not be illuminated.

When the 12 volt line goes below 11 volts, the non-inverting input goes below the inverting input, thus causing the output to fall to ground. This causes current to flow through the LED illuminating it at a current level determined by R4.

The initial value of R2 was arbitrarily chosen as 10K simply to keep the current consumption on the 12 volt line to a minimum. R1 and R2 could have been chosen to be 620K and 100K just as well, but since the zener consumes 10 times the current of the voltage divider, the current values were adequate. For selecting the trip level of the detector the voltage divider equation is used:

Vout = (R2/R1+R2) * Vin

In this case,

KVL: 6.8 = (10,000/(10,000 + R1)) *11
R1 = 6180; The nearest standard value is 6.2K ohms.

When the comparator output goes to a low output voltage the LED will be illuminated. The current through the LED is determined by using the data sheet for the selected part, a HLMP-1700. This part has a maximum continuous current of 7.5mA, and typical brightness is obtained at 2mA. A 4mA current level should provide good illumination while keeping the current at about half of the maximum allowed. The typical forward voltage of the LED is approximately 1.9V.

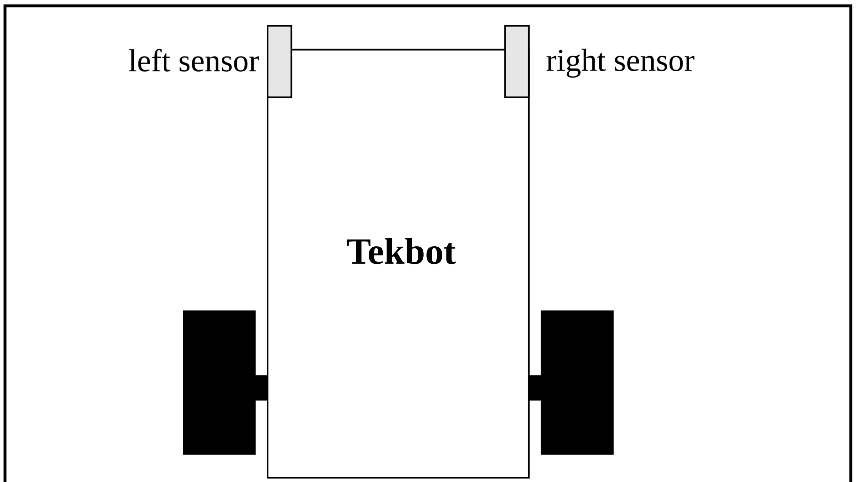
The value for R4 is determined from the desired 4mA current, the voltage of the supply rail when it turns on (11 volts), the forward voltage of the LED, and the “on” saturation voltage of the comparator. The comparator data sheet states a typical saturation output voltage of 0 .2V when sinking 4mA. From these values, a KVL loop can calculate the value of R4.

KVL: -11 + 1.9 + (.004)R4 + 0.2 = 0
R4 = 2225; The nearest standard value is 2.2K ohms.

A Photovore Circuit

The next circuit we will look at is a “photovore” circuit. If used with the Tekbot base and motor control board, the circuit causes the robot to drive towards the area of greatest light in a room. The sensors that allow light sensing are Cadmium Sulfide cells. These are essentially light sensitive resistors. They change their value more than two orders of magnitude from a “dark” to “light” conditions. When they are in the dark they present about 100K ohms to their

terminals. When in bright light the resistance drops to about 1k ohms.



Positioning of the CdS Sensors on the Robot

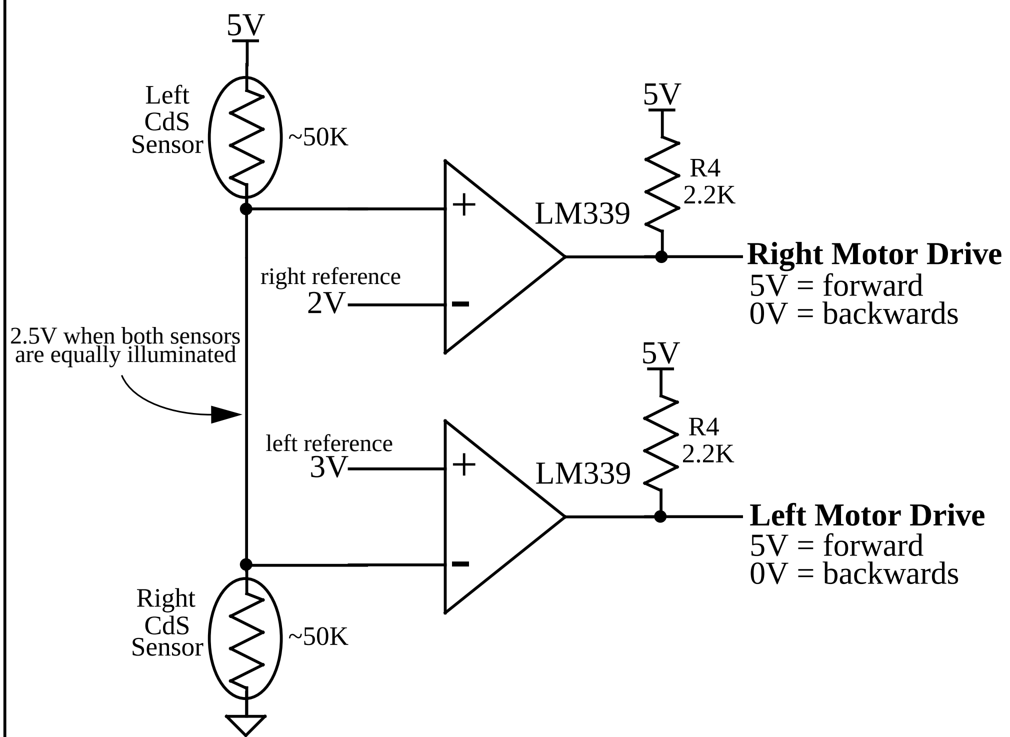
To understand the operation of the circuit, imagine that there is a CdS cell on each side of the robot. If the brightest area is directly in front of the robot, both cells are illuminated equally. This causes the voltage at the junction of the two cells to be 2.5 volts. This being the case, the upper and lower comparator's outputs will be at 5 volts causing both motors to go forward.

Note that the inverting and non-inverting terminals on the comparators have been switched to make the schematic easier to follow. Also the power supply connections to the comparators are not shown to lessen schematic clutter. Finally, note that two reference voltages are applied to the comparator inputs. These may be generated by a voltage divider or other circuit but is not shown.

Now suppose that the area of greatest light is to the left of where the robot is traveling. This means that the left sensor will receive more light and the right senor less. This means the resistance of the upper cell is going down and the lower cell is going up. This will raise the voltage at the junction of the cells. Eventually, when the voltage exceeds 3 volts, the bottom comparator will switch its output to 0 volts reversing the left motor and cause the robot to rotate toward the light source. This will occur until the voltage at the junction of the cells is less than 3 volts.

Identical behavior (with opposite results) will occur when the robot encounters more light on the right side. If a different orientation of terminals is chosen, the photovore can be changed

into a photophobe.



A Photovore Circuit