Wear Your Heart on Your Sleeve

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December 12, 2018

Our project goal was to build a LED heart that monitors heartbeat using an EKG and corresponds low frequencies (slower heart rate) to green and high frequencies (faster heart rate) to blue.

Figure 1

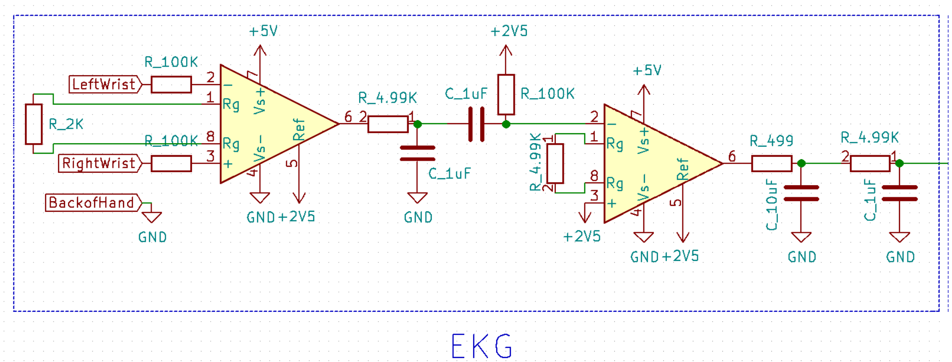

Figure 1: An EKG circuit with the RC values shown above was built in order to sense and measure a heartbeat.

First, an EKG was built in order to sense and measure a heartbeat. Figure 1 is a schematic of the first stage: the EKG. The EKG circuit contains 3 low pass filters and 1 high pass filter. A healthy resting heart rate is 70 beats per minute, which is about 1 Hz. Since the signal we want is relatively low voltage and 60 Hz noise dominates the initial signal, we use several aggressive low pass filters. The cutoff frequency for the first low pass filter is 32.5 Hz and the cutoff frequency for the second and third is 31.9 Hz. The cutoff frequency for the high pass filter is 1.6 Hz. In addition to filtering the signal, it was amplified twice. The total gain is 1045.

Figure 2

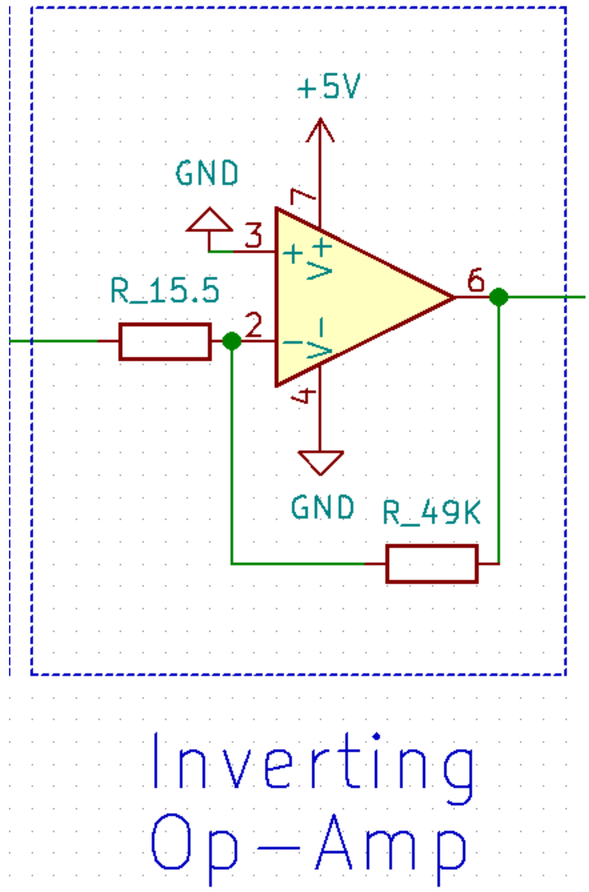

Figure 2: Because the EKG monitor electrodes are placed above the chest and on the stomach, the raw trace needs to be inverted using an inverting op-amp with a gain of -2.

At this point, the signal is filtered, but because the EKG monitor electrodes are placed above the chest and on the stomach, the raw trace spikes in the negative.In order to make sure the peaks are positive the signal needs to be inverted. Figure 2 is a schematic of the inverting amplifier used to invert and amplify the signal. We wanted to amplify the signal by a gain of -2.

Figure 3

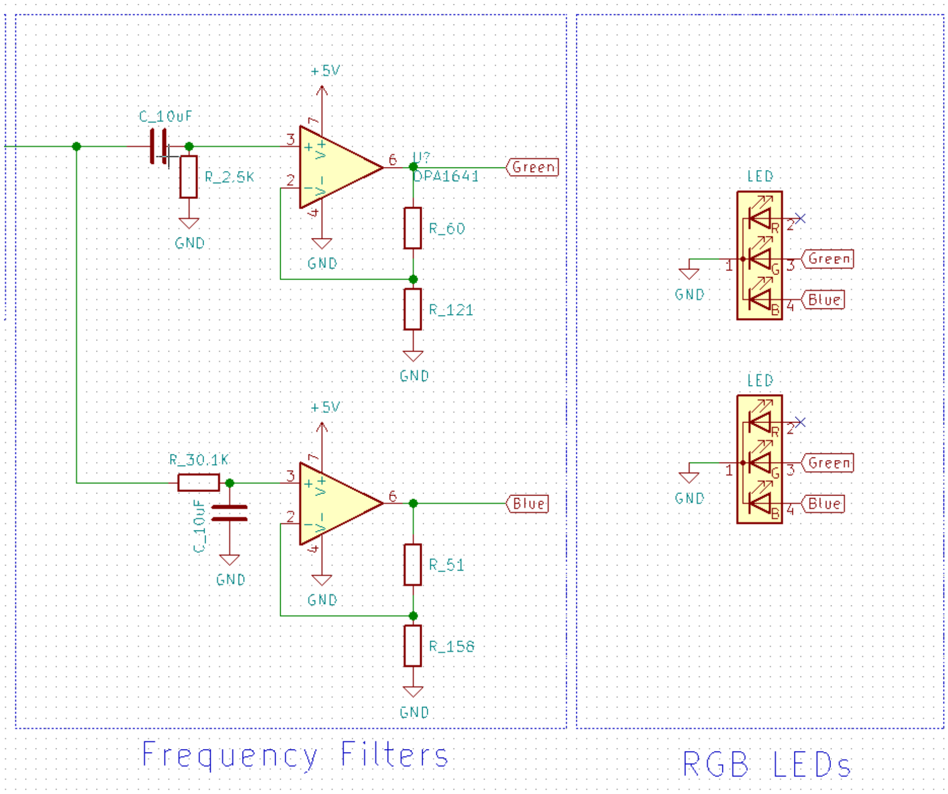

Figure 3:

The signal is then passed through a low pass filter and a high pass filter in parallel to instill a gradual shift from green to blue. As the frequency of the heartbeat increases, the LED goes from predominately flashing green to flashing blue. The low pass filter for the green anode pin has a cutoff frequency of 6.36 Hz and the high pass filter for the blue pins has a cutoff frequency of 0.52 Hz. These values were determined by mapping phase shifts with different RC and CR values for both green and blue. We looked for the values that allowed the green and blue phase shifts to intersect at mid-range.

Figure 4

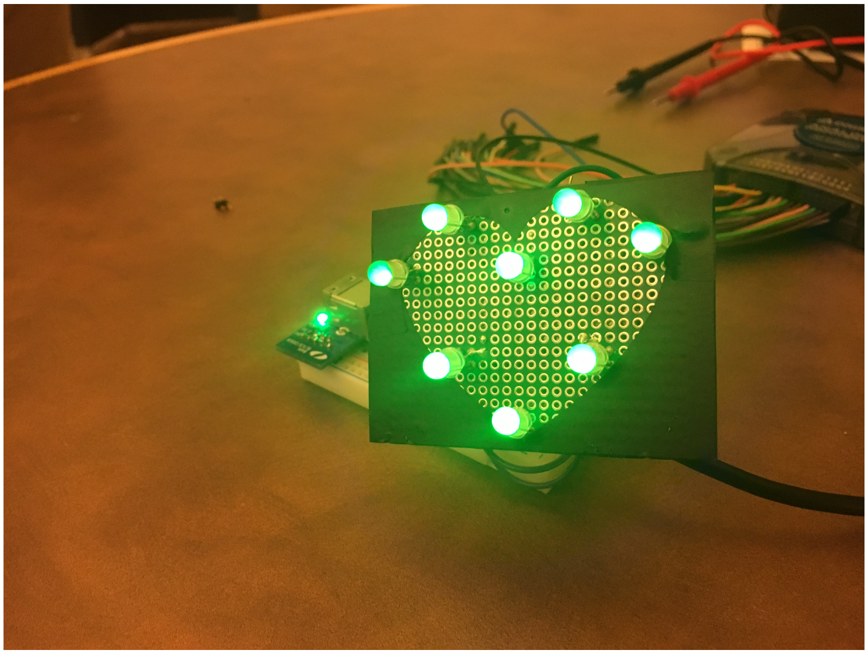

Figure 4:

Eight RGB LEDs are built in parallel in the shape of a heart on a protoboard. Each LED has a shared ground pin and separate pins for red, green, and blue. Figure 4 is the final assembly. The EKG is built onto 1 square breadboard and all the amplifiers and filters that follow are built onto another square breadboard. All boards are hidden in a box and straps are attached to the sides.