ELR 4202C Project: Heart Sound Pulse Display Module

Overview:

The project will use a stethoscope and electret microphone to create an electrical signal input to circuitry which will indicate the pulse with each heart beat. This signal is processed to produce a pulse display occurring with each heart beat. This is done by detecting and processing heart sounds. The display will be prduced on a 10-LED bar graph. Additionally, the laboratory equipment will be used to record and produce a hard copy of the measured heart sounds and the pulse output. Each team will design and fabricate a module, submit a written technical report, make a Powerpoint presentation, and a video demonstration to present live before the class as demonstration of its projects completion.

There are three aspects of this project to be divided among your team members:

- Report on the clinical aspects of heart sounds
- Create a sensing transducer and electronics to detect and process heart sounds.
- Design, fabricate and test the electronic module

A. Clinical Research

Heart sound origination – anatomic and physiologic
Heart sound propagation through the body and detection sites
Morphology of heart sound waveform
Clinical conditions affecting heart sounds
Determine appropriate frequency specifications for filter response allowing processing of signals.

B. Fabricate a Patient Interface

Sethoscope and electret microphone as devices
Mounting microphone to pick up sounds
Electret microphone principle of operation
Powering the microphone

C. Design and Test the Electronic module

Input amplifier, filter amplifier, scaling amplifier, bar graph
The attached information will help in carrying out this task.
The following sections give details of the electronics, arragned in the suggested order for building them.

D. The technical report

This must contain a summary of the clinical aspects of heart sounds measurement, processing, and show aspects to decide on the design elements of the project. The design of the patient interface must be described with respect to facilitating the measurement and optimize the detected signal. The electronic module design must be described with design equations, written rationale, and test results included.

E. Presentation

Summarize briefly the clinical aspects, the interface design and the electronic module. Then demonstrate the module with a human subject on the date assigned to your team. The demonstration will include a live presentation plus a PowerPoint slide set and a video of the device working.

Project Details:

Block Diagram

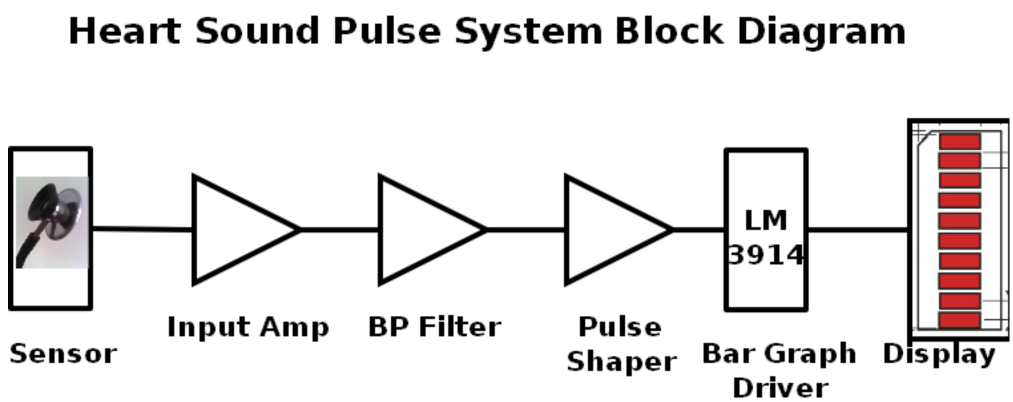


Illustration 1: Project Block Diagram

Hardware to be used

Fabricate the electronics on a "proto-board" and use ± 3 volts for the power source. You may use the lab power supplies for development but a battery pack will be substituted for the final demonstration. You will use the LM 3914 Display Driver IC, a 10-segment LED bar graph and the Quad op amp. Build the circuitry with carbon film resistors rated for 1/4 watt with 5% tolerance and capacitors such as polyester film or metallized film with a tolerance of 5% and a voltage rating of 50 volts. All of these components are available from the BME lab and ***must*** be returned at the end of the semester.

The display assembly

This section of the project implements the 10-segment bar graph display with a switch to select its display mode. The display is created by combining an LM 3914 (or equivalent) integrated circuit, a 10-segment LED and resistors. A typical circuit diagram is shown below, as taken from the reference listed below.

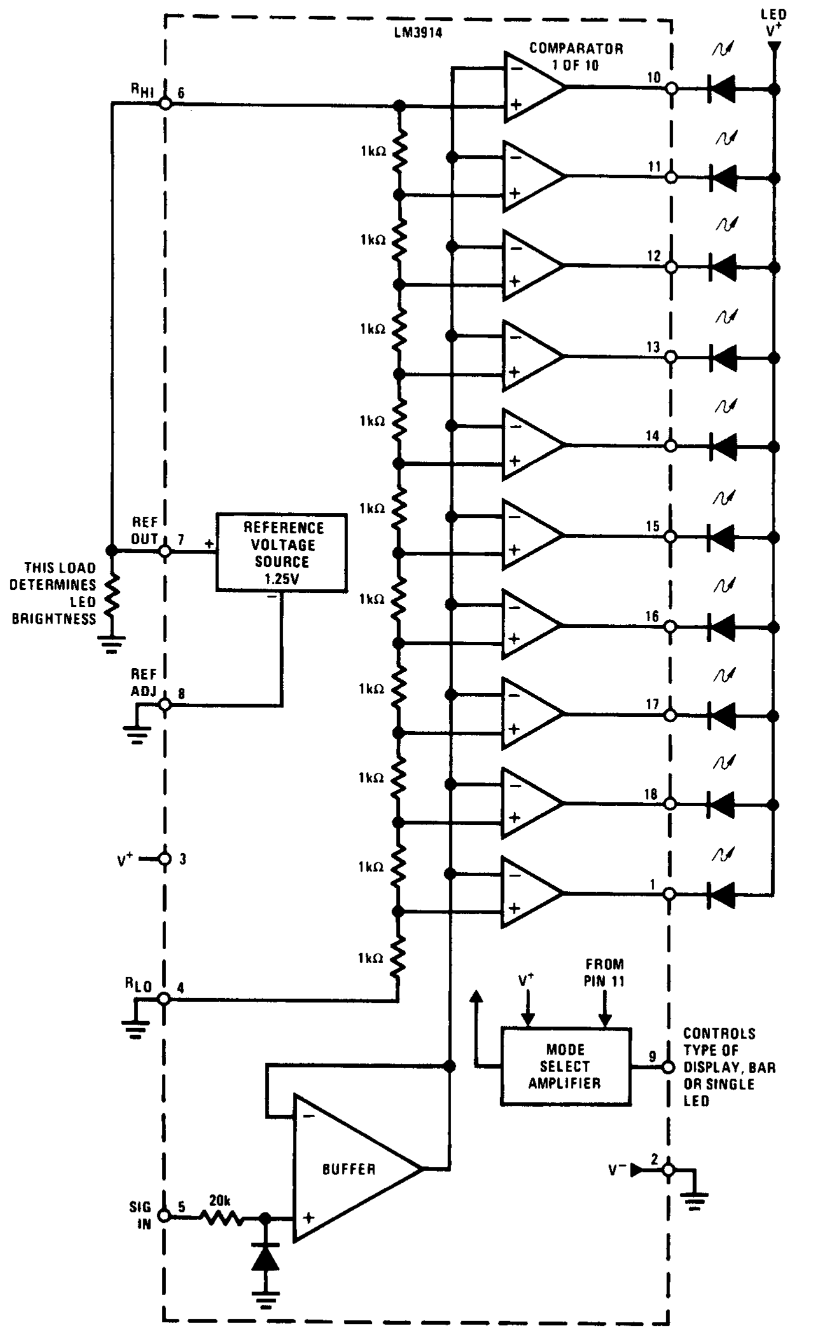


Illustration 2: LM 3914 Display Driver

ADDITIONAL NOTES:

The power connections are slightly different than shown above. Apply the +3 volts to pin 3 of the IC and to the common anode of the LED's. Apply the -3 volts to pin 2 of the IC. The "ground", the midpoint of the batteries, is applied to pins 4 and 8.

The resistor between pins 7 and 8 determines the brightness of the LED's and its value should be normally 1000 ohms or more with higher resistance causing less brightness. Of course, the life of the batteries is better with less brightness (see the reference).

Testing the display

The input signal is applied to pin 5 of the IC. The voltage levels on pins 6 and 4 establish the upper and lower voltage limits that will be displayed. With the circuit shown, those limits are +1.25 volts and ground.

Test the circuit by applying a sinusoidal voltage to pin 5, after first confirming the voltage on the oscilloscope. Use a sinusoid of 1 Hz with a peak voltage of ±1.25 volt. This should cause the display to sweep to full scale and back to dark and then remain dark for ½ second. Slowly reduce the amplitude and observe that the number of lit segments is reduced. When the amplitude drops to approximately 0.125 volt, only a single segment should light up. Document these events in your report.

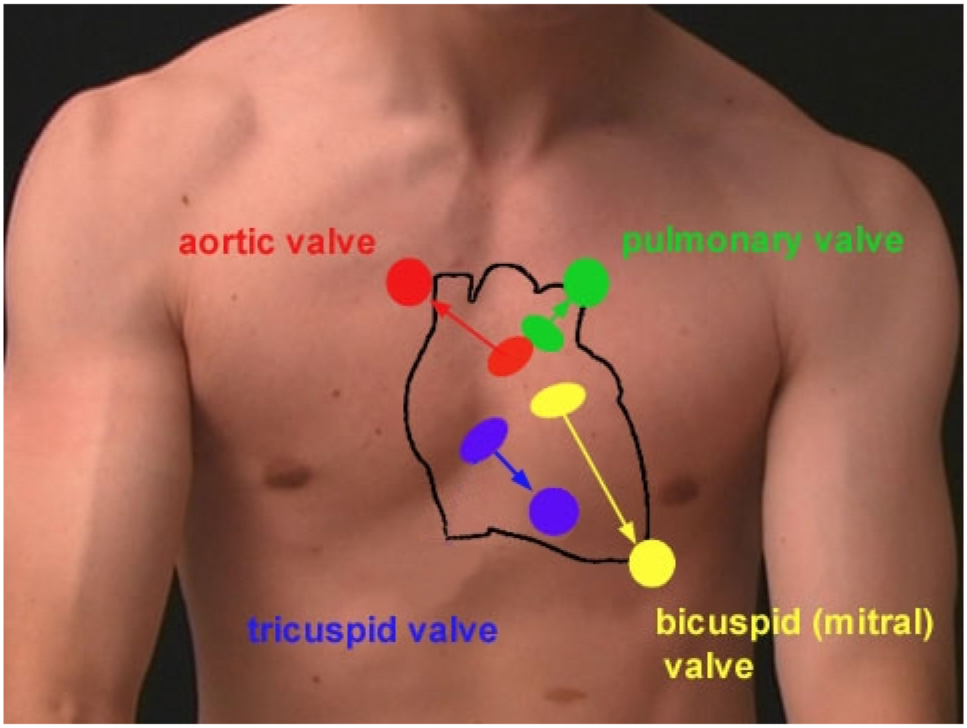
Alternative Power Supply

The class web site has the description for an alternative power supply arrangement using the remaining op-amp. This will allow the circuit to be powered by a battery aiding demonstration in the classroom.

Exercise #1 Obtaining a signal and design a sensor holder

Listen for the heart sounds using the stethoscope. Determine the location that will be used to detect sounds. Record this location for Exercise #1 report.

http://anatomy.med.umich.edu/surface/thorax/hsounds.html



Design a way to couple the stethoscope sensor head with an electret microphone. This design also must accommodate the wiring necessary to power and sense the microphone output   The design **MUST** also include a straign relief system to support the wiring between the electronics and the sensor plus insulation to prevent electrical shock.

Illustration 3: Separate head from sethoscope

Remove the head from the stethoscope to be coupled with the microphone.

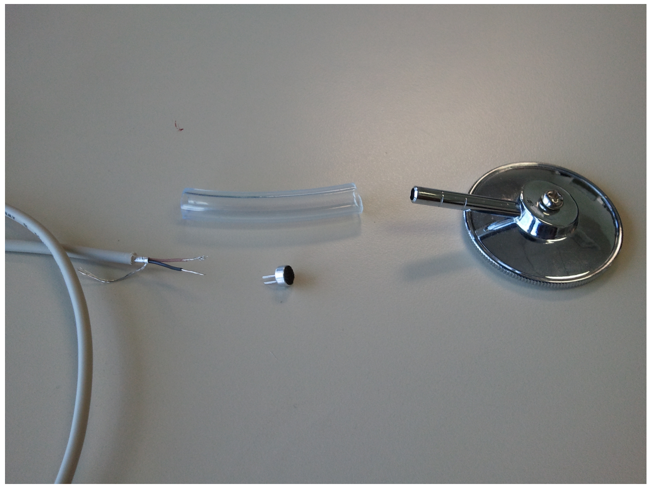


Illustration 4: Elements necessary for detecting sounds

Illustration 4 Shows the elements necessary to build a microphone interface for the stethoscope. First attach the microphone to the lead wire cable using solder.

Secondly, insert the microphone into a small piece of tubing. Refer to Illustration 5.

Silicone Seal can be applied to the wire end of the tubing to form a strain relief. Once the silicone has set the microphone and tube should be able to be attached to the stethoscope head without pulling the microphone and its cable from the tubing.

Some black tape or Scotch mending tape can be wrapped around the stem of the stethoscope head to provide a spacer. The spacer will allow a tight fit between the stem and the tubing.

Illustration 5: Microphone components in place

There should also be some kind of belt created to hold the transducer against the chest for continuous monitoring.

Configuration #1:

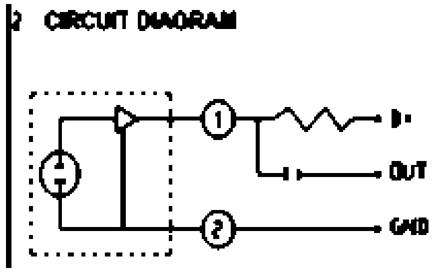
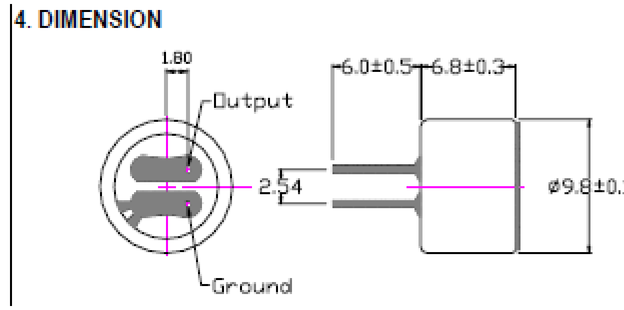


Illustration 6: Microphone Schematic



http://www.epanorama.net/circuits/microphone_powering.html

Connect microphone with 2KOhm resistor for observe voltage at Node 1 as shown in Illustration 6. V+ can be +4.5-5 volts. The oscilloscope probe can be connected directly to Node 1 without requiring the capacitor. First, DC couple the oscilloscope and determine the static voltage present at Node 1.

Next the oscilloscope should be switched to AC coupled input to elinimate the DC offset voltage present at the node. Make additional measuresments of the heart sounds. Adjust the gain and sweep speed to reliably show the image of the heart sounds. Measure the frequency and amplitude characteristics of the signal.

Capture a screen show of sounds traces from an Oscilloscope to include in Exercise #1 report.

The characteristics of this trace will be the basis for determining the circuit characteristic specifications.

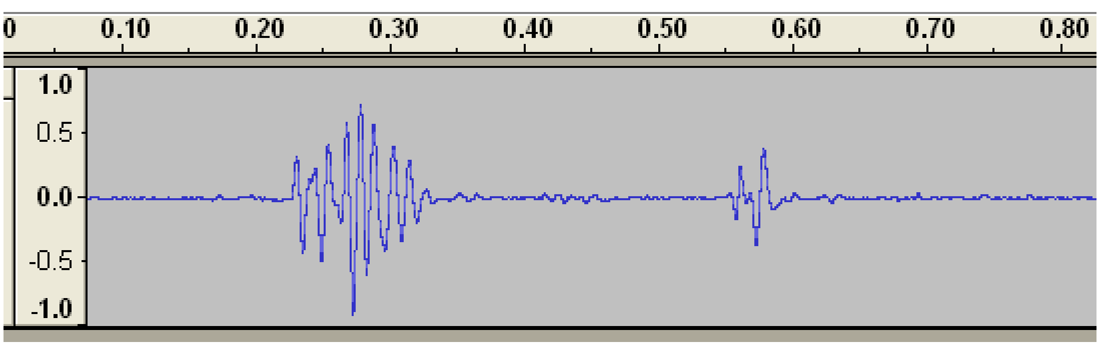


Illustration 7: Electronic image of heart sounds: Lub-Dub

Determine required specifications:

From the experimental observations and the traces recorded, determine the required specifications for buffer amplifiers gain and offset plus filter frequency responses based on size of the signal and the input requirements of the display plus research about the frequency characteristics of the photo pulse signal.

Exercise #2

Design a circuit to meet the specifications of the sensor output signal and the display input signal requirements. The full block diagram should be realized.

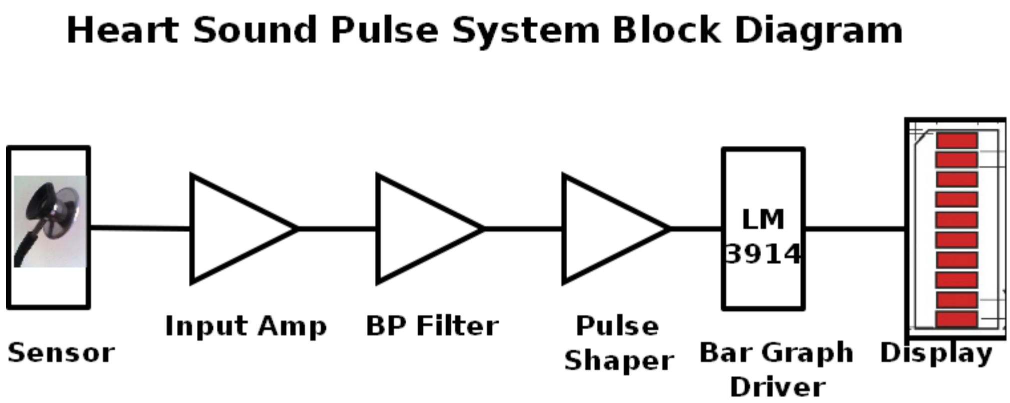


Illustration 8: System Block Diagram

A sample reference schematic is shwon in Illustration 9, is a copy of the schematic in Reference #1. The values must be changed based on the filter characteristics and sensor performance results from Exercise #1.. Determine the specific values and draw the complete circuit schematic with all the correct values used for this project.

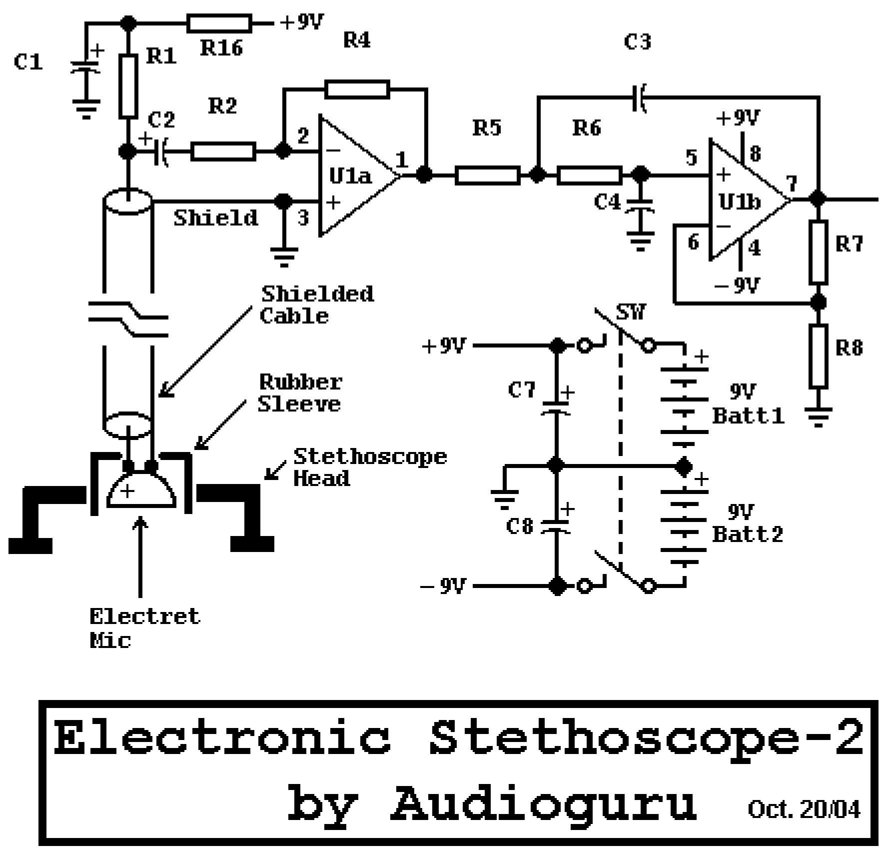


Illustration 9: Reference 1: Schematic

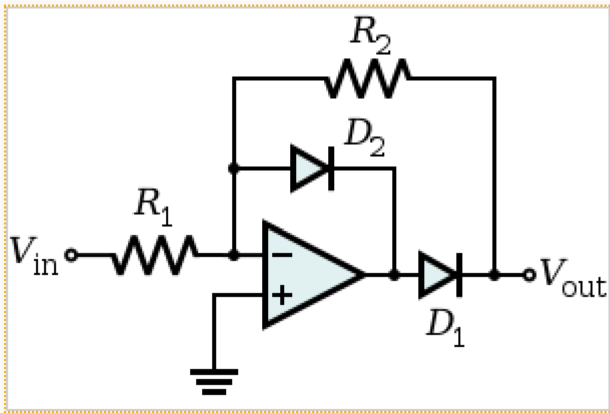
http://www.aaroncake.net/circuits/steth.asp?showcomments=all

Illustration 9 is shown by example and alternative circuit configurations can be used.

Using the input configuration #1 from Exercise #1 replaces R16 and R1. The gain of U1a can be set for the required amplification. U1b is a bandpass filter configuration similar to Figure 3.12 in Medical Instrumentation text book.

The signal from U1a should have enough gain to be useful as input of a personal computer sound card to allow long term recording of the signal for archive and analysis.

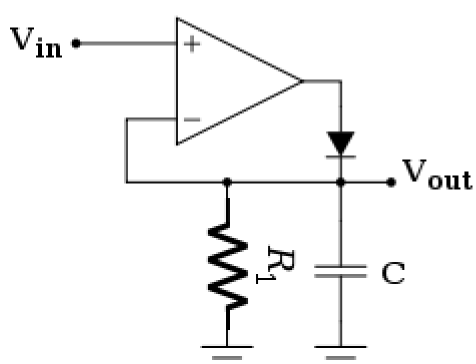
A precision half wave rectifier and a low pass filter can be used to implement the pulse shaper to drive the LM3914 bar graph driver. NOTE: the input the bar graph driver has a limited and specific range. Make sure the output of the pulse shaper conforms to those requirements.



An improved precision rectifier circuit.

http://en.wikipedia.org/wiki/Precision_rectifier

When configured in the precision rectifier mode, its output consists of the positive half-cycles of the input signal. When a capacitor is added across the load resistor, the envelope detector output holds the peak amplitude of the input signal. In this mode it must have a decay time constant suitable for the tremor frequency. It is recommended to use a capacitor value of 1.0 microfarad and set the decay time constant to give a good indication on the display.



R00927

Appendix:

TLC2274, TLC2274A,TLC2274Y
Advanced LinCMOS™ RAIL-TO-RAIL QUAD OPERATIONAL AMPLIFIERS

SLOS106B–D4001, MARCH 1992–REVISED OCTOBER 1992

D, J, N, OR PW PACKAGE
(TOP VIEW)

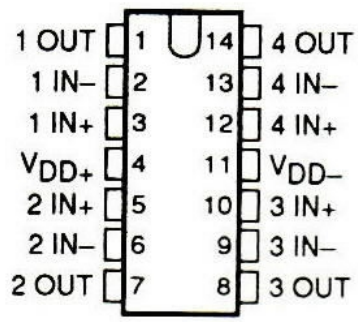
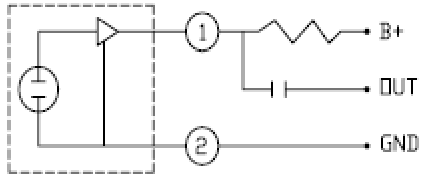


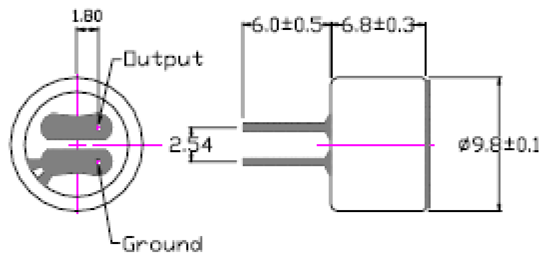
Illustration 10: Pinout for Quad Op-Amp

Eletctret Microphone Information

2. CIRCUIT DIAGRAM



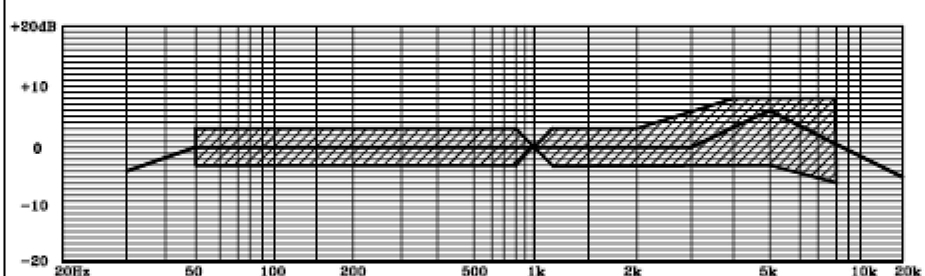
4. DIMENSION



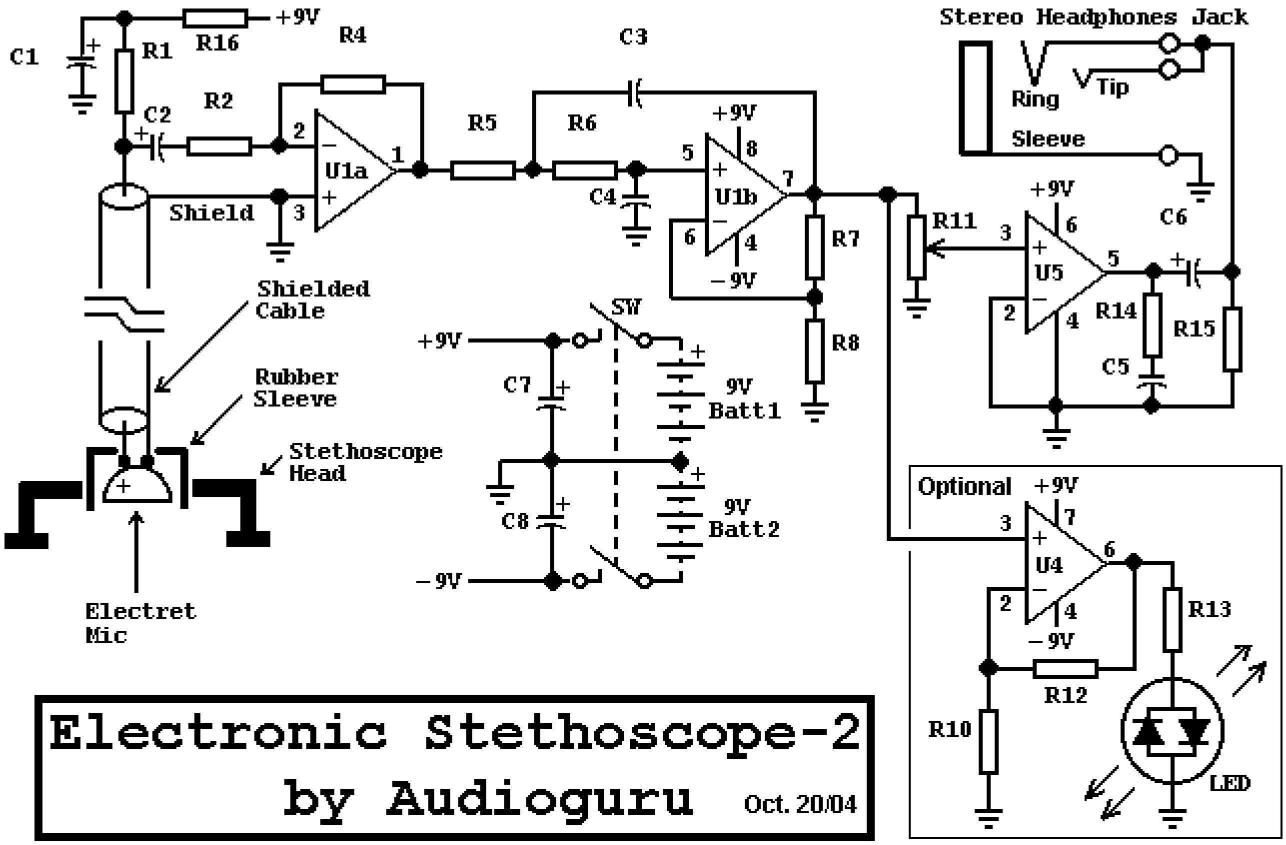
3. SPECIFICATIONS

1. IMPEDANCE : LOW
2. STANDARD VOLTAGE : 4.5V
3. RANGE OF OPERATING VOLTAGE : 1.5V TO 10V
4. CURRENT DRAIN : 0.5mA MAX
5. S/N RATIO : 40 dB or more
6. MAXIMUM INPUT SOUND PRESSURE : 120 dB SPL
7. RoHS Compliant.

5. TYPICAL FREQUENCY RESPONSE CURVE



http://www.jameco.com/Jameco/Products/ProdDS/136574.pdf



http://www.aaroncake.net/circuits/steth.asp?showcomments=all

http://www.freepatentsonline.com/4783813.html

An electronic sound amplification stethoscope including a battery powered self-contained sound amplification circuit contained in a hand held connector housing inserted in the flexible sound conduit of the stethoscope. The circuit includes a miniaturized microphone for receiving sound waves from the stethoscope pickup head and a miniaturized speaker for transmitting amplified sound waves to the stethoscope headpiece. Both the microphone and speaker may be housed in the connector housing and are vibration insulated from the housing itself. The electronic circuitry and battery power source are located in compartments separated from the microphone and speaker. A LED light source is placed in series between the amplifier circuit and the power source such that the fluctuations in its intensity are directly proportional to the power surges in the circuit. The LED is thus a visual indicator of such body functions as respiration and blood flow. The amplifier circuit is also provided with an on/off volume control thumbwheel located on the surface of the connector housing