University of Jordan

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Sensors & Transducers

Ultrasonic Trnasducer Design

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- **Introduction**

Ultrasonics is a name given to various specific topics in which the properties of ultrasound are exploited. Ultrasound is simply sound whose frequency is too high to be heard by the human ear, the frequency is above 20 kHz. At the top end of the scale, ultrasound is used at frequencies up to several GHz. Ultrasound waves are characterized by elastic oscillations of the material in which they travel, that is, they are essentially traveling vibrations. This entry gives a brief introduction to the physics of ultrasound, and the concepts underlying some of its applications in the fields of engineering.

- **Methodology:**

Ultrasonic Consists of 2 main parts the receiver which is the same part as the transmitter and the second part is an Active low pass filter which differs from the normal low pass filter that it is formed by using an op-amp. The operational amplifier will take the high impedance signal as input and gives a low impedance signal as output. The amplifier component in this filter circuit will increase the output signal's amplitude.

By this action of the amplifier, the output signal will become wider or narrower. The maximum frequency response of the filter depends on the amplifier used in the circuit design.

- **Signal conditioning circuits and the Mathematical equations:**
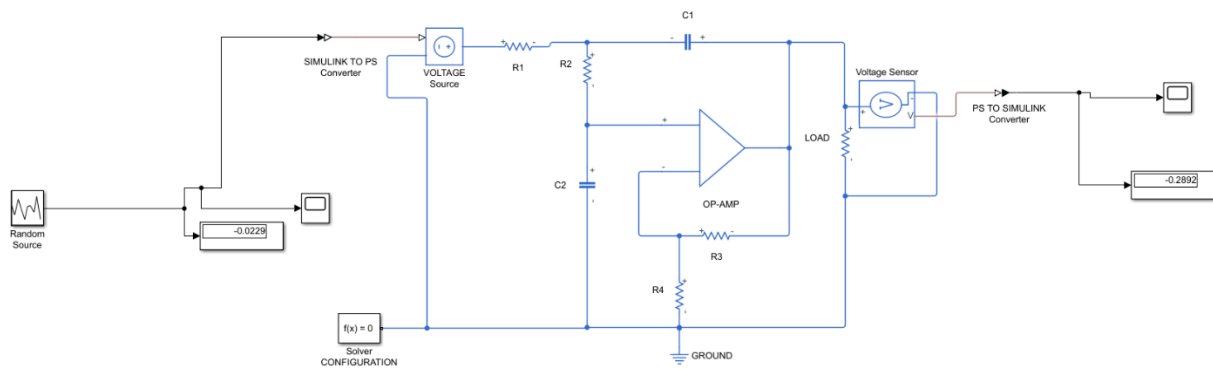
Here we used for the input A Random source frequency generator as a Receiver so we can get a precise reading without any noise then we connected it with a 2nd order Active low pass filter with high voltage gain

Second Order Active Low Pass Filter
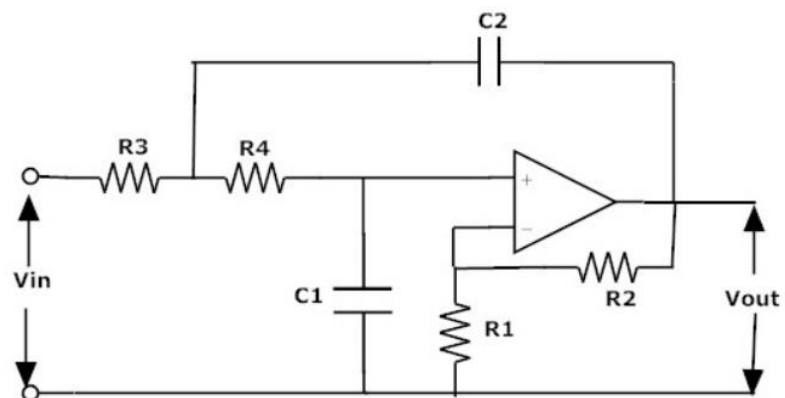
When the input signals are at low frequencies the signals will pass through the amplifying circuit directly, but if the input frequency is high the signals are passed through the capacitor C1. By this filter circuit, the output signal amplitude is increased by the pass band gain of the filter.
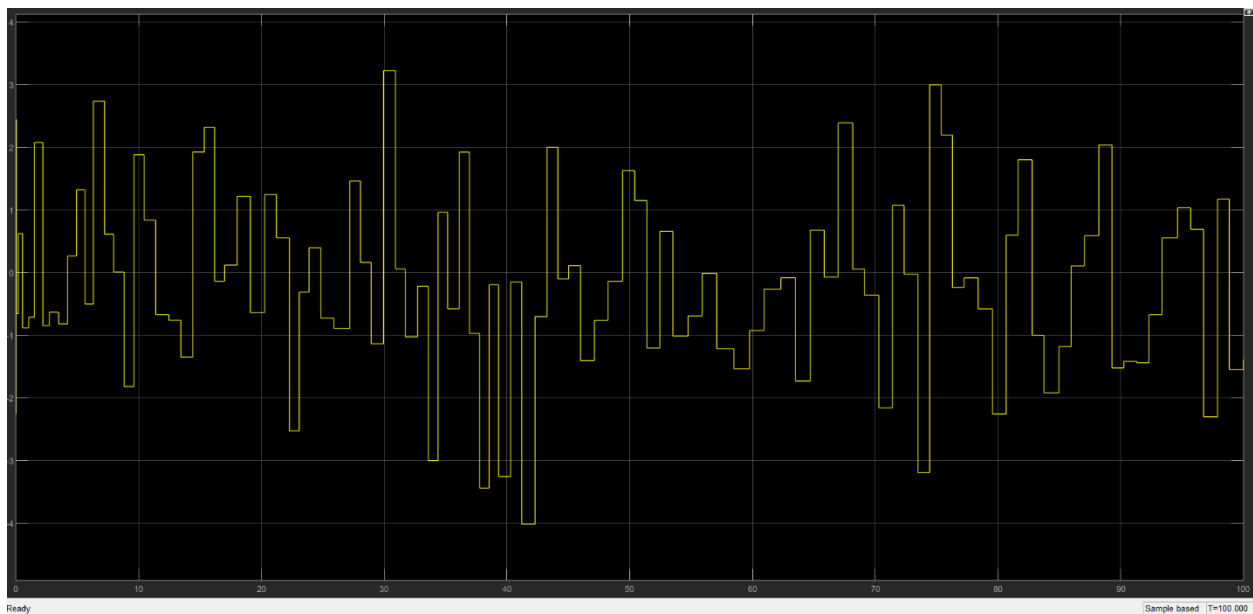
The gain of the above circuit is Amax = $1 + (R_2/R_1)$

The cut-off frequency of second order low pass filter is $f_c = 1 / 2\pi\sqrt{(C_1 C_2 R_3 R_4)}$
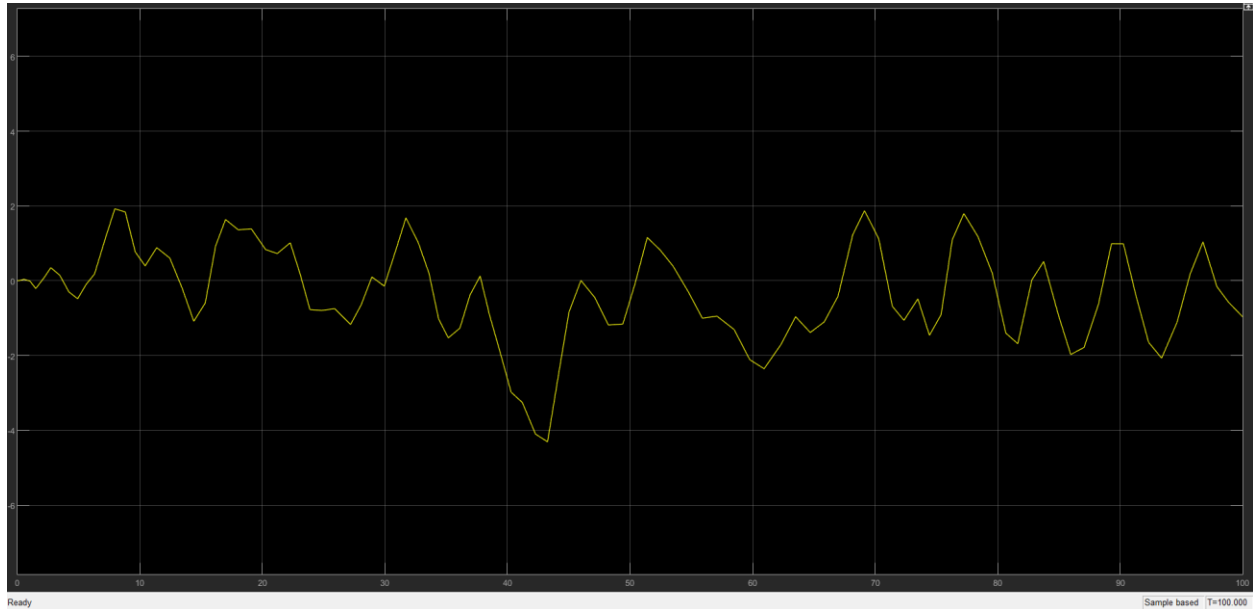
Where:

- A_{max} = Gain of the pass band = 1 + R_2/R_3
- f = operational frequency.
- f_c = Cut-off frequency.
- V_{out} = Output voltage.
- V_{in} = Input voltage.

Figures Of the simulation and Response:

- The Response Before the Low pass filter with high voltage gain:

- The Response After the Low pass filter with high voltage gain:

- **Advantages and Applications:**

- Not affected by color or transparency of objects.
- Can be used in dark environments.
- Low-cost option.
- Not highly affected by dust, dirt, or high-moisture environments.

- Some Applications:

- Anti-Collision Detection.
- People Detection.

- Contouring or Profiling.
- Presence Detection.
- Box Sorting using a Multi-Transducer System.

- **Conclusion:**

In conclusion, ultrasound imaging is highly focused on the acoustic impedances of various mediums. The waves of sound that are reflected back to the detector in the transductor are converted in to graphs and then to a clear 2D image.

Ultrasonic sensors are non-intrusive in that they do not require physical contact with their target, and can detect certain clear or shiny targets otherwise obscured to some vision-based sensors. On the other hand, their measurements are very sensitive to temperature and to the angle of the target. Temperature and humidity affect the speed of sound in air. Therefore, range finders may need to be recalibrated to make accurate measurements in a new environment.

- **References:**

1)http://pubs.sciepub.com/automation/3/3/6/

2) https://www.mathworks.com/help/phased/transmitters-and-receivers.html.

3) https://www.electronicshub.org/active-low-pass-filter/.

4) https://howtomechatronics.com/tutorials/arduino/ultrasonic-sensor-hc-sr04/.