

Ultrasonic Levitation – Applications

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Abstract

To report the application of an acoustic ultra-sonic levitation system. The sample of less than one half wavelength of the excitation frequency are levitated without contact, just below the pressure nodes. The transducer is excited by an ultrasonic signal through a voltage amplifier. This acoustic ultra-sonic levitation finds its place to an advanced biotechnological system in conditions like container free processing, non-contact handling, and dynamic control of objects especially in pharmaceutical where precision and purity is important. Industrially very useful in multi material and 3D imaging. Most importantly in the field of medicine where unknown diseases are cropping up with graft or transplantation being the only option and in tissue cultures, in both cases the concept of contamination being the highest criteria. The most recent application to quote is the next level of transportation, post disaster management, material study in space. Levitation allows contact less grafting and inoculation. This acoustic ultrasonic levitation for giving and saving lives.

Keywords: Levitation - Ultrasonic - Acoustic – Contactless - Grafting – Transplantation - Space material.

1. Introduction

Acoustic Levitation integrates engineering physics and the advanced technology. The high frequency standing wave generated doing the magic while finding applications in the most important areas like medicine, health, risky transport and disaster management to mention a few them. [1]

2. Literature Review

This research using transducers and reflectors create standing waves capable of levitating light objects. This creates a stable levitation area. This study tries to find the various avenues where Ultrasonic Levitation can become handy.

3. Methodology & Working

An acoustic levitator has 2 main parts a transducer, a vibrating surface that makes sound and reflector. A sound wave travels away from transducer and bounces off the reflector, this interaction of the travelling, reflecting wave help the object to be suspended in midair. The longitudinal pressure waves interact and form the standing waves with nodes and internodes. At the region of the node there is minimum acoustic pressure, this counteracts the force of gravity, creating a micro gravity environment and allow the object to float.

4. Components

- Arduino Uno R3

- Motor Driver
- SMPS (Switched Mode Power Supply)
- Ultrasonic Transducer
- Connecting Wires

5. Circuit Diagram

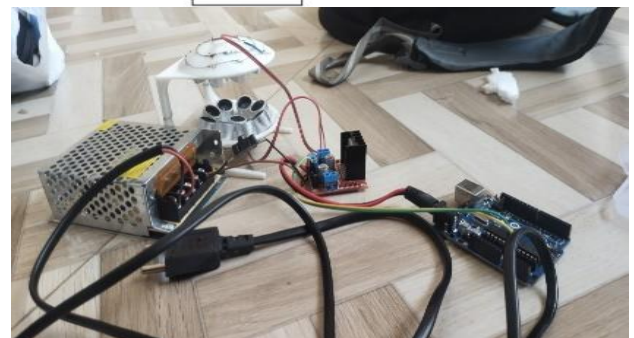
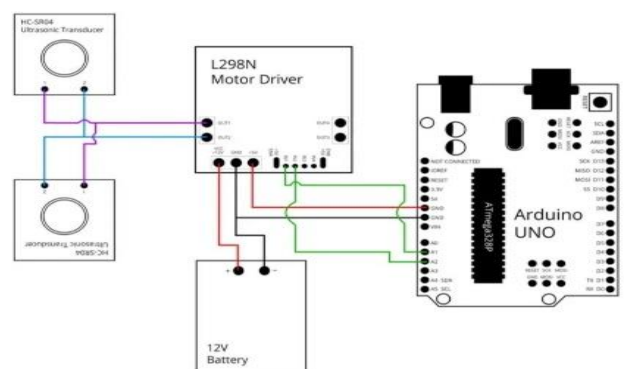


Figure 1 Circuit Diagram

5.1. Explanation

An ultrasonic levitator circuit is designed to generate high-frequency sound waves (typically in the ultrasonic range, above 20 kHz) to create standing wave patterns that can trap and levitate small objects in mid-air. The circuit consists of several key components that work together to achieve this effect:

5.2. Ultrasonic Transducer



Figure 2 Ultrasonic Transducer

- **Purpose:** Converts electrical signals into ultrasonic sound waves. (Figure 1)
- **Description:** Usually a piezoelectric transducer that vibrates at a specific frequency when an alternating voltage is applied. It emits sound waves that travel through the air.

5.3. Motor Driver

Purpose: Generates and amplifies the high-frequency signal needed to drive the transducer. (Figure 2)



Figure 3 Motor Driver

5.4. Components

5.4.1. Oscillator

Produces the ultrasonic signal at the desired frequency (e.g., 40 kHz). Often based on a crystal oscillator or a 555 timer configured for high-frequency generation.

5.4.2. Amplifier

Boosts the oscillator signal to a level sufficient to drive the transducer. Typically, MOSFETs or transistors are used. [2]

6. Resonance Tuning

6.1. Purpose

Ensures the transducer operates at its resonant frequency for maximum efficiency.

6.2. Description

Ultrasonic levitators often require precise tuning of the driving frequency to match the transducer's natural resonance. Variable resistors or capacitors can help adjust the frequency.

6.3. Opposing Reflector

- **Purpose:** Creates a standing wave by reflecting the ultrasonic waves back toward the transducer.
- **Description:** A reflector (often a flat or curved surface) is positioned at a specific distance from the transducer, usually an integer multiple of the Half-wavelength of the sound wave. This creates nodes (points of minimal pressure) and antinodes (points of maximal pressure).

6.4. Standing Wave Formation

How it Works: When the ultrasonic waves from the transducer interact with their reflections, they form a standing wave pattern. Small objects (e.g., Styrofoam beads) can be trapped at the nodes of the standing wave, where the acoustic pressure cancels out and creates a stable point.

6.5. Power Supply

- **Purpose:** Provides the necessary voltage and current to the circuit.
- **Description:** Typically, a regulated DC power source is used, and its voltage [3]

An ultrasonic levitator is a device that uses sound waves to suspend small objects in the air without any physical contact. It achieves this by creating a standing wave of ultrasonic sound (high-frequency sound waves above the range of human hearing). Here's how it works, step by step:

6.6. How Ultrasonic Levitation Works

6.6.1. Ultrasound Generation

- The system typically consists of an ultrasonic transducer and a reflector.

- The transducer generates high-frequency sound waves (usually 20 kHz or higher) using piezoelectric materials that convert electrical signals into mechanical vibrations.
- **Standing Wave Formation:** The transducer emits sound waves toward a reflector positioned at a specific distance.
- When the emitted waves and their reflections interfere with each other, they form a standing wave.

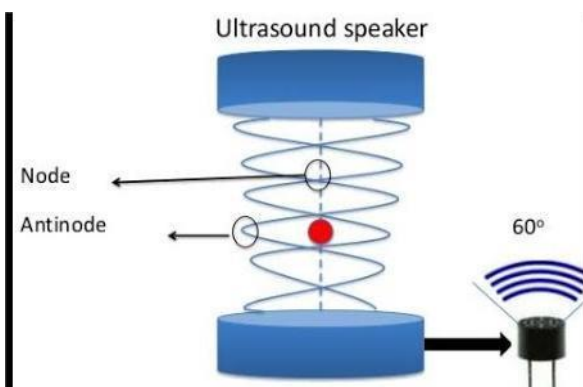


Figure 4 Standing Wave Formation

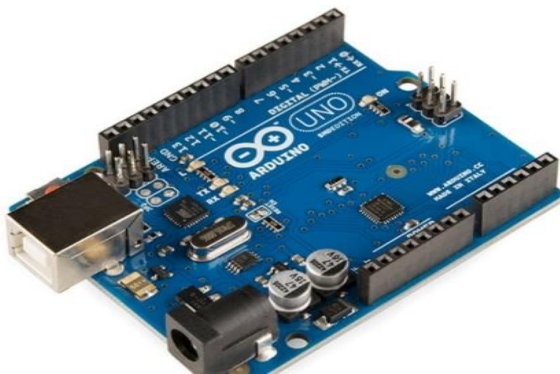


Figure 5 ARDUINO

An ultrasonic levitator utilizes high-frequency sound waves to suspend small objects in mid-air without any physical contact. When integrated with an Arduino, a versatile microcontroller, you can control and fine-tune the levitation process, making the system more adaptable and responsive. Below is a comprehensive explanation of how an ultrasonic levitator works with Arduino, including the key components, setup, and operation.

6.7. Circuit Diagram

The circuit typically includes: Oscillator (e.g., 555

timers, microcontroller, or crystal oscillator) Amplifier stage (e.g., MOSFET or BJT-based) Piezoelectric transducer connected to the output

6.8. Reflector for standing wave formation

6.8.1. Advantages

Ultrasonic levitators use high-frequency sound waves to suspend and manipulate small objects in the air without physical contact. Here are some advantages of ultrasonic levitation:

6.9. Contact-Free Manipulation

Objects can be levitated, moved, or rotated without touching them, which is ideal for handling delicate or sensitive materials.

6.10. No Contamination

Because there is no physical contact, there is no risk of contamination, making ultrasonic levitation suitable for applications in cleanrooms, laboratories, and medical fields.

6.11. Wide Range of Materials

Works on various materials, including liquids, powders, and solids, regardless of their magnetic or electrical properties.

6.12. Non-Invasive

No physical force is applied directly to the object, preserving its structural integrity, especially useful for fragile or valuable items.

6.13. Precise Control

The position and movement of the levitated object can be controlled with high precision by adjusting the sound wave parameters.

6.14. Versatility in Applications

Suitable for diverse uses, such as studying fluid dynamics, material science, microgravity simulation, and acoustic research.

6.15. Safety

Ultrasonic levitators are generally safe to use, as they do not involve harmful radiation or intense magnetic fields.

6.16. Non-Magnetic Operation

Unlike magnetic levitation, ultrasonic levitation can suspend non-magnetic materials, making it more universally applicable. [4]

6.17. Cost-Effective

Compared to other levitation technologies like magnetic or optical levitation, ultrasonic systems can be more affordable and simpler to build.



6.18. Enables Unique Research

Allows scientists to study phenomena like evaporation, phase changes, or crystal growth in a Controlled, microgravity-like environment.

Purpose: Creates a Non - Contaminative Environment

7. Applications

- Manufacturing very small electronic devices and microchips that require precision.
- Handling components of robots and machinery without physical contact.
- Handling of corrosive and unsafe materials for study. For contactless manipulation of droplets in Chemistry.
- For the study of space materials.
- For container less processing requiring purity and prevention of contamination.
- For graft and tissue transplantation.
- For debris lifting during disaster management.

Conclusion

The Ultrasonic Levitation system is a miniature portable design to demonstrate its different avenues of applications including risky transportation, lifting technology, non-contact manufacturing, medicine and chemical delivery, graft and other implantations, use in research where non-contact mechanism is required, to prevent contamination, all microgravity and space related simulation experiments, fluid dynamics, non-contact diagnostic procedures and many more. The state of the art technology that is of the future.

References

- [1]. "Review of Progress in Acoustic Levitation", Brazilian Journal of Physics, 2017, Andrade, M.A.B, Pere. N, and Adamowski.
- [2]. "Acoustic Levitation in the microgravity of a spacecraft", Drive Drinkwater 2016.
- [3]. "Applications of Acoustic Levitation in Chemical Analysis and Biochemistry", Tsujino, Soichiro and Tamizaki, 2020.
- [4]. "Acoustic Levitation ", Brzostowicz, Nadia, 2019.