CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

J1004

Project Title

Manipulation of Ultrasonic Force Field

Abstract

Objectives/Goals

The goal of the project is to generate an ultrasonic force field to levitate and manipulate small objects.

Methods/Materials

I developed a computer simulation algorithms using MATLAB to calculate the needed amplitude and phase configuration of the phased-array transmitter in order to generate a given field pattern.

I also experimentally verified the simulated field pattern by designing and building an ultrasonic phased-array transmitting system and a field scanning platform. I used an Arduino DUE to manage the amplitude and phase configurations, an FPGA to control the phases (FPGA code developed by others), digital potentiometers to attenuate the signal, and fixed gain amplifiers to drive an array of ultrasonic transducers. The field pattern was measured by an ultrasonic receiver mounted on an XYZ stage built by LEGO Technic parts and controlled by an Arduino MEGA through Bricktronics Megashield.

Results

Simulated 1-D field pattern matched very well with measured field strength pattern. It was found that uniformly spaced arrays showed strong spurious interference spikes. Smaller spacing in uniformly spaced arrays pushed spurious interference spikes further apart. Larger overall array dimension yielded smaller focal spot size. Randomly spaced arrays showed lower spurious interference spikes.

Levitating effect was observed that very light objects were moved by the ultrasonic field. However, full suspension of an object was not achieved. It was probably caused by insufficient field strength.

Conclusions/Discussion

The simulation program using gradient descent algorithm could effectively produce transducer amplitude and phase configurations to yield any arbitrary field strength pattern. Uniform amplitude algorithm was fast and did not require regression. It could maximize transducer output amplitude. However, it could only generate a single focal spot. Experimentally measured ultrasonic field matched with simulation very well. The generated field strength was sufficient to move small objects, but not enough to fully suspend objects.

Summary Statement

I simulated and experimentally verified a phased-array ultrasonic transmitter for generating a force field to levitate small objects.

Help Received

I designed and built all of the circuits and the testing platform. I wrote all of the Arduino code and MATLAB code, except for the Verilog code for the FPGA which was written by the mentor.