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Ultrasonic Levitation by Employing FPGA Controller

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Abstract
This paper presents self-contained flexible platform utilized levitation research of acoustic,which is based on ZynqSoCthat employsultrasonic emitter(s) array. Platform employs a low costZedBoard for providing fast motion of levitated objects and the object detectionbased upon produced echo. Multiple features are available in Zynq device that consists benefit for the platform: a hardware acceleration for phase shift calculations, huge numbers of I/O attachedwith"FPGA Mezzanine Connector (FMC)", ADC to capture various echo signals and easy programmability due to the C-based design for both CPU and FPGA.

Keywords: *FPGA, ultrasonic, ZYNQ, levitation.*

I. INTRODUCTION

"ACOUSTICLEVITATION" generates forces in form of waves to suspend any light weight object flew into air without any type of contact with it. Theseacoustic levitation isbroadly utilized tothe contactless movement of the particles in physics, biology and medicines with other fields.Someotherprocesses exists for the contactless particle handling, including magnetic, optical trapping and electrostatic. However, the acoustic preparing comprises moreadvantage of working at various materials and on various sizes. Hencethis can control conductors/covers and attractive/non-attractive substances with acoustic power.Theusual application ranges from blood washing to separate lipids, cell manipulation[1].

"Acoustic levitation"is generated by employing ultrasonic array. The device comprises of collection of many transducer elements that emits with a sample frequency and amplitude but having different phases. The emitted waves from the element interferesto each other in order to form beam of pattern. Focusing the emitted sound along into a desired path isconceivablehaving accuracy ofmillimetric and in milliseconds of time. In this project we will investigate the controllability based on FPGA controllerforgenerating high-performance and a economic levitating device able to work in closed-loop configuration that receive signal of echo by levitating object(s). Focus onmanipulating capabilities by a Zynq-SoCthat includes relative low-cost, user interaction and ease of programmability, with

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extended parallel Input-Yield capacities having superior by means of the equipment quickening and with blend signal abilities along withan inserted ADC changing over module.

II. RELATED WORK

Existsvery large range in number ofappsutilizes multiple ultrasonic module and it has resulted research in both commercial and the academic level. E.g., micro fluidsseperating chips referred as a Lab-on-Chip, that buildsusage of an ultrasonic transducerfittedunder them for generating standing wave that is perpendicularfor flowing channel that separates particles [2]. Other primary propelled utilization are haptic advancements withultrasonic waves that are utilized so as to reproduce a substantial sensation in the mid-air [3]. The midair material presentation unit, called as "Airborne Ultrasound Tactile Display (for example AUTD)" that had been reproduced for yielding material incitement from separation. Show makes the utilization of airborne ultrasound into energize human skin for a touch feel. This utilizes staged cluster centering innovation for creating the radiation pressure that will squeeze human skin toward a path of the spread. The innovation is assessed to be improved with the material input picture show and another UIs.Main use of the FPGAs to the above territories studied[4] that shows a reconfigurable, ease and successful FPGA with a PC-based ultrasonic gadget, that is intended for examining and instructing medicinal imaging research.

III. ULTRASONIC LEVITATION PLATFORM DESCRIPTION

The figure 1 illustrates the total rundown of proposed system case of the level UPA (for example ultrasonic staged cluster). The task takes a shot at Zedboard which interfaces with ultrasonic unit by sending a "Samtec FMC" connector comprises 68 single finished Input/Output. Created module that uses 64 channels (for example 8x8) & twofold channels can associate with 2 channels with Analog to advanced converter that is accessible in a Zynq gadget. Those two channels are used for getting ultrasonic sign though rests are utilized asan producer mode. Handling systeminZynqoperates a product which controls stage cluster drivers demands capacity of equipment to ascertain point of convergence. This likewise offers straightforward UI from that the client associates with system. By utilizing the given interface client can selecta favored point of convergence in set of 3-dimensional co-ordinates in said exhibit's space. Handling system gives computation of required stage delays for delivering point of convergence to client chose area. "Stage delays", passed on as number of CLK cycle for deferring a sign of the channel, these are straightforwardly written in "Ultrasonic Phased Array Controller" (for example UPAC) register(s) over AXI transport. UPAC creates a 40kHz sign and yields them into a FMC port. Stage shifts at 40kHz sign, these are then enhanced by 0-3.3 V range to 0-16 V utilizing different MOSFET drivers and afterward the intensified sign are bolstered to the transducers.

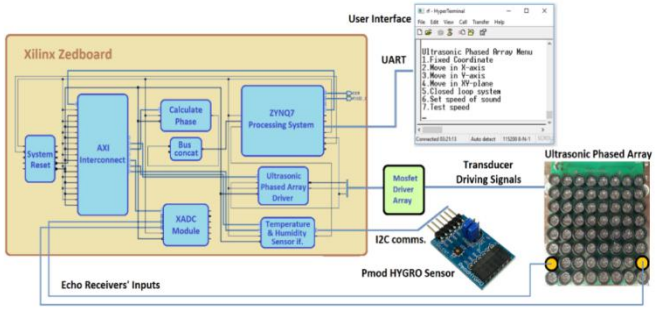

Fig. 1 Proposed System

Calculating the Phases

The ri (x,y,z) speaks to a three-dimensional Cartesian-directions of I-th transducer with in exhibit and the rf (x,y,z) speaks to comparable guidelines to target point of convergence, way length LP-I among them is communicated as Euclidean separation as Equation 1 shows. Required moving of stage for I-th transducer, as

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wavelengths, is leftover portion pursued by partitioning way length with wavelength. After this, it is expanded with 2π to get stage move in from of radians as outlined in theEquation 2. Staged clusters, size of point of convergence is communicated as capacity of wavelength (λ), the "central length (R)" & side length of an exhibit (D) as represented in Equation 3. Ordinarily, for "acoustic levitation" suspended particles are littler to half-wavelength, for example for this situation 4mm roughly.

$$L_P = \sqrt{(r_f(x) - r_i(x))^2 + (r_f(y) - r_i(y))^2 + (r_f(z) - r_i(z))^2} \quad (1)$$

$$\phi_i = 2\pi \times \mathrm{mod}\left(\frac{L_{Pi}}{\lambda}\right) \quad (2)$$

$$w = 2\lambda\frac{R}{D} \quad (3)$$

IV. ESTABLISHED PHASED ARRAY

Array fundamentals are combined intovarious ways for achieving acoustic pressure that is necessary for overwhelming the gravitational pull&for suspending object intomid-air. According to theproject, to investigate various degrees of motion& stability of particlefor controlling it,flat single-sided arrays had been considered for further investigation. Flat single-sided is shown in the Figure 2, it has multiple advantages, one of them is being easy to make the frame and second is for producingmultiple traps like twin-trap, bottle trap or vortex trap.

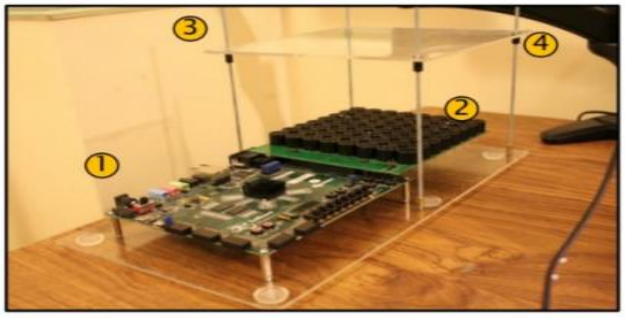

Fig. 2 Developed Phased Array

There are some limitations in the stability of levitator upon the removal of reflector plate due to lack of acoustic pressure that can be then provided to point of convergence through single-bar. Indicator plate generates standing wave for improving steadiness significantly high. Approaching and "reflected wave" are then interfaces with other while a pressure contacts with another pressure or rarefaction contacts with another rarefaction, adequacy additions to its twofold. Zones of the base weight in the standing wave is/are called node(s). Thosehaving maximum pressure is/are called antinode(s). The floating particles then suspends to just below node(s).

V. RESULTS

Fig. 3 Successful levitation of particle

The Fig. 3shows a successful levitation of a particle by system. Quality indication of levitation system consistsstrength,refreshingdegree and stability. To measure power/quality of said point of convergence of a sound-pressure-level (for example SPL) is determined. To gauge the SPL, ultrasonic transducer works as mic that is put at some arrange and cluster is told to generatethefocalpoint at given position. Terminals of mouthpiece are asociated with oscilloscope for estimating Vrms signal that is produced by the transducer. Producer gives affectability esteem that is used for ascertaining SPL for the given Vrms. For getting the profile of SPL over the point of convergence, amplifier is mounted on the arrangement of the sliding arms, that isutilizedfor adjustingthe x and y co-ordinates. Fig 9 illustrates strength analysis of said point.

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VI. CONCLUSION

This paper shows elite and usage of the ultrasonic suspending system by utilizing minimal effort coordinated arrangement based on Zynq gadget. Various types of arranged group blueprints and features of device are used to engage the unfaltering and a definite atom control in the shut circle arrangements. This paper shows that superior Zynq System on Chip offers an assortment of highlights and minimal effort stage for the application. Further future work includes the improving of reverberation system with expanded exact accepting sensor(s). High casing rates are conceivable with the many process modules that will empower levitation of numerous particles once in a parallel with expanded multiplexation of acoustic field. That would empower the novel application(s) to make the realistic portrayal in human machine emphasis.

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