Perspectives in Communication, Embedded-Systems and Signal-Processing (PiCES)
ISSN: 2566-932X, Vol. 2, Issue 4, July 2018
Proceedings of National Conference on Emerging Trends in VLSI, Embedded and Networking (NC-EVEN 18), April 2018

Luciola: A Floating Light Weighing 16.2mg

Naziya Sultana[1], Neelofar Kandagal[2]

1. B.E UG Students, Department of ECE, Brindavan College of Engineering, Bangalore, naziyayarab97@gmail.com
2. B.E UG Students, Department of ECE, Brindavan College of Engineering, Bangalore, neelukandagal20@gmail.com

Abstract: In this paper, we present an approach to realize the levitation of a small object with an embedded electronic circuit. Luciola is a light-emitting particle with a diameter of 3.5mm and a weight of 16.2mg moving in mid air The novelty of this paper is the acoustically levitated electronic object by the combined application of ultrasonic levitation and wireless powering to the levitated electronic object. In the design of the custom IC chip, a new voltage detector circuit enabling an accurate voltage detection and a correct output during the start-up is proposed to achieve an intermittent lighting of the LED to increase the maximum distance between the transmitter and the receiver coil. Luciola is applied to a self-luminous pixel in a mid-air display and drawings of characters in mid-air are demonstrated.

Keywords: Millimeter-scale; levitation; ultrasound; wireless powering; IC chip

I. INTRODUCTION

In this paper, we propose a smart millimeter-scale particle levitated in the mid-air, which has internal electronics. In the particle scale, it has been hard to install active levitation mechanisms on the object due to their size, weight, and power consumption. Thus, external fields such as electric, magnetic, air-flow have been adopted to generate levitation force and control particles in mid-air.

Among others, acoustic levitation is one of the most promising ways to keep the objects suspended in the air. By using ultrasonic phased array speakers, the system enables two-dimensional or three-dimensional position control of levitated particles. This approach has an advantage with quick and precise movement control of particles. Our ultimate goal is making a swarm of smart levitated particles. Each tiny particle has abilities to change their appearances by sensing the surroundings. We propose luciola a Levitating particle consisting of the LED, the receiver coil for wireless powering, and a custom IC chip for the rectifier, the voltage regulator, and the intermittent lighting of the LED implemented in 180-nm CMOS process. The 3D position, as well as the ON/OFF timing of the LED, can be computationally controlled, making it possible to control the lighting of the LED depending on the position and the context.

This paper includes the following contributions:

1) An acoustically levitated electronic object is realized for the first time.
2) A new shape of the levitated object and a new placement of the receiver coil are proposed to simultaneously realize the acoustic levitation and the wireless powering.
3) In the custom IC chip, a new voltage detector circuit enabling an accurate voltage detection and a correct output during the start-up is proposed to achieve the intermittent lighting of the LED to increase the maximum distance between the transmitter and the receiver coil.

II. SURVEY

In this section, related past works of the levitated small objects and the wireless powering to small objects are reviewed.

A. Levitated small objects

Conventional approaches to lifting up objects and keep it suspended in the air use invisible external forces in the field. An electromagnetic suspension system is used to keep a spherical dipole magnet suspended. Thus the levitating object needs to be made of magnetic material. An ultrasonic field is used to levitate a millimeter-scale particle, because the spatial resolution of the ultrasonic levitation is high. Based on the holographic method, three dimensional mid-air displays using levitated particles.

B. Wireless powering to small objects

The wireless powering to small objects are mainly implanted in medical devices or RFID's .In for the implanted glucose monitoring, the total system including the receiver coil for the wireless powering is integrated on a 1.4mm ´ 1.4mm IC chip and the power is wirelessly supplied at 900MHz from a transmitter coil with the distance of 1cm. The received power is 6μW, which is too low to light the LED requiring 3.5mW in Luciola.

III. OVERVIEW

Two 40-kHz 17 ´ 17 ultrasonic transducer arrays are placed face-to-face at a distance of 20cm and the ultrasound generated from each transducer is focused to a focal point by tuning the phase of each transducer [9]. The focal point is the location where the acoustic levitation force is generated. Luciola floats in mid-air as a result of being trapped at the focal point. By moving the focal point in 3D space using a computer, Luciola moves in mid-air in a 10.4cm ´ 10.4cm ´ 5.4cm space. The transmitter coil with a diameter of 31mm for wireless powering is placed near the focal point and transmits the power to the receiver coil in Luciola. By synchronously controlling the focal point of the ultrasound and the ON/OFF timing of the switch of the

Conference held at Brindavan College of Engineering, Yelahanka, Bagalur Main Rd, Dwarka Nagar, Bengaluru - 560063

wireless powering using the PC Luciola displays 3-D images.

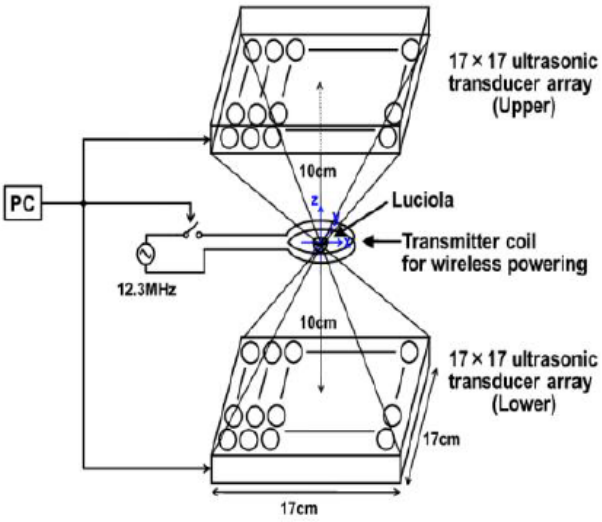


Fig 1. Details of Luciola

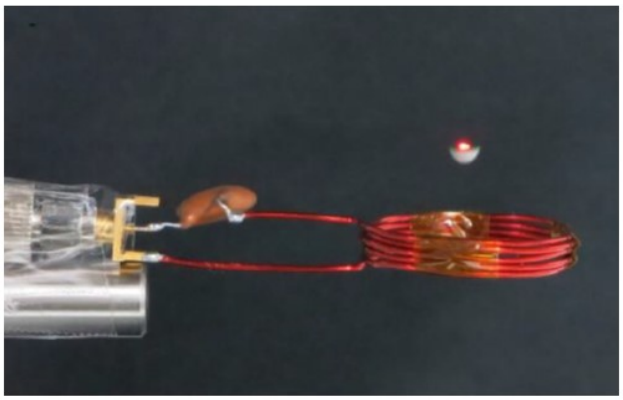


Fig 2. Luciola levitated by ultrasonic array and emitting light by wireless powering

IV. PROPOSED METHOD

Luciola a levitated light emitting particle in which a LED light is invented almost a size of 3.5mm.Using ultrasonic sound a light can float and using wireless power it can emit the light.

Luciola is a light emitting particle with a diameter of 4mm and a weight of 16.2mg moving in mid air .Any matter to be suspended freely in air we need an external force like electric, magnetic, airflow or acoustic. In this technology we use acoustic field with the help of ultrasonic sound wave a luciola particle is levitated. Wireless powering mostly exists in small objects like in medical devices and RFID's. Luciola is such a technology in which a levitated objects are given a wireless powering through which the led glows.

In luciola system two 17x17 ultrasonic transducer arrays are used to levitate the particle and are placed face to face at a distance of 20cm this transducer works on 40KHZ .This transducer generates a ultra sound and this sound is focused on focal point, by this focal point acoustic levitation force is generated this makes the luciola to float in mid air. Focal point can be moved accordingly through the pc by this luciola can also be moved in 3D.For wireless powering a transmitter of 31mm is placed around the focal point through which power can be transmitted to the receiver coil in luciola and led lights present in luciola can be switched on/off and can also be controlled.

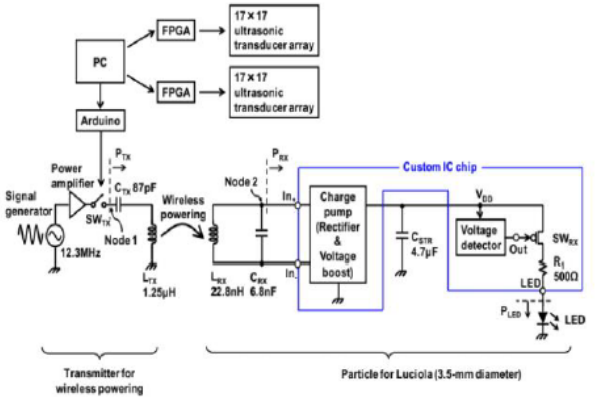


Fig 3. Block diagram of luciola system

Ultrasonic transducer consumes 134watts of total power. The coil used for transmitting wireless power is made of copper and works on frequency of 12.3MHZ.Luciola particle which is of 3.5mm in diameter consists of receiver coil, resonant capacitor, storage capacitor, led and custom IC chip through which it receives a transmitted power and makes the led glow, to glow the led 3.6milliwatt is required by this the distance between the transmitter and the receiver will be limited.

V. APPLICATION

- Luciola could fly to such objects to deliver a message.
- Help to make moving displays with multiple lights that can detect the presence of humans or participate in futuristics projection mapping events.
- Explores advances in information and communication technology.
- The developers expect luciola to find applications in the so called IOT, in which regular objects such as cars, or domestic appliances such as air conditioners are connected to networks to send and receive data.
- Tiny objects will have smart phone capabilities.
- It helps in long time exposure of image and in 3D positioning of image.

VI. LIMITATION

A limiting factor for the miniaturization is the receiver coil because the receiver coil is the largest in the particle and the heaviest in the electric components. Therefore, designing a smaller and lighter receiver coil is important.

Reducing the diameter of the receiver coil, however, will reduce the range of wireless powering.

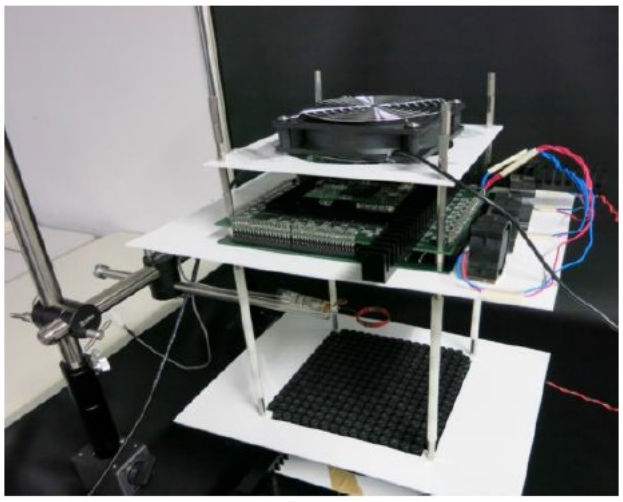
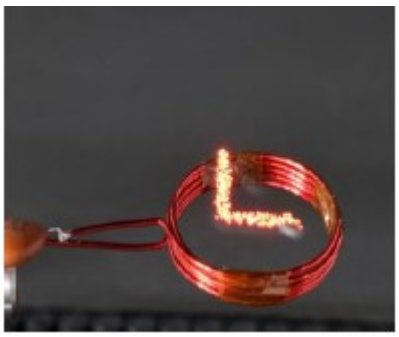
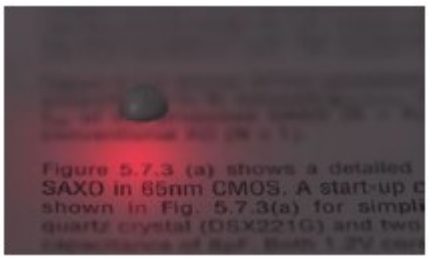


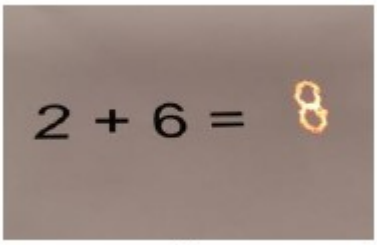
Fig 4. Setup



(a)



(b)



(c)

Fig 5. (b):levitating and moving light in mid air (c) long exposure photograph of drawing characters in 3D

VII. FUTURE SCOPE

In the next step luciola, will be to down scale the particles smaller and lighter to 2mm in diameter. Only one Luciola particle was in operation for demonstration on the stage. In the next step, however, it would be nicer if multiple Luciola particles can be independently operated on the stage.

VIII. CONCLUSION

Luciola is a millimeter scale light emitting particle moving in mid air based on acoustic levitation. Luciola is applied to aslef luminous pixel in a mid air display and drawing characters in a mid air is demonstrated.

ACKNOWLEDGMENT

This work is partially supported by JST ERATO Grant Number JPMJER1501, Japan.

REFERENCES

[1] Lee, J., Post, R., and Ishii, H. 2011. ZeroN: Mid-air tangible interaction enabled by computer controlled magnetic levitation. In Proceedings of the 24th annual ACM symposium on User interface software and technology (UIST '11). ACM, 327-336. DOI: https://doi.org/10.1145/2047196.2047239

[2] Yui, T. and Hashida, T. 2016. Floatio: Floating tangible user interface based on animacy perception. In Proceedings of the 29th Annual Symposium on User Interface Software and Technology (UIST '16). ACM, 43–45. DOI: https://doi.org/10.1145/2984751.2985699

[3] Ochiai, Y., Kumagai, K., Hoshi, T., Rekimoto, J., Hasegawa, S., and Hayasaki, Y. 2016. Fairy lights in femtoseconds: aerial and volumetric graphics rendered by focused femtosecond laser combined with computational holographic fields. ACM Transactions on Graphics, 35, 2 (May 2016), 1–14. DOI: https://doi.org/10.1145/2850414

[4] Ochiai, Y., Hoshi, T., and Rekimoto, J. 2014. Pixie dust: Graphics generated by levitated and animated objects in computational acoustic-potential field. ACM Transactions on Graphics, 33, 4 (July 2014), 85:1-85:13. DOI: https://doi.org/10.1145/2601097.2601118

[5] Whymark, R. R. 1975. Acoustic field positioning for containerless processing. Ultrasonics, 13, 6 (November 1975), 251-261. DOI: https://doi.org/10.1016/0041-624X(75)90072-4

[6] Foresti, D., Nabavi, M., Klingauf, M., Ferrari, A., and Poulikakos, D. 2013. Acoustophoretic contactless transport and handling of matter in air. Proceedings of the National Academy of Sciences, 110, 31 (July 2013), 12549-12554. DOI: https://doi.org/10.1073/pnas.1301860110

[7] Xie, W. J., Cao, C. D., Lv, Y. J., Hong, Z. Y., and Wei, B. 2006. Acoustic method for levitation of small living animals. Applied Physics Letters, 89, 21 (November 2006), 214102:1-214102:3. DOI: http://dx.doi.org/ 10.1063/1.2396893

[8] Kozuka, T., Yasui, K., Tuziuti, T., Towata, A., and Iida, Y. 2007. Noncontact acoustic manipulation in air. Japanese Journal of Applied Physics, 46, 7B (July 2007), 4948-4950. DOI: http://dx.doi.org/10.1143/JJAP.46.4948

[9] Hoshi, T., Takahashi, M., Iwamoto, T., and Shinoda, H. 2010. Noncontact tactile display based on radiation pressure of airborne ultrasound. IEEE Transactions on Haptics, 3, 3 (July 2010), 155-165. DOI: https://doi.org/10.1109/TOH.2010.4

[10] Ultrahaptics. Retrieved from https://www.ultrahaptics. com