WIRELESS POWER TRANSMISSION

USING MICROCONTROLLER CONTROLLED ACOUSTIC RESONANCE

Aditya Jain[1], Rahul Mehta[2], Shiv Wadhwa[3], Sumedh Vyas[4]

[1] *Scholar, Electrical and Electronics, Bharati Vidyapeeth's College of Engineering, New Delhi, India*
[2] *Scholar, Electrical and Electronics, Bharati Vidyapeeth's College of Engineering, New Delhi, India*
[3] *Scholar, Electrical and Electronics, Bharati Vidyapeeth's College of Engineering, New Delhi, India*
[4] *Scholar, Electrical and Electronics, Bharati Vidyapeeth's College of Engineering, New Delhi, India*

Abstract

Transmission and distribution losses of electric power in World was 8.31 percent of total power generation as of 2010. In India, average T & D (Transmission & Distribution) losses, have been officially indicated as 23 percent of the total electricity generated. However, as per random samples and studies, these losses have been estimated to be as high as 50 percent in some states[1]. A major part of these losses is contributed by energy dissipated in conductors used for transmission and distribution purposes. This paper presents an idea to transmit power wirelessly, which may prove to give another boost to electrical and electronics industry. We need to connect electronic devices to power supply using wires which increases the cost of devices and power losses and sometimes, the systems becomes a mess and irritating. Thus, wireless power transmission system may come out as the only solution to all the problems.

Key Words: *Wireless, Power transmission, Resonance, Piezoelectricity, Acoustic, Microcontroller*.

---***---

1. INTRODUCTION

Wireless Power Transmission (WPT) means transfer of electric power from a power source to a consuming device without use of any conducting material. WPT is a generic term used for all the techniques developed for the specified purpose[2]. The idea of wireless power transmission was first introduced by an electrical engineer, Nicola tesla in 1897[3]. Since then many new techniques have been developed namely inductive coupling, magnetodynamic coupling etc. to transmit power wirelessly over a wide range of distance. This paper puts forward the idea of acoustic resonance for WPT. Phenomenon of acoustic resonance can be observed in breaking of glass by the sound of an opera singer. WPT can be achieved by combining the properties of acoustic resonance and piezoelectricity. Resonance described above was by sound waves but for electric power transmission, this paper proposes use of ultrasound waves which are more energetic than the sound waves and are of higher frequency range.

1.1 Direct and converse piezoelectric effect

The word Piezoelectric is derived from the Greek word piezo, which means "push". Many single crystalline solids e.g. Quartz, Rochelle salt, Topaz, Tourmaline, Cane sugar, Berlinite ($AlPO_4$), Bone, Tendon, Silk, Enamel, Dentin, Barium Titanate ($BaTiO_3$), Lead Titanate ($PbTiO_3$), etc. are known to exhibit the property of piezoelectricity. Piezoelectric Effect is the ability of certain materials to obtain an electric charge in response to applied mechanical stress.

One of the unique characteristics of the piezoelectric effect is that it is reversible, meaning that materials exhibiting the direct piezoelectric effect (generation of electricity when stress is applied) also exhibit the converse (or inverse) piezoelectric effect (generation of stress when an electric field is applied)[4]. Although energy density of piezoelectric crystals is not as high as batteries, its durability, compactness and long shelf life make it useful for application where conventional power transmission methods are very difficult to apply.

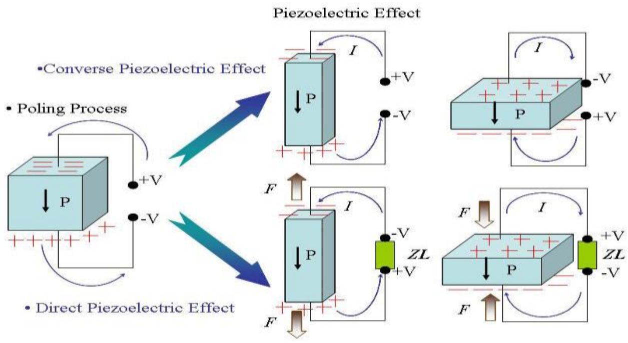

Fig. 1 – Direct and Inverse piezoelectric effect

One piezoelectric material, Rochelle salt, can be prepared at home in small quantities using Cream of tartar (Potassium bitartrate, $KHC_4H_4O_6$), baking soda (Sodium bicarbonate, $NaHCO_3$) and distilled water[5].

2. OPERATING PRINCIPLE

If a piezoelectric crystal is subjected to an alternating voltage (high frequency) then there will be successive attraction and repulsion between opposite parallel faces. If frequency of voltage applied matches with that of the natural frequency of the crystal, it starts vibrating vigorously and ultrasound waves of the same frequency as that of voltage supplied will be produced.

Another identical piezoelectric crystal (receiver) of same natural frequency as that of ultrasound is placed in vicinity of transmitter crystal then ultrasound waves will produce the same deformation in the receiver as that of transmitter due to duality of piezoelectricity and inverse piezoelectricity. Thus the electric field produced across the parallel faces of receiving crystal will be equal to that of first crystal resulting in electric power transfer.

2.1 Operational block diagram

Block diagram for the proposed work is given as follows.

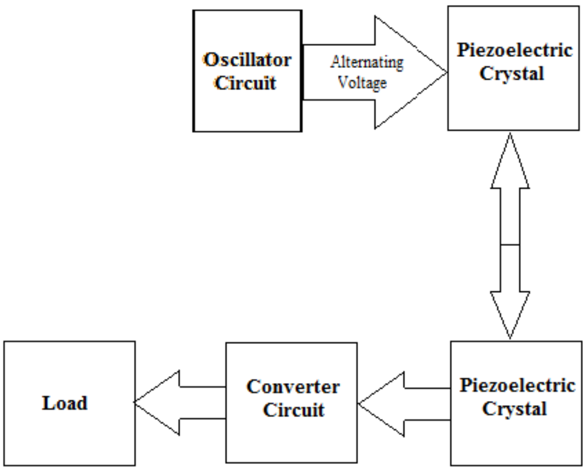

Fig. 2 – Block Diagram

2.2 Oscillator circuit

Every microcontroller needs a clock frequency for its operation. This clock can be used to produce alternating voltage from a constant dc voltage source. As the microcontroller operation is fast and efficient, very high frequency can be obtained for crystal efficiently.

2.3 Converter circuit

This circuit is used to convert high frequency ac voltage to dc voltage. The switch shown in fig. 3 can be coupled to the microcontroller so that the device gets the power only when it needs it. At other times, power can be stored in capacitor banks as shown[6].

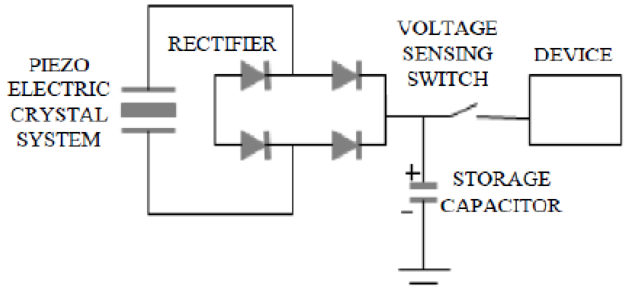

Fig. 3 – AC to DC converter circuit

3. OSCILLATOR CIRCUIT (USING MICROCONTROLLER)

To provide alternating voltage to the piezoelectric crystal, a microcontroller can be used in order to obtain desired frequency, voltage level with higher efficiency. A simple H-bridge can be used in order to obtain alternating voltage for crystal as shown in figure given below. Switching devices used in H-bridge can be MOSFETs or IGBTs, depending upon voltage and frequency of operation. Working of this model can be explained as further. One pin of microcontroller is connected to diametrically opposite switches and second pin to remaining pair of switches. Crystal is connected to the output of H-bridge.

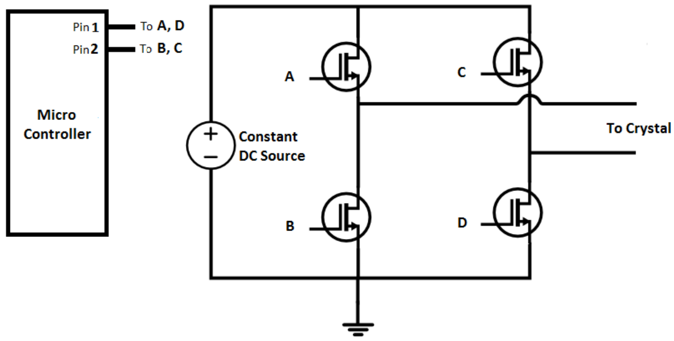

Fig. 4 - H-bridge circuitry

To obtain a two level output for crystal, pin 1 is set and reset alternatively with 50 percent duty cycle. Pin 2 is given complemented logic with respect to pin 1. Outputs at pin 1 and 2 are-

Pin 1 – 1010101010101010….

Pin 2 – 0101010101010101….

Switches A, D and B, C pairwise turns on and off alternatively and an alternating square wave is generated at oscillator output. A two level output is shown in fig. 5.

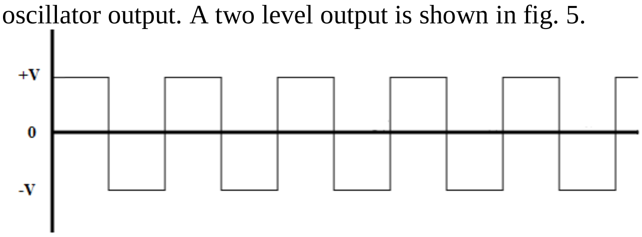

Fig. 5 – Alternating square wave (two level waveform)

Since the switching devices are practical (having switching and propagation delays) which may lead to short circuiting of dc voltage source. To avoid this, a three level output should be used.

In order to obtain a three level output, both pins 1 and 2 are kept at logic 0 before their transition to logic 1 i.e. if pin 1is at logic 1 then at its falling edge the dead time(both pins at logic 0) is started and continued uptill the rising edge of pin 2. Outputs at pin 1 and 2 are-

Pin 1 – 10001000100010001000….

Pin 2 – 00100010001000100010….

Thus, the order of conduction of all switches is as follows-
A, D conducts→ all in off state→B, C conducts→all in off state→A, D conducts. This generates an alternating quasi square wave at oscillator output. A three level output is shown in fig. 6.

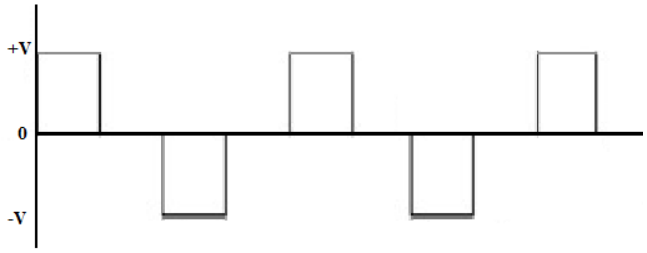

Fig. 6 –Alternating quasi square wave (three level waveform)

4. ATTENUATION OF ULTRASOUNDS IN DIFFERENT MEDIA

Attenuation of ultrasounds in any medium is calculated as follows

$$\text{Attenuation} = \alpha[\text{dB}/(\text{MHz} \cdot \text{cm})] \cdot \ell[\text{cm}] \cdot \text{f}[\text{MHz}]$$

Where α = attenuation coefficient
l = distance travelled
f = frequency

Attenuation coefficient can be calculated as

$$\alpha = \frac{0.1151}{v} U_t$$

Where **v** = velocity of wave in meters per second
$\mathbf{U_t}$ = decibels per second.

Attenuation coefficient of air is 1.64(20°C) and that of water is 0.0022[7].

5. CONCLUSION

Due to very low attenuation of ultrasounds in water, the above explained method can be implemented in underwater power transmission. The system can be useful to deliver power to low power appliances through a water pipeline. Since the piezoelectric crystals have long life, the whole system is durable. It is more cost effective as need of wires is eliminated. Further ultrasonic waves have no harmful effect on humans and also it doesn't interfere with communication lines. Also the main advantage of using a microcontroller for generating oscillations is that a wide range of frequency and voltage can be worked upon efficiently which is not possible in case of general analog oscillators. Also the power dissipation in microcontroller oscillator is much less than that in analog oscillators due to absence of any resistive element. In case for large dc voltage, power MOSFETs can be used. Since the microcontroller and switching devices (MOSFETs and IGBTs) have high speed of operation, the actual output waveform closely resembles the ideal waveforms as shown in fig. 5 and 6.

6. APPILCATIONS

- A piezoelectric power generator has great potential for some remote applications such as in vivo sensors, embedded MEMS devices, and distributed networking.
- RFID applications, radio-controlled models, fire, security and social alarms, vehicle radars, wireless microphones and earphones, traffic signs and signals (including control signals), remote garage door openers and car keys, barcode readers, motion detection, and many others.
- Devices such as wireless microphones and cameras, talking signs, baby monitors, cordless telephones, battery chargers etc, can also be powered wirelessly using piezoelectric generation of electricity.
- Also certain transducers can be made useful with the help of wireless transmission which will prove to be helpful in certain measurements.
- As the ultrasonic waves attenuate less in water, so the crystals can also be placed under water or in the water pipelines for better utilization of the ultrasonic wave energy.

ACKNOWLEDGEMENT

We would like to extend our gratitude towards our guide and mentor, Mr. Himanshu Kumar, Asst. professor, EEE dept., Bharati Vidyapeeth's College of Engineering and our friends and batchmates, Mr. Deekshant Bharti and Mr. Ashutosh Jindal for their support in completion of this project.

REFERENCES

[1]. http://www.teriin.org/upfiles/pub/papers/ft33.pdf
[2]. http://en.wikipedia.org/wiki/Wireless_power
[3]. http://www.teslasociety.com/tesla_tower.htm
[4]. http://www.nanomotion.com/piezo-ceramic-motor-technology/piezoelectric-effect/
[5].http://rimstar.org/materials/piezo/how_to_make_rochelle_salt_piezoelectric_crystal.htm
[6]. psrcentre.org/images/extraimages/49.%201011074.pdf
[7]. http://en.wikipedia.org/wiki/Attenuation

BIOGRAPHIES

Aditya Jain is UG Scholar, Electrical and Electronics Engineering, BVCOE, New Delhi-110063. E-mail- adityajn710@gmail.com

Rahul Mehta is UG Scholar, Electrical and Electronics Engineering, BVCOE, New Delhi-110063. E-mail- mehtarahul891@gmail.com

Shiv Wadhwa is UG Scholar, Electrical and Electronics Engineering, BVCOE, New Delhi-110063. E-mail- shivwadhwa364@gmail.com

Sumedh Vyas is UG Scholar, Electrical and Electronics Engineering, BVCOE, New Delhi-110063. E-mail- sumedhvyas1994@gmail.com