# Design of Ultrasonic MEMS Temperature Sensor

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## Introduction:

➢The attempt has taken to design a ultrasonic Micro Electronics Mechanical System (MEMS) of non-contact temperature sensor.

➢The piezoelectric material is used both transmitter & receiver ends for the miniature ultrasonic device.

➢In order to curb the expenses and save time, MEMS preferred to be done through a multidisciplinary simulation platform to test the feasibility of the proposed system.

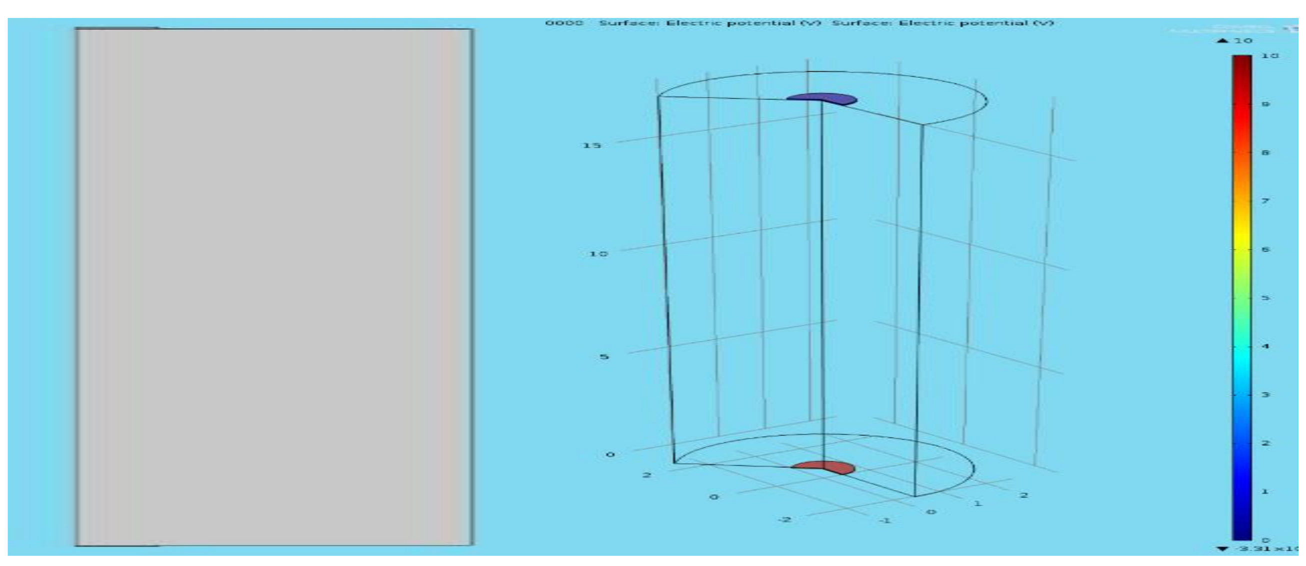

**Fig-1:** Asymmetrical Geometry of Ultrasonic Temperature Sensor

## Computational Method:

➢Speed of sound , Density of Air and Temperature of the Air co-related each other.

➢ They are defined as below

$$T = \left(\left[\frac{c}{c_0}\right]^2 - 1\right) * 273.15 \qquad T = \left[\frac{p}{\rho R} - 273.15\right]$$

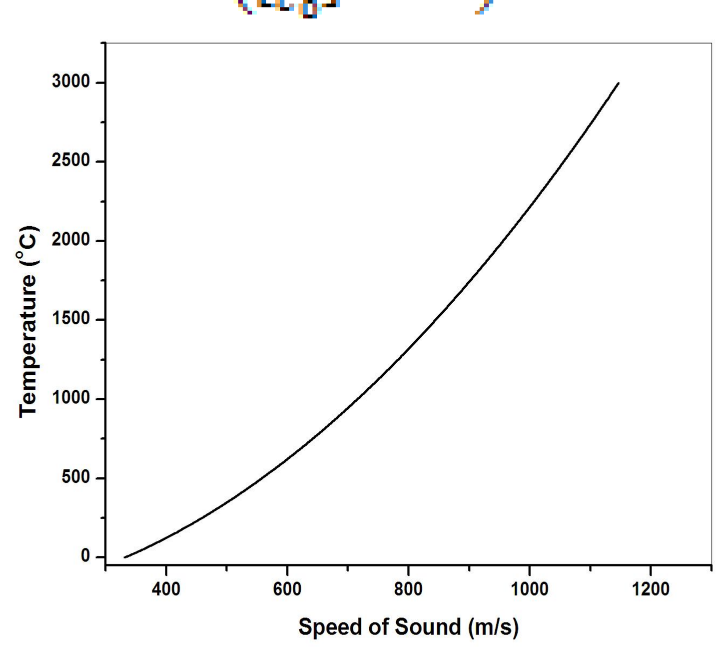


**Fig-1:** Speed of sound vs. Temperature

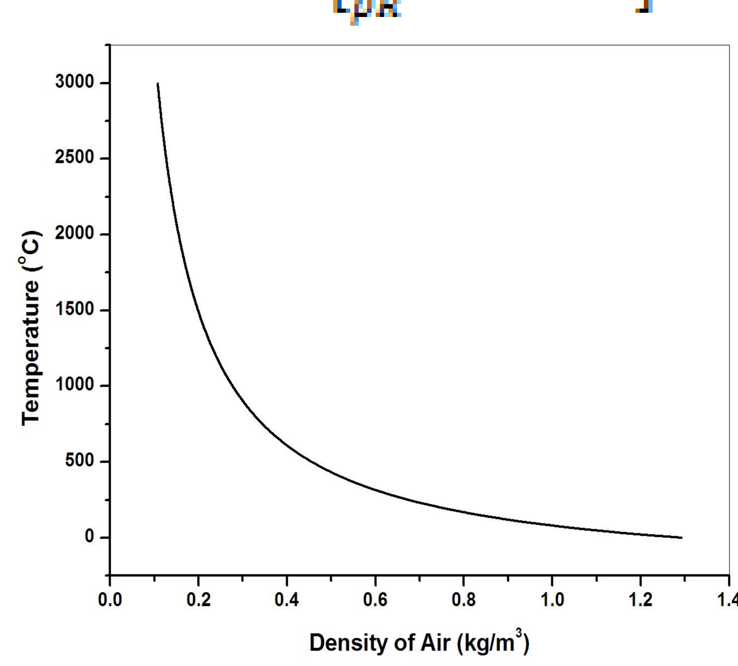


**Fig-3:** Air Density vs. Temperature

➢Speed of sound increases with increase in temperature.

➢Density of Air decreases with increases in temperature.

## Model Optimization:

**Transmitter & Receiver Thickness Optimization:**

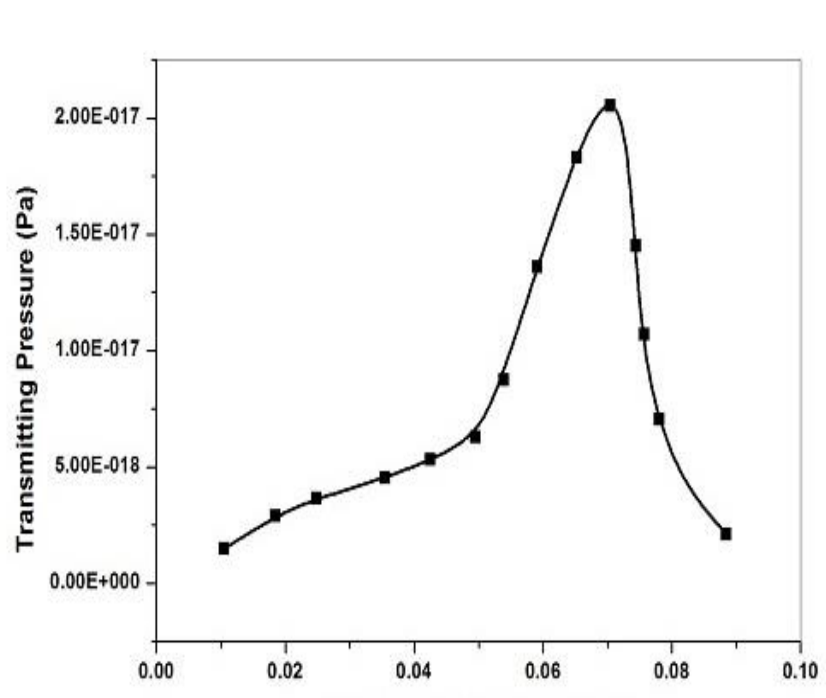


**Fig-5:** Transmitter Thickness Optimization

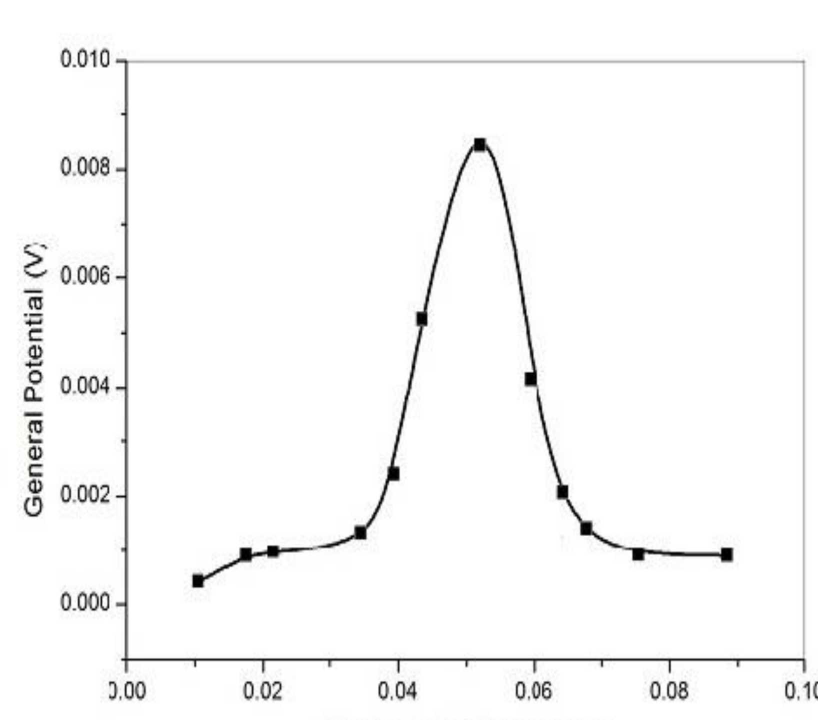


**Fig-6:** Receiver Thickness Optimization

➢The transmitter and the receiver is optimized for maximum transmitting pressure and for maximum generated voltage respectively at a constant width of 0.5475 cm the thickness of the transmitter and the receiver are varied from 0.01 cm to 0.0885 cm.

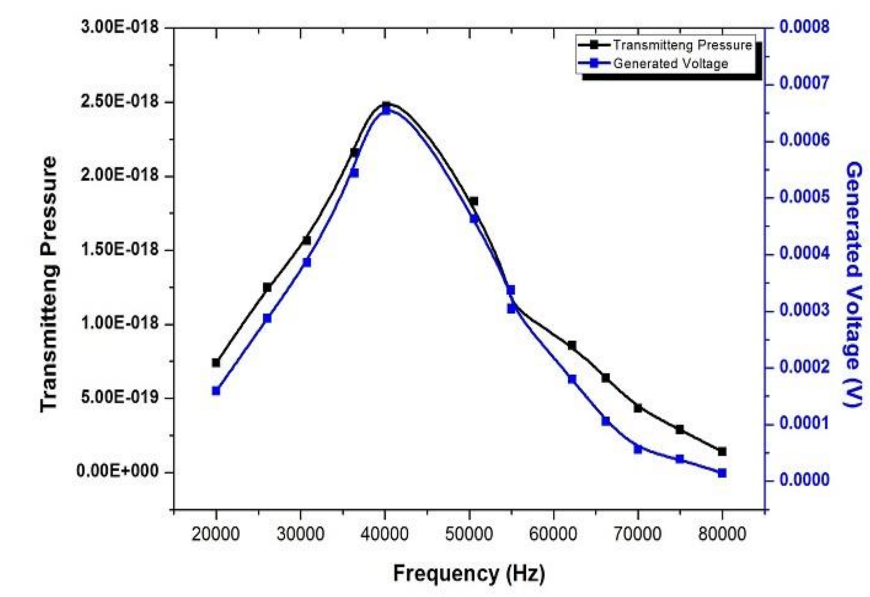


**Fig-4:** Frequency Optimization

➢The operating frequency of the transmitter is varied from 20 KHz to 80 KHz at a constant supplied voltage of 10 volts.

➢The optimum transmitting pressure and generated voltage is obtained at optimized frequency of 40 KHz.

## Result & Discussion:

➢The medium density and speed of sound is varied with changing temperature while keeping the shape and size intact.

➢When air density decreases, it results in less particles in the medium which shows in Fig-7.

➢Increasing temperature impacts the air density negatively which ultimately leads in decline of pressure received at the receiver.

➢Fig. 8 clearly shows that the receiving pressure is inversely proportional to temperature.

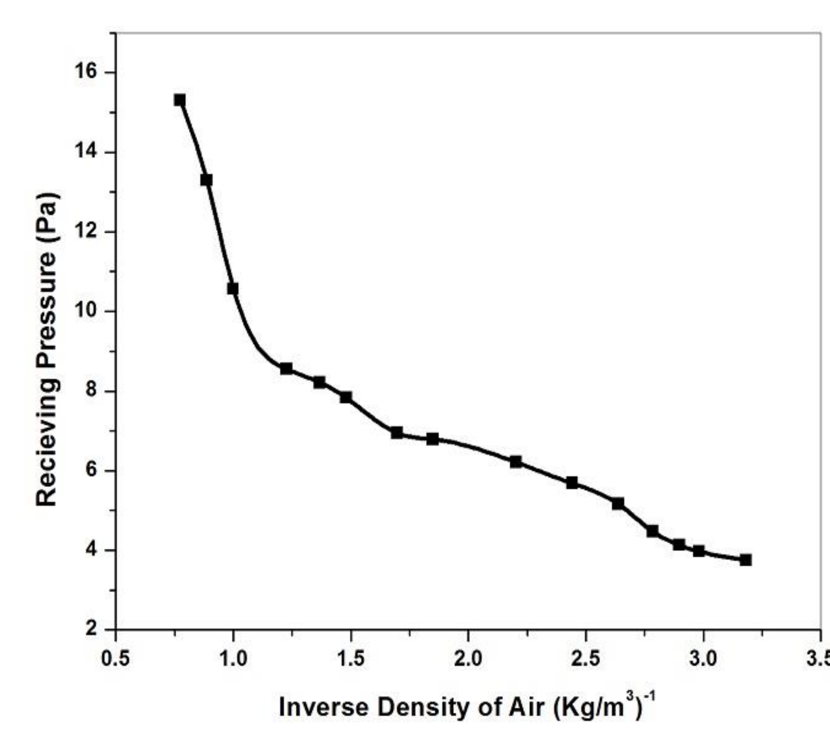


**Fig-7:** (Air Density)$^{-1}$ vs. Receiving Pressure

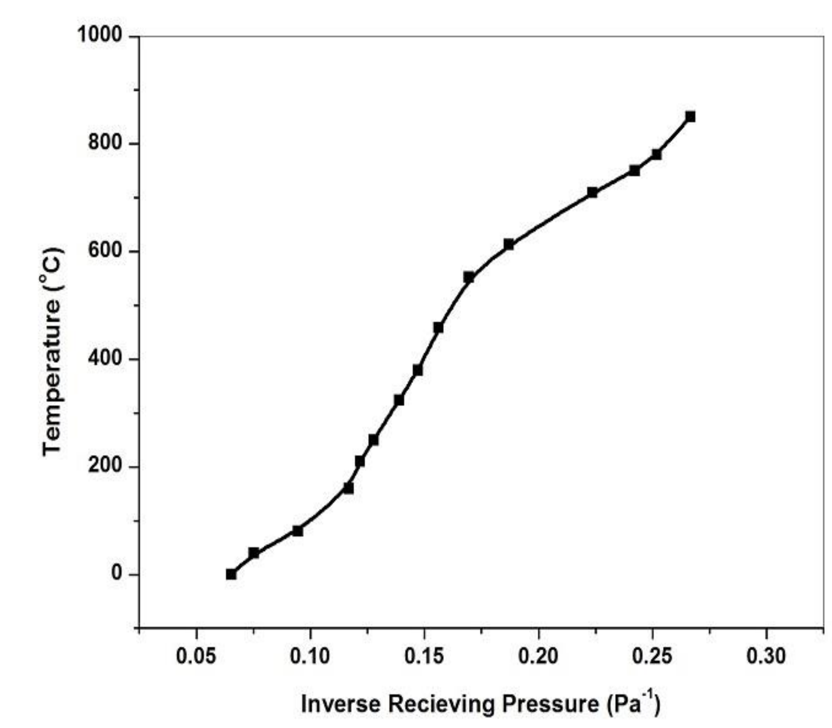


**Fig-8:**(Receiving Pressure)$^{-1}$ vs. Temperature

➢Generated potential is directly proportional to receiving pressure which is clearly indicated in graph in Fig. 9.

➢By comparing Fig. 7,8 &9, conclude that the generated voltage at the receiver end decreases as at the temperature rises.

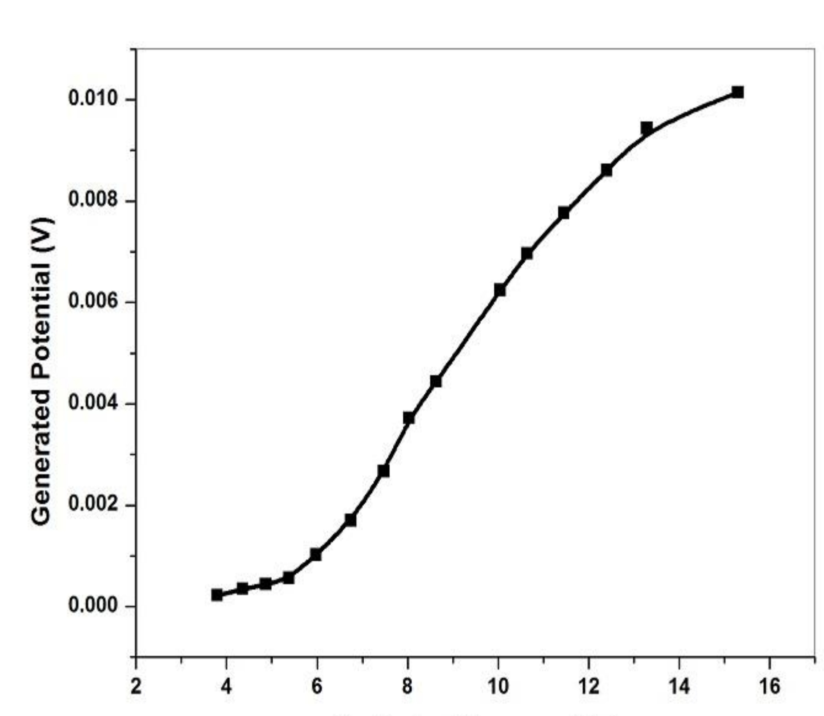


**Fig-9:**(Receiving Pressure)$^{-1}$ vs. Generated Voltage

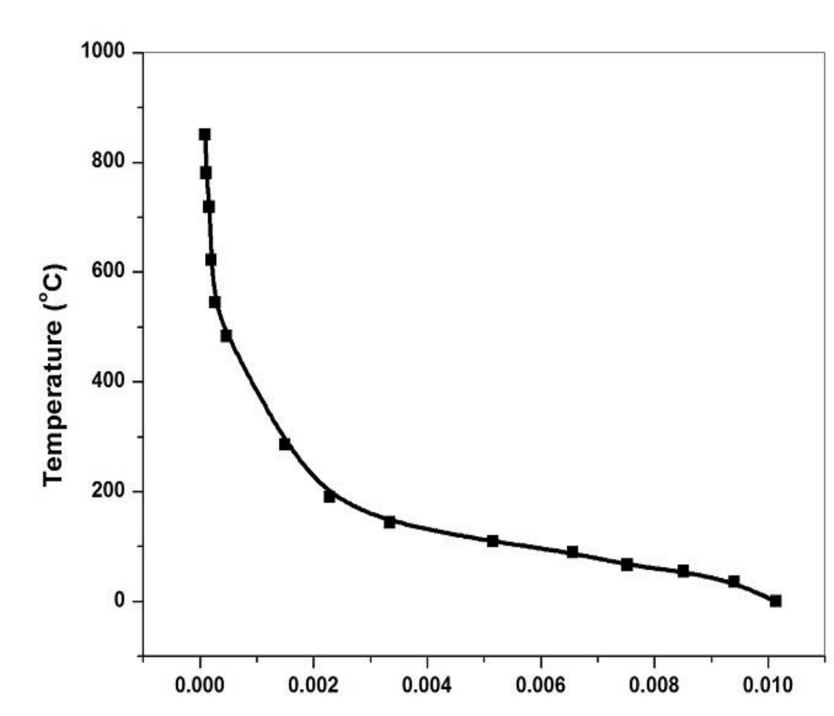


**Fig-10:** Generated Voltage vs. Temperature

## Conclusion:

➢Quartz is used to design this MEMS device, which squanders its piezoelectric property around 880 Deg. Celsius.

➢The temperature limitation is not exclusively related to the piezoelectric material's curie point and for successful design, all materials used in the construction of a device need to be consider.

➢For contactless sensing of very high temperature piezoelectric technology is highly efficient.

**References**:

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2. Li, Xin, Qin Liu, Shixin Pang, Kaixian Xu, Hui Tang, and Chensong Sun. "High-temperature piezoresistive pressure sensor based on implantation of oxygen into silicon wafer." Sensors and Actuators A: Physical, **no.179**, pp.277-282 (2012)

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