PIEZOELECTRIC PHOTOACOUSTIC SYSTEM FOR FLUID FLOW MONITORING

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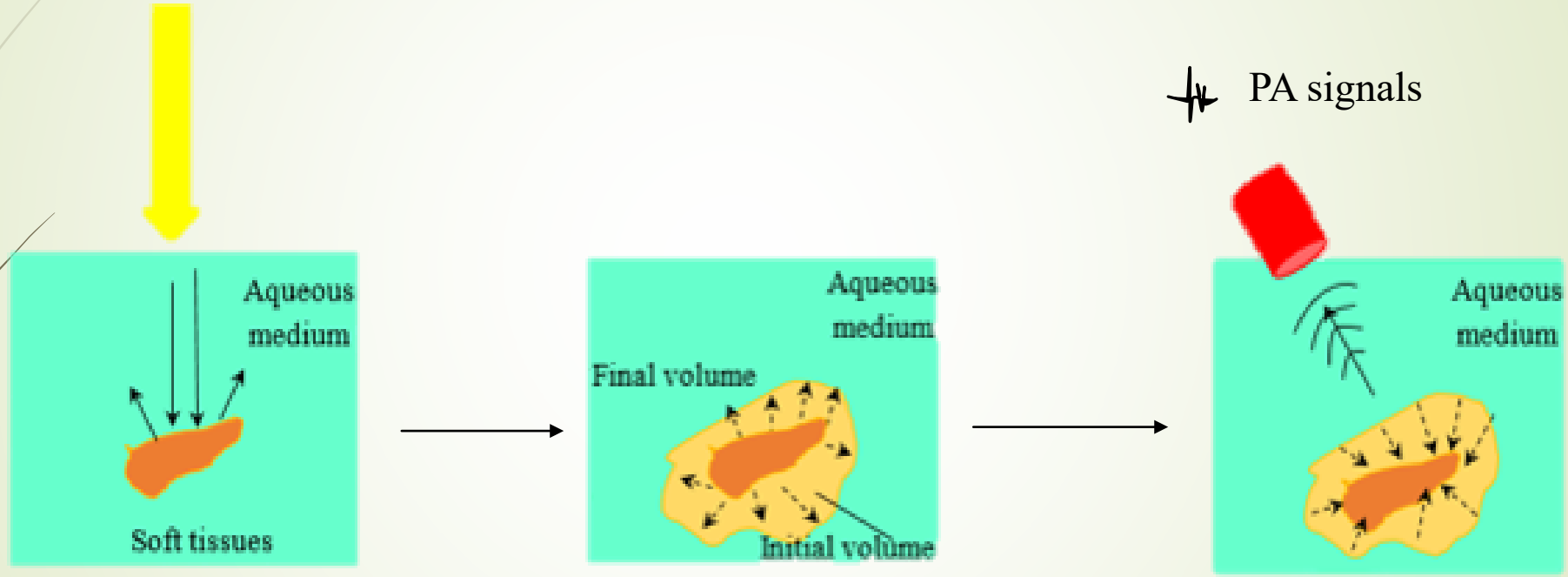
INTRODUCTION

- Flow measurement is a process of quantifying fluid movement.
- To date, fluid dynamics can be measured by using a variety of devices such as ultrasonic flowmeter, anemometer, positive-displacement flow meters and others
- Blood circulation is one of the most important flow measurement functions in a living organism's body to deliver blood carrying oxygen to the brain and other organs. It can also promote healthier skin and help with cell growth.
- Sound waves have been used extensively in the study of circulatory disorders.
- Imaging techniques: Magnetic Resonance Imaging (MRI), Doppler shift, Ultrasound, Photoacoustic (PA) Imaging

PHOTOACOUSTIC (PA) IMAGING

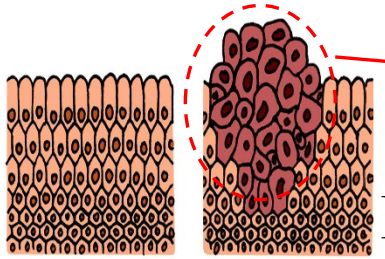


Optical absorption

Thermal expansion

Acoustic wave generation

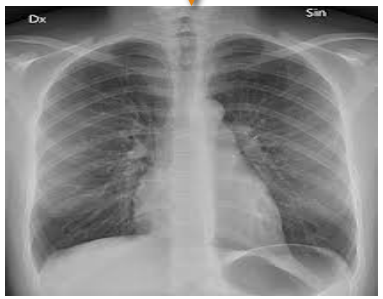
PROBLEM STATEMENT



Diseases cells

In-vivo imaging of soft tissues

Magnetic Resonance Imaging



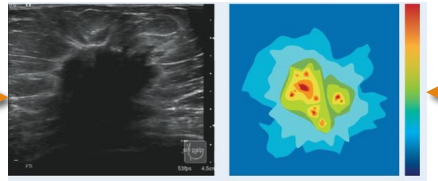
X-ray

- Bulky
- Non-portable
- Required dye to enhance visualization

Ultrasound Imaging

- Poor quality image result

Result of ultrasound

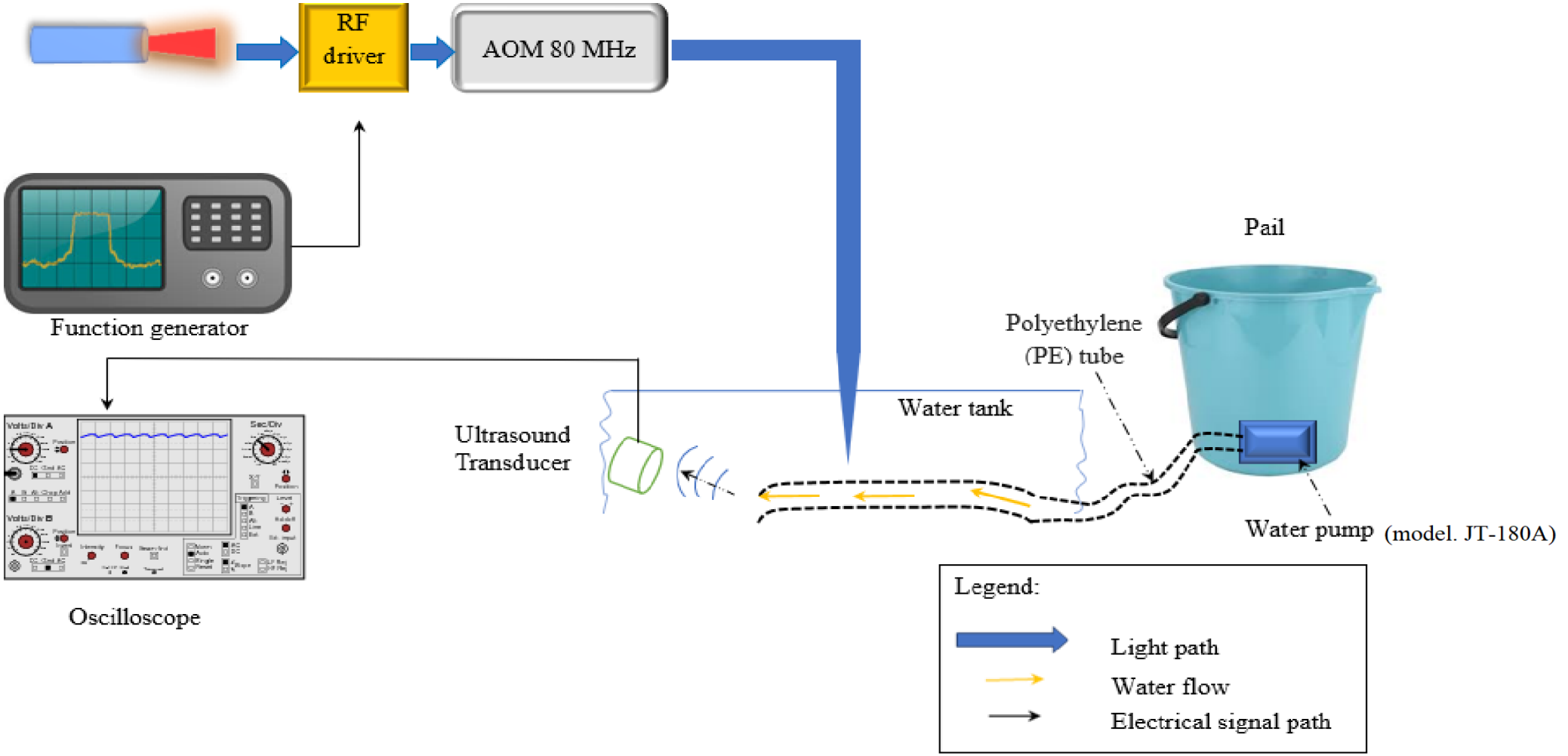


Current PA Imaging

- Bulky
- Tunable laser

Result of PA imaging

METHOD AND MATERIALS



ANALYTICAL TECHNIQUE

$$(\Psi_{re,}\ \Psi_{im}) = FFT\,(\psi(t))$$

$$\Phi = \tan\left(\frac{\Psi_{im}}{\Psi_{re}}\right)$$

$$\Delta\Phi = \Phi_{(y)} - \Phi_{(x)}$$

where

$\psi(t)$: acoustic wave in time domain

Ψ_{re} and Ψ_{im}: frequency domain signal

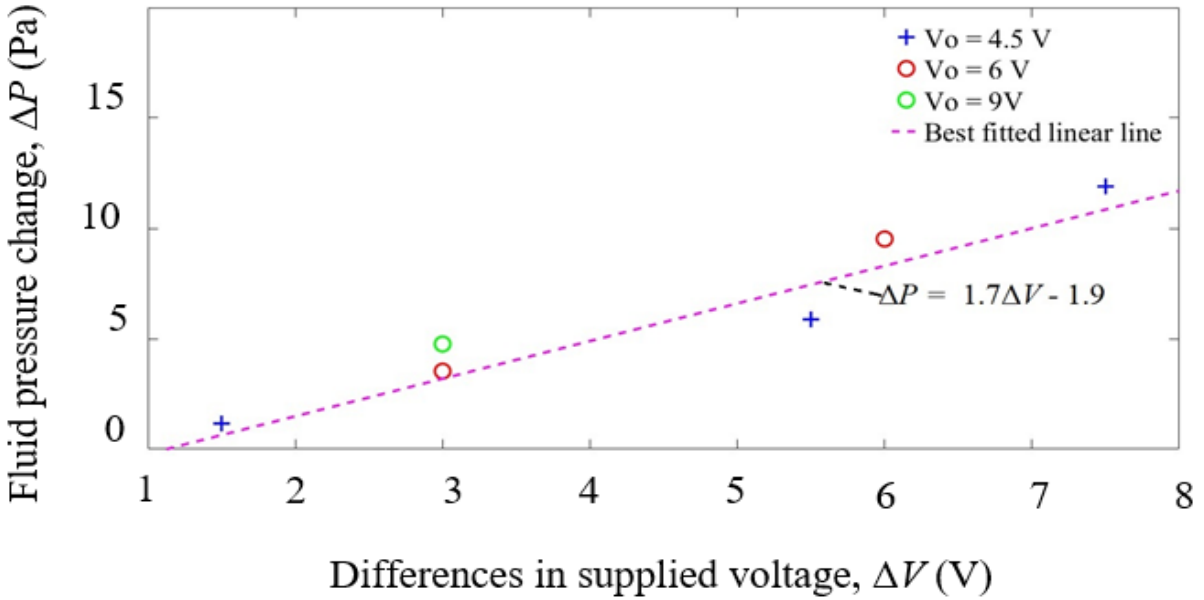
Φ : PA phase value

$\Delta\Phi$: PA phase difference

RESULT AND DISCUSSION

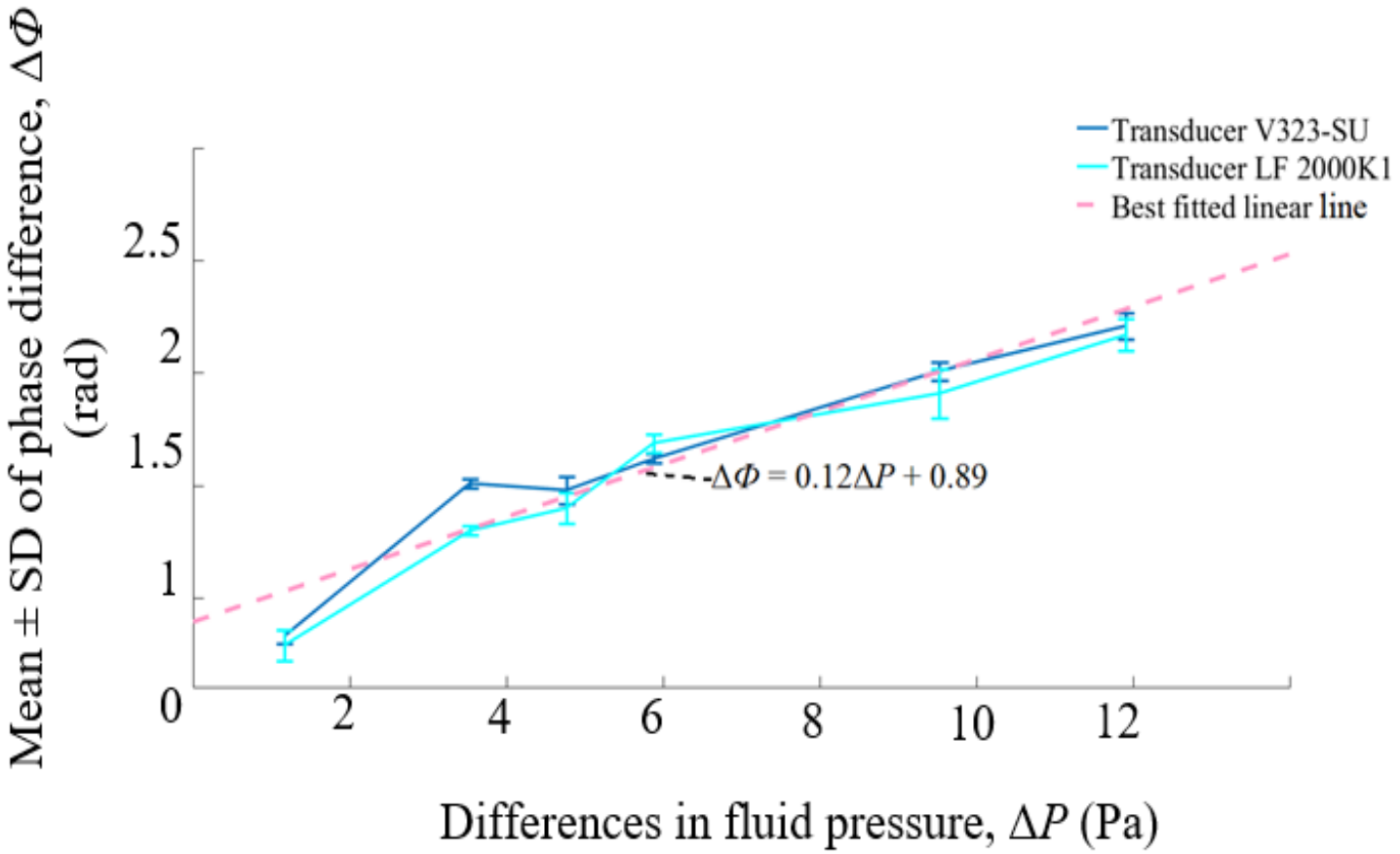
Table 1 - Changes in fluid pressure (ΔP) induced by different voltage supplied to phantom circulation system

Supplied voltage (V)		Difference in fluid pressure, ΔP (Pa)
V_1	V_2	
4.5	6	1.16
	9	5.88
	12	11.90
6	9	3.53
	12	9.52
9	12	4.76



This inconsistency may possibly be explained by the different shear rate produced by the applied voltage, supported by the fact that water is a Newtonian fluid, which viscosity is independent of shear rate.

An increase in voltage supply, and hence medium pressure, promotes higher shear rate and encourages fluid flow velocity



- An increasing trend of similar magnitude in the calculated phase change with fluid pressure difference detected by both systems.
- EPOCH system is able to focus spherically (spot) and cylindrically (line), this allows it to record a more concentrated PA signals as compared to the unfocused linear transducer used in the developed system.
- Low absolute difference in ΔP of 0.07 ± 0.01 Pa between these systems
- The linear change in phase difference with the fluid pressure agreed well with the principle of Doppler shift.

Thank you