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Ecometachip-Mini

A Low-Cost, Eco-Friendly Chemical Identifier Utilizing a Novel Coir-Rubber Dielectric Sensor

Abstract

This paper presents the Eco-MetaChip Mini, a novel, low-cost, and eco-friendly system for the preliminary identification of common liquids based on changes in their relative permittivity (ϵr) using a novel rubber coir material.

Authors : Abhiram B, Aaromal A, Devanarayanan CR, Ivana Anto

Affiliation : School of Engineering, CUSAT (Kerala, India)

The problem

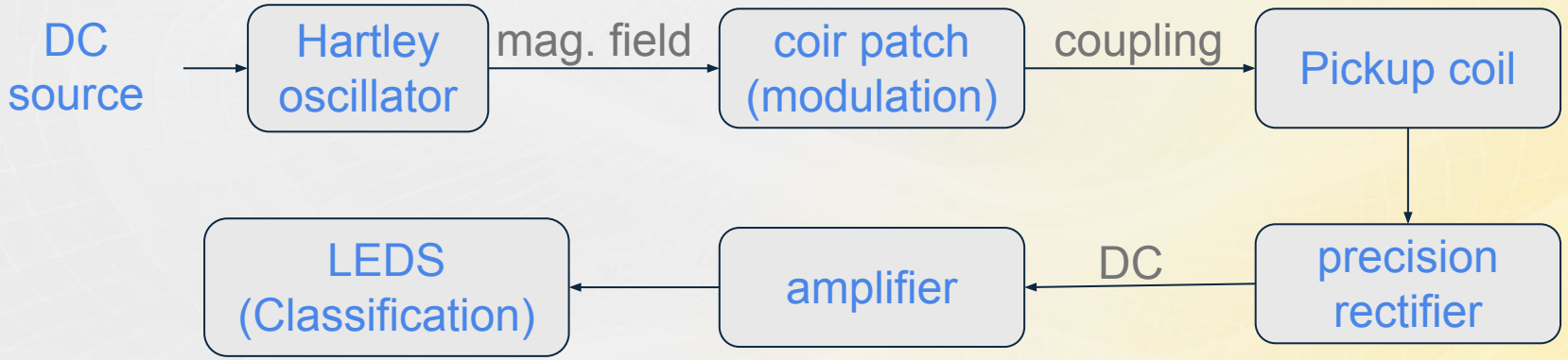
Benchtop FT-IR Spectrometers (current)

Need for low-cost, biodegradable sensing for field analysis

Materials Required

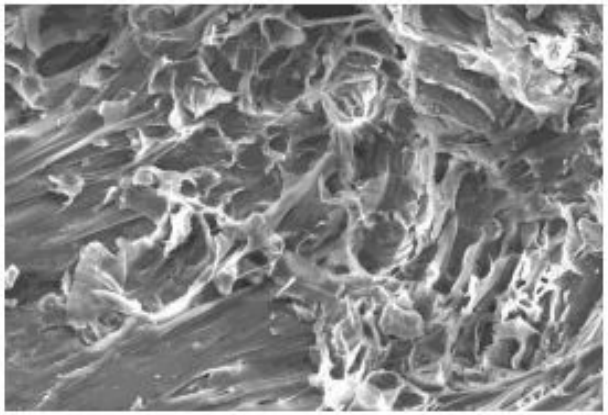
	Component	Specification	Quantity
1	Coir-Rubber substrate	30mm x 30mm (2mm thickness)	1
2	Copper Coils	Hand-wound (10u, 10u, 1m)	2
3	NPN Transistor	2N3904	2
4	Schottky Diode	1N5711	2
5	Capacitors	100p, 10u, 100n, 1n, 100u	
6	Resistors	47k, 10k (2), 1k, 100 (5), 100k(2)	
7	Breadboard	Standard 830-point	1
8	Battery/Power Source	8V	2
9	RGB LEDs w/ resistors	1k	3

System Architecture

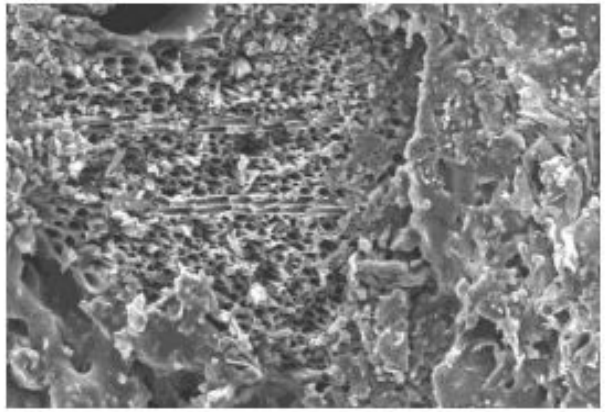


100 MHz Hartley Oscillator coupled with dielectric resonator

The Novel Material (Sensing Element)



(a)



(b)

Scanning electron microscopy of (a) CoR and (b) CoRC.

Coir-Rubber Composite: Porous matrix allows liquid integration

Methodology/Physics (Dielectric Loading)

$$f_o \propto 1/\sqrt{LC}$$

Liquid permittivity alters capacitance, modulating magnetic field amplitude

Addressing Signal Loss

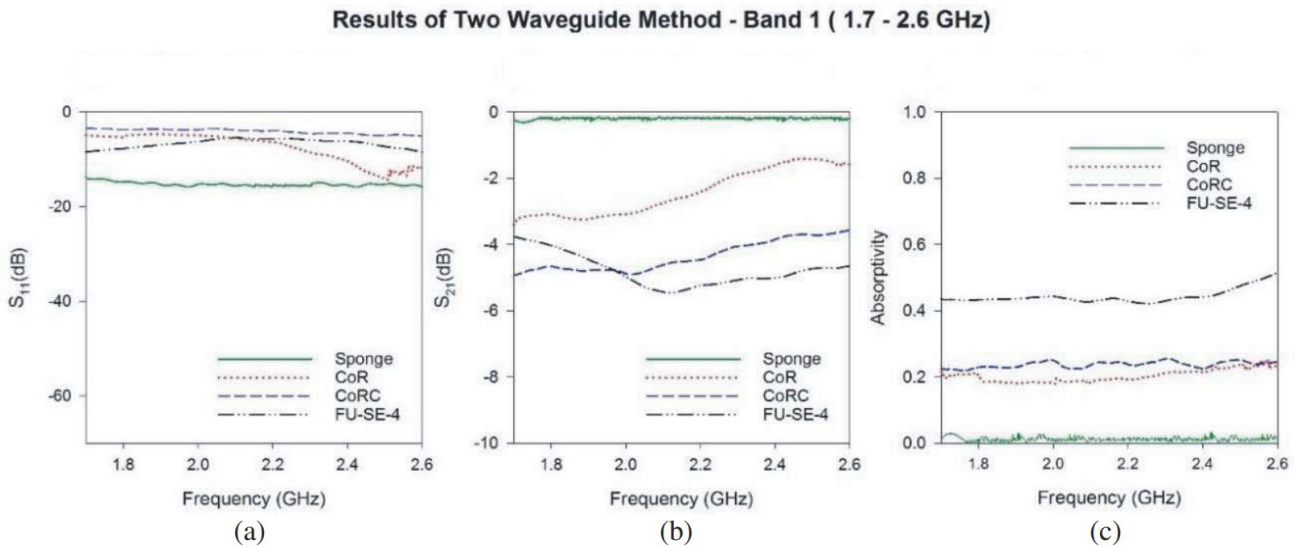
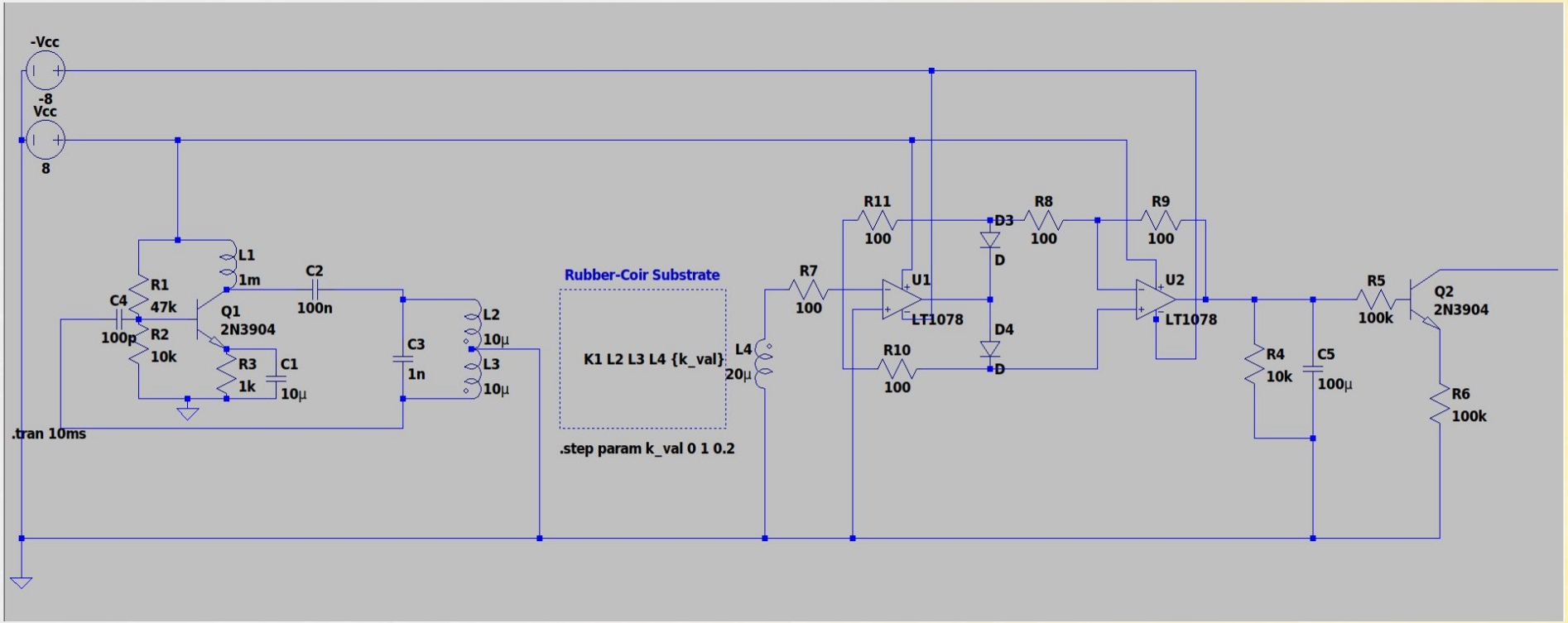


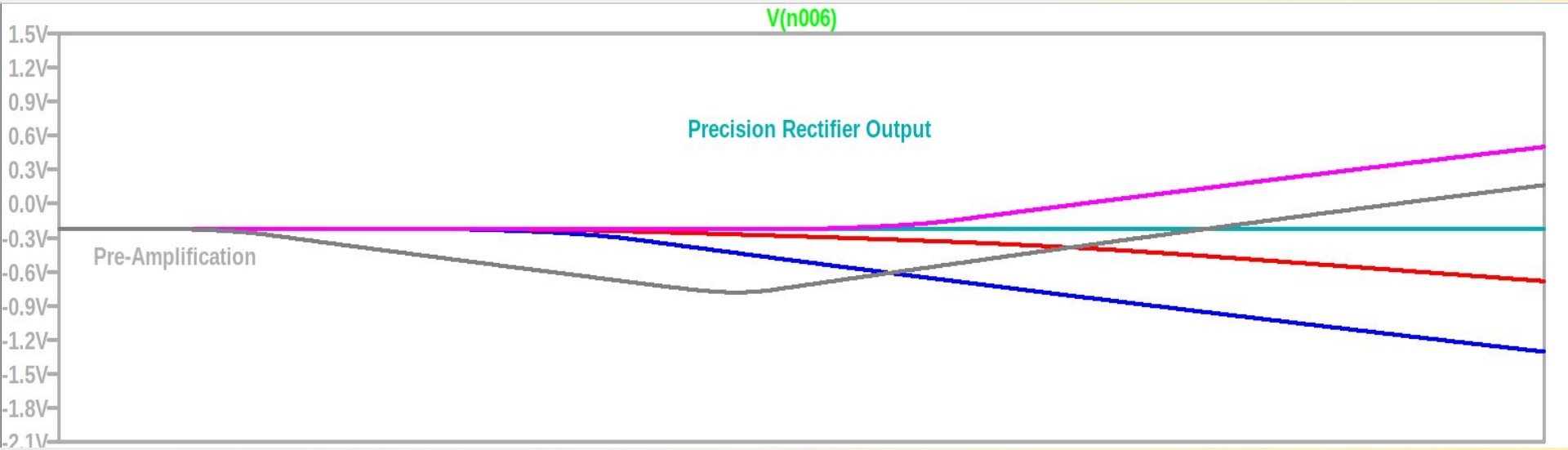
Figure 6. (a) Reflection, (b) transmission and (c) absorption Characteristics of absorbers with thickness = 6 mm.

Carbon content optimized for coupling, not just absorption (εr of rubber-coir substrate with liquid ∝ coupling factor)

Circuit Implementation



Simulation Results (Coupling)



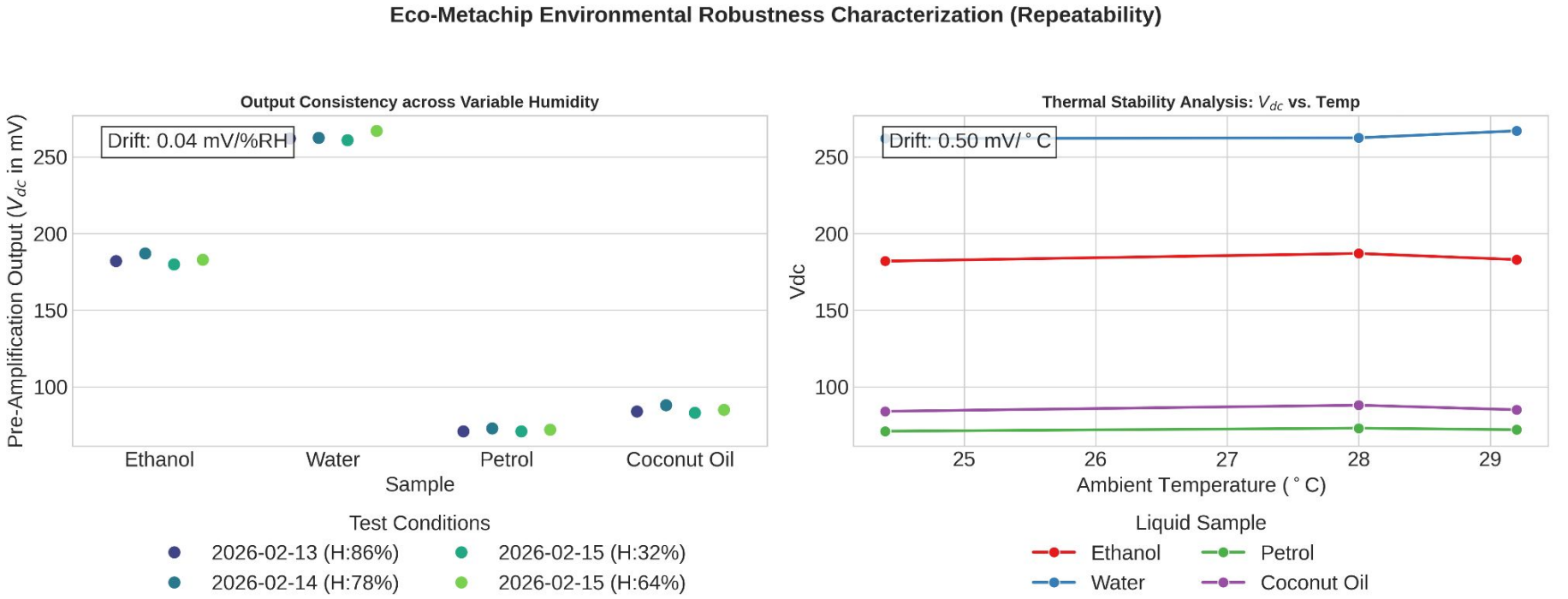
For increasing k_values btw coils 0, 0.2, 0.4, 0.6 (εr of rubber-coir substrate with liquid ∝ coupling factor k)

Experimental Observations

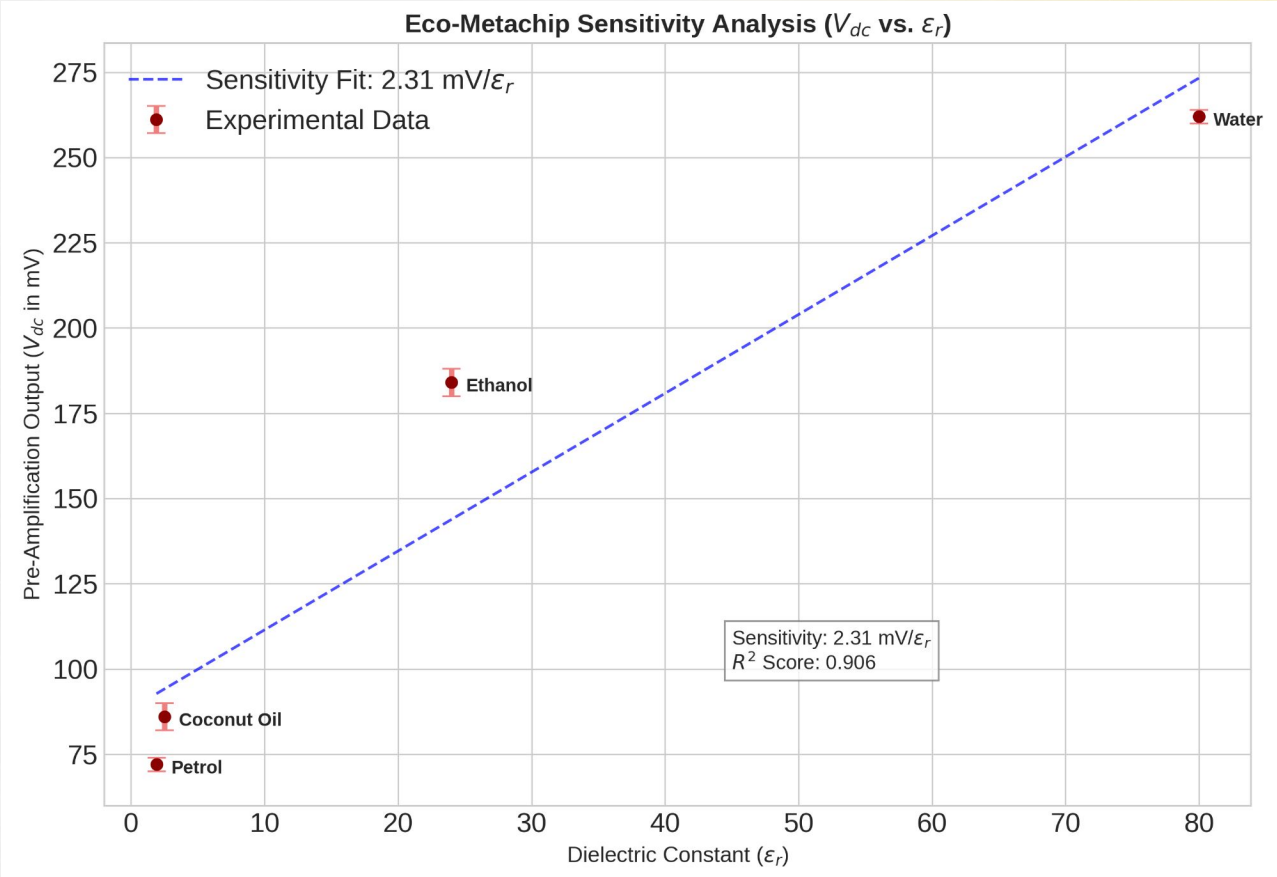
	Sample	Dielectric_Constant	Meav_Vdc(mV)	Min_Vdc(mV)	Max_Vdc(mV)
1	Water	80	262	260	264
2	Ethanol	24	184	180	188
3	Coconut Oil	2.5	86	82	90
4	Petrol	1.9	72	70	74

Higher permittivity liquids generate significantly higher output voltages.

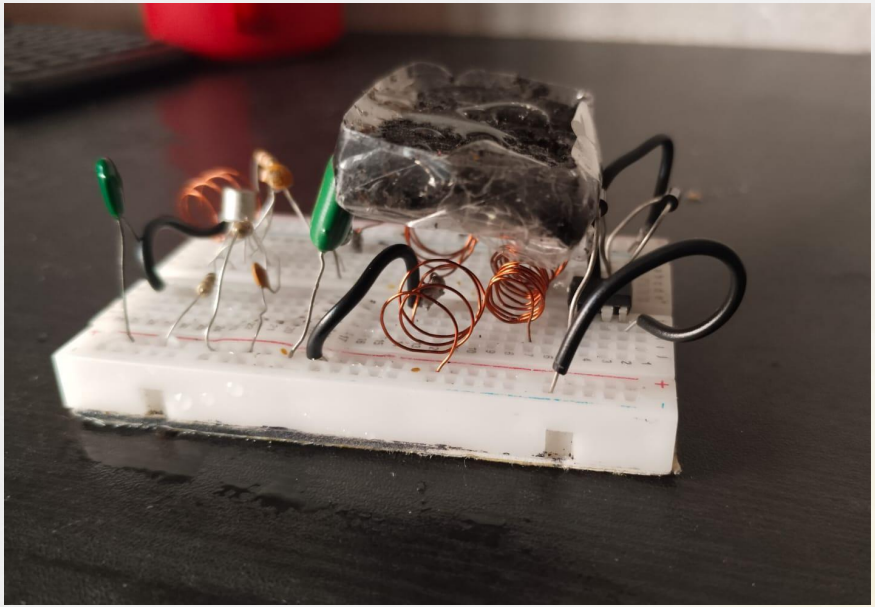
Repeatability



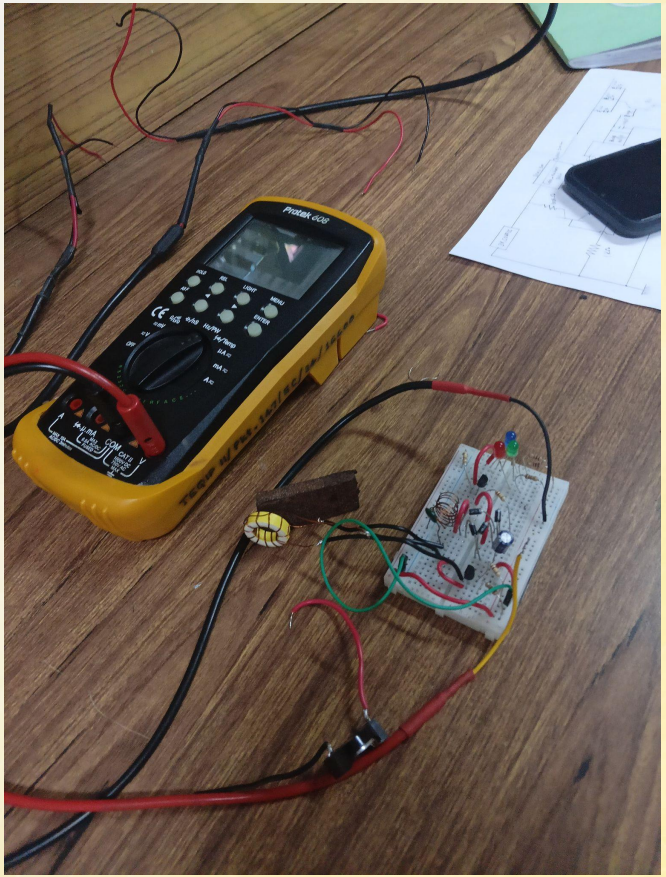
Sensitivity



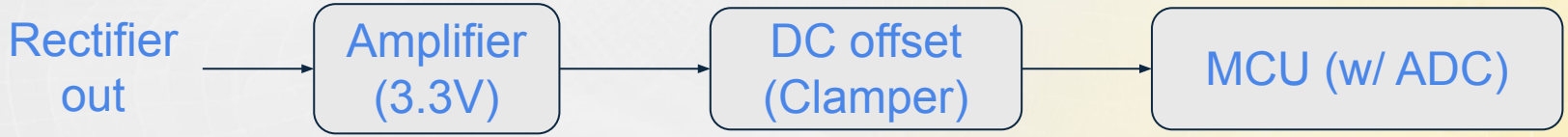
Exp-Setup & Visual Classification



$$V_{\mathrm{DC}} \propto \Delta\epsilon_r \propto \text{Number of Illuminated LEDs}$$



Future : MCU intg. & Digital classification



Op-amp and MCU bridge digitizes analog output for quantitative chemical classification of liquid permittivity.

Conclusion & References

Eco-friendly, low-power solution for real-time liquid analysis

Reference research thesis :

Design and Development of Radio Wave Absorber Using Eco-Friendly Materials

Odampilly R. Manohar[1, *], Anju Pradeep[1], and Pezholil Mohanan[2]