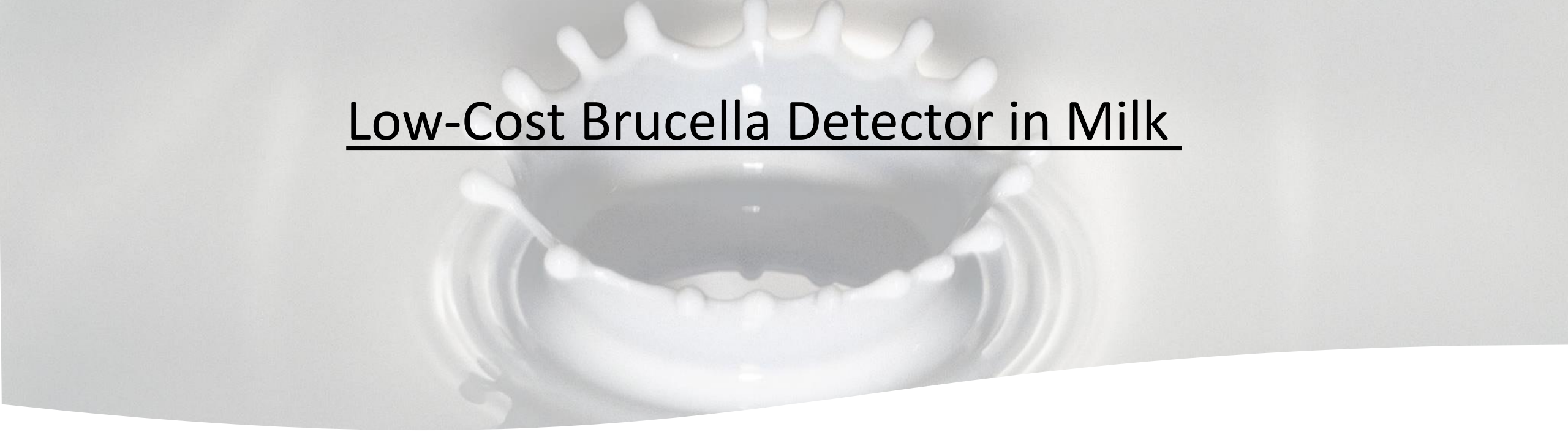

# Low-Cost Brucella Detector in Milk

## Methodology and Preliminary Results

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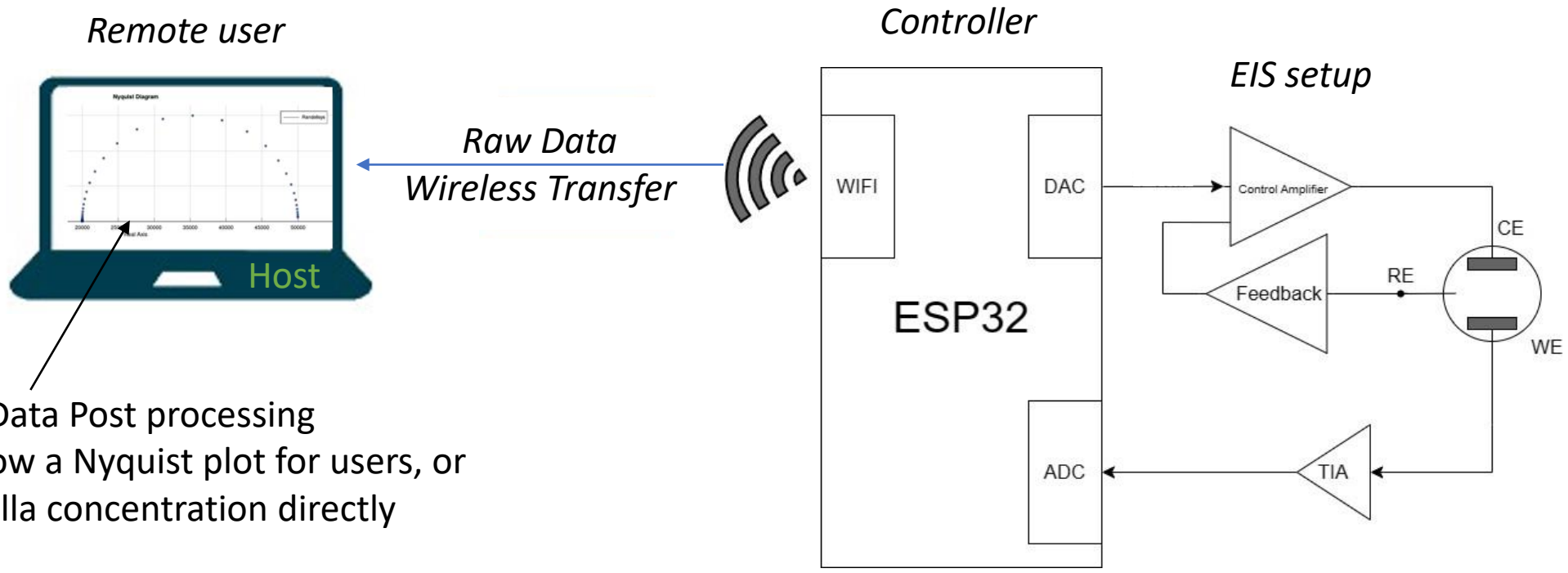
Progress Report # 3, Dec 10th, 2023

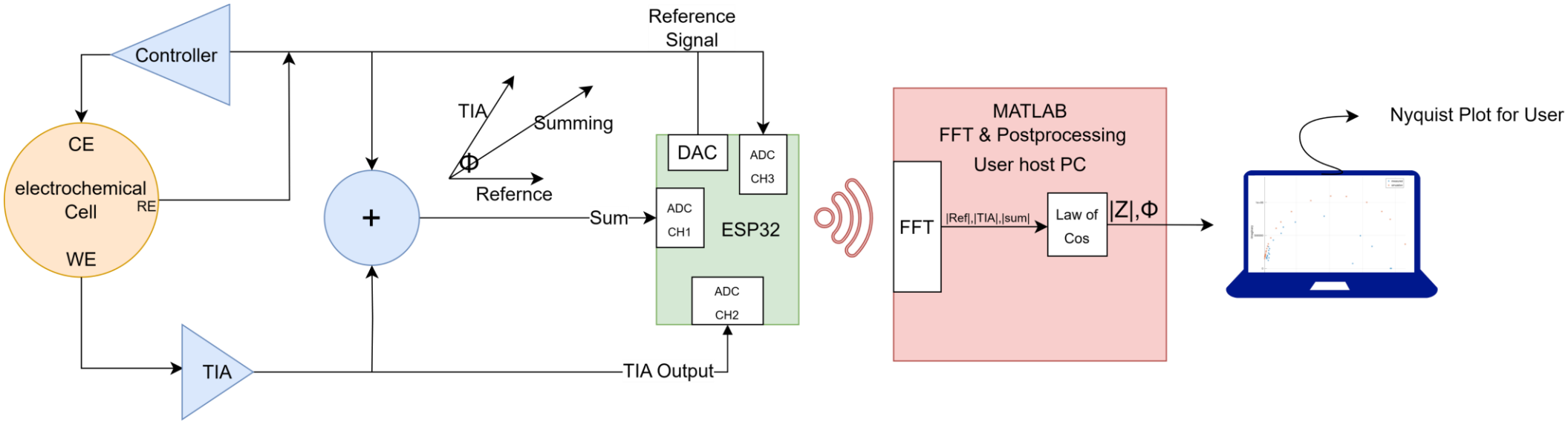
# Low-Cost Sensing Solution using Electrochemical Impedance Spectroscopy (EIS)

The proposed solution consists of:

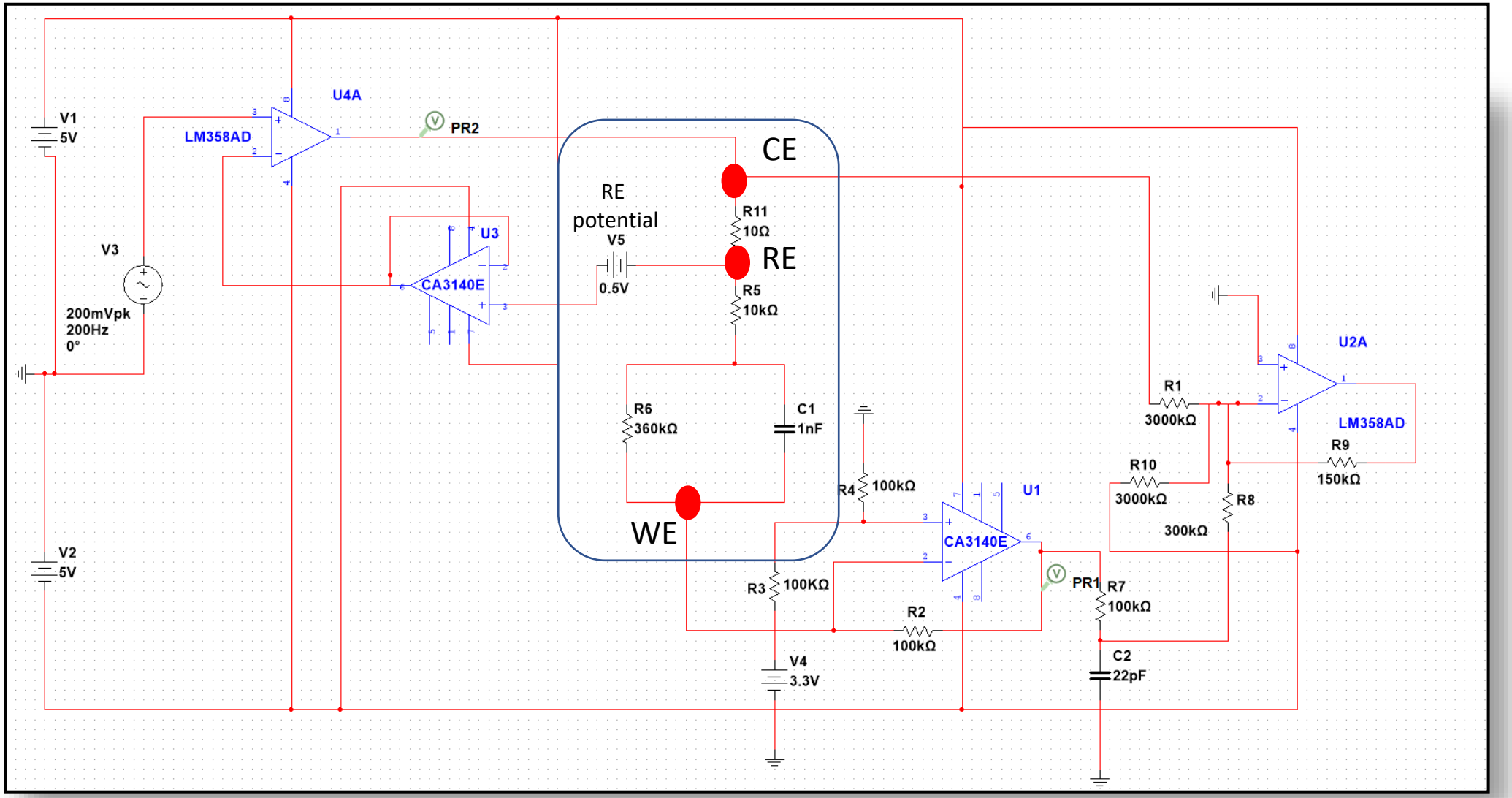
- Low cost potentiostat built from on the shelf components (COTS)
- ESP32 for signal generation and  data acquisition (I/O)
- Postprocessing MATLAB code



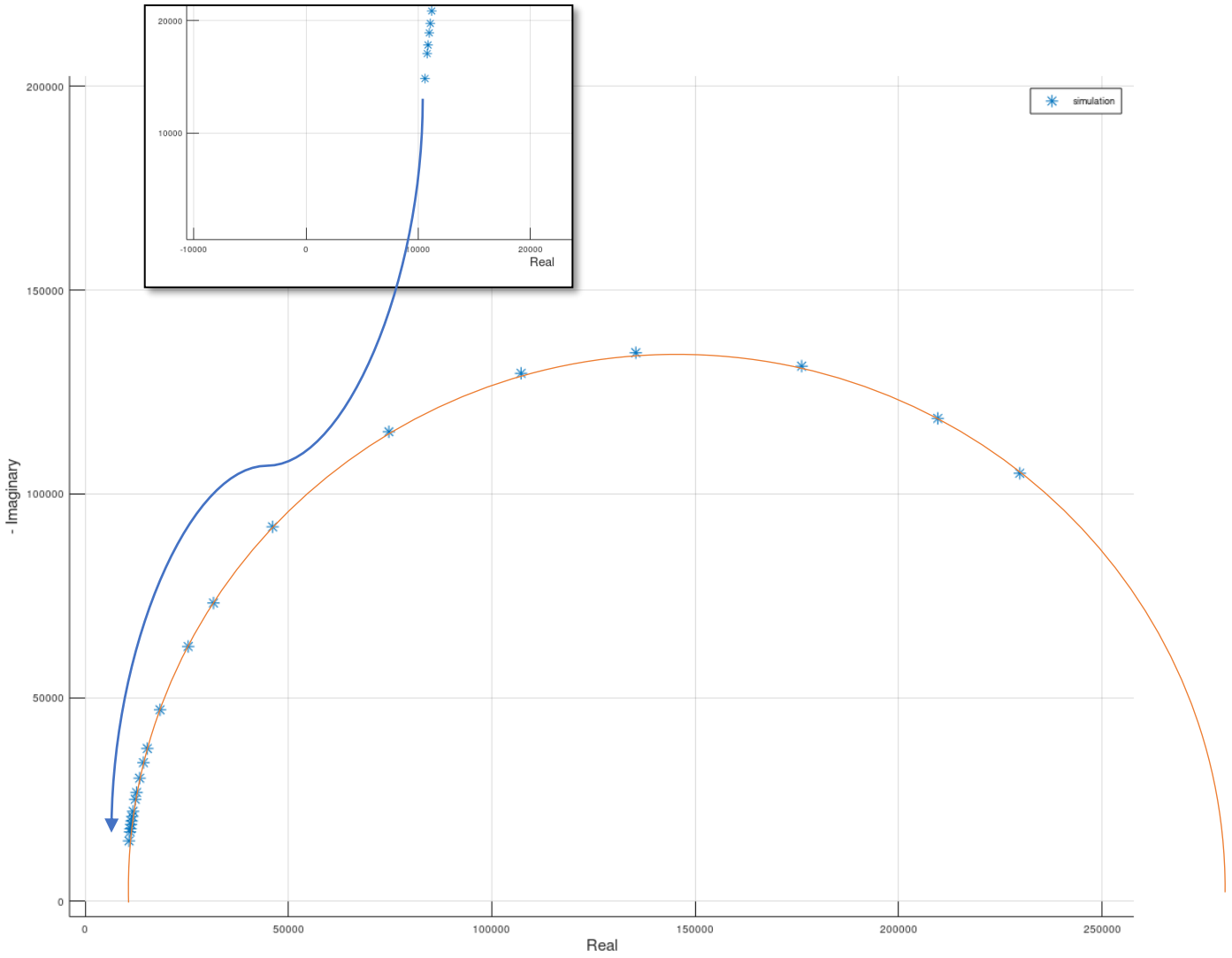
# Platform’s Functional Block Diagram



# EIS with 3-Electrode Sensor Equivalent Circuit for Testing



# Preliminary Simulation Results (Nyquist Plot)



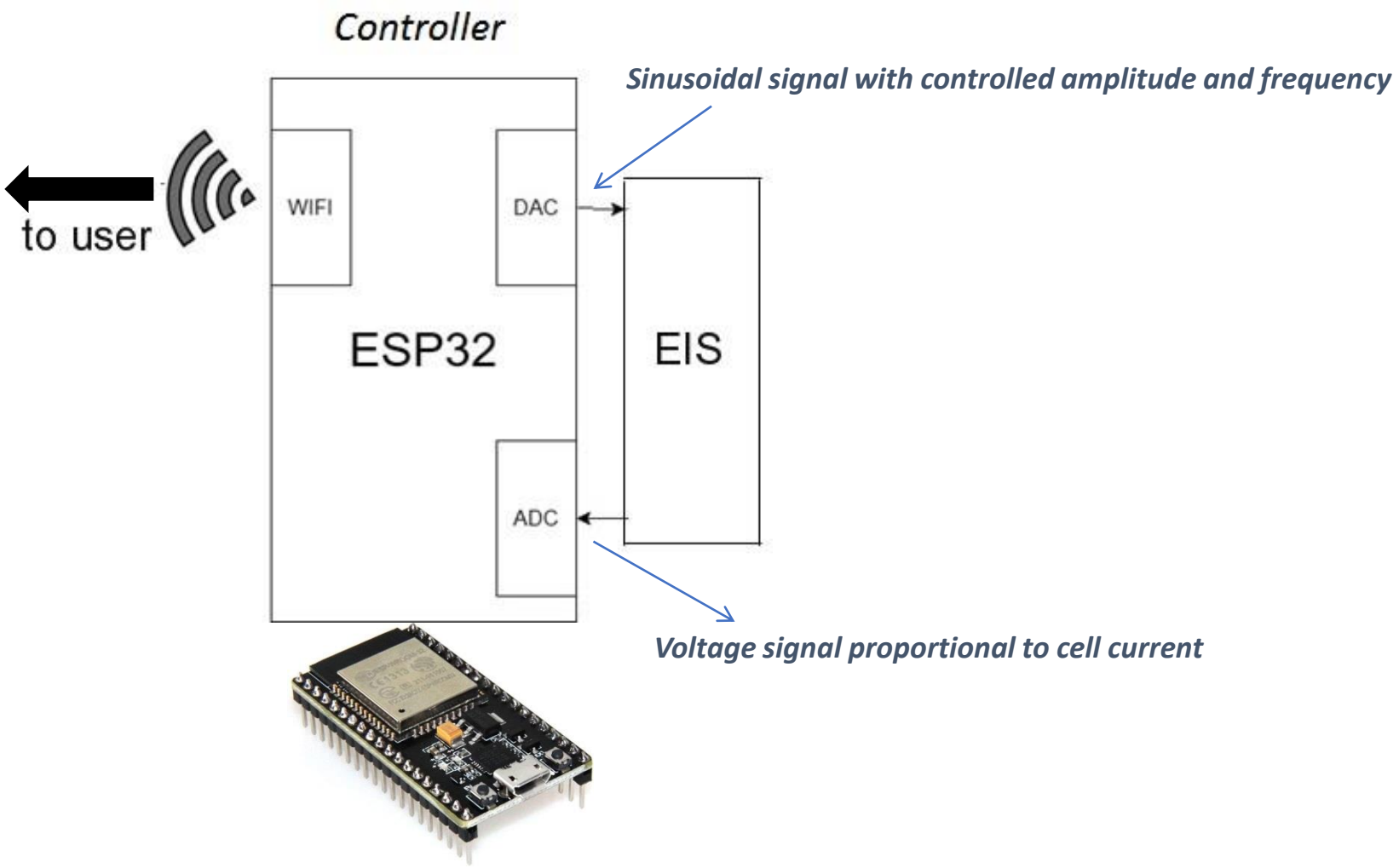

This simulation was done using:
Rp = 270K $\pm$ 10% $\Omega$
Rs = 10k $\pm$ 10% $\Omega$
Cd = 1nF

ESP32 EIS sweep from 100Hz to 10KHz

Input amplitude: 200mV

# ESP32

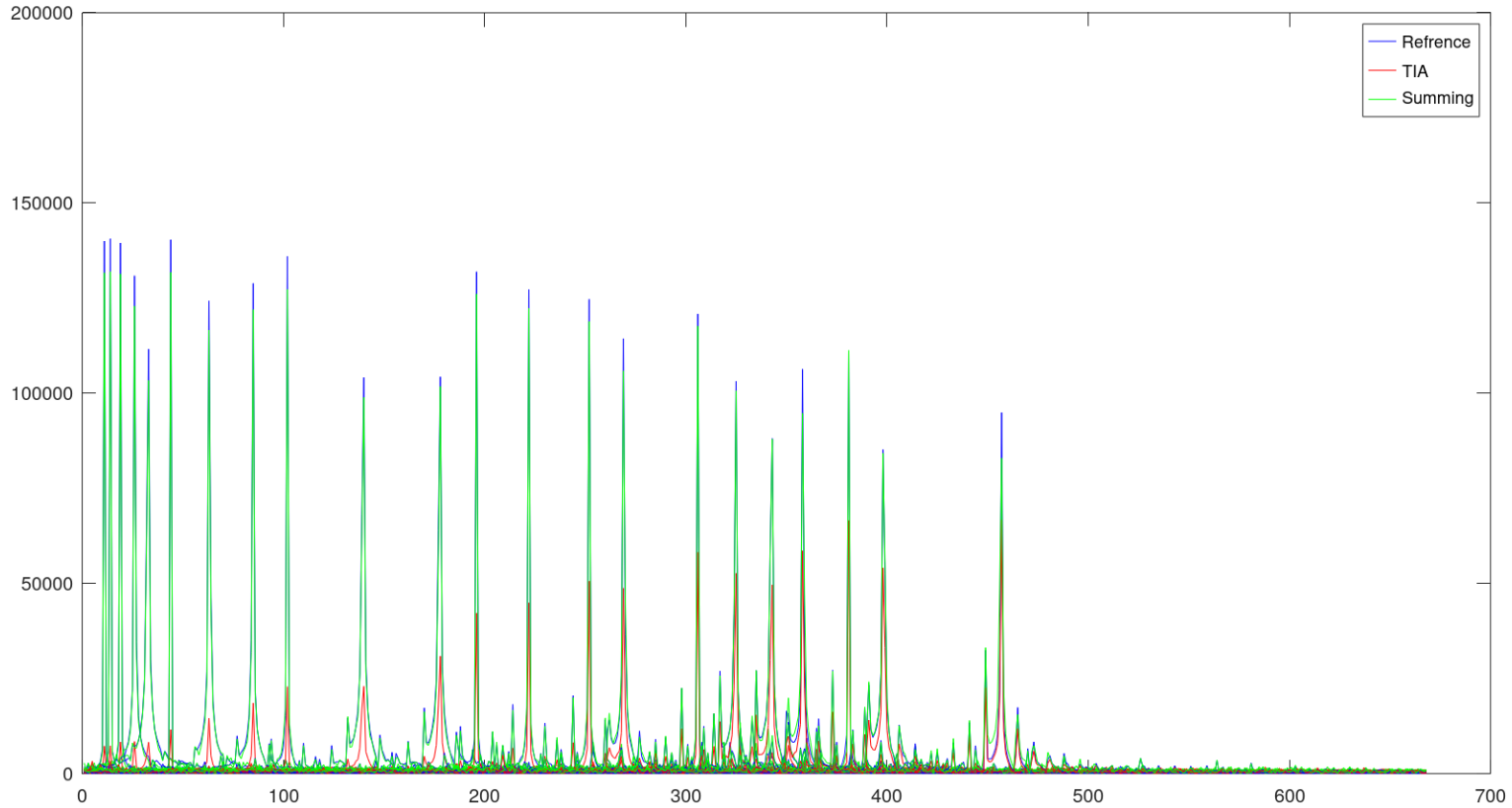
- Controls the EIS input signal frequency sweep from 100Hz to 10KHz
- Acquirers the signal generated from the cell-current to voltage converter (Transimpedance Amplifier TIA)
- Wirelessly sends data to the host where it is postprocessed and displayed



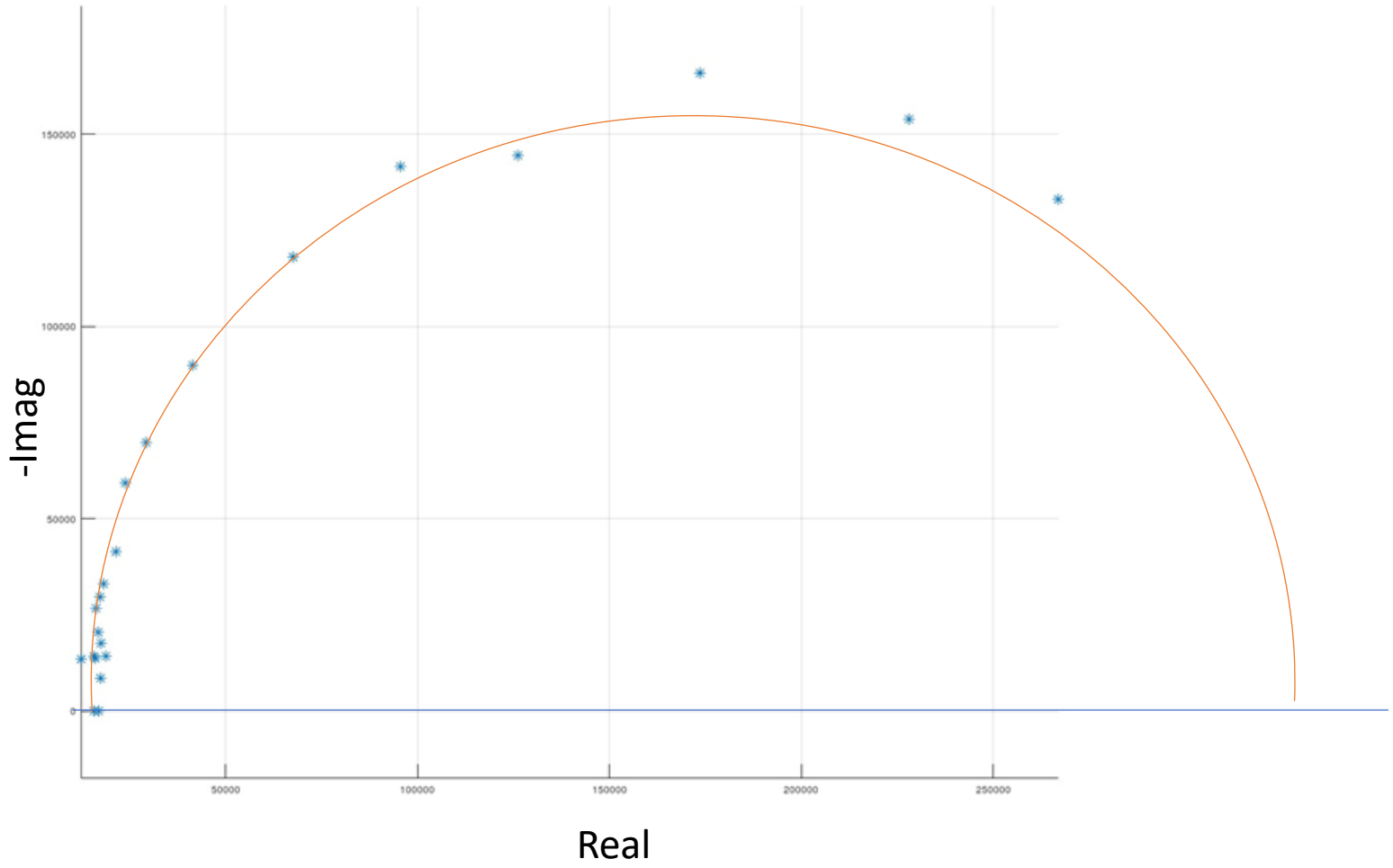
# MATLAB Postprocessing

A MATLAB script running on the host side calculates the parameters of the analyte (Rp & Rs) to extract brucella concentration

The Real and Imaginary components can be calculated by utilizing the Fast Fourier Transform (FFT) magnitudes of the Reference, TIA, and summing signals.



# Preliminary Measurement Results (Nyquist Plot)




This test was run using the values
**Rp = 360K ± 10% Ω**
Rs = 10k ± 10% Ω
Cd = 1nF

ESP32 EIS sweep from 100Hz to 10KHz

Input amplitude: 200mV

*The semi-circle is slightly skewed at high frequencies*
*Rs (measured) ≈ 10 – 20 kΩ*
***Rp (measured) ≈ 330 KΩ***

*Rp is the only parameter that depends on the Brucella concentration in this non-Faradaic scenario.*

# Next

- Tweak design parameters to get better semi-circle fit
- Replace the sensor equivalent circuit by the 3-electrode cell
- Calibration

# Estimated BOM Cost

| Unit | Number | Price |
|---|---|---|
| ESP32 | 1 | 10$ |
| CA3140 | 2 | 4x2 = 8$ |
| LM358 | 2 | 3x2 = 6$ |
| PCB | 5 | 4 $ |
| Laptop | 4GB Ram/Intel corei3/ Win10 | 30$ |
| | | **$ 58** |