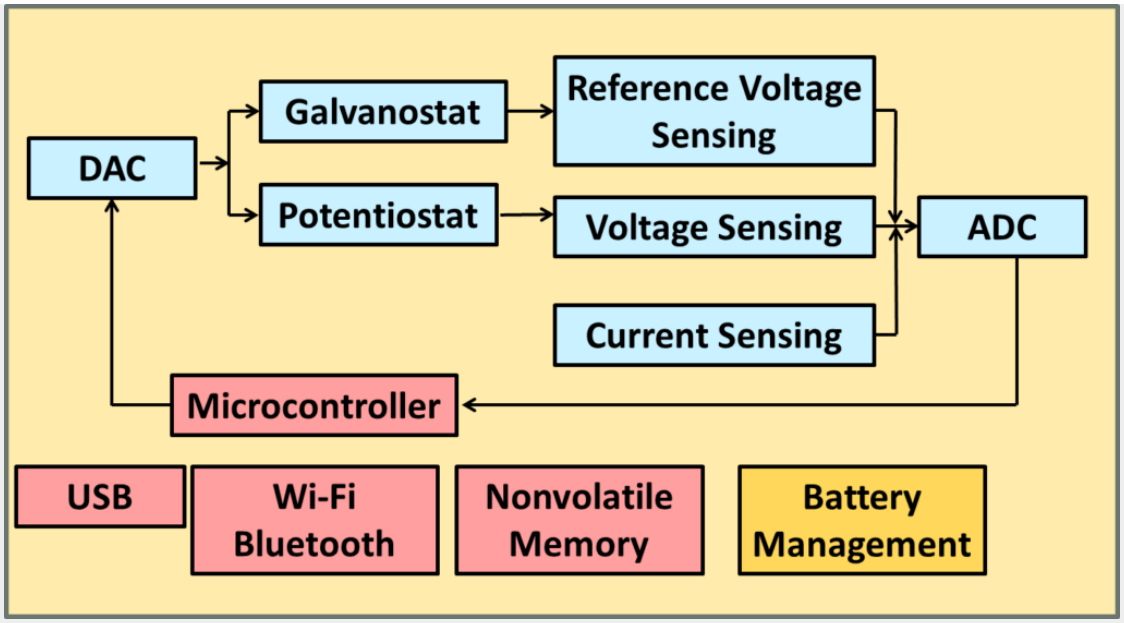
IoT Enabled ElectroChemical Platform

Electrochemistry is one of the most potent areas to be explored for healthcare products development. The electrochemical devices need to work with multi-analytes and multiple techniques depending upon the application. Some of the commonly used electrochemical techniques are: Chronoamperometry, Chronopotentiometry, Normal Pulse Voltammetry, Differential Pulse Voltammetry etc. In all these experiments, different excitation waveforms are given as inputs to a multi-electrode system. The above techniques use specialized electrochemical instrumentation. Most of the times researchers, to conduct their experiments, use standard but sophisticated electrochemical ***bench-top*** equipment which are imported and very expensive. Hence, we identified that there is a need to develop an electrochemical platform technology to cater the needs of the electrochemical researchers and electrochemical device developers in the country which is versatile, light weight and ***portable***.

The electrochemical platform technology being developed by us provides for programmability in the system to tune the system to a specific end use. The technology helps to develop electrochemical device prototypes for multi-analytes. The platform is a generic electrochemical technology which can lend itself for optimized device development with IoT provision which helps in enabling powerful graphic user interfaces available on PC's, Laptops and Mobile platforms. Also IOT enables fast computation, large data storage, ease of documentation, data transmission and presentation of results with the above platforms.

In order to perform electrochemical studies, a three electrode system is used consisting of a working electrode, counter electrode and a reference electrode. The hand held device being developed can work as a *potentiostat* as well as a *galvanostat* . When operated as a potentiostat, a known voltage or voltage waveform is given as an input to reference electrode and the output current is measured. When operated as a galvanostat, the input is a programmable constant current and the output voltage is measured.

The hardware has the capability to generate the various input waveforms. The measured output is converted to digital data and sent to a web server via a WIFI module by following a standard communication protocol, where it can be viewed and analyzed graphically. The generic block diagram of our device is shown below –

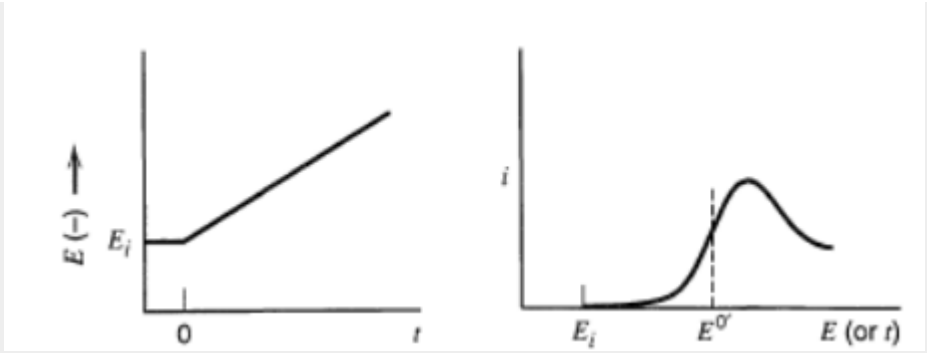


The various requirements for our hardware are -

- DC or AC Control

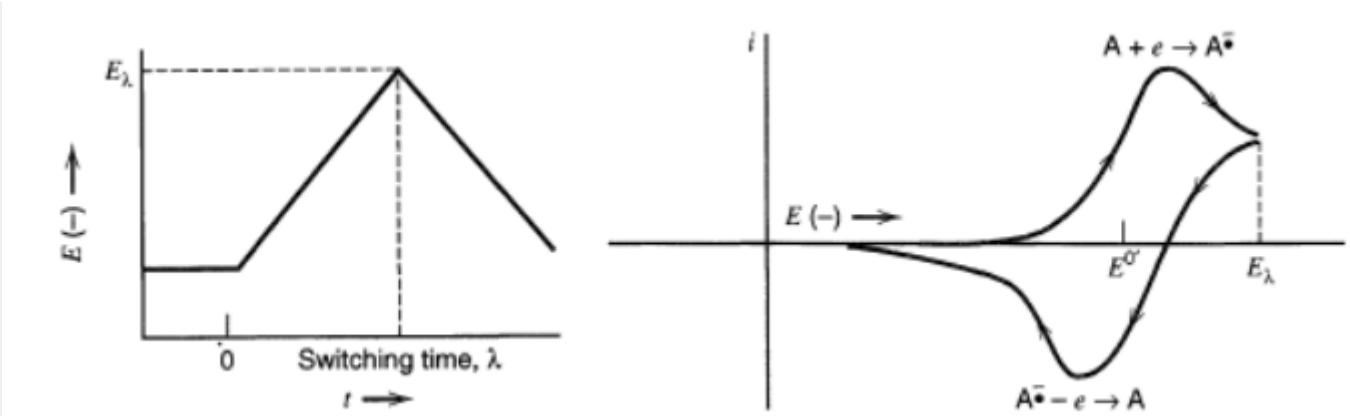
The voltage between Working Electrode (W.E) and Counter Electrode (C.E) is held constant and the current is measured.

- Linear Sweep Voltammetry



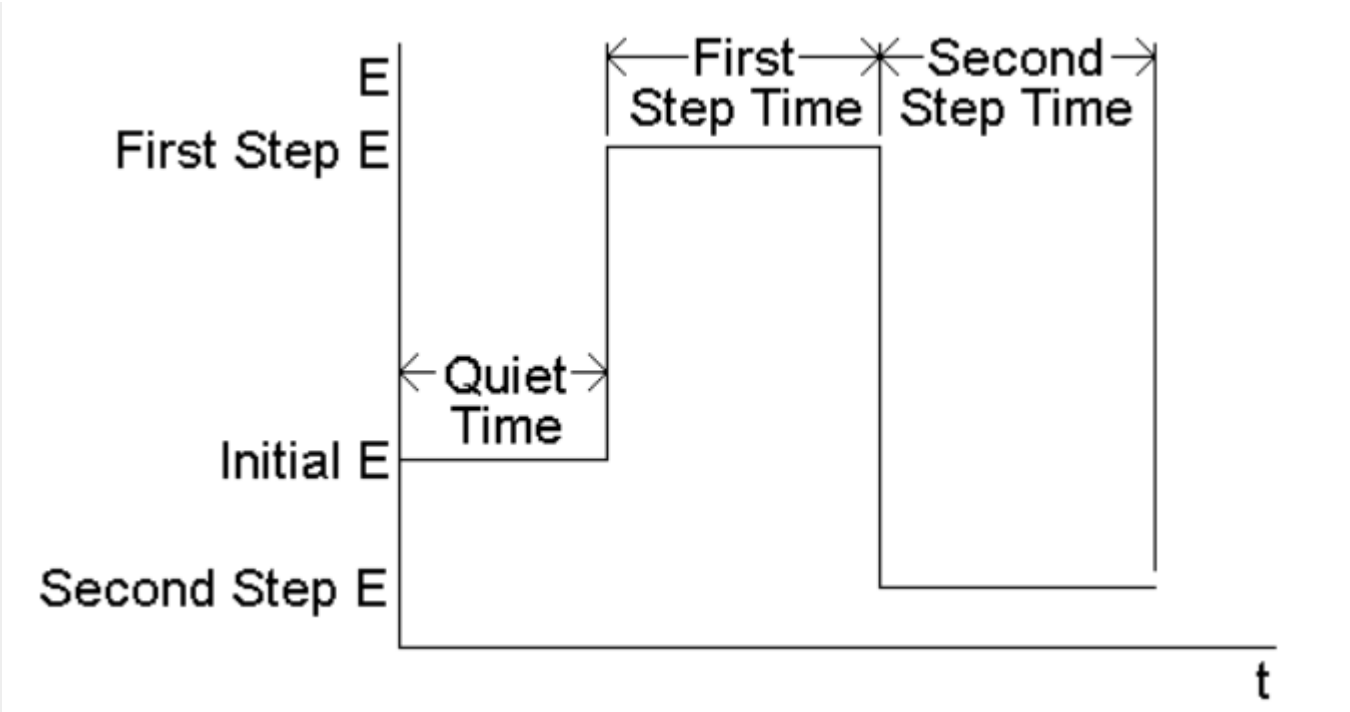
A ramp input is applied and the resulting I-V characteristics are displayed.

- Cyclic Voltammetry



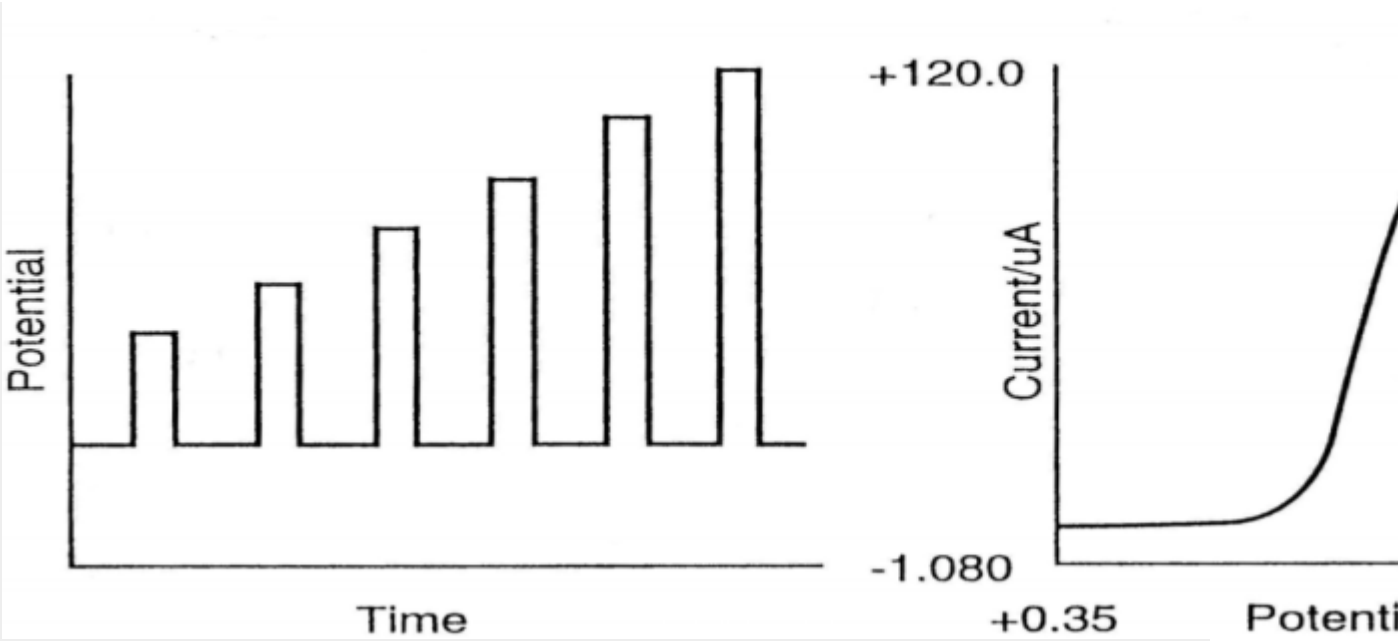
It is the same as Linear Sweep Voltammetry but with both Forward and Reverse Sweeps simultaneously. (input like triangular wave).

- Chrono-Amperometry



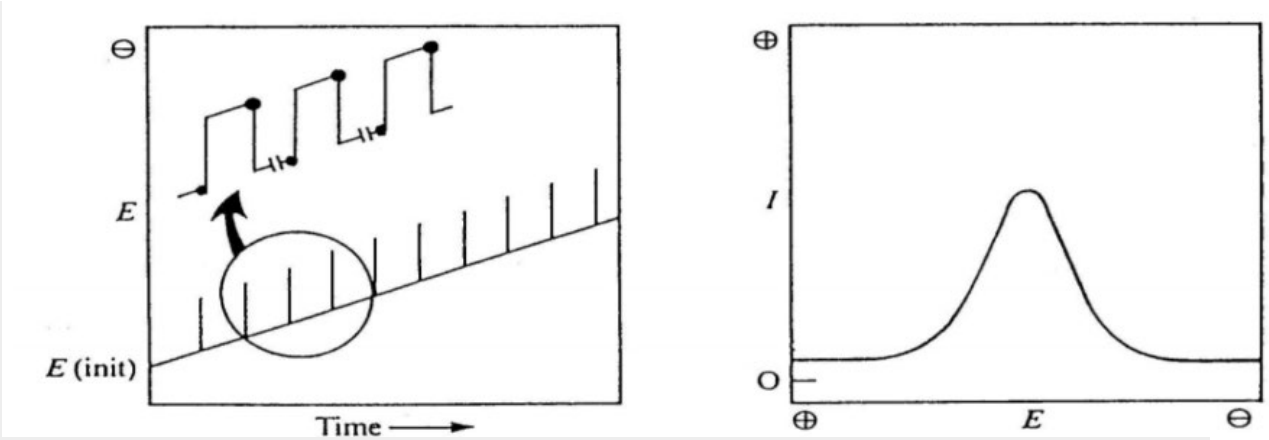
A step input pattern is the input waveform in this technique. Current is the measured output.

- Normal Pulse Voltammetry



Pulses of varying amplitudes are input and the resulting output I-V characteristic is displayed.

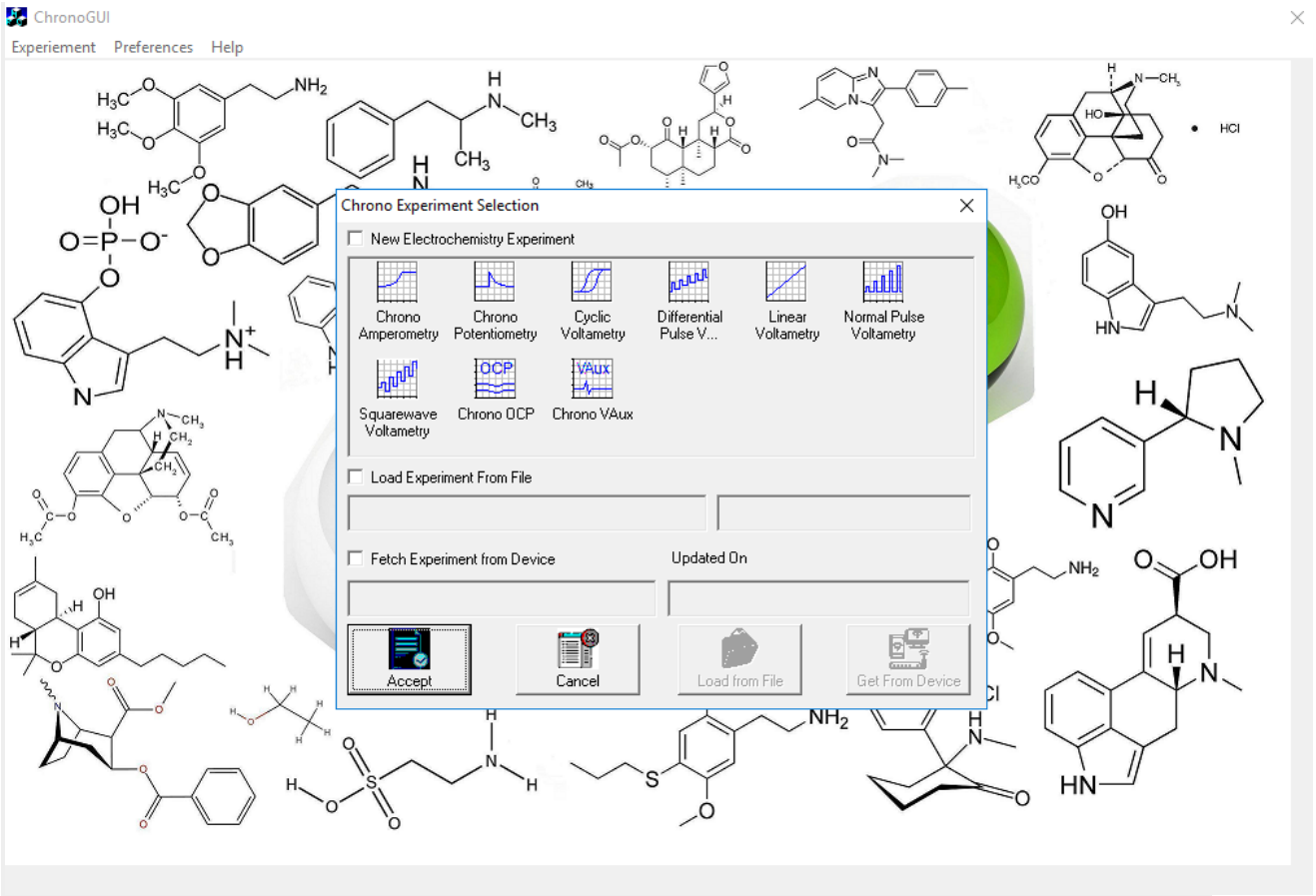
- Differential Pulse Voltammetry



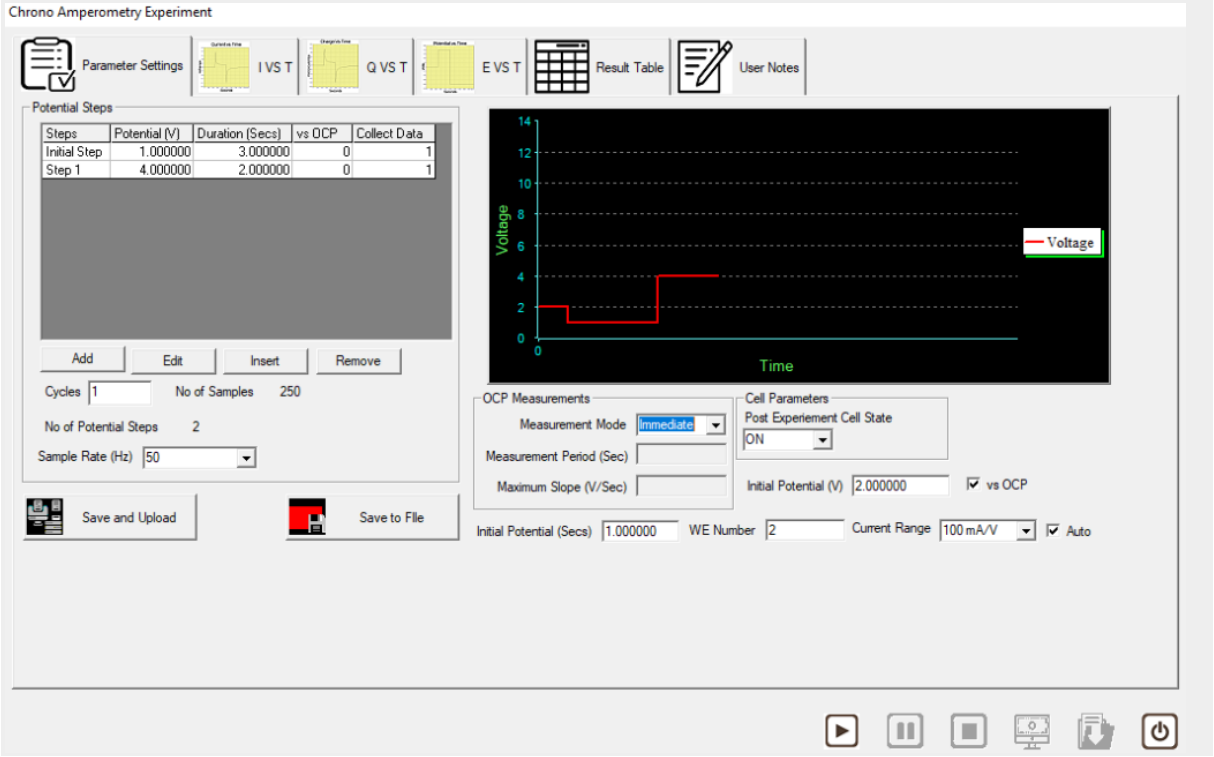
The input is a superimposition of a ramp and a pulse. Current is measured at the output.

WORKING

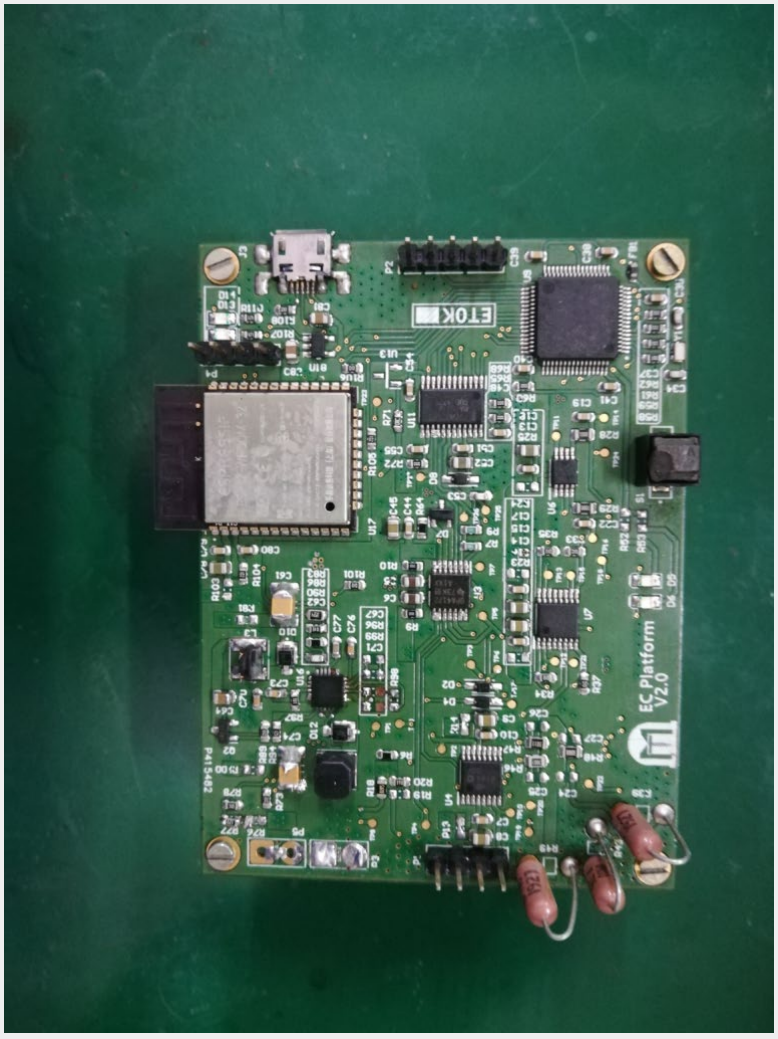
Using a desktop GUI developed by us, the experiment to run can be selected.



Once an experiment is selected, various parameters required for that selected experiment can be entered in the GUI.

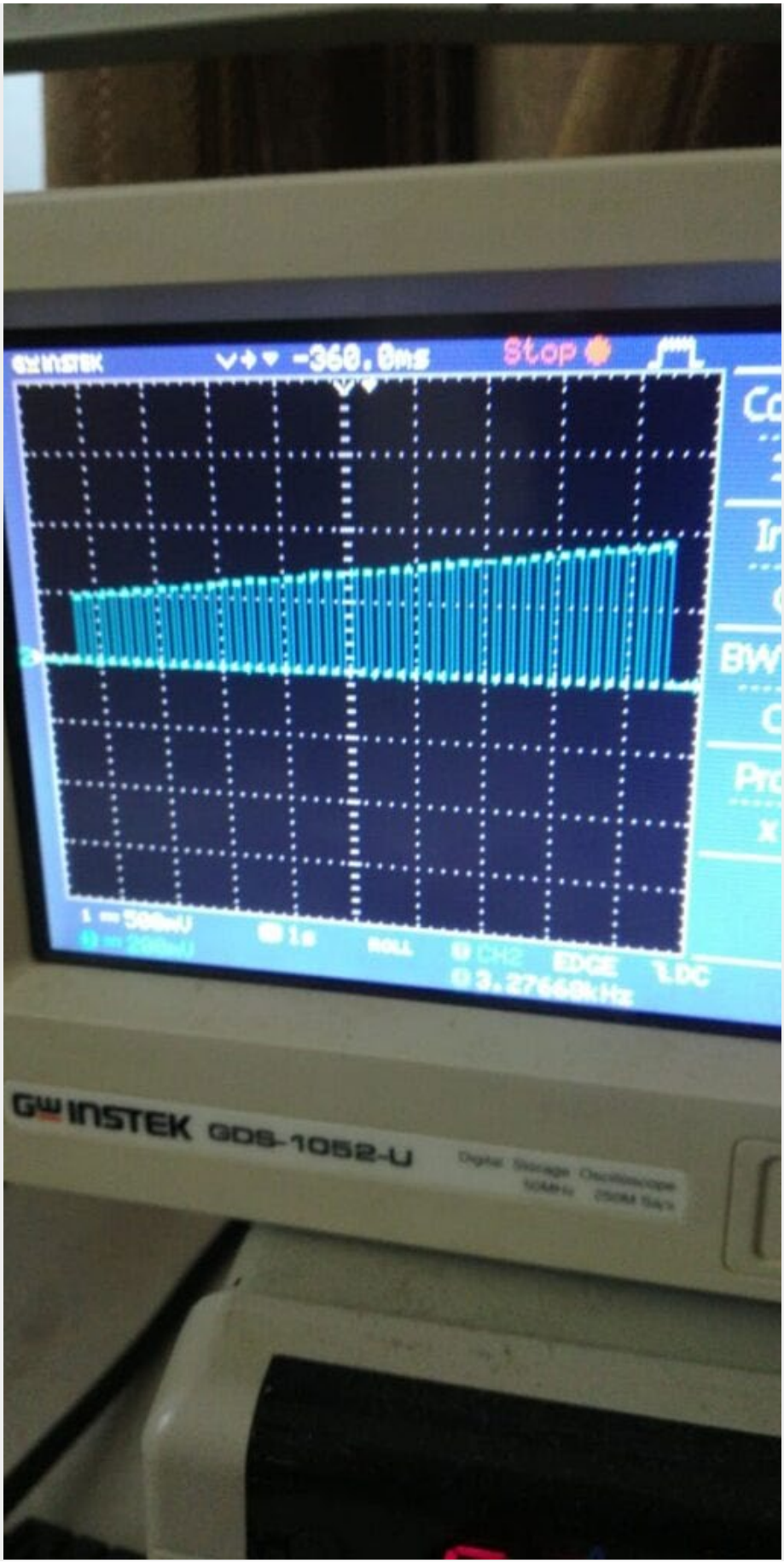


The Electrochemical Platform hardware has an ESP32 module to receive the parameters set from the desktop GUI app. Once these parameters are received, the DAC on the hardware circuit generates the required waveforms and is given as input to the electrochemical cell. The output current and voltages are converted from their analog values, back to digital, using an ADC on the hardware. The ESP32 sends these ADC values to the desktop app to plot the output waveforms.



The various input waveforms generated is shown below –

- Chronoamperometry Waveform Video
- Normal Pulse Voltammetry Waveform Video
- Cyclic Voltammetry Waveform Video
- Linear Sweep Voltammetry Waveform Video


-360.0ms
Stop
EDGE
GW INSTEK GDS-1052-U

The output waveforms of current v/s time variation plotted on the GUI app for a sample experiment is shown below –