MEASUREMENT AND SENSOR TECHNOLOGY

Department of
Electrical Engineering and
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CHEMNITZ UNIVERSITY OF TECHNOLOGY

# Graphical user interface (GUI) on PC for communication with potentiostat embedded system

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# Outline

- Motivation
- Introduction
- Graphical user interface (GUI) for electro chemistry techniques
- Embedded platform
- Conclusion
- References

# Motivation

- Reduce the manual effort to record the measurement readings.
- Increase the efficiency of the individual during the measurement process.
- Design a graphical user interface (GUI) to automate the measurement process
  - Record the measurement data
  - Plot real time graphs
  - Save the measurement data to excel file

Fig 1: Image showing the manual work during and after the experiment [7]

# Introduction

- Design the GUI on personal computer (PC) for electro chemical techniques
  - Cyclic voltammetry
  - Square wave voltammetry and
  - Impedance spectroscopy
- Read out the measurement data from the potentiostat over Universal Asynchronous Receiver Transmitter (UART) communication protocol
- Plot the real time graph and store the readings in an excel file

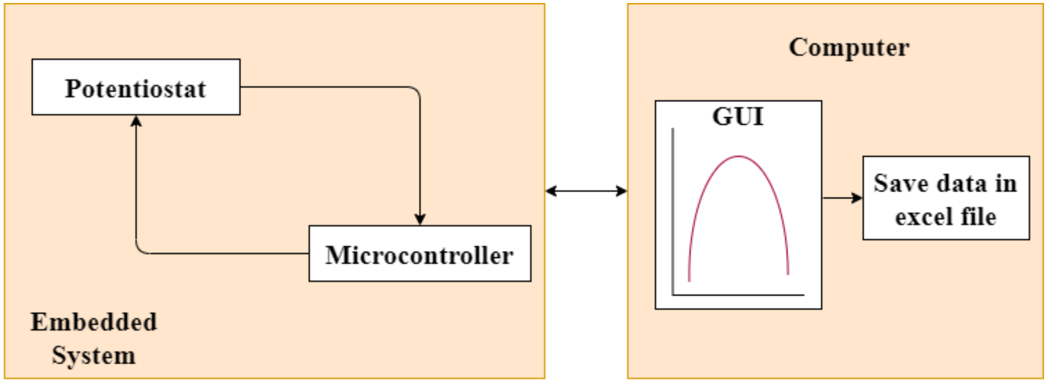



Fig 2: Image showing the overview of the project

# Graphical user interface (GUI)

- Based on Palmsens PSTrace software for electro chemical processes.
- Functions of PSTrace software:
  - Automate the electro chemical measurement process
  - Plotting the real time graphs of the measurement data
  - Analysis of the measurement data
  - Saving the data to excel file
- GUI consists of 4 pages namely:
  - Home page
  - Cyclic voltammetry
  - Square wave voltammetry
  - Impedance spectroscopy

# Home page

- Contains brief introduction about the project and various features included in the GUI.

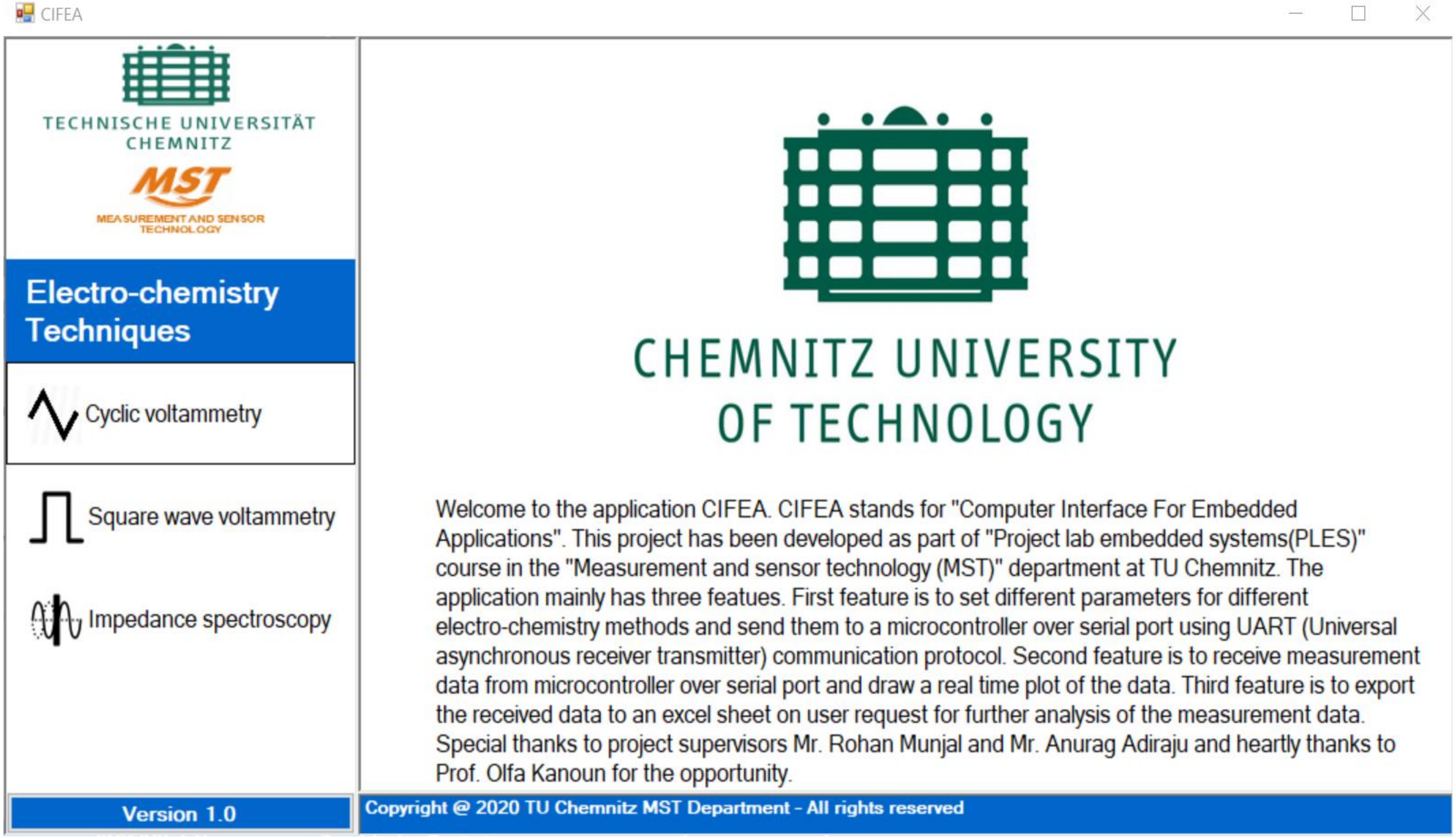



Fig 3: Home page of the GUI

# Cyclic voltammetry

- Cyclic voltammetry is a type of electrochemical measurement technique.

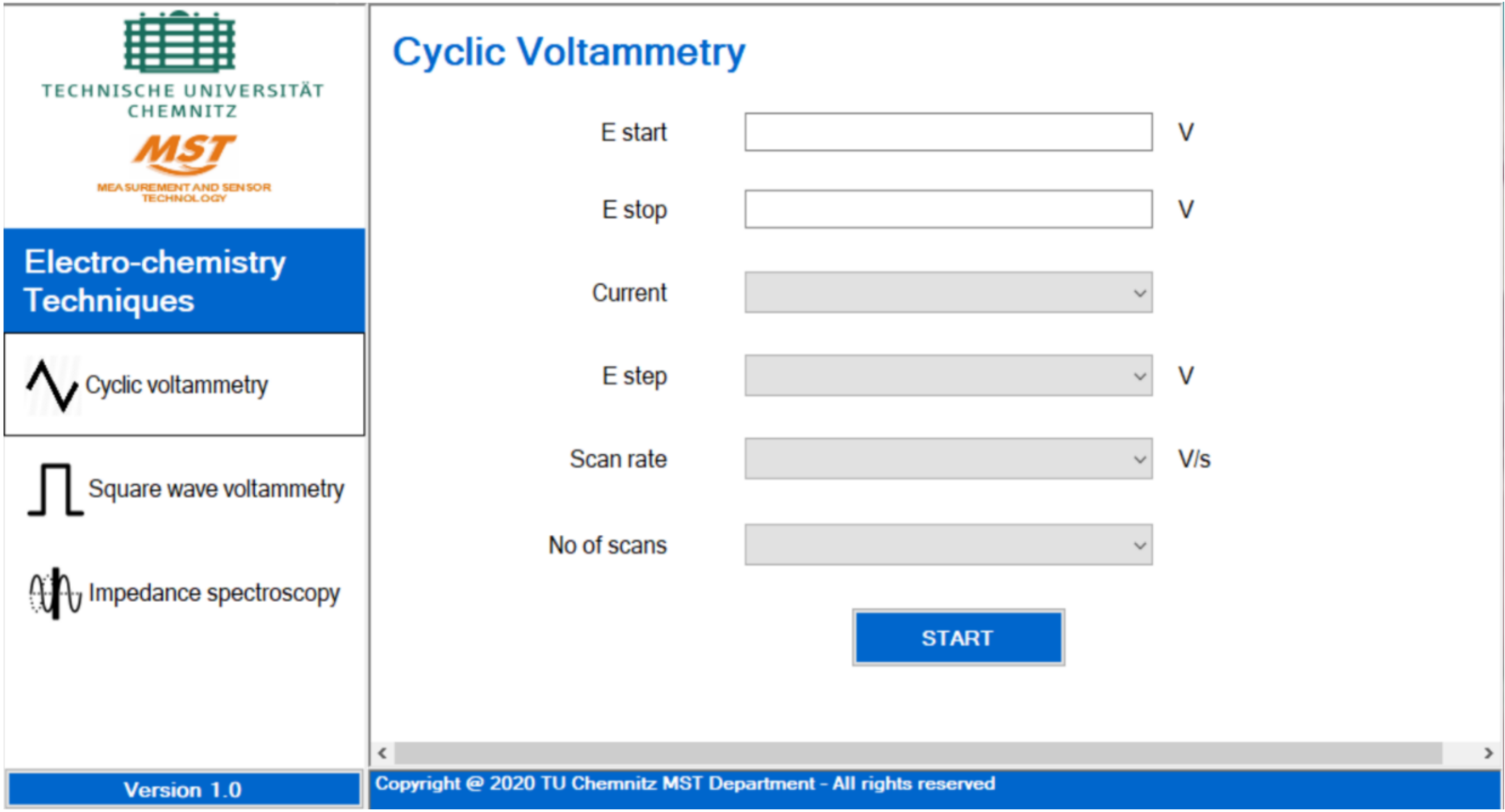



Fig 4: Home page of cyclic voltammetry

# Cyclic voltammetry

- Accepted values for the parameters are specified in the Table I

| No | Parameter | Value |
|---|---|---|
| 1 | $E_{start}$ | Between -1.5 V and +1.5 V |
| 2 | $E_{stop}$ | Between -1.5 V and +1.5 V and should be greater than E start |
| 3 | Current | Between 100 pA to 100 mA |
| 4 | $E_{step}$ | Between 0.01 V and 0.1 V |
| 5 | Scan rate | Between 0.01 V and 0.1 V |
| 6 | No of scans | Between 1 and 5 |

Table I: Range specification for parameters in cyclic voltammetry

# Cyclic voltammetry

- Data validations are carried out to make sure that no fields are left empty and data entered in the corresponding parameter fields is within the specified range.

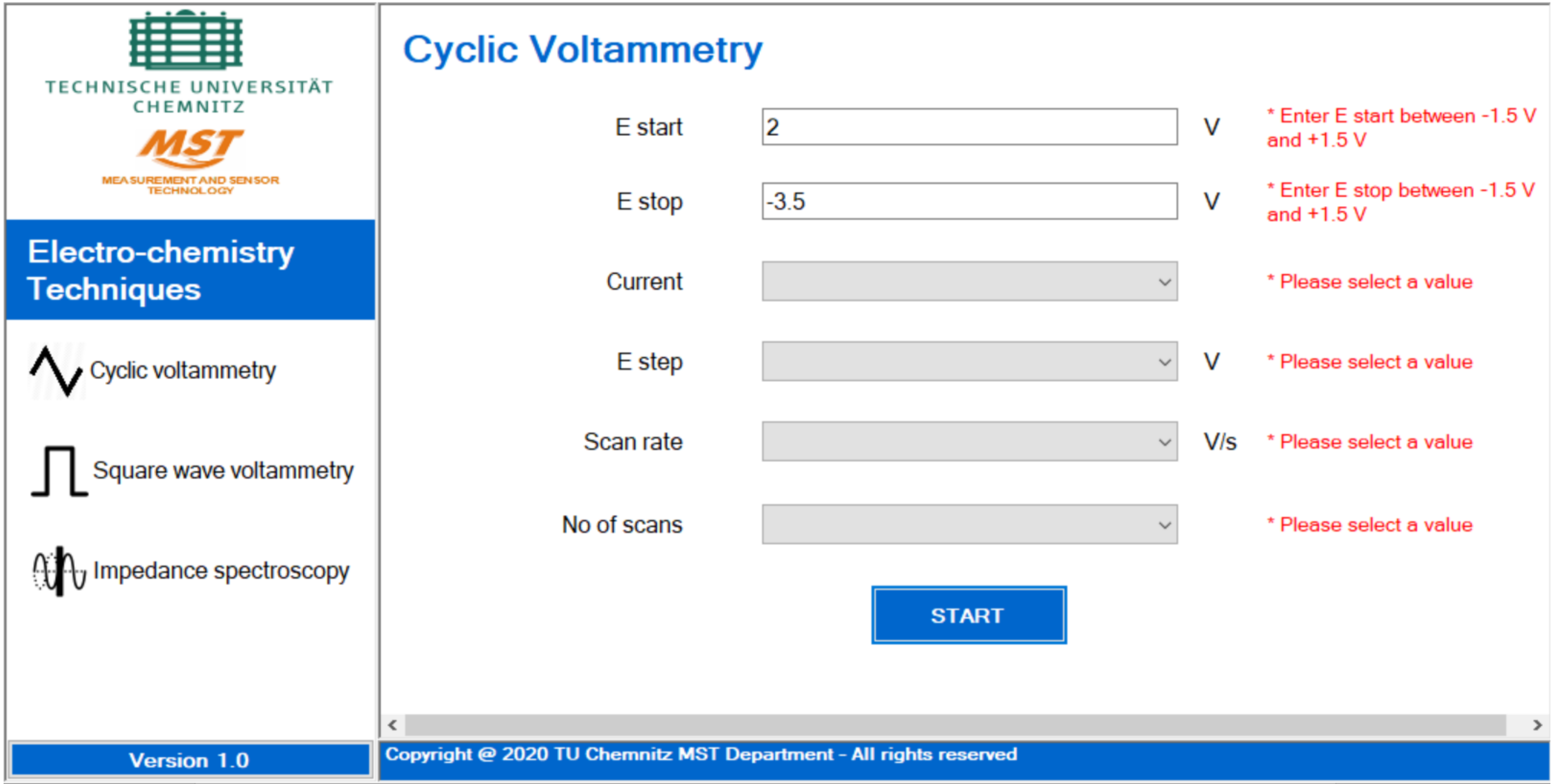



Fig 5: Range specific validations

# Cyclic voltammetry

- Parameters can be sent to the microcontroller when the data entered in the fields is within in range specified and the experiment can be started.

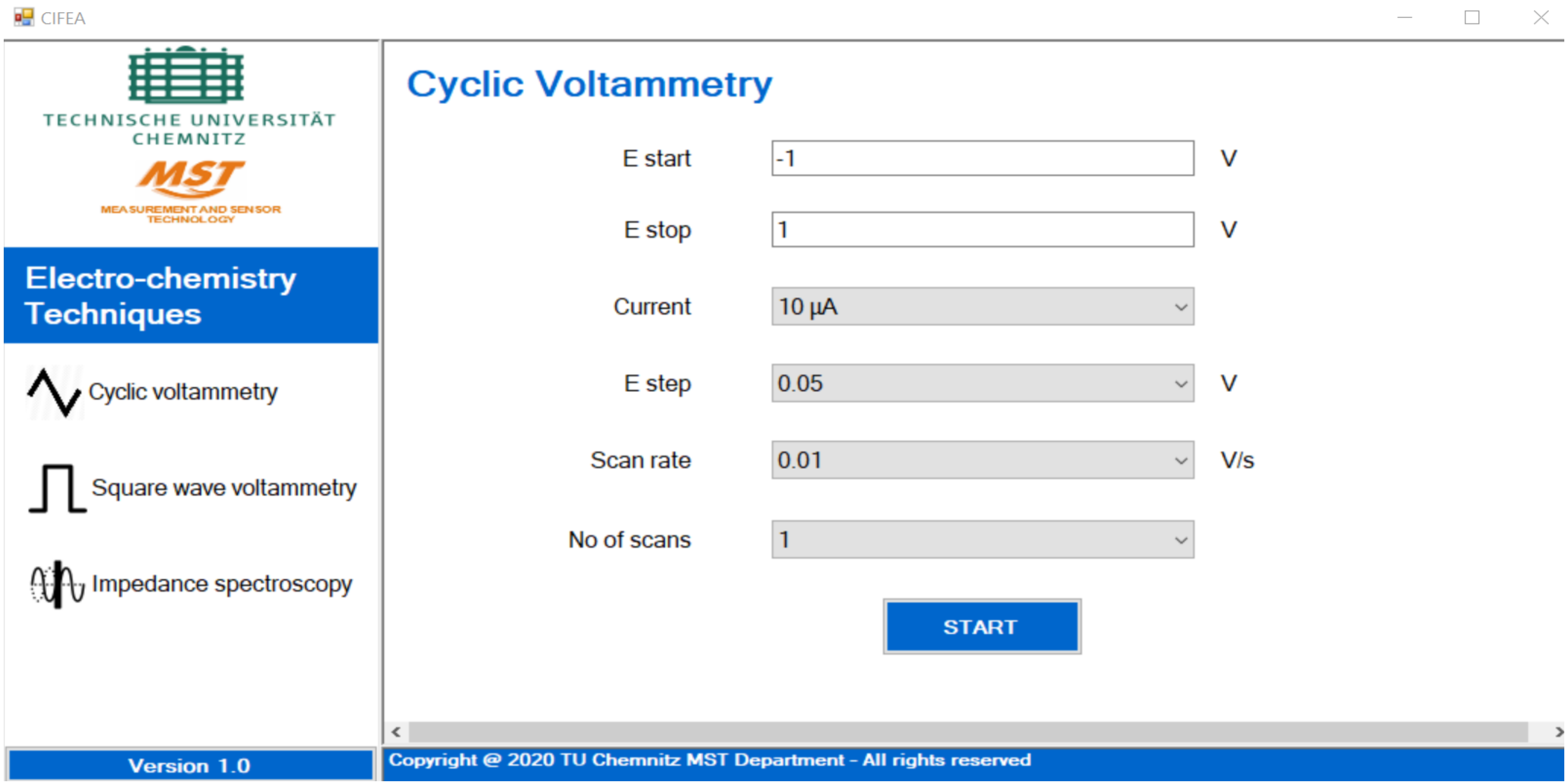



Fig 6: Correct data entered in the parameter fields

# Measurement data generation

- For cyclic voltammetry and square wave voltammetry techniques, the measurement current is generated using Ohm's law.
- Constant resistance of 10kΩ is used in the measurement data generation.
- Initial value of measured voltage is the value of the parameter $E_{start}$ and it increases until $E_{stop}$ in steps of $E_{step}$ value.
- Measurement current is calculated for each value of measurement voltage using ohm's law.
- For impedance spectroscopy technique, the measurement data of frequency and impedance is randomly generated.

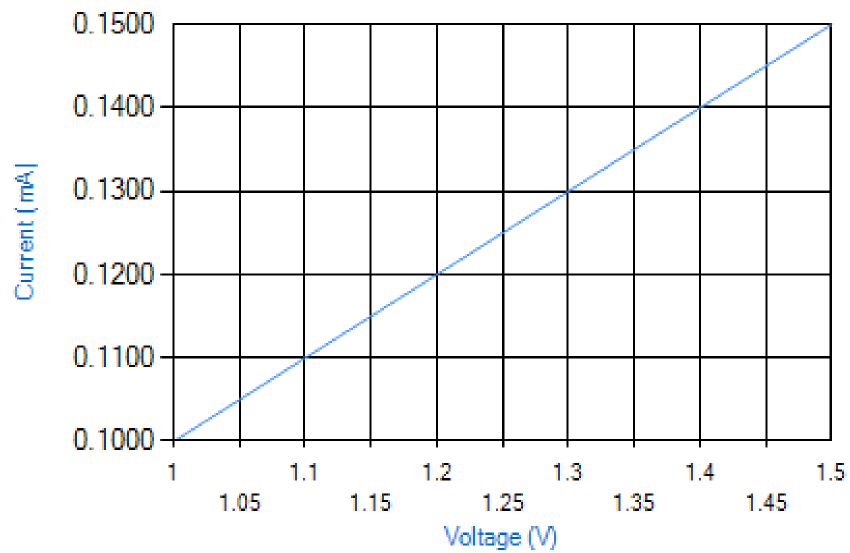



Fig 7: Sample graph in cyclic voltammetry method

# Cyclic voltammetry

- GUI receives output potential measured between the working electrode and the reference electrode, and the output current measured between the working electrode and the counter electrode as measurement data and plots the real time graph.

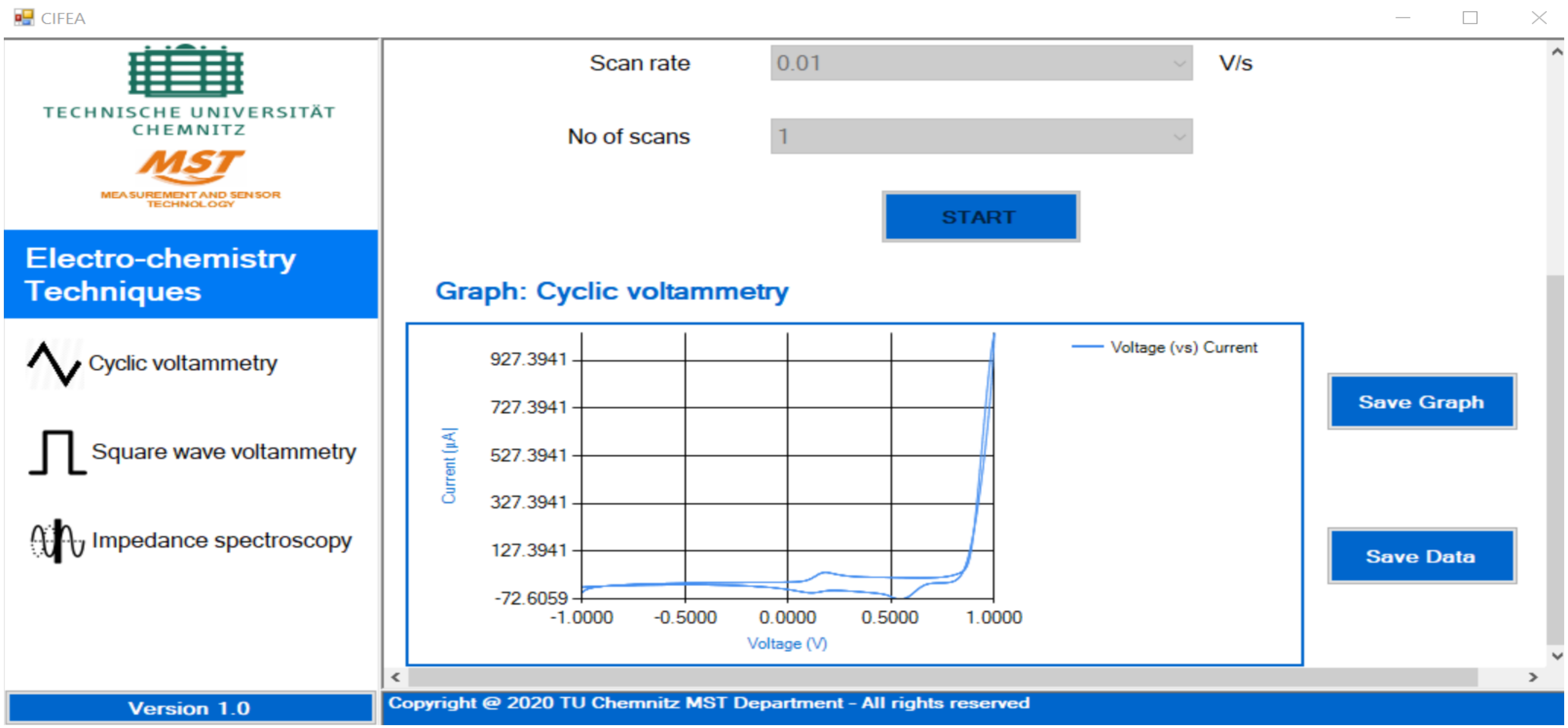



Fig 8: Real time graph of the received data

# Cyclic voltammetry

- Real time graph can be saved as an image and measurement data can be exported into an excel file.

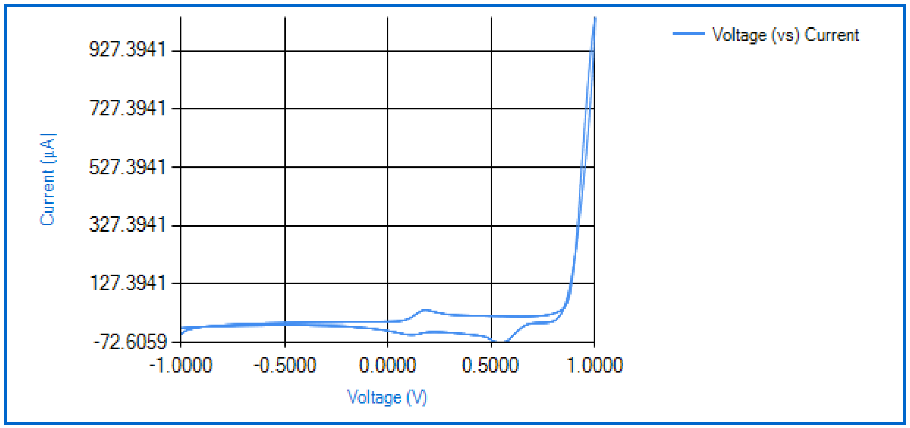
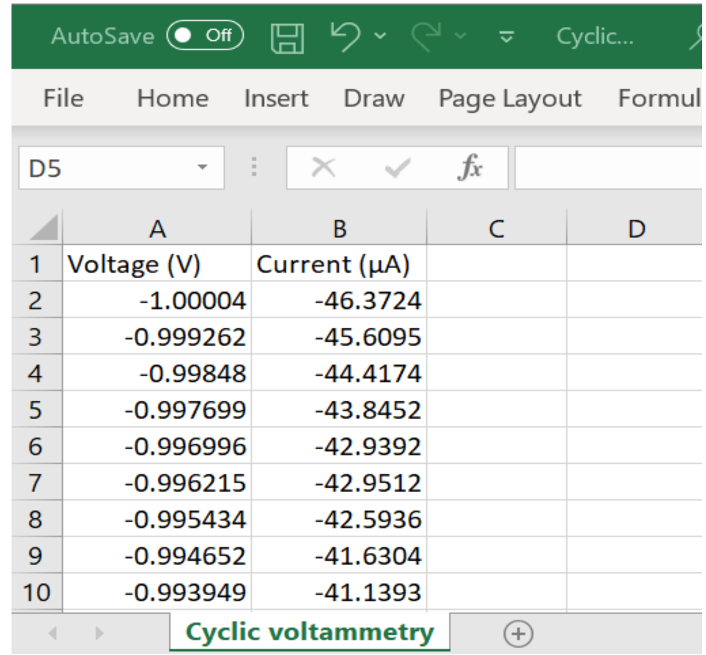



Fig 9: Real time graph saved as an image file




| | A | B | C | D |
|---|---|---|---|---|
| 1 | Voltage (V) | Current (µA) | | |
| 2 | -1.00004 | -46.3724 | | |
| 3 | -0.999262 | -45.6095 | | |
| 4 | -0.99848 | -44.4174 | | |
| 5 | -0.997699 | -43.8452 | | |
| 6 | -0.996996 | -42.9392 | | |
| 7 | -0.996215 | -42.9512 | | |
| 8 | -0.995434 | -42.5936 | | |
| 9 | -0.994652 | -41.6304 | | |
| 10 | -0.993949 | -41.1393 | | |

Fig 10: Real time graph data saved into an excel file

# Square wave voltammetry

- Square wave voltammetry is a form of pulse voltammetry method available in electro chemistry techniques.
- Input potential is a combination of a square wave and staircase potential applied to the working electrode.
- The current at the working electrode is plotted versus the applied voltage to give the square wave voltammogram trace.

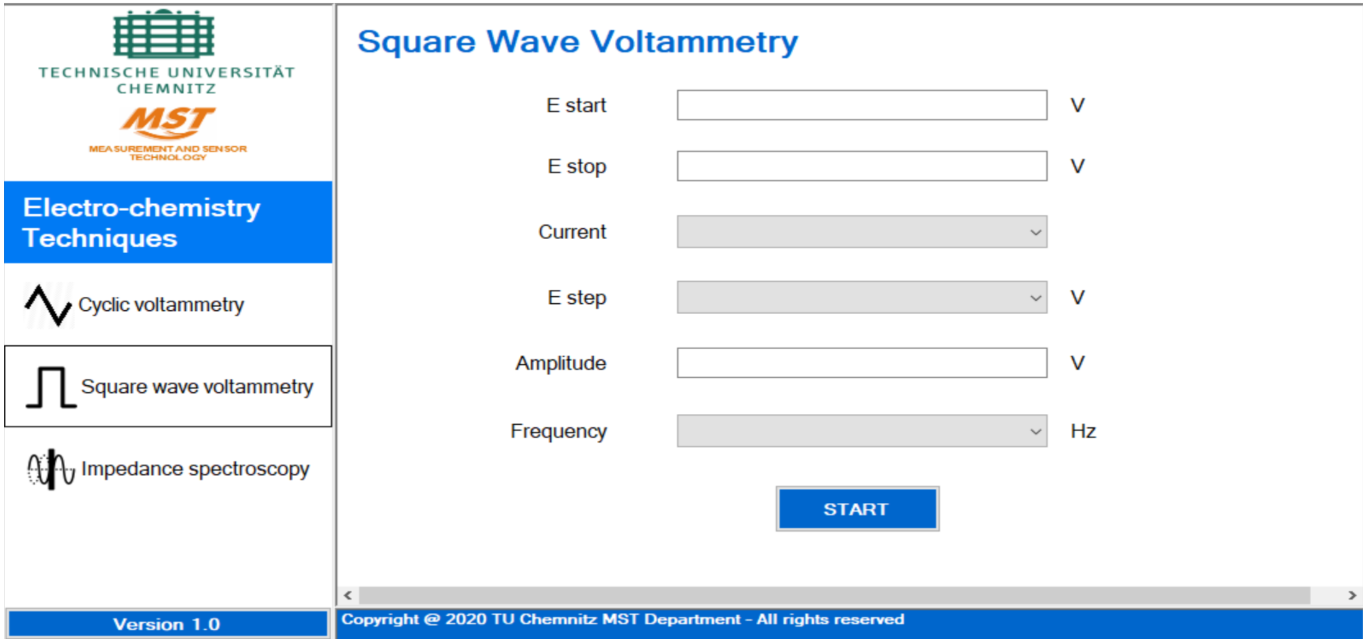



Fig 11: Home page of square wave voltammetry

# Square wave voltammetry

- Accepted values for the parameters are specified in the Table II.

| No | Parameter | Value |
|---|---|---|
| 1 | $E_{start}$ | Between -1.5 V and +1.5 V |
| 2 | $E_{stop}$ | Between -1.5 V and +1.5 V and should be greater than $E_{start}$ |
| 3 | Current | Between 100 pA to 100 mA |
| 4 | $E_{step}$ | Between 0.01 V to 1 V |
| 5 | Amplitude | Between 0.1 V to 1 V |
| 6 | Frequency | Between 1 Hz and 150 Hz |

Table II: Range specification for parameters

# Impedance spectroscopy

- Electrochemical Impedance Spectroscopy is one of the most complex techniques available in electrochemical research.
- This technique is widely used to measure the impedance of a system in dependence of the AC potentials frequency.

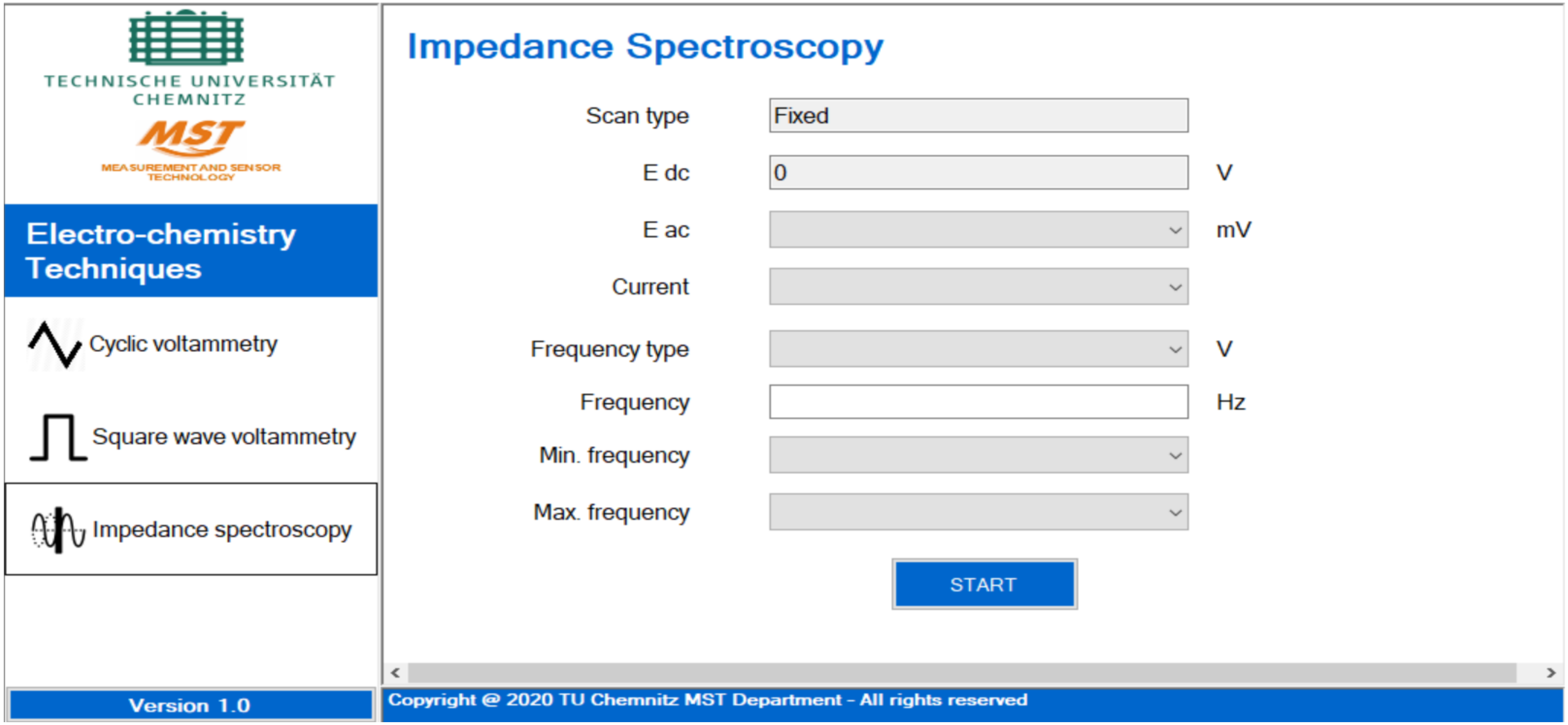



Fig 12: Home page of Impedance spectroscopy

# Impedance spectroscopy

- Accepted values for the parameters are specified in the Table III.

| No | Parameter | Value |
|---|---|---|
| 1 | Scan type | Fixed |
| 2 | $E_{dc}$ | 0 V |
| 3 | $E_{ac}$ | Between 10 mV and 50 mV |
| 4 | Current | Between 100 pA to 100 mA |
| 5 | Frequency type | Fixed (or) Scan |
| 6 | Frequency | Between 1 Hz and 150 Hz |
| 7 | Min frequency | Between 0.1 Hz and 100 kHz |
| 8 | Max frequency | 100 kHz |

Table III: Range specification for parameters

# Embedded platform

- Hardware used in this project is STM32 Nucleo-L4R5ZI board.
- Integrated development environment (IDE) used for configuration of peripherals, generation of code, compilation and debugging is STM32 CubeIDE.
- The peripherals Timer and Universal Asynchronous Receiver Transmitter (UART) are used in this project.
- LPUART1 (Lower Power UART) is used in this project with Baud Rate set to 9600bits/sec, words length set to 8 bits

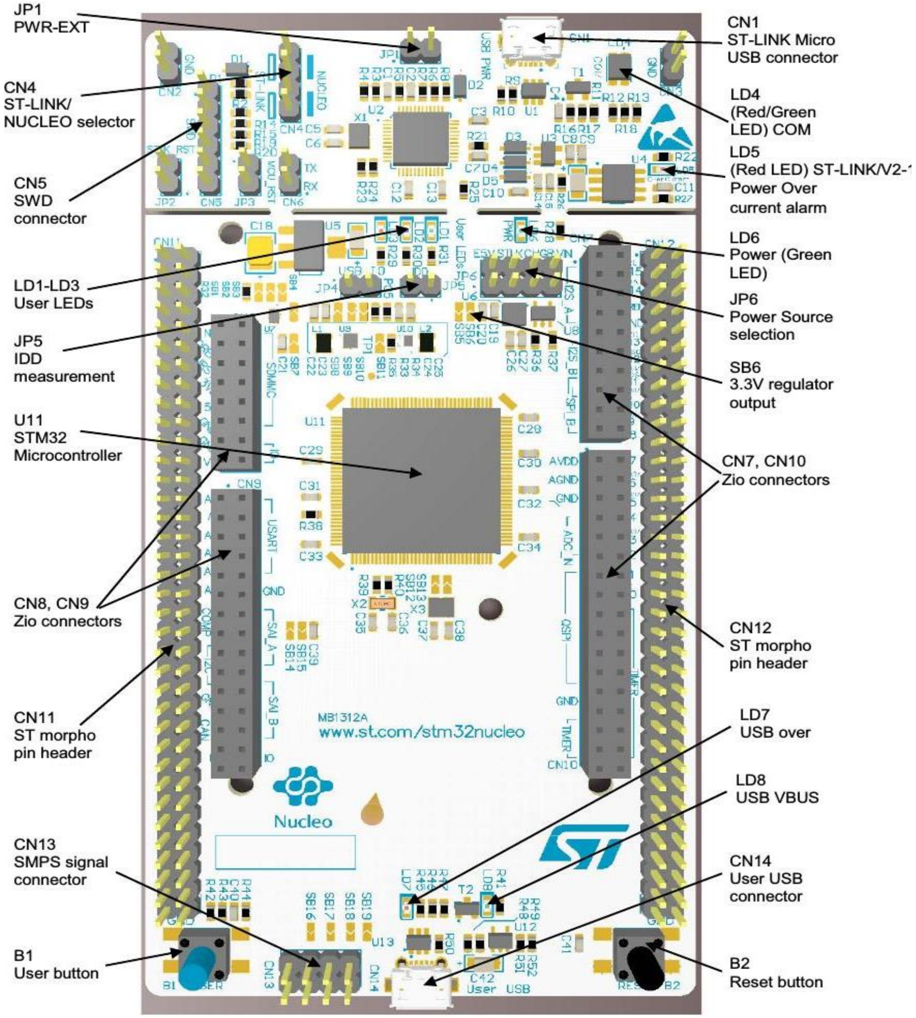



Fig 13: STM32 L4R5ZI board layout [6]

# Conclusion

- GUI was designed successfully to select different electro chemistry methods and adjusted their input parameters and sent them to the microcontroller.
- Microcontroller board was configured and programmed to read the parameters from the GUI and sent the measurement data to the GUI.
- Input parameters in the GUI were non editable while receiving the measurement data.
- GUI received the measurement data and correctly interpreted the data and simultaneously plotted the real time graph.
- Features to save the graph as an image file and to export the graph data into an excel file were implemented.
- Extensive debugging and unit testing of the software was carried out to ensure the smooth operation of the application.
- Easy and versatile GUI was developed with advanced features suitable for all levels of user experience.

# References


[1] STMicroelectronics. Discovery Kit with STM32 Nucleo-L4R5ZI MCU User Manual. April 2018. UM1570.

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[5]Norris, Donald J. Programming with STM32 Getting started with Nucleo Board and C/C++. s.l.: McGraw-Hill Education, 2018.

[6] Docs.zephyrproject.org. 2020. ST Nucleo L4R5ZI — Zephyr Project Documentation. [online] Available at: <https://docs.zephyrproject.org/latest/boards/arm/nucleo_l4r5zi/doc/index.html> [Accessed 28 June 2020].

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# *Thank you*