# Development of ARM-7 based Potentiostat for the Electrochemical Laboratory

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***Abstract -*** In this paper development of ARM-7 microcontroller based potentiostat for the electrochemical laboratory is described. Its operation is based on the three electrode potentiostat. The use of microcontroller allows; generation of excitation potential, acquisition of sensed analog current, processing and storage of data. The developed system is used for the identification and quantification of analyte with the use of computer program.

***Keywords :***

potentiostat, ARM-7, microcontroller, electrochemical laboratory.

## I. Introduction

Electrochemical sensors are widely used in the laboratory for the detection of physical signals in various processes, such as pH measurement [1], glucose detection [2], and nucleic acid identification [3]. Measurement based on electrochemical sensors is much more economical and convenient than chromatographic and spectroscopic techniques [4]. The reason is electrochemical sensors do not need expensive optical set-ups. The electrochemical sensors are passive type sensors. The physical parameters sensed by the sensors is converted into electrical signal with the use of transducer and DC power source. A potentiostat is commonly used transducer in the electrochemical sensing system. It converts the sensors output into the analog signal. Many scientists have developed the potentiostat required for sensing system. For instance, Frey developed potentiostat for biosensor chips [5], Turner investigated a CMOS potentiostat [6], Bandopdhyaya [7] developed a multichannel potentiostat.

Present study aims to develop a microcontroller based potentiostat for electrochemical sensing of analyte parameters. The measured electrochemical data will be analyzed for the identification and quantification purpose with the use of indigenously developed computer program.

## II. Methodology

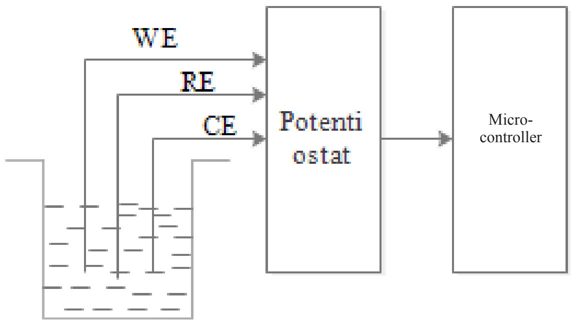



Fig. 1 Block diagram of t)he potentiostat

Fig. 1 shows the block diagram of developed potentiostat.

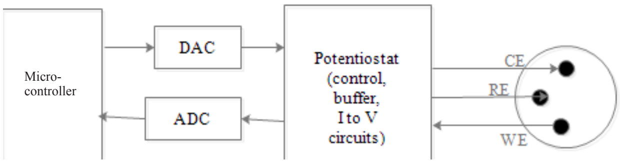
The electrochemical sensing cell consists of working (WE), reference (RE) and counter (CE) electrode. The electrode specifications are shown in Table1.

**TABLE 1**
**ELECTRODE SPECIFICATION**

| Electrode | | |
|---|---|---|
| Name | Material | Function |
| Reference | Saturated Calomel | Constant potential electrode |
| Counter | Pt/ steel wire | High current density electrode |
| Working | Dropping mercury/ carbon | Non-corrosive electrode |

Potentiostat has two functions: a) control the CE potential relative to RE, b) measure the current flowing between WE and RE. The microcontroller has four functions: a) generate analog electric potential, b) digitize the sensed signal, c) signal manipulation, and d) signal storage.

A detailed block diagram of potentiostat for the electrochemical sensing system is shown in Fig. 2.



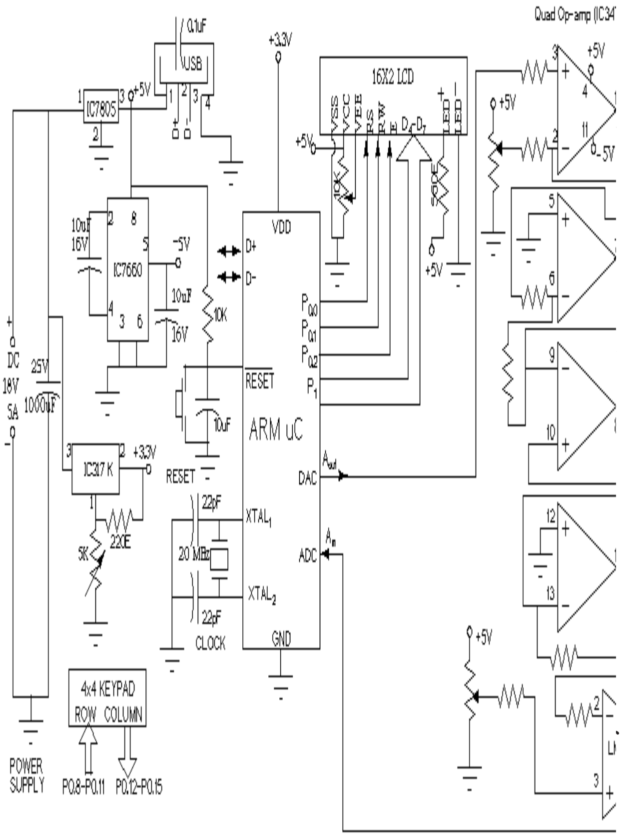




Fig. 3 Circuit diagram of the electrochemical sensing system

The microcontroller is used for signal generation, data acquisition and signal management. The in-built analog to digital converter (ADC) is used to measure the potential difference between RE and WE for reexamining whether the RE reaches the applied voltage or not. In order to avoid the loading effect caused by ADC in the RE, as judged by the difference between the RE and ADC, an operational amplifier must be connected to implement a voltage follower for the isolation of the two sides of the circuit. According to the output of ADC, the microcontroller will generate the corresponding signal with the use of in-built digital to analog converter (DAC). It will supply a current to the counter electrode. This feedback control procedure will continue until the voltage at reference electrode is equal to that applied voltage. The sensing current that flows between CE and WE is measured by current to voltage ( I to V) converter. The voltage drop across the feedback resistor represents a corresponding current from the sensing cell.

An inverting amplifier is needed to optimize the output voltage levels of I-to-V converter with respect to the maximum resolution of ADC.

## IV. Results and Discussion

Potentiostat can be used in one of the following two modes.

1. Sweep mode: The inbuilt DAC of microcontroller generates ramp signal by use of one of the registor as up-counter. In this mode potentiostat is used to detect the halfwave potential and the height of diffusion current.
2. Triangular wave mode: The triangular wave is generated by counter in up and down mode. The peak current corresponding to the concentration of analyte is obtained by solving the Randles- Sevcik equation, $Ip=2.69\times105\times n32\times A\times D12\times C\times V12$

Where, $I_p$ is peak current, n is no. of electrons in the transfer, A is surface area of the electrode, D is diffusion coefficient of the species, C is concentration, and V is scan rate.

## V. Conclusions

The present design of potentiostat is based on classical theory of Heyrovsky [8] which may be used for a wide range of electrochemical experiment. It is the intent of the authors to use the potentiostat as a teaching tool in electrochemical laboratory. The potentiometer presented here can be used in place of other expensive potentiostat and is capable of producing the same analytical results despite its lower cost. The potentiostat described here can be further improved by utilizing the modern microcontrollers that allow more programming features like floating point calculations.

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