IOSR Journal of Electronics and Communication Engineering (IOSR-JECE)
e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 11, Issue 2, Ver. III (Mar-Apr .2016), PP 20-23
www.iosrjournals.org

Embedded Based Polymers Electrical Conductivity Measurement System

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Abstract: *The conductivity of an electrolyte is a measure of the ability for solution, metal, or a gas to carry electric current. In solutions the current is carried by both cations and anions where as in metals the current is carried by electrons. This paper presents the measurement of the electrical conductivity for different solutions of polymers by embedded based system. Embedded based system is designed for the measurement of electrical conductivity automatically with good accuracy and high resolution. The conductivity of polymers depends on different parameters: concentrations, mobility of ions, valence of ions and temperature.*
Keywords: *Analyzer, Conductivity, Embedded, Polymer, synthetic.*

I. Introduction

Electrical Conductivity/Specific Conductance is the reciprocal of resistivity and material's ability to conduct an electric current. It is commonly represented by the Greek letter **σ,** Measured in Siemens per meter.

$$\sigma = 1/\rho$$

Where **ρ** is Electrical Resistivity in ohm meter.

The electrical conductivity of polymer varies depending on the amount of moisture held by polymers.

II. Theory

The conductivity of an electrolyte is a measure of the ability of the solution to carry electricity. The current through the solution takes place by the movement of electrically charged particles called ions. When a potential difference is applied to the electrode which is immersed in the solution, ions are instantaneously accelerated towards the electrode. Since the conductance of a solution of electrolyte is related to the concentration of electrolyte, analytical applications of conductance are possible. The electrical conductivity measurement system in the present study is shown in Fig 1.

Conductivity Cell

The conductivity cell comprises two electrodes which are two parallel sheets of platinum fixed in position by scaling the connecting tubes into the sides of the measuring cell. In order to reduce the polarization effects which produce a large cell capacitance, the effective area of the electrode is greatly increased by coating the electrode with platinum black.

The reciprocal of the resistance R of the electrolytic solution (1/R) is called the conductance. It is expressed in ohms or mhos. The resistance of a solution depends upon the length '**l**', area '**a**' and the intrinsic properties of the solution. It can be expressed as:

$$R = \rho(l/a)$$

Where ρ is known as specific resistance. The conductance of the cell is given by $1/R = 1/\rho(a/l) = \sigma(a/l)$
The constant σ is called the specific conductance of an electrolyte.

$$\sigma = 1/R(l/a) \quad \text{in} \quad \Omega^{-1}/Cm$$

The cell constant can be determined by measuring R for a solution of known specific conductance. Solutions of potassium chloride of known concentrations are invariably employed for this purpose.

Raspberry Pi micro computer:

The Raspberry Pi is a series of credit card–sized single-board computers developed inEngland, United Kingdom by the Raspberry Pi Foundation with the intent to promotethe teaching of basic computer science in schools and developing countries.

All Raspberry Pis include the same Video Core IV graphics processingunit (GPU), and either a single-core ARMv6-compatible CPU or a newerARMv7-compatible quad-core one (in Pi 2); and 1 GB of RAM (in Pi 2), 512 MB (in Pi 1models B and B+), or 256 MB (in models A and A+, and in the older model B). Theyhave a Secure Digital (SDHC) slot (models A and B) or a Micro SDHC one (modelsA+, B+, and Pi 2) for boot media and persistent storage In 2014.

The Raspberry pi can be used as, a mini Web browser, gaming console, Windows 3.0on a Pi, Robotics, RISC OS for Pi, RPi cloud server and RPi Weather Station.

Working of the circuit:

The individual blocks of the embedded based system for the measurement of electrical conductivity is designed and constructed. The block diagram of the measurement system is shown in Figure 1. The measurement system consists of conductivity electrode, its signal processing circuit, analog to digital converter and Raspberry Pi minicomputer. The schematic of the system is shown in Figure2. The processed results are send to PC for display and storage. The necessary MATLAB software is developed which runs in PC. The controller used in the present work is PIC 18F4553, which consists of 12 bit, 10 channel ADC which gives good accuracy and precision. The software for analog to digital conversion and serial communication is written in C language, which is flashed into the PIC microcontroller kit. The algorithm of measurement is shown in the form of flow chart in Figure 3.

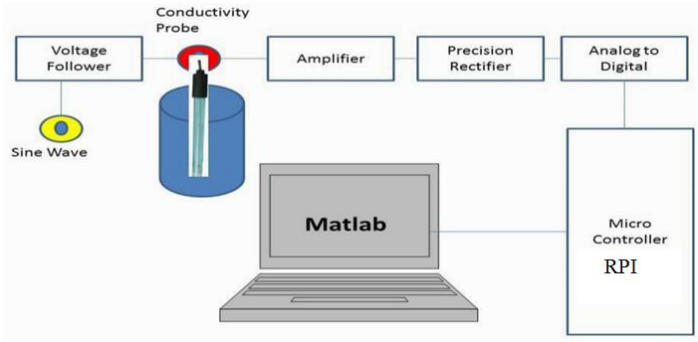


Figure 1: Conductivity Measurement

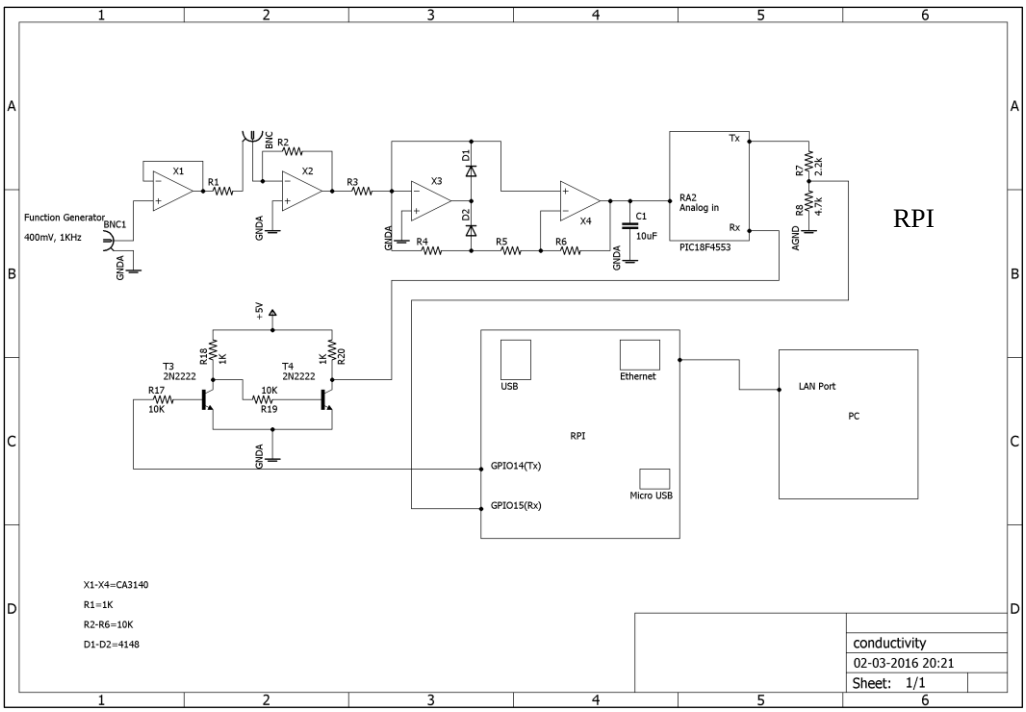


Figure 2: Schematic diagram of Conductivity Measurement

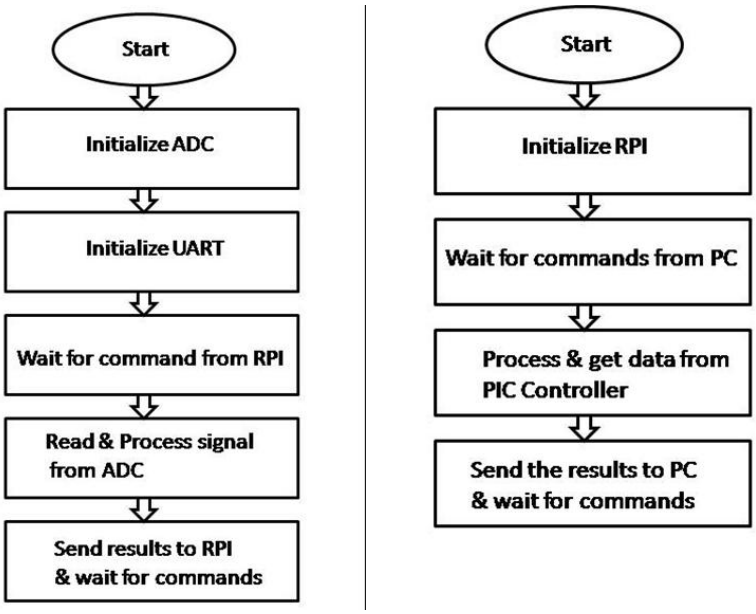
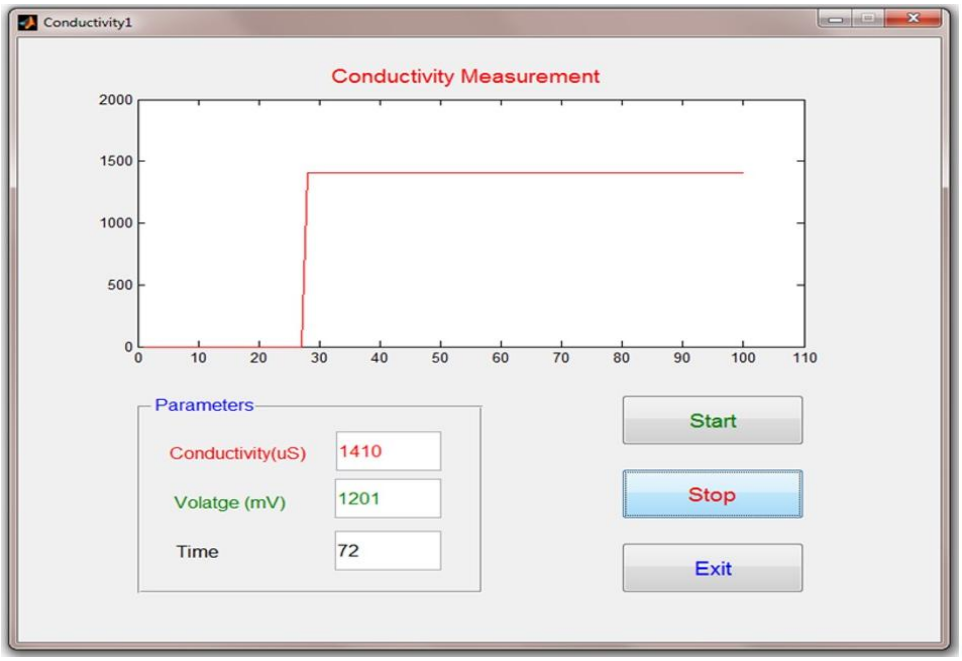


Figure3: Flow chart for the software written in PIC18f4553 and RPI

Calibration & Measurement procedure:

Before using the system, the electrode must be calibrated by measuring a series of known standard solutions, made by serial dilution of the 1M KCL standard solution. In the present study, the system is calibrated at three concentrations of standard KCL solution- 1M, 0.1M and 0.01M. The standard solutions were prepared by the dilution method.

In the calibration process, the slope of the conductivity electrode is calculated. Slope is defined as the observed change in potential (mV) with a decade change in concentration. Obtaining the slope ensures good operation of the electrode. Slope measurement involves the following steps.The slope is computed by measuring the voltages at 0.1M and 0.01M standard solutions. The calibration values are stored in MATLAB code for the measurement. The conductivity of a solution is highly temperature dependent. Therefore, it is to be temperature compensated, or calibrate the instrument at the same temperature as the solution being measured. Unlike metals, the conductivity of common electrolytes typically increases with increasing temperature. After the calibration the system is ready for the measurement by using the appropriate MATLAB application.



Screen Shot of the measurement GUI

III. Results

Known solution Electrical Conductivity for calibration

KCl Concentrations	Electrical Conductivity(uS)	Measured Conductivity(uS)
1M	111342	111341
0.1M	12854	12856
0.01M	1408	1410
0.001M	146.93	145.87

Measurement results of Unknown Solution Electrical Conductivity

IV. Conclusion

Embedded based conductivity measurement system for polymers is designed and tested with known samples and the performance of the system is quite satisfactory. This system can be enhanced as a remote measurement system by writing appropriate software.

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S.No	Concentration %	Conductivity(uS)
1	1	0.111
2	0.9	0.122
3	0.8	0.135
4	0.7	0.142