Department of Electronic and Telecommunication Engineering

University of Moratuwa

B. Sc. Eng. Semester 2

EN1093 Laboratory Practice I

Project Report

pH METER

Group No: 09

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Content

Introduction

pH value of a certain solution is the measure of how much acidic or basic is the solution. At room temperature, the pH value of pure water is 7. The scale is defined such that acidic solutions get low pH while basic solutions get high pH. According to chemistry, pH is logarithmic and inversely indicates the concentration of hydrogen ions in the solution.

pH meter is the device which measures the pH value of a solution. It consists of the probe with a pH measuring electrode and a reference electrode and a high input meter. The phenomenon take place here is when the probe is kept in contact with the sample, the two electrodes inside the probe measure voltage. Reference electrode is contained with a liquid of fixed pH and the other measures the avidity of the sample according to the amount of H+ ions. The voltmeter inside the probe measures the voltage difference between the two electrodes. Then the meter gives the relevant pH according to the voltage difference and displays it.

pH probe

pH probe is used to measure the voltage difference of solutions in instantaneous time intervals. So we use the pH probe used for micro controller related researches. Normally pH probes give the outputs in micro volt level. For that the probes are available with gain board in the market to amplify the voltage level. Here probes are made with some special properties to reduce the noise and gain board also help to reduce that. It helps to reduce the error percentage of readings from the originals.

Inside the pH probe, there are 2 electrodes.

1. Stationary electrode : work as a zero voltage point
2. Other electrode : used to measure the differential voltage point

-0.414mV to 0.414mV is the range of output voltage of general probes for the pH range 1-14. The gain board uses LMC4502 -low noise, low power, precise, rail to rail op amps to do the chore without creating noise interference. Here we used coaxial cable to connect the probes to reduce the noise level. Other than this we have to keep the pH probe in a proper way as it's more sensitive and fragile.

Ideal measuring conditions can be retained only if the reference pH electrode stays stable while the other probe works with the differential voltage inputs of the sample. If the solution is homogeneous, then the deviations of the readings are much smaller.

The relation between measured potential E (mV), pH and temperature (K):

$$E = ET + 2.303(RT/F)\ pH$$

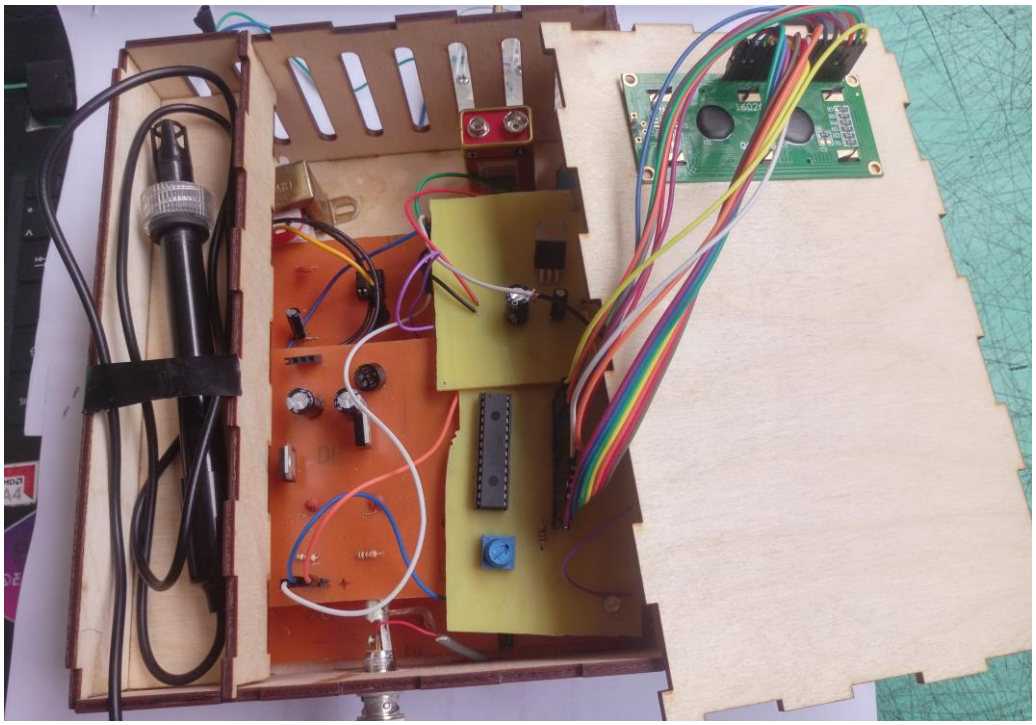
- E = Measured voltage (mV)
- ET = Temperature dependent constant (mV)
- R = Gas Constant (8.3144 J/K)
- T = Absolute Temperature (K)
- F = Faraday's constant (95484.56 C/mol)

Using the above equation we could find the pH value from the voltage difference gain from the pH probe. This equation also shows that temperature also depends on this calculation. But according to our device, we consider the temperature as atmospheric temperature and assume that the temperature change is very small. In this way we calculate the value of pH value using the voltage difference. This equation seems like a straight line. So here ET exists as the offset and temperature dependent factor as slope. At 25°C the slope gives -59.18 mV/pH.

Gain board

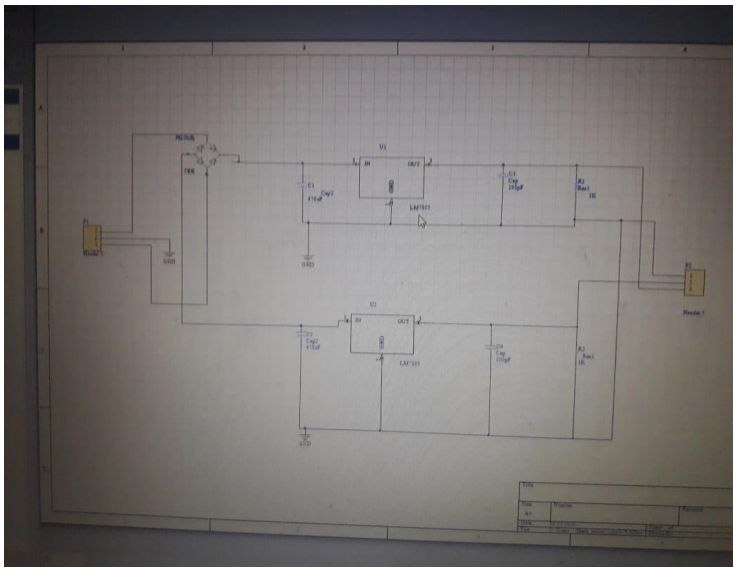
The most suitable gain board for this device costs more than 5000LKR. So we searched for the appropriate gain board with less cost and significantly effective to replace for the same gain and choose the gain board with tl072 op amps. So that, even though we had some drawbacks from the original, the performance is good enough to calculate the suitable pH value.

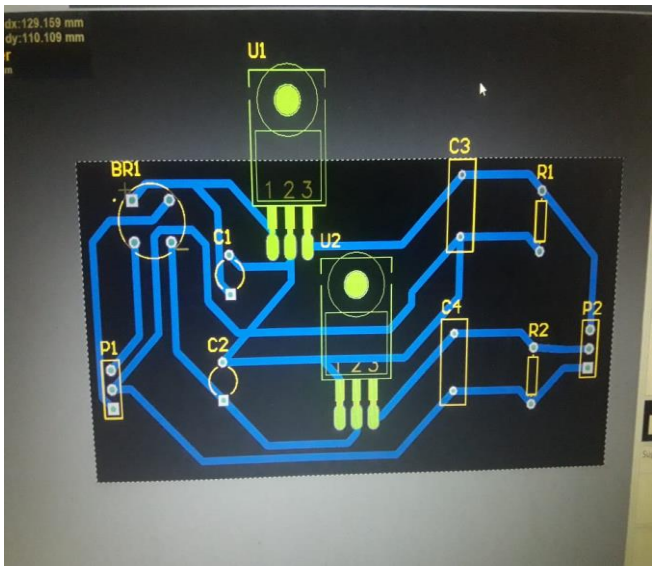
When we measured using pH probe, we could able to get only a small amount of voltage difference in millivolt range and so much of noise are added to that. So it was very hard to calculate the accurate pH value of solutions. Error percentage was high there. So we made a gain board as it is able to amplify the signal to a higher level in volt range. It is also giving an offset to replace the negative rail runs to positive to be given to the micro controller which has a dc range of 0-5V. Even though we check the output using different gain board stimulation, we used the gain board of using tl072 op amps as it is cheaper than the original and it is enough for this project. In our device, the gain was around. Even though we got the output in desired level, the readings are fluctuating because of the interruption of noise was significant.



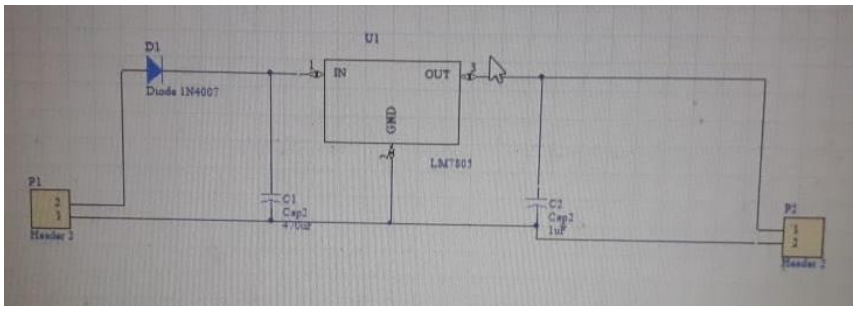
Circuits and PCB layouts

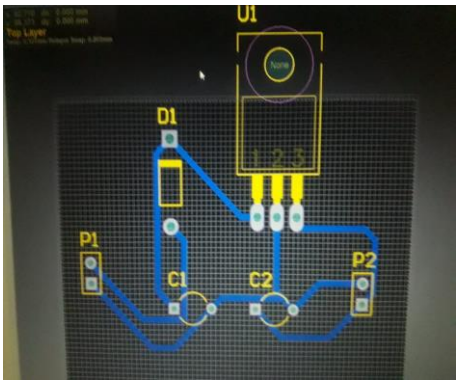
Power supply



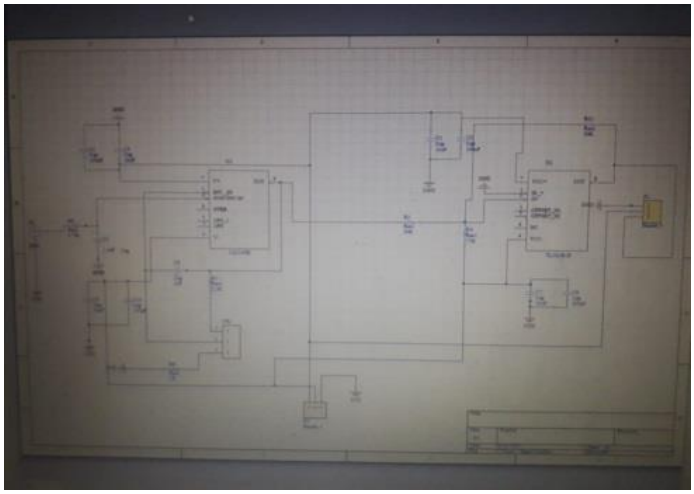


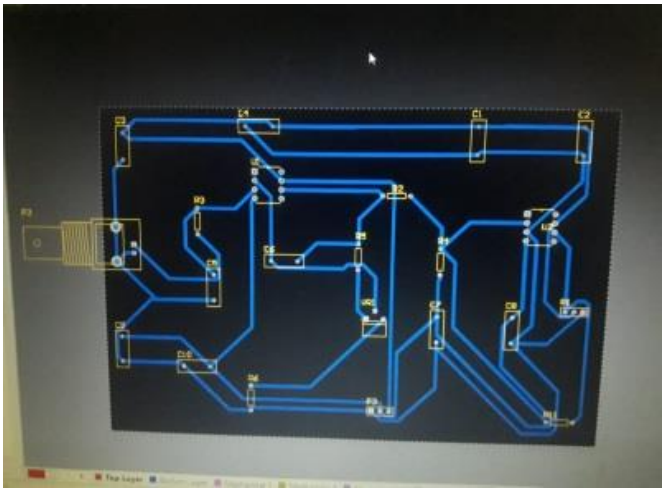
DC power supply





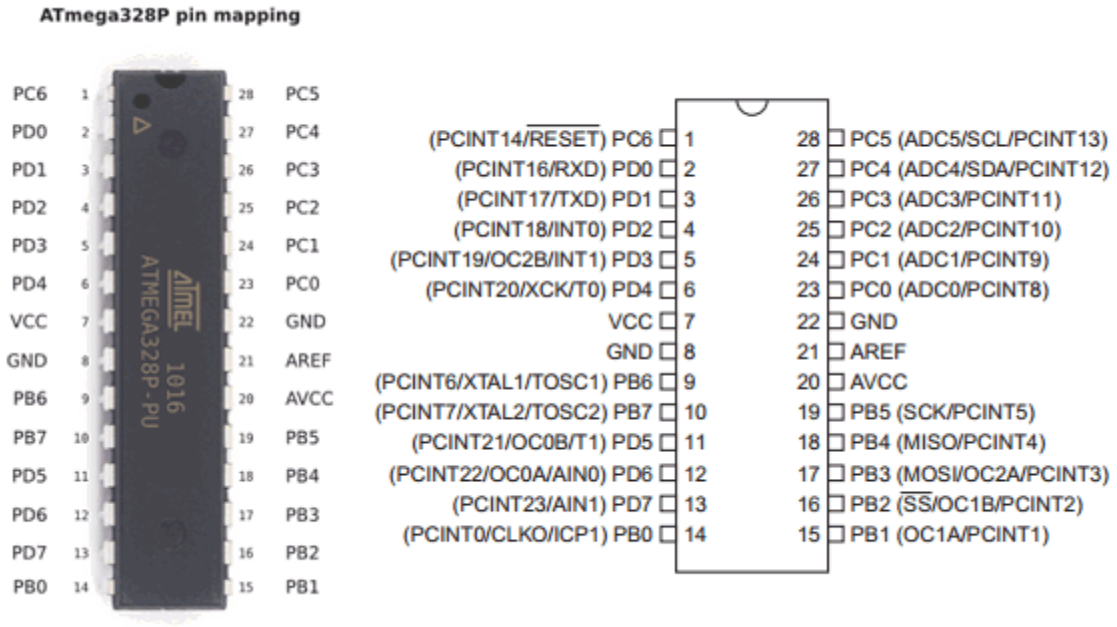
Gain board





Programming Base

We used Atmega328P as the microprocessor and Atmel studio 7 as the programing platform. Here the programming language used is C language.



Full Picture

Result of voltage difference which is gained by the pH probe, is converted into pH value using coding and it is straightly displayed on a 16x2 LCD screen. As we use the invertible op amps, we got the negative voltage. So that we use dc voltage supplies externally to get the positive output of voltage. Rather than this for the normal usage we gave AC power supply also. Microprocessor was powered by a power bank to reduce the risk of increasing further noise.

Calibration

The voltage difference we get from the two electrodes is a very weak voltage measured in millivolts. The meter converts this voltage to pH and display. To display the relevant pH for the corresponding voltage differences calibration is done. For that we use 3 solutions with known pH (more accurate when the number of solutions taken into consideration increases). Then by plotting the graph voltage difference versus pH value we can get the slope of the pH line or the least square line. Then assuming the meter is linear we can obtain the pH values of any solution.

The calibration can change when time goes on due to different reasons. Then the signal for the same pH value changes. Therefore a periodic calibration is required to get a reliable reading.

To prolong the life and accuracy of the electrode, it should be immersed in a specific solution called storage solution when not in use.

Results

- Reading of the pH meter was not much stable. This fluctuation from the original solution may happen due to the noise in the environment.
- We used pH known solutions for checking the accuracy.
- Main problem we faced when implementing the project was the output we obtain from the gain board gave a negative value with respect to the ground. As a solution we used a separate dc shift for the signal.

Solution	Actual pH	Measured pH
Tap Water	5	4-6
NaOH	2	1-3
Sulphuric	6	5-7

Discussion

The pH value we obtained from our pH meter fluctuates around the original pH value. The main purpose was to amplify the signal we obtain from the pH probe. In that case noise interferes a lot. So we had to add relevant filters to the gain board. With the gain board finally we amplified to the desired 0-5 V range with the minimum noise interference to the microcontroller. As a solution to the negative outputs we obtained from the gain board we applied an external dc power supply to shift the signal. With all these still the sensitivity and accuracy when compared with the actual pH was little different.

ACKNOWLEDGEMENTS

Even though it seems to be easy, there are so many problems we had faced to reduce the errors. But we could able to achieve our goal by the instructions and guidance from the professors, instructors and friends. Here we would like to thank Dr. Jayathu Samarawickrama for the guidance for the further modifications. And also very thankful to our instructor Mr.Heshan for giving as many information about pH meter and for helping us to do the project in correct way when we are struggling to overcome some problems like less amplifications, negative voltage output. Here I we also wish to thank our friends and seniors who helped to finish our project successfully.