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DEPARTMENT OF BASIC SCIENCES & HUMANITIES

ENGINEERING CHEMISTRY SELF-STUDY PROJECT REPORT

2ND SEMESTER 2018-2019

TOPIC: PPM METER USING MICROCONTROLLER

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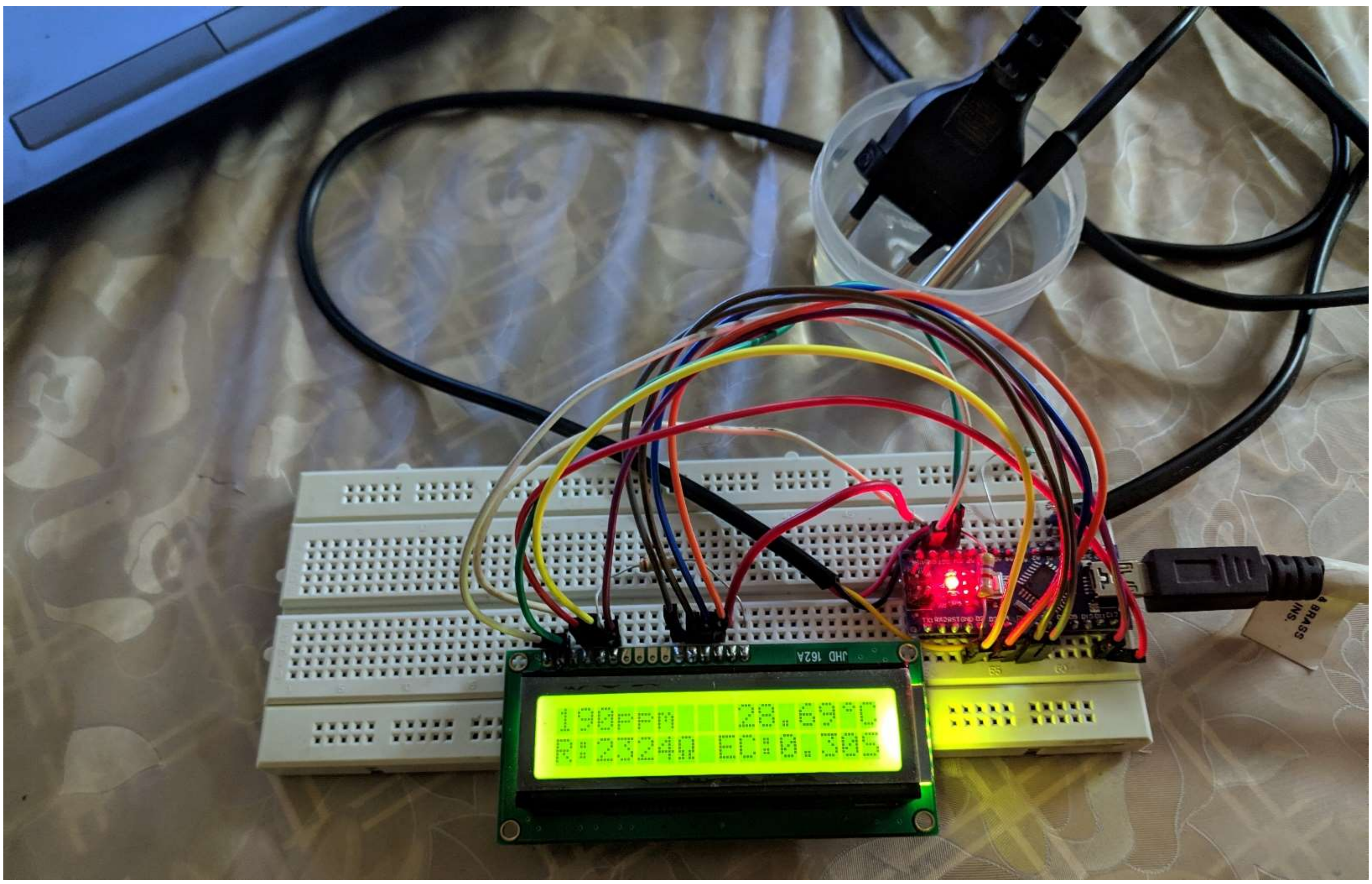
SECTION J

USN'S: 1NH18EC110, 1NH18CS189, 1NH18EC098, 1NH10EC120

PROJECT ON

PPM METER USING MICROCONTROLLER

WITH TEMPERATURE, RESISTANCE AND EC MONITORING USING A 16*2 LCD



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Introduction

This project uses the Arduino Nano as heart of the project, which is a microcontroller chip. It communicates between each part of the project and processes the input from the sensors and executes a program to give the output.

Using this project we can monitor the quality and temperature of water bodies continuously (24/7) and accurately.

It displays the output on a 16*2 LCD display as well as on the output screen of a computer. This data (ppm and temperature) could be further used for other aquaponics/hydroponics or water quality based projects. We have tried to recreate commercially available TDS meter and also adding a lot of other features to it. Our project refreshes the readings every five seconds and can run as long as required if the power input is provided.

Objective of the project

The objective of this project is to create a live water monitoring setup wherein we use technologies such as microcontrollers, sensors, C programming etc to display the ppm, resistance, electrical conductivity and temperature, all under an affordable price.

Materials Required

- Arduino Nano
- 2 pin EU plug
- DS18B20 Temerature sensor
- Bread Board
- Jumper Cables
- A few current limiting resistors
- 16*2 LCD display

These are all the things that we need, but in order to show the demo, a few more components are used:

- A laptop
- A comercially available TDS meter to check the accuracy ofour project.

What is hard water?

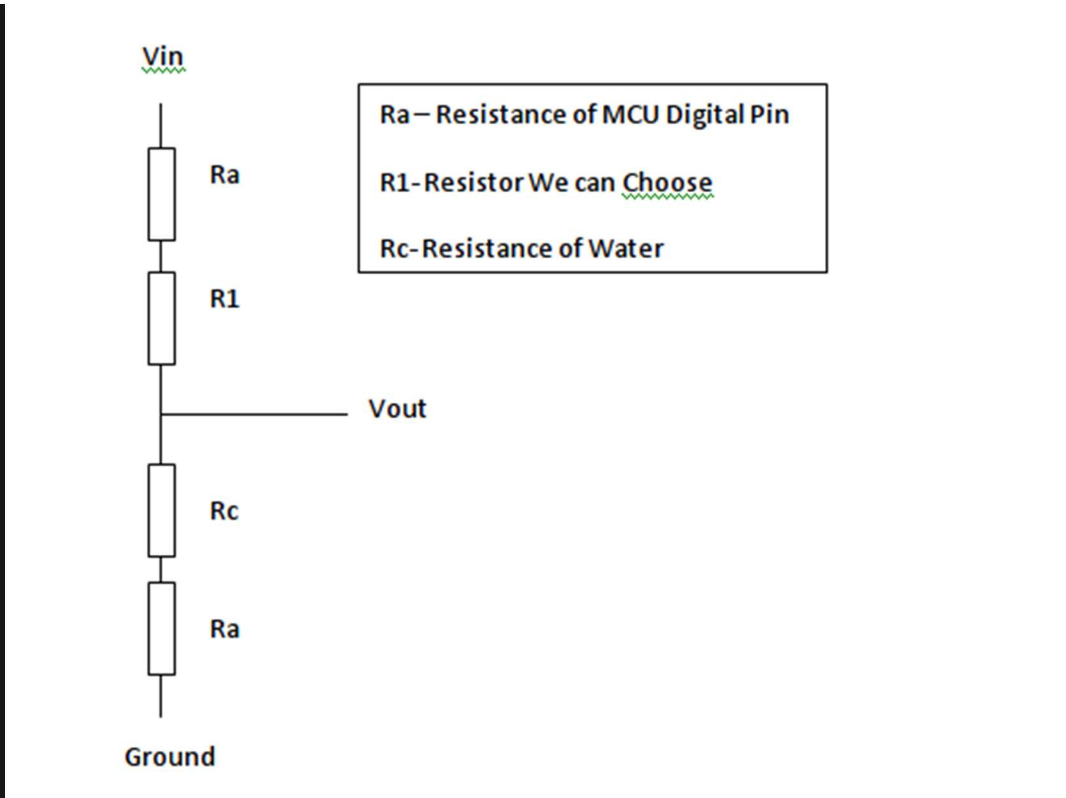
- Hard water is a common quality of water which contains dissolved compounds of calcium and magnesium and, sometimes, other divalent and trivalent metallic elements.
- The term hardness was originally applied to waters that were hard to wash in, referring to the soap wasting properties of hard water. Hardness prevents soap from lathering by causing the development of an insoluble curdy precipitate in the water; hardness typically causes the buildup of hardness scale (such as seen in cooking pans). Dissolved calcium and magnesium salts are primarily responsible for most scaling in pipes and water heaters and cause numerous problems in laundry, kitchen, and bath. Hardness is usually expressed in grains per gallon (or ppm) as calcium carbonate equivalent.
- The degree of hardness standard as established by the American Society of Agricultural Engineers (S-339) and the Water Quality Association (WQA) is:

Degree of Hardness	Grains per Gallon (gpg)	ppm (or mg/L)
Soft	<1.0	<17.0
Slightly Hard	1.0-3.5	17.1-60
Moderately Hard	3.5-7.0	60-120
Hard	7.0-10.5	120-180
Very Hard	>10.5	>180

• Operating Principal

- PPM is calculated from the EC of a fluid, EC is the inverse of the electrical resistance of the fluid. We are estimating the EC or PPM of a fluid by measuring the resistance between two probes [The plug pins] when the plug is submerged in the liquid of interest.

- Ec measurement needs to be done using AC or the liquid of interest is polarised and will give bad readings. This has got to be a great example of asking why instead of just accepting a statement as fact, it turns out we can take a very fast DC reading without suffering polarisation. meaning we can make a really cheap EC sensor.
- **Want to use it and dont care how it works? Skip to the main EC code and using the wiring diagram it will work.**
- **Temperature Compensation**
- Temperature has an effect on the conductivity of fluids so it is essential that we compensate for this.
- It is common to use a liner approximation for small temperature changes[1] to convert them to their equivelant EC at 25*C:
- EC25 = EC /(1 + a (T - 25))
- EC25- Equivelant EC at 25'C
- EC - Measured EC
- T- Temperature [Decgrees C] of Measurment
- a = 0.019 °C [Commonly used for nutrient solutions]
- **Deciding on Value of R1**
- //##
- //---------- Do not Replace R1 with a resistor lower than 300 ohms ------------
- //##
- We can change the Value of R1 in the voltage divider to change the range of EC we want to measure. Below is the Equivalent Voltage divider circuit.



- **Ra**
- Ra the resistance of the digital pins is not stated in the data sheet instead we need to pull it out from a graph.
- Going off the graph on page [387] of the atmel 2560 Data Sheet "Figure 32-25. I/O Pin Output Voltage vs. Source Current (VCC = 5V)"
- V=IR
- Ra= V/I [From Figure] V=0.4 I=1.5e-4 **R=25 ohms** estimated
- **Rc**
- Rc will change with EC [PPM] of the measured fluid. we will calculate the maximum and minimum values we expect to see for the range of fluids we wish to measure taking into account temperature changes and the cell constant K. [We will estimate K to be 3 for the plug probe, estimate from previous tests]
- EC = EC25*(1 + a (T - 25))
- R=(1000/(EC*K)) +Ra

- Min temp=0 [we are’nt going to care about EC if the pond is frozen]
- Max Temp = 40 *C [I doubt a pond should be above this]
- Minimum EC 25=0.3 EC= 0.3*(1+0.019*(0-25) Min EC= 0.16 S/sm
- Maximum EC 25= 3 EC= 0.3*(1+0.019*(40-25) Max EC = 3.9 S/cm
- Min Resistance = 1000/(MaxEC*K)+25 = 1000(3.9*2.88) =114 ohms
- Max Resitance = 1000/(MinEC*K)+25 = 1000/(0.16*2.88) = 2195 ohms
- **R1**
- Now we have enough information to calculate a good value for R1 to get the best resolution over our intended measuring range. We could sum it all up mathematically and differentiate to find the peak, but that hurts my head so I just did a quick excel spreadsheet for the Voltage divider for the EC I expect to see:

R1 ohm	V-Drop @114 ohm	V-Drop @ 2195 ohm	Vout Range
300	1.30	4.36	3.06
400	1.06	4.19	3.13
450	0.97	4.11	3.14
500	0.89	4.03	3.14
550	0.83	3.96	3.13
600	0.77	3.89	3.12
650	0.72	3.82	3.10
700	0.68	3.76	3.08
750	0.64	3.70	3.05
800	0.61	3.63	3.03
850	0.58	3.57	3.00
900	0.55	3.52	2.97
950	0.52	3.46	2.94
1000	0.50	3.41	2.91

-
-

As we can see we get the largest difference using a value for

R1 of 500 ohm, I only had 1Kohm to hand so I will have to live with a little less range.

- So we chose a 500 ohm resistor
- EC – Range /Voltage Range * (5/ADC steps)
- (3.9-0.16)/3.14 * 5/1024 = 5.8e-3 resolution so that is a resolution of 0.0058
- To put this is PPM [Tranchen [Australia] PPMconversion: 0.7] this is a resolution of **4ppm.**
- Much more than we need for aquaponics or hydroponics.
- If you want to measure the quality of drinking water you will need to calculate the expected Ec values and increase R1 accordingly.

Result

The project was successfully created and works as expected. We fullfilled the objective of theis project that was to create a,

“Live water monitoring setup wherein we use technologies such as microcontrollers, sensors, C programming etc to display the ppm, resistance, electrical conductivity and temperature, all under an affordable price.”

The whole cost of the project was well below a thousand rupees. This setup was built on a breadboard which means it is temporary. Creating a permanent setup by soldering on a perf-board or

a dot PCB would hardly increase the cost by a hundred rupees.

Bibliography

- **Arduino Nano Datasheet**

  https://www.arduino.cc/en/uploads/Main/ArduinoNanoManual23.pdf

- **DS18B20 Datasheet**

  https://datasheets.maximintegrated.com/en/ds/DS18B20.pdf

- **Project Idea / Reference**

  https://hackaday.io/project/7008-fly-wars-a-hackers-solution-to-world-hunger/log/24646-three-dollar-ec-ppm-meter-arduino

- **16*2 LCD Datasheet**

  https://www.sparkfun.com/datasheets/LCD/ADM1602K-NSW-FBS-3.3v.pdf

- **General Reference from:**
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  - Electronics Prescribed textbook 1st PUC and 2nd PUC by Deprtment of Pre-University Education

- **Basic concepts from:** https://www.youtube.com/user/greatscottlab