LINEARIZATION OF SENSOR USING MICRO CONTROLLER

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ABSTRACT

Rectification of Resistance Temperature Detector by using different approximation techniques such as Least Square Approximation method(LSM) and Group Average Method (GAM). After comparing these two methods, the more linear method is implemented to rectify the RTD using arduino interface. The practical and the theoretical values are also compared through these techniques and the objective of rectifying the RTD can be exactly achieved by removing its non-linear characteristics.

Keywords: Linearization, Callender Van Dusen Equation, Group Average Method, Resistance Temperature Detector,Least Square Approximation Method, Thermal Chamber.

I. INTRODUCTION

The objective of this paper is to rectify the nonlinearity of the Resistance Temperature Detector(RTD)[1]with the help of different approximation technique using MATLAB and Arduino platform. Arduino is an untied source microcontroller which can be easily programmed, erased and reprogrammed at any instant of time. Based on simple microcontroller boards, it is an open source computing platform that is used for constructing and programming electronic devices and acts as a mini computer by taking inputs and controlling the outputs for a variety of electronics devices. It receives and sends information over the internet with the help of various Arduino shields and uses a hardware known as the Arduino development board and software for developing the code known as the Arduino IDE (Integrated Development Environment).

On the other hand, RTD or the Resistance Temperature Detector is a temperature sensor which measures temperature using the principle that the resistance of a metal changes with temperature[3].As the temperature of a metal increases[10], the metal's resistance to the flow of electricity increases. Similarly, as the temperature of the RTD resistance element increases[9], the electrical resistance, measured in ohms (Ω), increases.

Adaptive filtering structure uses LMS algorithm to find its coefficients that relate to generate the least mean squares of the error coefficient. It is a stochastic gradient method which does the adaptation of the coefficients based on the error at that time.

LMS introduces an iterative process that results in consecutive corrections of weights to achieve minimum mean square error. This MSE(Mean Square Error)helps to evaluate the optimum performance of filtering with the variation of adaptive coefficient.

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II. NOTATION

The notation used throughout the paper is stated as

C2=Resistance at temperature t(o c)
C1=Resistance at temperature t. (where t=0oc)
T=Temperature in degree Celsius
i, j,k=Callendar-Van Dusen constants
n =n no of inputs & respective outputs
u=Gradient
v=Offset
$\sum_{i=1}^{n}(pi)$=voltage
$\sum_{i=1}^{n}(qi)$=Temperature .
E =Error

III. PROBLEM FORMULATION

OBJECTIVE FUNCTION

For defining the relationship between the resistance and temperature, Callender Van dusen Equation[8] plays an important role. The equation is discussed beneath.

If

C2 = Resistance at temperature t(o c)
C1= Resistance at temperature t. (where t=0oc)
T = Temperature in degree Celsius
i, j, and k = Callendar-Van Dusen constants
then we get ,
C2= C1[1+i*T +j*T2 +k*T3* (T - 100)]

Callendar-Van Dusen equation can be described below:

For Temperature: 0o ≤T ≤661oc ,
C2= C1[1+i*T +j*T2 +k*T3] ; for T≥0oc
C2= C1[1+i*T +j*T2 +k*T3* (T - 100)] ; for T≤0oc

Hence the problem of non linearization is becoming visible in this equation which is treated as the equivalentof the transmitter sensor using the RTD curve to get the temperature value.

LSM METHOD

"Least squares" describes the solutions which minimizes the sum of square value of the residuals of each particular equation. The least square approximation method is a standard way in regression analysis which is used to solve the systems having more unknown equations..The most important application is in value fitting. The least-squares sense minimizes the sum of squared residuals i.e.it is defined as the difference between a practical value and the fitted value. Consider the data set falls on this equation,

A straight line can be expressed as

P=uq+v .... (i)

Let, number of points = n i.e. "n" no of inputs & respective outputs are taken.

Where "u "= Gradient

" v" = Offset.

Now, the equation can be derived as-

$\sum_{i=1}^{n}(p_i) = u\sum_{i=1}^{n}(q_i) + n * v$ .... (ii)

Where $\sum_{i=1}^{n}(pi)$= the voltage Part.

$\sum_{i=1}^{n}(qi)$ =the Temperature Part...

If the equation is multiplied by"n" with "v", due to "n"-th number of iteration.

By calculating the value of "u" & "v"[5] using C programming, set of inputs &outputs can be plotted on graph using MATLAB platform and shows that-

The Error ,

E= $(p_1\text{-}f(q_1))2 + (p_2\text{-}f(q_2))2 + (p_3\text{-}f(q_3))2$ +.......+n .... (iii)

The equation can also be written as-

Error =$\sum_{i=1}^{n}(p_i - f(q_i))2$ .... (iv)

Therefore,

F(q)= uq+v .... (v) [Generalise form equation (i)]

$F(q_i) = u\ q_i + v$ .... (vi)

After putting the value, we find-

Error= $\sum_{i=1}^{n}(p_i - (uq + v))$ .... (vii)

Which can be solved as,

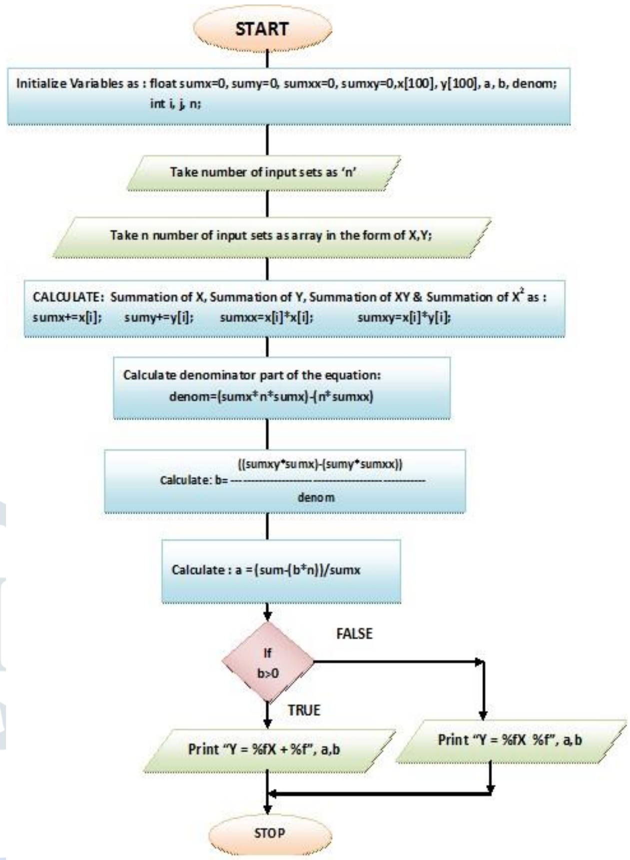
$\frac{d(error)}{db}=0 \rightarrow \sum p_i = u\sum q_i + v * n$ .... (viii)

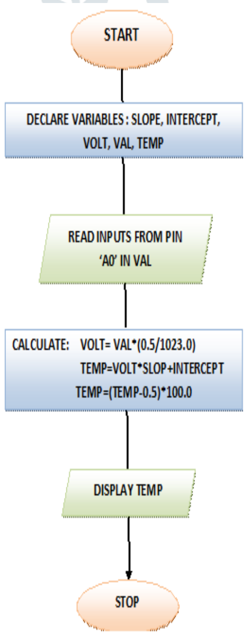
And

$\frac{d(error)}{db}=0 \rightarrow \sum p_i q_i = u\sum q_i^2 + v * .n\sum q_i$................ (ix)

After solving this two equation (eqn. No. (viii) and eqn. No.(ix)[2], We can find the mathematical value of "u" & "v" programming, sensing and controllingthe objects. The Arduino can interact with a large number of outputs by reacting to sensors and inputs.

IV FLOW CHART



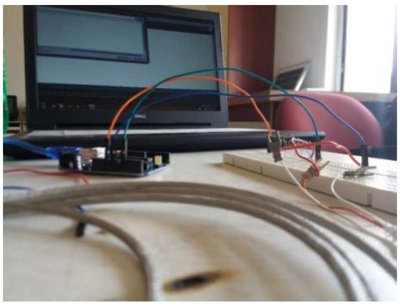


V EXPERIMENTAL TABLE

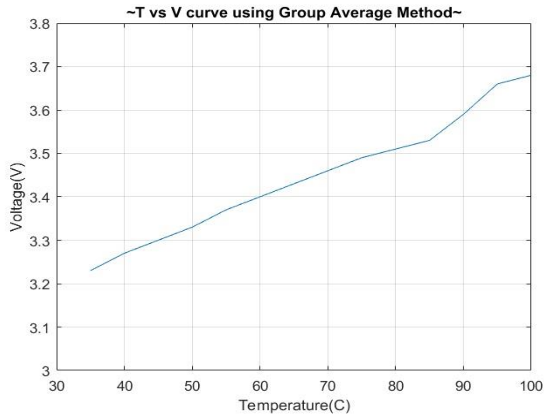
HARDWARE ANALYSIS VS SOFTWARE ANALYSIS

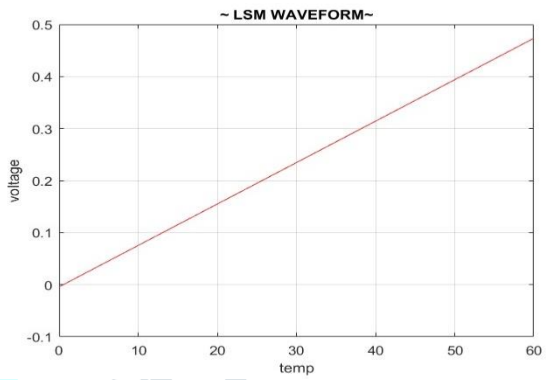
TEMP.	VOLT.	ACTUAL TEMP OF THE THERMOMETER	TEMP. AFTER RECTIFICATION
35	3.23	35	35.14
40	3.27	40	40.09
45	3.30	45	45.15
50	3.33	50	50.21
55	3.37	55	54.94
60	3.40	60	60.19
65	3.43	65	65.22
70	3.46	70	70.08
75	3.49	75	74.98
80	3.51	80	80.31
85	3.55	85	85.12
90	3.59	90	90.29
95	3.66	95	95.02
100	3.68	100	100.01

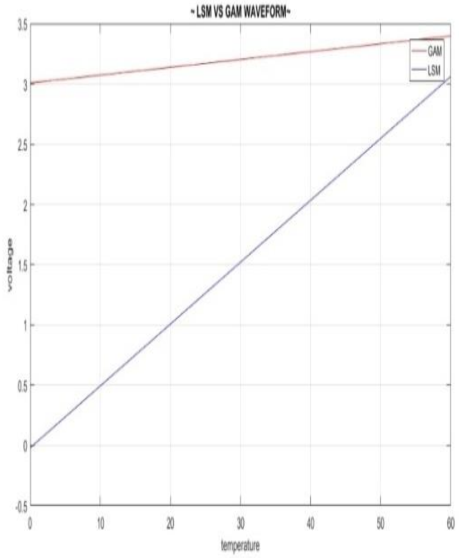
VI.EXPERIMENTAL PICTURES



VII..SIMULATED OUTPUT







VIII.CONCLUSION

The aim of this paper is to apply different approximation technique using MATLAB & arduino platform, we can remove & rectify the nonlinearity of RTD. The values of different temperature can be verified through this process. The agenda of this paper is to provide the solution of the nonlinearity of sensor by comparing practical and theoretical values of temperature.

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VII. REFERENCES

[1] Fabric Nanocomposite Resistance Temperature Detector by Nathaniel J. Blasdel ,Evan K. Wujcik , Joan E. Car-letta ; Published on 23 July 2014 by IEEE.

[2]http://www.jms-se.com/rtd.php.

[3]https://www.investopedia.com/terms/l/least-squares-method.asp.

[4] http://en.wikipedia.org/wiki/Resistance_thermometer

[5]http://www.idc-online.com/technical_refer-ences/pdfs/instrumentation/Temperature_Sensors.pdf.

[6] Numerical Methods by B.S Grewal

[7] http://aca-demic.sun.ac.za/mathed/174WG/LeastSquares.pdf.

[8]https://en.wikipedia.org/wiki/Callendar–Van_Dusen_equation

[9] http://www.thermometricscorp.com/3-wire-rtd

[10]http://www.instrumentationtoday.com/resistance-tem-perature-detector-rtd/2011/09/

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