Design of Linearizing Circuit for Thermistor

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Abstract: *A design of circuit which is used for linearization of the NTC thermistor is proposed. The circuit is basically a combination of a logarithmic amplifier and an analog divider. It is capable of producing a linear voltage output with temperature for virtually all commercially used thermistors. The linearized circuit is based on the use of a logarithmic amplifier. The basic idea is to logarithmically linearize the input-output relationship of NTC thermistor sensor. A linear relationship is obtained between the temperature of a thermistor and the voltage output from an electronic circuit into which the thermistor is incorporated. The scheme provides a low cost simple alternative technique of linearization, linearizing the NTC thermistor voltage output signals to a high accuracy.*

Key Words**: LCD display , AVR ATMega16 , Buzzer, IC 7805, Relay circuit, Transformer , Temperature sensor.**

1. INTRODUCTION

The temperature measurement application area is very broad and varies from basic measurements of ambient temperature to very complex measurements used in advanced space or laser technology. In order to select an appropriate temperature sensor for use, certain basic requirements must be discussed. All of them are the calculation accuracy and resolution, sensor measurements, facility for mounting and interfacing sensors with tools for instrumentation, the low cost of the sensor itself as well as its configuration phase. Research shows that NTC thermistors provide the most suitable sensor characteristics for most temperature sensing models[1]. An NTC thermistor is a sensitive thermal resistor that has a negative temperature coefficient, i.e. its power decreases with increased temperature. In addition, owing to the cost-effectiveness, roughness, high-temperature resilience and precise design, strong tolerance from electric noise and the large range of temperatures extendable from 80 ° C to 300 ° C[2].The NTC thermistors are also extremely non-linear in terms of characteristics and advantages. To achieve the digital representation of the measured temperature, a voltage signal proportional to the temperature must be given. Because of that, the thermistor has a continuous voltage or current source mounted in a circuit. To achieve the digital representation of the measured temperature, a voltage signal proportional to the temperature must be given. Because of that, the thermistor has a continuous voltage or current source mounted in a circuit. The output circuit Voltage is not related to temperature linearly because of a non-linear relationship between thermistor resistance and temperature. The linearisation of this relationship between voltage and temperature has been an problem for many years . As a result a significant variety of linearising approaches have been suggested. In that way a adequate output of a measuring system is provided with the probability of choosing an acceptable linearization process.

2. LITERATURE SURVEY

2.1 Linearizing of NTC thermister characteristics using serial resistive voltage divider :

Network resistive voltage divider comprising the thermistor with constant non-standard voltage source is the simplest linearization circuit of the NTC thermistor. Thermistors have a distinct advantage from other high sensitivity temperature sensors. Thermistors, though, come at a cost. The resistance is clearly not linear to the temperature curve. However, at least over a reasonable temperature spectrum, a basic procedure straightens the arc in the curve. Because the sensitivity of the sensor reduces, the importance of a linear response is generally worth the costs. [1].

2.2 The two-stage piecewise linear ADC linearization circuit:

The linearization of the NTC thermistor is introduced using a serial-parallel resistive tension divider and a two stage PWL ADC. The goal was to minimize the nonlinearity of the NTC thermistor, i.e. to improve the precision of the NTC thermistor. The purpose of this particular linearisation circuit combination. At the stand-alone resistive tension divisor output, the almost linear voltage is obtained. The linear flash ADC propagation function is a linear parts-wise approximation of the inverse function to the temperature dependence of the quasi-lineary tensions. This two-stage PWL ADC consisting of piece-wise linear flash ADCs is used for further linearisation of the quasi linear voltage. In other words, the piecewise linear flash ADC is achieved for linearization, which is why its resolution has the greatest impact on nonlinearity reduction. The absolute value of the difference between the measured temperature value and the actual temperature values was greatly decreased relative to the case in particular where only the parallel resistive voltage divider was used. The PWL ADC is used in two stages to linearize all forms of sensors. Depending on the temperature range and the ADC flash resolution, the residual non-linear error can be reduced to 0.001oC. The key benefit of the proposed modern linearization circuit is simultaneous linearization and numerisation of temperature control results of the NTC thermistor transition function. In other words, the serial parallel voltage division system using an NTC thermistor provides the option of using a normal voltage source compared with the conventional voltage division system, which is simpler but requires a non-standard voltation source. In other terms, there are two different and difficult operations that are used on the same system, offering savings in time, power and costs of output. By enhancing the resolution of the two flash ADCs, measuring accuracy can be increased significantly. The only constraint on the increase in resolution illustrates the difficulties of measuring the break voltages and adjusting the resistor values creating the linear flash ADC resistive voltage divider. These voltages are described. In line with the transmission sensor function, linearization is needed[2].

2.3 Linearization of NTC Thermistor Characteristic Using Op-Amp Based Inverting Amplifier :

A low cost linearizing circuit is built, which uses operational amplifier to position the NTC thermistor in a commonly used inverting amplifier circuit. The performance of the unit is verified experimentally. A linearity over 30 C -120 C is obtained of approximately 1 proportion. When used over a much smaller time a slightly greater linearity of 0.5% is obtained. The benefit of the device can be distributed over a wide spectrum by merely changing the feedback resistance. Simplicity of configuration guarantees improved efficiency and thereby decreases output loss by reducing the cumulation of drifts in different components and instruments of the circuit. The linearity with the proposed circuit, slightly stronger than any of the other researchers have recently reported, may be achieved. The simplicity of the method provided implies that the problem of linearizing the thermistor characteristics is a very cheap solution. The naivety of the circuit confignment means better reliability and therefore greater stability. The planned circuit can be conveniently used for the low-cost initial analog linearizer where processor-based systems are used and any software-based approach will further boost linearity after digitalisation of the output from the analog circuit. Non-linearity then resistance vs. temperature characteristics. Unsuitable for a wide temperature range. Very low excitation current to prevent self-heating.

3. PROBLEM DEFINITION

Thermistors have a high sensitivity which makes them ideal for various applications, but they show a highly nonlinear relationship between resistance and temperature which is exponential in nature. Such nonlinearity is an important issue and a lot of work has been done to address it. Thermistor linearization over a large temperature range is a challenge in many situations. It eventually affects device specifications such as temperature accuracy, power, and memory capacity.

4. OBJECTIVES

- Become familiar with the linearization techniques.
- Linearize your circuit to meet the desired requirement.
- Analyze the linearity of the circuit diagram.

5. WORKING

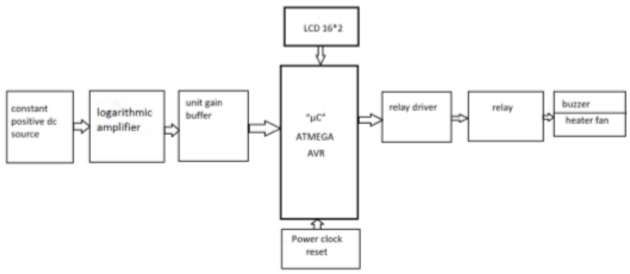

Fig.1: Circuit Diagram

Microcontroller :

In the Block diagram we have used ATmega16 Microcontroller. ATmel is a company and 16kb is memory.The ATmega16 uses RISC architecture so it is stable and also the advantage is that its speed is faster also it has 16kb memory .The ATmega16 has built in ADC, the ADC resolution is of 10 bit so due to which we can measure the temperature easily. This Microcontroller is 40 pin device.

Log Amplifier:

Log amplifier is a linear circuit in which the output voltage is the natural logarithm of the input being constant times. A log amplifier's simple output equation is v Vout = K ln (Vin / Vref); where Vref is the normalization constant, and K is the scaling factor. Log amplifier sees a great deal of use in electronic fields such as multiplication or division (they can be achieved by adding and subtracting operand logs), signal processing, computerized process control, compression, decompression, RMS value detection etc. There are essentially two versions of the log amps: Opamp-diode log amplifier and Opamp-transistor log.

Unity Gain Buffer:

A unity gain buffer (also known as a unity gain amplifier) is an op-amp circuit with a voltage gain of 1.This means that the op amp does not supply the signal with any amplifications. The reason it is called a unity gain buffer (or amplifier) is that it has a gain of 1, which means there is no gain; the voltage output signal is the same as the voltage input. So, for example, if 10V goes as input into the op amp, 10V comes out as output. A unity gain buffer functions as a true buffer and does not send the signal amplification or attenuation.

Relay:

A Single Pole Double Throw Relay (SPDT) is a high performing SPDT. The Relay consists of one line, one terminal, one terminal that is usually closed, and one terminal that is usually open. The traditional terminal and the usually closed terminal are continuous when the relay's coil rests (not energized). SPDT relays have a single Type C array, interrupts before any communication is made or transferred. This implies that the terminal is linked to each other, rarely at the same time. A relay has a total of five terminals, two of which are for the coil.

LCD:

An LCD is an electronic display module that creates a transparent image of fluid crystal. The 16 by 2 LCD panel is a very basic module used widely for DIYs and circuits. A panel of 16 digits in 2 such lines converts o by 16 characters per line. Every character in this LCD appears in a matrix of 5 à7 pixels. The LCD monitor shows the measured element temperature, which the microcontroller will determine. CMOS technology makes the device perfect for phone , smartphone and other low-power battery guidance.

Relay Driver:

The eight NPN Darlington attached transistors are suitable for interfacing low logic, device, industrial and consumer circuitry (such as TTL, CMOS or PMOS / NNMOS) and high current / voltage specifications for lamps, relay, press hammers or similar loads. Both systems have open-collector outputs and free diodes for immediate removal.

6. WORKING

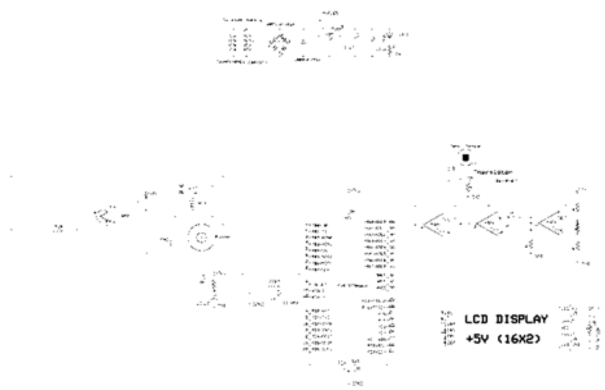

Fig.2: Circuit diagram

In the circuit diagram we have used Microcontroller. ATmel is a company and 16kb is memory.The ATmega16 uses RISC architecture so it is stable and also the advantage is that its speed is faster also it has 16kb memory. The ATmega16 has built in ADC the ADC resolution is of 10 bit so due to which we can measure the temperature easily. This Microcontroller is 40 pin device. It has two power supply pin no.11 and pin no.31 to which 5v is given at the input pin no.10 and pin no.30 are ground pin both the pins are grounded. The Crystal Oscillator is connected between pin no.12 and pin no.13.This oscillator is of 11.0592 MHZ. The two capacitor of 27 PF are used to start the oscillations of crystal. Pin no.9 is reset pin, It is also called as power on reset. When the power supply is turned on one pulse will go to the controller due to which the controller will get reset so our program will start from zero location. Port A, Port B, Port C, Port D are all 8 pin Bi-directional ports. Port A has built-in ADC. The sensor is connected to port A. In this circuit we have used logarithmic amplifier for achieving Linearization. In this along with the feedback element the logarithmic capacitor is used to compensate the distortion at the output. The opamp LM324IC is connected to the port A of microcontroller. The thermistor of this IC is of 10K ohms NTC. Due to this circuit the voltage will be developed 0 to 5V DC. One we get the digital output it will be displayed on LCD. The LCD display of 16*2 is connected to port C. The 5V is given to Vcc and ground pin is grounded. Also there are 3 control pin RS, Read/Write and enable out of the RS and enable pin are given to the controller. In LCD we have 4 data pins so the 4 bit data is send twice so based on that whatever output we get is converted to10 bit digit using ADC and that will be displayed on Lcd. In case our output is less than or greater than desired output than that output value is given to the transistor from port B as a relay driver to which we have connected the buzzer. If the temperature exceeds above 40 degree than the buzzer will start buzzing. In this way the overheating of the thermistor can be avoided. Therefore a good linearity is obtained over a wide range of temperature.

7. RESULTS

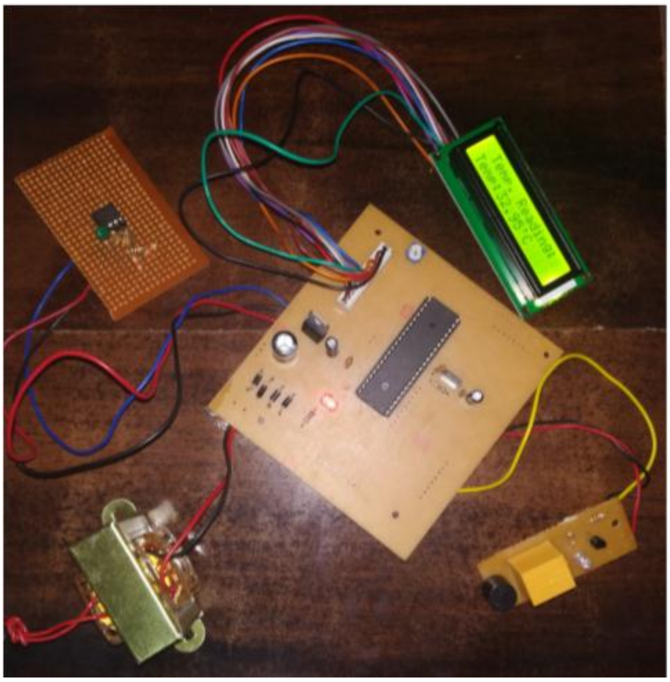

Fig.3: Model of Thermistor Linearization

Fig.4: Temperature Reading on LCD

TEMPERATURE(C)	VOLTAGE(V)
28.0	1.7
33.2	1.8
38.4	1.9
43.6	2.0
48.8	2.1
54	2.2

Fig.5: Reading on LCD

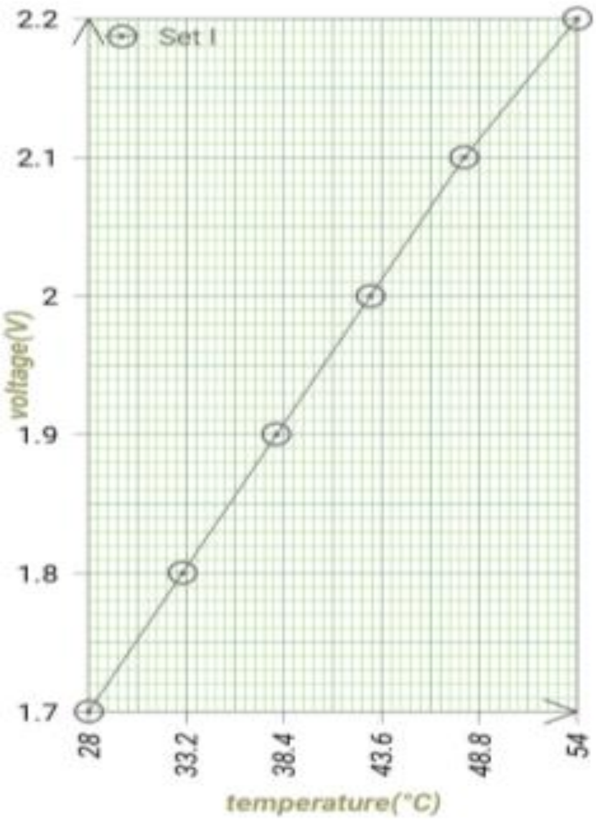

Fig.6 : Final Result

8. CONCLUSION

In this project two have successfully designed and developed linearization circuit for NTC thermistor. The linearization circuit generates linear voltage variation with a difference in the input temperature. The temperature of the thermistor is modified by means of the heater and the voltage across the changing temperature is determined by means of the voltmeter. Accordingly the temperature versus voltage graph is plotted which is linear. Also if the temperature exceeds above 40 degree than the buzzer will start buzzing. In this way the overheating of the thermistor can be avoided. Therefore a good linearity is obtained over a wide range of temperature.

9. FUTURE SCOPE

Linearization errors may be the primary cause of error in a limited temperature process. There are, however, a number of additional sources of error, including part tolerances and temperature drift and noise errors, which can contribute to the overall device error. Note that most of these errors are mitigated by the use of ratiometric. It is recommended to use the TMP61 Device Parameter Simulator tool to decide acceptable design compromises. The Thermistor family TMP61 provides a typical temperature sensitivity of 0.6 percent per K at 25 ° C. The TMP302 IC temperature transfer is a good alternative to discrete thermistor deployments for thermal safety applications that require guaranteed accuracy. The TMP302 provides button configuration and hysteresis. The optical temperature sensor TMP117 achieves the maximum sensitivity of ±0.1 ° C without external modification or linearization for applications of high system accuracy. The weak calm supply current around the working temperature limits the self-heating of these IC sensors. For the future, IC designers should be able to integrate the parts into a single IC for temperature control using a thermistor.

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11. BIOGRAPHIES

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