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Conversion of Thermal Energy to Electrical Energy using NTC

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Abstract

The basic aim of this paper is to depict the process by which temperature changes in the resistance of NTC can reflect in the output voltage which further can be used to produce various range of voltages. The output is connected to a siren circuit indicating whenever there is an increase in output voltage beyond certain value, the siren rings.The output is also connected to a comparator circuit for further analyisis of the amount of voltage produced. Thus with effective utilization of this circuit, it can be used in recovery of waste heat in industries, to generate power in geothermal heat and from the thermal gradient in sea (OTEC), generator driven by Solar energy or in pumps which are continuously driven by heat. There is variety of applications of this circuit model like temperature measurement and regulators. We can utilize the waste heat which is generated in various industrial processes in generating high output voltage by varying the temperature across the thermistor.

Keywords: Thermometry,NTC,geothermal heat, thermal gradient, OTEC, Solar energy.

Introduction

Modern Generation Electronics and Communication Engineers are discovering that thermometry is the new area to deal with in day to day applications.We need a lot of energy for our daily activities,therefore it is of prime importance to save as much of energy as we can and extract renewable sources of energy in all possible ways. One way to do this is to use Sun's heat in generating voltage and power in various industrial and household applications.Generally, for temperature sensing there are two methods which are used widely, one of them is Negative Temperature Coefficient of resistance (NTC) which is used in this paper. The second method is by using output IC voltage sensor. The paper describes the manner in which we can produce and detect voltages across a 741 IC by varying the resistance of a NTC resistor. The decrease of resistance is done by increasing the temperature of the thermistor, finding the source of this in Solar or waste heat in Industries. A NTC resistor value decreases as there is an increase in temperature of the surrounding.

A new technique to linearize the temperature-frequency relationship of an astablemultivibrator using one thermistor was proposed. The center frequency can be adjusted at any set frequency by an adjustable resistance. Furthermore, the oscillation frequency is not affected by the change of supply voltage [1].

An improved and inexpensive circuit using a thermistor in a logarithmic network is also presented whereby it is possible to realize a linear temperature conversion over a wide dynamic range with an output which is independent of fluctuations in ambient temperature. Test results are given to support the theoretical conclusions. The attractiveness of the scheme lies in its simplicity and the fact that the circuit can be assembled easily by using inexpensive off-the-shelf components [2].

Thermistor Multivibrator as the Temperature-to-Frequency Converter and as a Bridge for Temperature Measurement was proposed where The symmetrical multivibrator, one timing resistor of which is replaced by a network consisting of a thermistor and passive resistors, is analyzed. The circuit represents at the same time a linear temperature-to-frequency (T-f)

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converter and a multivibrator bridge (MB), both having the same linearity range at any thermistor network configuration. When the balancing state is reached at an inflection point, the sensitivities of the converter and the bridge are the same. The MB has higher sensitivity than the Wheatstone Bridge (WB) and can be balanced independently of the inflection point in the wide range. The converter and bridge performances with practical thermistor transducers are analyzed theoretically and numerically[3].

In this paper, a method is designed by which the waste heat generated during the industrial applications can be used to convert it to voltage by varying the resistance of the thermistor. The voltage is generated from the change in the temperature of the surrounding environment resulting in production of useful voltage.

Thermistors are easily available and user friendly sensors used for sensing temperature and also controlling the output voltage generated. This technique can be further utilized in different applications for sensing the temperature range, Power output from them and temperature indicators.

Generally thermistors are preferred over others because it produces reasonable sufficient output voltages which then can be used in driving other circuits and in variety of applications. Thermistors are not used for measuring high temperatures, but in normal operating temperature range where they work most efficiently. These are temperature sensitive resistors which vary with temperature, a Negative Temperature Coefficient resistor value decreases with increase in temperature and vice versa. Temperature and Resistance are inversely proportional to each other in NTC resistor. Thermistor is generally constructed of a typical semiconductor material whose resistivity is temperature dependent.Thermistors represent a convenient and reliable method of temperature measurement. When the thermistor is used within a suitable bridge, the change in its resistor value is significant and it considerably affects the output voltage. Thus by using a suitable bridge along with the NTC resistor, it can be applied in many productive applications. The change in output voltage with respect to temperature can be made linear by choosing a particular set of resistor values but generally it's non-linear and the response curve varies with different types of thermistors.

Circuit Design

The basic circuit operation is of temperature to voltage conversion. Due to temperature fluctuations in the surrounding, there is a change in resistance of the thermistor which in turn leads to change in the output voltage. In the circuit, a negative temperature coefficient resistor is used whose resistance value increases as there is a decrease in temperature of the surrounding. The overall circuit is divided into two halves, one is the general temperature to voltage converter circuit and other is the siren circuit. The output is then send to the Window comparator circuit for further analysis of the output voltage. The circuit consists of a closed loop 741 IC op-amp, where in the inverting terminal a potentiometer and few resistors are connected to vary the inverting input to the op-amp from a DC 12V supply.The inverting terminal is connected to a bridge of resistors where a thermistor is also connected. If the temperature of the thermistor increases, there is a decrease in the resistance of the thermistor. Now due to the decrease in the resistance of the thermistor, there is a decrease in the voltage V(-) of the inverting terminal. The general output equation of this basic circuit is given by,

$$V_{out} = 6.8(V^+ – V^-)$$

Where,
V^+ is the non inverting input voltage
V^- is the inverting input voltage
The gain of the circuit expressed as (R_f/R_1) is 6.8 with R_f=680kΩ and R_1=100kΩ.Now when there is a decrease in resistance leading to decrease in inverting terminal voltage, there is increase in the output voltage according to the above equation.The 4 resistors (including pot) on the left side form a resistance bridge circuit.The 470Ω resistor and zener form a shunt voltage regulator to minimize the influence of variations in the 12V power supply. The operational amplifier and the remaining resistors make up a classic differential amplifier that measures the voltage difference between the mid-points of the bridge.Virtually any operational amplifier may be used. The 1nF capacitor provides frequency compensation for the op amp to prevent oscillation. Most op amps have an internal capacitor for this function. The 100nF capacitor slows down the response of the circuit. The RC time constant = 680kΩ * 100nF = 68mS. Fast response is unnecessary because temperature variations are generally very slow. This is a 6.8V zener diode- it is required to provide voltage stability so that changes in voltage as the 12 V battery discharges do not appear as changes in temperature.

I have incorporated the siren circuit and the comparator circuit across the output of the temperature to voltage converter to show it as an application. The

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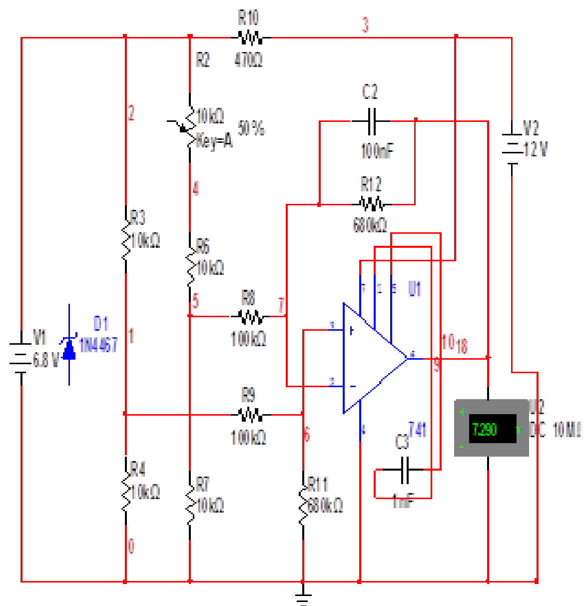
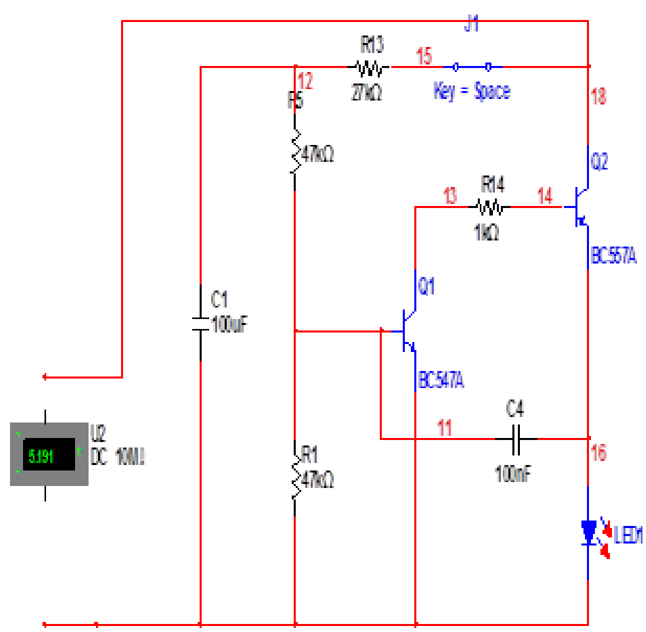
main application where I want to incorporate this is using this voltage again in Industries for generation and production.



Comparator Circuit: The output of the temperature to voltage converter circuit is given to the window comparator circuit. As the voltage fluctuates over a range from 0-9 volts, different LEDs glow at different input voltages. When the output from the temperature to voltage converter circuit is between 0-3 volts, yellow led LED3 glows as the other two leds cannot glow because of negative potential across it. When the output from the temperature to voltage converter circuit is between 3-6 volts, green led LED2 glows as the other two leds cannot glow because of negative potential across it. When the output from the temperature to voltage converter circuit is between 6-9 volts, red led LED1 glows as the other two leds cannot glow because of negative potential across it.A comparator circuit compares two voltages and outputs either a 1 (the voltage at the plus side; VDD in the illustration) or a 0 (the voltage at the negative side) to indicate which is larger. Comparators are often used, for example, to check whether an input has reached some predetermined value. In most cases a comparator is implemented using a dedicated comparator IC, but op-amps may be used as an alternative. Comparator diagrams and op-amp diagrams use the same symbols.

Siren Circuit: This circuit produces a wailing or siren sound that gradually increases and decreases in frequency as the 100u charges and discharges when the push-button is pressed and released. In other words, the circuit is not automatic. You need to press the button and release it to produce the up/down sound.The siren circuit is what importance in various alarm. For example the emergency alert, burglar alarm circuits, Fire alarm circuits, timer , sensor controls, etc. If we have not these circuit, We will not able to recognize the functionality of the circuit, we set out. Operation of the circuit is Q1 and Q2 will work with R3, R4 and C2 is a frequency generator circuit with output connected to LED1 and speakers SP1. When I press the switch S1 to the C1 will begin to charge allows the voltage to pin B of Q1 increase other. The Q1 is working and Q2 is working with at the C1 charge full cycle will stop oscillator speaker is not.The LED1 light and hold the release the pressure switch S1, resulting in C1 will start discharger through R3, Q1 to ground. The oscillator circuit sound Sirens in the lower out. If we press the switch S1 and then quickly leave many. The sound will be as continuous as C1 to charge and discharge alternately continuously.



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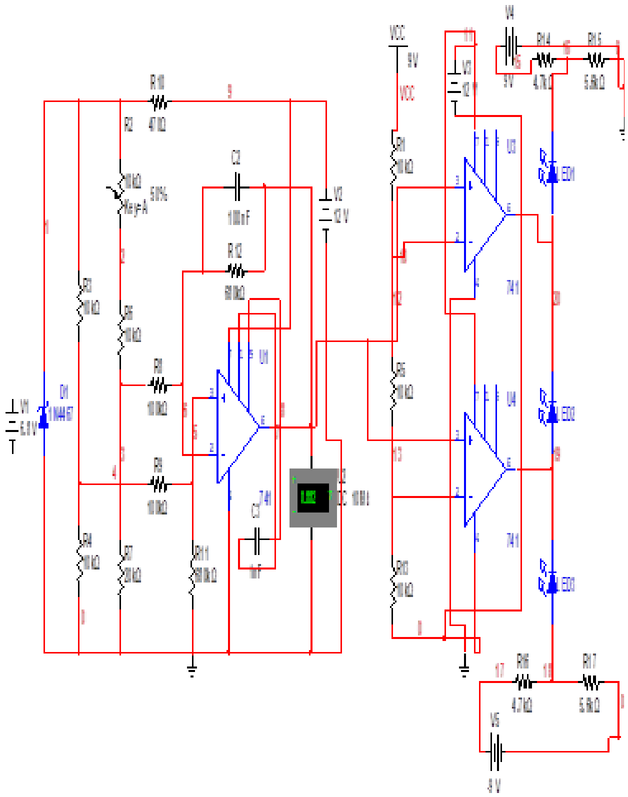
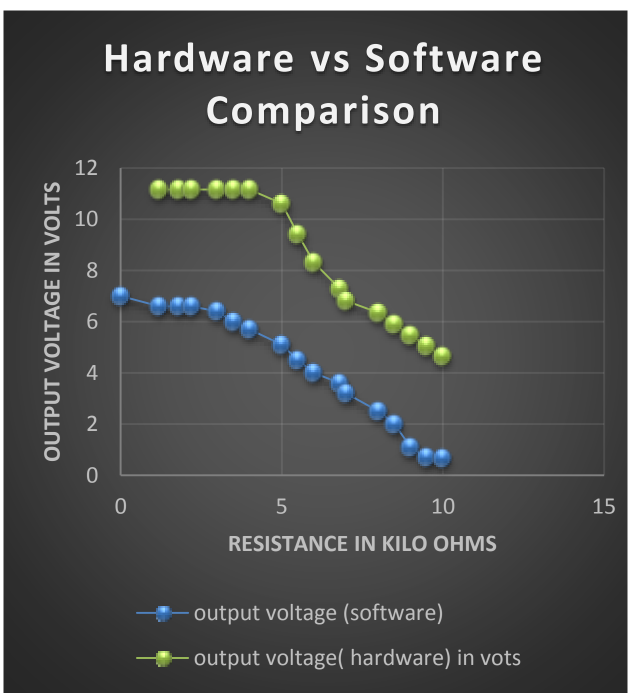
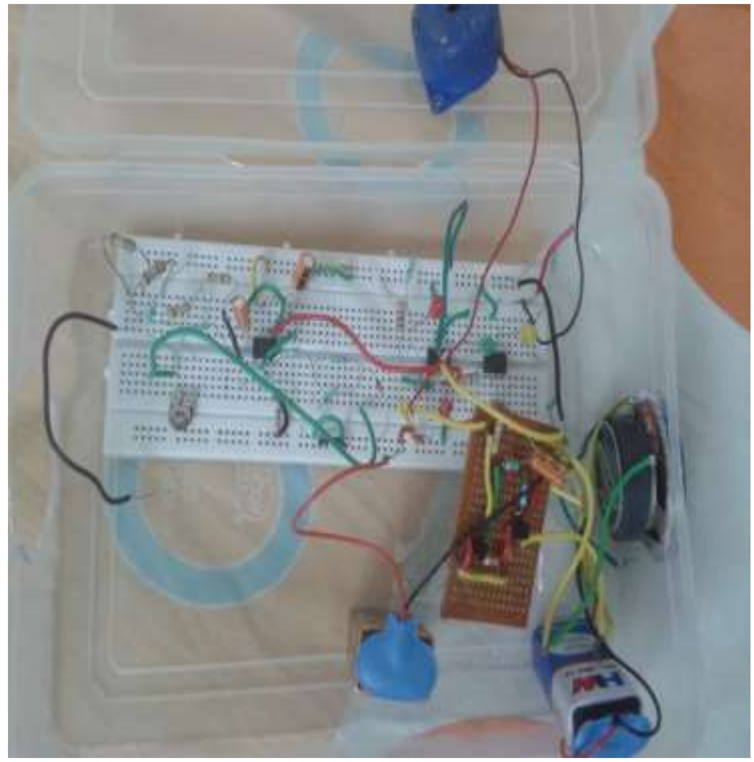
Software implementation

Total Circuit :





Hardware implementation



Analysis of result

As the Temperature of the thermistor and surrounding increases, there is a decrease in resistance of the thermistor due to which there is decrease in the inverting terminal voltage leading to the increase in the output voltage of the op-amp. The output voltage reaches a maximum value beyond which there is no increase as it has reached its saturation point. When we have the siren circuit incorporated in the circuit, the maximum output voltage reached is 5.191 V, without the siren circuit, it's 11.158 V. This is the way by which we are converting temperature to Voltage using a thermistor. The thermistor measures 33KΩ at around 68 degrees and varies about 3570 Ω over a range of 10 degrees. Thus there is a method of producing voltage in industries where a lot of processes is carried out requiring high surrounding temperature.

A comparison have been made between the hardware and software output of the circuit.

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Value of thermistor in kilo ohms	Output Voltage without siren in volts (Software)	Resisitance Values in kil ohms	Output Voltage in volts (Hardware)
1	11.158	0.01	7
2	11.158	1.2k	6.6
3	11.158	1.8k	6.6
4	11.158	2.2k	6.6
5	11.158	3k	6.4
6	11.158	3.5k	6
7	10.606	4k	5.7
8	9.411	5k	5.1
9	8.309	5.5k	4.5
10	7.290	6k	4.0
10.5	6.808	6.8k	3.6
11	6.344	7k	3.2
11.5	5.896	8k	2.5
12	5.464	8.5	2
12.5	5.047	9	1.1
13	4.644	9.5	0.7
13.5	4.254	10	0.66

Applications

This project can be used in various applications. The siren used in ambulance can be one such of them. In industries where we have various mining, extraction of metals from their ores, and heating furnances, this can be used to produce voltage and help in doing some other applications. While cooking in houses, we can find various use of this as the heat can be used to produce a decent output voltage. Solar panels and Solar cars can be benefited from this circuit. This circuit can also be used when we burn coal and other fossil fuels for producing energy.

Conclusion

With the high advancements in technology and Population growth in the world, there is an absolute need for saving a lot of power. There is also need for power regeneration and secure consumption whenever and wherever possible. Renewable sources of energy is thus given a lot of importance these days. People generally prefer to use products which will give them high output with minimal requirement of inputs. This paper deals with one such thing of producing a voltage where we have high temperatures be it in industrial processes or be it during hot and sunny day. The thermistor acts as a useful component which can help bring this change. The future scope of

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this project is that it can be expanded into every segment of the society, with proper modelling and design, we can produce enough voltage for doing a lot of applications.

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