Experimental study of temperature relationship for RTDs and precise method for measurement of human body temperature using Thermistor sensor

Vivek Bhati¹, Md.Meraj² and Ankita Bhatia³

¹,² Student, Electronics Instrumentation And Control Engineering, Poornima College Of Engineering
³ Assistant Professor, Electrical Engineering, Poornima College of Engineering Jaipur, India

Abstract—Electrical resistivity is a fundamental parameter of metals or electrical conductors. Since resistivity is a function of temperature, in order to completely understand the behaviour of metals, a temperature dependent theoretical model is needed. A model based on physics principles has recently been developed to obtain an equation that relates electrical resistivity to temperature. According to the experimental evidence it is shown that RTDs gives a linear relationship of temperature and by the help of equation we can understand the behaviour of resistivity with temperature. Recently, now a days demand of temperature measuring mobile devices are increasing day by day therefore a new precision method is introduced based on thermistor sensor to accurately measure the temperature of body in extremely difficult condition. Human body temperature can be measured using a thermistor sensor.

Index Terms—van Dusen, resistivity, resistance temperature detector (RTD), thermistor sensor.

I. INTRODUCTION

Electrical resistivity for conductors is a function of temperature and under certain conditions will be a function of the size of the material. As the number of circuits and interconnections between circuits on a microchip steadily increases, it is important to understand how these interconnects or conductors could be adversely affected over a certain temperature range (e.g., due to overheating).

Recently, there has not been a straightforward and reasonable model that explain the mechanisms that cause this resistivity-temperature relationship. Therefore, to explain the resistivity-temperature relationship a two dimensional model is introduced and this model gives an equation by which we can understand the behaviour of conductors. The resistivity-temperature equation contains variables that depend upon the atomic diameter, atomic spacing, electron travel time before being scattered, and the proportionality constant that relates atomic force and separation distance.

The resistivity-temperature relationships for platinum and nickel have been well characterized experimentally. The general equation that represents metals is known as the Calendar-van Dusen equation and each metal has its own set of distinct coefficients for this equation. The mean free path for conduction electrons represents the average distance that electrons travel before being scattered by another object associated with lattice structure of the material. The primary scattering mechanism for the conduction electrons is due to vibrating atoms.

II. TWO DIMENSIONAL MODEL

To get a better understanding of the behaviour of conductors, a two-dimensional model was created and solid-state physics principles were used to describe and characterize the electrical resistivity with respect to temperature for bulk conductor materials. A two dimensional is introduced for the FCC structure to determine how electrical resistivity is influenced by change in temperature.

![Fig-1: 2-D model when thermal energy is not applied across conductor](image-url)
A two-dimensional monatomic lattice with a face centered cubic (FCC) structure is used as the foundation for the theoretical model and the atoms are restricted to move in only one direction and conduction electrons are likewise restricted to travel in only one direction which is orthogonal to atomic motion. Gaps exist between the atoms within the lattice and some electrons travel in gaps through the material while other electrons do not travel in the gaps. When an electric field is applied to the material except that a drift velocity is now superimposed on the electrons. A microscopic examination of the material will reveal that the electrical resistivity depends upon the “mean free path” of the electrons or the average distance that electrons can travel before they are scattered. The electrical resistivity is inversely proportional to the mean free path of the electrons. And the scattering mechanism which gives rise to the mean free path of the electron is primarily governed by photons or vibrations (or motion) of the ion cores in the material.

Additionally, atoms in the lattice are vibrating and in this process a minimum distance between the atoms is achieved. As the temperature is increased the atoms obtain more energy and thus are able to move closer together and reduce the gaps.

where \( a \) is the atomic radius, \( b \) is the size of the opening between atoms (when the atoms are stationary), \( \tau_1 / \tau_2 \) is the ratio of travel time before scattering when an electron is in the gap to when an electron is not in a gap, \( k \) is Boltzmann’s constant, and \( T \) is temperature (in K).

### III. ASSUMPTIONS USED IN THIS MODEL

To create the resistivity-temperature model and obtain a straightforward equation, several assumptions and simplifications were used to make analysis less difficult. The assumptions include using a two-dimensional model, approximating the atomic radius as a point source, restricting electron motion to one direction, as well as restricting atom vibration to one direction. Furthermore, it was assumed that the only factors contributing to the force and energy terms were from forces in the [010] direction.

### IV. LATTICE DEFECT

The resistance or resistivity of a material is dependent not only upon electron interactions with photons (in a temperature dependent manner), but also upon impurities, lattice imperfections and/or boundary misalignments.

If a lattice were perfect and contained no defects, then at (or near) 0K the material would have zero electrical resistance and be able to sustain an electric current indefinitely.

### V. EXPERIMENTAL EVIDENCE
It is well known from experimental evidence that conductors (such as platinum) have temperature regions where the electrical resistivity is linear. Based on the operation of this theoretical model, as the temperature becomes higher, the gap becomes smaller, and has the resistivity becomes larger. The below graph shows a linear relationship for conductor such as platinum which gives a linear relationship with resistivity.

Fig:-(4) Graph showing various conductor relationship

VI. PRECISION METHOD
Human body temperature, as a manifestation of life activity, is an important physiological parameter. The body temperature not only has physiological significance, but also has important clinical significance, which can be considered as an important index for clinical diagnosis. This solution is good for people in constant movement or people who require continuous temperature monitoring. This precision method allows human body temperature to be measured with very high accuracy.

VII. THERMISTOR SENSOR
Human body temperature can be measured using a thermistor sensor (e.g. Exacon DS18). The resistance of a thermistor depends on ambient temperature. The sensor is attached to human skin and the measurement is performed with the assumption that the temperatures of the thermistor and skin are the same. This solution is good for people in constant movement or people who require continuous temperature monitoring.

A thermistor, or thermally sensitive resistor, is a resistor which changes resistance in response to a change in temperature. There are two basic types of thermistors: NTC, or Negative Temperature Coefficient, and PTC, or Positive Temperature Coefficient. NTC thermistor exhibit a decrease in resistance when temperature rises. PTC thermistors exhibit an increase in resistance when temperature rises.

The thermometer not only can accurately register the temperature, also has many functions such as broadcast and logic judgment on temperature, in which, the display module will judge and display the measurement results. Thermistors are a type of semiconductor, meaning they have greater resistance than conducting materials, but lower resistance than insulating materials. The relationship between a thermistor’s temperature and its resistance is highly dependent upon the materials from which it’s composed.

In NTC thermistor, the resistance decreases as the temperature increases, according to the following expression.

\[ R_T = R_0 e^{\beta \left( \frac{1}{T} - \frac{1}{T_0} \right)} \]

Where, \( R_T \) is the resistance at temperature \( T \) (K) \( R_0 \) is the resistance at temperature \( T_0 \) (K) \( T_0 \) is the reference temperature, normally 25°C \( \beta \) is a constant.

VIII. CONCLUSION
A two dimensional theoretical model that produces an equation relating the electrical resistivity to temperature has been evaluated which conform the experimental data. To further validate this theoretical model, analysis was performed on the resistivity temperature equation (that resulted from the theoretical model). As a result of this examination of the theoretical model, it is evident that the resulting equation is valid and provides significant insight into the mechanisms behind the temperature dependence of electrical resistivity for conductors.

This precision method allows human body temperature to be measured with very high accuracy. Development of these devices is caused by many
different factors, such as ageing societies, the need for monitoring people working in extremely difficult conditions or in remote and inaccessible locations, monitoring people responsible for other people's lives e.g. pilots, drivers, fire fighters, police officers or even soldiers.

REFERENCES


