Extended Abstract

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DEVELOPMENT OF DIGITAL THERMOMETER

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INTRODUCTION

1.1 THERMOMETER

The thermometer is one of history's greatest inventions. Since the ability to quantify changes in temperature was discovered in the late 1550s and the invention of the mercury thermometer 1714, humanity has utilized this to get a better understanding of the world around us. The thermometer is not just a biomedical device but it allows us to observe a fundamental measurable characteristic of the world. As biomedical engineers, it is up to us to use this concept in every fathomable way it concerns the human body. To do this we have to be willing to dissociate from old ideas in search for better ones. A thermometer is called primary or secondary based on how the raw physical quantity it measures is mapped to a temperature. Examples of these are thermometers based on the equation of state of a gas, on the velocity of sound in a gas, on the thermal noise voltage or current of an electrical resistor, and on the angular anisotropy of gamma ray emission of certain radioactive nuclei in a magnetic field.Thanks to the invention of the digital thermometer in the late 1990s we can now observe temperatures almost instantly and with higher accuracy and precision. The digital aspect allows the easy integration of temperature readings into any other device, which is extremely useful in an increasingly digital world.

1.2 CALIBRATION

A digital thermometer should always return accurate readings. Whether you use it for cooking, for measuring body temperature, atmospheric temperature, or any other relevant use, a thermometer should always be made to provide the correct temperature. From time to time, digital thermometers will require recalibrating. It also needs calibration when dropped since the impact may affect its ability to read correctly. It is also recommended that we calibrate a thermometer when it is used to measure extreme temperatures. Measuring very hot and very cold objects may cause slight errors the next time we go to test something. Finally, thermometers require regular calibration (daily or weekly) when they are used frequently. To set the minimum level (0°C), place the diode in a glass of water filled with crushed ice (check the temperature first with a normal thermometer) wait until the thermometer shows zero degrees centigrade.

1.3 NEED FOR THE PROJECT

Digital thermometers have been proven to be more accurate and precise when compared to traditional thermometers. They also have the added benefit of being safer, more convenient, and easy to use and the element of human error is absent.

Furthermore, the digital aspect allows it to be more easily integrated into other devices.

LITERATURE REVIEW

2.1 COMPONENTS

A large number of resistors , capacitors , IC's and sensors are used for the making of the digital thermometer. Below explained are each of the IC's and the main sensor that is used.

2.1.1 IC 741

The IC 741 operational amplifier looks like a small chip. The representation of 741 IC op-amp is given below that comprises of eight pins. The most significant pins are 2,3 and 6, where pin2 and 3 are pin 2 and 3 denote inverting & non-inverting terminals and pin6 denotes output voltage. The triangular form in the IC signifies an op-amp integrated circuit. The main function of this IC 741 is to do mathematical operations in various circuits. IC 741 op amp is made from various stages of

transistor which commonly have three stages like differential i/p, a push-pull o/p and an intermediate gain stage. The differential op-amps comprises of a set of FETs or BJTs.

2.1.2 IC 7805

7805 is a voltage regulator integrated circuit. It is a member of 78xx series of fixed linear voltage regulator ICs. The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. The voltage regulator IC maintains the output voltage at a constant value. The xx in 78xx indicates the fixed output voltage it is designed to provide. 7805 provides +5V regulated power supply. Capacitors of suitable values can be connected at input and output pins depending upon the respective voltage levels.

2.1.3 IC 7660

ICL7660 is a CMOS power supply circuits which offers unique performance advantages over previously available devices. The ICL7660 performs supply voltage conversions from positive to negative for an input range of +1.5V to +10.0V resulting in complementary output voltages of -1.5V to -10.0V.

2.1.4 BC 108

A BC108 Transistor is an NPN Bipolar Transistor: the most commonly used transistor configuration. Voltage between Collector and Emitter 3 - 20Volts max. The switching action of transistors is improved by combining them in a Darlington Pair configuration. Operational amplifier IC741 provides a constant flow of current through the base emitter junction of npn transistor BC108. The voltage across the base emitter this way makes a low cost sensor . A silicon diode could also be used instead of the transistor.

2.1.5 OTHER SUBSTITUTES

Resistance temperature detectors (RTDs) are wire windings or other thin film serpentines that exhibit changes in resistance with changes in temperature. They measure temperature using the positive temperature coefficient of electrical resistance of metals. The hotter they become, the higher the value of their electrical resistance.. Platinum is the most commonly used material because it is nearly linear over a wide range of temperatures, is very accurate, and has a fast response time. RTDs can also be made of copper or nickel, but these materials have restricted ranges and problems with oxidation. RTD elements are usually long, spring-like wires surrounded by an insulator and enclosed in a sheath of metal.

Thermocouples are accurate, highly sensitive to small temperature changes, and quickly respond to changes to the environment. They consist of a pair of dissimilar metal wires joined at one end. The metal pair generates a net thermoelectric voltage between their opening and according to the size of the temperature difference between the ends. A temperature reading is made by calibrating the device with known temperatures, then placing one of the metal junctions on ice (or something of a known temperature) and the other on the object whose temperature needs to be identified. The voltage displayed is read using the calibration formula and the temperature of the object can be calculated.

Thermistor elements are the most sensitive temperature sensors available. A thermistor is a semiconductor device with an electrical resistance that is proportional to temperature. There are two types of products.

Negative temperature coefficient (NTC) devices are used in temperature sensing and are the most common type of thermistor. NTCs have temperatures that vary inversely with their resistance, so that when the temperature increases, the resistance decreases, and vice versa. NTCs are constructed from oxides of materials such as nickel, copper, and iron.

Positive temperature coefficient (PTC) devices are used in electric current control. They function in an opposite manner than NTC in that the resistance increases as temperature increases. PTCs are constructed from thermally sensitive silicons or polycrystalline ceramic materials.

METHODOLOGY

3.1 CIRCUIT DIAGRAM

Figure 3.1 Complete circuitry of digital thermometer

Components Used :

- IC 741 x 2
- IC 7660
- IC 7805
- Resistors : 1. 10k x 2
  2. 100k
  3. 10k potentiometer
  4. 500k potentiometer
- Capacitors: 1. 220nF
  2. 1uF
  3. 10uF x 2
- Zener Diode (4.7V)
- Sensor BC108
- Multimeter

3.2 WORKING

Operational amplifier IC 741 (IC3) provides a constant flow of current through the base-emitter junction of n-p-n transistor BC108 (T1). The voltage across the base-emitter junction of the transistor is proportional to its temperature. The transistor used this way makes a low-cost sensor. You can use silicon diode instead of transistor.

The small variation in voltage across the base-emitter junction is amplified by second operational amplifier (IC4), before the temperature is displayed on the meter. Preset VR1 is used to set the zero-reading on the meter and preset VR2 is used to set the range of temperature measurement.

Operational amplifiers IC3 and IC4 operate off regulated ±5V power supply, which is derived from 3-terminal positive voltage regulator IC 7805 (IC1) and negative low-dropout regulator IC 7660 (IC2). The entire circuit works off a 9V battery.

Assemble the circuit on a general-purpose PCB and enclose in a small

plastic box. Calibrate the thermometer using presets VR1 and VR2. After calibration, keep the box in the vicinity of the object whose temperature is to be measured.

The digital thermometer circuit can measure temperatures up to 150°C with an accuracy of ±1°C. The temperature is read on a 1V full scale-deflection (FSD) moving-coil voltmeter or digital voltmeter.

Hence , here 1Volt=1 degree Celsius.

RESULTS OBTAINED

The voltmeter reading across the 4.7 V Zener Diode will directly correspond with the temperature and verified by the actual temperature using a calibrated digital thermometer.

We have observed a very small variation in temperature from the original temperature , which could possibly be due to the potentiometer connections or due to the open surrounding in which the calculations or experiment is being performed.

Room Temperature : 28 Degree Celsius

Recorded Temperature : 27-29 Degree Celsius

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