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Research Article

BLOOD INFUSION WARMER

Sanjay.S[1], Jintu Das[2]
[1]Assistant Professor, Dept. of Biomedical Engineering, Bharath University, Chennai, Tamil Nadu, India.
[2]Final Year Student, Dept. of Biomedical Engineering, Bharath University, Chennai, Tamil Nadu, India.
Email: sspv44@gmail.com and jin2das@gmail.com

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Abstract

Temperature maintenance is the prime consideration for the effective and safe handling of the patient. Any mistakes regarding to it can lead to life-threatening condition for the patient. We all know the blood is stored in blood bank at lower temperature. As the normal body temperature of human is 37.5 deg. Celsius so it is very dangerous to directly infuse cool blood in patient. To avoid hypothermic adverse effects in the patient body while transfusion, real time comparison of blood bag temperature and patient body temperature and accordingly heating is provided. Although blood warmer has advantages of no contamination, easy manipulation, portability, clear digital temperature indication, with fast result it has also limitations and challenges like inability to cool the heated blood and using restriction. The aspects of component specifications, accuracy, dynamicity and appearance may differ from the actual device. But, this project is sufficient to provide functional simulation to the actual real-time warmer for blood infusion. As the blood is precious so water or dextrose will be used for this project instead of blood.

Keywords: Blood Warmer, Blood Infusion, Hypothermic adverse effects.

1. Introduction

Patients who have major trauma have chances of getting affected by Hypothermia [1, 2]. The major factors that hypothermia contributes are severity of injury, and anaesthesia/sedation agents [1, 3, 4]. Unwarmed blood and crystalloid infusion results in coagulopathy, alterations in response to pharmacological agents, cardiac arrhythmias which results in life loss [2, 5, 6, 7]. Keeping these factors in mind it is always important to warm the Intravenous (IV) fluid before administering the patients.

The use of blood transfusion grew throughout the 20th century, with major changes in practice [8]. The blood banks are facing the biggest challenges as the rate of shortage of blood components is increasing day by day [9]. During the late 19th century it was simply accepted that blood transfusion was good, but it was too risky to transfuse to the patient as Acquired Immunodeficiency Syndrome (AIDS) and Hepatitis B was contaminated from the donors to the recipients [10, 11, 12, 13]. Although the blood bank has largely defeated the risks of AIDS and hepatitis from blood transfusion there still have to do so many improvements to prevent the contamination. The medical authority should take the responsibility to shift public opinion.

2. Experimental Methods

2.1 Generalized block diagram:

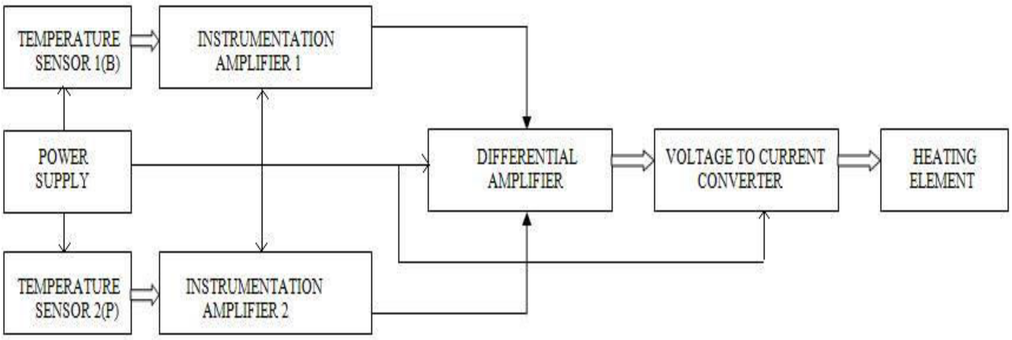


Fig 1: Generalized block diagram.

Power supply block to give DC supply to ICs and other devices. Temperature sensor with bridge to senses the temperature for blood bag temperature (B) and for patient body temperature (P). Instrumentation amplifier for channel-1 i.e. Blood bag-channel and Instrumentation amplifier for channel-2 i.e. Patient-channel. Differential amplifier block to obtain the temperature difference. Voltage to Current converter block to convert the voltage into compatible electrical signal for the heating coil. The heating element block i.e. a fabricated steel tube which is coil coated with mica wound.

2.2 Power supply block:

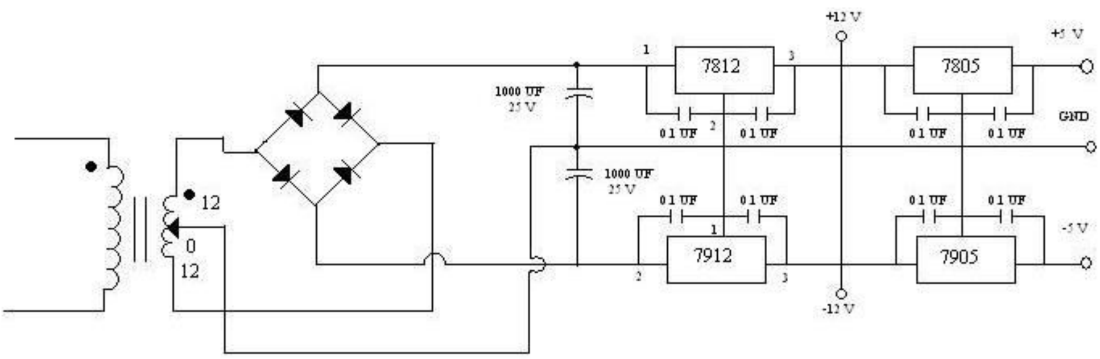


Fig 2: Power supply block.

IC 7812, 7912 (+12V,-12 V) and IC 7805, 7905 (+5V,-5V) are used to get 5 V output. The bridge rectifier is used to convert AC voltage into DC voltage. Center tapped transformer (12-0-12) is used to supply 12 V. This circuit provides power to the further circuit. Mains supply is given to the center-tapped transformer. Then output of secondary winding is given to the bridge rectifier IC. This bridge rectifier converts the ac current to dc current. Then to get peak-to-peak output voltage signal, capacitors are used.

2.3 Temperature Sensing Circuit (Blood bag):

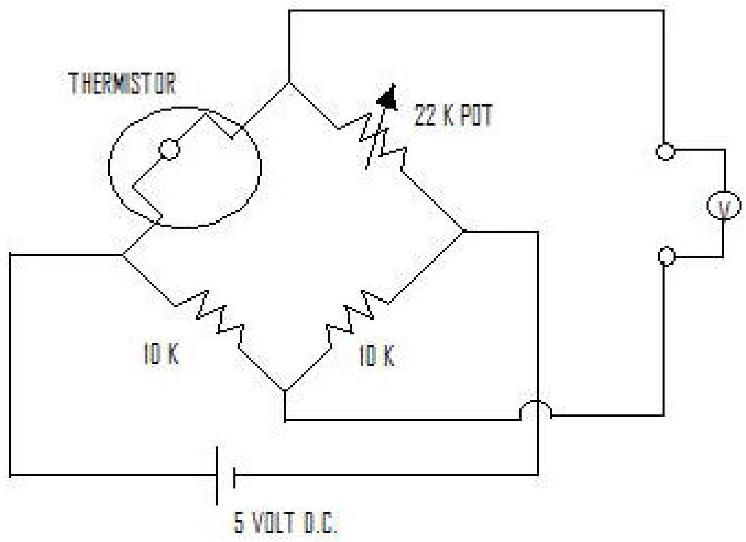


Fig 3: Temperature Sensing Circuit (Blood bag).

This block senses the temperature of the blood bag by thermistor as a sensor. Themistor are most commonly used for moderate temperature range (ofcourse not for very high temperatures).They have negative temperature co-efficient. Thermistors are temperature sensitive resistors. Thermistors are constructed of semiconductor material with a resistivity that is especially sensitive to temperature. Thermistor used here is in form of bridge configuration so as to provide temperature compensation and the circuit for it is given below.

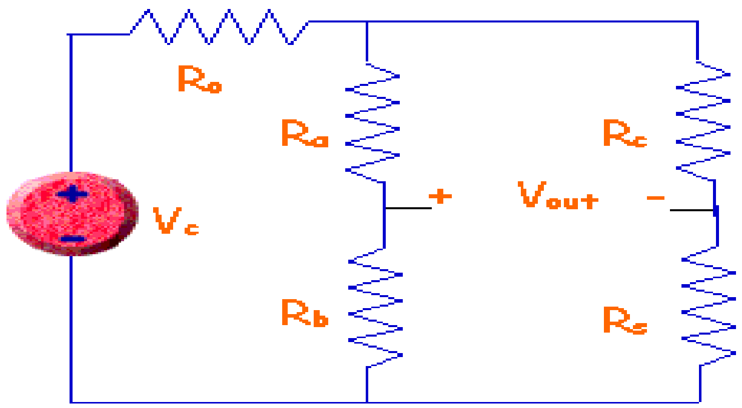


Fig 4: Temperature compensation circuit.

In this bridge circuit, three resistors are constant, R_a, R_b, and R_c, while the resistive sensor, R_s, varies depending upon some physical variable - like temperature, light level, etc. The thermistor can be placed anywhere in the bridge with three constant resistors, but different placements can produce different behaviour in the bridge. e.g., different placements might cause the output voltage to go in different directions as there are changes in temperature.

This is temperature sensing bridge. Firstly, temperature of interest is sensed and manually bridge balance condition i.e. null output is obtained by varying the pot. Now as the ambient temperature is changed, accordingly change in the output. This output is further given as input to the instrumentation amplifier.

2.4 Temperature Sensing Circuit (of Patient):

This block senses the temperature of the patient body by thermistor as a sensor. So all the details regarding to sensor will be same to that given in the description i.e. circuit diagram, components used etc. on the previous block.

Thermistor specifications:

NTC-Negative Temperature Co-efficient

Value of Co-efficient: $a = 1.40*10^{-3}$, $b = 2.37*10^{-4}$, $c = 9.90*10^{-8}$

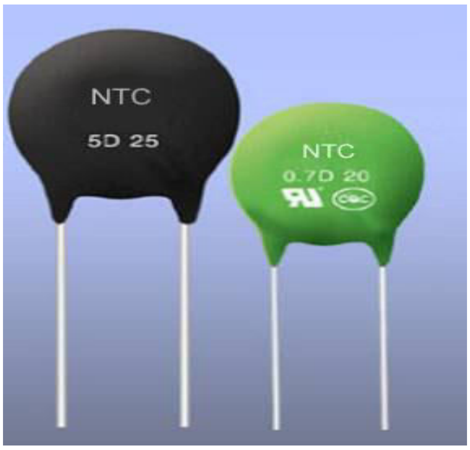


Fig 5: Thermistor.

2.5 Instrumentation Amplifier 1 Circuit (B Channel):

This block provides sensor output signal the sufficient amplification so as to drive further circuits properly and without loading. "B channel" refers to the blood-bag channel. As thermistor senses in range of micro volts, we have to amplify it in 2 stages of 1000 gain.

Instrumentation amplifiers are actually made up of 2 parts-

- a buffered amplifier OP1, OP2 and
- a basic differential amplifier OP3.

The differential amplifier part is often essential when measuring sensors. Because a sensor produces a signal between its terminals.

The buffered amplifier OP1 and OP2 provides gain. They also prevents the sensor resistance from affecting the resistors in the op amp circuit.

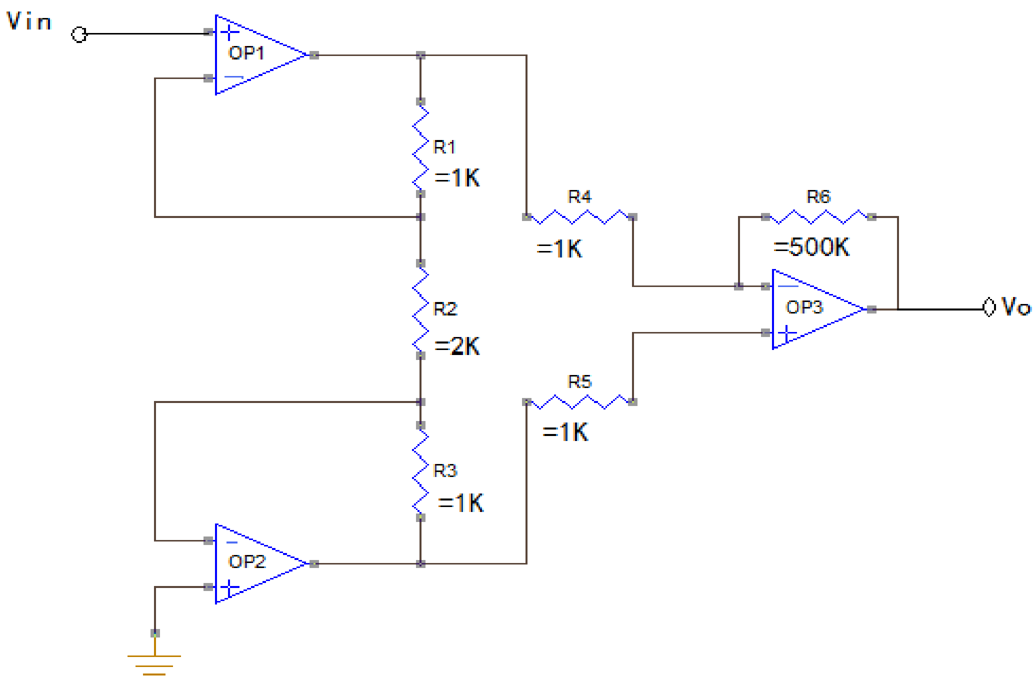


Fig 6: Instrumentation Amplifier 1 Circuit (B Channel).

IC OP07 is used as they offers excellent performance in applications requiring low offset voltage, low drift with time and temperature and very low noise. Power supply of 12 V DC is given as input power supply.

The instrumentation amplifier offers two useful functions-

- Amplify the difference between inputs and
- Reject the signal that is common to the inputs (Common Mode Rejection).

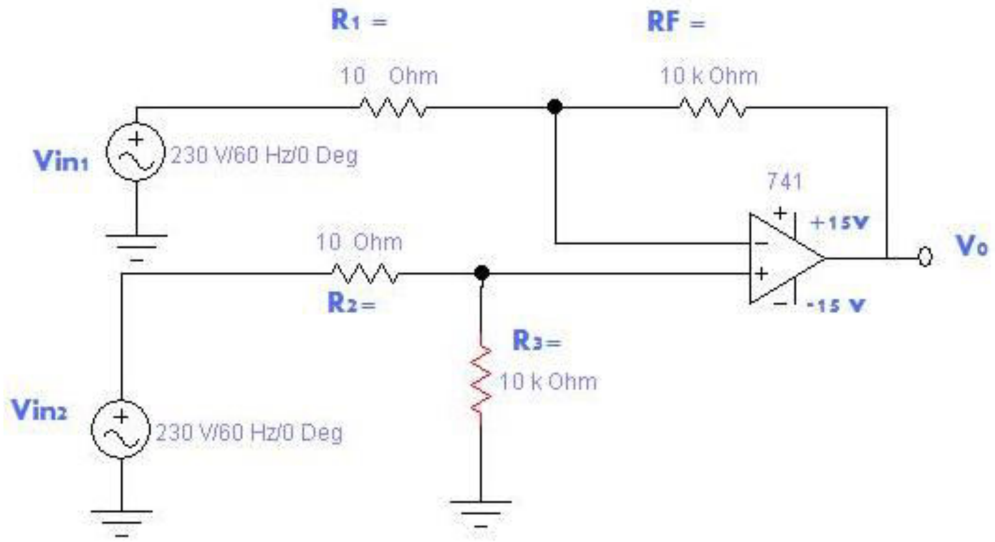
OP1 and OP2 are the two input amp's and connected in the non-inverting configuration. It provides high gain and high input impedance.

2.6 Instrumentation Amplifier 2 Circuit (P Channel):

The circuit diagram, working of the circuit, component specifications and all other details will be remaining same as above block except the change in channel. Here "P Channel" refers to Patient-channel.

2.7 Differential Amplifier Circuit:

This block provides error signal by detecting temperature difference of both channels.



There are 2 inputs in each terminal of op-amp.

1) From B-Channel instrumentation amplifier.

2) From P-channel instrumentation amplifier.

Fig 7: Differential Amplifier Circuit

Now as name suggests, It amplifies the difference between i/p 1&2 by gain 1000. So, finally the thermistor initial o/p is converted into volts.

2.8 Voltage to Current Converter Circuit:

This block provides conversion of the output of differential amplifier to the corresponding value of current that a heating coil is capable to handle.

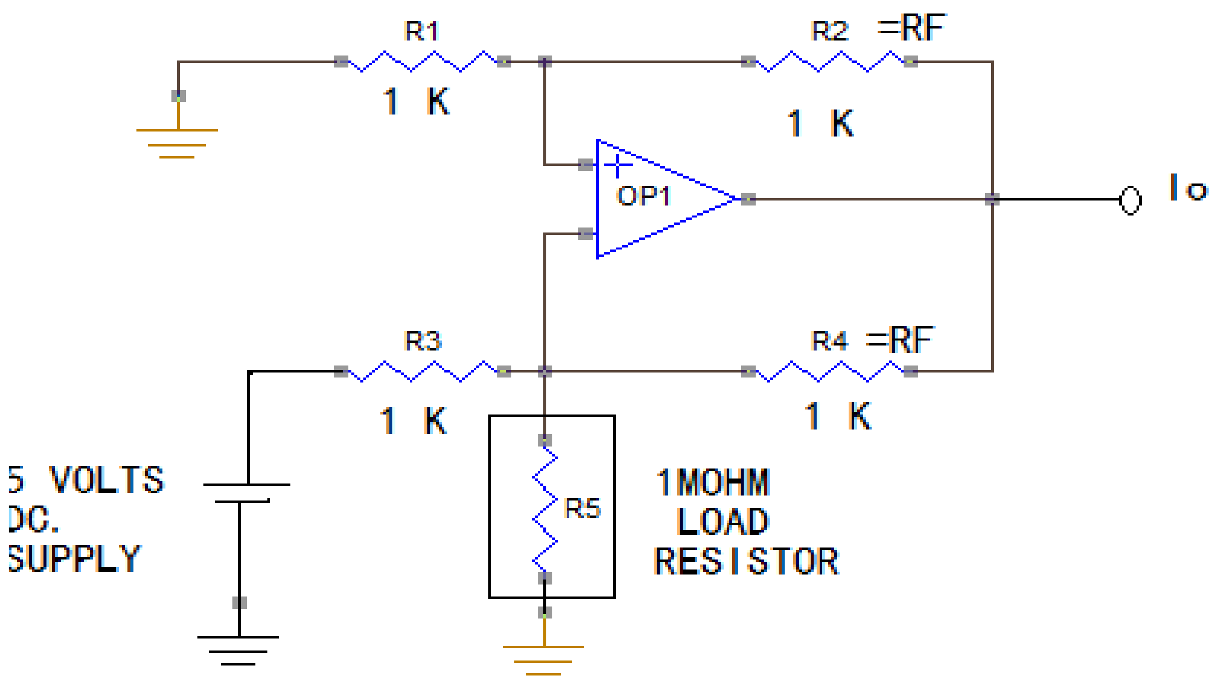


Fig 8: Voltage to Current Converter Circuit.

The main working is based on the well-known Ohm's law. According to this law, in the given conditions, voltage (V) and current (I) are directly proportional. It is given by-

$$V=IR \qquad (1)$$

(R is constant of proportionality called Resistance which is a property of material to oppose the current flow.)

$$I=(V/R) \qquad (2)$$

and here I=5/1000=5 mA.

2.9 Heating Element:

This block performs heating operation on the cold blood of the blood bag. A very thin coil of mica is wound on a stainless steel tube. This typical design requires the fabrication. As the no. of turns increases the heating efficiency also may increased. So it has to take care about heating path i.e. there should be no overlapping of coil. If so, it will lead to the damage of the coil material due to excessive heating. The schematic design of this block is given below.

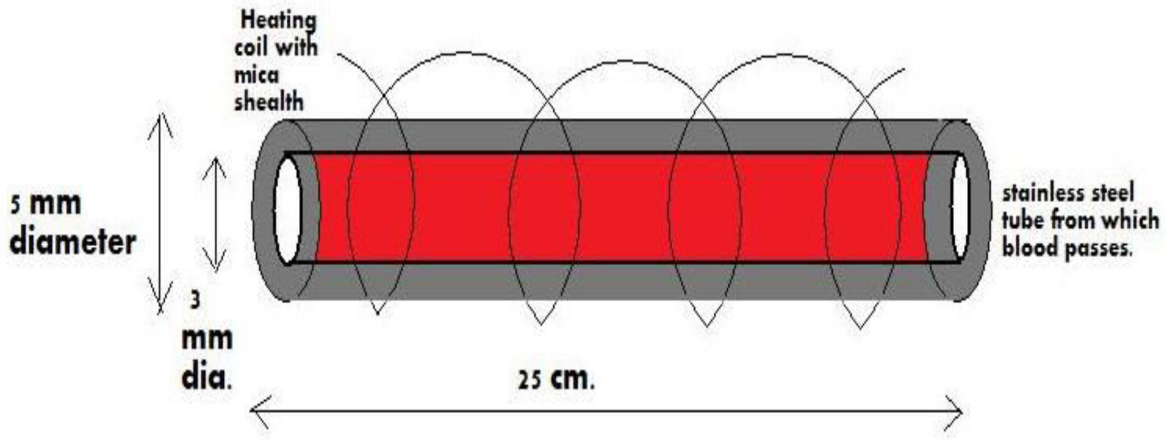


Fig 9: Heating Element.

3. Results and Discussion

The observation showed that an Intra Venous tube warmer is the most effective system for warming Intra Venous fluid at a relatively low flow rate. At the highest flow rates tested, which would be of greatest significance in terms of potential patient cooling. The choice of fluid warmer depends on patient needs, heat-transfer capabilities of the warmer, amount of in-line cool down expected, operator preference, and safety characteristics. There is no one ideal fluid warmer for use in all patients. This project is use of temperature difference signal for proportional heating of the cold blood. The design is hereby at the beginning phase with almost simulation of basic function of the warmer. So the Blood Infusion Warmer will be safely undergone on patient as expected.

4. Conclusion

Hereby we conclude that the possibility for making this device better than that is available in market. Temperature difference signal is use for proportional heating of the cold blood. The design is hereby at the beginning phase with almost simulation of basic function of the warmer. So the Blood Infusion Warmer will be safely undergone on patient as expected. For the future recommendation is to modify by adding the transfusion part in order to infuse the blood into the patient. Other than that, develop the High accurate digital control for temperature because it is the one of important parameter to warm the blood. With high accurate control temperature, the device become more efficient and can be used not only at non-clinical environment but also can be use at clinical environment such as at Operation Theatre and ICU department. Thinking with being more technological, this device can be made as better as that available in market by use of microcontroller based configuration and a more advanced version.

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Corresponding Author:

Sanjay.S*,

Email: sspv44@gmail.com and jin2das@gmail.com