DETECTION OF SENSITIVITY OF TRANSDUCER IN BIOMEDICAL INSTRUMENTS

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ABSTRACT

In biomedical instruments various transducers are used for measurements of various physiological parameters. The biomedical system cannot be designed until and unless proper transducer is selected for measuring physiological parameters. The present scenario of transducers in biomedical instruments is discussed in this paper. The various researchers had used different methods of measurements of body temperature. Some of these methods are discussed in this paper. The researcher has designed body temperature measuring transducer using UJT time base circuit, thermister and LDR. The designing technique of the transducer is discussed in this paper. The F-T characteristic of this transducer is[1] plotted and the performance of transducer is compared with existing transducers used in the instruments for the purpose.

Keywords: sensitivity, transducer, biomedical instruments

1. INTRODUCTION

Biomedical instruments have been developed in various stages. Old biomedical instruments, constructed by transducer/sensor worked on the principle of analog type (resistive, capacitive, and inductive). The ac or dc amplifiers constructed by the transistors was used to manipulate the output of the sensors/transducers. The analog meter (D'Arsonal movement), graph plotter, indicator were used to display or record of physical signal.

Research in the electronics field has developed biomedical instruments, stage-wise. The ac or dc amplifier has been replaced by operational amplifier, which is found suitable to detect even weak signals from the body. The advanced display system like Cathode Ray Oscilloscope (CRO), digital display, LED, LCD etc. have been used to display or record.

data either in form of waveform or digital display. The microprocessor, microcontroller and personal computer provide intelligence to biomedical instruments. Advanced biomedical instruments with their functional blocks are shown in Fig. 1.

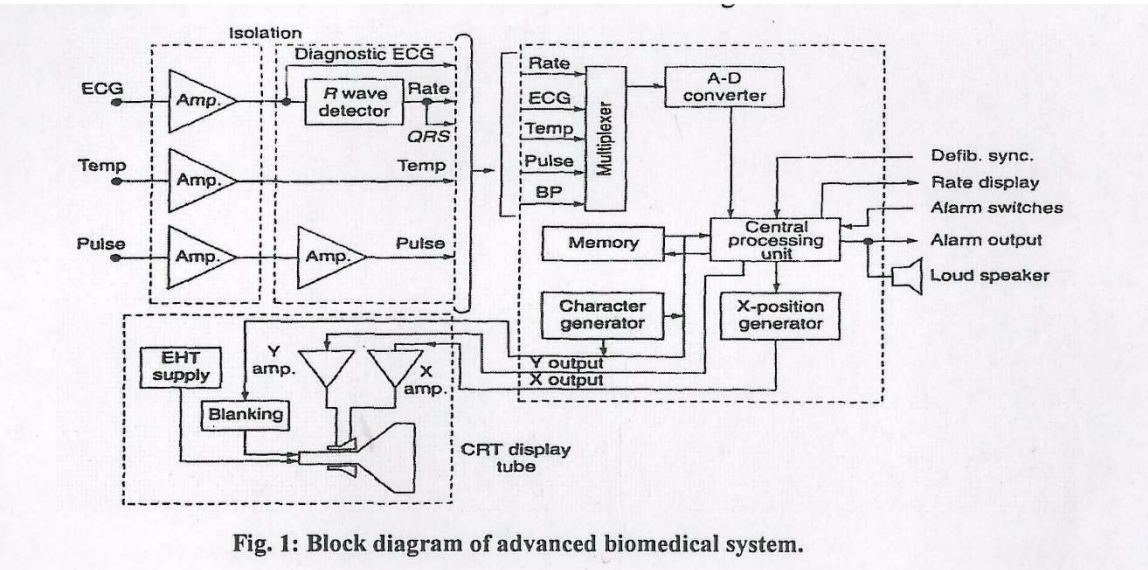


Fig. 1: Block diagram of advanced biomedical system.

2. SENSORS/TRANSDUCERS IN BIOMEDICAINSTRUMENTS-PRESENT SCENARIO

Advanced biomedical instruments function better than old ones only when new technology has been employed in the sensing part of biomedical instruments. This requirement has been fulfilled by reviewing the various technologies of sensors/transducers used in biomedical instruments for sensing physical activities of the body. Various physiological parameters have to be measured as such as body temperature, blood pressure by direct and indirect method, blood flow, cardiac output, heart rate, phonocardiogram, impedance cardiogram, respiration rate, tidal volume, and gases in expired air, diffusion of inspired gases during the treatment of patient in clinics or hospitals. The researcher has attempted to develop the biomedical instruments for body temperature measurement. Therefore, it was important to know the various methods for body temperature measurement. The biomedical system cannot be developed until and unless the proper sensors/transducers cannot be selected to measure the physiological parameter in biomedical system, which has been developed by the researcher.

3. METHODS OF MEASUREMENT FOR BODY TEMPERATURE IN BIOMEDICAL INSTRUMENTS

a.Temperature of human body :-

Thermal behavior of biological material, particularly living tissue depends on passive or intrinsic property and active response of the biological system to thermal stimuli. The intrinsic thermal physical properties influencing heat transfer in biological material are the same as those in any other material, thermal conductivity, diffusivity, and specific

heat. The magnitude of these properties tends to be quite variable not only in the body but also within the same tissue. These properties are directly dependent upon the inherent inaccuracies in the thermal calculation of living tissue. The physical parameters observed from tissue of human body are temperature, heat, fat and movement. Temperature of living tissue is a measure of tendency of the body to transfer heat from one body part to other. The average normal body temperature is in the range of 37°C to 41 °C and it remains almost constant with ±0.6°C for healthy person. In normal condition, it is generally considered to be 37°C.

b. Existing temperature measuring system for human body:-!. The body temperature is measured by expansion of mercury (Hg) in a glass capillary. Calibration and conversion was required for measurement of temperature, which is a difficult task.

c. Thermocouple is a junction of two different material wires, which is formed by two or more junctions. One junction is cold or reference junction (kept at 0°C) and other junction is hot or measuring junction. Thermo electromotive force (emf) generated across wire is developed current in the circuit. The emf generation range is in mill volt with resister to temperature Copper-constant. A combination of thermocouples is preferred for medical application. In this construction, a one junction is kept at 0°C while other is kept at 37°C. An ice bath is used to maintain constant temperature, which is a major drawback in measuring system.

d. The temperature dependence of resistance of certain metals (platinum or nickel) makes it convenient to construct temperature transducer for biomedical instruments. Most of the metal resistance depends on temperature. Thermometer constructed from coil of the metals is used for skin, rectal and oesophageal temperature measurement. The coefficient of receptivity of platinum is 0.004 ohm/°C. Practically the measurement of resistance with respect to temperature is quite difficult because circuit resistance and electrochemical changes affect the resistance of metal during measurement. The temperature coefficient is very small.

e. Thermistors: - Thermistors are the oxides of certain metals like manganese, cobalt, nickel which have large negative temperature coefficient (NTC) of resistance. The sensitivity is about 4% change In resistance per degree. This device Is a better solution for the measurement of temperature in medical applications. However a major disadvantage observed here is that, the resistance of thermistor are exponentially changes with respect to temperature. In a temperature-measuring instrument, resistance should change linearly with respect to temperature. The thermistor is a better solution for sensing of temperature, but its characteristic has to linearized by some technique. The researcher has proposed the technique for linearization of characteristic of thermistor.

4. TIME-BASED OSCILLATING CIRCUIT IN QUICK RECOVERY AS SENSOR

The pulses are developed across capacitor CE, RBI and Rg2- The voltage-time signals across RBI, RBI and CE during the continued time interval, are shown in (Fig. 2) during charging and discharging action of CE.

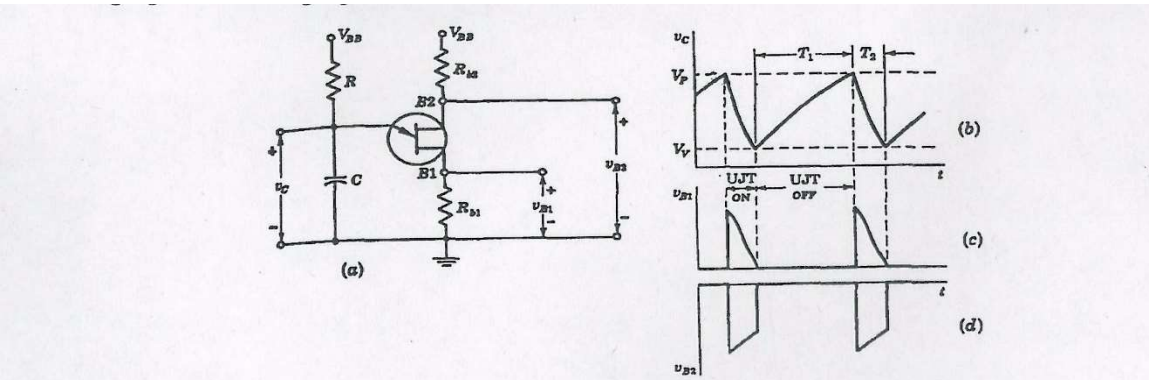


Fig. 2: Time- based oscillating circuit and its waveform.

The pulses at the base BI is an abrupt leading edge, but the anticipated drop at the trailing edge may not be easily apparent charging the holding current, which is small in comparison with the current at the moment of breakdown. The Ie2 current is smaller because the Base current IBI is equals the emitter current. lea is nearly constant during the capacitor discharge. The linearity of the waveform may be obtained by feedback methods.

5. STUDIES OF THERMISTOR CHARACTERISTICS

Another type of thermal resistor (the thermistor) is made of evaporated films, carbon or carbon compositions, or eeramic-like semiconductors formed of oxides of copper, cobalt, manganese, magnesium, nickel, titanium or uranium. Unlike the basic RTD device, thermistors can be molded or compressed into a variety of clever shapes to fit a wide range of applications. These devices have a resistance change characteristic of 4 to 6%/°C with generally a negative temperature coefficient. Special classes of thermistor, called posistors, which are made of barium titanate or strontium titanate ceramics, have a positive temperature coefficient. Positive temperature coefficients are also found in silicon thermistors in which the Si semiconductor is doped to a density of about $10^{I6}/cm^3$. The resistance vs. temperature characteristic of thermister is non linear in certain part of its range.

6. LIGHT DEPENDENT RESISTOR (LDR) CHARACTERISTICS FOR SENSOR

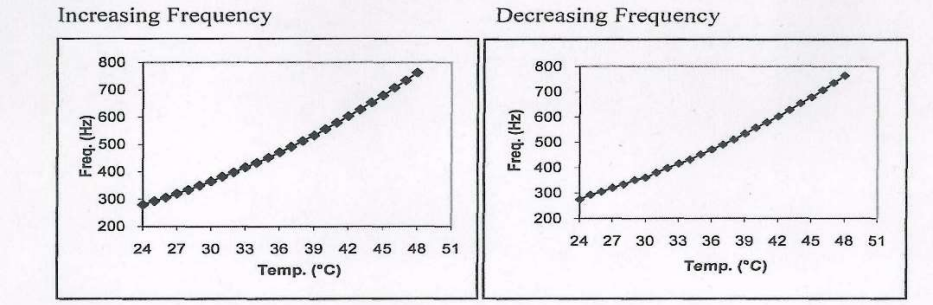
Optoelectronic devices generate electric current when they are subjected by light energy. The optoelectronic devices include photoconductive device, photodiodes, phototransistors, LEDs and injection laser diodes etc. These devices operate when they

are subjected to optical irradiation. The semiconductor material such as silicon and germanium cannot be used to construct a photoconductive cell. The most commonly used compounds are cadmium sulphide (CdS), cadmium selenide and cadmium telluride. CdS is mostly used photoconductive material.

Photoconductive cell is bulk device rather than junction device and it does not have any semiconductor junction. Photoconductor is commercially known as light dependent resistor (LDR). The photoconductive material CdS is deposited on a cylindrical ceramic base in a zigzag fashion. This construction adopted to increase the area of the CdS so that its resistance value can be controlled with light exposed on the surface. Metal contacts are formed at the end points of the zigzag structure from, which external leads are taken out. L-R characteristics of photoconductive cell show exponential decay in the resistance with respect to light intensity (light flux in lumens).

7. DESIGN TECHNIQUES OF QUICK RECOVERY TEMPERATURE TRANSDUCERS

Time based oscillating circuit; thermister, LED, and LDR may be used in designing the quick recovery temperature sensors. In the present study QRTS is designed by time based oscillating circuit and temperature sensing components as thermister. The thermister has been selected in a probe shape to measure surface temperature of the body easily. In time base oscillating circuit, the emitter resistance RE is replaced by thermister resistance RT. Before replacing emitter resistance by thermister resistance, it has been observed that output of sweep signals of the time base oscillating circuit depends on RE. The capacitor Cehas been chosen with fixed value to produce constant frequency of sweep signal. The resistor RE has been chosen to get the frequency of output signal in the frequency range of 200Hz to 300 Hz. It has been observed that the R-T (resistance-temperature) curve of thermister is mostly nonlinear in the range of medical temperature measurements. The graphs have been plotted between temperature sensed by thermister and the frequency of output sweep signal. F-T characteristics of QRTS are shown in figure-3. This characteristic has been plotted with rise (24 to 48 degree centigrade) and decay (48 to 24 degree centigrade) of temperatures. Accuracy has been achieved in the measurement of temperature with rise and decay of temperature and by repeating the experiment for four times.



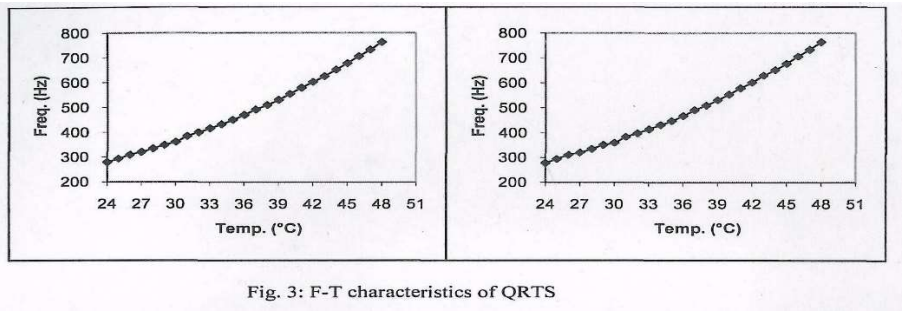


Fig. 3: F-T characteristics of QRTS

8. ANALYSIS & RESULTS

a. The QRTS transducer is designed by researcher for body temperature measurements by producing frequency output in the range of 200 Hz to 800 Hz which changes linearly with respect to change in temperature. The frequency output of QRTS is easily digitalized as compared to existing senor output.

b. The variation of output sweep signal frequency is linear in the body temperature range and QRTS is most useful for body temperature measurements in comparison to existing sensors studied by researcher.

c. The sensitivity is measured about 12 Hz per degree centigrade. The sensitivity is very good as compared to existing sensors studied by researcher.

d. QRTS is constructed by semiconductor components. It could be fabricated as a compact sensor by integrated technology. The smart sensor technique is popular now a day in designing of sensors/transducers to measure physiological parameters in biomedical instruments. QRTS could also constructed by SST for embedded biomedical instruments to measure body temperature.

e. QRTS is low cost, simple in construction and easy to operate with low power.

f. Researcher has found the response of QRTS is similar when compared with existing sensors used in body temperature measurements.

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