DESIGN OF TEMPERATURE AND HEAT FLUX MEASUREMENT SYSTEM USING MICROCONTROLLER FOR MONITORING THE OPHTHALMIC DISEASES

R. ROBERT

Assistant Professor,

Dept. of Electronics and Communication Engineering,

Annai Velankanni College of Engineering,

Kanyakumari .

Email id: rrobertraj@gmail.com

Dr. V.V. VINOTH., M.E, Ph.D

Associate Professor,

Dept. of Electronics and Communication Engineering,

Annai Velankanni College of Engineering,

Kanyakumari.

Email id: vinfo.vv@gmail.com

***Abstract*— Temperature sensing and heat flux measurement is an integral part of any industrial monitoring and control system. It is mostly used in the food industry, medicine, catering and supermarkets. In this paper, a medical thermoelectric device developed for diagnosing and monitoring ophthalmic diseases. Data acquisition unit consists of both a thermoelectric heat flux sensor and a thermocouple temperature sensor. From the ocular surface, the device allows high-precision measurements of both heat flux and temperature. This device measures the magnitude of the heat flux from the surface of the eye and it measures the temperature of the eyes surface with high accuracy.**

Keywords—Temperature measurement, Microcontroller, Ophthalmic disease.

I. INTRODUCTION

Temperature sensing and precise control forms is a widely used parameter in any given process controlled environment. Heat transfer processes in the human body occur according to the laws of thermodynamics. Thermodynamics studies the fundamental rules of energy conversion and transfer [1]. For heat transfer, the existence of a temperature gradient is necessary, [2]-[4]. In the human eye, the main source of heat is blood circulation in the choroid. Blood, the temperature of which is equal to that of the body, entering the eye forms a thermal gradient that produces the heat transfer from the blood to the tissues of the eye. The more severe blood circulation, the more heat is transferred to the structures of the eye. Thus, the temperature gradient present in the eye which can be registered on the ocular surface from results the existence of heat flux. In ophthalmology, the circulatory disorders of the eye should be accompanied by changes in the dynamics of heat transfer [7], [8]. Measurement of temperature and heat flux the evaluation of heat transfer processes is happened.

II.BLOCK DIAGRAM

The main functional blocks of the device are

- the heat flux measurement channel,
- the temperature measurement channel
- the measurement channel of supply battery voltage,
- the channel for measuring the ambient temperature
- the microcontroller
- the battery pack with a charger
- the digital display.

The measurement of heat flux is designed to measure the voltage produced by the thermoelectric sensor under the action of heat flux. For measuring the heat flux with a high accuracy, the resolution of voltage measurement is 1 μV. The temperature measurement is calculated for processing the signal from the thermocouple sensor. In this system, type L thermocouple is used. The voltage measurement of the battery power supply allows monitoring the charge of the battery .For measuring the ambient temperature by measuring the signal from the calibrated platinum resistance thermometer. The reference junctions of the type L thermocouple are connected, this thermometer measures the ambient temperature at the terminals. The ambient temperature measurements resolution is 0.001 K. The microcontroller is used to control measuring signals and normalization and conversion of the measured signals into physical quantities. The microcontroller is used to select either heat flux or temperature measuring mode and the measurement ranges.

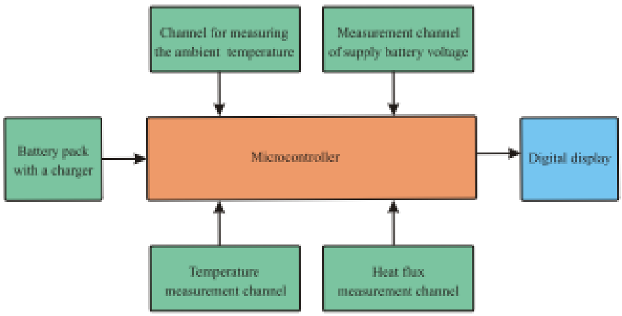

Fig.2. The block diagram of the thermoelectric device

Table 1. shows the technical parameters of the thermoelectric device, which are important application in ophthalmology. The main advantage of the device is its ability to measure both the heat flux and temperature.

Table 1. Technical parameters of thermoelectric device.

Parameter	Value
Maximum heat flux density	50 mW/cm^2
Uncertainty of heat flux density measurement	5 %
Temperature measurement range	273÷323 K
Temperature measurement resolution	0.01 K
Ambient temperature measurement range	273÷323 K
Ambient temperature measurement resolution	0.001 K
Battery supply voltage	3.7÷4.5 V
Time of continuous operation from a fully charged battery	12 h
Overall dimensions of the thermoelectric heat flux sensor	Ø3×0.7 mm
Overall dimensions of the data acquisition unit	180×140×90 mm
Weight	0.6 kg

III.DESIGN OF THE THERMOELECTRIC HEAT FLUX SENSOR

For this medical device, small thermoelectric heat flux sensor was developed. The structure of the sensor is shown in Fig.3. The main element of the sensor is a thermoelectric micromodule with the dimensions of (2×2×0.5) mm.The module comprises 100 pieces of n- and p-type crystals with the dimensions of (0.17×0.17×0.4) mm made of highperformance thermoelectric Bi2Te3-based materials. The Seebeck coefficient of such materials is about 200 μV/K at 300 K.The micro-module is placed between two insulating Al2O3 plates. The sensor diameter was selected for the medical requirements of ophthalmological devices. Thermoelectric sensor the electrical resistance value is 14 Ω. The developed heat flux sensor is not conventional, therefore it has to be calibrated prior to use. The sensor uses the blackbody radiator as the heat flux source. The schematic diagram of the apparatus is given in Fig.4.

Fig.3 The thermoelectric heat flux sensor

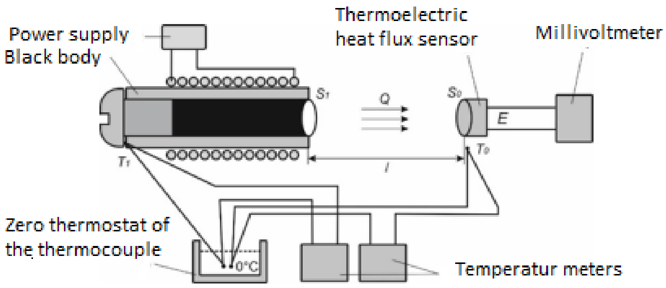

Fig.4. The schematic of the apparatus for measuring the volt-watt sensitivity of the thermoelectric sensor

The volt-watt sensitivity of the thermoelectric sensor is determined by the formula

$$v = \frac{E}{Q} \quad (1)$$

where E is thermoEMF developed by the sensor, Q is the heat flux radiated by the black body and absorbed by the receiving pad of the thermoelectric sensor. Q is determined as follows:

$$Q = \frac{\varepsilon_1 \varepsilon_2 \sigma \left(T_1^4 - T_0^4\right) S_1 S_0}{\pi l^2} \quad (2)$$

Table 2. Temperature and heat flux density of the right and left eye

Parameter	Right eye	Left eye	Significance level
Temperature [°C]	34.5 ± 0.7	34.6 ± 0.6	0.78
Heat flux density [mW/cm^2]	7.7 ± 1.3	7.7 ± 1.4	0.9

Table 3. The ocular surface temperature and the heat flux density before and after dilation.

Parameter	Before dilation	After dilation	Significance level
Temperature [°C]	34.6 ± 0.7	34.8 ± 0.5	0.07
Heat flux density [mW/cm^2]	7.7 ± 1.3	8.9 ± 1.1	0.000

IV.CONCLUSION

For the treatment of ophthalmic diseases, it is important to understand the patterns of thermal processes that occur in the eye body. From the ocular surface, the device allows high-precision measurements of both heat flux and temperature. In this proposed technique to measure the magnitude of the heat flux from the surface of the eye and the measures the temperature of the eye surface with high accuracy from the same device.

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