Accepted Manuscript

A Low-Cost, High-Accuracy Temperature Sensor Array

José A. Hidalgo-López, Jorge Romero-Sánchez, Raquel Fernández-Ramos, José F. Martín-Canales, José F. Ríos-Gómez

PII: S0263-2241(18)30366-X
DOI: https://doi.org/10.1016/j.measurement.2018.04.085
Reference: MEASUR 5486

To appear in: *Measurement*

Received Date: 7 February 2018
Revised Date: 10 April 2018
Accepted Date: 23 April 2018

Please cite this article as: J.A. Hidalgo-López, J. Romero-Sánchez, R. Fernández-Ramos, J.F. Martín-Canales, J.F. Ríos-Gómez, A Low-Cost, High-Accuracy Temperature Sensor Array, *Measurement* (2018), doi: https://doi.org/10.1016/j.measurement.2018.04.085

A Low-Cost, High-Accuracy Temperature Sensor Array

José A. Hidalgo-López*, Jorge Romero-Sánchez, Raquel Fernández-Ramos, José F. Martín-Canales and José F. Ríos-Gómez

Departamento de Electrónica, University of Málaga, 29071 Málaga, Spain
*Corresponding author. E-mail address: jahidalgo@uma.es

Abstract—Real-time two-dimensional mapping of temperature for totally or partially concealed medium- or large-sized surfaces is necessary in a variety of applications. In these cases, an array of thermistors can provide a good solution. This article describes a low-cost, scalable array of thermistors (maximum size 8 × 8), together with high-precision reading electronics. To select the electronics, which produced the best results in the array reading, two proposals from the literature were implemented and the performances were assessed taking into consideration different array sizes and thermistor resistance values. The precision of the readings was evaluated using the best electronic solution, with a maximum error of 0.036 °C, taking into account only the error in the resistance measurement and the manufacturer data. The sampling period of the complete array was 58.5 ms, thus allowing the sensor to be used in real-time applications.

I. Introduction

Real-time two-dimensional mapping of temperature distribution (2D-MTD) in medium- or large-sized surfaces is required for many applications. These surfaces may be visible, in which case infra-red thermography can be a good solution, or they may be totally or partially concealed. In the latter case, alternative technologies are needed to carry out surface measurements. This may be the case when obtaining the temperature map of a chair or cushion (when a person is seated) in order to study new manufacturing processes aimed at improving health and comfort of users [1][2]. Furthermore, measurements of brain temperature variations could reveal several neurological disorders, and systems to carry out these measurements on the surface of the cranium could help patients [3]. A handwritten digit recognition method based on a temperature sensor was presented in [4]. This proposal used sequential temperature measurements of a specific area touched by a finger to allow the identification of digits. Different electronic skin and wearable device systems use thermal sensor arrays to map temperature distribution [5–7].

Thermal sensor arrays are used to carry out measurements in all the above cases. The types of sensors used, how they are interconnect to each other and to the measuring equipment, and the electronics designed for the systems distinguish them from one another.

In [1][2] overall 64 commercial sensors were arranged on a seat surface with a separation of approximately 5 cm to cover an area of 33 × 39 cm^2. The sensors were connected individually to the data sampling unit. This requires a large number of wires (128) and complicated electronics. As a result, the acquisition time of each temperature frame was approximately one minute. In [8] Cr-Pt thin-film thermocouples were arranged in a 4 × 8 matrix. Arranging the sensors in the form of an $N \times M$ array decreases the number of wires needed for $M + N$. With this layout, the sensor array needs multiplexing in order to carry out the measurements (as described in [9]), where an array of thermocouples is multiplexed by an electrical-mechanical system. This type of multiplexers reduces the crosstalk [10–15]. which appears with the array structure and can generate significant errors in the measurement. However, the presence of electro-mechanical elements produces a minimum delay of 0.8–13 s for the 2D frames of sample temperatures. Another possibility is to multiplex using solely electronic elements. Unfortunately, errors due to crosstalk are not completely eliminated with this multiplexing technique. Thus, in [16] errors of 30% were reported for a 4 × 4 array with resistors (simulating sensors) ranging between 100 Ω and 1000 Ω. In [4], a 16 × 8 thermistor