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Implementation of a Differential Thermometer using 6B13

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1. Introduction

The measurement of temperature is an essential part of condition monitoring in a plant. Meanwhile, the aging problem of the equipment often arises during long term operation of a plant. Occasionally, the manufacturers discontinue the supply of their products due to the fast-changing in digital technology. In that case, it is necessary to develop a brand-new device to meet the operational condition of the previously installed device. As for the temperature measurement in the exchanger shown in Fig. 1, a higher resolution thermometer is required to control an accurate thermal power.

The purpose of this work is to show one of implementation techniques of a high resolution differential thermometer using RTDs (Resistor Temperature Detectors), and to verify the functional validation to be applicable to a monitoring system in the heat exchangers. A differential thermometer using an Analog Device 6B13 is implemented in this regard [1]. The input temperature is estimated using the *Callender-Van Dusen* equation, and the temperature difference is measured. The results show that the temperature difference of the proposed system matched the expected value well.

2. Implementation

2.1 Callender-Van Dusen Equation

The relation between resistance and a temperature above 0 [℃] is defined in the equation (1), as is called the *Callendar-Van Dusen* equation.

$$R_{RTD} = R_0\left(1 + At + Bt^2\right), \qquad t \geq 0[°C] \quad (1)$$

The coefficients A and B are defined in different ways [2], [3]. For the experiment, DIN 43760 (α=0.00385) was adopted for resistance calculation.

Table I: System Specifications

RTD Sensor	6B13 (for 3-Wire RTD)
Displayed Resolution	0.01 [℃]
Input Range	Platinum RTD ±100 [℃] (α=0.00385)
Channel	2 channels (A & C)
Calibration	Offset (60 ohm) / Span (140 ohm)
Baud Rate	RTD Sensor: 9,600 [bps] Monitoring System : 115,200 [bps]
Processor	TMS320F28335 (Floating Point)
Integration	100 /200 /300 /400 (reconfigurable)
Display	LCD (4 x 20)
Power	5 VDC

2.2 RTD Sensor Calibration

The RTD sensor (6B13) can be calibrated by setting the predefined digital signal. The implemented system was designed to be calibrated for the offset and span by connecting resistors of 60 and 140 [ohm], respectively.

2.3 Operation

Fig.1. shows a block diagram of the implemented system. The digital signal controller collects digital signals from two 6B13s. To achieve an accurate measurement, the average value is calculated by integrating the measured temperature after floating point operation. The integration numbers vary from 100 to 400, although these are reconfigurable. The calculated temperature is displayed on the LCD to check the measured temperature immediately. Table I summarizes the specification of the implemented system.

3. Test Results

Fig. 2 shows the implemented system. The test results of instantaneous measurement are shown in Fig. 3. The measurement was carried out under the factory setting condition, and two decade resistance boxes (Yokogawa 2793) were used. The input resistances were calculated by Equation (1). The assumed temperature at channel-A and C are 40 and 30 [℃], thus the expected temperature difference is 10 [℃]. The number of sample is 1,000. The test results show that the average temperatures were 39.964 and 29.962 [℃] at each channel, and the measured average temperature difference was 10.002 [℃]. Table II shows the experiment results.

4. Conclusions

A differential thermometer is proposed using 6B13. The resistance was calculated using the *Callender-Van Dusen* equation. The instantaneously measured temperatures show that the deviation is between 0.03 and 0.04 [℃] at each channel. Since the errors are canceled when the temperature difference is calculated, the measured average temperature difference is 10.00 [℃] as expected. The proposed system can be applied to a monitoring system for accurate thermal power control with high accuracy.

REFERENCES

[1] Analog Device, 6B Series User's Manual.1998.
[2] Analog Device, Circuit Note (CN-0381), 2015.
[3] National Instrument, Application Note 046, November 1996.

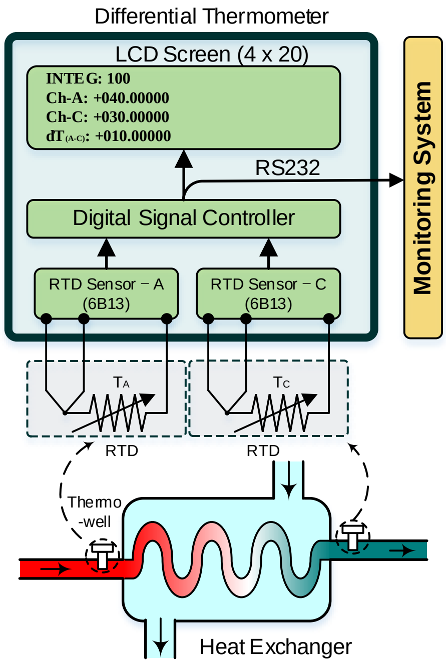


Fig. 1. Block diagram of the differential thermometer.

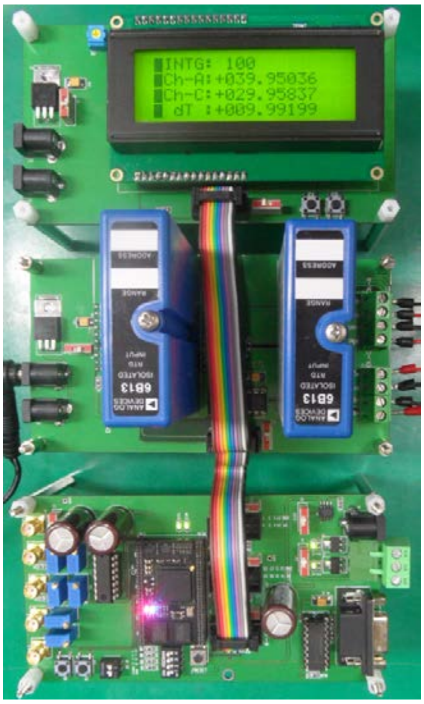
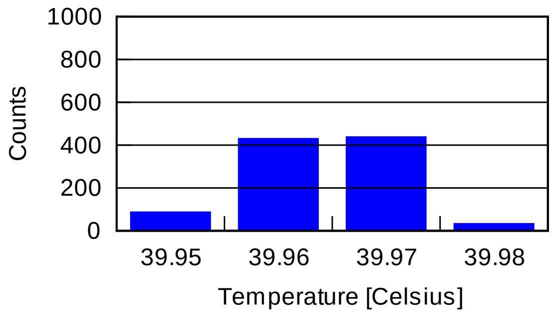
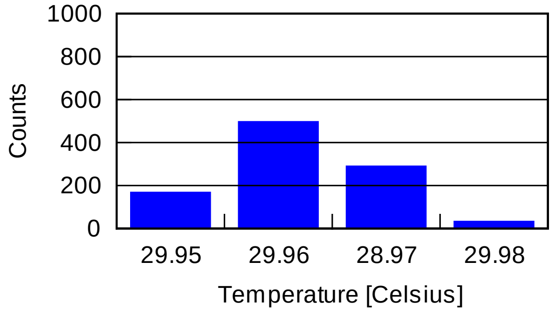


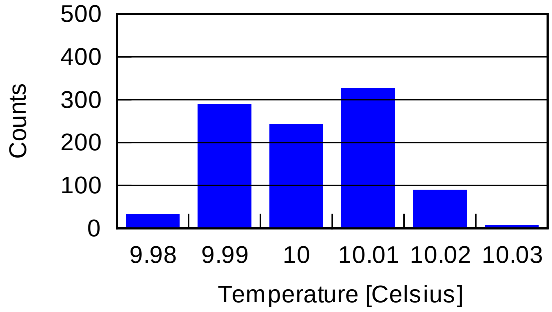
Fig. 2. The implemented system.



(a)



(b)



(c)

Fig. 3. Distributions of the instantaneously sampled temperatures: (a) Channel-A at 40 [℃], (b) Channel-C at 30 [℃], and (c) Temperature difference between channels A & C.

Table II: Summary of Experiment Results

	Temperature [℃] (Resistance [ohm] *)	Measured Mean [℃]	Sample Number
Ch.-A	40.00 (115.539)	39.964	
Ch.-C	30.00 (111.672)	29.962	1000
dT	10.00 (-)	10.002	

* Note that the resistances are calculated based on DIN 43760 (α=*0.00385*). The coefficients A and B are +3.9080E-3 & -5.8019E-7.