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Design of Temperature Data Logger Using Thermocouple

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Abstract - *There are various ideas emerge to help human works, one of them is a modern computer-based recording device with a soft file as the result, which can be opened using a computer to replace the conventional one. This paper delivers a temperature recording method by a type-K thermocouple using a data logger prototype. The tools and materials that are being used are a type-K thermocouple, a MAX6675 module, an Arduino Uno board, and an Arduino Data Logger Shield. The system was being tested with creating a folder, a subfolder, and a file on SD Card. The recording result will be a .csv type file that can be opened using a spreadsheet like Microsoft Excel. In the end, type-K thermocouple and MAX6675 module are able to read and send the input data to Arduino Uno, and the proposed data logging system is able to process and save the data from the sensor as a whole, and the recording file can be opened on a computer, with a folder, a subfolder, and a file using the intended format.*

Key Words: Data logger, Type-K Thermocouple, Arduino Uno, MAX6675, SD Card

1.INTRODUCTION

In this modern era, conventional recording method (writing on a sheet of paper) is rarely used anymore. Various ideas have been introduced to make a modern and up to date, one of them is a recording method that is computer-based with a soft file as a result which can be opened using a computer. Information on temperature measurement results of a process can be done [1–3] by monitoring and data logger [4–6]. Because of that, an idea comes to make an automatic temperature recording device that relies on microprocessor and SD Card as the data storage. The proposed temperature recording device uses an Arduino UNO board that is connected with a type-K thermocouple, a temperature sensor, and an SD Card to save the processed data by the system. Several methods used for calculating temperature measurements have been proposed [7-8] and error correction calculations have been carried out [9].

This paper proposed system uses data logging principle, where the data collecting, processing, and recording is being done in a device that is not connected to a computer and has own data storage system.

This paper provides a temperature recording method by type-K thermocouple sensor using an automatic temperature recording device. The recording system result will be a .csv *file* which can be opened using the spreadsheet Microsoft Excel.

2. METHODOLOGY

2.1 Tools and Material

Thermocouple temperature sensor is a thermoelectric temperature sensor that consist of two different metal wires (ex. chromel and constantan) that is being connected onthe probe tipand the reference junction. Fig -1 shows thermocouple cross-section [10].

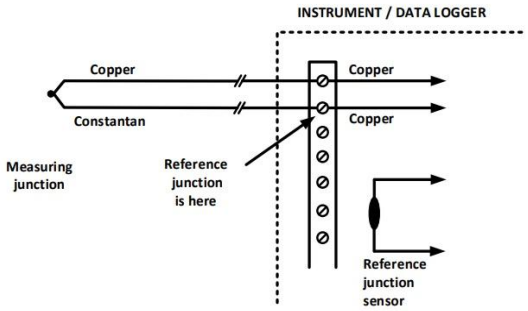

Fig -1: Thermocouple cross-section.

In the core, thermocouple consists of a pair of hot and cold transducer which is connected and melted together, where the difference on this junction will be compared with the reference junction. The thermocouples with the type E, J, K dan T are metal-based thermocouple and can be used to measure temperature up to 1000°C (1832°F). Type S, R, and B thermocouples are noble-metal thermocouples and can be used to measure temperature up to 2000°C (3632°F).

MAX6675 module is a tool that compensates the cold-junction and digitalize the signal from type-K thermocouple, can be called as a signal amplifier. The output data will have a 12-bit resolution, SPI™-compatible, andread-only format [11].

This converter has the measuring resolution of0,25°C, enables measuring up to +1024°C, and has the 8LSB thermocouple accuracy for measurement from 0°C to +700°C. Fig -2 shows pin configuration of MAX6675 module [11]. Arduino Unois microcontroller-based board, using an ATmega328 which has 14 digital input/output pins (where 6 pinscan be used as PWM output), 6 analog input pins, 16MHz oscillator crystal, type B USB jack, DC voltage input jack, and a reset button.

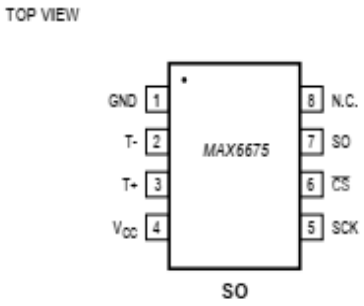

Fig -2: Pin configuration ofMAX6675 module.

These pins consist of everything needed to enhance the microcontroller. Fig -6 shows the Arduino Uno physical figure, and Arduino Uno specification is shown at Table 1 [12].

Fig -3: Arduino Uno physical figure

Table -1: Arduino Uno specification.

Component Type	Specification
Microcontroller	ATmega328
Operation voltage	5 Volt
I/O	14 pins (6 pinsfor PWM)
Current	50 mA
Flash Memory	32 KB
SRAM	2 KB
EEPROM	1 KB

Arduino Data Logger Shieldis a tool used to do thedata logging functions. It connects the Arduino with anSD Cardand aReal Time Clock (RTC) . This shield provides some features:

- Able to use any SD cardwith a FAT16 or FAT32format. 3.3V level shifter circuit enables fast data reading and writing, and prevents damages on SD Card.
- Real Time Clock (RTC) ensures the time will still be going even when the Arduino board is not connected to a power source.
- 3.3V voltage on-board regulator can be used as the reference potential (Vref) and to power up the SD card that needs a lot of power to work.
- Using an "R3 layout" for I2C dan ICSP SPI ports, so it will suit many types of Arduino board.

Fig -4 shows Arduino Data Logger Shield physical figure [13].

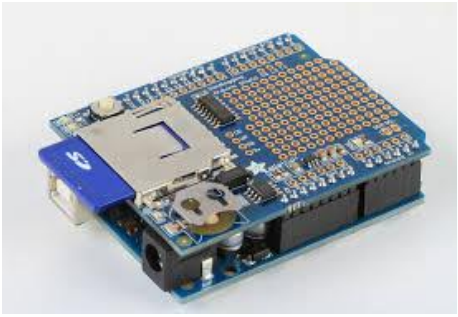

Fig -4: Arduino data logger shieldphysical figure.

2.2 Data Logger Design

The data logger design as a whole is represented by the block diagram on Fig -5.

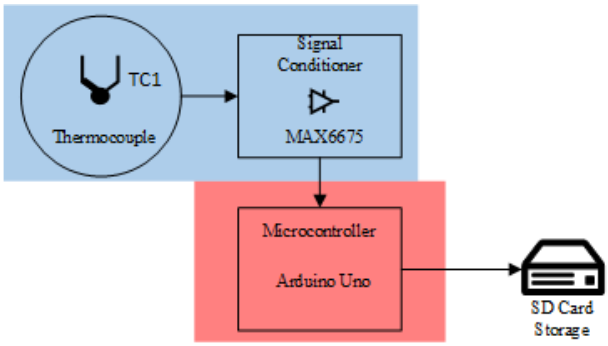

Fig -5: Data logger design diagram block.

The temperature data logger is design using a type-K thermocouple sensor with an amplifier circuit and an Arduino board. The type-K thermocouple senses the room temperature changes, and sends an electric signal to the amplifier, who will amplify the signal and sends it to the Arduino. After the Arduino receives the signal, the signal will be processed into a data that will be written onto the SD Card in a file with .csv format which can be opened using a spreadsheet application, like Microsoft Excel. The data writing will stop and create a new file when the data logger is being restarted or turned off. The program was made

using Arduino IDE with a Windows operating system. The data logger wiring is shown by Fig -6, and the physical figure of the data logger is shown by Fig -7.

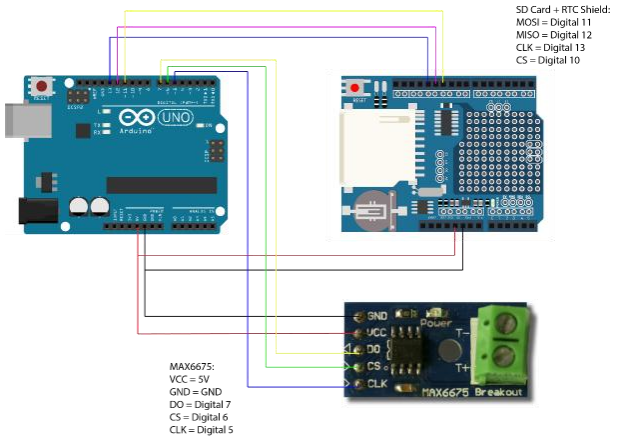

Fig -6: Data logger wiring.

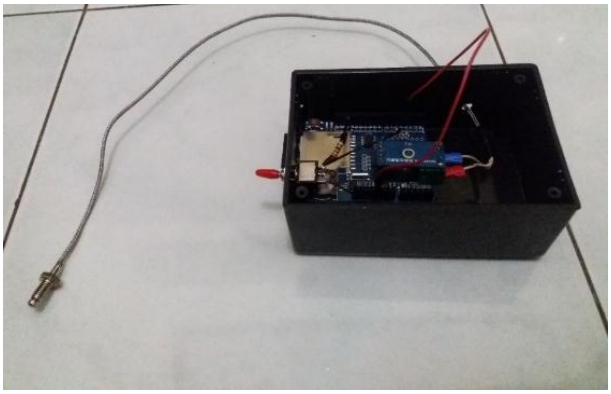

Fig -7: Physical figure of the data logger.

The type-K thermocouple that is being used were calibrated by comparing the thermocouple measuring result with a digital *thermometer*. The type-K thermocouple calibrating result is shown by Table -2.

Tabel -2: Type-K thermocouple calibrating result.

Thermometer reading (°C)	Thermocouple voltage output (mV)	Thermo-couple reading (°C)	Error (%)
30	1.203	27	10
34	1.366	35	2.85
42	1.694	42	0
53	2.147	53	0
64	2.602	64.5	0.77
72	2.934	70	2.7
74	3.017	73	1.35
80	3.267	79	1.25
102	4.179	102	0
Average			2.1

3. RESULTS AND DISCUSSION

The system was tested by creating a folder, a subfolder, and a file on the SD Card, then monitor it using a computer if the SD Card works well. Fig -8 shows successful folder making, Fig -9 shows successful subfolder making, Fig -10 shows successful file making, and Fig -11 shows the content of the created file.

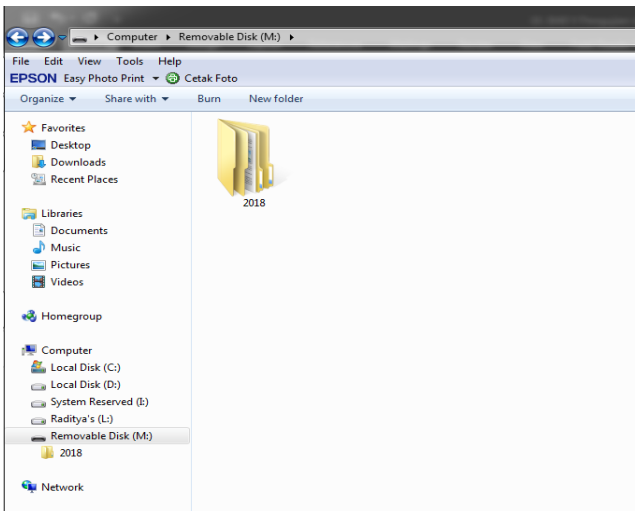

Fig -8: Successful folder making.

The first step done by the data logger system is making a folder, where the folder has been arranged to show the year when the system is being used.

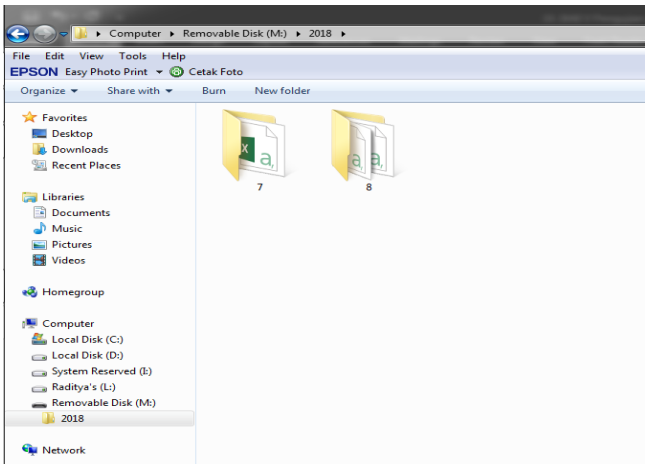

Fig -9: Successful subfolder making.

The second step done by the data logger system is making a subfolder, where the subfolder has been arranged to show the month in numeric when the system is being used.

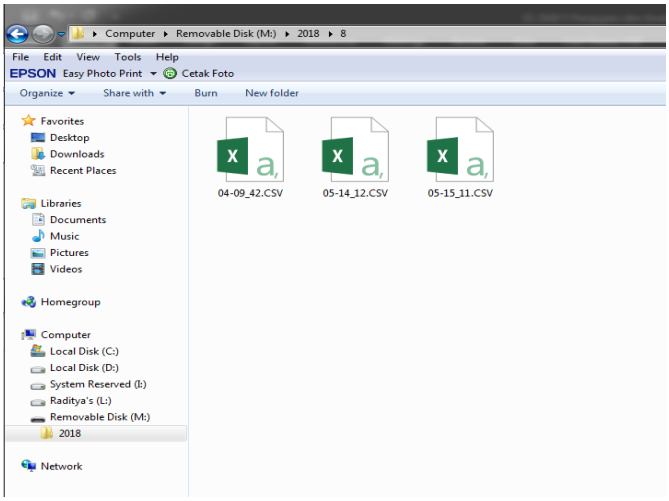

Fig -10: Successful file making.

The third step done by the data logger system is making a file, where the file has been arranged to show the date and clock when the system is being used on its title.

	A	B	C	D	E	F
1	Day	Date	Month	Year	Time	Temp (C)
2	Saturday	4	8	2018	9:43	29
3	Saturday	4	8	2018	9:44	30
4	Saturday	4	8	2018	9:45	29
5	Saturday	4	8	2018	9:46	29
6	Saturday	4	8	2018	9:47	29
7	Saturday	4	8	2018	9:48	29
8	Saturday	4	8	2018	9:49	29
9	Saturday	4	8	2018	9:50	29
10	Saturday	4	8	2018	9:51	29
11	Saturday	4	8	2018	9:52	29
12	Saturday	4	8	2018	9:53	29
13	Saturday	4	8	2018	9:54	29
14	Saturday	4	8	2018	9:55	29
15	Saturday	4	8	2018	9:56	29
16	Saturday	4	8	2018	9:57	29
17	Saturday	4	8	2018	9:58	29
18	Saturday	4	8	2018	9:59	29
19	Saturday	4	8	2018	10:00	29
20	Saturday	4	8	2018	10:01	29
21	Saturday	4	8	2018	10:02	29
22	Saturday	4	8	2018	10:03	29
23	Saturday	4	8	2018	10:04	29
24	Saturday	4	8	2018	10:05	29
25	Saturday	4	8	2018	10:06	29

04-09_42

Fig -11: Content of the created file.

In the file made by the data logger, the recording result in the working period by the data logger can be seen. The recording was done in order with a minute interval until the device is turned off.

4. CONCLUSIONS

Type-K thermocouple and the MAX6675 module works well on reading and giving the inputs to Arduino Uno microcontroller. The proposed data logger succeeds in processing and saving the data from the sensor completely. The data logger file can be opened on a computer with the wanted folder, subfolder, and file formats.

REFERENCES

[1] J. Kanetake, Y. Kanawaku, and M. Funayama, "Automatic continuous monitoring of rectal temperature using a button-type thermo data logger," *Leg. Med.*, vol. 8, no. 4, pp. 226–230, 2006, doi: 10.1016/j.legalmed.2006.04.001.

[2] P. Foltyński *et al.*, "Continuous monitoring of feet temperature using a data logger with wireless communication," *Biocybern. Biomed. Eng.*, vol. 32, no. 4, pp. 59–64, 2012, doi: 10.1016/s0208-5216(12)70049-9.

[3] I. Kwon and T. Kim, "Monitoring the effect of water temperature on the heart rate of olive flounder (Paralichthys olivaceus) using a bio-logger," *Aquaculture*, vol. 575, no. December 2022, p. 739739, 2023, doi: 10.1016/j.aquaculture.2023.739739.

[4] P. R. Kamerman, L. C. Di Zio, and A. Fuller, "Miniature data loggers for remote measurement of body temperature in medium-sized rodents," *J. Therm. Biol.*, vol. 26, no. 3, pp. 159–163, 2001, doi: 10.1016/S0306-4565(00)00037-1.

[5] M. Trezona and K. L. Moore, "75. pH/temperature loggers accurately measure muscle pH and temperature decline of pork carcasses," *Anim. - Sci. Proc.*, vol. 12, no. 2, p. 237, 2021, doi: 10.1016/j.anscip.2021.09.160.

[6] M. Pfender and H. Villinger, "Miniaturized data loggers for deep sea sediment temperature gradient measurements," *Mar. Geol.*, vol. 186, no. 3–4, pp. 557–570, 2002, doi: 10.1016/S0025-3227(02)00213-X.

[7] M. H. Nguyen, S. E. Ouldboukhitine, S. Durif, V. Saulnier, and A. Bouchair, "Method of measuring the temperature of wood exposed to fire with type K thermocouples," *Fire Saf. J.*, vol. 137, no. January, 2023, doi: 10.1016/j.firesaf.2023.103752.

[8] R. S. Volkov and P. A. Strizhak, "Methodology to calculating the temperature around an evaporating droplet using a set of thermocouples," *Measurement*, vol. 218, no. January, p. 113030, 2023, doi: 10.1016/j.measurement.2023.113030.

[9] X. Li, Q. Huang, X. Luo, and P. Wang, "Thermocouple correction method evaluation for measuring steady high-temperature gas," *Appl. Therm. Eng.*, vol. 213, no. October 2021, p. 118673, 2022, doi: 10.1016/j.applthermaleng.2022.118673.

[10] H. Lundström and M. Mattsson, "Modified thermocouple sensor and external reference junction enhance accuracy in indoor air temperature measurements," *Sensors*, vol. 21, no. 19, 2021, doi: 10.3390/s21196577.

[11] A. Com, "MAX6675 Datasheet (PDF) - Maxim Integrated Products Similar Part No . - MAX6675," pp. 6–8.

[12] P. R. Manual, "Arduino UNO R3 Features," pp. 1–13, 2022.

[13] B. Earl, "Adafruit Data Logger Shield," *Adafruit Ind.*, pp. 1–85, 2017, [Online]. Available: https://cdn-learn.adafruit.com/downloads/pdf/adafruit-data-logger-shield.pdf