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시각장애인을 위한 점자 체중계 회로 개발

박형우[*] · 김효우[*] · 신혜주[*] · 조성훈[**]

Development of Braille Weight Scale Circuit for Blind

Hyeong-Woo Park[*] · Hyo-Woo Kim[*] · Hye-Ju Shin[*] · Sung-Hun Jo[**]

요 약

본 논문에서는 시각장애인을 위한 점자 체중계 회로를 제안하였다. 시각장애인은 일반적인 체중계를 사용하는 데 있어 어려움을 겪고 있다. 제안하는 점자 체중계의 사용을 통해, 시각장애인들은 수월하게 체중을 측정할 수 있으며, 또한 체중 관리를 통한 건강 증진에 도움을 줄 수 있다. 본 연구의 결과는 시각장애인을 위한 점자 체중계의 개발 및 보급에 기여할 것으로 기대된다.

ABSTRACT

In this paper, we propose a braille weight scale circuit for the visually impaired. The visually impaired have difficulty using general scales. By using the proposed braille weight scale, the visually impaired can easily measure their weight and also help improve their health through weight management. The results of this study are expected to contribute to the development and distribution of braille weight scales for the visually impaired.

키워드

Amplifiers, Braille, Comparators, Load Cells, Priority Encoders, Weight Scale

Ⅰ. Introduction

In recent years, there has been a steady increase in the development of home appliances specifically designed for visually impaired individuals. Leading domestic appliance manufacturers have introduced a variety of prod

ucts, such as washing machines and microwave ovens, that incorporate Braille, thereby enabling visually impaired users to operate these devices with greater independence. However, there remains a significant gap in the availability of devices tailored for the health management of visually impaired individuals, with very few options that align with contemporary health management trends in South Korea. As health management gains prominence, the demand for equipment that facilitates independent health management at home for visually impaired individuals

* 한국공학대학교 나노반도체공학과 (wooluna@tukorea.ac.kr, hyowoo0105@tukorea.ac.kr, shinhj1618@tukorea.ac.kr)
** 교신저자 : 한국공학대학교 나노반도체공학과
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· Corresponding Author : Sung-Hun Jo
Dept. of Nano & Semiconductor Engineering, Tech University of Korea
Email : sunghun.jo@tukorea.ac.kr

is on the rise. Nonetheless, existing solutions frequently depend on external assistance, thereby underscoring their limitations[1], [2]. This paper aims to analyze the current state and necessity of health management devices for visually impaired individuals and propose directions for technological advancements to enhance independent health management.

The objective of this research is to develop a Braille scale that allows visually impaired individuals to independently measure and manage their weight. This scale is designed to provide weight information through Braille, enabling users to check and manage their weight without assistance from others. Currently, most scales available for visually impaired users utilize voice feedback to announce weight, whereas the scale proposed in this study displays weight solely through Braille, ensuring accurate weight measurement while protecting the user's privacy.

The primary aims of this research are, first, to design a user-friendly scale that provides accurate measurements; second, to integrate advanced features that address the limitations of existing models; and third, to evaluate the effectiveness of this scale in supporting the health management practices of visually impaired individuals. This paper will first explain the design and operational principles of the Braille scale, followed by a discussion of the technical challenges encountered during the development process and the solutions implemented. Finally, the implications of this research and potential areas for future study will be discussed.

Ⅱ. Implementation

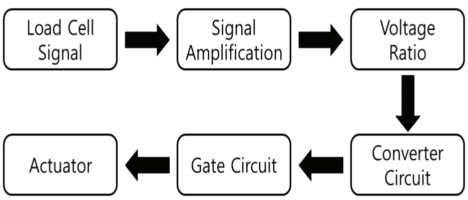

Fig. 1 Full circuit diagram

To measure weight, we decided to use a load cell. Figure 1 illustrates the overall operational diagram of the circuit. The load cell is fundamentally composed of a four-sided Wheatstone bridge structure. When an object is placed on the load cell, the resistance value of one of the four resistors in the Wheatstone bridge changes, and the weight is measured using the rate of change of the signal. Since the voltage signal from the load cell is very small, we decided to design a separate amplifier. The amplified signal was compared through an operational amplifier (Op Amp) for weights ranging from 0 kg to 99 kg.

In the middle, we designed a converter circuit to connect the gate circuit and the comparison circuit, utilizing the principle of non-alignment and Karnaugh maps for the gate circuit design. Thus, we conceptualized a total of three circuits: the amplification and comparison circuit, the converter circuit, and the gate circuit. Finally, the section where the Braille block is implemented uses an actuator to create Braille movement[3].

Additionally, we improved the issues of previously developed Braille scales through a new approach. The existing Braille scales utilized latches at the points where the Braille would emerge, making it difficult for users to feel the Braille. We addressed this issue by using actuators, which clearly indicate height, thereby solving the recognition problem. Furthermore, by tilting the Braille scale, we created a larger protrusion at the entrance where the latch does not rise, resolving the issue more effectively. The process of creating the larger protrusion involved multiple modeling iterations to find the appropriate size of the hole, which was then printed using a 3D printer.

2.1 Amplifier Circuit

The voltage value received from the load cell sensor increases by 0.2 mV as the weight increases by 1 kg. Since the voltage difference is not large, it has been confirmed that when connected to the comparator without an amplifier, noise occurs and the desired value is not output accurately. Therefore, we tried to use a 250 times amplified voltage value and used two amplifiers that were amplified 25 times and 10 times to reduce the noise.

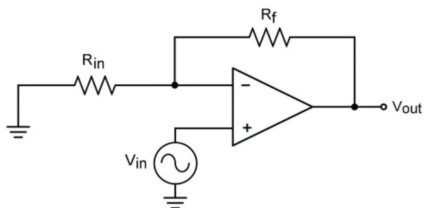

Fig. 2 Non-inverting amplifier circuit

As shown in Figure 2, it was used as a non-inverting amplifier circuit, with input voltage applied to the + input stage and a feedback resistor connected to the - input stage. Op amp has high input impedance and low output impedance, and has a large degree of amplification, so we connected high voltage. The larger the power supply voltage range, the longer the input signal that can be processed, which has the advantage of being more accurately measured when applying a high voltage.

Assume that 19.8 mV is input to V_{in}. When the load cell detects 99 kg, a voltage of 19.8 mV is output. It is amplified 25 times through the first amplifier.

The theoretical value is $(19.8\times10^{-3})\times25=495\times10^{-3}V$, and the actual simulation results in a 504.8 mV output with an error of about 9.8 mV.

The output voltage of the 25 times amplifier connects to the + input end of the next non-inverting amplifier. It has a theoretical value $(504.8\times10^{-3})\times10=5.048V$ that amplifies the input voltage 504.8 mV by 10 times, and as a result of actual simulation progress, 5.051 V was output, resulting in an error of only 3 mV.

When comparing the simulation result output voltage of 5.051v with the theoretical value output voltage $(19.8\times10^{-3})\times250=4.95V$, an error of 0.101v occurred, with an error rate of 2.04 %.

2.2 Comparator Circuit

The table 1 has the output of a total of 10 comparators from 0 kg to 9 kg.

Table 1. Comparator output truth table

Vdc	A	B	C	D	E	F	G	H	I
0mV (0kg)	0	0	0	0	0	0	0	0	0
2mV (1kg)	0	0	0	0	0	0	0	0	1
4mV (2kg)	0	0	0	0	0	0	0	1	1
6mV (3kg)	0	0	0	0	0	1	1	1	1
8mV (4kg)	0	0	0	0	1	1	1	1	1
10mV (5kg)	0	0	0	1	1	1	1	1	1
12mV (6kg)	0	0	1	1	1	1	1	1	1
14mV (7kg)	0	1	1	1	1	1	1	1	1
16mV (8kg)	0	1	1	1	1	1	1	1	1
18mV (9kg)	1	1	1	1	1	1	1	1	1

As shown in table 1, a part of the structure of a flash AD converter is cited to implement a circuit having a total of 100 output values from 99 kg to 0 kg with a difference of 1 kg using 100 comparators. An analog signal was connected to the + input terminal, a reference voltage divided by multiple resistor resistors was connected to the - input terminal, and each comparator was used for comparison. We used 101 identical resistors and 100 comparators to realize it in the corresponding structure[3].

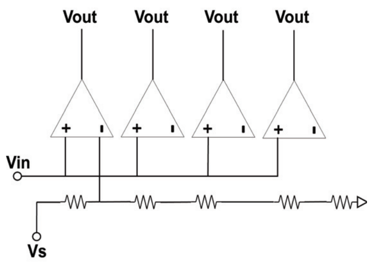

Fig. 3 Part of the comparator circuit

The 250 times amplified voltage is connected to the - input terminal of the comparator. A fixed voltage of 5 V was applied to the + input terminal, and a 1 *kohm* resistor was used to provide a 0.5 V difference before being input to each comparator, as seen in Figure 3[4].

When we put a Voltage Marker on the output part of each comparator and measured it, We got an error that we needed to add more resistors. Even if we connected Gnd directly to the output part of the comparator, tied it with a wire, or placed one resistor and Gnd, the same error occurred and did not work. Since each of the 100 comparators is recognized as one electronic component, we confirmed that the simulation would work properly unless we placed a resistor and Gnd that can make an electrical connection to each output.

Amplifiers that amplify 25 times and 10 times, respectively, have a supply voltage range of 10V or more, so OPA445, a high voltage and high current opamp that works properly even when the voltage is applied, was used.

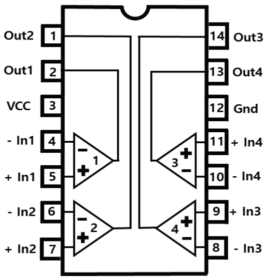

Fig. 4 LM339 pin configuration

Using 100 1-channel comparators would increase the PCB board size, so we used 4-channel LM339 as shown in Figure 4. The resistors are all SMD type, and the resistors also used small size components to reduce the board size.

2.3 Converter Circuit

The purpose of the converter circuit is to convert the signal from the previous circuit into binary. Since the output signal of the comparator is not a single signal but multiple signals, the circuit was designed with an emphasis on converting multiple signals into a single signal.

A priority encoder was used as the main component. A priority encoder is a component that can convert multiple signals into a single signal. A priority encoder is a circuit that receives multiple binary inputs and outputs the index of the highest priority input as a binary number[5]. Therefore, if the highest priority value is specified, it is output regardless of inputs of lower priorities. The output of the previous comparator shows a gradual increase in the number of 1's as the voltage magnitude, based on the weight, is converted into a digital signal.

The converter circuit was constructed using Texas Instrument's 74LS148 Priority Encoder component and Or Gate. The datasheet for this part is shown in the table below.

Table 2. Datasheet of priority encoder 74LS148

Inputs									Outputs				
EI	0	1	2	3	4	5	6	7	A2	A1	A0	GS	E0
H	X	X	X	X	X	X	X	X	H	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	H	L
L	X	X	X	X	X	X	X	L	L	L	L	L	H
L	X	X	X	X	X	X	L	H	L	L	H	L	H
L	X	X	X	X	X	L	H	H	L	H	L	L	H
L	X	X	X	X	L	H	H	H	L	H	H	L	H
L	X	X	X	L	H	H	H	H	H	L	L	L	H
L	X	X	L	H	H	H	H	H	H	L	H	L	H
L	X	L	H	H	H	H	H	H	H	H	L	L	H
L	L	H	H	H	H	H	H	H	H	H	H	L	H

Table 2 is the truth table of the 74LS148 component, which is confirmed through simulation[6]. In the table, L (Low Signal) means 0 in a digital signal, H (High Signal) means 1 in a digital signal, and X means that it does not matter what signal comes. The output signal exhibits a change when a high signal is followed by a low signal in the input.

The component used in this circuit was an 8-to-3 priority encoder, and several of these components were used to output 100 inputs. 8 inputs can be output with 3 bits, but 100 inputs require more than 7 bits outputs, so the circuit is connected in series. When only one component is used, up to 3 bits can be output, and by using the rules of binary numbers, a circuit with a total of 7 bits of binary output was built.

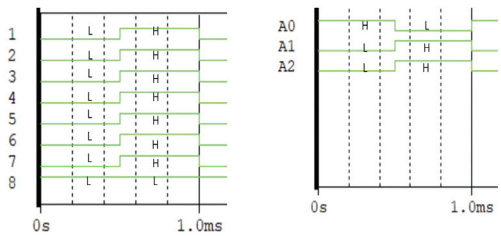

Fig. 5 74LS148 simulation results when signal of '6' is applied

As a result of the simulation shown in Figure 5, it was found that it matched the data sheet of the part. Figure 5 shows that when the input signal corresponding to '6' is applied, the binary number '110' is output.

Table 3. Binary conversion datasheet

	A6	A5	A4	A3	A2	A1	A0
0 *kg*	0	0	0	0	0	0	0
1 *kg*	0	0	0	0	0	0	1
2 *kg*	0	0	0	0	0	1	0
3 *kg*	0	0	0	0	0	1	1
4 *kg*	0	0	0	0	1	0	0
5 *kg*	0	0	0	0	1	0	1
6 *kg*	0	0	0	0	1	1	0
7 *kg*	0	0	0	0	1	1	1

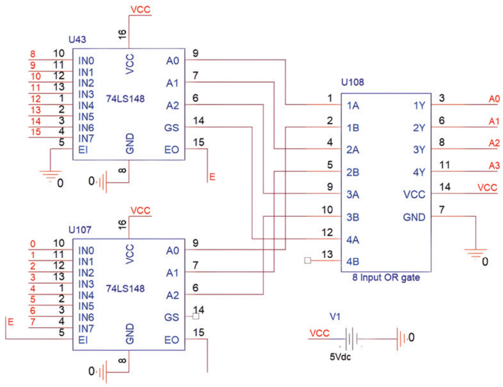

Fig. 6 Part of the converter schematic

Therefore, it is recognized that the circuit operates the same as the truth table in Table 3, and Figure 6 shows a portion of the converter circuit diagram as a circuit diagram[7].

This circuit is the part connected to the actuator circuit, that is, the operation circuit, that implements Braille. In this part, it was converted to binary to convey the exact value[8].

2.4 Actuator Circuit

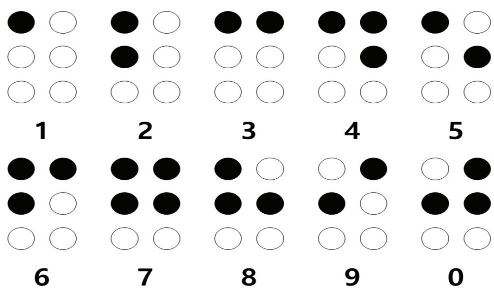

Fig. 7 Braille notation of numbers

Checking Table 4 reveals the truth table necessary for circuit design. A total of 7 signals A, B, C, D, E, F, and G follow the binary system and show an increase, with corresponding values for Large WXZY and Small wxzy also identifiable. The principles of the Karnaugh map and Boolean algebra were employed to design such a circuit. Eight types of circuits were designed, and among them, PSpice simulation results for Large Z were presented. The output was designed to represent a low value of 0 and a high value of 1[9].

Table 4. Actuator work truth table

	Inputs							Outputs							
	A	B	C	D	E	F	G	W	X	Z	Y	w	x	z	y
0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	1
1	0	0	0	0	0	0	1	0	1	1	1	1	0	0	0
2	0	0	0	0	0	1	0	0	1	1	1	1	0	1	0
3	0	0	0	0	0	1	1	0	1	1	1	1	1	0	0
4	0	0	0	0	1	0	0	0	1	1	1	1	1	0	1
5	0	0	0	0	1	0	1	0	1	1	1	1	0	0	1
97	1	1	0	0	0	0	1	0	1	1	0	1	1	1	1
98	1	1	0	0	0	1	0	0	1	1	0	1	0	1	1
99	1	1	0	0	0	1	1	0	1	1	0	0	1	1	0

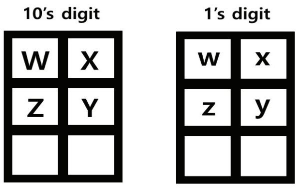

Fig. 8 Braille notation of numbers

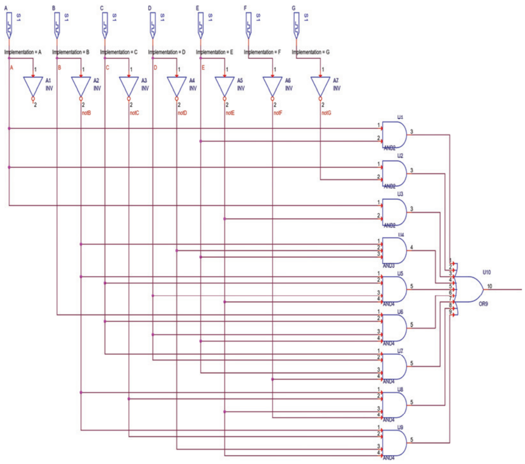

Fig. 9 Circuit of large Z

Figure 9 shows the circuit diagram of Large Z. The circuit is designed using analog components such as Or gates, And gates, and Not gates. Simulation results for all weights were intended to be attached; however, that would require attaching 100 simulation results. Checking table 5 reveals the output values of Large Z for each weight.

Table 5. Datasheet of large Z in the cases of 0 kg, 10 kg, and 87 kg

	A	B	C	D	E	F	G	Z
0kg	0	0	0	0	0	0	0	1
10kg	0	0	0	0	0	0	1	0
87kg	0	0	0	0	0	1	0	1

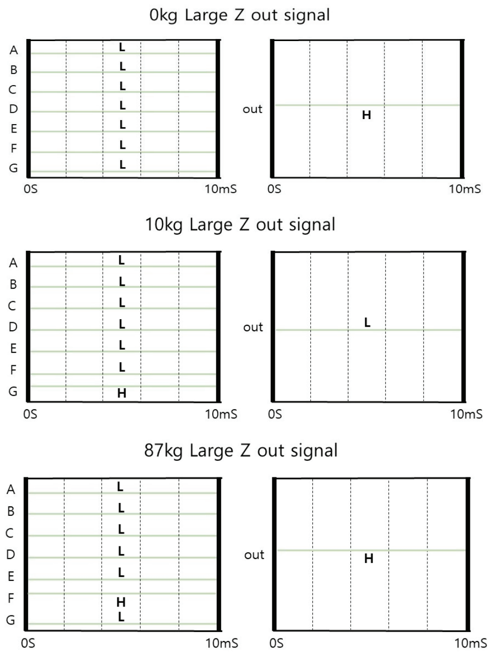

Fig. 10 Simulation results of large Z in the cases of 0 kg, 10 kg, and 87 kg

Figure 10 shows the results of the signal, which are presented in Table 5. Taking 0 kg as an example, when low signals are added to simulations A, B, C, D, E, F, and G, it was observed that a high signal is generated as output. Similarly, when checking 10 kg and 87 kg, results consistent with those in Table 5 were obtained. Through these low and high outputs, we ultimately achieved the ability to control the Braille movement of the actuator[10].

Ⅲ. Conclusion

Braille scales can make accurate measurements using a pressure sensor (load cell). In order to measure more accurate values by increasing the number of decimal places, more comparators were used to make detailed comparisons. Additionally, it was found that noise was the cause of the error in the signal output from the comparator from the theoretical value. Therefore, we would like to process noise using the Schmitt trigger to derive more accurate values.

By implementing a Braille scale for the visually impaired, people need less help from others to live their lives. In addition to the scale, it can be used in many other ways, such as measuring small scales or InBody. Considering people's recent interest in health, the demand for scales will increase and their marketability will increase.

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저자 소개

박형우(Hyeong-Woo Park)

현재 한국공학대학교
나노반도체공학과 재학

※관심분야 : 반도체집적회로설계

김효우(Hyo-Woo Kim)

현재 한국공학대학교
나노반도체공학과 재학

※관심분야 : 반도체집적회로설계

신혜주(Hye-Ju Shin)

현재 한국공학대학교
나노반도체공학과 재학

※관심분야 : 반도체집적회로설계

조성훈(Sung-Hun Jo)

현재 한국공학대학교
나노반도체공학과 조교수

※관심분야 : 반도체집적회로설계