Proposal of Triggered Touch Switch Model with High Accuracy

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Abstract: Recently, the smart switch becomes more and more popular in many applications, for example, the smart home system. Even in some legacy equipments, the switch also is changing from the mechanical contact type to a smart touch style. The touch switch described in this paper has the function of bending and adding. Furthermore, changing the number of switches can be performed without changing the center system. In our previous research, the availability is low because the maximum number of switch is limited which is less than 20. In order to solve this problem, a new touch switch model was proposed. In this study, human body is used as trigger only to activate touch switch but not as a part of closed current circuit for measuring anymore. For determining the touch switch number, DC current is used. The DC current obtains a large and stable current than that of conventional method, and the result is not affected seriously by noise. Benefit from this idea, the accuracy is tremendously improved. The number of switches are able to connect to a single system extends to 400. It is enough for a practical application.

Keywords: Touch switch, Adding arbitrarily, Detect

1. Introduction

Currently, smart home system gradually rises to replace the conventional home system. Switch as an important part of home system is also changing. In conventional family system, switch control system requires a lot of wiring before design the house [1]. It is complicated. Intelligent switch can satisfy more requirements in a smart system, such as voice control, light sensing [2], touch sensing, pressure detection and so on. These switches have more function than normal mechanical switch but still have some drawbacks. Voice-activated switch can turn on automatically in the case of having voice. However, the accuracy of voice recognition is not enough, so it sometimes works wrong. UMBREL-LAED touch switch using infrared transmit and receive circuits to identify touch operation [3]. This switch is safe but not convenient for blind people [4]. The shape of switch is stationary and also the position. The number of switch is set when the whole system is designed. In this situation, if we needs to increase the number of switches, the control system has to be changed and required rewiring [5].

For the improvement of these problems, a system of touch switch was proposed [6]. In this switch system, a metal film is used as the touch switch. When a finger touched the panel, small current flows through finger. After dealing the current signal, state of the switch can be easily detected. As this switch is metal film, the shape can be free to design, even bending is also available. It is easy to increase or decrease the switch number. However, according as the number of switches increases, the accuracy drops. The Maximum number of switch is just 20. It may not enough for ward call system or smart home system.

In order to solve this problem, a new touch switch model is proposed [7]. In conventional touch switch, the value of current flowing though human body is detected. The current level is under [mA] order. This is very small, so it may be fluctuated by a slight noise. This is because human body has high impedance about alternative current, so the value is very small and affected by noise. The principle was mentioned in Ref [7], but that was just a proposal. The content of electric circuit was not explained very much, and the accuracy was not discussed at all. In this study, Ref [7] is examined more in detail. Instead of the measurement of current flowing human body, human body is used as only trigger to activate touch switch. For determining the touch switch number, DC current is used. The value obtained by DC current is much larger than that of conventional method, so the result is not affected by error very much. Because of the idea, the accuracy is very improved. The number of switch connected to system can up to 300. It is enough for practical application.

This paper will introduce the touch switch system in the following sequence. Section 2 describes the principle of new touch switch model. Simulation of new method will be shown in section 3, and section 4 mentions the results. The last section mentions conclusion of this paper.

2. Proposal of High Accuracy Detecting Method

2.1 Principle of switch position detection for conventional method

Figure 1 shows the block diagram of touch panel switch of conventional model [7]. The part A
in the left side of Fig. 1 shows the detection circuit. The right side B shows the touch panel switches. Part A and part B are connected by only two lines. If human touches a metal film of a touch panel switch in part B, the current of $i_1$ and $i_2$ flows from detection circuit A. Figure 2 shows the equivalent electric circuit. In the backside of metal film of each touch panel switch, a resistance $R$ is connected. The principle will be mentioned next section. first level

Figure 1: Block diagram of touch panel switch of the model proposed in Ref. [7].

Figure 2: Equivalent electric circuit of Fig. 1.

Figure 3: Equivalent electric circuit in case of touching a panel by finger on the system in Fig. 1.

(a) Summary figure in case of touching a panel by finger in the system of Fig. 2.

(b) Equivalent electric circuit (I) of Fig. 3(a).

(c) Equivalent electric circuit (II) of Fig. 3(a).

where, $N$ is the touch switch number, and $n$ is the number touched from left side. Thus, the touched switch number is determined by measuring $i_1$ and $i_2$. In the right term of Equation (1), the values of $i_1$ and $i_2$ are not included. This means that the value of Rate does not change in spite of touching condition, if the same touch switch is touched. For example, even if a panel switch is touched strongly or slightly, long time or shortly, the value of Rate does not change. This is very useful characteristics. However, the value fluctuates in reality. This is because the values of $i_1$ and $i_2$ are in order of $\mu A$. Therefore, is affected by noise. In reality, the maximum panel number is about 20. For more application, we should increase the number. The principle will be mentioned next section.

2.2 Principle of switch position detection for proposed method

The equivalent electric circuit of the model proposed in this study is shown in Fig. 4. To specify the touched panel number, Equation (1) can be used as well as conventional method. The circuit is similar to that of Fig. 3(c), but a little different. The impedance of $R_s$ and $C_s$, which is corresponding to human body in Fig. 3(c), is not included in Fig. 4. Thus, the currents $i_1$ and $i_2$ in Fig. 4 are much larger than those of Fig. 3(c). In addition, instead of AC voltage source in Fig. 3(c), DC voltage source is used in Fig. 4. This makes the detecting circuit much simple compared with AC circuit. These two advantages are gotten in this proposed model. The reason is mentioned as follows.

Figure 5 shows the block diagram of touch panel switch proposed in this study. As understood from the comparison with Fig. 1, control lines are added. The lines are shown as blue lines in Fig. 5. Even if the number of touch panel switch increases, the line number does not change. Figure 6 illustrates the equivalent electric circuit of Fig. 5. Sub circuit are included in each touch panel switch, and relay switch is also included in it. The relay is connected to Vcc (DC) line. As understood from this figure, only DC voltage is supplied to resistance, so measurement of current is easy. Figure 7 shows equivalent electric circuit when human touches film. In Fig. 7(a), the second film from left side is touched, so the second relay switch is turned on. Since the relay is connected to Vcc (DC) line, the direct voltage is supplied to resistance. The equivalent circuit is shown Figs. 7(b) and 7(c). To specify the touched panel switch, Equation (1) is used. Although the same equation as con-
Figure 4: Equivalent electric circuit of the touch switch model proposed in this study.

Figure 5: Block diagram of touch panel switch of the proposed model.

Figure 6: Equivalent electric circuit of Fig. 5.

If the conventional model is used, the order of the current is much different. At least, the current in this study is 100 times larger than that of conventional model. Therefore, the effect of environmental noise is much lower than that of conventional model.

Figure 7: Equivalent electric circuit in case of touching a panel by finger on proposed model.

Figure 8: The definition of each part for the simulation of proposed model.

Figure 9: The circuit diagram for activation of DC switch by touching film.
3. Simulation of Sub Circuit Operation

In this study, different from conventional model, we does not utilize the value of current flowing through human body. Touch film is used only for connecting DC line. For it, sub circuit is embedded. The operation is mentioned here. Figure 8 explains the parts used for simulation. There are three parts, (a) finger, (b) sub circuit, and (c) switch part. When a human touches metal film, the sub circuit activate and the relay switch turns on. The corresponding circuit is shown in Fig. 9. The waveforms of points (A)-(E) in Fig. 9 are displayed in Fig. 10.

At point (A) in Fig. 9, 10 kHz clock is given from detection circuit (for the clock, see Fig. 6). The waveform is shown in Fig. 10 (A).

The finger part in Fig. 9 simulates the panel switch and the touch by finger. Touch and release are repeated at an interval. Finger is regarded to RC series circuit. The values of R and C are set to be the representative values of human. When the pulse in Fig. 10 (B) is ON, it corresponds that human touches panel films. This means that SW (S3) in Fig. 9 is ON.

For the period, the voltage at the point of (C) lowers. This is shown in Fig. 10 (C). When a human touches metal film, the impedance of finger (R1 and C1) is connected in parallel of R3, so the combined impedance decreases. As the result, the voltage of point (C) decreases.

At the point of (D) in Fig. 9, the envelope of (C) is extracted. The operational amplifier U1 is a buffer circuit. The output of U1 is the same as input of U1 which is the voltage of point (C). The envelope is gotten by D1, R8 and C3. The waveform is displayed in Fig. 10 (D).

The waveform is divided into two voltages by comparator U2 in Fig. 9. This is shown in Fig. 10 (E). The voltage of the point (E) is supplied to relay switch (SW1) in Fig. 9, and the DC voltage is connected to “Line 1”. Thus, when human touches film, DC voltage is supplied to signal line. After that, since the touch switch circuit is regarded as DC circuit as shown in Fig. 7(b) and 7(c), we can easily judge which panel is touched.
In this study, we confirmed the validity of the model by the use of simulation. The real circuit is not be made yet. We should make it in the future.

5. Conclusion

In conventional touch switch, the connected switch number is small. This is because human body is used as a part of closed circuit for the detection of current value. The value is very small and easily affected by noise. In this study, the proposed model is examined more in detail. For the touched switch detection, instead of measuring the current flowing through the human body conventionally, proposed method use the human body only as a trigger to close the circuit of the touched switch. For determining the touch switch number, DC current is used. The DC current obtains a large and stable current than that of conventional method, and the result is not affected seriously by noise. Benefit from this idea, the accuracy is tremendously improved. The number of switches are able to connect to a single system extends to 400. It is enough for a practical application. In future, we are planning to implement this touch switch to smart house system, and develop more convenient applications for the hospital and home care.

References

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