## An Optimal Design of New Touching Key

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Abstract— JST080 is a capacitive touch-sensitive chip based on the principle of relaxation, which can design and implement touch key system with MCU. The system is qualified with simple hardware circuit, reliable performance and convenient usage. To improve the reliability of capacitive touch key system, in terms of the working principle of JST080, the implementation scheme of capacitive touch key in the aspects of anti-interference ability and self-adaptive capability is proposed. This scheme can effectively deal with all kinds of interference signals, and at the same time is qualified with functions of self-adaptive processing and the adjacent sensing key suppression. By applying this scheme, the optimal design of JST080 touch key is achieved, which provides a new solution to the implementation of touch key.

# Keywords- principle of relaxation, capacitive touch key, JST080, anti-interference, self-adaption

In the electronic products of our daily life, the touch sensing technology has gained increasingly more attention and application. Capacitive touch sensing is rapidly replacing the traditional push-button switch user interface, for it requires no mechanical action, can make the product completely sealed, makes the design more aesthetic and durable, and is qualified with greater sensitivity, stability and reliability. In addition to the increasing expansion in consumer market , the touch sensing is also beginning to be applied in medical, industrial and automotive applications because of its aesthetic appeal , maintenance, cost, cleanliness and so on.

Microchip, current world's leading provider of microcontroller and analog semiconductor, proposes a brand new mTouch solution that enables engineers to easily add touch-sensitive application surface while using applications of PIC microcontroller. The technology of this new mTouch solution mainly applies two methods: principle of relaxation and measurement of direct capacitance.

JST080 is a kind of capacitive touch sensing ASIC based on the principle of relaxation. It has built-in 8-BIT MCU, 8-channel capacitive touch sensing IC, self-developed algorithms that can effectively deal with all kinds of interference signals, self-adaptive processing program and function of adjacent sensing key suppression. It can be widely used in consumer electronics products, such as handheld communications , MP3, MP4, household appliances , education, toys , PC , instrumentation, medical equipment , handheld remote control and some other products.

## I. WORKING PRINCIPLE OF JST080





Fig.1 Principle of capacitive touch buttons

The basic principle of JST080 capacitive touch-sensitive key is a constant charging and discharging relaxation oscillator<sup>[1]</sup>, as is shown in Figure 1. If the switches haven't been touched, relaxation oscillator has a fixed charging and discharging cycle and the frequency can be measured. If we touch switch with finger or stylus, the dielectric constant of the capacitor would be increased, the charge-discharge cycle becomes longer, and the frequency will be reduced accordingly. Therefore, the cycle measured can detect touch action.

Relaxation oscillator is a self-excited RC oscillator<sup>[2]</sup>, and it uses two comparators with SR latches to change the voltage charging direction of sensing capacitor, as is shown in Figure 2. The positive input of comparator determines the minimum and maximum charge, C1 + is an internal signal, C2 + connects external signal to set the lower limit of charging, and 1000PF capacitance is applied to filter out the high frequency noise from power supply and to ensure a stable lower limit. Voltage V-will be charged and discharged in a specified range, and it is driven by C2OUT logic level signals.



Fig.2 Relaxation Oscillator Circuit

The charge limits are set through the positive input of comparator. The time that the lower limit is charged to the upper limit and in turn the upper limit is discharged back to the lower limit is the cycle of oscillator. When the voltage V<sub>2</sub> of capacitor Cs is below the lower limit, the system starts charging. If V<sub>2</sub> is between the upper and lower limits, the system remains the previous state (charging or discharging). When V<sub>2</sub> is higher than the upper limit, the system starts discharging, and then continues to discharge in the middle region. The whole charge and discharge cycle<sup>[2]</sup> is shown in Figure 3, namely oscillation waveform of capacitive touch key.



The feedback resistor R and the sensor plate (represented as Cs) together form an RC circuit, as is shown in Figure 4, and the rate of capacitor charging and discharging is determined by RC time constant.

When finger approaches the bonding pad, the additional capacitance brought in by the finger makes the total capacitance become large, resulting in changes in RC time constant of the oscillator. As is shown in Figure 5, the frequency of oscillator decreases while RC time constant increases, and this frequency change would be detected by microcontroller. Capacitance increment is the basis for the testing.





Fig.5 RC time constant change

#### B. Working Principle of JST080

JST080 senses the slight change in the external analog signal through KEY0-KEY7 port to identify whether there is an interference source approaching or exposing to KEY0-KEY7 port. As is shown in Figure 6, KEY0-KEY7 is made into a key port by using this principle, and whether a button is pressed can be identified by sensing the slight change of analog signal around the key port.



Fig.6 JST080 hardware circuit diagram

#### Inching Key+Infrared Communication

When pressing the panel, the electric charge migrates from the panel to the PAD of the sensing key below the panel and the PAD is connected to the sensing feet of sensor chip. At this time, the chip's internal circuits sense the voltage change, give the corresponding time value, and then identify whether there is a key through systematic algorithm. flowchart.

### II. OPTIMAL DESIGN OF JST080

In the design of touch-sensitive key, the charge or level of capacity of touch key and some associated conversion relationships should be firstly detected, that is, the system must be calibrated. Secondly, changes in charge / level would be affected by external environment, electrostatic discharge and electromagnetic interference both would lead to malfunction, environmental changes like temperature change would affect the calibration of system, and other contaminants deposited on the surface would affect the accuracy and repeatable operability. Therefore. anti-interference and self-adaption become the key elements in the design of touch-sensitive key.

## A. Implementation Program of Self-adaptive Capacity

Keys should be qualified with self-adaptive capacity, for the charging time of key would vary with the temperature and humidity changes in environment. The judgment of whether the key is pressed is achieved by comparing the difference between the two key charging time values read with the difference previously required. The key charging time value firstly read after electrified is applied as the charging time value when no key is pressed, if the charging time value without key pressed remains unchanged, the real charging time value with no key pressed would change slowly with time going by. When this difference is greater than the standard difference prescribed, it is considered a key is pressed.

The following program is proposed to solve this problem. Charging time with no key is always in flux and varies with environmental changes. The keyless charging time value saved is made equal or close to the real keyless charging time value all the time, to achieve the self-adaption of key.

Formula :  $T_{nkn} = \frac{T_{nkn}^0 + T_{nkn}^1}{2}$ 

 $T_{nkn}$  : new keyless charging time value,  $T_{nkn}^0$  : previous

(1)

keyless charging time value,  $T_{nkn}^1$ : newly read keyless charging time value.

Refreshing key value according to above formula, if hand touches the key slowly, the software would not be able to recognize a key pressing.

## B. Implementation Program of Anti-interference Ability

Anti-interference ability can be achieved from two aspects: increasing the charging time on the hardware and examining PCB board design closely to improve anti-interference ability; adding software to the software to avoid repeated press.

For hardware, due to the constraint on the key scanning time, key charging time is limited to a relatively short period. Therefore, it can only increase the anti-interference of key by examining PCB design closely.

1) Key is formed into fork shape, two small forks cross but do not link to each other, and one small fork is connected to key port while the other is connected to earth.

2) The gap between the keys is covered with earth wire<sup>[3]</sup>, so that the interference signal the key, as is shown in Figure 8.

3) The wiring of key should try to follow a straight line.

4) The size of key should be made the same size of ordinary people's finger, to increase touch area between hand and key<sup>[8]</sup>.

Adding software to the software to avoid repeated press, the main procedures are as follows.

1) The affirmation of whether the key is pressed requires that the counting values twice pressed should be the pressed values.

2) In the case of counting value decrease, if no key is pressed, whether the counting value of key should be refreshed needs to be determined, which can prevent the case that keys can not be detected when the speed of key touching is relatively slow.

### III. APPLICATION EXAMPLES OF OPTIMAL PROGRAM

The above self-adaption and anti-interference program has been successfully applied in JST080. In the design of judgment programs of JST0180 key pressing and loosening, self-adaptive refreshing of keyless counting value and anti-shaking practice with software are applied, which improves the self-adaptive capability and anti-interference ability of touch key and makes the whole touch key system be more reliable.

## A. Judgment Program Design of JST080 Key Pressing

In the design of judgment program of key pressing, to determine whether the key is pressed, if the difference between read-out value (represented as N) and previous

key value (represented as B) is greater than the standard value of key pressed (represented as DC), namely BN> DC, there is a key press action. As is shown in Figure 10, when the key press action is identified, an anti-shaking program is applied; when no key press action is identified, self-adaptive program is applied.

The selection of standard value of key pressed DC is relevant with customer's requirements for key sensitivity. The higher the sensitivity is, the smaller the corresponding selected standard value is. Meanwhile, DC is selected according to the standard of anti-interference and key action identification. Anti-interference refers to the selected standard values should not be too small, and the case that the difference changes caused by temperature, moisture, or other interferences are treated as key pressing action should be prevented. Being able to achieve key action recognition refers to the selected determining difference can not be too large to prevent judgment of key action.

#### B. Judgment Program Design of JST080 Key Loosening

The above self-adaptive program is also applied in judgment program of key loosening, as is shown in Figure 11. Assuming the standard value of key loosened is UC, if NB> UC, there is a key loosening action. Finally, keyless counting value is refreshed through self-adaption before exiting the program. The selection rule of UC is the same with DC.

### IV. CONCLUSION

Through thorough research on dedicated chip JST080 of capacitive touch, the programs that self-adaption is applied to refresh keyless charging time, software is added to software to avoid repeated press, and optimized PCB design is applied in hardware are proposed. Repeated practices have proved that the programs effectively improve the self-adaptive capability and anti-interference ability of capacitive touch key. It provides a new solution for the realization of touch key, is widely used in this series of products, and also wins the praise from the masses of users.

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