The Design and Application of Infrared Pedometer

Ting LU¹, Yue-lin DU¹ and Shu-chao ZHANG²

¹College of Electronics Science and Engineering, Nanjing University of Posts and Telecommunications, Nanjing China
²Overseas Education College, Nanjing University of Posts and Telecommunications, Nanjing China

Keyword: Pedometer, Acceleration transducer, Reflected infrared sensor, LCD.

Abstract. Nowadays, our country's economy is developing rapidly, and a lot of people have improved their standard of living, especially citizens living in city centers. More and more people are paying attention to health rather than money. Walking, the most convenient means of exercise, is getting more and more popular. But, how do we determine the number of kilometers should we walk each day, and how many calories should we consume per hour. All of us should find a balance between time, energy and health. So, this situation has created a demand for technology of the pedometer. Recently, a variety of pedometers have appeared on the market. Most of them are designed with important components called acceleration transducer. However, in some cases such as running to fast or going upstairs, it will make some errors when counting the number of the steps. In order to improve the weakness of the pedometer with acceleration transducer, we tried to design new kind of pedometer based on infrared technology. By observing the walking process of more than 300 people, we found that the most obvious changes happen at the feet. We decided to focus on this aspect of motion to design the infrared pedometer. The basic principle of our design is just like the infrared counter.

Introduction

Background

Nowadays, our country's economy is developing rapidly, and a lot of people have improved their standard of living, especially citizens living in city centers. More and more people are paying attention to health rather than money. Walking, the most convenient means of exercise, is getting more and more popular. But, how do we determine the number of kilometers should we walk each day, and how many calories should we consume per hour. All of us should find a balance between time, energy and health. So, this situation has created a demand for technology of the pedometer[1-4]

Before beginning this design, we have done a lot of research about how much exercise should be done by each person and how many calories should be consumed per day. The brief answer is 1,500 kilocalories, but for different people the answer is obviously different. The old and child should do fewer exercises and the fat and the youth should consume more calories. Especially for the pregnant women and patients, we should exactly know the number of consumed calories.

By searching on the Internet, it is easy for us to get the equation below:

Walking Consumed Calorie (kcal) = Weight (kg) * Walking Time (hour) * Index

Index(K) = 30 / speed (minute/400 meter)

Walking time can be shown from the watch, weight can measure by the weigher. In order to get the speed, we should know the step number and the step length. The relationship between height and step length is shown below:

Height = Step Length * 6.875

With these equations, we can count the walking consumed calories for every person as long as he knows how many steps has he walked. That's the main task of our design.
The Current Situation and the General Technology in Our Research Area

Recently, a variety of pedometers have appeared on the market. Most of them are designed with important components called acceleration transducer. It's a special sensor which is designed to measure the acceleration of an object.

**The Principle of Pedometer with Acceleration Sensor.** When people are walking, there will be a vertical acceleration appears on the waist. Of course, nearly every part of our body will change the rate of acceleration when we are walk. However, in order to simplify the problem, people choose to monitor the acceleration changes on the waist. There are two reasons for this. The first is that the motion of the waist when we are walking is much simpler than the motion of legs and feet. Secondly, compared to other parts of our body, the biggest acceleration change in a vertical direction happens at the waist[5,6].

Acceleration transducer can transform the acceleration information to electric signal, so the MCU can count the steps by monitor the peaks of the electric signal.

**The Weakness of Pedometer with Acceleration Sensor.** This is an effective way to plan for the design of a pedometer. That's why so many companies are manufacturing this kind of pedometer. However, we discovered some problems with these pedometers with acceleration transducer. When people run at high speed or go upstairs, it will make some errors when counting the number of the steps. This is because the principle of acceleration transducer counting is based on judging the changes in acceleration happen at the waist. When these kinds of changes in vertical direction are big enough, the pedometer regards people have walked one step. However, when some complicated actions happen on the waist or when acceleration changes on the waist exceed the range we set there must be something wrong during the counting process.

When the CPU try to change the peak-to-peak signal into TTL signal, there will be something difficult to get the right answer. Because the signal get from the acceleration transducer may has lots of noise signal. The noise signals not only come from the devices, but also come from the original signal collection. Walking is a kind of action happen in three dimensions. And it is a random process which means the acceleration change in the vertical direction must not just like peak-to-peak shape, but has many small peaks. This will bring us some problems to count the number of steps.

The Brief Introduction of Our Design and Main Task for Us

In order to improve the weakness of the pedometer with acceleration transducer, we tried to design new kind of pedometer based on infrared technology. By observing the walking process of more than 300 people, we found that the most obvious changes happen at the feet. When we are walking, we can stop swinging our hands or even can walk as slowly as we can to avoid the intense changes of the acceleration in any direction, but we cannot stop our feet. Furthermore, we have to cross our feet by before and after in period. We decided to focus on this aspect of motion to design the infrared pedometer. As we all know, the technology of infrared counter is very mature. This makes our design to be feasible. What's more, our design also has a most important advantage that its precision won't influence by the intense, speed and direction of your steps[7,8].

**Three Different Kinds of Photoelectric Sensor.** As we all know the most important part of our design is to transform the step number information to optical signal. Then change the optical signal to electric signal and analysis by MCU. So we should find the most appropriate infrared sensor. A photoelectric sensor or some people called photo eye. It is one kind if infrared sensor used to detect the distance, absence, or presence of an object by using a light transmitter. There are three different functional types: opposed (through beam), retro reflective, and proximity-sensing (diffused).

An opposed (through beam) arrangement consists of a receiver located within the line-of-sight of the transmitter. In this mode, an object is detected when the light beam is blocked from getting to the receiver from the transmitter.
A retro-reflective arrangement places the transmitter and receiver at the same location and uses a reflector to bounce the light beam back from the transmitter to the receiver. An object is sensed when the beam is interrupted and fails to reach the receiver.

A proximity-sensing (diffused) arrangement is one in which the transmitted radiation must reflect off the object in order to reach the receiver. In this mode, an object is detected when the receiver sees the transmitted source rather than when it fails to see it.

**Our Device Analysis and Plan.** Considering about the distance between two legs are too small, we cannot use diffuse arrangement kind of photoelectric sensor. The width of legs is about 10 centimeter but the distance between two legs is only 30 centimeter. If we use the proximity-sensing arrangement kind of photoelectric sensor, it may be able to detect the action of legs crossed, and then it is not able to count the number of steps. The opposed arrangement kind of photoelectric sensor seems good enough to be used to design the infrared pedometer. However, if we use this kind of photoelectric, the accuracy of this device is depending on the position of the light projector and the light receiver. It means we should adjust the position of these two devices every time when we use this kind of infrared pedometer. Obviously it is not convenient for the user. So we choose the second kind of photoelectric, the retro-reflective one.

To accomplish this task, we have separated this design into five steps. Firstly, we will try to complete the design of the steps counter with infrared sensor within two week. The most important component is the optoelectronic switch. Then we will display the number of steps on the liquid crystal display (LCD). We will control this function by MCU in order to converse the analog signal to the digital signal and process the signal. Before finishing the design, we will take a few days to polish up the whole system and make a conclusion.

**The Significant of This Design**

With the high speed development of the economy and the high pressures from life, health has become more and more important to us. Only keeping healthy can enable us to have enough energy to fight with the difficulties and have an opportunity to enjoy life. We can say that this situation has created demand this technology, or we can say that this kind of design can motivate people to pay more attention to their lives.

On the other hand, to complete this design, we will try to use the knowledge we learned from college, and attempt to make a contribution to the society with what we learned.

**Overall Design Scheme of the Infrared Pedometer**

**The Current Technology of Infrared Counter**

The main technology of infrared counter today has two different types, the first is active type and the other is passive type. However, both of them are base on the light dependent resistor. Because the light dependent resistor’s value is base on the intensity of light, and the object can influence the intensity of light, we can use this character to judge if there some objects or how many objects have shown up. As we all known, resistor’s value is easy to be reacted by the electric signal.

**Our Design of Infrared Pedometer**

After all these compares and analysis, we have got the decision of our overall scheme. However, first of all, we should we should make sure our design requirements.

a) The infrared pedometer should be small and should be easy to use by people. Firstly, all the device can be worn on one leg.

b) The distance of detection can be adjusted, so it can be used by different people with different leg length and wearing different kinds of pants.

c) The number of the steps should be showed up on the LED.

d) The whole system should be steady and it should be as cheep as possible.

Considering about all the requirements above, we choose the diffuse arrangement kind of photoelectric to detect the action of walking, then transmit the signal get from the infrared sensor to
MCU, then we analyze the signal and show the number of steps on the LED. In order to adjust the distance of detection we try to add some variable resistors in the infrared emission circuit.

**Deep Research about Hardware Design**

**Infrared Emission Circuit**

We connect the circuit as the picture blow, the chip NE555 in this circuit is to help to excite the diode to emission the infrared.

![Figure 1. Infrared Emission Circuit.](image1)

![Figure 2. Infrared receive circuit.](image2)

**Infrared Receive Circuit**

We connect the circuit as the picture blow, the chip LM567 is used to amplify the signal, and help to consist the infrared receive circuit. LM567 is a kind of phase locked loop integrated chips, it is used to be consist of the frequency discriminating circuit. With the help of LM567 the phase locked loop integrated chips, we can improve the sensitivity of the frequency discriminating circuit. So it can avoid the side effect of light and so on[11,12].

![Figure 3. Circuit of LM567.](image3)

The impulse signal got by the infrared receiving diode go though the capacity C1 and be influenced by the triode. Then the amplified circuit Q1 amplified the signal more than 100 times, LM567 receives the signal by the third pin to finish the discriminating process. Then judge eighth pin put out the high voltage or low voltage.

**The Display Circuit**

The display part circuit is controlled by AT89C51[13]. The basic principle is when the infrared detection part have fount the two feet have cross each other, the eighth pin of LM567 will send a low voltage signal. The LCD part circuit will depend the number of the low voltage signal to show the number of steps.
The Whole circuit

The Introduction of Software Design

STC89C52RC microcontroller can be programmed by C computer language. It is easily to be understand by person but also easily to be compiled by machine. When the first time start the infrared pedometer, the system should be initialized. And when we press the reset button, the LCD should show 0. If the number has been exceed the number we set, it should show 0 too[14].

Testing and conclusion

After designing this infrared pedometer, we should test it to make sure it can work in the right way. It is the last work we should do, but it also the most important thing. It needs patient and time. The software test is a easy part of testing. Because most of the work have been finished by the programming software. All we need know is how to use Keil. Hardware test separates in to two part. The first one is simulate the whole system with the simulation software to find the weakness of our design and improve the property by try again and again. The second one is the most difficult one, which need us test the circuit with multimeter. We have found lots of problem such as connecting two wrong points together or some circuit line was break down.

References


