Detection and Identification the Human Surface Electromyogra Signal

Guobiao Yang*, Zhenyuan Sun, Zhao Wang and Gangdong Sun
Xidian University, Xi’an, Shannxi, China

*Corresponding author e-mail: gbyang@xidian.edu.cn

Abstract. The pre-amplifier circuit in this design uses the INA 128. In order to make the collected signal more authentic and eliminate the influence of the interference signal, a 50Hz industrial sink-wave circuit and a band pass filter circuit are designed in the subsequent circuit. And then, a secondary amplification was also used to make the A/D chip work smoothly. The designed circuit was simulated by Multisim test. The results obtained fully meet the expected requirements. Finally, the hardware circuit is built, and the real-time acquisition of electromyogram signal is realized. Based on the above equipment, time domain and frequency domain analysis of the collected electromyogram signal are carried out. The obtained test results conform to the general spectrum characteristics of the electromyogram signal, the frequency range is mainly concentrated at 0Hz -500 Hz, and the amplitude is relatively high in the range of 50Hz -200 Hz. The experimental results show that the relationship between the amplitude of the force stimulus and the amplitude of the electromyogram signal is positive, which verifies the accuracy of the test system design.

1. Introduction
Clinical research has shown that the surface electromyograph (sEMG) is made up of the brain bio-electrical activity of spinal cord motor neurons controlled by motor cortex, which directly reflects the body's muscle state and movement intentions [1-3]. SEMG is a comprehensive reflection of muscle movement patterns on the skin surface of the human body. It is a superposition of action potentials of different muscle fiber groups on the skin surface. It is a random signal and an alternating signal. Its size and amplitude are uncertain. However, to a certain extent, it is positively related to the contraction force produced by muscles. Compared with the collection method of needle electrodes, sEMG has the advantages of non-invasive, convenient, convenient, and non-invasive. Although it obtains electromyogram signals that contain more noise, there is no pain in the collection process that does not harm human muscle tissue. Therefore, it has been widely used. Different muscle fiber motor units on the skin produce different signals at the same time. sEMG signals obtained from different parts of the human body carry information of movement and function of different parts. It is of great value to transform human motion state into surface EMG signals for research [4]. With the rise of detection technology and artificial intelligence, how to identify the movement patterns of limbs from sEMG has become an important research hotspot in clinical medicine, rehabilitation medicine, intelligent prosthesis, Bionic robot and intelligent hardware.
In the field of clinical rehabilitation, surface EMG can be used for the rehabilitation of injured muscles of patients [5, 6]. In the field of bionics, SMG can provide a reliable technical guarantee for the control of artificial limbs. Surface electromyography can also play an important role in sports medicine. By detecting the surface EMG signals of athletes during exercise, it is helpful to reflect the fatigue and excitement of muscles in time, and to establish scientific training methods [7, 8]. Accurate acquisition and analysis of surface electromyography (sEMG) signal has very important engineering application value [9, 10].

Although many company's EMG acquisition products can accurately detect and analyze the SEMG signal [11]. For most products, a very expensive electromyoelectric signal acquisition instrument is used to collect surface electromyogram signals, and then the collected signals are input into the PC for simulation, although the collected signals are more accurate [12-15]. However, the expensive and difficult to carry characteristics make it not universally used. Which is the worst part, the whole acquisition system's program is closed. As a user, only the processed and analyzed EMG signal can be obtained, and the original EMG signal cannot be obtained, nor can it be compatible with the spectrum analysis and action recognition system of the subsequent development of EMG signal. It is impossible to get the relationship between the EMG signal we need and the motion state and function of human body. There are also some limitations in the design of this kind of acquisition system: (1) special instruments are needed to complete signal acquisition, and the application occasions are limited, such as the inability to collect SEMG of human limbs in high-speed motion; (2) more components are separated and too long wires are connected. When limbs move, it is easy to cause relative movement between electrodes and skin, which affects the accuracy of acquisition results, and will also be introduced into the environment. Other interference, such as electromagnetic interference, etc. (3) The power supply is acquired by the municipal power processing, which introduces large power frequency interference, which increases the difficulty of data processing. In order to solve the above problems, this paper designs a device for collecting EMG signals on human body surface, which collects SEMG signals from the flexor carpi ulnaris, extensor digitorum, flexor carpi radialis and brachioradialis muscles of forearm before and after specific movements by patch electrodes, and then processes the signals through follow-up circuits, achieves analog-to-digital conversion through A/D of CPU, and carries out spectrum analysis of EMG signals. Through the algorithm, the recognition of some specific actions is preliminarily realized.

2. Characteristic analysis of the surface EMG signal

Through the study, the electromyogram has the following characteristics: (1) Weakness: The amplitude of the myoelectric signal is generally between 50μV and 2000μV, which is a weak signal that is difficult to process directly. (2) Interchangeable: Surface electromyogram is an AC signal that belongs to an AC voltage. Its amplitude is generally proportional to the strength of muscle movement. (3) Regularity: After repeated experiments, it is known that the different movements of the same muscle show obvious regularity. This regularity plays an important role in accurately extracting the electromyogram signal and subsequent control of the movement. (4) Low frequency characteristics: The body's surface myoelectric signal is low frequency, and its main energy is concentrated in 10Hz ~ 300Hz Between them, depending on the action of the human body, the frequency bands of the energy generated by each muscle are also different, but they are generally concentrated below 300Hz. (5) Noise: because the sEMG signal is relatively weak and collected by the human skin surface, while at the same time being. The differences between individuals and the influence of the collection environment lead to the collection of the sEMG signal contain a lot of noise information. Therefore, it is important that the collection the sEMG signal is de-noised.
3. Identification system of surface EMG signals

(1) Signal Acquisition Electrode: Surface EMG signal can be collected by surface electrodes. This design adopts silver-silver chloride electrode, which is made of sensor (silver or silver chloride), sponge tape, sand and medical conductive adhesive. The diameter of the electrode sheet is about 55mm. It has good adhesion to skin and low contact noise.

(2) Pre-amplifier circuit (Fig.2): Because the surface EMG signal is very weak and is disturbed by various kinds of noise, the instrument amplifier used must have a high common mode rejection ratio in order to effectively attenuate the common mode interference of the signal to obtain effective differential signal. In this design, the instrument amplifier adopts INA128 of Texas Instruments. In order to ensure the performance of the device, the simulation analysis is carried out by Multisim. The input voltage at the cursor is 9.907 mV, the output voltage is 396.796 mV, and the amplification factor is 40.05. The results meet the expected performance requirements. The front magnification is designed to be about 40 times, so its matching electrical resistance is 1.28 K. The gain size at this point is 40, which meets the design requirements. It is necessary to string a resistance of 1.28 KΩ between the pins 1 and 8 of the INA128 chip.

Figure 1. Overall design flow chart of the detection and identification system

Figure 2. Pre-amplifier circuit
(3) 50Hz power-frequency notch circuit (Fig.3): Although the preamplifier has a high common-mode rejection ratio, it can filter out some common-mode signals, but there may still be some power-frequency interference in the form of differential-mode signals into the circuit, and there are some factors such as unstable electrodes and input circuits. The integrated operational amplifier designed in this paper uses LM324.

![Figure 3. 50Hz power-frequency notch circuit](image)

(4) Filter and secondary amplifier circuit (Fig.4): The high-pass and low-pass filter should be kept between 10-500 Hz, and the amplification factor of the second amplifier should be between 3-20 times, depending on the user's age and location. In this design, the amplification factor is 3 times, the high-pass cut-off frequency is 10.62 Hz, and the low-pass cut-off frequency is 497.61 Hz.

![Figure 4. Filter and secondary amplifier circuit](image)
(5) Voltage lifting circuit (Fig.5): The collected signals are differential mode signals, positive and negative. In order to ensure the effectiveness of negative signals, voltage lifting is realized by adding a reference voltage. In this design, the reference voltage chip is LM385D-1.2, which can provide a stable voltage of 1.237V. Its working current is between 15 and 20 mA, and it has the characteristics of low power consumption [16].

![Voltage lifting circuit diagram](image)

**Figure 5.** Voltage lifting circuit

(6) Power supply circuit: The analog circuit part instrument amplifier INA128 and integrated operational amplifier LM324 are powered by dual power supply. The external power supply is a dual 9V dry battery, which is reduced to 5V through AMS1117 chip, and then converted to -5V through TPS60400 chip. AMS1117 is a linear voltage regulator chip of AMS (Advanced Monolithic Systems) company. It integrates overheat protection and current limiting protection. Its output current range is 10 mA~1A. It has low static current. It is more practical in some portable devices, and the design circuit of this chip is very simple. TPS60400 is a power converter chip of TI (Texas Instruments) company. It has relatively high power efficiency. It has only about 100mA static current and simple peripheral circuit.

![Power supply circuit diagram](image)

**Figure 6.** Design drawing of EMG signal identification and acquisition system
4. Acquisition system of surface EMG signals

In this article, we mainly study the following four movements: extended arm fist, extended arm fist, curved arm fist, curved arm fist. Bending arms and extended arms are controlled by the arm muscle group, and the opening and holding fists are controlled by the forearm muscle group. We chose the biceps in the arm as the location of the electrode, because it is located in the shallow layer of the muscle, its signal is easy to extract, the muscle group is large, the signal is obvious, and in the forearm we choose the ulnar carpal flexor muscle to place the electrode. It is the main muscle group that controls the fist. Using the Ag-AgCl double electrode method to collect the sEM signal. The detection electrode diameter is 1cm, the center distance is 2cm, and it is distributed along the muscle fiber. The reference electrode is placed near the detection electrode. In order to reduce impedance, use the 75 tins of alcohol to clean the skin surface before the electrode is placed. Continuous recording of all electromyogram signals of subjects are made during the completion of torso movement in different directions. EEG sampling frequency is 1000HH, common mode inhibition ratio (CMRR) > 130 dB, total gain is 1000, noise is $1\mu$V. The signal number is transferred to A/CD (12 B mett) and deposited into the computer for processing. Make use of the Mega-Win software to read the original sEMG signal number, select the sEMG signal number of the trunk in the course of performing a specified action movement into the AEMG analysis, and calculate and standardize AEMG to reduce the difference between the subjects, as an index to reflect the activation strength of the lumbar vertical spine muscle and multi-crack muscle.

As shown in the Fig.8, 9, they are the time domain analysis curve of surface EMG signal, the amplitude-frequency characteristics of surface EMG signals, the phase frequency characteristics of surface EMG signals and the Frequency spectrum of surface EMG signal.
Figure 8. Time domain analysis curve of surface EMG signal

As shown in Fig.8, the Means value is -0.00012, the Standard deviation is 0.17024, Variance=0.02898, the Integral EMG value (IEMG) is 0.10011 and the RMS is 0.17024.

Figure 9. Amplitude-frequency characteristics of surface EMG signals

As shown in the Fig.9, Using the EMG signal frequency chart collected by the EMG signal system, we can see that the frequency concentration is between 10Hz and 150Hz, and the energy of the EMG signal is larger between 10Hz and 150Hz, which can collect our suitable surface EMG signal.

Pattern recognition is based on the attributes or characteristics of the object of study [17]. It uses computer-based machine system and certain algorithm analysis to identify its categories, so as to make the results of recognition conform to objective facts as far as possible [18, 19]. In this design, a simple average power method is used for feature extraction. Surface EMG signals can be reflected by energy as the human body moves [20]. The energy of signal x(n) is expressed as follows:
For a periodic signal $x(n)$, if its period is $N$, its power can be expressed as follows:

$$P_x = \frac{1}{N} \sum_{n=-\infty}^{\infty} |x(n)|^2$$

The above formula can also be used to calculate the average power of quasi-periodic signals and random signals, because their time and periodic signals are equally infinite. In the program, the average power is calculated from the nearest 10 points (specific points can be adjusted in the test). Firstly, the average power of a channel is calculated, and the action amplitude of the current channel can be judged according to the average power threshold of the corresponding channel signal. From the test results, the amplitude and frequency of surface EMG signals on different arms are quite different, so the threshold parameters of average power should be debugged separately in practical applications.

5. Conclusion
Aiming at the problems of closed data processing process, too many components and incompatibility with EMG data processing system of existing surface EMG signal acquisition products in the market at present. In this paper, a portable device for collecting EMG signals on human surface is designed. The system was used to test the flexor carpi ulnaris, extensor digitorum, flexor carpi radialis and radial brachioradialis. The spectrum characteristics of the sampled surface EMG signal are analyzed, and the practicability and validity of the EMG signal acquisition system are verified.

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