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Introduction: Since the frequency of the low-frequency oscillation signal [1] (LFO) of the blood oxygen is 0.01 Hz to 0.15 Hz and it is independent of the heart beat signal and the respiratory signal, the slow change of the hemodynamic parameters can be detected. In order to facilitate the low frequency oscillation signal to the non-hair-bearing forehead, we have developed a frequency-division-multiplexed modulated continuous wave functional near-infrared spectroscopy imaging system [2]. The light source emits laser light of the same wavelength at the same time, and the carrier frequency of the emitted light source is different at the same time [3]. This method is called frequency division multiplexing and can effectively eliminates crosstalk between light sources [4].

Method: The program flow chart is shown in Figure 1(a): the system uses laser output at optimal wavelengths of 690nm and 830nm to minimize crosstalk, and it penetrates deeper into the non-hair-bearing forehead tissue because its light intensity is strong. Using the chip to output digital carrier signals and complete the design of frequency division multiplexing. Then converting to analog signal by D/A conversion. Most high-frequency noise is removed from the carrier signal via a low-pass filter. The light source driving circuit drives the laser diode to convert the filtered carrier signal into an optical signal. The light source driving chip is ic-NZP, and the laser diode is HL6738MG and HL8338MG. The light source works as follows: First, the 690-nm light source for channel 1 and channel 2 is driven with frequencies of 2 kHz and 2.2 kHz respectively. Then the 830-nm light source for channel 1 and channel 2 is driven at frequencies of 2 kHz and 2.2 kHz respectively. This completes a drive of the time division of the light source and the frequency division of the wavelength, and this allows the wavelengths between the channels to not interfere with each other. Its working principle is shown in Figure 1(b). The laser diode converts the filtered carrier signal into an optical signal. The optical signal modulated by the forehead reaches the photodetector through the optical fiber, and the photoelectric detector uses C12703-01. Then passes through the Butterworth band-pass filter, programmable gain amplifier. Finally, it is converted into a digital signal after A/D conversion. The digital signal is transmitted via USB to the PC, and it is performing data processing.

The data processing interface is shown in Figure 1(c): The acquisition software uses LabVIEW which solves the concentration change of oxygenated hemoglobin and deoxygenated hemoglobin by using the modified Beer-Lambert law, and then the concentration change passes the 2nd-order Butterworth low-pass filter to obtain the LFO.

Valsalva's experimental results are shown in Figure 1(d) in Figure 1. The experimental results are basically consistent with the predicted results of Valsalva's movement, which shows that the system can effectively detect the relative change of the hemoglobin signal concentration and prove the reliability of the system. In order to be able to more sensitively sense changes in hemoglobin concentration and further reflect neural activity, LFO signals were extracted from the experimental results, as shown in Figure 2 (d) in Figure 2.

Results: The device we built meets the goal of strong light intensity, deep penetration through the non-hair-bearing forehead, less interference, and ease of use, high-precision two-channel NIRS system that can be used to measure LFO signals on the non-hair-bearing forehead.

References:

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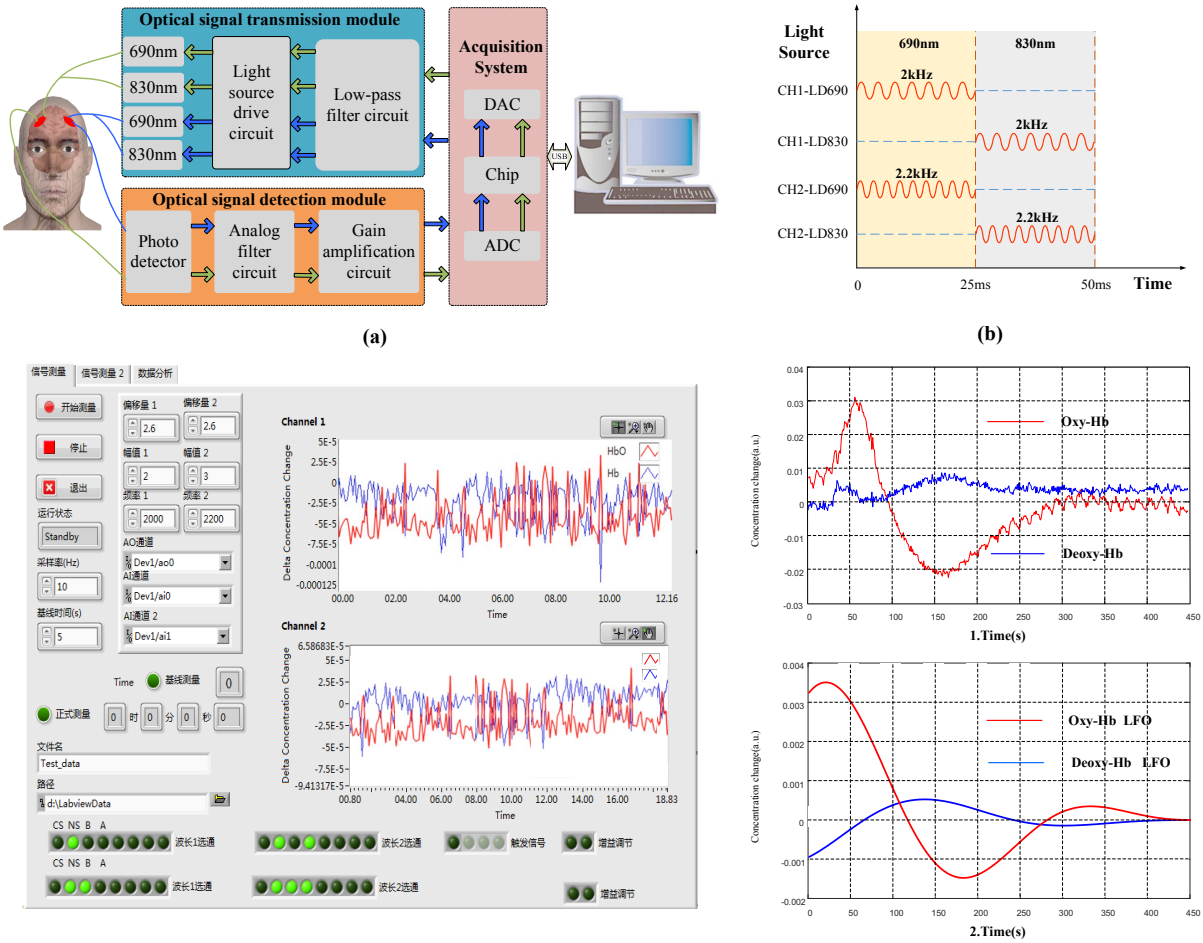

Figure 1. Two-channel NIRS spectrometer. (a) Overall scheme flow diagram; (b)The time division of the light source and the frequency division of the wavelength; (c) LabVIEW uses a modified Beer-Lambert law to calculate the concentration of oxyhemoglobin and deoxyhemoglobin, and then the LFO is obtained after the second-order Butterworth low-pass filter. (d) Figure 1 shows the variation of oxygenated hemoglobin and deoxygenated hemoglobin in the Valsalva test results. Figure 2 shows the LFO obtained after passing through a low-pass filter.