International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

# The Front-End Design of Portable EEG Acquisition System Based On the ADS1299

**Xingpan Cui[1], Pengpeng Yang[2]**

[1]Tianjin Key Laboratory of Information Sensing and Intelligent Control, Tianjin University of Technology and Education No.1310,Dagu South Road, Hexi District, Tianjin 300222, China

[2]Tianjin Key Laboratory of Information Sensing and Intelligent Control, Tianjin University of Technology and Education No.1310,Dagu South Road, Hexi District, Tianjin 300222, China

**Abstract:** ***This paper introduces a new type of brain signal acquisition device, users simply select the appropriate setting and electrode, the device can be real-time acquisition of EEG data, and the data can be displayed and stored. It has high precision, small size and low power consumption. Eliminating a large number of peripheral circuits, the device is mainly composed of STM32F103VET6 made by the company of ST and TI's ADS1299 analog front-end IC. The acquisition device communicate with the host computer for data transfer with a wireless transmission protocol, the source code of the application have been compiled with VC to receive EEG data and accurately shown in the display software. The study provides the basis for BCI to the practical conversion.***

**Keywords:** EEG, wireless module, microprocessor, portable

## 1. Introduction

EEG (electroencephalogram) is a weak low-frequency physiological signal, due to the EEG signal is very weak, combining with the reasons of the particularity of the human body impedance, external and internal interference and so on, the traditional EEG acquisition system through a complex amplifying filter circuit design in order to meet the EEG acquisition of requirements, but this will cause the circuit board size is too large, high-power, not conducive to the design of acquisition system of portable. References [1] was developed for 6-channel EEG acquisition of the driver fatigue detection system, the acquisition front-end modules based on multi-layer circuit board, while greatly reducing the volume of the acquisition front-end, but the volume of the design is still too large for portable device. EEG source by suppressing common mode interference component can reduce the filter and trap circuit requirements, and drivin-right-leg circuit is a common and effective means [2], which not only improving the system of common-mode interference suppression, but reduced size of the system. Reference [3] was developed for the acquisition front-end integrating various of components including amplifiers, filters, controllers into a system on a chip (SoC), in order to reduce system size and power consumption, the scheme require professional development tools and technology requirements, high cost and difficult.

In recent years, the company of TI following the chip of ADS1298 introduce the chip of ADS1299 for EEG acquisition with analog-digital conversion, the paper with high precision, portable, low-power EEG Acquisition System as the background, try to use the chip to design a wearable EEG acquisition front-end system.

## 2. The Overall Design

System principle block diagram as shown in Figure 1, the EEG signals, going through a low-pass filter preprocessing, input the integrated analog front-end ADS1299 , the front-end completing the amplification and acquisition for 8 channels electrical analog signal obtain a high-resolution digital signal. Digital signal through the SPI interface (Serial Peripheral Interface) of analog front-end transmit to MCU (management control unit), the data obtained MCU will be stored or transmitted.

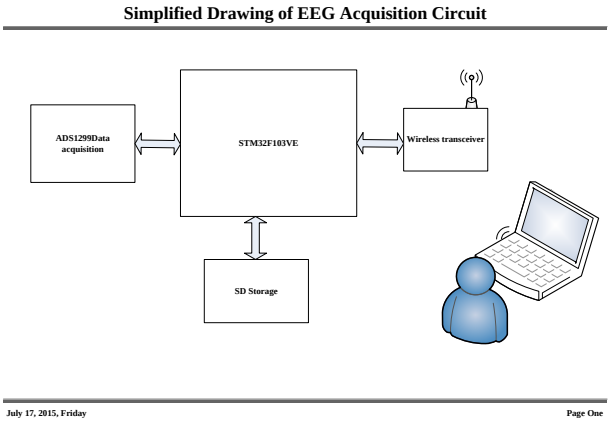


**Figure 1:** Simplified Drawing of EEG Acquisition Circuit

## 3. Each Module Design of the System

### 3.1 The front-end preprocessing module

Due to the frequency of EEG single is only 0.5 ~ 100Hz, the effective range of the experimental analysis is generally 0.5 ~ 30Hz, it must be passed through a low-pass anti-aliasing filter preprocessing before the analog-to-digital conversion, as a consequence, pre-processing circuit is designed for each channel, as shown in Figure.2.

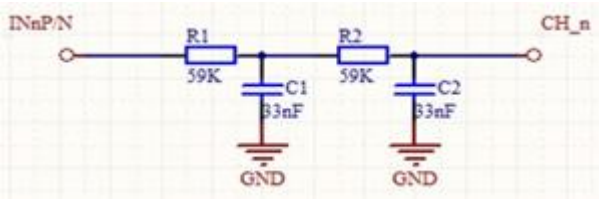


**Fig. 2:** Pre-processing Circuit

The circuit consists of the second-order passive RC low-pass filter, and the frequency response function of the second-order passive RC low-pass filter as shown in Eq. (1).

$$H(jf) = \frac{1}{1-(2\pi f)^2 C_1 C_2 R_1 R_2 + 2j\pi f [R_1(C_1+C_2)+R_2 C_2]} \quad (1)$$

When $C_1$=$C_2$=C，$R_1$=$R_2$=R, you can get Eq. (2).

$$|H(jf)| = \frac{1}{\sqrt{(1-R^2C^2(2j\pi f)^2)^2+9R^2C^2(2\pi f)^2}} \quad (2)$$

Its -3dB cutoff frequency is shown in Eq. (3).

$$f_h = \frac{1}{5.3448\pi RC} \quad (3)$$

Take R = 59kΩ, C = 33nF, you can get:$f_h$ = 30.46Hz. Figure 3 for the second-order passive RC low-pass filter logarithmic amplitude-frequency characteristic curve.

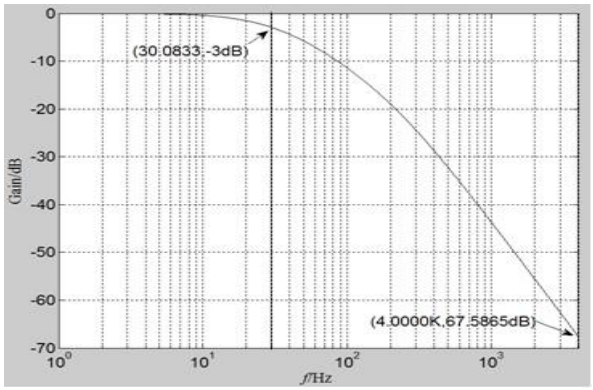


**Figure 3:** Logarithmic Amplitude-Frequency Characteristic Curve

As can be seen from the amplitude-frequency characteristic curve, when selecting 8 kHz sampling frequency, it shows the frequency attenuation at 4 kHz reached at 67dB. Therefore, the second-order passive RC low-pass filter has a good anti-aliasing effects, by oversampling technology enables the filter to meet the performance requirements.

### 3.2 The analog front-end ADS1299 module

The analog front-end of the system uses TI's ADS1299 [4], as shown in Figure 4. The chip has multichannel, simultaneously-sampling, 24-bit with a high resolution can reach 0.1μV / bit, delta-sigma analog-to-digital converter (ADC) with an integrated programmable gain amplifier (PGA). ADS1299 has all the usual characteristics of EEG required for the application. Its internal functional block diagram has shown in Figure 4. The main characteristics of ADS1299 are:

1. 8 channel simultaneous sampling 24 high-resolution ADC conversion chip, which offer data rates from 250 SPS to 16 kSPS;
2. Each channel contains a low-noise programmable gain amplifier (PGA), which gain can be chosen from one of seven settings (1, 2, 4, 6, 8, 12, and 24);
3. Built right leg drive amplifier circuit;
4. Low-power, 5mW per channel.

Multiple devices can be synchronized using the START pin. As shown in Figure 5, two daisy-chained ADS1299 can be achieved the 16 pilot.

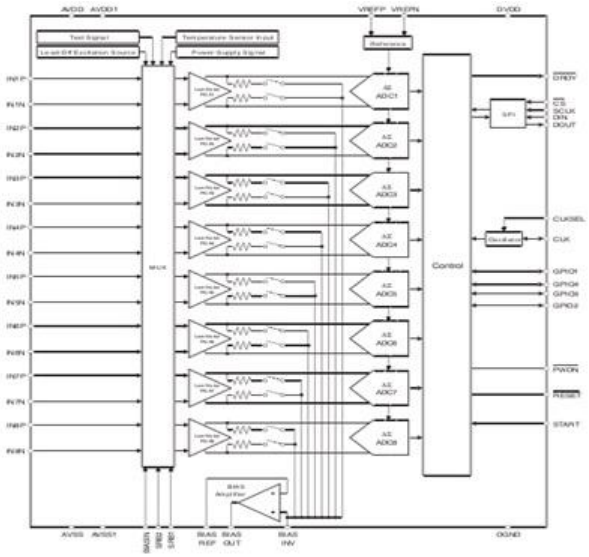

**Figure 4:** Functional Block Diagram

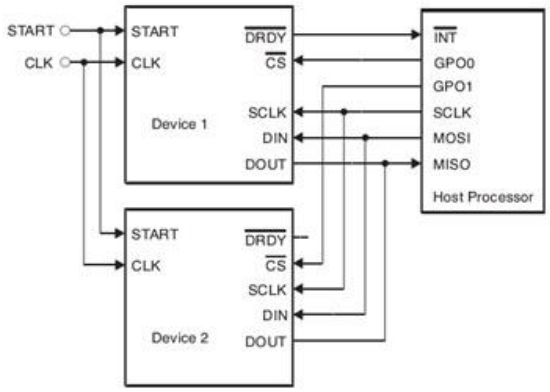


**Figure 5:** Synchronizing Multiple Converters

### 3.3 On the signal control and processing module of MCU

STM32F103VET6 chip is chosen as the MCU of the system. The chip has the characteristics of high-performance, low-power, high-density storage and rich peripherals and so on. For analog front-end ADS1299, communication to MCU as a host is accomplished using an SPI compatible interface. When the system is powered up, the corresponding registers of the ADS1299 are set, and the conversion results of the ADC are read after the signal is detected by ADS1299.For the PC, MCU as a slave communicate with the host computer by WIFI. The connection state of the MCU and the host computer can be constantly monitored in the work, when the abnormal state is

detected, the acquisition of data will be temporarily stored on the SD card, that can effectively solve the data loss of problem of the real-time system; and when the normal state is detected, MCU will upload data directly, the MCU program flow diagram, as shown in Figure 6.

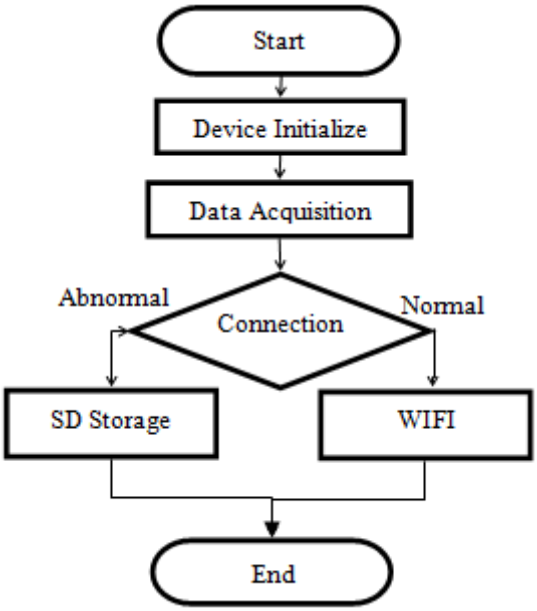


**Fig. 6:** The Program Flow Diagram

### 3.4 The Wireless Transmission Module

In this paper, the EEG acquisition circuit is designed, and the original EEG signal collected by the device is transmitted to the upper computer by WIFI, which is prepared for the following signal processing. The core of the WIFI transmission circuit is RW04. RW04 is a bidirectional conversion module of the serial port and WIFI , the signal received by its RXD pin may be converted into WIFI network signal to be sent, but also can be converted signal received by WIFI network into RS232 signal output to external device by its TXD pin .

## 4. Experimental Results

In the room temperature environment, the human body tested naturally relax, the brain awaking. The sampling frequency of EEG acquisition is 250Hz and PGA amplification is 12, by the International 10-20 system for EEG electrode placement method of the electrode signal waveform as shown in Figure 7 shows (reference electrode located in the root of right ear), the experiment have obtained more satisfactory results.

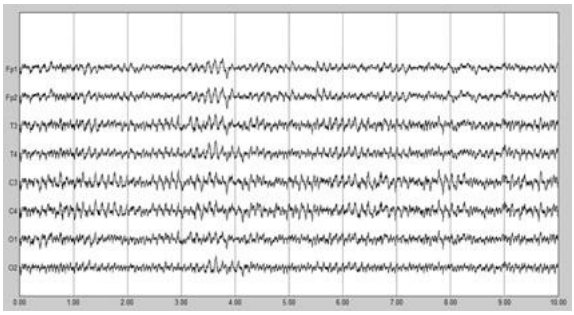

**Figure 7:** EEG Waveform of Experiment

## 5. Conclusions

This paper designs a kind of EEG signal acquisition and wireless transmission system based on the small size, portable and low power consumption. Choose STM32F103VET6 microcontroller as the main controller, using its own SPI and USART module for ADS1299 and RM04 respectively controlled to achieve EEG WIFI wireless transmission and waveform display. The system needs to use the PC display, microcontroller to complete control, characteristics of easy to carry and high level of integration, can provide a feasible solution for the lack of medical resources in the area of EEG disease diagnosis.

## References

[1] LIN C T, et al. Development of wireless brain computer interface with embedded multitask scheduling and its application on real-time driver's drowsiness detection and warning [J]. IEEE Transactions on Biomedical Engineering, 2008, 55(3):1582-1591
[2] WINTER B B, WEBSTER J G. Driven-right-leg circuit designs [J]. IEEE Transactions on Biomedical Engineering, 1983, 30 (1):62-66
[3] HELLEPUTTE N V, TOMASIK J M, et al. A flexible system-on-chip (SoC) for biomedical signal acquisition and processing [J]. Sensors and Actuators a-Physical, 2008, 142(1):361-368
[4] TI.ADS1299Datasheet [OL]. [2012-08]. http://focus.ti.com.cn/cn/lit/ds/symlink/ads1299.pdf

## Author Profile

**Xingpan Cui** reading the M.S. degrees in Mechanical Engineering from Tianjin University of Technology and Education