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Design of Processing System of Vibration Signals

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Abstract: A signal processing electric circuit used in vibration signals processing system has been designed, which contains the pre-amplifier, the single chip ATMEGA16 and the microprocessor programmable MAX262 and so on. Its feasibility test is carried out. The center frequency and other parameters are input into the computer by VC software programmed, and the computer sends these instructions to the single chip. The single chip controls MAX262 filter to work regularly and the noise signals are well filtered. The signals output from the data sampler are analyzed and processed, and the vibration signals can be clearly recognized. The experimental results show that the designed signal processing electric circuit is feasible and its effect of application is good.

Keywords: MAX262 chip, vibration signals, low pass filter, programmable, Multi-frequency filter

1 Introduction

In the diagnosis of mechanical fault, vibration signals are indispensable for judging. Due to the vibration signal is extremely weak, and because of their environment and other reasons, vibration signal need to go through the sensor, amplifier or intermediate converter and data acquisition systems. The ingredients of the measured signal due to the various external and internal factors of test system mix with interference, and there are some differences between the real signals and test signals, and it is possible to cause frequency aliasing and it can not be directly processed by A / D conversion, which requires amplify the signal and filtering methods before A / D converter to making measurements results is similar to actual vibration signal as true as possible, to meet with requirements of the A / D conversion. Therefore, it is significant for capturing the vibration signal with effective and feasible means. Guo Jianping, et al. [1] design the front signal conditioning module with single channel; Xiejian et al [2] designed vibration acceleration measurement system of the launch vehicle; CHEN Zhao et al [3] developed the ant alias filter is d based on the 8-order

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low pass elliptic switched capacitor filter (MAX293), Zengyong et al [4] developed vibrometer based on MEMS micro accelerometer, Xuejun et al [5] developed integrated multifunctional vibration measurement system; Wangliang et al [6] designed a vibration signal conditioning module based on practical machine equipment; Li Shujun, et al. [7] designed a kind of filter module for vibration accelerometer signal; Qi Yongqian et al [8] realized tracking anti-aliasing filtering of vibration signals, but they can only realize the capacity of single-frequency chip point filtering.

There are several methods to realize the multipoint low pass filter. The first one, which uses the multi-circuits in series for the component parameter is difficult to be realized.

The second one is constructed by operational amplifier and RC component which uses the analog switch to choose the different value of resistor to realize the change of frequency. Because the distributing parameter is high, and the precision of the cut-off frequency must be good, the complex circuit is difficult to design and debug.

Therefore, it had better use the integrated filter chip with simple peripheral component to realize it.

2 Design of hardware system

2.1 Design of pre- amplifier circuit

The signal is relatively weak, which is received by receiving sensor, mixed with some noise signals, so pre-amplification circuit must be used. The circuit should have high gain and wide frequency range can be adjusted to meet with the basic requirements of the amplifier. Generally, the amplifier of the high input impedance, low output impedance is chosen to reduce the impact of an input weak signal, and increase the load capacity. Also it can inhibit variety of common mode interference signals. With negative feedback circuit parameters can be stable and improve noise immunity of the circuit. The differential amplifier with characteristics of differential input, single-ended output, a relatively high rate of common-mode rejection, anti-noise, often is used as input stage of measurement instrument sensor or front-end amplifier, and to overcome the zero drift of direct coupled circuit. There are two schemes to be laid:

Scheme 1: Differential amplifier is formed by the separation of the device. It is very to complicated built differential amplifier with discrete transistor, is difficult to debug, is easy to burn out the transistor, and is not convenient to change.

Scheme 2: The amplifier chip of differential integrated. Typical applications of differential amplifier of integrated circuit chip needn't be debugged, and the circuit is simple with rapid replacement.

Differential amplifier of integrated chip AD620 is chosen. The gain range is from1 to 1000; single power supply is from 2.3 to 12 V, with high precision, low noise. It is more commonly used instrument differential amplifier. The AD620 chip pin diagram is as shown in Figure 1 [9] and the application circuit of AD620 is as shown in Figure 2.

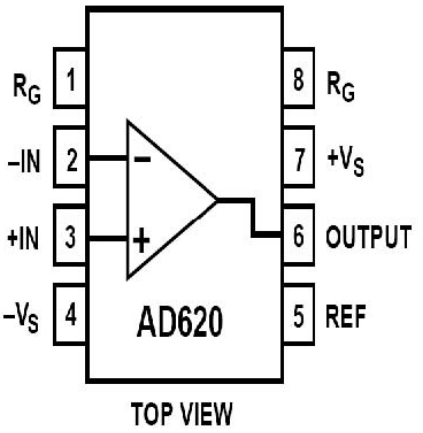

Figure 1: The pin configurations of AD620

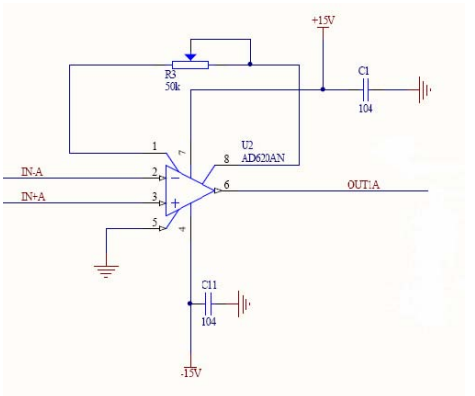

Figure 2: The application circuit of AD620

2.2 Design of programmable amplifier circuit

Due to different input frequencies, vibration signal amplitude is different, so it is necessary for program-controlled amplifier to change the gain of receiving circuit, making the signal clear. There are three schemes to be laid:

Scheme 1: Digital potentiometer is chosen. Change the resistance of negative feedback with microchip to change the gain, but its accuracy is not high enough.

Scheme 2: Selection circuit is chosen. Branch is controlled by the gate chip. The discrete components can greatly improve the accuracy of magnification and match to the circuit very well, but the circuit is complex.

Scheme 3: The integrated programmable chip is chosen. This scheme not only has the advantages of scheme 2, but also has the advantages of simple circuit structure.

PGA204 is the product of Burr-Brown Corporation in U.S. PGA204 is low-cost, multi-purpose programmable gain amplifier. The PGA204 and PGA205 are laser trimmed for very low offset voltage (50mV), drift (0.25mV/˚C) and high common-mode rejection (115dB at G=1000). They operate with power supplies as low as

±4.5V, allowing use in battery operated systems. Quiescent current is 5mA. The PGA204 are specified for the –40˚C to +85˚C temperature range. TTL or CMOS logic can be two signals A1, A0 select their digital gain [10]. The chip pin diagram of PGA204 is as shown in Figure 3, and application circuit of PGA204 is as shown in Figure 4.

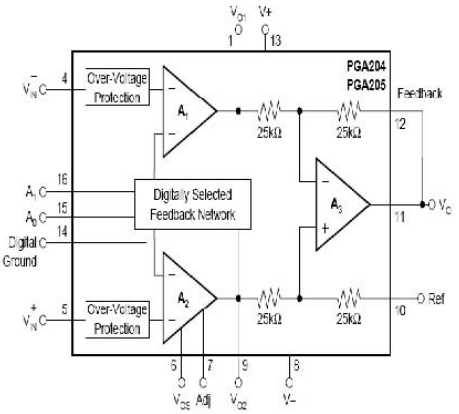

Figure 3: The pin configurations of PGA204

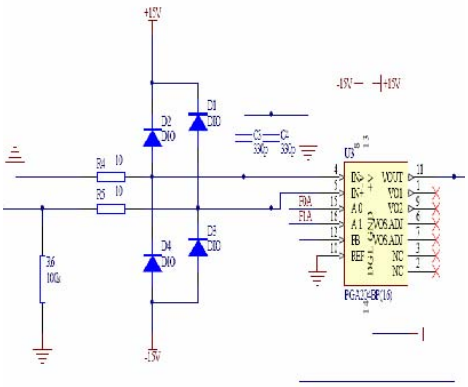

Figure 4: The application circuit of PGA204

There are four gain levels of PGA204 —1, 10, 100, 1000. The digital inputs A0 and A1 select the gain according to the logic table in Table 1.

Table 1: The control relationship between A1, A0 and amplification multiple

A1	A0	Gain
0	0	1
0	1	10
1	0	100
1	1	1000

2.3 Design of low pass filter circuit

The microprocessor programmable universal active filters MAX262 produced by the American MAXIM Corporation [1112] is chosen by comparing different kinds of integrated filter chips. No external components are required for a variety of band pass, low pass, and high pass, notch, and all pass configurations. Each device contains two second-order filter sections that place center frequency, Q, and filter

operating mode under programmed control. The chip MAX262 extends the center frequency range to 75 kHz by employing lower clock-to-f0 ratios.

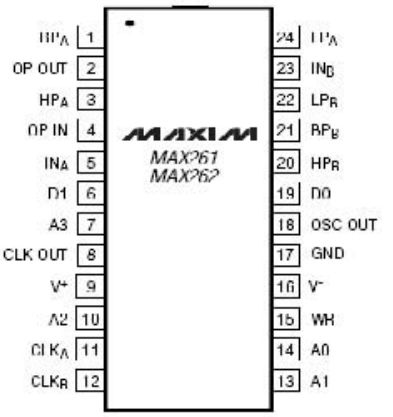

Figure 5: The pin configurations of MAX262

To get better vibration signal, the bandwidth must be narrow. The approach of designing filter is as follows:

1. Confirm cut-off frequency f_c and consequently the center frequency f_o according to the designation demands;

2. Choose the Q value of the filter;

3. Confirm the operating mode of the filter. Generally, the mode 0 is chosen for the low pass filter;

4. Confirm the clock frequency f_{clk} according to the Q and f_o;

5. Program the center frequency, the Q value, and the filter operating mode to the chip MAX262.

In operating mode 0, the control byte F can be expanded as [1112]

$$F = \frac{f_{CLK}}{f_0} \times \frac{2}{\pi} - 26 + 0.5 \tag{1}$$

The Q value can be expanded as [5]

$$Q = 128 - \frac{64}{q} + 0.5 \tag{2}$$

Parameter of filter can be expanded as

$$F_0 = f_p / \sqrt{1 - \frac{1}{2 * Q^2}} \tag{3}$$

3 Design of software system

Software Keil C51 is one of the splendid software in the field of single chip which contains edition, compilation and emulation with assembler language, PIM language and C language, which could be mastered conveniently. Four channels of signals are collected simultaneously with two SCM four MAX262 chip. When PC interface gets the user's input, the input parameters will convert into data packets of fixed format, which will be sent to the single chip A through the serial port. Then wait single chip A return to state of data receiver. When single chip A realizes peripheral initialization, it will wait serial data input. After data reception is completed and data packets are verified, it will return to PC port with the state of reception. If data is received correctly, send received packets to the single chip B, then the settings of PGA204 and Max262 is completed. When single chip B realizes peripheral initialization, it will wait serial data input. After data reception is completed and data packets are verified set the PGA204 and Max262. Software flow chart is as shown in Figure 6 and Figure 7.

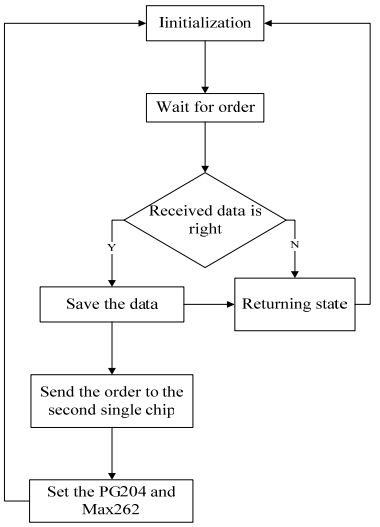

Figure 6: Single chip A diagram of program

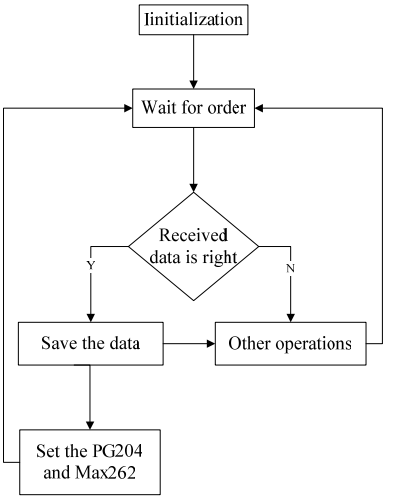

Figure 7: Single chip B diagram of program

PC interface is developed with Visual C software, including the settings of MAX262, settings of serial port. f_0 is calculated by input q and fp in interface, then the filter parameters F and Q are gained. f_0 clock frequency is calculated according to the input filter frequency. After MCU microcontroller receives a packet, it will set

filter and the output frequency. MCU baud rate is 19200; the crystal frequency is 8M. Two filters of each Max262 share a clock and the same configuration in this procedure, realize any frequency point low-pass filter, whose center frequency is from 1 KHz to 5 KHz.

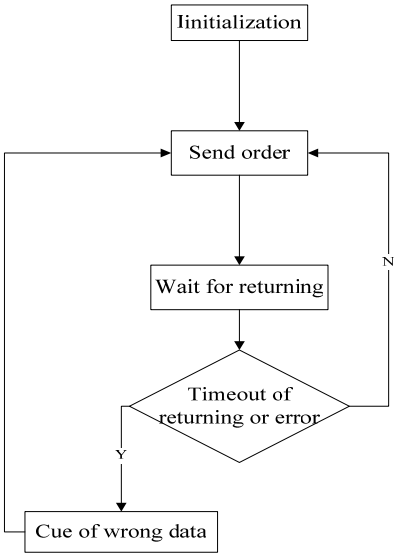

Figure 8: The flow diagram of program

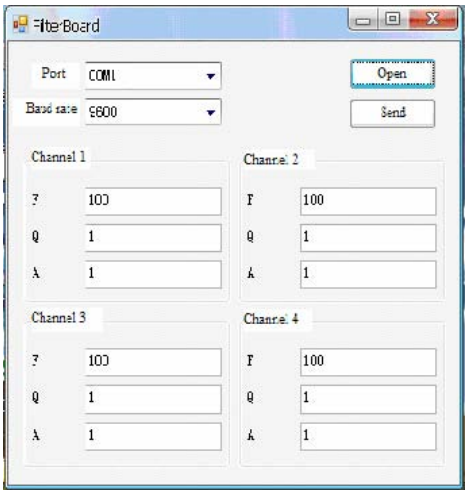

Figure 9: Filter controlling interface

Single chip ATMEGA16 is chosen, and the order is sent out by serial interface of PC. This kind chip is very cheap and low-cost with resourceful program. Only one serial interface line can to write the program online. The chip has two assignments: send the clock signal of MAX262 and the control byte. Vibration signals can be obtained through the collection, and the structure of the system can be as shown in Figure 10.

4 Conclusion

The design of front-end vibration signal processing circuit with multi-frequency low-pass filtering is practical which is validated by experiment, solving the problem of unstable signal conditioning, impact of the environmental seriously, operational complexity and other issues; It will be further improved to meet with the needs of acquisition of vibration signal field.

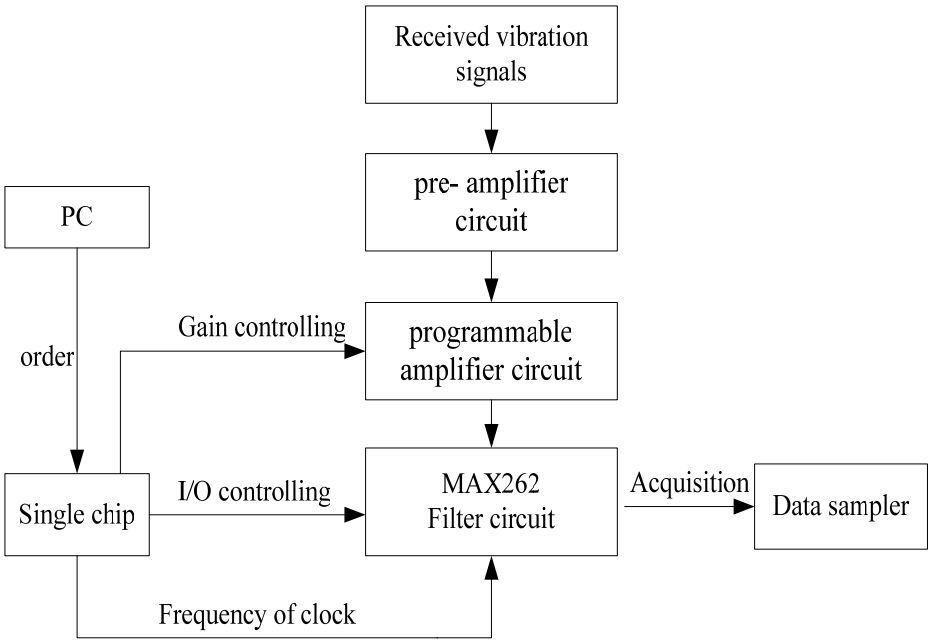

Figure 10: The system diagram of vibration signal processing

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