Design of Numeric Control High-Gain and Wide Bandwidth Amplifier

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Abstract

This paper proposes a high gain and wide bandwidth amplifiers with numerical approach. It is improved that the low-frequency characteristics and the range of gain refers to direct-coupling. The gain is controlled with numerical approach, which makes the gain stability. It is easy to control the gain of the multistage amplifier with adopting uniform gain control voltage. It is useful for numerical approach because of the linear between control voltage and the gain. AVR microcontroller is the heart of numerical unit. The gain is been preset and adjusted through keyboard. Most of index can be showed through LCD. NC linkage switching technology is used to switch between two or three multistage amplifier, it is useful to enabling a more flexible application of the amplifier.

Keywords

adjustment of gain with numeric control； auto control of gain； multistage amplifier； direct-coupling.

1. Introduction

With rapid development of electronic and communication technology, it is the important that the amplifier with high gain and wide band in engineering field. It is widely used in signal processing, video amplifier and other circuits. The need of these circuits for amplifier is not only broad bandwidth, but also high gain.

2. Amplifier Gain-bandwidth Product

Gain and bandwidth are very important indicators for amplifiers, while the gain and bandwidth is a contradiction of the reference .Because the gain of the amplifying circuit decreases with the increase of the frequency. It could be obtained the minimum gain in the frequency range used with the product of gain and bandwidth. Gain bandwidth product is an important index of amplifier, determined by the internal structure of the amplifier. With the gain increasing, the corresponding bandwidth will be decreased. While the bandwidth increasing, the gain will be reduced. The product is a constant. If the bandwidth of the amplifier is F, the upper limit of the amplifier is =x, and the lower cutoff frequency =y. When the gain of the 3dB, the voltage amplification factor A_u is

$$AU=3/(1+ x/F)(1+ y/F) \quad (1)$$

Then, Bandwidth gain product = (Po/Pi) * voltage amplification factor, Po is the amplifier output power, Pi is the amplifier input power.

3. System Design Scheme

It is not satisfied with an amplifier stage to achieve gain over 60dB and broadband more than 4MHz. So the paper presents a method that uses multistage amplifiers, which takes the low frequency characteristics of the amplifier into consideration. The multistage amplifier is cascaded with the direct coupling method. It could be set through the keyboard that the gain by step and displayed on the LCD based on AVR. The gain auto-control circuit is constituted with ADC, MCU and peak detector

circuit. It can monitor the fluctuation of amplifier gain and guarantee the stability of gain. Compared with two stages amplifier s, three stages amplifier has more gain and little bandwidth. So, the amplifier of the paper is designed with a ganged switch controlled by MCU. It can be chosen that between two or three stage amplifier to satisfy with different need of gain and bandwidth.

3.1 The design of two stage amplifier circuit

AD603 is an integrated chip with 8 pins that has adjusted high gain and bandwidth. It has maximum gain of 50dB, the maximum bandwidth of 90MHz. The bandwidth can be changed through adjusting the resistance between 5 and 8 pin. The gain can be changed through adjusting the voltage between 1 and 2 pin. The gain can reach -10 ~ 30dB when bandwidth in 90MHz, 0~ 40dB when bandwidth in 30MHz, 10 ~ 50dB when bandwidth in 9MHz. But if only use one AD603, loading capacity is poor, and the gain adjustment range is limited. It is adopted that two-stage AD603 amplifier, the bandwidth guaranteed by first stage amplifier with low amplification factor, high gain guaranteed by second stage amplifier. It can be achieved that the 30MHz bandwidth by set a 5 MΩ resistance between 5 and 8 pin. The gain is :

$$Gain(dB)=40VG+20 \quad (2)$$

V_G is the voltage between 1 and 2 pin.

It is adopted that numerical control to adjust the amplifier gain. But if control the two stage independently, it makes that numerical control more complex. The design uses the connection mode of Figure 2, which will be set the voltage 0.5V on 2 pin of first stage amplifier and set the voltage 1.5V on 2 pin of second stage amplifier. It is linked to 1 pin of first and second amplifier that output voltage of Gain numerical control DAC. Then, it can control the gain of two stage amplifier at the same time. The curve of gain variety is show in figure2.The gain can be adjusted continuously from 0 to 60dB.

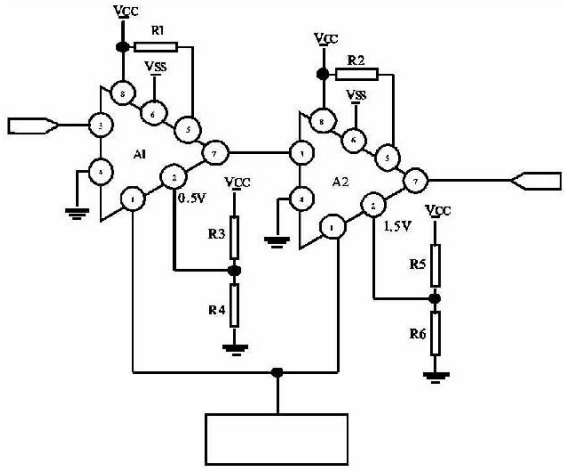

Fig.1 Circuit of two-stage AD603 amplifier

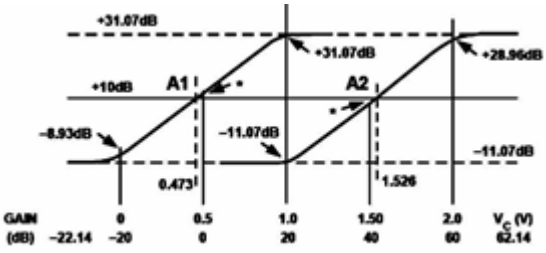

Fig.2 Change of gain with control voltage

3.2 Design of 3rd stage amplifier circuit

The maximum supply voltage of AD603 is 6.2V. Therefore, the output signal voltage maximum amplitude is 5V. If the gain of amplifier is set to 60dB, the maximum input signal is 5mV. It is bad for real application because the input signal is too small. AD811 is a video driver amplifier; the MAX gain is 12dB, and supply voltage ±18V. The output signal amplitude can be reached 15V. As a video driver amplifier, with strong belt

Ability, can drive 50 loads. Its amplification gain will be AD811 Gain is set to 2 times to ensure its bandwidth. The third stage amplifier is added to make the bandwidth ratio of the whole amplifier two Stage amplifier. In order to adapt to different input signals to gain, band The need of wide, signal amplitude, the use of numerical control two-way linkage switch, can To switch between two or three levels of amplification, to adapt to different zoom Need.

3.3 The circuit design of gain controlled automatically

It is adopted that the control of gain is digitized. The output voltage is sampled by peak detector, then the voltage sampled is converted to digital signal by ADC0809 and transmitted to MCU for processing. DAC0832 converts the signal provided by MCU to control voltage and transmits the voltage to two AD603 amplifiers, so that to guarantee the stability of the amplifier. The base polar of transistor is controlled by MCU, which provides 10us high level to make capacitor discharging. It can recede the influence that forward frequency to latter and boost the measuring accuracy of amplitude.

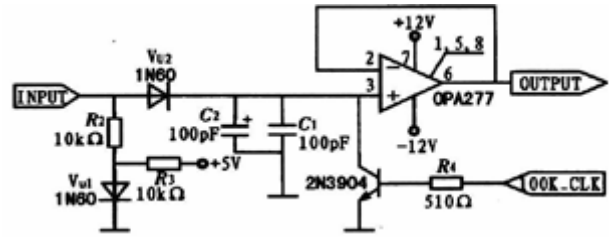

Fig.3 Circuit schematic diagram of peak detection

3.4 The circuit design of gain control and adjust

One of the innovations in the paper is the use of numerical control mode for the amplifier gain adjustment. It is utilized that the voltage provided by DAC0832 to control the 1 pin of the two stages AD603, so that to change the gain of the amplifier. It can be set that the gain from 0 to 60dB step by 5dB trough the keyboard.

4. Test results

The design of the amplifier in the paper, is achieved that the gain is controlled digitally. The control voltage is linear relation with gain in effective bandwidth, as shown in figure 4.

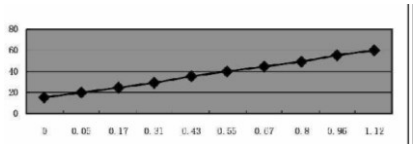

Fig.4 Curves of gain with control voltage

When the input signal 10mVrms, the amplifier gain is 40dB, the effective frequency range is from 4Hz to 6MHz, the gain changes <1dB within 1KHz to 5MHz,, as shown in figure5.

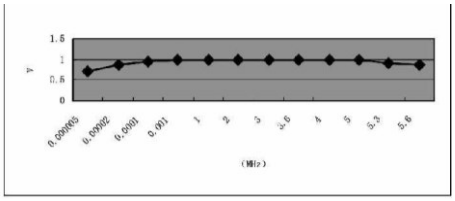

Fig.5 Curves of bandwidth with 40dB

When the input signal 5mVrms, the amplifier gain 60dB, the effective frequency range is from 4Hz to 4.4MHz, the gain changes <1dB within 1KHz to 3.8MHz,, as shown in figure6.

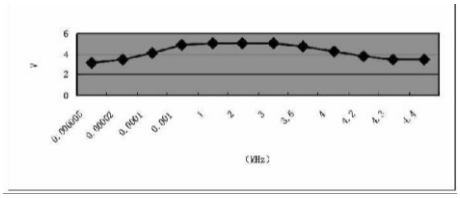

Fig.6 Curves of bandwidth with 60dB

5. Conclusions

The design of the amplifier in the paper is adopted three stages amplifier coupled directly. It has good low frequency characteristic; the lower limit frequency can reach a few hertz. The bandwidth is large, it can reach 6MHz; the amplifier gain adjustment range is large that can be 60dB; gain stability can be controlled automatically, and adjusted numerically; the output resistance of the amplifier is small, and the driving power is strong. The amplifier is can be applied widely in weak signal processing circuit, video driving circuit.

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