Research and Design of Gain Controllable System in RF Receiver

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Abstract

This paper studies and designs a gain controllable radio frequency amplifier system. As the hardware core of the whole system, the variable gain amplifier realizes the data function of the amplifier combined with the single chip microcomputer. After adjusting the gain of RF amplifier, the input signal can be amplified or attenuated, and the ideal output signal can be obtained. Using ADS simulation, the gain controllable RF amplifier system designed in this paper has better control effect, meets higher index, and has stable performance. The experiment shows that the gain controllable RF amplifier system has certain practicability.

Keywords: radio frequency amplifier, gain controllable, single chip microcomputer

1. Introduction

1.1. Research background and significance

As a transmission module in a communication system, RF amplifiers are now widely used in various communication systems, such as various types of communication equipment and digital image transmission. Gain control technology is an essential content inside these systems.

In recent years, more low-noise amplifier designs and applications have appeared, such as an optical amplifier that has low noise characteristics for a wide range of input signal electric power [エラー! 参照元が見つかりません。], and low-power low-noise amplifiers for portable Electrocardiogram recording system applications [2], but different for other types of design schemes, this topic is designed a stable and mid-low frequency RF signal gain controllable amplification system. The single-chip microcomputer implements the numerical control function on this system. Theoretically, it can meet higher indicators and can better control gain. It can be applied to a variety of occasions and has a wide range of practical significance.

1.2. Main content of this paper

In the hardware part, full reference is made to various types of RF amplifier modules to build a gain-controllable amplifier system that meets the requirements. The ADS software is used to simulate the feasibility of the scheme. In the software part, the AT89C52 is used as the main control microcontroller to implement the key control function for the entire variable gain system. At the same time, a display module is added to display the input signal, output signal and gain of the amplifier in the receiver in real time.

2. RF Receiver Overview

The common basic architecture of the RF receiver is shown in Fig.1. It is mainly composed of five parts: filter, low-noise amplifier, mixer, band-pass filter, and analog-to-digital conversion.

The LNA low-noise amplifier module in Fig. 1 has multiple design schemes. According to the design of the controllable gain system in this article, this LNA can be replaced with VGA.

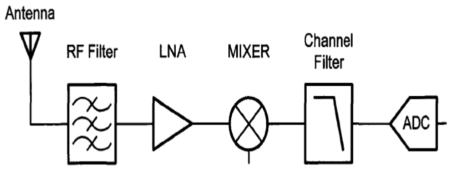

Fig.1 RF receiver basic structure

3. Controllable gain system design

Fig. 2 shows the block diagram of the system designed in this paper, which mainly includes detectors, variable gain amplifiers, AD converters, DA converters, and microcontrollers.

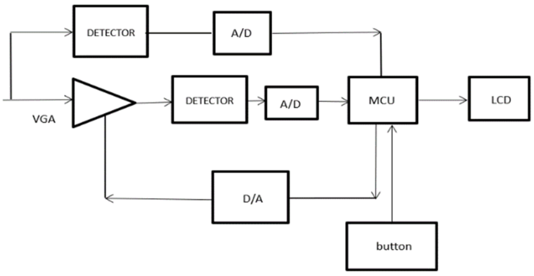

Fig.2 System structure block diagram

3.1. Detector

The AD8361 selected in this paper is an average response power detector, suitable for high-frequency receivers up to 2.5GHz. This device can convert a complex modulated RF signal up to 2.5 GHz into a dc voltage representing the rms level of the RF signal [3]. The circuit design of the module is shown in the Fig.3.

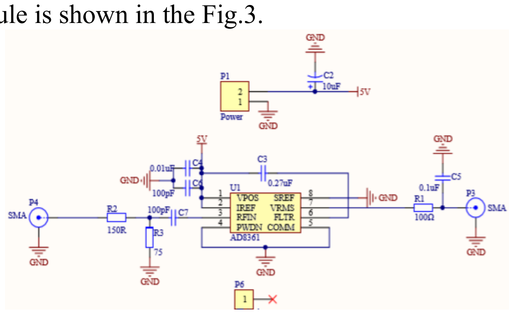

Fig.3 AD8361 module circuit diagram

3.2. Variable gain amplifier

In this subject, because the goal is to achieve the amplification of low-frequency RF signals, the amplifier module with AD8367 chip as the core is selected in this subject. This module is a variable gain intermediate frequency amplifier. The module is mainly composed of two parts, one is a 9th order resistance attenuation network, and the other is a fixed gain amplifier. The AD8367 is an example of a VGA that uses variable attenuation followed by a post-gain amplifier [4]. Providing the module with DC voltage enables it to work in VGA mode, which is the working mode used in this project. The module's peripheral circuit is designed with a shielded shell and an anti-reverse protection diode, which has a good protection function for the module. As shown in Fig.4.

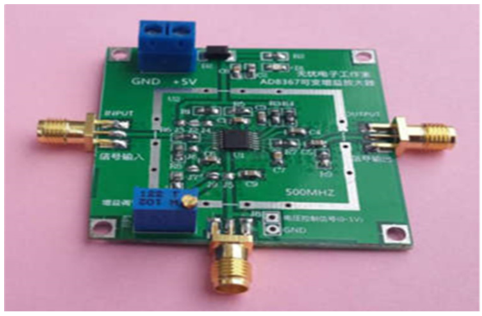

Fig.4 Variable gain amplifier module

3.3. ADS simulation design

ADS, Advanced Design System, is a commonly used RF circuit simulation software. Using this software, the variable gain amplification system of this subject is simulated. The simulation is shown in Fig.5.

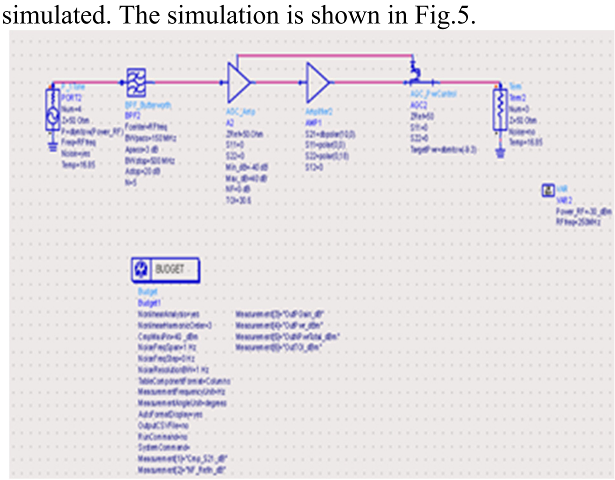

Fig.5 Simulation circuit diagram

In this model, by setting different output powers, the simulation of the variable gain system of this subject is completed. Because the working frequency of the variable gain amplifier is 0-500MHz, in this simulation, the input RF signal frequency is set to 250MHz and the input power is -30dBm. At the same time, when the input signal is 250MHz obtained in the actual test, the output RF signal power of the system is -9.3dBm.

3.4. AD module

The analog-to-digital conversion module in this subject is the PCF8591 module. PCF8591 is an 8-bit data acquisition device [5]. All data in the module is serially input or output through the I2C. Through the setting of the single-chip microcomputer, data collection and conversion functions can be realized.

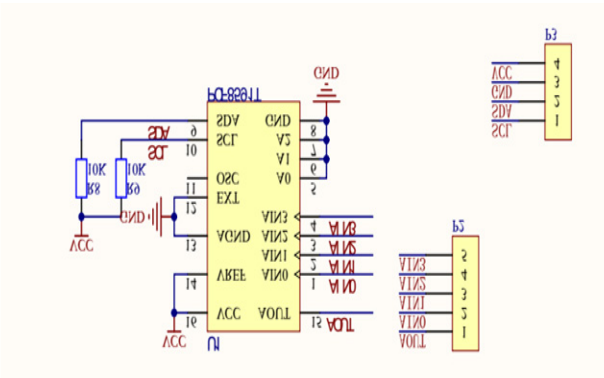

Fig.6 PCF8591 schematic

3.5. DA module

The system hardware designed in this paper adopts a modular design, taking the 89C52 single-chip microcomputer as the core of the system, controlling the DA conversion circuit, AD conversion circuit, and key control circuit to form the entire control system. The function of DA is to output the analog voltage signal through the single chip microcomputer, and send it back to the variable gain amplifier VGA module. Through the control of the single-chip microcomputer, the outputs are analog voltage value, so as to control the variable gain amplifier and realize different gains.

DAC0832 is an electric current exports type 8 bits D/A converter, adopting to reversing T type resistor network [6]. Through this module, it is possible to output different point flows with three keys and output corresponding analog voltage values through the load resistor. This voltage signal is supplied to the variable gain amplifier, which can make the variable gain amplifier module AD8367 have different gain, and finally realize the control function of the microcontroller to the amplifier. Combining key control with DA analog-to-digital conversion [7], through actual tests, the actual system requirements can be achieved, the test results are good, and the control performance is stable.

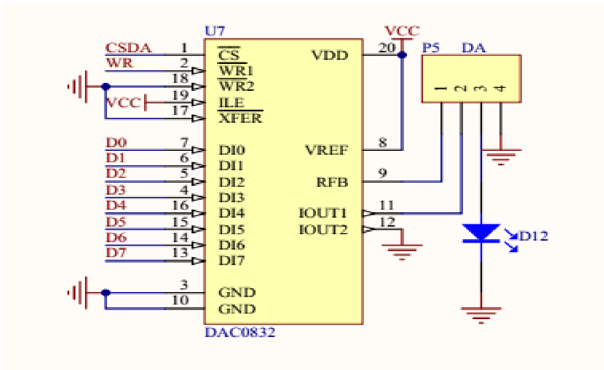

Fig.7 DAC0832 schematic diagram

4. System test

After building the entire system and connecting the modules, the actual tests were performed. The experimental effect is obvious, and obvious waveform changes can be obtained on the spectrum analyzer. Next, list some data, objects and graphics in actual tests.

In this subject, first set the RF input signal: 250MHz, -30dBm.

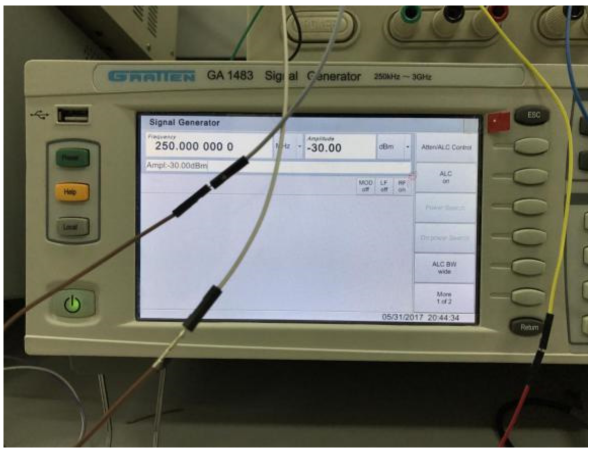

Fig.8 Input signal

As shown in Fig.9, the output signal passing through the amplifier is: 250MHz with an amplitude of -9.28dBm.

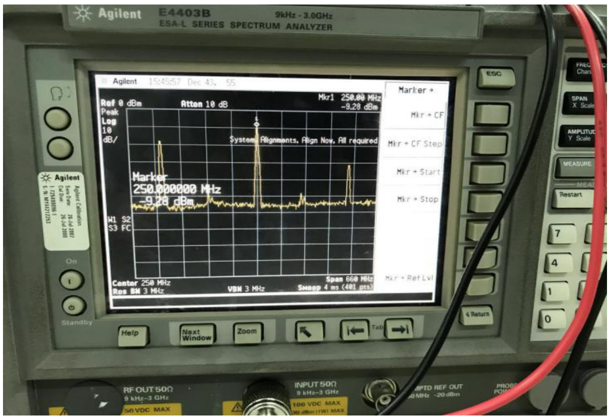

Fig.9 Output signal

As shown in Fig.10, The liquid crystal display of the single-chip microcomputer: IN: 026; OUT: 060; DEV: 00043.

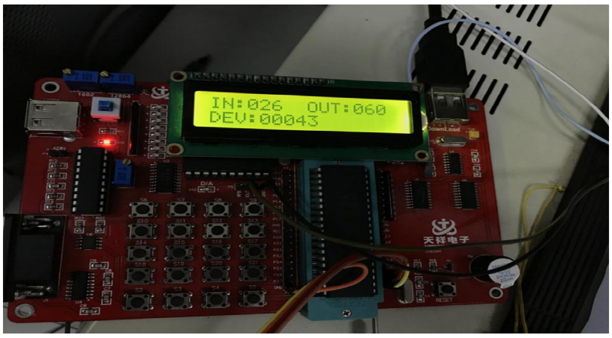

Fig.10 LCD display

In the liquid crystal display section, IN is the input RF signal source (V) of the system, and OUT is the amplified output value (V) of the system. DEV is the gain, which is the ratio of the OUT value to the IN value. The displayed value is 100 times the actual ratio.

Under the test conditions, the input signal is 250MHz with an amplitude of -30dBm and the output signal is 250MHz with an amplitude of -9.28dBm. It can be deduced that the actual gain is 20.72dB and the actual magnification is about 11 times. The single chip microcomputer collects and converts the value on the LCD after being collected by AD and converted into a digital quantity. The ratio of the two numbers is 0.43, and the gain of the amplifier is 2.3 times.

5. Conclusion

The full text starts from the design of the variable gain amplifier and aims to achieve the gain controllability of the amplifier, and realizes the design of a variable gain amplifier system at the front end of the RF receiver. The simulation of the amplifier was completed, and the single-chip microcomputer controlled the gain of the amplifier accurately and stably. However, there were some discrepancies in the liquid crystal display and gain calculation of the system's analog quantity transmitted to the single chip microcomputer.

Acknowledgements

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