Ideal Advanced Amplifier Technology

Zhuohao Chang*

School of Engineering, University of California, Irvine, California, USA

*Corresponding author: zhuohac@uci.edu

Abstract: A signal's amplitude or strength can be increased using an amplifier, which is a crucial component of signal processing in automation technology tools. The energy source is controlled using the input data, and the energy source also supplies the power needed for amplification. This results in the amplification of the amplifier. Although the amplifiers sold in the market are of good quality, the circuits are complicated and expensive, which are not easily accepted by consumers. By improving the technology of today's amplifiers and striving towards ideal amplifiers, that is, noise-free, with infinite gain, infinite input impedance, zero bias current, and zero detuning voltage, regardless of package size, energy conversion efficiency can greatly improve energy conversion efficiency and reduce energy consumption. The improvement of the amplifier process itself, the reduction of cost and power consumption are also driving the communication technology and the overall technology of human beings to a new level.

Keywords: Amplifier, Signal transfer, Efficiency.

1.Introduction

According to the physical quantity of the signal being processed, amplifiers are classified as mechanical, electromechanical, electrical, hydrodynamic, and pneumatic amplifiers, with electronic amplifiers being the most popular [1, 2]. According to the active devices employed, electronic amplifiers are categorized into vacuum tube amplifiers, transistor amplifiers, solid-state amplifiers, and magnetic amplifiers, with transistor amplifiers being the most popular [3]. Transistor amplifiers are frequently employed in automation equipment for voltage and current amplification of signals, primarily as single-ended amplification, and push-pull amplification. In addition, they are frequently employed in isolation, impedance matching, current-to-voltage conversion, and charge-to-voltage conversion (using charge amplifiers, for instance), and the usage of amplifiers to perform a specific function between input and output (e.g., operational amplifiers) [4]. With the development of wireless communication, people's requirements for communication technology are increasing, and they want to be able to communicate with anyone at any time and any place, including voice calls, data exchange and image transmission [5-7]. The power amplifier is an essential component of the wireless transmitter, and is the most energy-consuming component of the entire transmitter, and the output power is generally high. The future of the amplifier market growth drivers is mainly three. First, the portable application of low-power requirements will promote the growth of amplifiers with low operating supply voltage/current. Second, high-resolution applications need to reduce noise and distortion amplifiers. Third, the performance and price pressure continue to rise, so the ability to integrate other functions of the amplifier outlook is optimistic. To enhance the performance of the amplifier, advanced applications are used in test and measurement, communications, medical imaging, and other domains. DSL and consumer video applications account for the greatest market, and the future will continue this trend. Among them, the growth of DSL amplifier mainly lies in the line driver. The integration of filtering, multiplex technology and DC recovery features of consumer video amplifiers are also favored [8]. The two most significant areas of amplifier technology improvement are amplifier production cost and amplifier integration. The reduction of amplifier production cost can be achieved through the use of CMOS high-voltage transistors, while the integration degree is closely related to the noise of the amplifier, which can be effectively reduced through the improvement of resistors, electronic tubes and transistors, thus improving the integration degree

[9,10]. All these theories and approaches are based on the basic components of an operational amplifier, which is the basic amplifier circuit, as shown in Figure 1.

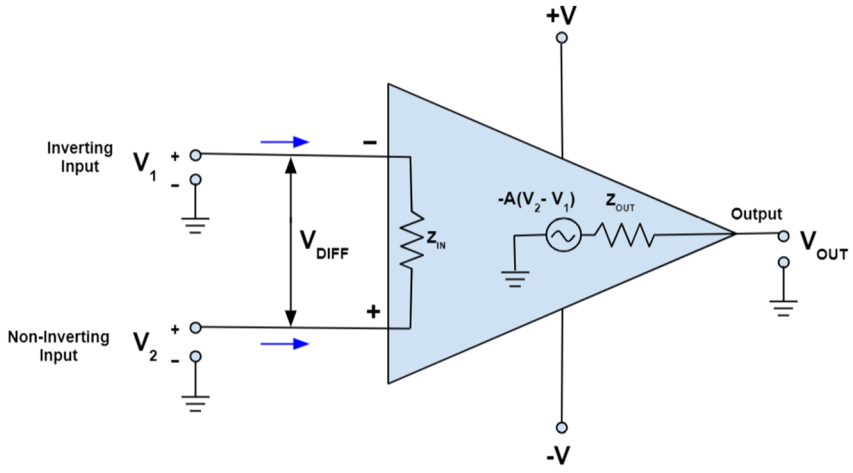


Figure 1. Operational amplifier basic circuit

2.Status of Amplifier Research

2.1 The history of amplifiers

The advancement of fundamental science and engineering technology was significantly accelerated by the creation of the first Lock-in Amplifier (LIA) by EG&G PARC (the forerunner of SIGNAL RECOVERY) in 1962. The creation of tools and technology for weak signal detection has led to their widespread use in numerous scientific and technical fields today. Future scientific research will continue to raise the bar for this technology while also encouraging the emergence of new weak signal detection principles and techniques.

After the first LIA were realized by analog circuits, a hybrid analog and digital LIA, or more analog-to-digital conversion (ADC), digital-to-analog conversion, emerged as a result of the development of digital technology. This LIA only used digital filters in the signal input channel, reference signal channel, and output channel to suppress noise (DAC). However, the core phase sensitive detector (PSD) or demodulator is still implemented using analog electronics, which is also essentially ALIA, until the phase sensitive detector or demodulator is realized by digital signal processing. Then, the digital phase lock-in amplifier (DLIA for short), which is considerably more well-liked and has numerous remarkable advantages over ALIA, appears. Although DLIA offers numerous distinct advantages over ALIA and has emerged as a hub for research on weak signal detection, ALIA nevertheless fills an indispensable role for DLIA on occasion.

2.2 Current statue of amplifier

The current status of amplifier research is to use higher processes to produce more reliable and lower cost products; allowing amplifiers to move toward higher bandwidth and lower power consumption, such as Fujitsu's development of CMOS logic high-voltage transistors for power amplifiers using a 45nm process.

Along with the global trend towards telecommunications deregulation and technological development nowadays, this wireless communication industry tends to be active and make the product categories more diversified, the application level includes home wireless phone, wireless LAN, personal wireless phone, and the popular Bluetooth, etc.. RF power amplifier is the key

component of the whole wireless communication system. Its output power determines the distance of communication and the efficiency of use determines the battery consumption. Therefore, power amplifier will be the focus of research and development in the industry.

After decades of development, op amps have evolved from the early vacuum tubes to the current integrated circuits, which are primarily split into four categories: general-purpose, low-voltage/low-power, high-speed, and high-precision op amps depending on the needs of various applications. In general, test and measurement equipment, video systems, and communication devices are the principal applications for high-speed op amps; low-voltage/low-power op amps are mainly for cell phones and other battery-powered portable electronic products; high-precision op amps are mainly for test and measurement instruments, automotive electronics and industrial control systems. General-purpose operational amplifier is the most widely used, almost any electronic system that needs to add simple signal gain or signal conditioning function can use general-purpose operational amplifier. The emergence of new applications such as information appliances, cell phones, and networks has provided an active stage for operational amplifiers, while also putting forward new technical requirements.

3.Development approach

3.1 Improvement of component parts

With the advancement of science and technology, there is a significant breakthrough in amplifier manufacturing process. Because the use of new processes allows for more reliable and lower cost products, Fujitsu Laboratories and Fujitsu Limited have jointly developed a CMOS high-voltage transistor with high breakdown voltage and based on a logic process for power amplifiers for wireless devices. As a pioneer in advanced technology, Fujitsu has completed the development of the world's first generation of CMOS transistors based on a 45nm process capable of handling 10 V power output, which allows the transistor to manage the large power prerequisites of power amplifiers for use in WiMAX as well as other high-frequency applications. This new innovation enables the integration of functional amplifiers and CMOS logic control circuits on the same chip, allowing for a single-chip operating mode, making it feasible to produce functional amplifiers with high performance and low power consumption.

By incorporating the novel transistor technology into a regular transistor for 3.3 V I/O utilizing 45 nm process technology, Fujitsu has created the first transistor in the world capable of boosting breakdown voltage from 6 V to 10 V. Additionally, the novel transistor performed well in fundamental reliability tests. The recently created high-voltage transistor by Fujitsu opens the door for the usage of CMOS logic transistors in power amplifiers that have high breakdown voltages.

Taking advantage of further developments in manufacturing technology and fabrication processes, scientists in various countries will continue to make efforts in integrating amplifier and control circuits on a single chip to realize amplifier modules with lower cost and higher performance.

3.2 Noise reduction for better integration

Noise is a very critical indicator for operational amplifier. Reducing noise and improving integration are the bottlenecks of future op amp development. When dealing with small signals, special attention must be paid to the noise generated by the line. These noises may originate from ohmic law resistors, electronic tubes and transistors, etc. An ADC and processor follow the op-amp in the majority of applications, and together they make up a typical signal transmission line. If the op-amp itself is extremely noisy, as are the components surrounding the op-amp configuration, the noise would then drown out the efficient signal for the ADC. As a result, regardless of the ADC's resolution and bandwidth, its outcome to the processor will only be noise, which has a significant negative impact on the system's regular operation.

Therefore, regardless of the general-purpose, low-voltage / low-power, or high-precision or high-speed op amps, it is necessary to suppress the noise of the components themselves to a minimum, In order to efficiently achieve the overall matching of the signal route and the greatest application effect. In addition, to meet the increasingly rich application requirements, amplifiers are no longer just a single product, but integrated with other devices to enhance performance and product value. For example, the integration of filtering, multiplex technology and DC recovery in video amplifiers.

Therefore, one of the most important enhancement methods for amplifiers today is to improve the production process to reduce its noise and power consumption, increase the integration, reduce the size and cost to meet the requirements of today's electronic products for high speed, high precision, low power consumption and mass production.

4.Conclusion

As the rapid development of mobile communication, digital TV, fiber optic transmission and other communication technologies and technology updates make amplifiers play an increasingly important role in the realm of technology and science today, while the improvement of the amplifier process itself, the cost and power consumption has also driven the communication technology and the overall level of human technology to a new level.

References

[1] Anshu Gupta, Pallavi Sharma, S. C. Malik, et al. Productivity Improvement in the Chassis Preparation Stage of the Amplifier Production Process: A DMAIC Six Sigma Methodology, 2016.

[2] Zhang Bo. Research and design of CMOS RF power amplifier, 2009.

[3] Byeong Ho Eom, Peter K. Day, Henry G. LeDuc, et al. A wideband, low-noise superconducting amplifier with high dynamic range, 2012.

[4] Vadim V. Ivanov, Igor M. Filanovsky. Operational amplifier speed and accuracy improvement, 2004.

[5] Maitraiyee Konar, Rashmi Sahu, Sudip Kundu. Improvement of the Gain Accuracy of the Instrumentation Amplifier Using a Very High Gain Operational Amplifier, 2019.

[6] Babak Mazhab Jafari, MohammadYavari. A UWB CMOS low-noise amplifier with noise reduction and linearity improvement techniques, 2015.

[7] W. Gerhard, R. Knoechel. Improvement of power amplifier efficiency by reactive Chireix combining, power back-off and differential phase adjustment, 2006.

[8] Mi Ae Jang, Sung Yong Kim, Ki Kyung Jeon, et al. Linearity improvement of power amplifier using modulation of low frequency IMD signals, 2006.

[9] JhenJiWang, Duanyu Chen, SanFuWang, et al. A multi-band low noise amplifier with wide-band interference rejection improvement, 2016.

[10] Trung-Kien Nguyen, Chung-Hwan Kim, Gook-Ju Ihm, et al. CMOS low-noise amplifier design optimization techniques, 2004.