Unit 2　Analog Electronics

2.1　Analogue Signal

Analogue electronics are electronic systems with a continuously variable signal, in contrast to digital electronics where signals usually take only two levels.

An analogue signal uses some attribute of the medium to convey the signal's information. Electrical signals may represent information by changing their voltage, current, frequency, or total charge. Information is converted from some other physical form (such as sound, light, temperature, pressure, position) to an electrical signal by a transducer which converts one type of energy into another (e. g. a microphone).

The signals take any value from a given range, and each unique signal value represents different information. Any change in the signal is meaningful, and each level of the signal represents a different level of the phenomenon that it represents. For example, suppose the signal is being used to represent temperature, with one volt representing one degree Celsius. In such a system 10 volts would represent 10 degrees, and 10.1 volts would represent 10.1 degrees.

Another method of conveying an analogue signal is to use modulation. In this, some base carrier signal has one of its properties altered: amplitude modulation (AM) involves altering the amplitude of a sinusoidal voltage waveform by the source information, frequency modulation (FM) changes the frequency. Other techniques, such as phase modulation or changing the phase of the carrier signal, are also used.

In an analogue sound recording, the variation in pressure of a sound striking a microphone creates a corresponding variation in the current passing through it or voltage across it. An increase in the volume of the sound causes the fluctuation of the current or voltage to increase proportionally while keeping the same waveform or shape.[3]

The primary disadvantage of analog signals is that any system has noise-i. e. , random unwanted variation. As the signal is copied and re-copied, or transmitted over long distances, or electronically processed, the unavoidable noise introduced by each step in the signal path is additive, progressively degrading the signal-to-noise ratio, until in extreme cases the signal can be overwhelmed. This is called generation loss. Noise can show up as "hiss" and inter-modulation distortion in audio signals, or "snow" in video signals. This degradation is impossible to recover, since there is no sure way to distinguish the noise from the signal; amplifying the signal to recover attenuated parts of the signal amplifies the noise as well. Digital signals can be transmitted, stored and processed without introducing noise. Even if the resolution of an analog signal is higher than a comparable digital signal, after enough processing the analog signal to noise ratio will be lower.

Words & Expressions

convert	转换
physical form	物理形状
pressure	压力
position	位置
phenomenon	现象；事件
amplitude modulation	幅度调制
frequency modulation	频率调制
fluctuation	波动
unavoidable	不可避免的

2.1.1 Noise

Analogue systems invariably include noise that is random disturbances or variations, some caused by the random thermal vibrations of atomic particles. Since all variations of an analogue signal are significant, any disturbance is equivalent to a change in the original signal and so appears as noise. As the signal is copied and re-copied, or transmitted over long distances, these random variations become more significant and lead to signal degradation. Other sources of noise may include crosstalk from other signals or poorly designed components. These disturbances are reduced by shielding and by using low-noise amplifiers.

Because of the way information is encoded in analogue circuits, they are much more susceptible to noise than digital circuits, since a small change in the signal can represent a significant change in the information present in the signal and can cause the information present to be lost. Since digital signals take on one of only two different values, a disturbance would have to be about one-half the magnitude of the digital signal to cause an error.[4] This property of digital circuits can be exploited to make signal processing noise-resistant. In digital electronics, because the information is quantized, as long as the signal stays inside a range of values, it represents the same information. Digital circuits use this principle to regenerate the signal at each logic gate, lessening or removing noise.

2.1.2 Precision

A number of factors affect how precise a signal is, mainly the noise present in the original signal and the noise added by processing. Fundamental physical limits such as the shot noise in components limits the resolution of analogue signals. In digital electronics, additional precision is obtained by using additional digits to represent the signal. The practical limit in the number of digits is determined by the performance of the analogue-to-digital converter (ADC), since digital operations can usually be performed without loss of precision. The ADC takes an analogue signal and changes it into a series of binary numbers. The ADC may be used in simple digital display devices, for example thermometers or light meters, but it may also be used in digital sound recording and in data acquisition. However, a digital-to-analogue converter (DAC) is used to change a digital signal to an analogue signal. A DAC takes a series of binary numbers and converts it to an analogue signal. It is common to find a DAC in the gain-control system of an op-amp which in turn may be used to control digital amplifiers and filters.

2.1.3 Design Difficulty

Analogue circuits are typically harder to design, requiring more skill, than comparable digital systems. This is one of the main reasons why digital systems have become more common than analogue devices. An analogue circuit must be designed by hand, and the process is much less automated than for digital systems. However, if a digital electronic device is to interact with the real world, it will always need an analogue interface. For example, every digital radio receiver has an analogue preamplifier as the first stage in the receive chain.

Words & Expressions

random	随机	precision	精确度
disturbance	干扰	factor	因素
significant	重要的	analogue-to-digital converter	模数转换器
shield	屏蔽,保护	digital-to-analogue converter	数模转换器
exploit	开发	a series of	一系列
quantize	量化	comparable	可比较的

2.2 Ideal Operational Amplifiers and Practical Limitations

In order to discuss the ideal parameters of operational amplifiers, we must first define the terms, and then go on to describe what we regard as the ideal values for those terms. At first sight, the specification sheet for an operational amplifier seems to list a large number of values, some in strange units, some interrelated, and often confusing to those unfamiliar with the subject.

The approach to such a situation is to be methodical, and take the necessary time to read and understand each definition in the order that it is listed. Without a real appreciation of what each means, the designer is doomed to failure. The objective is to be able to design a circuit from the basis of the published data, and know that it will function as predicted when the prototype is constructed.

It is all too easy with linear circuits, which appear relatively simple when compared with today's complex logic arrangements, to ignore detailed performance parameters which can drastically reduce the expected performance.

Let us take a very simple but striking example. Consider a requirement for an amplifier having a voltage gain of 10 at 50 kHz driving into a 10 kW load. A common low-cost, internally frequency-compensated op amp is chosen; it has the required bandwidth at a closed-loop gain of 10, and it would seem to meet the bill. The device is connected, and it is found to have the correct gain.

But it will only produce a few volts output swing when the data clearly shows that the output should be capable of driving to within two or three volts of the supply rails. The designer has forgotten that the maximum output voltage swing is severely limited by frequency, and that the maximum low-frequency output swing becomes limited at about 10kHz.

Of course, the information is in fact on the data sheet, but its relevance has not been appreciated. This sort of problem occurs regularly for the inexperienced designer. So the moral is clear: always take the necessary time to write down the full operating requirements before attempting a design. Attention to the detail of the performance specification will always be beneficial. It is suggested the following list of performance details be considered:

1. Closed loop gain accuracy, stability with temperature, time and supply voltage
2. Power supply requirements, source and load impedances, power dissipation
3. Input error voltages and bias currents. Input and output resistance, drift with time and temperature
4. Frequency response, phase shift, output swing, transient response, slew rate, frequency stability, capacitive load driving, overload recovery
5. Linearity, distortion and noise

6. Input, output or supply protection required. Input voltage range, common-mode rejection

7. External offset trimming requirement

Not all of these terms will be relevant, but it is useful to remember that it is better to consider them initially rather than to be forced into retrospective modifications.

Never forget this fact. How many times has a circuit been designed using typical values, only to find that the circuit does not work because the device used is not typical? The above statement thus poses a tricky question: when should typical values and when should worst-case values be used in the design?

This is where the judgment of the experienced designer must be brought to bear. Clearly, if certain performance requirements are mandatory, then worst-case values must be used. In many cases, however, the desirability of a certain defined performance will be a compromise between ease of implementation, degree of importance, and economic considerations.

In the end, we are all controlled by cost, and it is really pointless taking a sledgehammer to crack a nut. Simplicity is of the essence since the low parts count implementation is invariably cheaper and more reliable.

Words & Expressions

operational amplifier	运算放大器(op amp)	closed-loop gain	闭环增益
parameters	参数	output swing	输出电压变化范围
specification	指标	supply rails	电源供给线
methodical	有方法的；有系统的	data sheet	技术规格表
doom	注定	relevance	有关；适当
objective	目的	moral	道德，寓意
prototype	原型；样机	impedance	阻抗
drastically	激烈地；彻底地	dissipation	消耗
striking	惊人的；醒目的	bias current	偏置电流
gain	增益	resistance	电阻

drift	漂移
transient	瞬态的
slew rate	转换率；斜率
linearity	线性
trimming	微调
retrospective	回顾的
tricky	机敏的；狡猾的
worst-case value	最不利的数值
mandatory	命令的；必须的
desirability	可取性；值得
sledgehammer	大锤
transducer	传感器；变换器
offset voltage drift	补偿电压的漂移
negligible	可忽略的
unquoted	未注明的
proportion	比例
plug	插入

2.3 Nature of Phase Lock

A phase-lock loop contains three components：

1. A phase detector（PD）
2. A loop filter
3. A voltage-controlled oscillator（VCO）whose frequency is controlled by an external voltage

The phase detector compares the phase of a periodic input signal against the phase of the VCO. Output of PD is a measure of the phase difference between its two inputs. The difference voltage is then filtered by the loop filter and applied to the VCO. Control voltage on the VCO changes the frequency in a direction that reduces the phase difference between the input signal and the local oscillator.

When the loop is locked, the control voltage is such that the frequency of the VCO is exactly equal to the average frequency of the input signal. For each cycle of input there is one, and only one, cycle of oscillator output.

One obvious application of phase-lock is in automatic frequency control（AFC）. Perfect frequency control can be achieved by this method, whereas conventional AFC techniques necessarily entail some frequency error.

To maintain the control voltage needed for lock it is generally necessary to have a nonzero output from the phase detector. Consequently, the loop operates with some phase error present. As a practical matter, however, this error tends to be small in a well-designed loop.

Words & Expressions

detector	检测器，检波器
oscillator	振荡器
entail	引起
corrupt	毁坏
additive	相加的；加性的
instantaneous	瞬时的
suppress	抑制
track	跟踪
eliminate	消除，淘汰
homodyne	零差式的
superheterodyne	超外差的
mixer	混频器
beat-note	差拍信号
tune	调谐
garble	篡改；歪曲；使混乱
fraction	片断；小数
interlace	相间；隔行扫描
frame	（电视的）帧
raster	光栅
strip	剥离
trigger	触发
sweep generator	扫描发生器
relaxation	松弛；放松
premature	未成熟的
susceptible	易受影响的
inferior	差的；处于劣势的
superior	优越的
jitter	抖动，颤抖
misfiring	误触发
streak	条纹
fluctuation	起伏
discrepancy	偏差；偏离
flywheel	飞轮
color burst	色同步信号
spectacular	惊人的
coherent	相干的
offset	偏移；补偿
transponder	应答器；转发器
discriminator	鉴别器；鉴频器

Exercises

I. Fill in the blanks with the information given in the text.

1. An operating system is the basic ________ that controls a computer.

2. If you want to run more than one process at a time, you must use an operating system with ________ capability.

3. Operating systems can use ________ memory to run processes that require more main memory than is actually available.

4. OS/2 is an operating system developed jointly by ________ and Microsoft Corporation for the personal computer.

5. ________, whose popularity is due in large part to the growth of the Internet, is a(n) ________, multitasking operating system.

6. The most widely used operating system in the world is ________, which provides users with a(n) ________ user interface.

7. MS-DOS, the acronym for Microsoft Disk Operating System, is a single-tasking, single-user operating system with a(n) ________ interface.

8. A(n) ________ OS is designed for a connected, but independent, collection of computers that share resources.

II. Translate the following terms or phrases from English into Chinese and vice versa.

1. data set
2. pointing device
3. graphical user interface
4. time-slice multitasking
5. object-oriented programming
6. click on an icon
7. context switching
8. distributed system
9. pull-down lists of commands
10. simultaneous access
11. 命令行界面
12. 多任务化环境
13. 电子制表程序
14. 主存
15. 存储介质
16. 磁盘文件
17. 命令解释器
18. 网络连接
19. 磁盘操作系统
20. 拷贝数据文件

III. Fill in each of the blanks with one of the words given in the following list, making changes if necessary.

program interface system user storage classify unauthorized control document efficiently function detect internal security password input

Operating systems for micro, mini, and mainframe computers perform many services. These services can be ________ either as “external” or “internal.” The operating system provides external services that help ________ start programs，manage stored data，and maintain ________. You，as the computer user，control these external ________. Using a command-line，menu-driven，or GUI user ________，an operating system provides you with a way to select the ________ you would like to use. The operating system also helps you find，rename，and delete ________ and other data stored on disk or tape. On many，but not all computer ________，the operating system helps you maintain security by checking youruser ID（用户标识）and ________，as well as protecting your data from ________ access and revisions（修改）. The operating system provides ________ services “behind the scenes” to ensure that the computer system functions ________. These internal services are not generally under your ________，but instead are controlled by the operating system itself. The operating system controls ________ and output，allocates（分配）system resources，manages the ________ space for programs and data，and ________ equipment failure without any direction from you.

IV. Translate the following passage from English into Chinese.

Multitasking，in computer science，is a mode of operation offered by an operating system in which a computer works on more than one task at a time. There are several types of multitasking. Context switching is a very simple type of multitasking in which two or more applications are loaded at the same time but only theforeground（前台的）application is given processing time；to activate（激活）a background（后台的）task，the user must bring the window or screen containing that application to the front. In cooperative（合作的）multitasking，background tasks are given processing time during idle times in the foreground task（such as when the application waits for a keystroke），and only if the application allows it. In time-slice multitasking each task is given the microprocessor's attention for a fraction of a second. To maintain order，tasks are either assigned priority levels or processed in sequential（顺序的）order. Because the user's sense of time is much slower than the processing speed of the computer，time-slice multitasking operations seem to be simultaneous.

Reading Materials

Programming Language

Programming languages, in computer science, are the artificial languages used to write a sequence of instructions (a computer program) that can be run by a computer. Similar to natural languages, such as English, programming languages have a vocabulary, grammar, andsyntax. However, natural languages are not suited for programming computers because they are ambiguous, meaning that their vocabulary and grammatical structure may be interpreted in multiple ways. The languages used to program computers must have simple logical structures, and the rules for their grammar, spelling, andpunctuation must be precise. Programming languages vary greatly in their sophistication and in their degree of versatility. Some programming languages are written to address a particular kind of computing problem or for use on a particular model of computer system. For instance, programming languages such as FORTRAN1 and COBOL2 were written to solve certain general types of programming problems—FORTRAN for scientific applications, and COBOL for business applications.

Although these languages were designed to address specific categories of computer problems, they are highlyportable, meaning that they may be used to program many types of computers. Other languages, such as machine languages, are designed to be used by one specific model of computer system, or even by one specific computer in certain research applications.

The most commonly used programming languages are highly portable and can be used to effectively Programming languages can be classified as either low-level languages or high-level languages. Low-level programming languages, or machine languages, are the most basic type of programming languages and can be understood directly by a computer. Machine languages differ depending on the manufacturer and model of computer. High-level languages are programming languages that must first be translated into a machine language before they can be understood and processed by a computer.

Examples of high-level languages are C, C++, PASCAL, and FORTRAN. Assembly languages are intermediate languages that are very close to machine languages and do not have the level of linguistic sophistication exhibited by other high-level languages, but must still be translated into machine language.