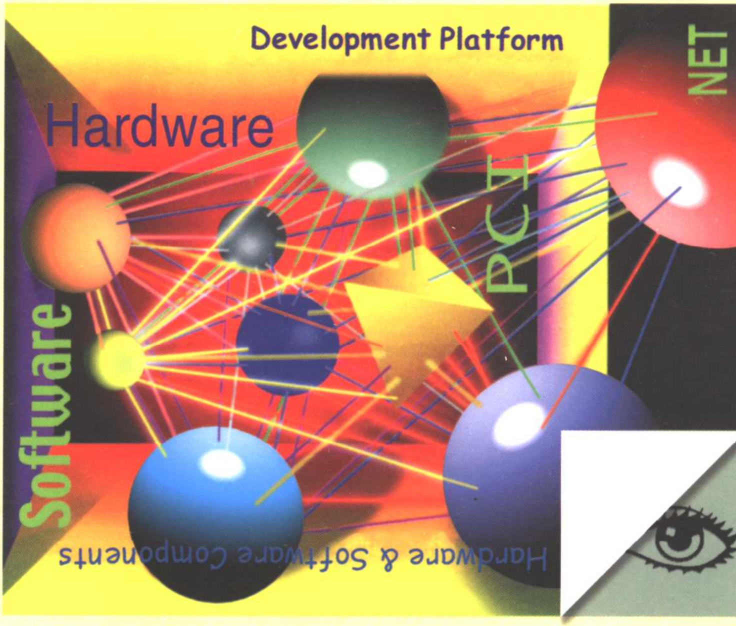
专业英语阅读丛书

电子信息与通信专业英语

ENGLISH IN

ORMATION AND COMMUNICATION



赵淑清 主编

哈尔滨工业大学出版社

电子信息与通信
专业英语

赵淑清　主编

哈尔滨工业大学出版社
哈尔滨

内容提要

本书以培养学生专业英语阅读能力为主要目标。内容包括：基础电子学、信号的信息处理及通信的理论、计算机原理及应用、信号处理专题以及一些电子仪器、设备及部件的说明书。

本书可作为大学电子信息工程和通信工程专业三、四年级本科生的专业英语教材，也可供广大工程技术人员使用。

电子信息与通信专业英语
Dianzi Xinxi yu Tongxin Zhuanye Yingyu
赵淑清　主编
*
哈尔滨工业大学出版社出版发行
哈尔滨工业大学印刷厂印刷
*
开本 850×1168　1/32　印张 9.75　字数 286 千字
2000 年 3 月第 1 版　2001 年 3 月第 2 次印刷
印数 5 001—10 000
ISBN 7-5603-1450-3/H·141　定价 12.00 元

前　言

国家教委颁布的“大学英语教学大纲”把专业英语列为必修课而纳入英语教学计划，强调通过四年不断线的教学使学生在到顺利阅读专业刊物的目的。据此精神，编写本书，以满足高等院校电子信息工程和通信工程专业及相关专业的专业英语教学的需要和从事上述专业的工程技术人员学习英语的要求。

本书从基本电子线路到计算机应用，基本覆盖了电子信息工程和通信工程专业技术基础课所学的内容。考虑到学生将来可能从事的科学研究和电子及通信设备的应用、研制和开发，还选择了一些热门研究领域的课题和一些电器备以及 DSP 芯片或部件的说明书。

本书共有五章，第一章基础电子学包括模拟电子线路、数字电子线路、以及信号理论和数字信号处理；第二章是信号和信息处理及通信的基本理论；第三章是电子信息工程和通信工程专业将涉及的计算机原理及应用的内容；第四章信号处理专题包括了近年来信号处理领域中的一些热门课题；第五章收集了一些电子仪器、设备以及 DSP 芯片或部件的说明书。每节后面列出一些单词，并对一些句子进行了注释。单词和注释以专业词汇和专业性较强的句子为主，主要是使读者能够正确理解书中所叙述的原理和阐述的观点。

本书内容新颖，文体规范，难度适中，可作为电子信息工程和通信工程专业大学三、四年级学生的专业英语阅读材料。

本书由哈尔滨工业大学赵淑清、王大明、谷光琳编写。在编写的过程中得到了哈尔滨工业大学电子与通信工程系的一些博士、硕士研究生的大力帮助，在此表示诚挚的感谢。由于编者水平有限，书中难免还存在一些缺点和错误，殷切希望广大读者批评指正。

编　者

1999 年 10 月

Contents

Chapter 1 Basic Electronics

1.1 Receiver Circuits

The purpose of a receiver is to select a desired group of frequencies from one transmitter, get rid of all unwanted signals and noise, and then demodulate the signal to obtain the modulating information. The better the receiver does its job, the closer the demodulated signal will resemble the original signal from the transmitter. Regardless of the type of demodulation required, the main functions performed by a receiver are filtering and amplifying. The superheterodyne receiver is the logical choice for the job.

1.1.1 Superheterodyne Receiver

Since it is easier to design narrow-band, steep-skirt filters and obtain high gains at lower frequencies, the "superhet" receiver is an efficient design. All incoming signals are mixed with the output of a local oscillator and the difference frequency is selected and amplified by the intermediate frequency amplifiers. The big benefit is that these amplifiers remain at a fixed frequency and only the RF amplifier and local oscillator need be tunable. Fig. 1.1 is a block diagram of a typical superhet receiver. One further benefit is the fact that the gain is concentrated at two or sometimes three different frequencies. This reduces the gain required at

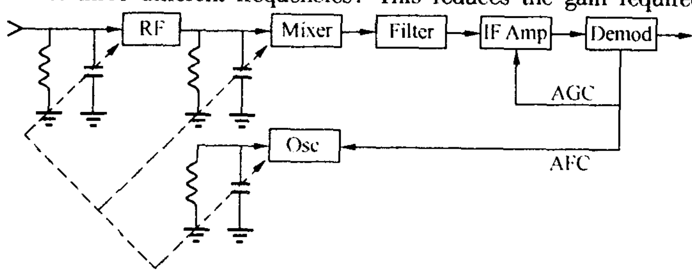


Fig. 1.1 Block diagram of a superheterodyne receiver

any one frequency and leads to more stable amplifiers. When over 120 dB of RF gain is involved, every little bit helps.[1]

The function of each item in Fig. 1.1 can be explained as follows:

1. *RF amplifier*

It should have just enough gain, usually about 10 dB, to establish the overall noise figure of the receiver. The tuned circuits at the input and output need only be selective enough to reject image signals and other spurious signals that could intermodulate and appear at the intermediate frequency. Some AGC may be needed to prevent overloading on strong signals. The RF amplifier may also be called on to suppress any tendency for the local oscillator to radiate out to the antenna and interfere with other listeners.

2. *Mixer and local oscillator*

The mixer has two inputs, one from the RF amplifier and one from the local oscillator. The nonlinearities of the mixer will create numerous intermodulation products, and one of these, the sum or difference frequency, will occur at the IF frequency. Usually, there will be a second frequency, the image, that can also mix with the oscillator frequency and produce an output at the IF. Depending on the type of mixer used, conversion gains from − 10 dB to + 30 dB are common. The local oscillator must be tunable, yet have a low drift rate and relatively low sideband noise, since this could increase the noise level of the receiver.

3. *IF filters and amplifiers*

This section establishes the overall bandwidth and adjacent channel selectivity of the receiver. The bulk of the receiver's gain will be concentrated here and some type of automatic gain control will be included to adjust for variations in received signal strength. The IF is usually at a lower frequency than the RF, but, in some special cases, the IF may be higher to reduce spurious intermodulation and image problems.

4. *Demodulators*

For each type of modulation used (i.e., AM, FM, SSB, PM), a number of different circuits exist. Some will have gain, others a loss.[2]

Some will require a reference input(i.e., SSB and phase modulation), others won't. The demodulation may also be required to produce outputs to AGC or AFC circuits. The recovered audio level (or video, etc.) will determine the amount of gain required in the following audio or video amplifiers.

1.1.2 Specifications

Before beginning the design of a receiver, it is necessary to consider the specifications required of the final result. In most cases this ends up as a compromise between what the designer would like and what is possible. The determining factor will usually be financial limitations. The following should then be considered before proceeding:

1. *Tuning range*

What range of frequencies must be tuned and will it be tuned continuously or in discrete channels? A short-wave receiver, for example, must continuously tune from 3 to 30 MHz and will usually require some band switching. The local oscillator will be a continuously tunable type. Demodulators will be needed for AM, SSB, and CW, and IF bandwidths should correspond. For CB, a narrow range of frequencies from 26.965 to 27.405 are needed and will be tuned as 40 discrete channels. The local oscillator will therefore likely be a phase-locked loop synthesizer. Demodulation could be either AM or SSB.

2. *Sensitivity*

Often, too much emphasis is put on sensitivity without attention to other details. For example, a 100-kHz navigation receiver will pick up so much atmospheric noise that a 100-μV desired signal from the antenna could be obscured at times. On the other hand, a 0.1-μV signal at 150 MHz will often be readily distinguishable from background noise.

3. *Bandwidth*

When the modulation type and channel spacing are known, it is possible to determine the IF bandwidth and its skirt characteristics. For FM-stereo broadcasting, a bandwidth of 350 kHz is required. For AM aircraft communications, a bandwidth of 30 kHz is common—not to provide wide bandwidth for high audio-frequency response but to accommodate frequency tolerances in the transmitters and receivers. The filter-skirt characteristics will be set to reject adjacent channel signals as required.

4. *Spurious signals*

An otherwise good design can be useless if unwanted signals can sneak into the receiver at the IF frequency(s), the image frequency, at various spurious frequencies related to intermodulation products, and through cross-modulation problems.[3]

Typical specifications for several good receivers are as follows:

(1) *FM stereo tuner*: frequency range 88 ~ 108 MHz

Sensitivity:	1.8 μV across 300-Ω input for 20 dB of quieting
Selectivity:	100 dB for channels 400 kHz either side of center frequency
Bandwidth:	350 kHz at −6-dB points
Image rejection:	90 dB
Spurious rejection:	90 dB
IF rejection:	90 dB
AM suppression:	65 dB
Capture ratio:	1.5 dB[4]

(2) *Shortwave receiver*: frequency range 3.0 ~ 30 MHz

Sensitivity:	0.5 μV for 10 dB S + N/N ratio[5]
Bandwidth:	2.3 kHz at −6 dB, 5.5 kHz at −60 dB (SSB mode)
Image rejection:	60 dB
IF rejection:	75 dB

(3) *CB receiver*: frequency range 26.965 ~ 27.405 MHz

Sensitivity:	0.5 μV for 10 dB S + N/N ratio
Bandwidth:	6 kHz at −6 dB 20 kHz at −60 dB
Image rejection:	60 dB

Once the specifications are carefully determined, it is time to start the design. But what is the best starting point? Generally, the most sensitive points will be the two nonlinear circuits, the mixer and the detector. The IF amplifier takes up the slack between the two, and the RF amplifier picks up the deficiencies of the mixer.

1.1.3 Mixers

The mixer section of the receiver should ideally produce an IF output only at the difference (or sum, for up-conversion) of the two input frequencies. One of these inputs will be the local oscillator signal and the other will be the desired RF signal. Again, ideally, no other combination of input signals should produce an IF output. If such frequencies do exist, filters must be provided to remove them before they reach the mixer.

The closest thing to an ideal mixer is any circuit with a perfect square-law transfer characteristic. In addition to the input signals and their second harmonics appearing at the output, the sum and the difference will also appear. The difference is usually the one signal desired and so is selected by IF filtering. The amplitude of the difference signals will be proportional to the product of the original RF signal level and the local oscillator level. Any other two signals at the input could also produce an output at the IF if they are separated by an amount equal to the difference frequency. However, the output level they produce will be proportional to their signal levels.

Some discrimination against unwanted mixing products can therefore be had if all RF input levels to the mixer are kept as low as possible and the local oscillator signal kept as high as possible.[6] The one desired signal will therefore be stronger than all the undesired ones. This is described in Fig.1.2. Themixer circuit has four signals at its input, all of the same level. The local oscillator signal level is included for reference and is much higher than the other four. The IF filters only pass signals between 0.4 and 0.6 MHz. RF frequencies C and D can mix with the oscillator and produce outputs at 0.45 and 0.55 MHz, respectively, well within the IF passband. One will be the desired signal and the other is the image, which should be removed by filtering before reaching the mixer.

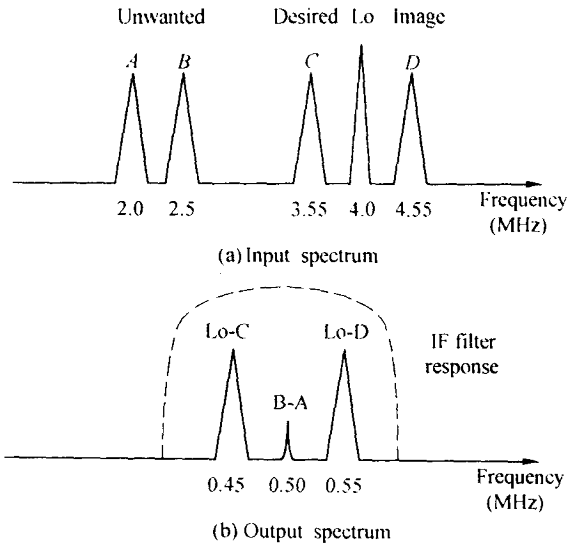


Fig.1.2 Spectrum of input signal for a square-law mixer and the outputs within the IF passband

Two other signals, A and B, happen to be separated by 0.5 MHz, so they will also produce a mixing product (which contains the combined modulation of each) within the IF passband. However, the amplitude of this signal will be much lower than the desired IF signal. Therefore, best results are obtained by:

(1) Selecting a square-law mixer.

(2) Using high local oscillator levels.

(3) Maintaining low RF signal levels.

(4) Providing proper filtering ahead of the mixer.

1.1.4 Filtering Requirements

If the ideal square-law mixer can be built, what is the minimum filter that is required ahead of it? We have already seen that the image has to be removed and also any group of frequencies that could themselves mix and produce an IF output.[7] The limiting case is shown in Fig.1.3. The

IF filters are placed at 5.0 MHz and have nearly vertical skirts. The RF filters ahead of the mixer also have nearly vertical skirts and cover the range 5.5 ~ 10.0 MHz, nearly a 1-octave range. The RF bandwidth is just narrow enough (4.5 MHz) that no two signals can exist within the passband to cause mixing. The image frequencies would lie in the range 15.5 ~ 20.0 MHz and are also outside the filter range. In a practical design, the filters would have wider skirts, so the useful range of the mixer would be an even smaller portion of the theoretical 1-octave bandwidth.

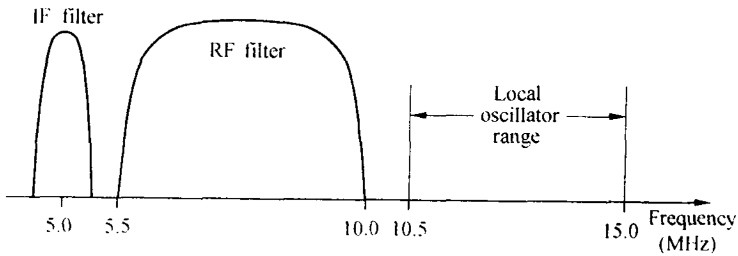


Fig. 1.3 Ideal filter requirements for a square-law mixer

1.1.5 Conversion Gain and Noise

Since any practical circuit will generate excess noise, mixers are no exception. Each type of mixer circuit will therefore have its own noise figure. If the combination of this noise figure and any losses in the RF filters ahead of the mixer are low enough, no amplification is required nor even desired before mixing. Amplifiers would inevitably have some nonlinearities and would increase the signal input level to the mixer so that other mixing products could appear. When considering a mixer noise figure, it should be remembered that two frequencies could contribute to noise output at the IF frequency, the desired frequency and its image. Removal of the image by placing a filter between the antenna and the mixer is not always sufficient. If the mixer "sees" a resistive impedance at the image frequency, thermal noise will be added. The filter should therefore appear as a short circuit at the image frequency.

If the noise figure is too high, an RF amplifier will be necessary. Its gain must be just adequate to set the overall noise figure to the desired level and no more. In fact, a little negative feedback in this stage will improve the linearity and the resulting loss of gain will actually be welcome.

The mixer may produce an IF signal that is either higher or lower in amplitude than the RF input signal. The relative size would be indicated by the conversion gain or loss. Conversion gain should be a secondary consideration, as any deficiency can always be made up for with other amplifiers. The only real problem involves setting the overall noise figure of the receiver. With no RF stage and a mixer with a conversion loss, the first stage of the IF must have a very low noise figure.

1.1.6 RF Amplifiers

Once the desired range of input signal levels to the mixer has been chosen, the RF amplifier can be designed (or eliminated) as required. Its gain should be just sufficient to bring the weakest signal from the antenna up to whatever level is needed to override noise generated in the RF amplifier and mixer. The total noise factor of the receiver will be given by

$$F = F_1 + \frac{F_2 - 1}{G_1}$$

where, F_1 = noise factor of the first stage

F_2 = noise factor of the second stage

G_1 = power gain from input to second stage

For the arrangement shown in Fig. 1.4, the RF amplifier has a gain of 12 dB (8:1) and the mixer has a loss of 4 dB (0.398:1). The noise figure of the RF stage is 2.0 dB(1.585) and of the IF amplifier is 2.5 dB (1.778). The overall noise figure would then be

$$F = F_1 + \frac{F_2 - 1}{G_1} = 1.585 + \frac{1.778 - 1}{8 \times 0.398} =$$

$$1.829 \text{ (or } 2.62 \text{ dB)}$$

The RF amplifier has therefore provided enough gain so that the overall noise figure of 2.62 dB is only 0.62 dB higher than that of the RF amplifier itself. Higher gain would provide little overall improvement and would simply cause more problems with the mixer.

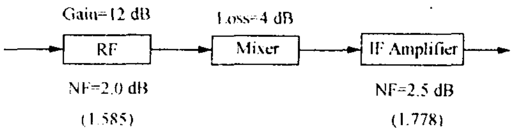


Fig. 1.4 Noise figures, gains, and losses of the first three stages of a receiver

After the gain and noise figure are set, the next requirement is the filtering associated with the RF amplifiers. Part of this will depend on the mixer and part on the amplifier itself. The minimum filter requirements needed to complement the perfect square-law mixer were discussed in Section 1.1.4. If the mixer also has a significant third-order component, several new frequencies could end up in the IF passband. These would be:

(1) IF = RF ± 2OSC, RF = 16 or 26 MHz

(2) IF = 2RF ± OSC, RF = 2.75 or 7.75 MHz

(3) IF = 3RF, RF = 1.667 MHz

The examples shown alongside assume an IF of 5.0 MHz and the local oscillator at 10.5 MHz, a situation taken from Fig. 1.3. The first new frequencies (1) at 16 MHz and 26 MHz would be outside the passband of the minimum 1-octave filters (5.5 ~ 10 MHz) and, also, if balanced mixers are used, the mixer would not function at even harmonics of the oscillator. This frequency then does not present any problem. The second pair (2) represents signals at 2.75 or 7.75 MHz. The latter lies right in the middle of the 1-octave filter range, so that if the mixer has significant third-order distortion, added filtering would be needed. The one choice is half-octave filters, the other is narrow-band, continuously tunable filters (with their tracking problems). Other spurious signals can be created by harmonics produced within the RF amplifier itself; such is the case with frequency (3) where a third harmonic created by amplifier nonlinearities could pass straight through the mixer. The 1.667-MHz input can easily be eliminated with filters ahead of the RF amplifier.

The total spurious frequency problem therefore depends to a great extent on the linearity of the RF stage, on filters before and after this stage, and on the mixer itself. The big problem involves gain control. To maintain low-level signals at the mixer input, the gain of the RF stage may need to be reduced at some time. For automatic gain control, the amplifier must have a nonlinear transfer characteristic so that a change of bias produces a change in gain. The resulting second-order nonlinearities could then produce spurious signals, which would cause mixing products to appear within the IF passband, particularly since the filters ahead of the RF stage are usually minimal. If AGC is used, good RF filtering is required.

A better approach is to make the amplifiers very linear, even by going to the extremes of balanced amplifiers with negative feedback. Gain control can then be manual—either turning a potentiometer or switching in resistive pads, or automatic if linear devices are used.

The idea of a linear, two-terminal device that will not distort a signal yet can change its resistance with a voltage change may seem strange. A small incandescent lamp is one example. If a DC voltage is applied across the lamp and slowly changed, the current flowing into the bulb will not change linearly with the applied voltage. As the filament heats up, its resistance will increase. Any rapid voltage changes, however, will cause linear current changes, since the thermal time constant of the filament will be long enough to hold the resistance constant for a while.[8] Such an idea has been used for automatic level control of good-quality audio oscillators for years. The modern equivalent of the lamp is the PIN diode. At low frequencies the device acts like a diode, but at higher frequencies it acts like a variable resistor, since the lifetime of its charge carriers is quite long (up to 500 ns). Above about 10 MHz (depending on the particular diode), a linear attenuator can be made that can be varied with a DC. control voltage.

1.1.7 IF Amplifiers

The intermediate frequency section of a receiver is placed between the first mixer and the final detector circuits. It must:

(1) Provide a high amount of gain, 60 ~ 100 dB, and reduce this when strong signals are present.

(2) Filter out all unwanted signals outside the passband.

(3) Limit amplitude variations in the case of FM signals, thereby determining the FM capture ratio.

(4) Limit the amplitude of noise pulses in the case of AM and SSB signals.

These tasks must be performed without destroying the noise figure set by the receiver's front end and without introducing distortion products within the desired passband.

For the majority of receivers, a total gain of at least 20 dB will exist in the RF and mixer stages, so the IF noise figure is usually not significant. For the few cases where no RF stage is used and the mixer operates with a conversion loss, the IF noise figure will be very important. Any losses in the IF filters ahead of the amplifying stages must be considered; for if an RF gain of 15 dB, a mixer loss of 6 dB, and an IF filter loss of 9 dB occur, the IF signal level will be right back to where it was at the antenna terminals. The IF noise figure would then be very important.

Attention to noise figure itself is not sufficient, as the total noise bandwidth must also be considered. One part of this has already been pointed out; the image frequency from the mixer will add thermal noise in addition to the possibility of interfering signals. The total noise bandwidth could then be twice as wide as the IF filter bandwidth. The other noise problem can occur whenever separate filters and amplifiers are used.

As shown in Fig.1.5, there is no filtering after the integrated circuit used for the gain. The total noise output to the detector would then be the narrow-band noise through the IF filter from the RF amplifier and mixer plus the broadband 10 or 20 MHz generated within the IC. Some additional noise bandwidth filtering should therefore be provided between the IC and the detector.

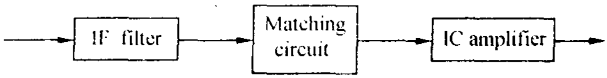


Fig. 1.5 IF amplifier with a packaged filter and integrated-circuit amplifier

Distortion must also be considered. Since the IF amplifiers must be capable of automatic gain control, they must have a square-law or second-order transfer characteristic (V_{out}/V_{in}). Gain can then be changed by varying the amplifier's bias. As long as the second-order characteristic is maintained, no distortion will occur, assuming that the IF filters are relatively narrow band, less than 1 octave. All harmonics and intermodulation products will then fall outside the passband, so the amplifier will appear linear. But if any odd-order distortion is present, undesirable in-band mixing products and compression will appear. This type of distortion can obviously occur in the bipolar transistors normally used for the IF amplifiers, and the amount can be controlled through careful biasing and selection of the transistors used. It can also occur in some not-so-obvious components. Any quartz, ceramic, or mechanical filters involve physical movement of their internal elements and there will be symmetrical limits to this linear motion. The filters themselves can therefore be a source of distortion, particularly if the applied signal level is too high. Ferrite materials commonly used in filters can also be a source of nonlinearities. For very demanding applications, then, each component of the receiver must be carefully analyzed for its contribution to the final performance of the receiver.

New words and phrases

bias	*n*.	偏置
bulk	*n*.	大多数