



# Technical English



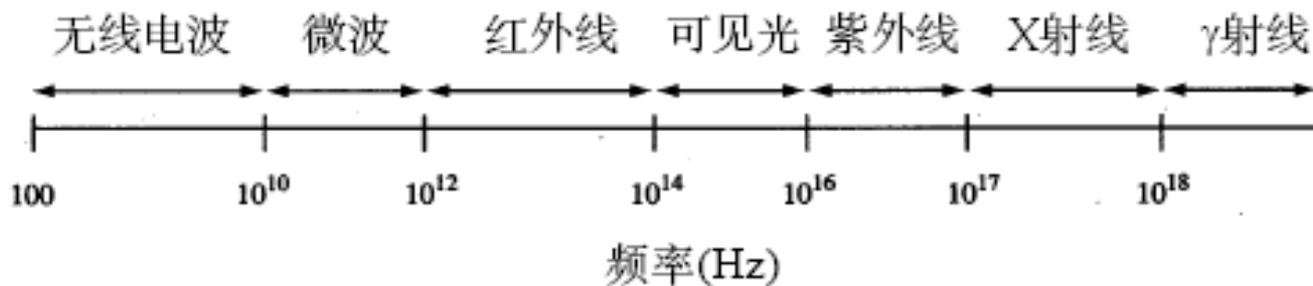
## Unit 13

# What Are Microwaves?



# 概述

## ■ 电磁频谱



$$\lambda = \frac{c}{f}$$

- 微波频率、波长
- 微波的典型特性
- 微波的应用



portion	部分
originate	起源于
power generation	产生功率，发电
amplification	放大
phase difference	相位差
interconnection	互联
negligible	可忽略的
adequate	足够的
electromagnetic	电磁的
amplitude	振幅，幅度
incident	入射的
reflected	反射的
impedance	阻抗
lumped component	集总元件
capacitor	电容器



resistor	电阻器
inductor	电感器
transmission line	传输线
transformer	变压器，变换器
constitute	组成，构成
resonator	谐振器
microelectronics	微电子学
discontinuity	不连续性
vacuum tube	真空管
triode	三极管
transit time	过渡时间，渡越时间
carrier	载流子
innovation	改良，改革
klystron	速调管
magnetron	磁控管



avalanche	雪崩
accommodate	容纳
antenna	天线
directivity	指向性
diameter	直径
metallic	金属的
velocity	速度
missile	导弹
absorb	吸收
dock	靠码头，靠岸
molecular	分子的
periodic	周期性的
emission	发射，发出
reciprocal	反的，逆的，倒的
ferrite	铁的，铁磁的



频谱范围大约从1GHz到30GHz  
的电磁波

**‘Microwaves’ is a descriptive term used to identify electromagnetic waves in the frequency spectrum ranging approximately from 1 Giga Hertz ( $10^9$  Hertz) to 30 Giga Hertz. This corresponds to wavelengths from 30 cm to 1 cm. Higher frequencies (extending up to 600 GHz) are also called “microwaves”. These waves present several interesting and unusual features not found in other portions of the electromagnetic frequency spectrum. These features make “microwaves” uniquely suitable for several useful applications.**



与通常使用的元器件的大小相比

## Characteristic Features of Microwaves

The main characteristic features of microwaves originate from the small size of wavelengths (1 cm to 30 cm) **in relation to the sizes of components or devices commonly used**. Since the wavelengths are small, **the phase varies rapidly with distance**; consequently the techniques **of** circuit analysis and design, **of** measurements and **of** power generation and amplification at these frequencies are distinct from those at lower frequencies.

相位随着距离快速变化



不同元件之间的互连或者单个元件的不同部分引起的相位差是不可忽略的

For dealing with these small wavelengths, methods of circuit representation and analysis need to be modified. **The phase difference caused by the interconnection between various components or various parts of a single component is not negligible.** Consequently, **analysis based on Kirchhoff's laws and voltage current concepts are not adequate to describe the circuit behavior at microwave frequencies.**

基于基尔霍夫定律的分析



## 用与微波关联的电磁场的方法

**It is necessary to analyze the circuit or the component in terms of electric and magnetic fields associated with it. For this reason microwave engineering is also known as electromagnetic engineering or applied electromagnetics. A background of electromagnetic theory is a prerequisite for understanding microwaves.**



根据场幅度、相位差和波携带的功率

Not only analytical techniques, the methods of measurement also become specialized at microwave frequencies.

Measurements are carried out **in terms of field amplitudes, phase differences and powers carried by the waves.** A very commonly used method of microwave measurements is based on the study of **a standing wave pattern formed along the line because of the interference of incident and reflected waves.**

因为入射波和反射波的干涉而沿传输线方向形成的驻波图



**Ratio of the amplitudes and phase relationship** between incident and reflected waves tell us about **impedance characteristics** of the components causing the reflection. Several other special techniques have been developed for use at microwave frequencies.

阻抗特性



集总元件

Microwave circuit components also have a different look. Use of **lumped elements** at microwave frequencies becomes difficult because of small wavelengths involved. For realizing the lumped behavior of a capacitor, an inductor or a resistor, the component size must be much smaller than the wavelength. Because of this reason microwave systems employ **distributed circuit elements** very often.

分布式的电路元件



## 小段的传输线和波导

These elements are made up of **small sections of transmission lines and waveguides**. For example, a quarter wavelength section of a transmission line is used as an impedance transformer. A half wavelength section, on the other hand, constitutes a **resonant circuit** to be used in place of an L-C resonator. Use of miniature lumped elements at microwave frequencies has been made possible by the advancement in microelectronics technology during the last ten years.

谐振电路



制作比微波的短波长更小的大约1mm或2mm大小的电感、电容和电阻

**These techniques allow us to fabricate inductors, capacitors and resistors that are about a millimeter or two in size; much smaller than small wavelengths at microwave frequencies.**

**Another aspect unique to microwave circuits is the possibility of radiation from discontinuities in distributed circuits. This necessitates a more careful and accurate circuit design.**



真空管

The challenge of generation of microwaves has resulted in a variety of devices — both in **vacuum tube** and in semiconductor device areas. When an attempt is made to use a lower frequency source (**triode or transistor**) at microwave frequencies, the operation is limited by the fact that **transit time of the carriers through the device** (i.e., electrons in triodes and electrons or holes in transistors) **becomes comparable to the time period of the wave.**

真空三极管或  
半导体三极管

载流子穿过器件的渡越时间  
和波的时间周期是相当的



**This problem has been solved by technological innovations (in case of transistors) and by totally novel ideas (as in case of klystrons, magnetrons, transferred electron devices and avalanche diodes).**

**速调管，磁控管，转移电子器件和雪崩二极管**



## Applications of Microwaves

Study and research in microwaves has not only been an interesting and challenging academic endeavor, it has led to several useful applications in communications, in radar, in physical research, in medicine and in industrial measurements and also for **heating and drying of agricultural and food products.**

农产品和食品的加热和干燥



在3GHz上10%的带宽意味着可  
得到300MHz频谱

A significant advantage associated with the use of microwaves for communications is their large bandwidth. **A ten percent bandwidth at 3 GHz implies availability of 300 MHz spectrum.** This means **all the radio, television and other communications that are transmitted in the frequency spectrum from DC to 300MHz can be accommodated in a 10% bandwidth around 3 GHz (say from 2850 to 3150 MHz).**

在3GHz周围的10%的频带内能容纳从直流到300MHz频谱中所有传输的无线电（广播）、电视和其他通信



无线电频谱的较低频率  
部分日益拥挤

Since **the lower frequency part of the radio spectrum is getting crowded**, there is a trend to use more and more of **microwave region (and beyond) for various different services**. Presently, **microwave communications are widely used for telephone networks, in broadcast and television systems and in several other communication applications by services, railways, etc.**



## 天线孔径与发射信号的波长之比

Short wavelengths also simplify the design and installation of high directivity antennae. Antenna directivity depends on **the ratio of antenna aperture to the wavelength of the signal to be transmitted**. At 10 GHz, **a pencil beam with 1° beamwidth** can be obtained by using a 6.9 feet diameter antenna. At 10 MHz, this will require an antenna diameter of 6,900 feet. This becomes impractical, especially if it is desired to rotate the antenna so that the beam can look in various directions.

1°波速宽度的电子束



在其它手段不能使用的距离和情况下  
检测飞机（或其它目标）的出现

Small antenna size and the property of reflection of microwaves from metallic surfaces make it practical to operate radar systems at these frequencies. Radar is an electronic method of **detecting the presence of aircraft (or other objects) at ranges and in circumstances where other means of detection are not possible.** Operation of the radar is based on the measurement of the time **it takes for a pulse transmitted from an antenna to get reflected by the object to be detected and to return at the antenna and the receiver.**

由天线发射的脉冲被要检测的目标反射，又回到天线和接收机所花的时间



## 由多普勒效应引起的反射信号频率的漂移

Also, in many radar systems, a shift in the frequency of reflected signal caused by the Doppler effect can be recorded. Velocity of the target can be calculated from this measurement. The reflection from the object to be measured is significant only when the wavelength is much smaller than the size of the object. For this reason, the radar could not become practicable at lower frequency and had to wait for the development of microwave technology during the Second World War period.



Today, radars constitute about 70% of microwave equipment. There are a whole variety of radars: **early-warning radar, missile-tracking radar, missile-guidance radar, fire-control radar, weather-detection radar, air-traffic control radar** and even radars to detect and control the speed of automobiles.

预警雷达，导弹跟踪雷达，导弹制导雷达，火炮控制雷达，气象检测雷达，空中交通控制雷达



电离层不反射，实际上也不吸收这些微波

There are other advantages associated with the small wavelengths at microwave frequencies. Unlike lower radio frequencies, **these waves are not reflected and practically not absorbed by the ionosphere.** This has led radio astronomers to use these frequencies to study electromagnetic radiations originating from stars and other astronomical objects. Also, this property makes microwaves suitable for space communication and satellite communication.

这已经使得射电天文学家使用这些频率去研究由星体和其它天体产生的电磁辐射



脉宽非常小的脉冲

Microwave techniques are now being introduced in extremely fast computer operations. **Pulses with very small widths** are used in high-speed logic circuits. When the pulse width lies in the sub-nanosecond range, the major portion of the pulse spectrum is in the microwave region. Thus microwave techniques are useful in transmission and handling of these pulses. **These sub-nanosecond pulses are also useful in several special purpose radars for docking the pre-collision sensing etc.**

在一些用于避碰检测的专用雷达中，亚毫秒脉冲也是有用的（dock: 靠码头，进港）



当把分子的、原子的和原子核的系统放在周期性的电磁场中，它们显示出各种谐振现象

**Microwaves exhibit another interesting feature. Molecular, atomic, and nuclear systems display various resonance phenomena when placed in periodic electromagnetic fields. Several of these resonance absorption lines lie in the microwave frequency range. The resonance absorption is due to rotational transitions in the molecules and the absorption spectra provide information on the molecular structure and intramolecular energies.**

谐振吸收是由于分子中的旋转跃迁



Thus microwaves become a very powerful experimental tool for the study of some of the basic properties of materials. Besides scientific research, absorption of microwaves by molecular resonances is well suited for various industrial measurements. It can be used to measure **the concentration of different gases**, e.g., **in an exhaust chimney in order to control the emission of pollutants**, or in chemical processes in order to record continuously the concentration of gases evolved in the process.

不同气体的浓度

在排气烟囱中为了控制污染物的散发



采用铁氧体的不可逆器件 和称为  
脉泽的固态微波放大器和振荡器

The study of microwave resonances in molecules has led to several useful devices. The most significant ones are **the non-reciprocal devices employing ferrites and solid-state microwave amplifiers and oscillators called masers.** **The magnetic properties of microwave ferrites are due to the electron spins in solids.**

**maser: microwave amplification by stimulated emission of radiation**

微波铁氧体的磁特性是由于  
固体中的电子自旋



**The coupling between spins is such as to divide the magnetic atoms into groups having oppositely oriented magnetic dipoles.**

**When placed in an external static magnetic field these materials exhibit non-reciprocal behavior at microwave frequencies.**

自旋间的耦合把磁原子分成相对面向的磁偶极子群



顺磁的

The maser is a microwave amplifier or oscillator which employs, as its working substance, a paramagnetic material having a suitable set of electron-spin energy levels separated by energy intervals that correspond to the frequencies in the microwave range.

它采用具有一系列合适的电子自旋能级的顺磁材料作为它的工作物质，而电子自旋能级是由对应于微波段频率的能量间隔来划分的



从高能态到低能态的受激  
跃迁导致辐射

**Stimulated transition from a higher energy state to a lower state results in radiation at microwave frequencies. Masers have lower noise figure than any other type of amplifier known and are used in the communication systems where extremely low noise characteristics are desired.**

噪声系数



用于烹饪的微波炉遵循  
电介质加热原理

Just like any other form of energy, microwave energy can also be used for heating. Thermal effects produced by microwaves have a variety of industrial applications. **Microwave ovens for cooking follow the principle of dielectric heating.** Cooking is done very quickly and uniformly by microwaves since the food is cooked by the waves on the inside at the same time as on the outside.



象通过传导、对流和辐射的  
热传导一样

**Like transfer of heat by conduction, convection and radiation, microwave heating can be considered as another mode of heat transfer. In this mode, heat is produced directly at the locations of the dielectric losses. Water has higher dielectric loss than the other ingredients in food products.**

在电介质损耗的地方直接  
产生热能



水囊首先被加热，对烹饪目的而言，这正是需要加热的地方

Thus water pockets get heated first which is exactly where heat is required for cooking purposes. Microwave diathermy machines produce heat inside the muscles without heating the tissues and skin outside. Also, microwave drying machines are used in printing, textile, and paper industries.

**diathermy:**  
透热疗法

微波透热疗法机在肌肉内产生热量而不加热外面的组织和皮肤

## 结合课文的思考题



- **What are microwaves?**
- **What makes microwaves so different from EM waves in other sectors of the frequency spectrum?**
- **List some applications of microwaves.**





- There is common confusion due to the different meanings of the term “Media”, which can refer to communications industry such as the press, newspapers and television, or it can refer to the plurality of medium by which information is conveyed to and between humans.

媒体（Media）一词有不同含义而常引起混淆，它可以指传媒业例如出版、报纸、电视，也可以是向人们传递信息或人们相互间传递信息的媒介（medium）一词的复数。



- **In this latter case the information is conveyed by text, sounds and vision, touch and smell. The computer has made it possible to handle several of these medium simultaneously, in particular those which can be digitized easily.**

在后一种情况下信息通过文本、声音和视觉、触觉和嗅觉来传递。计算机使得同时处理多种媒体成为可能，特别是容易数字化的那些媒体。



- Documents can be scanned or typed into electronic formats which can be handled in sophisticated ways, altering the layout, font styles and sizes etc. with ease. These documents can include pictorial and graphic information.

文件可以用扫描或键入方式变为电子格式，这种格式可用复杂的方式来处理，方便地改变版面、字体和大小等。文件中可以包括照片和图形信息。



- **Pictures and graphics can be digitized and handled either as bitmaps or as vector drawings. The JPEG standards exist for bitmap images. Animations can also be produced to support text information.**

照片和图形可用位图或向量形式来处理。JPEG标准用于位图。还可以生成动画来（支持）加强文本信息。



- **Visual information is very flexible and if the time factor is taken into account moving images can be handled as well as still pictures. Much recent research has been carried out into the handling of moving images, and when this information is synchronized with digitized audio information video is available.**

视觉信息十分灵活，如果考虑时间因素就可以处理活动图像也可以处理静止图像。许多近期工作致力于研究活动图像，当这种信息与数字音频信息同步时就是视频。



- This technology is covered by a number of MPEG standards, some hybrids such as Motion-JPEG and the H.26X standards used in video-conferencing.

视频技术由多种MPEG标准、一些混合技术如活动JPEG、以及用于视频会议的H.26X标准所覆盖。



- **The System-on-Chip (SoC) technology is the next step in the evolution of computer science. Unlike a big chip stuffed mainly with random (glue) logic, SoC is designed as a programmable platform that integrates most of the functions of the end product in a single chip.**

片上系统（SoC）技术是计算机科学的下一步进展。不同于一个充塞随机逻辑的大芯片，SoC被设计成一个可编程平台，在一块芯片上集成了最终产品的大部分功能。



- **It incorporates at least one processing element (microprocessor, DSP, etc.) that runs the system's embedded software. SoC includes peripherals, random logic and interfaces to the outside world and employs a bus-based architecture. It may contain both memory and analog functions.**

它至少包含一个处理单元（微处理器、**DSP**等），运行系统的嵌入软件。**SoC**包括外围设备、随机逻辑、与外界的接口，并使用基于总线的结构。它可能包含存储器和模拟功能。



- **The ability to produce SoCs is a result of new manufacturing techniques that are capable of producing ever-smaller transistors and putting more of them on a single chip — Moore’s Law in action — and the development of new tools that make it possible to automate the design and verification of such complex devices.**

生产SoC的能力是新型制造技术的结果，这种制造技术能生产出愈来愈小的晶体管并将更多的晶体管放进单个芯片（Moore定律的实现）；生产SoC的能力也是新工具开发的结果，这些新工具使得自动设计和验证如此复杂的器件成为可能。



- **It has now become possible to create complex electronic systems that are very small and portable, use very little power and are very reliable. Miniature cell phones and digital cameras are good examples.**

现在已经可以造出尺寸很小而且可移动（移植）、功率极低、非常可靠的复杂电子系统。小型蜂窝式电话和数字照相机就是很好的例子。



- **Thus far, SoCs have been used almost exclusively in high volume consumer applications, since they are the ones that have the armies of engineers and can afford the burden of time, cost and risk involved in the traditional development of SoC based systems.**

迄今为止SoC几乎无一例外地用于大批量消费产品中，因为正是这些应用领域才拥有大量的工程师，并能承受基于SoC系统传统开发中的时间、成本和风险负担。



- **The public telephone network, which, it should be remembered, is based mostly upon outdated technology, is currently being pressed for a tremendous expansion both in capacity and in the facilities provided.**

公众电话网目前正受到压力要在容量和所提供的功能方面有一个巨大的扩展，而应当记住，这一电话网大部分是建立在过时的技术基础上的。



- **Operation of the radar is based on the measurement of the time it takes for a pulse transmitted from an antenna to get reflected by the object to be detected and to return at the antenna and the receiver.**

雷达的工作是基于对天线发出的脉冲被所要探测的目标反射，（然后）回到天线和接收机所需时间的测量。



- **During an experiment in December 1947, two closely spaced gold-wire probes were pressed into the surface of a germanium crystal. It was found that the voltage output at the collector probe with respect to the base was greater than the input to the emitter probe. It was immediately recognized that this was the effect to be looked for; and the solid-state amplifier was born. These first transistors, however, were very noisy and unreliable due to the metallic point contacts.**

在1947年12月的一次实验中，两个十分接近的金丝探针被压入一片锗晶体表面。人们发现在集电极探针上相对于基片的输出电压大于加在发射极上的输入电压，立刻意识到这正是寻求的效应。固体放大器就此诞生。但由于金属接点的关系，这些第一批晶体管噪声很大，也不可靠。



- At the present, state of the art microwave amplifiers and oscillator tubes can operate in a frequency range up to 40GHz and solid-state microwave devices up to 100GHz.
  - A. recent and most advanced
  - B. high tech related
  - C. sophisticated
  - D. artistically manufactured

# Exercises



- **If you are unable to separate man from machine then, Turing says, we will have to attribute intelligence to the computer.**
  - **A. to make an intelligent computer**
  - **B. to consider the computer as being intelligent**
  - **C. to contribute to the computer with intelligence**
  - **D. to let the computer have intelligence**



- **As DoD urgently wanted military command and control networks that could survive a nuclear war, ARPA was charged with inventing a technology that could get data to its destination reliably even if arbitrary part of the network disappeared as a result of a nuclear attack.**
  - **DoD urgently needed networks of military command and control that would not be crippled in a nuclear war**
  - **DoD urgently needed both the military command and the control networks that could save a nuclear war**
  - **DoD desperately wanted the ability of commanding and controlling the networks in case of a nuclear war**
  - **DoD eagerly wanted to make military command, and to control the network so that they could keep working in a nuclear war**