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Radio engineering and radio systems

Методические указания для студентов специальности 5B071900

Алматы, 2014

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Данные методические указания предназначены для развития умений чтения и перевода технических текстов в области радиотехники и связи. Методические указания включают в себя аутентичный текстовый материал технического характера с упражнениями и заданиями для усвоения лексико-грамматических конструкций и терминов по данной специальности. Содержательная сторона методических указаний современна, актуальна и соответствует тематике изучаемой дисциплины.

Материал может найти применение, как на аудиторных занятиях, так и в практике самостоятельной работы с целью формирования иноязычной профессиональной компетенции студентов – бакалавров специальности 5В071900.

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Unit 1 Radio engineering systems

1. Memorize the words:

To travel – распространяться
transmitting range – дальность передачи
a receiver – приемник
a transmitter – передатчик
a high-frequency oscillator – высокочастотный генератор колебаний
an oscillatory circuit – колебательный контур
a capacitor – конденсатор
an amplifier – усилитель
a detector – детектор, следящий механизм
a rectifier – выпрямитель, детонатор
the audio frequency – звуковая частота
to couple together – соединять, спаривать
by means of a switch – с помощью переключателя (коммутатора)
means of communication – средства связи
telegraph sending key – телеграфный ключ
dots and dashes – точки и тире
the mirror galvanometer – зеркальный гальванометр
powdered carbon – порошковый углерод
a far sensitive receiver – гораздо более чувствительный приемник
wireless communication – беспроводная связь
a transmitting / receiving coil – передающая / приемная катушка

2. Read the text and explain the operation principle of radio communication:

Radio communication

Radio communication is the transmission of high frequency energy from the transmitter to the receiver without wires. Radio is a device that transmits and receives signals and programs by electromagnetic waves. Since the process of radio communication includes transmission and reception of signals, the two necessary components of radio are a transmitter and a receiver.

The first component of radio, *the transmitter,* is a device producing radio-frequency energy. The transmitter consists of a high-frequency oscillator including an oscillatory circuit (a coil and a capacitor) and one or more amplifiers. Electric oscillations are produced in the antenna of the transmitter. They travel in all directions. Electron lamps are used to amplify currents and give greater transmitting range and better reception.

Radio waves are electric waves of very high frequency; they travel through space at a speed of light, and differ from other wave forms only n frequency (number of vibrations per second).

The second important component of radio communication is *the receiver,* a device that receives waves sent out by a transmitter. Radio receiver demodulates these waves, and they are heard as speech, music or signals. To understand this process let us consider the principle of operation of these devices.

A microphone is connected to the circuit of the transmitting antenna. When we speak into the microphone its resistance varies with the audio frequency. An alternating current is established in the microphone and antenna circuits, and its frequency is the same as the audio frequency. Oscillations of the same frequency are induced in the antenna and the oscillatory circuit of a receiver. These oscillations are in fact a high-frequency current. In order to reproduce the transmitted sound, this current modulated by audio frequency should be sent through the telephone, and a detector or rectifier should be connected to the telephone circuit. The audio frequency rectified current passes through the telephone and produces oscillations. These oscillations will reproduce the sounds produced at the transmitting station. The operation of a radio set will be the better, the more energy is received by its oscillatory circuit. The oscillatory circuit is also provided with a ground. It is important for god operation of the receiver. The antenna should be grounded by means of a switch.

Internet radio, also known as web radio or net radio is an audio broadcasting service transmitted via the Internet. Internet radio services are usually accessible from anywhere in the world. This makes it popular among listeners with interests that are not adequately served by local radio stations. Internet radio services offer news, sorts, talk and various genres of music – everything that is available on traditional radio stations.

3. *Look through the text and answer the questions:*

1. What is radio communication? 2. What are the main components of radio? 3. What is a transmitter? 4. What does it consist of? 5. What is used for amplifying currents? 6. What happens in the microphone when we speak into it? 7. What kind of current is established in the microphone and antennas circuit? 8. What device should be connected to the circuit in order to reproduce the transmitted sounds? 9. By what means is the antenna grounded? 10. How are transmitted sounds reproduced in the receiver?

4. *Find out synonyms between:*

Nouns: specialist; improvement; traffic; dot; instrument; speed; transport; operation; expert; wire; point; conversation; invention; wireless; communication; tool; state; link; power; connection; perfection; possibility; prize; oscillations; bonus; capacitors; vibrations; energy; radio; feasibility; country; rate; work; conductor; discovery; speech; condenser; device.

Verbs: to provide; to produce; to establish; to demonstrate; to induce; to amplify; to involve; to build; to improve; to receive; to lay; to link; to continue; to invent; to use; to go on; to apply; to supply; to install; to intensify; to construct; to perfect; to connect; to put; to get; to advance; to include; to move forward; to excite; to show; to generate.

Adjectives: distant; fast; important; modern; several; wonderful; various; intelligible; simple; different; quick; some; far; primitive; understandable; remarkable; present-day; significant.

5. Read the text and tell about developed communication systems:

Communication systems development

Long ago men found it necessary to communicate at a distance. When the alphabet was invented, they began to use papyrus and something like the modern letter appeared. The first to send letter were the ancient Egyptians. A runner delivered them. However, the Romans organized the best *postal system* of ancient times.

From then on until the 19-th century, there were practically no advances in the means of communication. Even when Queen Victoria began to rule England in 1837, her means of communication with distant parts of her empire were no faster than those of Julius Caesar.

The first practical electromagnetic *telegraph* was invented by the Russian scientist *Pavel Shilling* in 1828, and in 1832 he established telegraph communication between the Winter Palace and the Ministry of Transport in St. Petersburg. Shilling's work was continued in Russia by *B. Yakobi,* who made several improvements in the electromagnetic telegraph and linked St. Petersburg with Tsarskoye Selo. This 25 kilometer-line was the longest in the world at that time. Yakobi invented the telegraph sending key, adopted by the American *Samuel Morse.* Morse, however, invented the telegraph code of dots and dashes, which is used all over the world to this day.

The first transatlantic telegraph cable from Europe to America was laid in 1858 due to the great British scientist Professor *William Thomson.* He also invented the mirror galvanometer, the very sensitive instrument used at first to receive signals transmitted over very long cables. Three letters could be transmitted per minute over the first transatlantic cable. The present speed of operation of telegraph cables reaches 2,500 letters per minute.

The telephone is a much younger invention than the telegraph. The French mechanic *Charles Boursel* first suggested the idea of transmitting speech electrically. The first telephone that found application was invented by the American *Graham Bell* in 1876. Russian inventors made several important improvements in the telephone. In 1879 the Russian engineer *Mikhalsky* made a microphone with powdered carbon, a prototype of the present-day microphone. Next year another Russian inventor, *Golubitsky* made a far sensitive receiver than the receiver of Bell. In 1880 the Russian military communication expert *G. Ignatyev* invented a device that made it possible to use the same wire simultaneously for a telephone conversation and for telegraph communication. Today the method of frequency modulation makes it possible to transmit several hundred telephone conversations over the same wire simultaneously.

The telegraph and the telephone were soon followed by an even more wonderful invention, which made possible communication without wires. Numerous scientists from different countries contributed to the appearance of *wireless communication. Heinrich Hertz,* constructed a primitive radio system capable of transmitting and receiving space waves through free space. In 1893, *Nikola Tesla,* in America, first demonstrated the feasibility of wireless communications. He proved that intelligible messages could be transmitted without wires and established a system which was composed of a transmitting coil (or conductor) and a receiving coil. At last, in 1895, the Russian scientist *A.S. Popov* demonstrated his first radio receiver. In March 1897 *G. Marconi,* an Italian inventor, transmitted wireless telegraphy signals over a distance of two miles and later he established the first transatlantic radio communication between Canada and England. For this achievement, he was awarded the Nobel Prize.

Early uses of communication were maritime for sending telegraphic messages using Morse code between ships and land. Radio was used to pass on orders and communications between armies and navies in World War I. Broadcasting became possible in the 1920s with the introduction of radio receivers in Europe and the U.S.A. Another use of radio was the development of detecting and locating aircraft and ships by the use of radar.

Today radio takes many forms, including wireless networks and mobile communications of all types, as well as radio broadcasting.

6. Look through the text. Answer the questions using the information from the text:

1. When and how did the first messages appear? 2. Where were the first letters delivered? 3. Who established the first telegraph and when? 4. Who continued and improved the achievements of P. Shilling? 5. What did B. Yacobi invent? 6. What is S. Morse famous for? 7. Who first suggested the idea of transmitting speech? 8. What Russian engineers perfected the idea of telephone conversation? 9. What scientists contributed to the development of wireless communication? 10. Who was awarded the Nobel Prize and what for?

7. Translate the following word combinations:

Postal system; from then on; to establish telegraph communication; communication system development; to make several improvements; the telegraph sending key; he telegraph code of dots and dashes; to lay the cable; due to; to invent the mirror galvanometer; at first; to transmit per minute; to reach the speed of operation; the idea of transmitting speech; to find application; powdered carbon; a far sensitive receiver; to use the same wire simultaneously ; the feasibility of wireless communications; intelligible messages; a transmitting coil; at last; a radio receiver; to be awarded the Nobel Prize; to pass on orders; radio broadcasting; to become feasible; detecting and locating aircrafts and ships.

8. Memorize the words:

Information Communication Technologies (ICT) – информационно-коммуникативные технологии
the source output – исходный вывод
a sequence of binary digits – последовательность двоичных цифр
a storage medium – запоминающая среда, носитель ЗУ
distinguishing characteristics – отличительные свойства
the theory of probability – теория вероятности
an encoder – кодирующее устройство, шифратор
a decoder – декодирующее устройство, дешифратор
level of performance – уровень пропускной способности
random processes – беспорядочные, случайные процессы
additive noise – аддитивный (дополнительный) шум
prescribed delay – заданная задержка
software applications – прикладное программное обеспечение
installing applications – установка (размещение) прикладных программ
data management – управление (работа с) данными
networking – объединение в сеть
engineering computer hardware – конструирование аппаратного обеспечения компьютера
manipulate – управлять; обращаться с; обрабатывать; преобразовывать
disseminate - распространять
stem (from) - происходить

9. Read the text and tell what the information communication technologies are:

Communication systems and information theory

Communication theory deals primarily with systems for transmitting information from one point to another. The source output might represent a voice waveform, a sequence of binary digits from a magnetic tape, he output of a set of sensors in a space probe, or a target in a radar system. The channel might represent a telephone line, a high frequency radio link, a space communication link, or a storage medium.

As it is known, in the early 1940's a mathematical theory for dealing more fundamental aspects of communication systems was developed. The distinguishing characteristics of this theory are, first, a great emphasis on the theory of probability and, second, a primary concern with the encoder and decoder, both in terms of their functional roles and in terms of their achieving a given level of performance. In the past 20 years, information theory has been made more precise, has been extended and brought to the point where it is being applied in practical communication systems.

Much of modern communication theory stems from works of communication systems as well as from desirability of modelling both signal and noise as random processes. N. Wiener was interested in finding the best linear filter to separate the signal from additive noise with a prescribed delay. His work had an important influence on subsequent research in modulation theory.

Information technology (IT) is the study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware. Information technology deals mainly with the use of electronic computers and computer software to convert, store, protect, process, transmit and securely retrieve information.

Today the term information technology includes many aspects of computing and technology and covers many fields. Information technology professionals perform a variety of duties that range from installing applications to designing complex computer networks and information databases. The duties of IT specialists may involve data management, networking, engineering computer hardware, database and software design, as well as the management and administration of the whole system. When computer and communication technologies are combined, the result is information technology, or “infotech”. Information technology describes any technology that helps to produce, manipulate, store, communicate and/or disseminate information.

Thus, Information Communication Technology (ICT) embraces all technologies for the communication of information. It includes any medium to record information (paper, pen, magnetic disc / tape, optical discs – CD / DVD, flash memory, etc.) and technology for broadcasting information – radio, television. It involves any technology for communicating through voice and sound or images – microphone, camera, loudspeaker, and telephone. At present it is apparently culminating to information communication with the help of Personal Computers (PCs) networked through the Internet, information technology that can transfer information using satellite system or intercontinental cables.

10. Revise the text and answer the questions:

1. What system does communication theory deal with? 2. When was the mathematical theory for communication systems developed? 3. What are the distinguishing features of the theory? 4. What does modern communication theory stem from? 5. What was Wienner’s contribution into the development of communication theory? 6. What is IT? 7. What does it deal with? 8. What jobs are IT experts engaged in? 9. What do you understand by “infotech”? 9. What technologies does ICT include?

11. Memorize the following word combinations:

Communication theory; primarily; the source output; a voice wave form; a sequence of binary digits; a set of sensors; a space probe; a high frequency radio link; a storage medium; distinguishing characteristics; a great emphasis on the theory of probability; a primary concern; encoder and decoder; in terms of; a given level of performance; to stem from; as well as; desirability; linear filter; additive noise; a prescribed delay; to have influence on subsequent research; implementation; support; management; particularly; software applications; computer hardware; to retrieve information securely; to cover many fields; perform a variety of duties; installing applications; to design complex computer networks and information databases; data management; networking; engineering computer hardware; database and software design; to disseminate information; to communicate through voice and sound or images; a loudspeaker; to network through the Internet.

12. Translate the following terms and word combinations into English:

Цифровая связь; технология организации дальней связи; методы управления; беспроводная связь; дополнительная информация; передача в режиме реального времени; заданная задержка; установка прикладных программ; сигнал от аддитивных шумов; набор датчиков; отличительные свойства; высокочастотная радиосвязь; теория вероятности; беспорядочные процессы; охватывать многие области; автоматизированные информационные системы; последовательность двоичных цифр; управлять; размещать прикладные программы; видеосвязь; уровень пропускной способности.

13. Read the text and translate it into Russian:

Radio waves

Radio waves are a type of electromagnetic radiation with wavelengths in the electromagnetic spectrum longer than infrared light. Radio waves have frequencies from 300 GHz to as low as 3 kHz, and corresponding wavelengths ranging from 1 millimeter (0.039 in) to 100 kilometers (62 mi). Like all other electromagnetic waves, they travel at the speed of light. Naturally, occurring radio waves are made by lightning, or by astronomical objects. Artificially generated radio waves are used for fixed and mobile radio communication, broadcasting, radar and other navigation systems, communication satellites, computer networks and innumerable other applications. Different frequencies of radio waves have different propagation characteristics in the Earth's atmosphere; long waves may cover a part of the Earth very consistently, shorter waves can reflect off the ionosphere and travel around the world, and much shorter wavelengths bend or reflect very little and travel on a line of sight.

To prevent interference between different users, the artificial generation and use of radio waves is strictly regulated by law, coordinated by an international body called the International Telecommunications Union (ITU). The radio spectrum is divided into a number of radio bands based on frequency, allocated to different uses.

Radio waves were first predicted by mathematical work done in 1867 by Scottish mathematical physicist James Clerk Maxwell. Maxwell noticed wavelike properties of light and similarities in electrical and magnetic observations. He then proposed equations that described light waves and radio waves as waves of electromagnetism that travel in space, radiated by a charged particle as it undergoes acceleration. In 1887, Heinrich Hertz demonstrated the reality of Maxwell's electromagnetic waves by experimentally generating radio waves in his laboratory. Many inventions followed, making the use of radio waves to transfer information through space. The study of electromagnetic phenomena such as reflection, refraction, polarization, diffraction, and absorption is of critical importance in the study of how radio waves move in free space and over the surface of the Earth. Different frequencies experience different combinations of these phenomena in the Earth's atmosphere, making certain radio bands more useful for specific purposes than others.

Radio waves travel at the speed of light in a vacuum. When passing through an object, they are slowed according to that object's permeability and permittivity. The wavelength is the distance from one peak of the wave's electric field to the next, and is inversely proportional to the frequency of the wave. The distance a radio wave travels in one second, in a vacuum, is 299,792,458 meters (983,571,056 ft) which is the wavelength of a 1-hertz radio signal. A 1-megahertz radio signal has a wavelength of 299.8 meters (984 ft).

In order to receive radio signals, for instance from AM/FM radio stations, a *radio antenna* must be used. However, since the antenna will pick up thousands of radio signals at a time, *a radio tuner* is necessary to *tune in* a particular signal. This is typically done via *a resonator* (in its simplest form, a circuit with *a capacitor* and *an inductor*). The resonator is configured to resonate at a particular frequency, allowing the tuner to amplify sine waves at that radio frequency and ignore other sine waves. Usually, either the inductor or the capacitor of the resonator is adjustable, allowing the user to change the frequency at which it resonates. The etymology of "radio" or "radiotelegraphy" reveals that it was called "wireless telegraphy", which was shortened to "wireless" in Britain. The prefix *radio-* in the sense of wireless transmission was first recorded in the word *radio conductor*, a description provided by the French physicist Edouard Branly in 1897. It is based on the verb *to radiate* (in Latin "radius" means "spoke of a wheel, beam of light, ray").

The word "radio" also appears in a 1907 article by Lee De Forest. It was adopted by the United States Navy in 1912, to distinguish radio from several other wireless communication technologies, such as the photo phone. The term became common by the time of the first commercial broadcasts in the United States in the 1920s. (The noun "broadcasting" itself came from an agricultural term, meaning "scattering seeds widely.") The term was adopted by other languages in Europe and Asia. British Commonwealth countries continued to use commonly the term "wireless" until the mid-20th century, though the magazine of the BBC in the UK has been called Radio Times ever since it was first published in the early 1920s.

In recent years, the more general term "wireless" has gained renewed popularity through the rapid growth of short-range computer networking, e.g., Wireless Local Area Network (WLAN), Wi-Fi, and Bluetooth, as well as mobile telephony, e.g., GSM and UMTS. Today, the term "radio" specifies the actual type of transceiver device or chip, whereas "wireless" refers to the lack of physical connections; one talks about *radio* transceivers, but other talks about *wireless* devices and *wireless* sensor networks.

14. Translate the verbs and their derivatives:

To communicate – communication; communicative; uncommunicative; communicator.

To transmit – transmitter; transmission; transmitted; transmissible; transmitting (coil).

To receive – receiver; reception; receptive; receptivity; receiving (coil).

To follow – follower; following.

To contribute – contribution; contributor; contributory.

To invent – inventor; invention; invented.

To implement – implementation; implemented.

To retrieve – retrieval; retrievable; irretrievable.

To improve – improvement; improver; improved; unimproved; improvable; unimprovable.

To appear – to disappear; appearance; disappearance.

To establish – to disestablish; established; establishment.

To predict – predicted; prediction; predictor.

To address – addressability; addressable; addressee; addressing; addressless; addressness.

Sequence – sequent; sequential; sequencer; consequently.

Function – functional; functionality; functionally/

15. Read the texts, study basic types of modulation and speak of them:

Basic types of modulation

Today vast amounts of information are communicated using radio communications systems. Both analogue radio communications systems and digital or data radio communications links are used.

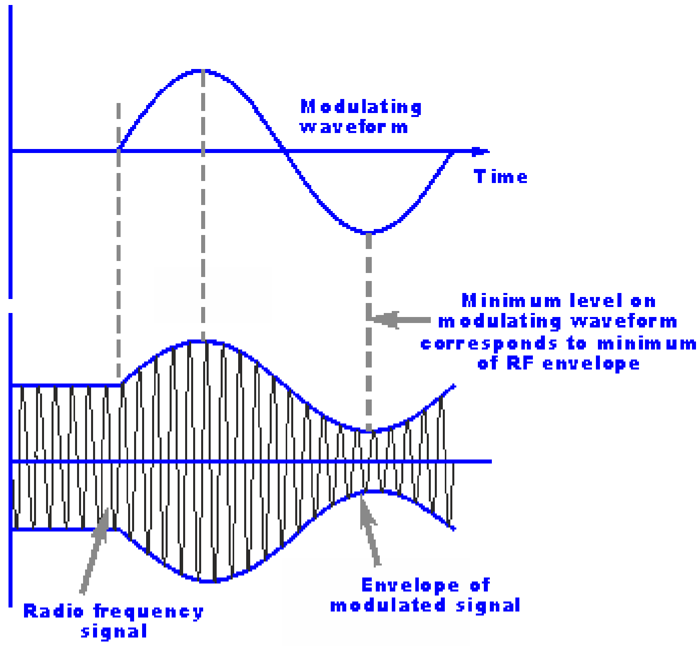
However, one of the fundamental aspects of any radio communications transmission system is *modulation*, or the way in which the information is superimposed on the radio carrier.

In order that a steady radio signal or "radio carrier" can carry information, it must be changed or modulated in one way so that the information can be conveyed from one place to another.

There are very many ways in which a radio carrier can be modulated to carry a signal, each having its own advantages and disadvantages. The choice of modulation have a great impact on the radio communications system. Some forms are better suited to one kind of traffic whereas other forms of modulation will be more applicable in other instances. Choosing the correct form of modulation is a key decision in any radio communications system design.

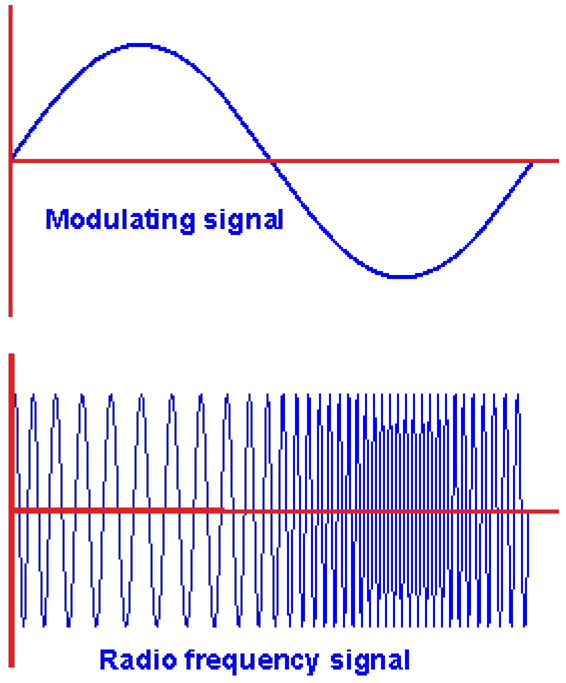
There are three main ways in which a radio communications or RF signal can be modulated:

- *Amplitude modulation, AM:* as the name implies, this form of modulation involves modulating the amplitude or intensity of the signal.



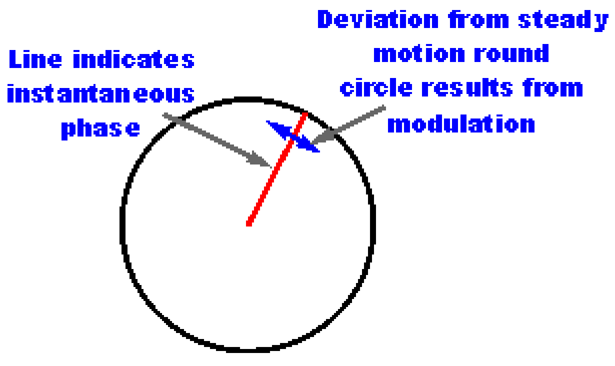
Amplitude modulation was the first form of modulation to be used to broadcast sound, and although other forms of modulation are being increasingly used, amplitude modulation is still in widespread use.

- *Frequency modulation, FM:* this form of modulation varies the frequency in line with the modulating signal.



Frequency modulation has the advantage that, as amplitude variations do not carry any information on the signal, it can be limited within the receiver to remove signal strength variations and noise. As a result, this form of modulation has been used for many applications including high quality analogue sound broadcasting.

- *Phase modulation, PM:* as the name indicates, phase modulation varies the phase of the carrier in line with the modulating signal.



Phase modulation and frequency modulation have many similarities and are linked - one is the differential of the other. However, phase modulation lends itself to data transmissions, and as a result, its use has grown rapidly over recent years.

Each type of modulation has its own advantages and disadvantages, and accordingly they are all used in different radio communications applications.

In addition to the three main basic forms of modulation or modulation techniques, there are many variants of each type. Again, these modulation techniques are used in a variety of applications, some for analogue applications, and others for digital applications.

Angle Modulation

Angle modulation is a name given to forms of modulation that are based on altering the angle or phase of a sinusoidal carrier. Using angle modulation there is no change in the amplitude of the carrier.

The two forms of modulation that fall into the angle modulation category are frequency modulation and phase modulation.

Both types of angle modulation, namely, frequency modulation and phase modulation are linked because frequency is the derivative of phase, i.e. frequency is the rate of change of phase.

Another way of looking at the link between the two types of modulation is that a frequency modulated signal can be generated by first integrating the modulating waveform and then using the result as the input to a phase modulator. Conversely, a phase modulated signal can be generated by first differentiating the modulating signal and then using the result as the input to a frequency modulator.

Signal bandwidth

One key element of any signal is the bandwidth it occupies. This is important because it defines the channel bandwidth required, and hence the number of channels that can be accommodated within a given segment of radio spectrum. With pressure on the radio spectrum increasing, the radio signal bandwidth is an important feature of any type of radio emission or transmission.

The bandwidth is governed by two major features:

- *The type of modulation:* Some forms of modulation use their bandwidth more effectively than others. Accordingly, where spectrum usage is of importance, this alone may dictate the choice of modulation.

- *The bandwidth of the modulating signal:* A law called Shannon's law determines the minimum bandwidth through which a signal can be transmitted. In general, the wider the bandwidth of the modulating signal, the wider the bandwidth required.

Modulating signal type

Apart from the form of modulation itself, the type of signal being used to modulate the carrier also has a bearing on the signal. Analogue and data are two very different forms of modulating signal and need to be treated differently. While different formats of actual modulation may be used, the type of signal being applied via the modulator also have a bearing on the signal.

Signals for high quality stereo broadcasting will be treated differently to signals that provide digital telemetry for example. As a result, it is often important to know the signal type that needs to be carried by the RF carrier.

By Ian Poole

Unit 2 Radio transmitters and receivers

1. Memorize the words:

carrier wave – несущая волна
sine - синус
refer – отсылать; направлять; справляться; упоминать
slight – тонкий; хрупкий; легкий; незначительный
power supply – источник энергии
to amplify – усиливать
omnidirectional – действующий по всем направлениям
transverse – поперечный
conversely – наоборот
to exert – осуществлять; оказывать
back and forth – назад и вперед

2. Read the text and speak about the principle of operation of a transmitter:

Radio transmitters

A radio transmitter consists of several elements that work together to generate radio waves that contain useful information such as audio, video, or digital data.

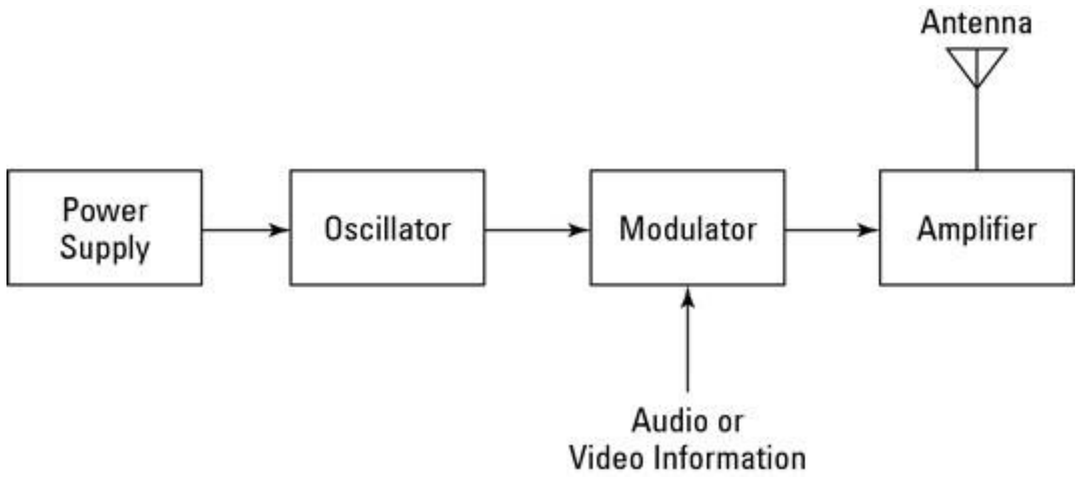
- *Power supply:* provides the necessary electrical power to operate the transmitter.

- *Oscillator:* creates alternating current at the frequency on which the transmitter will transmit. The oscillator usually generates a sine wave, which is referred to as a *carrier wave.*

- *Modulator:* adds useful information to the carrier wave. There are two main ways to add this information. The first, called amplitude modulation or AM, makes slight increases or decreases to the intensity of the carrier wave. The second, called frequency modulation or FM, makes slight increases or decreases to the frequency of the carrier wave.

- *Amplifier:* amplifies the modulated carrier wave to increase its power. The more powerful the amplifier, the more powerful the broadcast.

- *Antenna:* converts the amplified signal to radio waves.



3. *Read the text and define the role of antennas in radio communication:*

Radio antennas

An *antenna (or aerial)* is an electrical device that converts electric power into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. In transmission, a radio transmitter supplies an electric current oscillating at radio frequency (i.e. a high frequency alternating current (AC)) to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals, which is applied to a receiver to be amplified.

Antennas are essential components of all equipment that uses radio. They are used in systems such as radio broadcasting, broadcast television, two-way radio, communications receivers, radar, cell phones, and satellite communications, as well as other devices such as garage door openers, wireless microphones, Bluetooth-enabled devices, wireless computer networks, baby monitors, and RFID tags on merchandise.

Typically an antenna consists of an arrangement of metallic conductors (elements), electrically connected (often through a transmission line) to the receiver or transmitter. An oscillating current of electrons forced through the antenna by a transmitter will create an oscillating magnetic field around the antenna elements, while the charge of the electrons also creates an oscillating electric field along the elements. These time-varying fields radiate away from the antenna into space as a moving transverse electromagnetic field wave. Conversely, during reception, the oscillating electric and magnetic fields of an incoming radio wave exert force on the electrons in the antenna elements, causing them to move back and forth, creating oscillating currents in the antenna.

Antennas can be designed to transmit and receive radio waves in all horizontal directions equally (omnidirectional antennas), or preferentially in a particular direction (directional or high gain antennas). In the latter case, an antenna may also include additional elements or surfaces with no electrical connection to the transmitter or receiver, such as parasitic elements, parabolic reflectors or horns, which serve to direct the radio waves into a beam or other desired radiation pattern.

The first antennas were built in 1888 by German physicist Heinrich Hertz in his pioneering experiments to prove the existence of electromagnetic waves predicted by the theory of James Clerk Maxwell. Hertz placed dipole antennas at the focal point of parabolic reflectors for both transmitting and receiving.

4. Read the text and tell how radio receivers work:

Radio receivers

A radio receiver is the opposite of a radio transmitter. It uses an antenna to capture radio waves, processes those waves to extract only those waves that are vibrating at the desired frequency, extracts the audio signals that were added to those waves, amplifies the audio signals, and finally plays them on a speaker.

- *Antenna:* captures the radio waves. Typically, the antenna is simply a length of wire. When this wire is exposed to radio waves, the waves induce a very small alternating current in the antenna.

- *RF amplifier:* A sensitive amplifier that amplifies the very weak radio frequency (RF) signal from the antenna so that the signal can be processed by the tuner.

- *Tuner:* A circuit that can extract signals of a particular frequency from a mix of signals of different frequencies. On its own, the antenna captures radio waves of all frequencies and sends them to the RF amplifier, which dutifully amplifies them all.

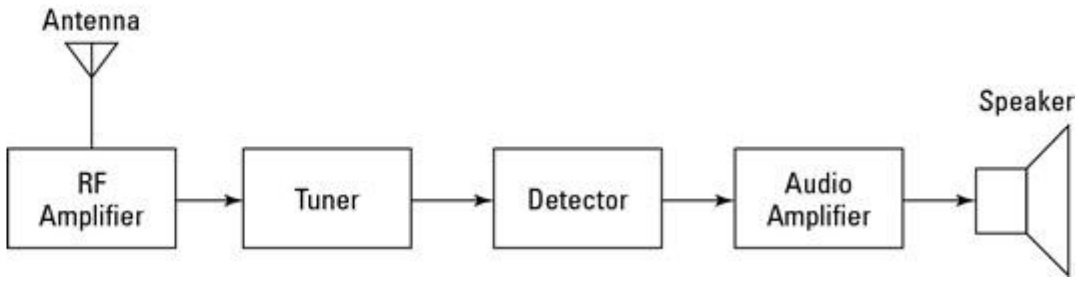
Unless you want to listen to every radio channel at the same time, you need a circuit that can pick out just the signals for the channel you want to hear. That’s the role of the tuner.

The tuner usually employs the combination of an inductor (for example, a coil) and a capacitor to form a circuit that resonates at a particular frequency. This frequency, called the *resonant frequency*, is determined by the values chosen for the coil and the capacitor. This type of circuit tends to block any AC signals at a frequency above or below the resonant frequency.

You can adjust the resonant frequency by varying the amount of inductance in the coil or the capacitance of the capacitor. In simple radio receiver circuits, the tuning is adjusted by varying the number of turns of wire in the coil. More sophisticated tuners use a variable capacitor (also called a *tuning capacitor*) to vary the frequency.

- *Detector:* Responsible for separating the audio information from the carrier wave. For AM signals, this can be done with a diode that just rectifies the alternating current signal. What is left after the diode has its way with the alternating current signal is a direct current signal that can be fed to an audio amplifier circuit. For FM signals, the detector circuit is a little more complicated.

- *Audio amplifier:* This component's job is to amplify the weak signal that comes from the detector so that it can be heard. This can be done using a simple transistor amplifier circuit.



Of course, there are many variations on this basic radio receiver design. Many receivers include additional filtering and tuning circuits to better lock on to the intended frequency — or to produce better-quality audio output — and exclude other signals. Still, these basic elements are found in most receiver circuits.

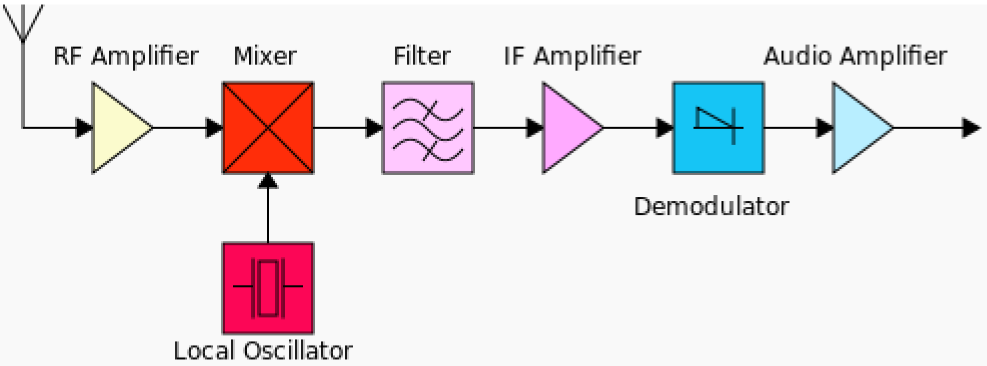
5. Read the text and tell about the design and principle of operation of a super heterodyne receiver. Use the bloc diagram:

Super heterodyne receiver

In electronics, a *super heterodyne receiver* (often shortened to *superhet)* uses frequency mixing to convert a received signal to a fixed intermediate frequency (IF) which can be more conveniently processed than the original radio carrier frequency. It was invented by US engineer Edwin Armstrong in 1918 during World War I. Virtually all modern radio receivers use the super heterodyne principle. At the cost of an extra frequency converter stage, the super heterodyne receiver provides superior selectivity and sensitivity compared with simpler designs.

Design and principle of operation

The principle of operation of the super heterodyne receiver depends on the use of heterodyning or frequency mixing. The signal from the antenna is filtered sufficiently at least to reject the *image frequency* and possibly amplified. A local oscillator in the receiver produces a sine wave, which mixes with that signal, shifting it to a specific intermediate frequency (IF), usually a lower frequency. The IF signal is itself filtered and amplified and possibly processed in additional ways. The demodulator uses the IF signal rather than the original radio frequency to recreate a copy of the original information (such as audio).



Block diagram of a typical super heterodyne receiver

The diagram at right shows the minimum requirements for a single-conversion super heterodyne receiver design. The following essential elements are common to all super heterodyne circuits: a receiving antenna; a tuned stage, which may optionally contain amplification (RF amplifier); a variable frequency local oscillator; a frequency mixer; a band pass filter and intermediate frequency (IF) amplifier; and a demodulator plus additional circuitry to amplify or process the original audio signal (or other transmitted information).

6. Write down the translation of these two texts and entitle them:

Text A

As it is known the history of radio transmitters dates back to 1895 when a great Russian scientist A. Popov transmitted the first radiogram. Since that time many Russian and foreign scientists contributed much to the theory of radio transmitting devices.

The function of the radio transmitter is to convert the electrical power received from a primary source into radio-frequency energy modulated with a signal for transmission by means of electromagnetic waves through space.

The radio transmitter consists of two principal components: the radio-frequency section and the audio-frequency one. The radio-frequency section produces radio-frequency power of continuous waves, the audio-frequency section being concerned with modulation of radio signals.

The parameters of the radio transmitter are output power, frequency stability, efficiency and modulation. Radio transmitters are classified into many different types. When classifying them according to the service for which they are used, radio transmitters may be of communication, broadcast, radar and other types. Taking into consideration the type of transmitting signals, specialists subdivide radio transmitters into telegraph, telephone and pulse transmitters. According to the power consumed transmitters are of low power, medium power and other types. At last, they may be of fixed and mobile types. To meet the requirements of high transmission quality of radio transmitters much is being done for improving radio transmitters' performance by developing new design of these devices.

Text B

As it is known, that Russian scientist V. Siforov worked out the theory of radio receiving devices. However, A. Popov invented and demonstrated the first radio receiving set. Since that time, radio devices have been improving and perfecting.

The receiver performs the function of converting the current in the receiving antenna into the intelligence contained in the transmission the man parameters of radio receivers are sensitivity, selectivity and fidelity. Sensitivity is a measure of the receiver's ability to receive weak signals, as it is known that the farther an electromagnetic wave travels, the weaker is its energy. Selectivity is the ability of the receiver to reject undesirable signals. Fidelity is a measure of the receiver's ability to reproduce clearly audio-frequency currents, which are in accordance with the modulation envelope of the received signals.

However simple the radio receiver may be, it includes an antenna, an input tuning circuit, a detector and a pair of earphones.

The principle of operation of the radio receiver is not very difficult to understand. The electromotive force is impressed upon the receiving antenna and produces a current; this current is a reproduction of the current of the transmitting antenna.

There are various types of receivers, communication and broadcast receivers being the principal types of them. Communication receivers are used in radiotelephone and telegraph service, broadcast receivers finding application for the reception of sound and visual programs. Wherever radio receivers were applied, they must meet an important requirement as reliability in operation.

7. Answer the following questions:

What is radio communication?

What are the main components of radio communication?

What does a transmitter consist of?

What is used for amplifying currents?

What happens in the microphone when we speak into it?

What are the advantages of Internet radio?

What new sciences could develop due to radio communication?

What are distinguishing features of mathematical theory dealing with communication system?

What does the modern communication theory stem from?

What was Wienner's contribution into the development of communication theory?

Unit 3 Basic principles of television

1. Memorize the words:

capability – способности, возможности
to override the effects - устранить эффекты
appropriate – соответствующий, подходящий
to distinguish – различать
loudness – громкость
pitch (of voice) – высота
to intersect – пересекать(ся); перекрещивать(ся)
to reflect – отражать(ся)
distortion – искажение
to diverge – отклоняться
to perceive – чувствовать; ощущать
to converge – сходиться; стремиться к пределу
regardless of – не считаясь с
to emanate – излучаться
a curved mirror – искривленное зеркало
likeness – сходство
a concave mirror – вогнутое зеркало
a plane mirror - плоское зеркало
to sight – наблюдать, видеть
a lens - линза
incidental – случайный, несущественный, побочный

2. Read the texts, translate them and speak about different techniques of image formation:

A television picture

Human perception of motion.

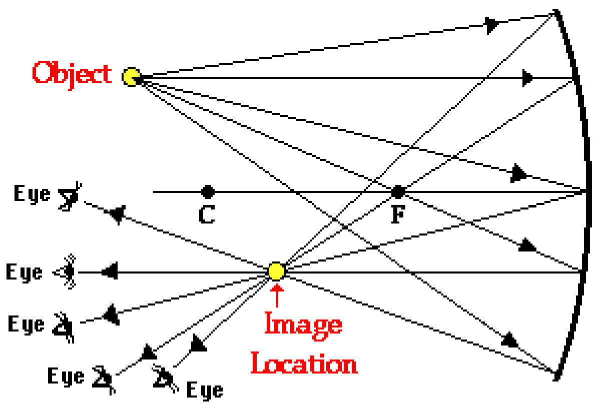
A television system involves equipment located at the source of production, equipment located in the home of the viewer, and equipment used to convey the television signal from the producer to the viewer. The purpose of all of this equipment is to extend the human senses of vision and hearing beyond their natural limits of physical distance. A television system must be designed, therefore, to embrace the essential capabilities of these senses, particularly the sense of vision. The aspects of vision that must be considered include the ability of the human eye to distinguish the brightness, colors, details, sizes, shapes, and positions of objects in a scene before it. Aspects of hearing include the ability of the ear to distinguish the pitch, loudness, and distribution of sounds. In working to satisfy these capabilities, television systems must strike appropriate compromises between the quality of the desired image and the costs of reproducing it. They must also be designed to override, within reasonable limits, the effects of interference and to minimize visual and audial distortions in the transmission and ... (200 of 21,814 words).

Plane mirror image formation

An image is formed by a plane mirror as light emanates from an object in a variety of directions. Some of this light reaches the mirror and reflects off the mirror according to the law of reflection. Each one of these rays of light can be extended backwards behind the mirror where they will all intersect at a point (the image point). Any person who is positioned along the line of one of these reflected rays can sight along the line and view the image - a representation of the object. Thus, *an image* location is a location in space where all the reflected light appears to come from. Since light from the object appears to diverge from this location, a person who sights along a line at this location will perceive a replica or likeness of the actual object. In the case of plane mirrors, the image is said to be a *virtual image*. Virtual images are images that are formed in locations where light does not actually reach. Light does not actually pass through the location on the other side of the plane mirror; it only appears to an observer as though the light were coming from this position.

Curved mirror image formation

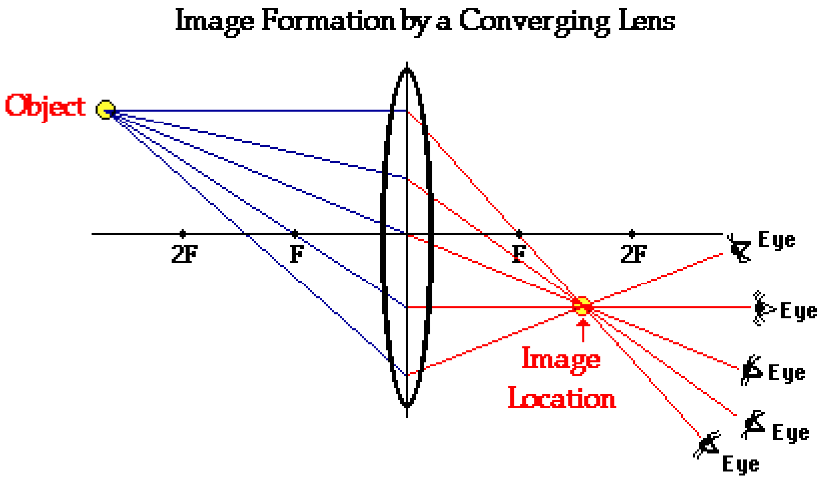
We have also seen how images are created by the reflection of light off curved mirrors. Suppose that a light bulb is placed in front of a concave mirror; the light bulb will emit light in a variety of directions, some of which will strike the mirror. Each individual ray of light will reflect according to the law of reflection. Upon reflecting, the light will converge at a point. At the point where the light from the object converges, a replica or likeness of the actual object is created; this replica is known as the image. Once the reflected light rays reached the image location, they begin to diverge. The point where all the reflected light rays converge is known as the image point. Not only is it the point where light rays converge, it is also the point where reflected light rays appear to an observer to be coming from. Regardless of the observer's location, the observer will see a ray of light passing through the real image location. To view the image, the observer must line her sight up with the image location in order to see the image via the reflected light ray. The diagram below depicts several rays from the object reflecting from the mirror and converging at the image location. The reflected light rays then begin to diverge, with each one being capable of assisting an individual in viewing the image of the object.



For plane mirrors, *virtual images* are formed. Light does not actually pass through the virtual image location; it only appears to an observer as though the light was emanating from the virtual image location. The image formed by this concave mirror is a *real image.* When a real image is formed, it still appears to an observer as though light is diverging from the real image location. Only in the case of a real image, light is actually passing through the image location.

Converging Lens Image Formation

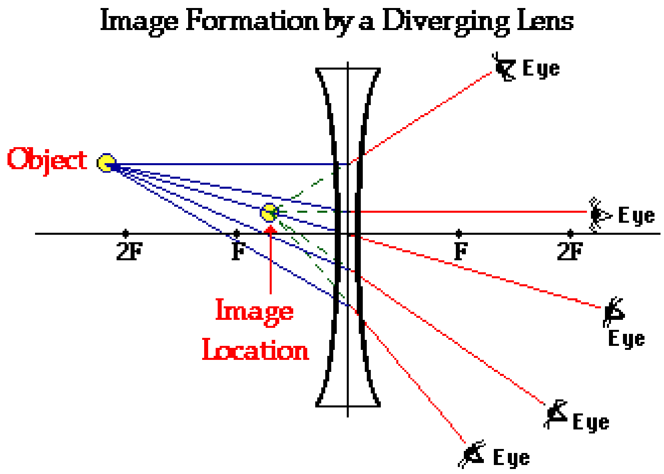
Converging lenses can produce both real and virtual images while diverging lenses can only produce virtual images. The process by which images are formed for lenses is the same as the process by which images are formed for plane and curved mirrors. Images are formed at locations where any observer is sighting as they view the image of the object through the lens. Therefore, if the path of several light rays through a lens is traced, each of these light rays will intersect at a point upon refraction through the lens. Each observer must sight in the direction of this point in order to view the image of the object. While different observers will sight along different lines of sight, each line of sight intersects at the image location. The diagram below shows several incidental rays emanating from an object - a light bulb. Three of these incident rays correspond to our three strategic and predictable light rays. Each incident ray will refract through the lens and be detected by a different observer (represented by the eyes). The location where the refracted rays are intersecting is the image location.



In this case, the image is a real image since the light rays are actually passing through the image location. To each observer, it appears as though light is coming from this location.

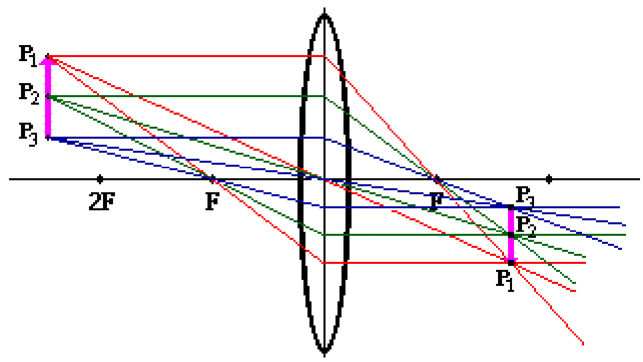
Diverging lens image formation

Diverging lenses create virtual images since the refracted rays do not actually converge to a point. In the case of a diverging lens, the image location is located on the object's side of the lens where the refracted rays would intersect if extended backwards. Every observer would be sighting along a line in the direction of this image location in order to see the image of the object. As the observer sights along this line of sight, a refracted ray would come to the observer's eye. This refracted ray originates at the object, and refracts through the lens. The diagram below shows several incident rays emanating from an object - a light bulb. Three of these incident rays correspond to our three strategic and predictable light rays. Each incident ray will refract through the lens and be detected by a different observer (represented by the eyes). The location where the refracted rays are intersecting is the image location. Since refracted light rays do not actually exist at the image location, the image is said to be a virtual image. It would only appear to an observer as though light were coming from this location to the observer's eye.



Images of objects that do not occupy a single point

The above discussion relates to the formation of an image by a "point object" - in this case, a small light bulb. The same principles apply to objects that occupy more than one point in space. For example, a person occupies a multitude of points in space. As you sight at a person through a lens, light emanates from each individual point on that person in all directions. Some of this light reaches the lens and refracts. All the light that originates from one single point on the object will refract and intersect at one single point on the image. This is true for all points on the object; light from each point intersects to create an image of this point. The result is that a replica or likeness of the object is created as we sight at the object through the lens. This replica or likeness is the image of that object. This is depicted in the diagram below.



All the rays of light emanating from each individual point on the object will refract and intersect at a single point in space. An image is created - the image is merely a replica or reproduction of the object.

Now speaking about image formation, we will turn our attention to the use of ray diagrams to predict the location and characteristics of images formed by *converging* and *diverging lenses*.

In electronics, a *digital-to-analog converter (DAC, D/A, D2A or D-to-A)* is a function that converts digital data (usually binary) into an analog signal (current, voltage, or electric charge). An analog-to-digital converter (ADC) performs the reverse function. Unlike analog signals, digital data can be transmitted, manipulated, and stored without degradation, albeit with more complex equipment. But a DAC is needed to convert the digital signal to analog to drive an earphone or loudspeaker amplifier in order to produce sounds (analog air pressure waves).

DACs and their inverse, ADCs, are part of an enabling technology that has contributed greatly to the digital revolution. To illustrate, consider a typical long-distance telephone call. The caller's voice is converted into an analog electrical signal by a microphone, and then the analog signal is converted to a digital stream by an ADC. The digital stream is then divided into packets where it may be mixed with other digital data, not necessarily audio. The digital packets are then sent to the destination, but each packet may take a completely different route and may not even arrive at the destination in the correct time order. The digital voice data is then extracted from the packets and assembled into a digital data stream. A DAC converts this into an analog electrical signal, which drives an audio amplifier, which in turn drives a loudspeaker, which finally produces sound.

There are several DAC architectures; the suitability of a DAC for a particular application is determined by six main parameters: physical size, power consumption, resolution, speed, accuracy, cost. Due to the complexity and the need for precisely matched components, all but the most special DACs are implemented as integrated circuits (ICs). Digital-to-analog conversion can degrade a signal, so a DAC should be specified that that has insignificant errors in terms of the application.

DACs are commonly used in *music players* to convert digital data streams into analog audio signals. They are also used in *television sets* and *mobile phones* to convert digital video data into analog video signals that connect to the screen drivers to display monochrome or color images. These two applications use DACs at opposite ends of the speed/resolution trade-off. The audio DAC is a low speed high resolution type while the video DAC is a high speed low to medium resolution type. Discrete DACs would typically be extremely high speed low resolution power hungry types, as used in military radar systems. Very high-speed test equipment, especially sampling *oscilloscopes,* may also use discrete DACS.

3. *Read the texts without a dictionary and retell them:*

Television and telecommunication

Television is a widely used telecommunication medium for sending (broad-casting) and receiving moving images, either monochromatic (black and white) or color, usually accompanied by sound.

In its early stages of development, television included only those devices employing a combination of optical, mechanical and electronic technologies to capture, transmit and display a visual image. As it is known, all modern television systems are based on electronic technologies, however the knowledge gained from the work on mechanical-dependent systems was important in the development of electronic television.

In 1884 Paul G. Nipkow, a 20-year old university student in Germany invented the first electromechanical television system which employed a scanning disk, a spinning disk with a series of holes spiraling toward the center, for “rasterization”, the process of converting a visual image into a stream of electrical pulses. The beginning of the 20-th century brought advances in amplifier tube technology and the use of a rotating mirror-drum scanner to capture the image. Most of the 20-th century television sets depended also upon the cathode-ray tube invented by Karl Braun in 1921.

Telecommunication, transmission of signals over a distance for the purpose of communication, is an important part of modern society. In telecommunication, a communication system is a collection of individual communications networks, transmission systems, relay stations, substations and data terminal equipment usually capable of interconnection and interoperation to form an integral whole. The components of a communication system serve a common purpose, they are technically compatible, use common procedures, respond to controls and operate in unison.

Radar

The word “radar” means *Ra*dio *D*etermination *a*nd *R*anging. Radar equipment is capable of determining by radio echoes the presence of objects, their direction, range and recognizing their character. Radar detects objects at a distance by reflecting radio waves off them. The delay caused by the echo measures he distance. The direction of the beam determines the direction of the reflection. The polarization and frequency of the return can sense the type of surface.

There are several types of radar sets, all of them consisting of six essential components, namely: a transmitter, a receiver, an antenna system, an indicator, a timer and, of course, a power supply.

A radar set detects by sending out short powerful pulses of ultra-high frequency radio wave energy from a high power transmitter. The directional antenna takes this energy from the transmitter and radiates it in a beam (similar to that of a searchlight). As the transmitted energy strikes an object, a portion of it is reflected back. The receiver picks up the returning echo through its antenna and translates it into visual readable signals on a fluorescent screen. The appearance of these signals show the presence of an object within the field of view of radar.

Navigational radars scan a wide area two to four times per minute. They use very short waves that reflect from earth and stone. They are common on ships and long-distance aircraft. General-purpose radars generally use navigational radar frequencies, but modulate and polarize the pulse so he receiver can determine the type of surface of the reflector. Search radars scan a wide area with pulses of short radio waves and sometimes use the Doppler effect to separate moving vehicles from clutter. Weather radars can even measure wind speed.

4. Coordinate the words given in the left column with their interpretation in the right:

1) Radio	a) a system for conveying speech over distances by converting sounds into electric impulses sent through a wire.
2) Computer	b) a method, process for handling a specific technical problem
3) Internet	c) communicating over by converting sounds or signals into electromagnetic waves and transmitting them through space.
4) Telegraph	d) a circuit devise that determines the content of a given instruction or performs digital – to – analog conversion.
5) Telephone	e) an apparatus or system that converts a coded message into electric impulses and sends it to a distant receiver.
6) Decoder	f) an electronic machine which, by means of stored instructions and information, performs complex calculations
7) Networking	g) process of development or gradual progressive change
8) Evolution	h) a world-wide network of computers, communicating with each other by using Internet Protocol.
9) Modulation	i) the interconnection of computer systems over communication lines.
10) Technology	j) a variation in the amplitude frequency or phase in accordance with some signal.

Unit 4. Supplementary texts

Communication systems

Communication is the basic process of exchanging information. The basic components of an electronic communication system are:

1) Transmitter.
2) Communication channel.
3) Receiver.

A *Transmitter* is a collection of electronic circuits designed to convert the information into a signal suitable for transmission over a given communication medium.

A *Receiver* is a collection of electronic circuits designed to convert the signal back to the original information.

The *Communication channel* is the medium by which the electronic signal is transmitted from one place to another.

A *radio communication system* sends signals by radio. Types of radio communication systems deployed depend on *technology*, standards, regulations, radio spectrum allocation, user requirements, service positioning, etc. The *radio equipment* involved in *communication systems* includes a *transmitter* and a *receiver*, each having an *antenna* and appropriate *terminal equipment* such as a *microphone* at the transmitter and a *loudspeaker* at the receiver in the case of a voice-communication system.

The power consumed in a transmitting station varies depending on the distance of communication and the transmission conditions. The power received at the receiving station is usually only a tiny fraction of the transmitter's output, since communication depends on receiving the *information*, not the *energy* that was transmitted.

Classical radio communications systems use *frequency-division multiplexing* (FDM) as a strategy to split up and share the available *radio-frequency bandwidth* for use by different parties communications concurrently. Modern radio communication systems include those that divide a radio-frequency band by *time-division multiplexing* (TDM) and *code-division multiplexing* (CDM) as alternatives to the classical FDM strategy. These systems offer different tradeoffs in supporting multiple users, beyond the FDM strategy that was ideal for broadcast radio but less so for applications such as *mobile telephony*.

A radio communication system may send information only one way. For example, in broadcasting a single transmitter sends signals to many receivers. Two stations may take turns sending and receiving, using a single radio frequency; this is called "simplex." By using two radio frequencies, two stations may continuously and concurrently send and receive signals - this is called "*duplex*" operation.

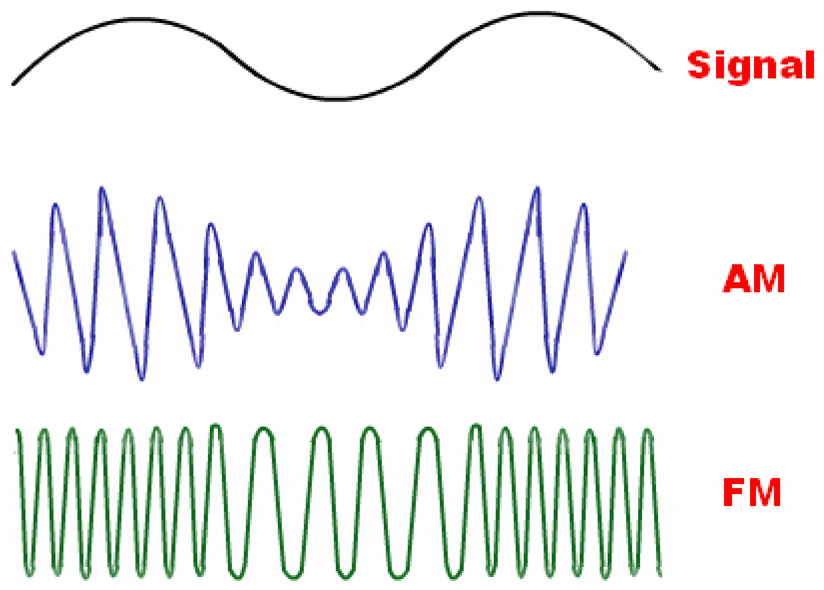
Do the following tasks:

1) Translate into Russian.

2) Write a summary.

What is Modulation?

Modulation is the process of superimposing the information contents of a modulating signal on a carrier signal (which is of high frequency) by varying the characteristics of carrier signal according to the modulating signal.



Modulation is a process in which the base band signal modifies another high-frequency signal called the carrier.

Types of Modulation

We can modulate the information-bearing signal into two types namely.These are called *Modulation Techniques*.

1. Analog Modulation
2. Digital Modulation

Analog modulation is the process of converting an analog input signal into a signal that is suitable for RF transmission.

Digital modulation is the process of converting a digital bistream into an analog signal suitable for RF transmission.

Modulation Index

Modulation Index indicates the depth of modulation. As the amplitude of the modulating signal increases, modulation index increases. For amplitude modulation, the modulation index is given as

m =EmEc

m = Amplitude of modulating signal Amplitude of the carrier.

For frequency modulation,

m = δfm

m = Maximum frequency deviation Modulating frequency.

Analog modulation

The *Analog carrier signal* is modulated by analog information signal so that information bearing analog signal can travel larger distance without the fear of loss due to absorption.

The Analog modulation is of two types:

1) Amplitude Modulation

2) Angle Modulation

The Angle modulation is further classified as Frequency modulation and Phase Modulation.

Amplitude Modulation:

In this type of modulation, the strength of the carrier signal is varied with the modulating signal.

Frequency Modulation: In this type of modulation, the frequency of the carrier signal is varied with the modulating signal.

Phase Modulation: In this type of modulation, the phase of the carrier signal is varied with the modulating signal. It is the variant of the frequency modulation.

The analog carrier signal is modulated by digital information signal. It is also considered as digital to analog conversion.

Do the following tasks:

1)Translate the texts.

2)Speak about types of modulation.

Channels of communications

Old telephone wires are a challenging communications channel for modern digital communications.

In telecommunications and computer networking, a *communication channel*, or *channel*, refers either to a physical *transmission medium* such as a wire or to a logical connection over a *multiplexed medium* such as a radio channel. A channel is used to convey an information signal, for example, a digital bit stream, from one or several *senders* (or transmitters) to one or several *receivers*. A channel has a certain capacity for transmitting information, often measured by its *bandwidth* in Hz or its *data rate* in bits per second.

Communicating data from one location to another requires some form of pathway or medium. These pathways, called communication channels, use two types of media: cable (twisted-pair wire, cable, and fiber-optic cable) and broadcast (microwave, satellite, radio, and infrared). Cable or wire line media use physical wires of cables to transmit data and information. Twisted-pair wire and coaxial cables are made of copper, and fiber-optic cable is made of glass.

In information theory, a channel refers to a theoretical *channel model* with certain error characteristics. In this more general view, a *storage device* is also a kind of channel, which can be sent to (written) and received from (read).

A channel can take many forms. Examples of communications channels include:

1) A connection between initiating and terminating nodes of a circuit.

2) A single path provided by a *transmission medium* via either physical separation, such as by multipair *cable* or electrical separation, such as by *frequency-division* or *time-division multiplexing*.

3) A path for conveying electrical or electromagnetic signals, are usually distinguished from other parallel paths. It includes:

-A *storage* that can communicate a message over time as well as space.

-The portion of a storage medium, such as a *track* or band, that is accessible to a given reading or writing station or head.

-A buffer from which messages can be 'put' and 'got'.

In a communication system, the physical or logical link connects a data source to a data sink.

4) A specific *radio frequency*, pair or band of frequencies, are usually named with a letter, number, or code word, and often allocated by international agreement.

All of these communications channels share the property that they transfer information. The information is carried through the channel by a signal.

A channel can be modelled physically by trying to calculate the physical processes, which modify the transmitted signal. For example in wireless communications the channel can be modelled by calculating the reflection off every object in the environment. A sequence of random numbers might also be added in to simulate external interference and/or electronic noise in the receiver.

Statistically a communication channel is usually modelled as a triple consisting of an input alphabet, an output alphabet, and for each pair *(i, o)* of input and output elements a transition probability *p (i, o)*. Semantically, the transition probability is the probability that the *symbol o* is received given that *i* was transmitted over the channel.

Statistical and physical modelling can be combined. For example in wireless communications the channel is often modelled by a random attenuation (known as fading) of the transmitted signal, followed by additive noise. The attenuation term is a simplification of the underlying physical processes and captures the change in signal power over the course of the transmission. The noise in the model captures external interference and/or electronic noise in the receiver. If the attenuation term is complex it also describes the relative time a signal takes to get through the channel. The statistics of the random attenuation are decided by previous measurements or physical simulations.

Channel models may be continuous channel models in that there is no limit to how precisely their values may be defined.

Communication channels are also studied in a discrete-alphabet setting. This corresponds to abstracting a real world communication system in which the analog->digital and digital->analog blocks are out of the control of the designer. The mathematical model consists of a transition probability that specifies an output distribution for each possible sequence of channel inputs. In information theory, it is common to start with memoryless channels in which the output probability distribution only depends on the current channel input.

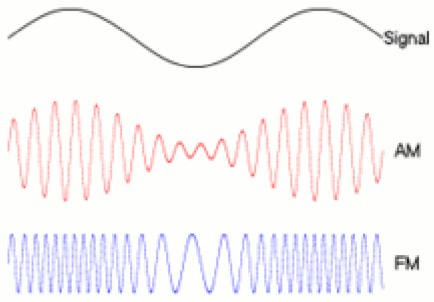
A channel model may either be digital (quantified, e.g. binary) or analog.

Do the following tasks:

1) Read and translate the text.
2) Write a summary.
3) Speak on the forms, which channels of communication can take.

Transmitter and modulation

Each system contains a transmitter. This consists of a source of electrical energy, producing *alternating current* of a desired *frequency* of oscillation. The transmitter contains a system to *modulate (change)* some property of the energy produced to impress a signal on it. This modulation might be as simple as turning the energy on and off, or altering more subtle properties such as amplitude, frequency, phase, or combinations of these properties. The transmitter sends the modulated electrical energy to a tuned *resonant antenna*; this structure converts the rapidly changing alternating current into an *electromagnetic wave* that can move through free space (sometimes with a particular *polarization*).



An audio signal (top) may be carried by an AM or FM radio wave.

Amplitude modulation of a *carrier wave* works by varying the strength of the transmitted signal in proportion to the information being sent. For example, changes in the signal strength can be used to reflect the sounds to be reproduced by a speaker, or to specify the light intensity of television pixels. It was the method used for the first audio radio transmissions, and remains in use today. "AM" is often used to refer to the *medium wave* broadcast *band.*

Frequency modulation varies the *frequency* of the carrier. The instantaneous frequency of the carrier is directly proportional to the instantaneous value of the input signal. Digital data can be sent by shifting the carrier's frequency among a set of discrete values, a technique known as *frequency-shift keying*.

FM is commonly used at *VHF radio frequencies* for *high fidelity broadcasts* of music and speech. Normal (analog) TV sound is also broadcast using FM.

Angle modulation alters the instantaneous *phase* of the carrier wave to transmit a signal. It is another term for *phase modulation*.

Antenna

An *antenna* (or *aerial*) is an electrical device, which converts *electrical currents* into *radio waves*, and vice versa. It is usually used with a *radio transmitter* or *radio receiver*. In *transmission*, a radio transmitter applies an oscillating *radio frequency* electric current to the antenna's terminals, and the antenna radiates the energy from the current as *electromagnetic waves* (radio waves). In reception, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminals that is applied to a receiver to be *amplified*. An antenna can be used for both transmitting and receiving.

Propagation

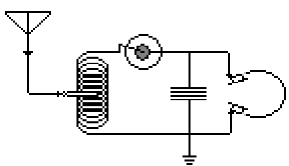
Once generated, electromagnetic waves either travel through space directly, or have their path altered by *reflection, refraction or diffraction*. The intensity of the waves diminishes due to geometric dispersion (the inverse-square law); some energy may also be absorbed by the intervening medium in some cases. *Noise* will generally alter the desired signal; this *electromagnetic interference* comes from natural sources, as well as from artificial sources such as other transmitters and accidental radiators. Noise is also produced at every step due to the inherent properties of the devices used.

If the magnitude of the noise is large enough, the desired signal will no longer be discernible; this is the fundamental limit to the range of radio communications.

Resonance

Electrical resonance of tuned circuits in radios allow individual stations to be selected. A resonant circuit will respond strongly to a particular frequency and much less so to differing frequencies. This allows the radio receiver to discriminate between multiple signals differing in frequency.

Receiver and demodulation



A *crystal receiver* consists of an *antenna, rheostat, coil, crystal rectifier, capacitor, headphones and ground connection.* The electromagnetic wave is intercepted by a tuned receiving antenna; this structure captures some of the energy of the wave and returns it to the form of oscillating electrical currents. At the receiver, these currents are *demodulated*, which is conversion to a usable signal form by a *detector* sub-system. The receiver is "*tuned*" to respond preferentially to the desired signals, and reject undesired signals.

Early radio systems relied entirely on the energy collected by an antenna to produce signals for the operator. Radio became more useful after the invention of *electronic* devices such as the *vacuum tube* and later the *transistor*, which made it possible to amplify weak signals. Today radio systems are used for applications from walkie-talkie children's toys to the control of *space vehicles*, as well as for *broadcasting*, and many other applications.

A *radio receiver* receives its input from an *antenna*, uses *electronic filters* to separate a wanted radio signal from all other signals picked up by this antenna. It amplifies the signal to a level suitable for further processing, and finally converts through *demodulation* and decoding the signal into a form usable for the consumer, such as sound, pictures, digital data, measurement values, navigational positions, etc.

Transmission and Reception of Radio Waves

For the propagation and interception of radio waves, a transmitter and receiver are employed. A radio wave acts as a carrier of information-bearing signals; the information may be encoded directly on the wave by periodically interrupting its transmission (as in dot-and-dash telegraphy) or impressed on it by a process called *modulation*. The actual information in a modulated signal is contained in its *sidebands*, or frequencies added to the carrier wave, rather than in the carrier wave itself. The two most common types of modulation used in radio are amplitude modulation (AM) and frequency modulation (FM). Frequency modulation minimizes *noise* and provides greater fidelity than amplitude modulation, which is the older method of *broadcasting*. Both AM and FM are analog transmission systems, that is, they process sounds into continuously varying patterns of electrical signals, which resemble sound waves. Digital radio uses a transmission system in which the signals propagate as discrete voltage pulses, that is, as patterns of numbers; before transmission, an analog audio signal is converted into a digital signal, which may be transmitted in the AM or FM frequency range. A digital radio broadcast offers compact-disc-quality reception and reproduction on the FM band and FM-quality reception and reproduction on the AM band.

In its most common form, radio is used for the transmission of sounds (voice and music) and pictures (television). The sounds and images are converted into electrical signals by a microphone (sounds) or video camera (images), amplified, and used to modulate a carrier wave that has been generated by an *oscillator* circuit in a transmitter. The modulated carrier is also amplified, then applied to an *antenna* that converts the electrical signals to electromagnetic waves for radiation into space. Such waves radiate at the speed of light and are transmitted not only by line of sight but also by deflection from the *ionosphere*.

Receiving antennas intercept part of this radiation, change it back to the form of electrical signals, and feed it to a receiver. The most efficient and most common circuit for radio-frequency selection and amplification used in radio receivers is the super heterodyne. In that system, incoming signals are mixed with a signal from a local oscillator to produce intermediate frequencies (IF) that are equal to the arithmetical sum and difference of the incoming and local frequencies. One of those frequencies is applied to an amplifier. Because the IF amplifier operates at a single frequency, namely the intermediate frequency, it can be built for optimum selectivity and gain. The tuning control on a radio receiver adjusts the local oscillator frequency. If the incoming signals are above the threshold of sensitivity of the receiver and if the receiver is tuned to the frequency of the signal, it will amplify the signal and feed it to circuits that demodulate it, i.e., separate the signal wave itself from the carrier wave.

There are certain differences between AM and FM receivers. In an AM transmission, the carrier wave is constant in frequency and varies in amplitude (strength) according to the sounds present at the microphone; in FM, the carrier is constant in amplitude and varies in frequency. Because the noise that affects radio signals is partly, but not completely, manifested in amplitude variations, wideband FM receivers are inherently less sensitive to noise. In an FM receiver, the limiter and discriminator stages are circuits that respond solely to changes in frequency. The other stages of the FM receiver are similar to those of the AM receiver but require more care in design and assembly to make full use of FM's advantages. FM is also used in television sound systems. In both radio and television receivers, once the basic signals have been separated from the carrier wave they are fed to a loudspeaker or a display device (usually a cathode-ray tube), where they are converted into sound and visual images, respectively.

Telephony

Mobile phones transmit to a local *cell site* (transmitter/receiver) that ultimately connects to the public switched telephone network (PSTN) through an optic fiber or microwave radio and other network elements. When the mobile phone nears the edge of the cell site's radio coverage area, the central computer switches the phone to a new cell. Cell phones originally used FM, but now most use various digital modulation schemes. Recent developments in Sweden (such as DROPme) allow for the instant downloading of digital material from a radio broadcast (such as a song) to a mobile phone.

Satellite phones use satellites rather than cell towers to communicate.

Video

*Televisio*n sends the picture as AM and the sound as AM or FM, with the sound carrier a fixed frequency (4.5 MHz in the NTSC system) away from the video carrier. Analog television also uses a *vestigial sideband* on the video carrier to reduce the bandwidth required.

Digital television uses 8VSB modulation in North America (under the ATSC digital television standard), and COFDM modulation elsewhere in the world (using the DVB-T standard). A *Reed-Solomon error correction* code adds redundant correction codes and allows reliable reception during moderate data loss. Although many current and future codecs can be sent in the *MPEG transport stream container format*, as of 2006 most systems use a standard-definition format almost identical to DVD: MPEG-2 video in *anamorphic widescreen* and *MPEG layer 2*

(*MP2*) audio. *High-definition television* is possible simply by using a higher-resolution picture, but *H.264/AVC* is being considered as a replacement video codec in some regions for its improved compression. With the compression and improved modulation involved, a single "channel" can contain a high-definition program and several standard-definition programs.

Navigation

All *satellite navigation* systems use satellites with precision clocks. The satellite transmits its position, and the time of the transmission. The receiver listens to four satellites, and can figure its position as being on a line that is tangent to a spherical shell around each satellite, determined by the *time-of-flight* of the radio signals from the satellite. A computer in the receiver does the math.

Radio direction-finding is the oldest form of radio navigation. Before 1960 navigators used movable loop antennas to locate commercial AM stations near cities. In some cases, they used marine radiolocation beacons, which share a range of frequencies just above AM radio with amateur radio operators. LORAN systems also used time-of-flight radio signals, but from radio stations on the ground.

Very High Frequency omnidirectional Range (VOR), systems (used by aircraft), have an antenna array that transmits two signals simultaneously. A directional signal rotates like a lighthouse at a fixed rate. When the directional signal is facing north, an omnidirectional signal pulses. By measuring the difference in phase of these two signals, an aircraft can determine its bearing or radial from the station, thus establishing a line of position. An aircraft can get readings from two VORs and locate its position at the intersection of the two radials, known as a "fix".

When the VOR station is collocated with DME (Distance Measuring Equipment), the aircraft can determine its bearing and range from the station, thus providing a fix from only one ground station. Such stations are called VOR/DMEs. The military operates a similar system of navaids, called TACANs, which are often built into VOR stations. Such stations are called VORTACs. Because TACANs include distance measuring equipment, VOR/DME and VORTAC stations are identical in navigation potential to civil aircraft.

Radar

Radar (Radio Detection And Ranging) detects objects at a distance by bouncing radio waves off them. The delay caused by the echo measures the distance. The direction of the beam determines the direction of the reflection. The polarization and frequency of the return can sense the type of surface. Navigational radars scan a wide area two to four times per minute. They use very short waves that reflect from earth and stone. They are common on commercial ships and long-distance commercial aircraft.

General purpose radars generally use navigational radar frequencies, but modulate and polarize the pulse so the receiver can determine the type of surface of the reflector. The best general-purpose radars distinguish the rain of heavy storms, as well as land and vehicles. Some can superimpose sonar data and map data from GPS position.

Search radars scan a wide area with pulses of short radio waves. They usually scan the area two to four times a minute. Sometimes search radars use the Doppler effect to separate moving vehicles from clutter. Targeting radars use the same principle as search radar but scan a much smaller area far more often, usually several times a second or more. Weather radars resemble search radars, but use radio waves with circular polarization and a wavelength to reflect from water droplets. Some weather radar use the Doppler effect to measure wind speeds.

Radio systems

Most new radio systems are digital, including Digital TV, satellite radio, and Digital Audio Broadcasting. The oldest form of digital broadcast was spark gap telegraphy, used by pioneers such as Marconi. By pressing the key, the operator could send messages in Morse code by energizing a rotating commutating spark gap. The rotating commutator produced a tone in the receiver, where a simple spark gap would produce a *hiss*, indistinguishable from static. *Spark-gap transmitters* are now illegal, because their transmissions span several hundred megahertz. This is very wasteful of both radio frequencies and power.

The next advance was continuous wave *telegraphy*, or CW (Continuous Wave), in which a pure radio frequency, produced by a *vacuum tube electronic oscillator* was switched on and off by a key. A receiver with a local oscillator would "heterodyne" with the pure radio frequency, creating a whistle-like audio tone. CW uses less than 100 Hz of bandwidth. CW is still used, these days primarily by amateur radio operators (hams). Strictly, on-off keying of a carrier should be known as "Interrupted Continuous Wave», ICW, or on-off keying (OOK).

Radio teletype equipment usually operates on short-wave (HF) and is much loved by the military because they create written information without a skilled operator. They send a bit as one of two tones using *frequency-shift keying*. Groups of five or seven bits become a character printed by a tele printer. From about 1925 to 1975, radio teletype was how most commercial messages were sent to less developed countries. These are still used by the military and weather services.

Aircraft use a 1200-Baud radio teletype service over VHF to send their ID, altitude and position, and get gate and connecting-flight data. Microwave dishes on satellites, telephone exchanges and TV stations usually use *quadrature amplitude modulation* (QAM). QAM sends data by changing both the phase and the amplitude of the radio signal. Engineers like QAM because it packs the most bits into a radio signal when given an exclusive (non-shared) fixed narrowband frequency range. Usually the bits are sent in "frames" that repeat. A special bit pattern is used to locate the beginning of a frame.

Modern GPS receivers.

Communication systems that limit themselves to a fixed narrowband frequency range are vulnerable to *jamming*. A variety of jamming-resistant *spread* *spectrum* techniques were initially developed for military use, most famously for *Global Positioning System* satellite transmissions. Commercial use of spread spectrum began in the 1980s. *Bluetooth*, most cell phones, and the 802.11b version of Wi-Fi each use various forms of spread spectrum.

Systems that need reliability, or that share their frequency with other services, may use "coded orthogonal frequency-division multiplexing" or COFDM. COFDM breaks a digital signal into as many as several hundred slower sub channels. The digital signal is often sent as QAM on the sub channels. Modern COFDM systems use a small computer to make and decode the signal with digital signal processing, which is more flexible and far less expensive than older systems that implemented separate electronic channels.

COFDM resists *fading* and *ghosting* because the narrow-channel QAM signals can be sent slowly. An adaptive system or one that sends error-correction codes can also resist interference, because most interference can affect only a few of the QAM channels. COFDM is used for Wi-Fi, some cell phones, *Digital Radio Mondiale*, Eureka 147, and many other local area network, digital TV and radio standards.

Do the following task:

1) Read the texts and try to speak on the information presented in these texts.

Contents

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